## CLEO: QELS-Fundamental Science

### Executive Ballroom 210A

**08:00–10:00**
**FM1A • Quantum Engineering**
*Presider: Nicholas Peters; Applied Communication Sciences, USA*

**FM1A.1 • 08:00** Tutorial
**Quantum Optomechanics,** Markus Aspelmeyer[1]; [1]*Universitat Wien, Austria.* This tutorial provides an introduction to the current state-of-the-art, the challenges and the prospects of achieving quantum optical control over nano-, micro- and macro-mechanical devices, i.e. quantum optomechanics.

Markus Aspelmeyer is Professor of Physics at the University of Vienna, and Speaker of the Vienna Center for Quantum Science and Technology (VCQ). He is regarded as one of the pioneers of the field of cavity optomechanics. His research combines the development of new quantum technologies with fundamental quantum experiments.

### Executive Ballroom 210B

**08:00–10:00**
**FM1B • Relativistic Laser-Plasma Interactions**
*Presider: Sergei Tochitsky; Univ. of California Los Angeles, USA*

**FM1B.1 • 08:00** Invited
**High energy ion acceleration and neutron production using relativistic transparency in solids,** Markus Roth[1], Daniel Jung[2], Katerina Falk[2], Nevzat Guler[2], Vincent Bagnoud[3], Stefan Bedacht[1], Oliver Deppert[1], Matthew J. Devlin[2], Andrea Favalli[2], Juan Fernandez[2], Cort D. Gautier[2], Matthias Geissel[4], Robert C. Haight[2], Chris E. Hamilton[2], Manuel B. Hegelich[2], Randall P. Johnson[2], Annika Kleinschmidt[1], Frank E. Merrill[2], Alex Ortner[1], Gabriel Schaumann[1], Kurt Schoenberg[2], Marius Schollmeier[4], Thomas Shimada[2], Terry N. Taddeucci[2], Alexandra Tebartz[1], Joshua L. Tybo[2], Florian Wagner[1], Stephen A. Wender[2], Carl H. Wilde[2], Glen A. Wurden[2]; [1]*Inst. for Nuclear Physics, Technische Universität Darmstadt, Germany;* [2]*Los Alamos National Lab, USA;* [3]*Helmholtzzentrum für Schwerionenforschung - GSI, Germany;* [4]*Sandia National Lab, USA.* Neutrons are unique to diagnose materials and excite nuclear reactions with a large field of applications. For the first time a new ion acceleration mechanism (BOA) has been used to generate intense, directed neutron beams.

**FM1B.2 • 08:30**
**GeV Electrons and High brightness Betatron X-rays from Petawatt-Laser-Driven Plasma Accelerators,** Xiaoming Wang[1], Rafal Zgadzaj[1], Neil Fazel[1], Zhengyan Li[1], Watson Henderson[1], Yen-Yu Chang[1], Rick Korzekawa[1], S. Yi[2], V. Khudik[1], X. Zhang[1], Hai-En Tsai[1], Chih-Hao Pai[3], H. Quevedo[1], G. Dyer[1], E. Gaul[1], M. Martinez[1], A. Bernstein[1], M. Spinks[1], Michael Donovan[1], Gennady Shvets[1], Todd Ditmire[1], Michael C. Downer[1]; [1]*Univ. of Texas at Austin, USA;* [2]*Tsinghua Univ., China;* [3]*Los Alamos National Lab, USA.* We identify three regimes of correlated GeV-electron/keV-betatron-x-ray generation by a laser-plasma accelerator driven by the Texas Petawatt laser, and relate them to variations in strength of blowout, injection geometry and beam loading.

### Executive Ballroom 210C

**08:00–10:00**
**FM1C • Hyperbolic and Epsilon-near-zero Materials**
*Presider: Philippe Tassin; Chalmers Univ., Sweden*

**FM1C.1 • 08:00**
**Wave Propagation in Magnetized Epsilon-Near-Zero Metamaterials,** Arthur Davoyan[1], Nader Engheta[1]; [1]*Univ. of Pennsylvania, USA.* In this work we theoretically study light propagation in magnetized epsilon-near-zero (ENZ) metamaterials. We reveal novel regimes of propagation, including optical isolation of circularly polarized waves and back-scattering immune surface wave propagation.

**FM1C.2 • 08:15**
**Nonlocal Response in Transition Metamaterials,** Zhaxylyk A. Kudyshev[1], Natalia M. Litchinitser[1]; [1]*Electrical Engineering, Univ. at Buffalo, USA.* We investigate resonant enhancement of light in transition metamaterialsunder the local and nonlocal response function approximations, and analyze the influence of nonlocality on the field distribution in the near-zero region.

**FM1C.3 • 08:30**
**All Semiconductor Negative-Index Plasmonic Absorbers,** Christopher Roberts[1], Stephanie Law[3], Torin Kilpatrick[3], Lan Yu[3], Troy Ribaudo[2], Eric Shaner[2], Dan Wasserman[3], Viktor A. Podolskiy[1]; [1]*Physics and Applied Physics, Univ. of Massachusetts Lowell, USA;* [2]*Sandia National Labs, USA;* [3]*Electrical and Computer Engineering, Univ. of Illinois Urbana Champaign, USA.* We demonstrate all-semiconductor thin-film plasmonic absorbers, where strong absorption in these structures is linked to the excitation of highly-confined negative-index surface plasmon polaritons. We present numerical and analytical descriptions of guided modes of the system.

### Executive Ballroom 210D

**08:00–10:00**
**FM1D • PT Symmetry and Related Phenomena**
*Presider: Matthias Heinrich, Univ. of Central Florida, USA*

**FM1D.1 • 08:00**
**Beyond PT-symmetry: SUSY-mediated real spectra in complex refractive index landscapes,** Mohammad-Ali Miri[1], Matthias Heinrich[1], Demetrios N. Christodoulides[1]; [1]*CREOL The College of Optics and Photonics, Univ. of Central Florida, USA.* In the presence of gain and loss, supersymmetric transformations facilitate the arbitrary removal of modes from wave-guiding structures. We show how SUSY gives rise to non-PT-symmetric families of complex potentials with entirely real-valued eigenvalue spectra.

**FM1D.2 • 08:15**
**Observation of Gravitational Effects in Nonlocal Nonlinearity,** Rivka Bekenstein[1], Ran Schley[1], Maor Mutzafi[1], Carmel Rotschild[1], Ido Dolev[2], Ady Arie[2], Mordechai Segev[1]; [1]*Physics Dept. and Solid State Inst., Technion Israel Inst. of Technology, Israel;* [2]*Dept. of Physical Electronics, Fleischman Faculty of Engineering, Tel Aviv Univ., Israel.* We demonstrate optical analogues of gravitational effects such as gravitational lensing, tidal forces and gravitational redshift in the Newton-Schrödinger mainframe, by utilizing long-range interactions between solitons and accelerating beams in nonlocal nonlinear media.

**FM1D.3 • 08:30**
**PT symmetric large area single mode DFB lasers,** Hossein Hodaei[1], Mohammad-Ali Miri[1], Matthias Heinrich[1], Demetrios N. Christodoulides[1], Mercedeh Khajavikhan[1]; [1]*CREOL The College of Optics and Photonics, Univ. of Central Florida, USA.* We propose a novel class of large-area single-mode semiconductor lasers in which notions from parity-time symmetry is employed to reliably suppress higher-order modes. The feasibility of our design is investigated in InGaAsP quantum-well arrangements.

Executive Ballroom 210E

Executive Ballroom 210F

Executive Ballroom 210G

Executive Ballroom 210H

## CLEO: Science & Innovations

### 08:00–10:00
### SM1E • Atmospheric Sensing
*Presider: Mark Phillips; Pacific Northwest National Lab, USA*

**SM1E.1 • 08:00** Tutorial

**Recent developments in measurements of atmospheric trace gases,** Steven C. Wofsy[1], Eric Kort[2], Eric Crosson[3], Frank Keutsch[4]; *[1]Harvard Univ., USA; [2]Dept. of Atmospheric, Oceanic and Space Sciences, Univ. of Michigan, USA; [3]Picarro, Inc, USA; [4]Dept. of Chemistry, Univ. of Wisconsin, USA.* Lasers are used to measure extremely low concentrations of reactive species and minute variations greenhouse gases in the atmosphere. Instrument challenges differ sharply, illustrated in case studies for atmospheric glyoxal, methane and others.

Steven Wofsy has a background in chemistry and physics, with interests and experience spanning stratospheric and tropospheric chemistry, from remote clean environments to urban areas, engaging sensor development from the fundamentals to commercialization, field and laboratory applications, and modeling and synthesis.

### 08:00–10:00
### SM1F • Solid State Laser Systems for Secondary Source Generation
*Presider: Thomas Spinka, Lawrence Livermore National Lab., USA*

**SM1F.1 • 08:00** Invited

**Cryogenic Composite Disk Laser for Peak and Average Power Scaling,** Luis E. Zapata[1,2]; *[1]Research Lab of Electronics, Dept of Electrical Engineering and Computer Science, MIT, USA; [2]Center for free electron laser science, Deutsches Elektronen Synchrotron, Germany.* We demonstrate high gain producing 60 mJ, 200 ps pulses at 200 Hz from a single 4-mm ASE limited gain-cell. A scaling paradigm utilizing a monolithic array of gain cells is proposed.

**SM1F.2 • 08:30**

**Low temperature active mirror Yb:YAG laser amplifier gain studies,** Thierry Gonçalves-Novo[1], Samuel Marrazzo[1], Bernard Vincent[1], Jean-Christophe F. Chanteloup[1]; *[1]Laboratoire Utilisation des Lasers Intenses, Ecole Polytechnique, CNRS, CEA, UPMC, France.* Single pass gain of 77mm crystal and ceramic Yb:YAG disks are compared in the 100-200K temperature range. Experiments are performed on a laser amplifier cooled through a static low pressure helium gas cell.

### 08:00–10:00
### SM1G • Optical Signal Processing
*Presider: Takahide Sakamoto; National Inst. of Information & Communication Tech, Japan*

**SM1G.1 • 08:00**

**Photonic Generation and Wireless Transmission of W-band Arbitrary Waveforms with High Time-Bandwidth Products,** Amir Rashidinejad[1], Yihan Li[1], Jhih-Min Wun[2], Daniel E. Leaird[1], Jin-Wei Shi[2], Andrew M. Weiner[1]; *[1]Electrical and Computer Engineering, Purdue Univ., USA; [2]Electrical Engineering, National Central Univ., Taiwan.* We report photonic radio-frequency arbitrary waveform generation in the W-band, enabled through optical pulse shaping and a near-ballistic uni-traveling-carrier photodiode. Example waveforms spanning 75-110GHz with long time apertures are generated and measured after wireless propagation.

**SM1G.2 • 08:15**

**High Resolution Unambiguous Ranging Based on W-band Photonic RF-Arbitrary Waveform Generation,** Yihan Li[1], Amir Rashidinejad[1], Jhih-Min Wun[2], Daniel E. Leaird[1], Jin-Wei Shi[2], Andrew M. Weiner[1]; *[1]Electrical and Computer Engineering, Purdue Univ., USA; [2]Electrical Engineering, National Central Univ., Taiwan.* We demonstrate high resolution W-band ranging based on photonic radio-frequency arbitrary waveform generation. Arbitrarily long unambiguous detection of multiple simultaneous targets is successfully executed using a photonic-assisted time-aperture expansion technique.

**SM1G.3 • 08:30**

**A Novel Intensity Modulator for Photonic ADCs using an Injection-Locked Mode-Locked Laser,** Edris Sarailou[1], Abhijeet Ardey[1], Peter J. Delfyett[1]; *[1]Univ. of Central Florida, CREOL, USA.* A novel intensity modulator for pulsed light is proposed and demonstrated here for the first time. This has been realized by introducing an injection-locked AlGaInAs mode-locked laser into one arm of a Mach-Zehnder interferometer.

### 08:00–10:00
### SM1H • Advanced Fabrication Techniques
*Presider: Koji Yamada; NTT Microsystem Integration Labs, Japan*

**SM1H.1 • 08:00**

**Arbitrary photonic wave plate operations on-chip: Realizing Hadamard and Pauli-X gates for polarization encoded qubits,** René Heilmann[1], Markus Graefe[1], Stefan Nolte[1], Alexander Szameit[1]; *[1]Inst. of Applied Physics, Germany.* We present arbitrary wave plate operations on-chip based on the reorientation of the waveguide's optical axis caused by additional stress fields. A successful implementation of Hadamard and Pauli-X gates for quantum light is shown.

**SM1H.2 • 08:15**

**Mimicking Heterostructure Behavior Within a Single Material at Room Temperature Using Strain,** David S. Sukhdeo[1], Donguk Nam[1], Ju-Hyung Kang[2], Jan Petykiewicz[1], Jae-Hyung Lee[1], Woo Shik Jung[1], Jelena Vuckovic[1], Mark Brongersma[2], Krishna C. Saraswat[1]; *[1]Electrical Engineering, Stanford Univ., USA; [2]Materials Science and Engineering, Stanford Univ., USA.* We present a new platform for mimicking heterostructure behavior within nanowires of a single material by using non-uniform strain. These pseudo-heterostructures have lithographically customizable band profiles and show effective carrier confinement at room temperature.

**SM1H.3 • 08:30**

**Low-Stress Silicon Nitride Platform for Broadband Mid-Infrared Microphotonics,** Pao T. Lin[1], Vivek Singh[1], Hao-Yu Greg Lin[2], Tom Tiwald[3], Lionel Kimerling[1], Anuradha Agarwal[1]; *[1]Microphotonics Center, MIT, USA; [2]Center for Nanoscale Systems, Harvard, USA; [3]J. A. Woollam Co., Inc., USA.* We demonstrate a sophisticated mid-IR microphotonics platform adopting engineered Si-rich and low-stress silicon nitride thin films where transparency up to $\lambda = 8.5$ μm and loss less than 0.2 dB/cm were achieved.

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## Meeting Room
## 211 B/D

## CLEO: Science & Innovations

**08:00–10:00**
**SM1I • Parametric Sources**
*Presider: Peter Schunemann; BAE Systems, USA*

**SM1I.1 • 08:00**
**Ultra-broadband DFG in CdSiP2 at 6.5 μm with 2.3 cycle transform limit from an Er:Tm:Ho fiber laser,** Daniel Sanchez[1], Michael Hemmer[1], Matthias Baudisch[1], Heinar Hoogland[2], Ronald Holzwarth[2], Kevin Zawilski[3], Peter G. Schunemann[3], Jens Biegert[1,4]; [1]*ICFO-Institut de Ciences Fotoniques, Spain;* [2]*Menlo Systems GmbH, Germany;* [3]*BAE Systems, USA;* [4]*ICREA-Instituciò Catalana de Recerca i Estudis Avancats, Spain.* We generate ultra-broadband 6.5 μm pulses with 2.3 cycle transform limit and 85 pJ energy at 100 MHz from a phase-coherent, two-color, two-arm Er:Tm:Ho all-fiber MOPA system in CdSiP2.

**SM1I.2 • 08:15**
**Idler-Resonant Femtosecond Optical Parametric Oscillator with High Mid-Infra-Red Beam Quality,** Lin Xu[1], David Shepherd[1], David J. Richardson[1], Jonathan H. Price[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK.* We report an idler-resonant femtosecond optical parametric oscillator (OPO) with average output power of 520 mW, repetition-rate of 80 MHz, pulse duration of 90 fs and nearly diffraction-limited beam quality at ~2.4 μm.

**SM1I.3 • 08:30**
**Difference-Frequency Generation of Fs And Ps Mid-IR Pulses in Liinse2 Based on Yb-Fiber Laser Pump Sources,** Marcus Beutler[1], Ingo Rimke[1], Edlef Büttner[1], Valentin Petrov[2], Ludmila Isaenko[3]; [1]*APE, Germany;* [2]*Max Born Inst., Germany;* [3]*Inst. of Geology & Mineralogy, Russia.* Difference-frequency generation between signal and idler of Yb-fiber laser synchronously-pumped femtosecond / picosecond OPOs at 53/80 MHz provides maximum single pulse energies exceeding 1 nJ and continuous tuning from 5 μm to 12 μm.

## Meeting Room
## 212 A/C

**08:00–10:00**
**SM1J • UV and Visible LEDs**
*Presider: Hongping Zhao, Case Western Reserve Univ., USA*

**SM1J.1 • 08:00**
**Anisotropic optical polarization of AlGaN based 275 nm light-emitting diodes due to quantum-size effects,** Jonathan J. Wierer[1], Ines Montano[1], Mary Crawford[1], Andy A. Allerman[1]; [1]*Sandia National Labs, USA.* Quantum-size effects strongly influence the valance band and optical polarization of 275nm emitting Al0.44Ga0.56N layers. It's shown experimentally and theoretically that thinner quantum wells and lower carrier densities result in polarization preferential for light extraction.

**SM1J.2 • 08:15**
**Temperature dependence of Sub-220nm Emission from GaN/AlN Quantum Structures by Plasma Assisted Molecular Beam Epitaxy,** SM Islam[1], Vladimir Protasenko[1], Huili G. Xing[1], Debdeep Jena[1], Jai Verma[1]; [1]*Univ. of Notre Dame, USA.* GaN/AlN structures are utilized to achieve deep-UV emission. By reducing thickenss of GaN QW to 1 ML, 224nm emission is achieved. A further shift to 219nm is gettable as GaN islands are introduced.

**SM1J.3 • 08:30**
**Enhanced Light Extraction Efficiency of Deep-Ultraviolet Light-Emitting Diodes by Al-Coated Selective-Area-Grown GaN stripes,** Dong Yeong Kim[1], Jong Won Lee[1], Jeung Jae Oh[1], Sunyong Hwang[1], Junhyuk Park[1], Jong Kyu Kim[1]; [1]*Materials Science and Engineering, POSTECH, Korea.* We present a new type of AlGaN-based deep ultraviolet light-emitting diodes with Al-coated selective-area-grown n-type GaN stripes to extract strong side emission perpendicular to the [0001] c-axis and to improve the electrical property.

## Meeting Room
## 212 B/D

## CLEO: QELS-Fundamental Science

**08:00–10:00**
**FM1K • Applications of Localized Surface Plasmons**
*Presider: Hatice Altug, Boston Univ., USA*

**FM1K.1 • 08:00** Invited
**Coherent Plasmonics: Optimized for Sensing and Energy Transfer,** Naomi J. Halas[1]; [1]*ECE, Rice Univ., USA.* Metallic nanostructures give rise to bright and dark plasmon modes, and through their interactions can support a variety of coherent phenomena more typically associated with atomic systems, providing new sensing and energy transfer strategies.

**FM1K.2 • 08:30**
**Surface and Volume Photoemission of Hot Electrons from Plasmonic Nanoantennas,** Alexander Uskov[1,2], Igor Protsenko[1], Renat Ikhsanov[3], Viktoriia Babicheva[4,5], Sergei Zhukovsky[4], Andrei Lavrinenko[4], Eoin O'Reilly[6], Hongxing Xu[2,7]; [1]*P. N. Lebedev Physical Inst. and Advanced Energy Technologies Ltd, Russia;* [2]*Wuhan Univ., China;* [3]*Research Inst. of Scientific Instruments, Russia;* [4]*Technical Univ. of Denmark, Denmark;* [5]*National Research Univ. for Information Technology, Mechanics, and Optics, Russia;* [6]*Tyndall National Inst., Ireland;* [7]*Inst. of Physics, Chinese Academy of Sciences, China.* We theoretically compare surface- and volume-based photoelectron emission from spherical nanoparticles, obtaining analytical expressions for the emission rate in both mechanisms. We show that the surface mechanism prevails, being unaffected by detrimental hot electron collisions.

## Marriott
## Salon I & II

## CLEO: Applications & Technology

**08:00–10:00**
**AM1L • Advanced Material Processing** ▶
*Presider: Michael Mielke; Raydiance Inc, USA*

**AM1L.1 • 08:00** Invited ▶
**Innovative Applications of Femtosecond Laser Induced Nanostructure,** Yasuhiko Shimotsuma[1], Taiga Asai[1], Masahiro Mori[1], Sho Kubota[1], Tomoaki Sei[1], Kazuki Fujiwara[1], Masaaki Sakakura[1], Kiyotaka Miura[1], Peter G. Kazansky[2]; [1]*Dept. of Material Chemistry, Kyoto Univ., Japan;* [2]*Optoelectronics Research Centre, Univ. of Southampton, UK.* The nanostructure induced by the direct-writing of femtosecond-laser pulses can open a new opportunity to develop avant-garde devices such as a 5D optical storage, polarization imaging sensor, thermoelectric conversion elements.

**AM1L.2 • 08:30** ▶
**Nanotexturing of Glass Surface by Ultrafast Laser Assisted Wet Etching,** Rokas Drevinskas[1], Mindaugas Gecevičius[1], Martynas Beresna[1], Yves Bellouard[2], Peter G. Kazansky[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK;* [2]*Mechanical Engineering Dept., Eindhoven Univ. of Technology, Netherlands.* Surface texturing with 30 nm resolution is demonstrated by KOH wet etching and ultrafast laser nanostructuring of silica. An increase of three times in retardance is achieved leading to the fabrication of dichroic glass-metal patterns.

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**Monday, 9 June**
SC270 • High Power Fiber Lasers and Amplifiers
SC301 • Quantum Cascade Lasers: Science, Technology, Applications and Markets
SC376 • Plasmonics
SC402 • Transformational Optics

**Tuesday, 10 June**
SC271 • Quantum Information-Technologies and Applications
SC352 • Introduction to Ultrafast Pulse Shaping—Principles and Applications
SC362 • Cavity Optomechanics: Fundamentals and Applications of Controlling and Measuring Nano- and Micro-mechanical Oscillators with Laser Light
SC379 • Silicon Photonic Devices and Applications
SC410 • Finite Element Modelling Methods for Photonics and Optics

## CLEO: Science & Innovations

### Marriott Salon III

**08:00–10:00**
**SM1M • Frequency Combs and Novel Light Sources** ▶
*Presider: Yoshitomo Okawachi; Cornell Univ., USA*

**SM1M.1 • 08:00** Invited ▶
**Ga(In)N Nanowire Light Emitting Diodes and Single Photon Sources,** Pallab K. Bhattacharya[1], Saniya Deshpande[1], Shafat Jahangir[1]; *[1]Univ. of Michigan, USA.* Abstract: Ga(In)N nanowires and Ga(In)N quantum disks can be grown defect-free on silicon with p- and n-doping to form diodes. We will describe the characteristics of light-emitting diodes and electrically injected single nanowire single photon sources. OCIS codes: (230.3670) Light-emitting diodes; (250.5590) Quantum-well, -wire and -dot devices.

**SM1M.2 • 08:30** ▶
**Gallium Nitride Nanowire Distributed Feedback Lasers,** Jeremy B. Wright[1,2], Salvatore Campione[1,3], Sheng Liu[1,3], Julio Martinez[3,4], Huiwen Xu[2], Ting S. Luk[1,3], Qiming Li[1], George T. Wang[1], Brian S. Swartzentruber[1,3], Igal Brener[1,3]; *[1]Sandia National Labs, USA; [2]Center for High Technology Materials, The Univ. of New Mexico, USA; [3]Center for Integrated Nanotechnology, Sandia National Labs, USA; [4]Dept. of Chemical Engineering, New Mexico State Univ., USA.* We have demonstrated single-mode lasing in a single gallium nitride nanowire using distributed feedback by external coupling to a dielectric grating. By adjusting the nanowire grating alignment we achieved a mode suppression ratio of 17dB.

### Marriott Salon IV

**08:00–10:00**
**SM1N • SDM and Bandgap Fibers**
*Presider: Siddharth Ramachandran; Boston Univ., USA*

**SM1N.1 • 08:00** Tutorial
**Emerging Fiber Technology for Space Division Multiplexed Optical Communications,** David J. Richardson[1]; *[1]Optoelectronics Research Centre, Univ. of Southampton, UK.* Space Division Multiplexing (SDM) offers the potential for ultrahigh information-flux optical communications at the petabit/s level, as well as reduced costs-per-bit. I review progress to date and discuss some of the technological/commercial challenges and opportunities that lie ahead.

David Richardson is Deputy Director of the Optoelectronics Research Centre at the University of Southampton. His current research interests include amongst others: optical fiber communications, microstructured optical fibers and high-power fiber lasers. He is a Fellow of The Optical Society, the Institute of Engineering and Technology and was made a Fellow of the Royal Academy of Engineering in 2009.

### Marriott Salon V & VI

**08:00–10:00**
**SM1O • Pulse Generation and Amplification** ▶
*Presider: Jeffrey Nicholson; OFS Labs, USA*

**SM1O.1 • 08:00** ▶
**Sub-50fs all-fiber source based on a 100ps passively Q-switched microchip laser,** Pascal Dupriez[1], Christophe Pierre[1]; *[1]Alphanov, France.* We demonstrate a fiber-based source producing 50fs pulses at 1055nm starting from fiber amplified 100ps pulses produced by a passively Q-switched microchip laser. Pulse compression is achieved monolithically through succession of spliced microstructured fibers.

**SM1O.2 • 08:15** ▶
**Spectrally coherent efficient femtosecond Stokes pulse generation from a photonic crystal fiber with two zero dispersion wavelengths (TZDW),** Yuhong Yao[1], Wayne Knox[1]; *[1]Inst. of Optics, Univ. of Rochester, USA.* We report the first experimental characterization of spectral coherence of Stokes-side continuum from fiber with two zero dispersion wavelength. We achieve 3-nJ, coherent Stokes pulses localized ~1.28 µm from 300-fs Yb:fiber laser with 32% efficiency.

**SM1O.3 • 08:30** ▶
**Ultrafast fiber ring lasers with a pair of chirped fiber Bragg gratings,** Simon Duval[1], Michel Olivier[1,2], Martin Bernier[1], Réal Vallée[1], Michel Piché[1]; *[1]Centre d'optique, photonique et laser, Université Laval, Canada; [2]Département de physique, Cégep Garneau, Canada.* The performance of mode-locked fiber ring lasers incorporating two opposite-dispersion chirped fiber Bragg gratings is presented in different dispersion regimes. Pulses of nanojoule energy and duration well below 100 fs are generated.

## CLEO: Applications & Technology

### Marriott Willow Glen I-III

**08:00–10:00**
**AM1P • Symposium on Advances in Molecular Imaging I** ▶
*Presider: Yu Chen; Univ. of Maryland at College Park, USA*

**AM1P.1 • 08:00** Invited ▶
**Clinical Translation and Discovery with Near-infrared Fluorescence Lymphatic Imaging,** John C. Rasmussen[1], Eva M. Sevick-Muraca[1]; *[1]The Brown Foundation Inst. of Molecular Medicine, Univ. of Texas Health Science Cente, USA.* Near-infrared fluorescence (NIRF) lymphatic imaging enables, for the first time, non-invasive visualization and quantification of human lymphatic architecture and contractile function in health and disease. This contribution reviews NIRF lymphatic imaging and its clinical translation.

**AM1P.2 • 08:30** Invited
**Clinical translation of near-infrared image-guided surgery: Where do we stand?,** Sylvain Gioux[1]; *[1]Medicine, BIDMC / Harvard Medical School, USA.* In this presentation, we will review our translational efforts in image-guided surgery using diffuse NIR light. We will present our latest developments in imaging devices and contrast agents towards clinically-realistic image guidance during surgical interventions.

# CLEO: QELS-Fundamental Science

## Executive Ballroom 210A

### FM1A • Quantum Engineering—Continued

**FM1A.2 • 09:00**
**Ultrasensitive measurement of MEMS cantilever displacement below the photon shot noise limit,** Benjamin Lawrie[1], Raphael Pooser[1]; [1]*Quantum Information Science Group, Oak Ridge National Lab, USA.* We demonstrate sub-shot-noise microcantilever displacement sensitivity using simple differential measurements with multi-spatial-mode squeezed light, a result that may be critical for ultra-trace sensing and imaging applications.

**FM1A.3 • 09:15**
**Displacement of entanglement back and forth between the micro and macro domains,** Natalia Bruno[1], Anthony Martin[1], Nicolas Sangouard[1], Rob Thew[1], Nicolas Gisin[1]; [1]*Group of Applied Physics, Univ. of Geneva, Switzerland.* We report an experimental observation of heralded entanglement involving two components that can be distinguished with detectors resolving only large photon number differences. We demonstrate entanglement in states containing over 500 photons.

## Executive Ballroom 210B

### FM1B • Relativistic Laser-Plasma Interactions—Continued

**FM1B.3 • 08:45**
**Ion Acceleration by the 10^{21} Wcm-2 Intensity High Contrast Laser Pulses Interacting with the Thin Foil Target,** Mamiko Nishiuchi[1], Sakaki Hironao[1], Katsuhisa Nishio[2], Richard Orlandi[2], Hiroyuki Sako[2], Tatiana Pikuz[1,6], Anatoly Faenov[1,6], Timu Esirkepov[1], Alexander Pirozhkov[1], Kenya Matsukawa[4], Akito Sagisaka[1], Koichi Ogura[1], Masato Kanasaki[1,4], Hiromitsu Kiriyama[1], Yuji Fukuda[1], Hiroyuki Koura[2], Masaki Kando[1], Tomoya Yamauchi[4], Yukinobu Watanabe[5], Sergei Bulanov[1], Kiminori Kondo[1], Koichi Imai[2], Shoji Nagamiya[7]; [1]*Kansai Photon Science Inst., Japan Atomic Energy Agency, Japan;* [2]*Advanced Science Research Center, JAEA, Japan;* [3]*J-PARC Center, Japan;* [4]*Graduate School of Science Maritime Science, Kobe Univ, Japan;* [5]*Interdisciplinary Graduate School of Engineering Sciences, Kyushu Univ., Japan;* [6]*Joint Inst. for High Temperature of RAS, RAS, Russia;* [7]*RIKEN, Japan.* Almost fully stripped aluminum ion acceleration up to 12 MeV/u from the interaction between the ultra-intense short pulse high contrast laser and the micrometer thick foil target is presented.

**FM1B.4 • 09:00**
**Increasing Laser Contrast by Relativistic Self-Guiding and its Application to Laser-Based Proton Acceleration,** Yu-hsin Chen[1], David Alessi[1], Derrek Drachenberg[1], Bradley Pollock[1], Félicie Albert[1], Joseph Ralph[1], Constantin L. Haefner[1]; [1]*Lawrence Livermore National Lab, USA.* Laser-produced energetic protons via target normal sheath acceleration are deteriorated by amplified spontaneous emission (ASE). Here we test a new method of reducing ASE and increasing proton energy by relativistic self-guiding in the plasma.

**FM1B.5 • 09:15**
**Generating ultrashort hundreds-of-keV electron bunches using radially polarized laser pulses,** Vincent Marceau[1], Charles Varin[2], Thomas Brabec[2], Michel Piché[1]; [1]*Centre d'Optique, Photonique et Laser, Université Laval, Canada;* [2]*Center for Research in Photonics, Univ. of Ottawa, Canada.* Particle-in-cell simulations show that quasimonoenergetic electron bunches with one-femtosecond initial duration may be produced from direct acceleration in a low-density gas. These bunches could find applications in ultrafast electron diffraction experiments.

## Executive Ballroom 210C

### FM1C • Hyperbolic and Epsilon-near-zero Materials—Continued

**FM1C.4 • 08:45**
**Broadband Absorption Engineering of Hyperbolic Metafilm Patterns,** Dengxin Ji[1], Haomin Song[1], Xie Zeng[1], Haifeng Hu[1], Kai Liu[1], Nan Zhang[1], Qiaoqiang Gan[1]; [1]*Dept. of Electrical Engineering, The State Univ. of New York at Buffalo, USA.* We experimentally realize a patterned hyperbolic metafilm with engineered and freely tunable absorption band from near-IR to mid-IR spectral regions based on multilayered metal/dielectric hyperbolic metamaterial waveguide taper.

**FM1C.5 • 09:00**
**Enhancement of Radiative Emission using a Hyperbolic Metamaterial Nano-antenna,** Caner Guclu[1], Ting S. Luk[2], George T. Wang[2], Michael B. Sinclair[2], Filippo Capolino[1]; [1]*Electrical Engineering and Computer Science, Univ. of California, Irvine, USA;* [2]*Sandia National Labs, USA.* A hyperbolic metamaterial resonator is utilized as a nano-antenna for enhancing the radiative emission from a quantum emitter at 660 nm wavelength. Simulated power radiation enhancement up to 100 folds is demonstrated.

**FM1C.6 • 09:15**
**Control of chemical reactions in the vicinity of hyperbolic metamaterials and metallic surfaces,** Vanessa Peters[1], Thejaswi U. Tumkur[1], Mikhail A. Noginov[1]; [1]*Center for Materials Research, Norfolk State Univ., USA.* We show that photo-oxidation of organic semiconducting films can be controlled by geometry and composition of metallic and metal/dielectric substrates, in agreement with increase of the chemical reaction rate by the density of photonic states.

## Executive Ballroom 210D

### FM1D • PT Symmetry and Related Phenomena—Continued

**FM1D.4 • 08:45**
**Light Transport in PT Photonic Structures with Hidden Symmetries,** Ramy El-Ganainy[1], Mohammad Teimourpour[1], Alexander Eisfeld[2], Demetrios N. Christodoulides[3]; [1]*Physics, Michigan Technological Univ., USA;* [2]*Max Planck Inst. for the Physics of Complex Systems, Germany;* [3]*College of Optics and Photonics-CREOL, Univ. of Central Florida, USA.* We introduce a bosonic quantization technique for generating PT photonic structures that possess hidden symmetries. We investigate light transport in these geometries under linear and nonlinear conditions and we demonstrate a host of new effects.

**FM1D.5 • 09:00**
**Scattering off PT-symmetric particles,** Mohammad-Ali Miri[1], Mohammad Amin Eftekhar[1], Margarida Facao[2], Demetrios N. Christodoulides[1]; [1]*CREOL/College of Optics and Photonics, Univ. of Central Florida, USA;* [2]*Dept. of Physics, Univ. of Aveiro, Portugal.* We investigate scattering properties of parity-time-symmetric cylinders. We show that, the scattering pattern of such structures changes drastically by changing the angle of incidence. In addition PT particles preferentially deflect light at a certain angle.

**FM1D.6 • 09:15**
**Spontaneous symmetry breaking induced by tachyon condensation in amplifying metal-dielectric multi-layered media,** Andrea Marini[1], Truong X. Tran[1,2], Samudra Roy[1,3], Stefano Longhi[4], Fabio Biancalana[1,5]; [1]*Max Planck Inst., Germany;* [2]*Physics, Le Quy Don Univ., Viet Nam;* [3]*Physics and Meteorology, Indian Inst. of Technology, India;* [4]*Physics, Politecnico di Milano, Italy;* [5]*School of Engineering and Physical Sciences, Heriot-Watt Univ., UK.* We theoretically investigate an optical analogue of tachyon condensation in amplifying plasmonic arrays. We demonstrate that the vacuum state is unstable and acquires an expectation value with broken chiral symmetry.

## SM1E • Atmospheric Sensing—Continued

**SM1E.2 • 09:00**

**Isotopic Ratiometry of Nitric Oxide using a Dual-modulation Faraday Rotation Spectrometer,** Eric J. Zhang[1], Farhan Nuruzzaman[2], Yin Wang[1], Daniel Sigman[2], Gerard Wysocki[1]; *[1]Electrical Engineering, Princeton Univ., USA; [2]Geosciences, Princeton Univ., USA.* A dual-modulation Faraday rotation spectrometer is employed for isotopic ratiometry of nitric oxide (NO) converted from nitrate/nitrite. Excellent linearity of measured NO to dissolved nitrate is demonstrated. Ratiometry of IAEA-NO-3 standards indicates ~3 % accuracy.

**SM1E.3 • 09:15**

**Compact, Automated Differential Absorption Lidar for Tropospheric Profiling of Water Vapor,** David M. Sonnenfroh[1], Kevin Repasky[2], Amin Nehrir[3]; *[1]Physical Sciences Inc., USA; [2]Montana State Univ., USA; [3]NASA Langley Research Center, USA.* We describe the engineering development of a compact differential absorption lidar, using a diode laser-seeded semiconductor optical amplifier as the transmitter, for profiling water vapor in the lower atmosphere.

## SM1F • Solid State Laser Systems for Secondary Source Generation—Continued

**SM1F.3 • 08:45**

**Fiber-seeded, 10-ps, 2050-nm, multi-mJ, cryogenic Ho:YLF CPA,** Michaël Hemmer[1], Daniel Sanchez[1], Michal Jelínek[2], Helena Jelínková[2], Václav Kubeček[2], Jens Biegert[1,3]; *[1]ICFO -The Inst. of Photonic Sciences, Spain; [2]Czech Technical Univ., Czech Republic; [3]ICREA - Institucio Catalana de Recerca i Estudis Avancats, Spain.* We demonstrate the first picosecond cryogenic Ho:YLF CPA system with Er:Tm:Ho fiber seeder. The system delivers energy-scalable 13-mJ pulses with 10-ps duration at 100 Hz repetition rate.

**SM1F.4 • 09:00** Invited

**1 Joule, 100 Hz Repetition Rate, Picosecond CPA Laser for Driving High Average Power Soft X-Ray Lasers,** Brendan A. Reagan[1], Cory Baumgarten[1], Keith Wernsing[1], Herman Bravo[1], Mark Woolston[1], Alden Curtis[1], Federico J. Furch[1], Brad Luther[1], Dinesh Patel[1], Carmen Menoni[1], Jorge J. Rocca[1]; *[1]Colorado State Univ., USA.* A diode-pumped cryogenic Yb:YAG CPA laser that produces 1J, 5ps pulses allowed for the first time the uninterrupted generation of 1.8x10^5 sub-20nm wavelength laser pulses with microjoule energy at 100Hz repetition rate on a table-top.

## SM1G • Optical Signal Processing—Continued

**SM1G.4 • 08:45**

**Experimental Demonstration of Vpi Reduction in EO Modulators using Modulation Instability,** David Borlaug[1], Peter DeVore[1], Bahram Jalali[1]; *[1]Dept. of Electrical Engineering, Univ. of California, Los Angeles, USA.* An electrooptic modulator's half-wave voltage is experimentally lowered by 10-fold for intensity modulated waveforms using modulation instability. Results are reported up to 50 GHz.

**SM1G.5 • 09:00**

**Experimental Demonstration of a 2-Stage Continuously Tunable Optical Tapped-Delay-Line in which N+M Pump Lasers Produce N×M Taps,** Amirhossein Mohajerin Ariaei[1], Mohammed Chitgarha[1], Morteza Ziyadi[1], Salman Khaleghi[1], Ahmed Almaiman[1], Joseph Touch[2], Moshe Tur[3], Loukas Paraschis[4], Carsten Langrock[5], Martin M. Fejer[5], Alan Willner[1]; *[1]Electrical Engineering, Univ. of Southern California, USA; [2]Information Sciences Inst.-Univ. of Southern California, USA; [3]Electrical Engineering, Tel Aviv Univ., Israel; [4]Cisco Systems, USA; [5]Edward L. Ginzton Lab-Stanford Univ., USA.* We experimentally demonstrate a 2-stage continuously tunable optical tapped-delay-line in which N+M pump lasers produce N×M number of taps. A 3×2-taps optical correlator is implemented to search multiple patterns among 20-Gbuad QPSK signals using nonlinearities and coherent comb source.

**SM1G.6 • 09:15**

**High-speed ultrawideband compressed sensing of sparse radio frequency signals,** Bryan T. Bosworth[1], Mark A. Foster[1]; *[1]Johns Hopkins Univ., USA.* Using chirp processing of ultrafast laser pulses to perform pseudorandom measurements for compressed sensing, we successfully reconstruct multi-tone sparse- frequency microwave signals with an effective sampling rate well beyond the electronic limit.

## SM1H • Advanced Fabrication Techniques—Continued

**SM1H.4 • 08:45**

**Fabrication of Diffractive Optical Elements with Digital Projection Photochemical Etching,** Christopher A. Edwards[1], Kaiyuan Wang[1], Benjamin G. Griffin[1], Renjie Zhou[1], Basanta Bhaduri[1], Gabriel Popescu[1], Lynford L. Goddard[1]; *[1]Dept. of Electrical and Computer Engineering, Univ. of Illinois at Urbana-Champaign, USA.* We demonstrate a new fabrication technique called digital projection photochemical etching and apply it to make complicated gray-scale diffractive optical elements, such as a radial sinusoidal grating, in a single processing step.

**SM1H.5 • 09:00**

**Tuning the Visible-to-Infrared Reflectance Spectra of Arrays of Vertical Ge Nanowires,** Amit Solanki[1], Hyunsung Park[1], Kenneth B. Crozier[1]; *[1]School of Engineering and Applied Sciences, Harvard Univ., USA.* We experimentally demonstrate that, by varying their diameter, the visible-to-infrared reflectance spectra of arrays of vertical Ge nanowires can be tuned. The results could enable future nanowire-based photodetectors with tailored responsivity spectra.

**SM1H.6 • 09:15**

**On-chip Optical Isolators Based on a Ring Resonator with Bismuth-iron-garnet Overcladding,** Kuanping Shang[1], Stanley Cheung[1], Binzhi Li[2], Ryan P. Scott[1], Yayoi Takamura[2], S. J. Ben Yoo[1]; *[1]Electrical Engineering and Computer Science, Univ. of California, Davis, USA; [2]Chemical Engineering and Materials Science, Univ. of California, Davis, USA.* This paper discusses on-chip optical isolators with bismuth-iron-garnet (BIG) overcladding on a ring resonator for photonic integrated circuit applications. Characterization of BIG prepared by RF magnetron sputtering and pulsed laser deposition methods are also discussed.

## CLEO: Science & Innovations

### Meeting Room 211 B/D

### SM1I • Parametric Sources—Continued

**SM1I.4 • 08:45**
**Mid-Infrared $ZnGeP_2$-Based Source with 0.2 J Pulse Energy,** Magnus W. Haakestad[1], Helge Fonnum[1], Espen Lippert[1]; [1]*Norwegian Defense Research Establishment, Norway.* Mid-infrared (3-5 µm) pulses with up to 207 mJ energy at 1 Hz repetition rate are produced using nonlinear conversion in a $ZnGeP_2$-based master oscillator-power amplifier, pumped by a cryogenic Ho:YLF oscillator.

**SM1I.5 • 09:00**
**Multiwatt-level Continuous-Wave Midwave Infrared Generation using Difference Frequency Mixing in Periodically Poled Lithium Niobate,** Shekhar Guha[1], Jacob O. Barnes[2], Leonel P. Gonzalez[1]; [1]*US Air Force Research Lab, USA;* [2]*UES, Inc., USA.* More than 2 Watts of continuous-wave external power at 3400 nm was obtained by difference frequency mixing of 1064.6 nm and 1549.8 nm fiber lasers in a periodically poled lithium niobate crystal at 50 C.

**SM1I.6 • 09:15**
**Tunable mid-infrared (6.3-7.8 µm) optical vortex laser,** Micheal Tomoki Horikawa[1], Kenji Furuki[1], Yu Tokizane[1], Katsuhiko Miyamoto[1], Takashige Omatsu[1,2]; [1]*Chiba Univ., Japan;* [2]*CREST, Japan.* We demonstrate a tunable mid-infrared (6.3-7.8-µm) vortex laser formed of a 1-µm vortex pumped optical parametric oscillator and a difference frequency generator. Maximum output energy of 160-µJ was obtained at a wavelength of 6.5-µm.

### Meeting Room 212 A/C

### SM1J • UV and Visible LEDs—Continued

**SM1J.4 • 08:45**
**Excellent Color Rendering Index Quantum Dots White Light-Emitting Diode with Distributed Bragg Reflector Structure,** Kuo-Ju Chen[1], Bing-Cheng Lin[1], Hau-Vei Han[1], Chien-Chung Lin[2], Chia-Yu Lee[1], Shih-Hsuan Chien[1], Kuan-Yu Wang[2], Sheng-Huan Chiu[1], Teng-Ming Chen[3], Min-Hsiung Shih[1,4], Hao-chung Kuo[1]; [1]*Dept. of Photonic, Inst. of Electro-Optical Engineering, National Chiao Tung Univ.,, Taiwan;* [2]*Inst. of Photonic System, Taiwan;* [3]*Dept. of Applied Chemistry, Inst. of Molecular Science,National Chiao Tung Univ., Taiwan;* [4]*Research Center for Applied Sciences, Academia Sinica, Taiwan.* This study demonstrated the high CRI and excellent uniformity colloidal quantum dot white-light-emitting diodes with the DBR structure at different correlated color temperature from 2500 K to 4500K.

**SM1J.5 • 09:00** Invited
**Auger recombination in light-emitting materials,** Emmanouil Kiopakis[1,2], Qimin Yan[2,3], Chris G. Van de Walle[2]; [1]*Materials Science and Engineering, Univ. of Michigan, USA;* [2]*Materials Dept., Univ. of California, USA;* [3]*The Molecular Foundry, Lawrence Berkeley National Lab, USA.* First-principles calculations show that phonon-assisted Auger recombination and its interplay with the polarization fields in polar nitride LEDs play an important role in the efficiency-droop and green-gap problems of these devices.

## CLEO: QELS-Fundamental Science

### Meeting Room 212 B/D

### FM1K • Applications of Localized Surface Plasmons—Continued

**FM1K.3 • 08:45**
**Metal single-nanowire plasmonic sensors,** Fuxing Gu[1], Heping Zeng[1,2]; [1]*School of Optical-Electrical and Computer Engineering, Univer. of Shanghai for Science and Tech, China;* [2]*3State Key Lab of Precision Spectroscopy, East China Normal Univ., China.* Metal nanowires including Pd nanoparticle-coated Au nanowires, polyacrylamide film-supported Ag nanowires, and single-crystal Pd nanowires are used for hydrogen and humidity plasmonic sensing, with higher sensitivity and faster response than those in conventional photonic nanowires.

**FM1K.4 • 09:00**
**Titanium nitride nanoparticles for therapeutic applications,** Urcan Guler[1], Alexander Kildishev[1], Alexandra Boltasseva[1,2], Vladimir M. Shalaev[1]; [1]*School of Electrical & Computer Engineering and Birck Nanotechnology Center, Purdue Univ., USA;* [2]*Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark.* Titanium nitride nanoparticles exhibit plasmonic resonances in the biological transparency window where high absorption efficiencies can be obtained with small dimensions. Both lithographic and colloidal samples are examined from the perspective of nanoparticle thermal therapy.

**FM1K.5 • 09:15**
**Bidirectional Wavelength Multiplexing with an Optical Fano Nanoantenna,** Rui Guo[1], Manuel Decker[1], Isabelle Staude[1], Dragomir N. Neshev[1], Yuri S. Kivshar[1]; [1]*Nonlinear Physics Centre, Australian National Univ., Australia.* We introduce the novel concept of a single-element Fano nanoantenna allowing for strong directional scattering of light in opposite directions depending on wavelength. Our design opens the way for novel bi-directional wavelength multiplexers.

## CLEO: Applications & Technology

### Marriott Salon I & II

### AM1L • Advanced Material Processing—Continued

**AM1L.3 • 08:45** ▶
**Femtosecond laser processing for mobile display manufacturing,** Eric Mottay[1], Clemens Hoenninger[1], Laurie Wipliez[2], Jiyeon Choi[3], Sung-Hak Cho[3]; [1]*Amplitude Systemes, France;* [2]*Alphanov, France;* [3]*Korean Inst. of Machinery and Materials, Korea.* The development of new display technologies, such as organic LEDs and flexible displays, put stringent requirements in term of manufacturing processes. We report on new results aiming at improving processing quality and yield.

**AM1L.4 • 09:00** ▶
**Fiber Laser Annealing of Ti CP1 and Al6060 aimed at improving formability in Hydroforming Technology,** Stefano Zarini[1], Ehsan Moasted[1], barbara previtali[1], Maurizio Vedani[1]; [1]*Dept. of Mechanical Engineering, Politecnico di Milano, Italy.* This paper presents the feasibility study of laser annealing of two materials: Ti CP1 and Al6060. Effectiveness of the method is proved firstly on planar samples and then applied on a real industrial component.

**AM1L.5 • 09:15** ▶
**Modeling of Powder Absorption in Additive Manufacturing,** Charles Boley[1], Saad Khairallah[1], Alexander M. Rubenchik[1]; [1]*Lawrence Livermore National Lab, USA.* We have investigated optical absorption by a powder of metal spheres, via ray-trace calculations. The absorptivity significantly exceeds that for normal incidence, because of multiple scattering. The effect of beam size is also discussed.

Marriott
Salon III

Marriott
Salon IV

Marriott
Salon V & VI

Marriott
Willow Glen I-III

## CLEO: Science & Innovations

## SM1M • Frequency Combs and Novel Light Sources—Continued

**SM1M.3 • 08:45** ▶
**Spectral Coherence in Microresonator Combs,** Victor Torres-Company[1], Enrique Silvestre[2], David Castello-Lurbe[2]; [1]*Dept. of Microtechnology and Nanoscience, Chalmers Univ. of Technology, Sweden;* [2]*Departament d'Optica, Universitat Valencia, Spain.* We provide a quantitative analysis of the coherence in microresonator frequency combs. We show how to achieve coherent transform-limited pulses on-chip without actively manipulating the pump setting conditions in the course of comb formation.

**SM1M.4 • 09:00** ▶
**Switchable Optical Frequency Comb in Aluminum Nitride Microring Resonator,** Hojoong Jung[1], King Y. Fong[1], Chi Xiong[1], Xufeng Zhang[1], Hong Tang[1]; [1]*Yale Univ., USA.* Aluminum nitride is a promising nonlinear optical material with its strong Kerr and Pockels effects. Here we report optical frequency comb generation from aluminum nitride microring resonators and electrical switching of the comb.

**SM1M.5 • 09:15** ▶
**Tailoring of a Broader and Flatter Frequency Comb using a Microring Resonator with a Low-Index Slot,** Changjing Bao[1], Lin Zhang[2], Yan Yan[1], Hao Huang[1], Guodong Xie[1], Anu Agarwal[2], Lionel Kimerling[2], Jurgen Michel[2], Alan Willner[1]; [1]*Dept. of Electrical Engineering, Univ. of Southern California, USA;* [2]*Dept. of Material Science and Engineering, MIT, USA.* A dispersion-flattened microresonator based on slot waveguide exhibits great performance improvement of Kerr frequency combs by engineering the 2nd-order dispersion amount and anomalous-dispersion bandwidth with all-order dispersion taken into account.

## SM1N • SDM and Bandgap Fibers—Continued

**SM1N.2 • 09:00**
**37-cell hollow-core-fiber designs with improved single-modedness,** John M. Fini[1], Brian Mangan[1], Linli Meng[1], Eric M. Monberg[1], Jeffrey W. Nicholson[1], Robert S. Windeler[1]; [1]*OFS Labs, USA.* Simulations show that the PRISM strategy for suppression of higher-order modes can be applied broadly, to cores larger than 19-cell and core thicknesses larger than half the lattice web thickness.

**SM1N.3 • 09:15**
**Ultra low-loss hypocycloid-core kagome hollow-core photonic crystal fiber for the green spectral-range applications,** Benoît Debord[1], Meshaal Alharbi[1], Aurélien Benoît[1], Madhoussoudhana Dontabactouny[1], Jean-Marc Blondy[1], Frédéric Gérôme[1], Fetah Benabid[1]; [1]*GPPMM group, Xlim Research Inst., UMR CNRS 7252, France.* We report on the development of hypocycloidal-core kagome HC-PCF operating efficiently in the 450nm-650nm visible spectral range. Transmission loss as low as 70dB/km is achieved. Strong Raman comb generation and laser beam delivery are demonstrated.

## SM1O • Pulse Generation and Amplification—Continued

**SM1O.4 • 08:45** ▶
**Tunable Broadband Source of Femtosecond Pulses in the 2 µm Region,** Andrew Klose[1], Daniel Maser[1,2], Gabriel Ycas[1,2], Scott A. Diddams[1]; [1]*NIST, USA;* [2]*Physics, Univ. of Colorado, USA.* A polarization maintaining Er:fiber-based source of femtosecond pulses was constructed using a 250 MHz mode-locked oscillator, fiber amplifier, and highly nonlinear fiber. The system generated 35 fs pulses with power variation of 1.3% on a timescale of days.

**SM1O.5 • 09:00** ▶
**FCPA System at 2.08 µm and 7 MHz in All-PM Design Delivering Pulses at 10 nJ and 390 fs Pulse Duration,** Heinar Hoogland[1], Steffen Wittek[1], Wolfgang Hänsel[1], Ronald Holzwarth[1,2]; [1]*Menlo Systems GmbH, Germany;* [2]*Max-Planck-Inst. of Quantum Optics, Germany.* We report on an all-PM fiber oscillator-CPA system at 2.08 µm running at 7 MHz pulse repetition rate with 10 nJ pulse energy and 390 fs pulse duration behind external compression.

**SM1O.6 • 09:15** ▶
**Visible short pulse generation in waterproof fluoro- aluminate glass fibers using graphene thin film,** Takafumi Suzuki[1,2], Ricardo Arturo Ochante Muray[1], Moto-ichiro Murakami[1], Takashi Hirayama[1,2], Minoru Yoshida[2], Osamu Ishii[3], Masaaki Yamazaki[3], Hiroyuki Shiraga[1], Yasushi Fujimoto[1]; [1]*Osaka Univ., Japan;* [2]*Kinki Univ., Japan;* [3]*Sumita Optical Glass, Inc., Japan.* We have successfully generated a Q-switched short pulse in a Pr-doped waterproof fluoro-aluminate glass fiber using a single layer graphene as a saturable absorber. The laser pulse duration was observed to be 17.6 ns.

## CLEO: Applications & Technology

## AM1P • Symposium on Advances in Molecular Imaging I—Continued

**AM1P.3 • 09:00** Invited ▶
**In Vivo Molecular Imaging using Cerenkov Luminescence,** Simon Cherry[1]; [1]*Univ. of California Davis, USA.* Many radionuclides, upon decay, produce visible light via the Cerenkov effect. This allows radiotracers to be imaged using sensitive optical technologies providing opportunities for in vivo optical molecular imaging using Cerenkov luminescence.

## CLEO: QELS-Fundamental Science

### Executive Ballroom 210A

### FM1A • Quantum Engineering—Continued

**FM1A.4 • 09:30**
**Parametric Interaction between Two Single Photons,** Thiago B. Guerreiro[1], Anthony Martin[1], Bruno Sanguinetti[1], Nicolas Sangouard[1], Jason Pelc[2], Carsten Langrock[2], Martin M. Fejer[2], Hugo Zbinden[1], Rob Thew[1], Nicolas Gisin[1]; [1]*Group of Applied Physics, Univ. of Geneva, Switzerland;* [2]*E. L. Ginzton Lab, Stanford Univ., USA.* We report the experimental demonstration of an interaction between two independent single photons. The interacting photons are generated via parametric downconversion in distinct sources. An efficient waveguide is employed to realise the first single photon demonstration of sum frequency generation.

**FM1A.5 • 09:45**
**On-chip generation and analysis of maximal path-frequency entanglement,** Raffaele Santagati[1], Joshua W. Silverstone[1], Damien Bonneau[1], Michael J. Strain[2], Marc Sorel[2], Jeremy L. O'Brien[1], Mark G. Thompson[1]; [1]*H. H. Wills Physics Lab, Univ. of Bristol, UK;* [2]*School of Engineering, Univ. of Glasgow, UK.* We present a silicon-on-insulator quantum photonic device able to generate and analyze two maximally entangled qubits. Quantum interference between resonant four-wave mixing sources, phase-stable frequency-selection, and quantum state tomography are shown.

### Executive Ballroom 210B

### FM1B • Relativistic Laser-Plasma Interactions—Continued

**FM1B.6 • 09:30**
**Two-dimensional Supercontinuum Spectral Interferometry for Measurement of Laser-induced Plasmas,** Jared K. Wahlstrand[1], Sina Zahedpour[1], Howard Milchberg[1]; [1]*Univ. of Maryland at College Park, USA.* The plasma-induced phase shift of a probe is measured in 2D spatially with ~3 μm resolution and temporally with ~5 fs resolution. From this ionization rates for the noble gases are found for a 40 fs, 800 nm pulse, for intensities up to nearly full depletion of the neutral population.

**FM1B.7 • 09:45**
**Electron Injection into a Capillary Laser Wakefield Accelerator,** Mark Wiggins[1], Ranaul Islam[1], Gregory Vieux[1], Gregor Welsh[1], Salima Abuazoum[1], Enrico Brunetti[1], Silvia Cipiccia[1], Bernhard Ersfeld[1], David Grant[1], Cristian Ciocarlan[1], Dino Jaroszynski[1]; [1]*Univ. of Strathclyde, UK.* The role played by self-focusing of a high-intensity femtosecond laser in the entrance plume of a gas-filled capillary discharge waveguide is investigated for laser-plasma wakefield acceleration of electrons.

### Executive Ballroom 210C

### FM1C • Hyperbolic and Epsilon-near-zero Materials—Continued

**FM1C.7 • 09:30**
**Mie resonance based transition metamaterial,** Liu Xiaoming[1], Sun Jingbo[2], Litchinitser Natasha M[2], Zhou Ji[1]; [1]*Tsinghua Univ., China;* [2]*The State Univ. of New York at Buffalo, USA.* We design a Mie resonance based transition metamaterial whose effective permeability gradually changed from positive to negative values. We demonstrate anomalous field enhancement near the zero permeability point under oblique incidence of the microwave radiation.

**FM1C.8 • 09:45**
**Visible-Frequency Unidirectional Transmission Device incorporating a Hyperbolic Metamaterial,** Ting Xu[1], Henri J. Lezec[1]; [1]*NIST, USA.* We propose and experimentally demonstrate that unidirectional transmission of visible light can be provided by a reciprocal and passive planar device of wavelength-scale-thickness, incorporating subwavelength-pitch gratings and a hyperbolic metamaterial.

### Executive Ballroom 210D

### FM1D • PT Symmetry and Related Phenomena—Continued

**FM1D.7 • 09:30**
**Stimulated Brillouin Scattering, hybrid acoustic modes and nonreciprocal mode-conversion in nanophotonic waveguides,** Chris G. Poulton[1], Iman Aryanfar[2], Christian Wolff[1], Alvaro Casas-Bedoya[2], Michael J. Steel[3], Benjamin J. Eggleton[2]; [1]*CUDOS, School of Mathematical Sciences, Univ. of Technology Sydney, Australia;* [2]*CUDOS, IPOS, School of Physics, Univ. of Sydney, Australia;* [3]*CUDOS, School of Physics, Macquarie Univ., Australia.* We theoretically investigate non-reciprocal mode-conversion arising from Stimulated Brillouin Scattering (SBS) in sub-micron nanophotonic waveguides. We find that hybrid acoustic modes can be efficiently generated via radiation pressure, leading to enhancement of SBS-based mode conversion.

**FM1D.8 • 09:45**
**Using Nonlinear Optical Networks for Optimization: Primer of the Ant Colony Algorithm,** Wenchao Hu[1], Kan Wu[1], Ping Perry Shum[1], Nikolay I. Zheludev[1,2], Cesare Soci[1]; [1]*Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore;* [2]*Optoelectronics Research Centre, Univ. of Southampton, UK.* Using nonlinear Erbium doped optical fiber network we have implemented an optimization algorithm for the famous problem of finding the shortest path on the map for the ant colony to travel to the foraging area.

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**10:00–10:30 Coffee Break,** *Concourse Level*

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NOTES

## CLEO: Science & Innovations

### Executive Ballroom 210E

### SM1E • Atmospheric Sensing—Continued

**SM1E.4 • 09:30**
**QCL Based Absorption Sensor for Simultaneous Trace-Gas Detection of $CH_4$ and $N_2O$,** Wei Ren[1], Wenzhe Jiang[1], Frank K. Tittel[1]; [1]*Dept. of Electrical and Computer Engineering, Rice Univ., USA.* A quantum cascade laser (QCL) absorption sensor system operating at 7.83 µm was developed for simultaneous dual-species monitoring of $CH_4$ and $N_2O$ using a novel compact multipass gas absorption cell with a sampling volume of 225 mL.

**SM1E.5 • 09:45**
**Widely tunable Distributed Bragg Quantum Cascade laser for gas sensing applications,** Abdou Diba[1], Ihor Sydoryk[1], Barry Gross[1], Fred Moshary[1], Feng Xie[2], Zah Chung-En[2]; [1]*Electrical Engineering, City College of New York, USA;* [2]*Science and Technology, Corning Incorporated, USA.* We report continuous mode-hope free tuning of a sample-grating distributed Bragg reflector (SG-DBR) quantum cascade laser (QCL) operating at 4.55µm wavelength observing N2O features in this range by controlling all three sections of laser namely: front DBR, back DBR and the phase.

### Executive Ballroom 210F

### SM1F • Solid State Laser Systems for Secondary Source Generation—Continued

**SM1F.5 • 09:30**
**Table-top hard x-ray source driven by sub-100 fs mid-infrared pulses,** Jannick Weisshaupt[1], Vincent Juvé[1], Shian Ku[1], Marcel Holtz[1], Michael Woerner[1], Thomas Elsaesser[1], Skirmantas Alisauskas[2], Audrius Pug<\#193>zlys[2], Andrius Baltuska[2]; [1]*Max-Born-Institut Berlin, Germany;* [2]*Photonics Inst., Austria.* Powerful 90 fs pulses at a midinfrared wavelength of λ=3.9µm drive a femtosecond hard x-ray source (Cu Kα: hbarω=8.05 keV). Up to 10^8 X-ray photons/pulse are generated which is twice as many as with 800 nm drivers of a 100 times higher peak intensity.

**SM1F.6 • 09:45**
**Compact 10 TW laser to generate multi-filament arrays,** Benjamin Webb[1], Joshua Bradford[1], Khan Lim[1], Nathan Bodnar[1], Andreas Vaupel[1], Erik McKee[1], Matthieu Baudelet[1], Magali M. Durand[1], Lawrence Shah[1], Martin Richardson[1]; [1]*College of Optics, Univ. of Central Florida, USA.* The design and construction of a compact 10 TW Ti:sapphire CPA system for the generation of filament arrays is presented. The design and implementation challenges are discussed, in particular the optimization of beam quality.

### Executive Ballroom 210G

### SM1G • Optical Signal Processing—Continued

**SM1G.7 • 09:30**
**Large-bandwidth compressive sampling based on multi-channel random optical pulses with nonuniform time delays,** Yunhua Liang[1], Minghua Chen[1], Hongwei Chen[1], Shizhong Xie[1]; [1]*Tsinghua Univ., China.* In this paper, a four-channel photonic-assisted compressive sampling system with large bandwidth is demonstrated, where sparse spectrum in the 2-19 GHz range with 50-kHz resolution is recovered from samples of compressed spectrums with 360-MHz bandwidth.

**SM1G.8 • 09:45**
**Recirculating Frequency Shifting Based Photonic-assisted Broadband Instantaneous Radio-frequency Measurement,** Cheng Lei[1], Minghua Chen[1], Hongwei Chen[1], Sigang Yang[1], Shizhong Xie[1]; [1]*Tsinghua Univ., China.* By trapping the RF signal within the RFS loop and measuring the frequency components slice by slice, the proposed method provides a promising candidate for broadband instantaneous radio-frequency measurement with simple structure and commercial devices.

### Executive Ballroom 210H

### SM1H • Advanced Fabrication Techniques—Continued

**SM1H.7 • 09:30**
**Polycrystalline Anatase Micro-Ring Resonators at Telecommunication Wavelengths,** Orad Reshef[1], Katia Shtyrkova[2], Michael G. Moebius[1], Christopher Evans[1], Sarah Griesse-Nascimento[1], Erich Ippen[2], Eric Mazur[1]; [1]*School of Engineering and Applied Sciences, Harvard Univ., USA;* [2]*Dept. of Electrical Engineering and Computer Science, MIT, USA.* We fabricate and characterize integrated polycrystalline anatase TiO2 micro-ring resonators at around λ = 1550 nm. We obtain quality factors of 1.5×10^4 and calculate a propagation loss of 8.0 ± 1.3 dB/cm.

**SM1H.8 • 09:45**
**Simple Microfluidic Integration of 3D Optical Sensors Based on Solvent Immersion Lithography,** Andreas E. Vasdekis[1], Michael J. Wilkins[1], Jay W. Grate[1], Allan E. Konopka[1], Sotiris S. Xantheas[1], Tsun-Mei Chang[2]; [1]*Pacific Northwest National Labs, USA;* [2]*Chemistry, Univ. of Wisconsin-Parkside, USA.* We will present Solvent Immersion Lithography (SIL) for microsystem prototyping in less than one minute. Our focus will primarily be on 3D optical sensor integration for biological applications in microfluidics and chemical microreactors.

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**10:00–10:30 Coffee Break,** *Concourse Level*

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## CLEO: Science & Innovations

**Meeting Room 211 B/D**

### SM1I • Parametric Sources—Continued

**SM1I.7 • 09:30**
**Influence of Pump Pulse Duration on Doubly Resonant Optical Parametric Oscillators Build-up Time,** Guillaume AOUST[1], Myriam Raybaut[1], Jean-Michel Melkonian[1], Guillaume Canat[1], Jean-Baptiste Dherbecourt[1], Antoine Godard[1], Michel Lefebvre[1]; [1]*ONERA-The French Aerospace Lab, France.* A single-frequency doubly resonant optical parametric oscillator is pumped by a master oscillator-fiber power amplifier whose pulse duration is varied for 40 ns to 10 µs, enabling to optimize the pumping parameters.

**SM1I.8 • 09:45**
**Autoresonant Harmonic Generation in Nonuniform Crystals,** Oded Yaakobi[1], Anna Mazhorova[1], Matteo Clerici[1,2], Gabriel Dupras[1], Daniele Modotto[3], François Vidal[1], Roberto Morandotti[1]; [1]*INRS-EMT, Univ. of Quebec, Canada;* [2]*School of Engineering and Physical Sciences, Heriot-Watt Univ., UK;* [3]*Dipartimento di Ingegneria dell'Informazione, Università di Brescia, Italy.* An experiment of second harmonic generation in a nonuniform crystal is presented, and interpreted in terms of an autoresonant wave-mixing theory. A good agreement is found between numerical simulations, analytical solutions and experimental data.

**Meeting Room 212 A/C**

### SM1J • UV and Visible LEDs—Continued

**SM1J.6 • 09:30**
**Utilizing Two-Dimensional Photonic Crystals to Investigate the Correlation between the Air Duty Cycle and the Light Extraction Efficiency of InGaN-Based Light-Emitting Diodes,** Ming-Lun Lee[1], Yao-Hong You[1], Cheng-Ju Hsieh[1], Vin-Cent Su[1], Chun Nien[1], Po-Hsun Chen[1], Hung-Chou Lin[1], Han-Bo Yang[1], Yen-Pu Chen[1], Shen-Han Tsai[1], Chieh-Hsiung Kuan[1]; [1]*Graduate Inst. of Electronics Engineering, National Taiwan Univ., Taiwan.* By incorporating two dimensional photonic crystals into the surface of InGaN-based LEDs, the strong correlation between the air duty cycle and the light extraction efficiency of LEDs was demonstrated by optical and electrical measurement results.

**SM1J.7 • 09:45**
**Electrically Driven Light Emission from an Atomic Monolayer Crystal,** Andreas Pospischil[1], Marco M. Furchi[1], Thomas Mueller[1]; [1]*Inst. of Photonics, Vienna Univ. of Technology, Austria.* We report electrically driven light emission from a two-dimensional monolayer of tungsten diselenide (WSe2). Our device is operated as a lateral p-n junction diode, formed by electrostatic doping.

**Meeting Room 212 B/D**

## CLEO: QELS-Fundamental Science

### FM1K • Applications of Localized Surface Plasmons—Continued

**FM1K.6 • 09:30**
**Plasmonic quasi-dark mode excitation,** Daniel E. Gomez[1,2], Ranjith Rajasekharan[3], Zhi Qin Teo[3], Timothy James[2,3], Timothy J. Davis[1,2], Ann Roberts[3]; [1]*Division of Materials Science and Engineering, CSIRO, Australia;* [2]*Melbourne Centre for Nanofabrication, Australian National Fabrication Facility, Australia;* [3]*School of Physics, Univ. of Melbourne, Australia.* Progress in the excitation of 'dark-modes' in plasmonic structures is reported. The interaction of vector beams possessing a spatially inhomogeneous polarization profile with plasmonic nanostructures provides an avenue to probe these resonances.

**FM1K.7 • 09:45**
**Experimental Demonstration of Q-factor Control in Plasmonic Meta-Surfaces Exhibiting Double-Continuum Fano Resonances,** Nihal Arju[1], Alexander B. Khanikaev[1,2], Purtseladze Purtseladze[1], Kaya Tatar[1], Chih-Hui Wu[1,3], Hossein S. Mousavi[1], Gennady Shvets[1]; [1]*Univ. of Texas at Austin, USA;* [2]*City Univ. of New York, Queens College, USA;* [3]*Univ. of California, Berkeley, USA.* Fano resonant metamaterials (FRAMM) with varying degree of symmetry breaking were designed, tested, and simulated. Field enhancement of different FRAMM designs were simulated. This will help design FRAMMs suitable for a specific requirement.

**Marriott Salon I & II**

## CLEO: Applications & Technology

### AM1L • Advanced Material Processing—Continued

**AM1L.6 • 09:30** Invited
**Ultra-Short Pulse Lasers as Versatile Tools in the Fabrication of Medical Micro Implants,** Nils-Agne Feth[1], Martin Strobel[1]; [1]*Admedes Schuessler GmbH, Germany.* We give an overview of the application of ultra-short pulse (USP) lasers in the fabrication of miniaturized medical implants and devices like stents. Furthermore, we estimate the economic requirements to be fulfilled by USP lasers.

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**10:00–10:30 Coffee Break,** *Concourse Level*

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## CLEO: Science & Innovations

**Marriott**
**Salon III**

### SM1M • Frequency Combs and Novel Light Sources—Continued

**SM1M.6 • 09:30** ▶

**Modifying the Coherence Properties of Microresonator Combs with Feedback Loop Filtering,** Yufeng Jiang[1], Xin Zhao[1], Jian Wang[2], Ben Niu[2], Pei-Hsun Wang[2], Minghao Qi[2], Zheng Zheng[1]; [1]*School of Electronic and Information Engineering, Beihang Univ., China;* [2]*School of Electrical and Computer Engineering & Birck Nanotechnology Center, Purdue Univ., USA.* The coherence properties of a frequency comb generated by a SiN microring resonator is shown to be changed by the feedback through a self tracking, narrowband single longitudinal mode filter in an active fiber loop.

**SM1M.7 • 09:45** ▶

**Analysis and experiments on harmonic mode locking in an optical microcavity,** Takumi Kato[1], Ryo Suzuki[1], Tomoya Kobatake[1], Takasumi Tanabe[1]; [1]*Keio Univ., Japan.* We investigated harmonic mode locking in a microcavity with split-step Fourier method and demonstrated it experimentally. Harmonic mode locking in an ultra-small cavity allows us to obtain ultra-high repetition rate pulse trains.

**Marriott**
**Salon IV**

### SM1N • SDM and Bandgap Fibers—Continued

**SM1N.4 • 09:30**

**Doppler-Assisted Tomography of Photonic Crystal Fiber Structure by Side-Scattering,** Alessio Stefani[1], Michael H. Frosz[1], Tijmen G. Euser[1], Gordon K. L. Wong[1], Philip St.J. Russell[1,2]; [1]*Max Planck Inst. for the Science of Light, Germany;* [2]*Dept. of Physics, Univ. of Erlangen-Nuremberg, Germany.* Using a non-destructive side-scattering technique, the internal structure of a microstructured fibre is determined. The rotating fiber is illuminated by a laser beam and an inverse Radon transform is applied to the frequency-modulated scattered signal.

**SM1N.5 • 09:45**

**Chalcogenide negative curvature hollow-core photonic crystal fibers with low loss and low power ratio in the glass,** Chengli Wei[1], Robinson Kuis[2], Francois Chenard[2], Jonathan Hu[1]; [1]*Baylor Univ., USA;* [2]*IRflex Corporation, USA.* We study the chalcogenide negative curvature hollow-core PCFs. The leakage loss and power ratio in the glass decrease as the number of tubes increases or the ratio of tube wall thickness to diameter decreases.

**Marriott**
**Salon V & VI**

### SM1O • Pulse Generation and Amplification—Continued

**SM1O.7 • 09:30** ▶

**Widely Tunable Normal Dispersion Fiber Optical Parametric Oscillato,** Khanh Q. Kieu[1], Nam Nguyen[1], Roopa Gowda[1], Takefumi Ota[2,1], Shinichiro Uno[2,1], Nasser Peyghambarian[1]; [1]*Univ. of Arizona, USA;* [2]*Canon USA Inc., Canon, USA.* We demonstrate a very wide tuning range normal dispersion fiber optical parametric oscillator (FOPO) using a femtosecond, fixed wavelength fiber laser as the pump source. We believe that the proposed laser design will be useful for developing widely tunable fiber laser sources.

**SM1O.8 • 09:45** ▶

**Passive Waveform Amplification by Self-Imaging,** Reza Maram[1], James Van Howe[1,2], Ming Li[1,3], José Azaña[1]; [1]*INRS-Energie Materiaux et Telecom, Canada;* [2]*Dept. of Physics and Astronomy, Augustana College, USA;* [3]*Inst. of Semiconductors, Chinese Academy of Sciences, China.* We show experimentally undistorted, intensity amplification of optical pulse waveforms with gain from 2 to ~20 without using active gain by recycling energy already stored in the input repetitive signal.

**Marriott**
**Willow Glen I-III**

## CLEO: Applications & Technology

### AM1P • Symposium on Advances in Molecular Imaging I—Continued

**AM1P.4 • 09:30** Invited ▶

**3D Optoacoustic Tomography: From Molecular Targets in Mouse Models to Functional Imaging of Breast Cancer,** Alexander A. Oraevsky[1]; [1]*TomoWave Labs, Inc, USA.* A review of our recent works advancing three-dimensional optoacoustic tomography systems and their applications in preclinical imaging using small animal models and clinical application in diagnostic imaging of breast cancer is presented.

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**10:00–10:30 Coffee Break,** *Concourse Level*

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## CLEO: QELS-Fundamental Science

### Executive Ballroom 210A

10:30–12:30

### FM2A • Quantum Logic and Interference

*Presider: Julio Barreiro; Univ. of California San Diego, USA*

**FM2A.1 • 10:30**

**Network of femtosecond degenerate OPOs for solving NP-Hard Ising problems,** Alireza Marandi[1,2], Kenta Takata[2], Zhe Wang[1], Robert L. Byer[1], Yoshihisa Yamamoto[1,2]; [1]*Stanford Univ., USA;* [2]*National Inst. of Informatics, Japan.* We report implementation of a configurable network of four degenerate optical parametric oscillators as an Ising spin system using time-multiplexed femtosecond pulses. This coherent Ising machine solves an instance of NP-hard MAXCUT problem without error.

**FM2A.2 • 10:45**

**Solving The Ising Problem Using Degenerate Optical Parametric Oscillators,** Zhe Wang[1], Alireza Marandi[1,2], Kai Wen[1], Robert L. Byer[1], Yoshihisa Yamamoto[1,2]; [1]*Stanford Univ., USA;* [2]*National Inst. of Informatics, Japan.* A degenerate optical parametric oscillator network is proposed to solve the NP-hard problem of finding a ground state of the Ising Hamiltonian.

**FM2A.3 • 11:00**

**An integrated programmable quantum photonic processor for linear optics,** Jacob C. Mower[1], Nicholas C. Harris[1], Greg Steinbrecher[1], Yoav Lahini[2], Dirk Englund[1]; [1]*EECS, MIT, USA;* [2]*Physics, MIT, USA.* We introduce a reconfigurable silicon quantum photonic network for implementing general linear optics transformations in the spatial mode basis. This network enables implementation of a range of quantum algorithms; we discuss the phase estimation algorithm.

### Executive Ballroom 210B

10:30–12:30

### FM2B • New Trends in Attoscience

*Presider: Eiji Takahashi; RIKEN, Japan*

**FM2B.1 • 10:30**

**Photoionization Time Delay Measurement close to a Fano Resonance Using Tunable Attosecond Pulses,** Marija Kotur[1], Diego Guenot[1], David Kroon[1], Esben Witting-Larsen[1], Miguel Miranda[1], Maite Louisy[1], Samuel Bengtsson[1], Stefanos Carlström[1], Johan Mauritsson[1], J. Marcus Dahlström[2], Sophie Canton[3], Mathieu Gisselbrecht[1], Cord L. Arnold[1], Anne L'Huillier[1]; [1]*Dept. of Physics, Lund Univ., Sweden;* [2]*Dept. of Physics, Stockholm Univ., Sweden;* [3]*Dept. of Synchrotron Radiation Instrumentation, Lund Univ., Sweden.* We investigate the influence of a Fano resonance on the delays for electron emission in two-photon, near-resonant ionization of argon. The delays were measured using an interferometric method that employed an attosecond pulse train.

**FM2B.2 • 10:45**

**Temporal characterization of emitted field from autoionization state stimulated by isolated attosecond pulse,** Hiroki Mashiko[1], Tomohiko Yamaguchi[1,2], Katsuya Oguri[1], Akira Suda[2], Hideki Gotoh[1]; [1]*Quantum Optical Physics Research Group, NTT Basic Research Labs, Japan;* [2]*Physics, Tokyo Univ. of Science, Japan.* We characterized field emission from autoionization transition in atomic neon stimulated by isolated attosecond field. The spectrum of the emitted field broadens approximately 1 eV bandwidth, which corresponds to shorter than 2.5 fs-duration

**FM2B.3 • 11:00**

**Attosecond Transient Absorption in Molecular Hydrogen,** Yan Cheng[1], Michael Chini[1], Xiaowei Wang[1,2], Yi Wu[1], Zenghu Chang[1]; [1]*CREOL and Dept. of Physics, Univ. of Central Florida, USA;* [2]*Dept. of Physics, National Univ. of Defense Technology, China.* Isolated attosecond pulses are used to probe laser-perturbed hydrogen molecules using attosecond absorption spectroscopy. We observe dynamic features in the delay-dependent absorption on both the electronic and nuclear timescales for the first time.

### Executive Ballroom 210C

10:30–12:30

### FM2C • Optics in Random Media I

*Presider: Qiaoqiang Gan, State Univ. of New York at Buffalo, USA*

**FM2C.1 • 10:30**

**3D Optical Invisibility Cloak in the Diffusive-Light Limit,** Robert Schittny[1], Muamer Kadic[1,2], Martin Wegener[1,2]; [1]*Inst. of Applied Physics, Karlsruhe Inst. of Technology, Germany;* [2]*Inst. of Nanotechnology, Karlsruhe Inst. of Technology, Germany.* We design, fabricate, and characterize three-dimensional macroscopic free-space omnidirectional polarization-independent visible-wavelength broad-bandwidth invisibility cloaks in the diffusive limit of light propagation. The simple core-shell geometries are inspired by near-field optics.

**FM2C.2 • 10:45**

**Metamaterial Broadband Angular Selectivity,** Yichen Shen[1], Ivan Celanovic[1], Marin Soljacic[1], John Joannopoulos[1]; [1]*MIT, USA.* We present a method that achieves light selection based purely on the angle of propagation, by tailoring the overlap of the bandgaps of multiple one-dimensional photonic crystals, each contains metamaterial and with a different periodicity.

**FM2C.3 • 11:00**

**Long Range Correlations of Light Intensity inside Photonic Nanostructures,** Raktim Sarma[1], Alexey G. Yamilov[2], Boris Shapiro[3], Hui Cao[1]; [1]*Yale Univ., USA;* [2]*Missouri Univ. of Science & Technology, USA;* [3]*Physics, Technion-Israel Inst. of Technology, Israel.* We measured directly long range spatial intensity correlations inside quasi-two dimensional disordered photonic waveguides. Enhancement of long-range correlations is observed in narrower waveguides due to localization effects, enabling manipulation of intensity correlations inside random media.

### Executive Ballroom 210D

10:30–12:30

### FM2D • Graphene and Novel Phenomena

*Presider: Zhigang Chen, San Francisco State Univ., USA*

**FM2D.1 • 10:30** Invited

**Optical Phenomena in Graphene/Boron Nitride Heterostructures,** Feng Wang[1,4], Zhiwen Shi[1], Chenhao Jin[1], Wei Yang[2], Hans A. Bechtel[3], Michael C. Martin[3], Guangyu Zhang[2]; [1]*Univ. of California Berkeley, USA;* [2]*Chinese Academy of Sciences, China;* [3]*Advanced Light Source Division, Lawrence Berkeley National Lab, USA;* [4]*Materials Science Division, Lawrence Berkeley National Lab, USA.* Electrons in graphene are described by massless Dirac Fermions with unusual electrical and optical properties. The Moire superlattice in graphene/boron nitride heterostructure strongly modifies the electronic structure, and leads to unusual changes in infrared absorption.

**FM2D.2 • 11:00**

**Direct observation of "pseudospin"-mediated vortex generation in photonic graphene,** Daohong Song[1], Liqin Tang[1], Yi Zhu[2,3], Mark Ablowitz[3], Vassilis Paltoglou[4], Nikolaos K. Efremidis[4], Jingjun Xu[1], Zhigang Chen[1,5]; [1]*Nankai Univ., China;* [2]*Tsinghua Univ., China;* [3]*Univ. of Colorado, USA;* [4]*Univ. of Crete, Greece;* [5]*San Francisco State Univ., USA.* We observe vortex generation by selective excitation of two honeycomb sublattices at the vicinity of Dirac points. Such vortices arise from graphene "pseudospin", suggesting that "pseudospin" could be observable and possess real angular momentum.

## CLEO: Science & Innovations

## Executive Ballroom 210E

### 10:30–12:30
### SM2E • Spectroscopic Chemical Detection
*Presider: Gerard Wysocki; Princeton Univ., USA*

**SM2E.1 • 10:30** Invited

**Solvent-driven Ionic Processes In Water: Surface Adsorption and Cation-Cation Pairing, Studied by X-ray Absorption and UV-SHG Spectroscopy,** Richard James Saykally[1]; [1]*Univ. of California Berkeley, USA.* Seemingly unlikely processes that ostensibly conflict with fundamental electrostatics can occur in polar liquid media, and underlie important natural phenomena. We have recently examined the above phenomena by state of the art experiments and theory.

**SM2E.2 • 11:00**

**Ultra-Sensitive Mid-Infrared Photoexpansion Nanospectroscopy with Background Suppression,** Feng Lu[1], Mingzhou Jin[1], Mikhail A. Belkin[1]; [1]*Electrical and Computer Engineering, Univ. of Texas at Austin, USA.* The ultimate sensitivity of mid-infrared photoexpansion nanospectroscopy is limited by the background signal from photoexpansion of the sample substrate and the probe tip. Here we demonstrate suppression of this signal using a second mid-infrared laser.

## Executive Ballroom 210F

### 10:30–12:30
### SM2F • Advanced Solid State Laser Architectures
*Presider: Dennis Harris; MIT Lincoln Lab, USA*

**SM2F.1 • 10:30**

**Intracavity Coherent Beam Combining of Solid-State Gain Elements using Active Phase Control,** Juan Montoya[1], Steve Augst[1], Jan Kansky[1], Kevin Creedon[1], Antonio Sanchez-Rubio[1], Tso Yee Fan[1]; [1]*Massachusetts Inst of Tech Lincoln Lab, USA.* Here we report on intracavity coherent beam combining (iCBC) of nine solid-state gain elements resulting in 27 W of combined power with a combining efficiency of 87% and a beam quality of M^2 = 1.7.

**SM2F.2 • 10:45**

**Simple Non-PM Fiber Based Beam Combination Architecture,** Andrew Benedick[1], Michael Riley[1], Shawn Redmond[1], Tso Yee Fan[1]; [1]*MIT Lincoln Lab, USA.* Efficient combination of an array of lasers requires alignment of their polarization states. We demonstrate a simple architecture for polarization control by coherently combining eight passive non-PM fibers resulting in a PER of 19 dB.

**SM2F.3 • 11:00**

**Theory and Experimental Verification of Kramers-Kronig Self-Phasing in Coherently Combined Fiber Lasers,** James R. Leger[1], Hung-Sheng Chiang[1], Johan Nilsson[2], Jayanta K. Sahu[2]; [1]*Univ. of Minnesota Twin Cities, USA;* [2]*Optoelectronics Research Centre, Univ. of Southampton, UK.* The recently observed self-phasing of coherently coupled fibers due to Kramers-Kronig effects is theoretically described using a simple model. Direct measurements of the Kramers-Kronig effect and Henry's alpha parameter are reported.

## Executive Ballroom 210G

### 10:30–12:30
### SM2G • Silicon Photonic Modulators
*Presider: Joyce Poon; Univ. of Toronto, Canada*

**SM2G.1 • 10:30**

**Enhanced modulation performance by cascaded uncoupled dual-ring,** Tingyi Gu[1,2], Chee Wei Wong[2], Youngkai Chen[1], Po Dong[1]; [1]*Bell Labs, Alcatel-Lucent, USA;* [2]*Columbia Univ., USA.* We demonstrate enhanced modulation speed by using serial uncoupled microring modulators. By reducing photon lifetime, the extinction ratio of eye diagram increases from 5.9 dB to 7.1 dB, by driving two rings at 20 Gbps.

**SM2G.2 • 10:45**

**Low-Voltage 25 Gbps Modulators Based On Si Photonic Crystal Slow Light Waveguides,** Yosuke Terada[1], Toshihiko Baba[1]; [1]*Yokohama National Univ., Japan.* 25 Gbps operation was obtained with extinction ratios of 2 - 4 dB for $V_{pp}$ = 1.00 - 1.75 V in MZI modulator consisting of 200-µm photonic crystal slow light waveguide phase shifters.

**SM2G.3 • 11:00**

**Monolithic Travelling-Wave Mach-Zehnder Transmitter with High-Swing Stacked CMOS Driver,** Douglas M. Gill[1], Jonathan E. Proesel[2], Chi Xiong[1], Jessie Rosenberg[1], Marwan Khater[1], Tymon Barwicz[1], Solomon Assefa[1], Steven M. Shank[3], Carol Reinholm[3], Edward Kiewra[1], John J. Ellis-Monaghan[3], Swetha Kamlapurkar[1], William M. Green[1], Yurii Vlasov[1]; [1]*Electronic/Photonic Integrated Systems Research and Applications Development, IBM T.J. Watson Research Center, USA;* [2]*Analog & Mixed-Signal Circuit Design, IBM T.J. Watson Research Center, USA;* [3]*Microelectronics Division, IBM Systems & Technology Group, USA.* We present a 20 Gb/s monolithically integrated transmitter with stacked CMOS driver and periodic-loaded PN-junction Mach-Zehnder modulator (MZM) fabricated in IBM's sub-100nm technology node. Transmitter extinction ratios of 10 dB at 20 Gb/s are demonstrated.

## Executive Ballroom 210H

### 10:30–12:30
### SM2H • Novel Approaches for Detection, Sensing and Characterization
*Presider: Ofer Levi; Univ. of Toronto, Canada*

**SM2H.1 • 10:30**

**Direct observation of electromagnetic near field in silicon nanophotonics devices using Scanning Thermal Microscopy (SThM) technique,** Meir Y. Grajower[1], Liron Stern[1], Borid Desiatov[1], Ilya Goykhman[1], Uriel Levy[1]; [1]*Dept. of Applied Physics, Hebrew Univ. of Jerusalem, Israel.* We observe directly for the first time optical near field in silicon nanophotonics devices with nanoscale resolution using near field scanning thermal microscopy and demonstrated its advantage over the NSOM technique.

**SM2H.2 • 10:45**

**Silicon Wire Refractive Index Characterization using Microring Resonator Effective Length from Interferograms,** Shih-Hsiang Hsu[1], Yung-Chia Yang[1], Yu-Hou Su[1]; [1]*National Taiwan Univ of Science & Tech, Taiwan.* The optical low-coherence interferometry built with an optical ruler was proposed to demonstrate silicon-wire transverse-magnetic polarized indices of refraction and birefringence as 2.02 and 0.64, respectively, from the microring resonator effective length using various interferograms.

**SM2H.3 • 11:00** Invited

**Nano-focused ultrafast spectroscopy and imaging reaching the single quantum level,** Markus B. Raschke[1]; [1]*Univ. of Colorado at Boulder, USA.* The near-field tip-antenna enhanced signal transduction with femtosecond laser pulses allows for spatio-spectral and spatio-temporal imaging and quantum coherent control with the perspective to reach the single electronic or vibrational quantum level.

## CLEO: Science & Innovations

### Meeting Room 211 B/D

**10:30–12:30**
**SM2I • Mode-locked OPOs**
*Presider: Yen-Hung Chen; National Central Univ., Taiwan*

**SM2I.1 • 10:30**
**FM Mode-Locked Optical Parametric Oscillator: Pulse Formation and Spectral Characteristics,** Kavita Devi[1], Suddapalli Chaitanya Kumar[1], Majid Ebrahim-Zadeh[1,2]; *[1]ICFO -The Inst. of Photonic Sciences, Spain; [2]2Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain.* We report pulse formation and spectral characteristics of a FM mode-locked OPO in the mid-IR. The singly-resonant OPO based on MgO:PPLN, pumped by a cw Yb-fiber laser at 1064 nm, generates 236ps pulses at 80MHz.

**SM2I.2 • 10:45**
**Dynamics and Design Trade-Offs in CW-Pumped Singly-Resonant Optical Parametric Oscillator Based Combs,** Christopher R. Phillips[1], Ville Ulvila[2], Lauri Halonen[2], Markku Vainio[2,3]; *[1]ETH Zurich, Switzerland; [2]Univ. of Helsinki, Finland; [3]Centre for Metrology and Accreditation, Finland.* We analyze frequency comb generation in CW-pumped singly-resonant optical parametric oscillators using cascaded second-order nonlinearities. We explain experimental results, trade-offs and current limits on performance, and examine scaling towards broader bandwidths in the future.

**SM2I.3 • 11:00** Invited
**Asynchronous Mid-Infrared Optical Parametric Oscillator Frequency Combs and Applications in Spectroscopy,** Zhaowei Zhang[1], Tom Gardiner[2], Derryck T. Reid[1]; *[1]Heriot-Watt Univ., UK; [2]National Physical Lab, UK.* Principles of asynchronous optical parametric oscillator frequency combs are introduced and their performance in dual-comb mid-infrared molecular spectroscopy is presented, including a specific demonstration of methane absorption spectroscopy with a resolution of 0.2 cm-1.

### Meeting Room 212 A/C

**10:30–12:30**
**SM2J • Nanostructured LEDs and Photovoltaics**
*Presider: Jonathan Wierer; Sandia National Labs, USA*

**SM2J.1 • 10:30**
**Selective-Area Growth of III-Nitride Core-Shell Nanowalls for Light-Emitting and Laser Diodes,** Ashwin Rishinaramangalam[1], Michael Fairchild[1], Saadat Ul Masabih[1], Darryl Shima[1], Ganesh Balakrishnan[1], Daniel Feezell[1]; *[1]Electrical and Computer Engineering, Univ. of New Mexico, USA.* We demonstrate selective-area growth of patterned III-nitride core-shell nanowalls with nonpolar InGaN quantum well shells over large areas. Transmission electron microscopy and photoluminescence are utilized to examine the growth morphology and emission characteristics.

**SM2J.2 • 10:45**
**Red to Near-Infrared Emission from InGaN/GaN Quantum-Disks-in-Nanowires LED,** Tien Khee Ng[1], Chao Zhao[1,2], Chao Shen[1], Shafat Jahangir[3], Bilal Janjua[1], Ahmed B. Slimane[1], Chun H. Kang[1], Ahad A. Syed[2], Jingqi Li[2], Ahmed Y. Alyamani[4], Munir M. El-Desouki[4], Pallab K. Bhattacharya[3], Boon S. Ooi[1]; *[1]Photonics Lab, King Abdullah Univ. of Science and Tech, Saudi Arabia; [2]Advanced Nanofabrication and Imaging Core Lab, King Abdullah Univ. of Science and Tech, Saudi Arabia; [3]Dept. of Electrical Engineering and Computer Science, Univ. of Michigan, USA; [4]National Center for Nanotechnology, King Abdulaziz City for Science and Tech, Saudi Arabia.* The InGaN/GaN quantum-disks-in-nanowire light-emitting diode (LED) with emission centered at ~830nm, the longest emission wavelength ever reported in the InGaN/GaN system, and spectral linewidth of 290nm, has been fabricated with p-side-down on a Cu substrate.

**SM2J.3 • 11:00**
**InGaN Quantum Dots for High Efficiency Blue and Green Light Emitters,** Arthur J. Fischer[1], Xiaoyin Xiao[1], Jeffrey Y. Tsao[1], Daniel D. Koleske[1], Ping Lu[1], Jeremy B. Wright[1], Sheng Liu[1], George T. Wang[1]; *[1]Sandia National Labs, USA.* InGaN quantum dots at high densities (~10^11 dots/cm^2) are demonstrated using metalorganic chemical vapor deposition combined with post growth processing of InGaN materials. Optical and structural studies are performed to characterize InGaN quantum dots.

## CLEO: QELS-Fundamental Science

### Meeting Room 212 B/D

**10:30–12:30**
**FM2K • Plasmonic Nanoantennas**
*Presider: Uriel Levy, Hebrew Univ. of Jerusalem, Israel*

**FM2K.1 • 10:30**
**All-Semiconductor Plasmonic Nano-Antennas,** Stephanie Law[1], Lan Yu[1], Aaron Rosenberg[1], Dan Wasserman[1]; *[1]Electrical and Computer Engineering, Univ. of Illinois, USA.* We demonstrate a new type of infrared plasmonic antenna for long-wavelength nano-scale enhanced sensing. The plasmonic materials utilized are epitaxially-grown semiconductor engineered metals, which results in high-quality, low-loss infrared plasmonic metals with tunable optical properties.

**FM2K.2 • 10:45**
**Meta-Coaxial Nanoantenna,** Alexei Smolyaninov[1], Lin Pang[1], Lindsay Freeman[1], Yeshaiahu Fainman[1]; *[1]Dept. of Electrical and Computer Engineering, Univ. of California San Diego, USA.* Novel meta-coaxial nanoantennas are studied numerically, fabricated and experimentally characterized. These antennas provide local field enhancements of 200-800, super-localized fields with spatial FWHM of ~1nm, and wide spectral ranges with FWHM bandwidths greater than 900nm.

**FM2K.3 • 11:00**
**Interacting dark resonances with metallic nano-antennas,** Michael Mrejen[1], Pankaj K. Jha[1], Jeongmin Kim[1], Chihhui Wu[1], Yuan Wang[1], Xiaobo Yin[1], Xiang Zhang[1,2]; *[1]NSF Nano-scale Science and Engineering Center (NSEC), Univ. of California, Berkeley, USA; [2]Materials Science Division, Lawrence Berkeley National Lab, USA.* We theoretically investigate interacting dark resonances in a plasmonic meta-molecule comprising a bright nano-antenna coupled to cascaded dark elements. This structure enables efficient energy transfer and exhibits sub-natural spectral response analogous to the atomic counterpart.

## CLEO: Applications & Technology

### Marriott Salon I & II

**10:30–12:30**
**AM2L • Innovative Laser Sources Detectors and Beam Delivery** ▶
*Presider: Eric Mottay; Amplitude Systemes, France*

**AM2L.1 • 10:30**
**15 mW of CW emission at 193 nm using the crystal KBBF,** Matthias Scholz[1], Dmitrijs Opalevs[1], Jürgen Stuhler[1], Patrick Leisching[1], Wilhelm Kaenders[1], Guiling Wang[2], Xiaoyang Wang[2], Rukang Li[2], Chuangtian Chen[2]; *[1]Research and Development, TOPTICA Photonics AG, Germany; [2]Key Lab of Functional Crystals and Laser Technology, Beijing Center for Crystal Growth and Development, China.* We report on a narrowband continuous-wave laser source in the deep-ultraviolet with an output power of > 15 mW at 193 nm. We see applications of this laser source in semiconductor metrology and high-resolution spectroscopy.

**AM2L.2 • 10:45** ▶
**Yb-doped LMA Fiber Fabricated by Chelate Deposition System for High Power Laser Applications,** Tengfei Shi[1,2], Zhou Zhiguang[1,2], Xiao Xusheng[1,2], Zhang Aidong[1,2], Lin Aoxiang[1,2]; *[1]Chinese Academy of Sciences (CAS), China; [2]State Key Lab of Transient Optics and Photonics, Xi'an Inst. of Optics and Precision Mechanics (XIOPM), China.* We report Yb-doped LMA fiber fabricated by chelate doping system (CDS). All-fiber laser output (η=54.2% at 1080 nm) is 700W. CDS is found effective to fabricate homogeneous preform for high power fiber laser development.

**AM2L.3 • 11:00**
**Withdrawn**

## CLEO: Science & Innovations

### Marriott
### Salon III

**10:30–12:30**
**SM2M • Novel Platforms for Silicon Photonics** ▶
*Presider: Chi Xiong, IBM TJ Watson Research Center, USA*

**SM2M.1 • 10:30** Tutorial ▶
**Organic Electro-optic Materials and Devices: Molecular Engineering Driving Device Performance and Technology Innovation,** Robert A. Norwood[1]; [1]*Univ. of Arizona, USA.* Electro-optic polymers have developed dramatically, with commercially available materials exhibiting EO coefficients > 250pm/V with excellent stability. This has resulted in low voltage (< 1V), ultrahigh bandwidth EO modulators and integration with silicon photonics is emerging.

Robert A. Norwood received a B.S. in physics and mathematics from MIT and the Ph.D. in physics from the University of Pennsylvania. After several leadership positions in industry, he became a Professor in the College of Optical Sciences at the University of Arizona, where he performs research on a broad range of organic photonic materials and devices. He has more 100 refereed publications, 7 book chapters, 30 issued US patents, and has delivered more than 60 invited talks. He is a Fellow of The Optical Society and SPIE.

### Marriott
### Salon IV

**10:30–12:30**
**SM2N • Modes in Fibers**
*Presider: John Fini; OFS Labs, USA*

**SM2N.1 • 10:30**
**Optical Activity Enhanced by Orbital Angular Momentum Resonances in Helically Twisted PCF,** Gordon K. Wong[1], Xiaoming Xi[1], Thomas Weiss[1,3], Philip St.J. Russell[1,2]; [1]*Max Planck Inst. for the Science of Light, Germany;* [2]*Dept. of Physics, Univ. of Erlangen-Nuremberg, Germany;* [3]*4th Physics Inst. and Research Center SCOPE, Univ. of Stuttgart, Germany.* We demonstrate that twisted solid-core PCF develops strongly enhanced optical activity and circular dichroism in the vicinity of orbital angular momentum resonances in the cladding. It may be used as a circular polarizer.

**SM2N.2 • 10:45**
**OAM Stability in Fiber due to Angular Momentum Conservation,** Patrick Gregg[1], Poul Kristensen[2], Siddharth Ramachandran[1]; [1]*Boston Univ., USA;* [2]*OFS-Fitel, Denmark.* We demonstrate that degenerate, higher order (|L|>1) OAM modes resist polcon-like perturbations, with coupling efficiencies at least 10dB less than that of SMF. We attribute this stability to the large angular momenta of these modes.

**SM2N.3 • 11:00** Invited
**The Photonic Lantern,** Timothy A. Birks[1], Itandehui Gris-Sánchez[1], Stephanos Yerolatsitis[1]; [1]*Univ. of Bath, UK.* Photonic lanterns are made by adiabatically merging several single-mode cores into one multimode core. They provide low-loss interfaces between single-mode and multimode systems where the precise optical mapping between cores and modes is unimportant.

## CLEO: Applications & Technology

### Marriott
### Salon V & VI

**10:30–12:30**
**AM2O • Endoscopy & Minimally Invasive Optical Imaging** ▶
*Presider: Yu Chen; Univ. of Maryland at College Park, USA*

**AM2O.1 • 10:30** Invited ▶
**Mueller Polarimetric Endoscopy,** Ji Qi[1], Mohan Singh[1], Neil Clancy[1], Daniel S. Elson[1]; [1]*Imperial College London, UK.* Mueller polarimetric imaging is a promising technique which is able to provide additional polarisation contrast for surgical imaging. In this work, improved 3×3 and 4×4 Mueller matrix endoscopic systems were constructed and tested with tissue samples.

**AM2O.2 • 11:00** ▶
**Multiphoton GRIN Endoscope for Evaluation of Human Prostatic Tissue Ex Vivo,** David Huland[1], Manu Jain[2], Dimitre Ouzounov[1], Brian D. Robinson[3], Ashutosh Tewari[2], Chris Xu[1]; [1]*School of Applied and Engineering Physics, Cornell Univ., USA;* [2]*Dept. of Urology of Weill Medical College of Cornell Univ., New York-Presbyterian Hospital, USA;* [3]*Dept. of Surgical Pathology of Weill Medical College of Cornell Univ., New York-Presbyterian Hospital, USA.* We characterize the diagnostic performance of a multiphoton GRIN endoscope using human prostate samples obtained from radical prostatectomy surgery. Ex vivo images of benign and tumor areas and images of peri-prostatic tissue are shown.

### Marriott
### Willow Glen I-III

**10:30–12:30**
**AM2P • Symposium on Advances in Molecular Imaging II** ▶
*Presider: John Rasmussen; Univ. of Texas Health Science Center, USA*

**AM2P.1 • 10:30** Invited ▶
**NIR fluorescent contrast agents for detection of inflammation of lungs in vivo,** Haiying Zhou[1], Shawn He[1], Sean Gunsten[2], Steven Brody[2], Walter Akers[1], Mikhail Berezin[1], Jeff Thompson[3] ; [1]*Radiology, Washington Univ. School of Medicine, USA;* [2]*Medicine, Washington Univ. School of Medicine, USA;* [3]*Harvard Univ., USA.* Inflammatory responses to lung injuries are mediated through enhanced production of reactive oxygen species (ROS). We describe the use of activatable NIR fluorescent agents with high sensitivity to ROS to image the lung during conditions of high inflammation.

**AM2P.2 • 11:00** Invited ▶
**Emerging Trends with Molecularly Targeted Optobeacons for Photoacoustic Tomographic Imaging,** Dipanjan Pan[1]; [1]*Univ of Illinois at Urbana-Champaign, USA.* In this talk we will discuss the potential of photoacoustic imaging in combination with molecularly targeted contrast agents to detect early, sprouting angiogenic expression and the opportunities for improved recognition of cancer metastases.

### FM2A • Quantum Logic and Interference—Continued

**FM2A.4 • 11:15**

**All-Optical Continuously Tunable Delay of Single Photons,** Stéphane Clemmen[1], Alessandro Farsi[1], Alexander L. Gaeta[1]; [1]*School of Applied and Engineering Physics, Cornell Univ., USA.* We report the first demonstration of all-optical continuously tunable delay imparted on single photons using a frequency conversion-dispersion technique. Delays tunable over 23 times the photon duration are demonstrated with on/off efficiency of 20-55%.

**FM2A.5 • 11:30** Invited

**Quantum Information Processing with Photons,** Yuao Chen[1]; [1]*Shanghai Branch, National Lab for Physical Sciences at Microscale and Dept. of Modern Physics, Univ. of Science and Technology of China, China.* In this talk I shall present a brief overview on some recent exciting experimental progress towards scalable quantum information processing (QIP), e.g., quantum communication, quantum computation and quantum simulation, via manipulation of photonic qubits.

### FM2B • New Trends in Attoscience—Continued

**FM2B.4 • 11:15**

**Following Attosecond Photoemission from Solids Using Interferometry,** Lukas Gallmann[1,2], Matteo Lucchini[1], Luca Castiglioni[3], Reto Locher[1], Michael Greif[3], Jürg Osterwalder[3], Matthias Hengsberger[3], Ursula Keller[1]; [1]*Dept. of Physics, ETH Zurich, Switzerland;* [2]*Inst. of Applied Physics, Univ. of Bern, Switzerland;* [3]*Dept. of Physics, Univ. of Zurich, Switzerland.* Implementing RABBITT on solids for the first time, we record energy-resolved absolute photoemission delays from noble metal surfaces. The structure of the observed delays in Ag(111) and Au(111) is inconsistent with previously promoted models.

**FM2B.5 • 11:30**

**Coherent VUV Emission from Field-Controlled Bound States,** Michael Chini[1], Xiaowei Wang[1,2], Yan Cheng[1], He Wang[3], Yi Wu[1], Eric Cunningham[1], Peng-Cheng Li[4,5], John Heslar[4], Dmitry Telnov[6], Shih-I Chu[4,7], Zenghu Chang[1]; [1]*Univ. of Central Florida, USA;* [2]*National Univ. of Defense Technology, China;* [3]*Lawrence Berkeley National Lab, USA;* [4]*National Taiwan Univ., Taiwan;* [5]*Northwest Normal Univ., China;* [6]*St. Petersburg State Univ., Russia;* [7]*Univ. of Kansas, USA.* We demonstrate a dramatic enhancement of the below-threshold harmonics in the vicinity of atomic resonances. The dependence on the driving laser carrier-envelope phase suggests a nonperturbative mechanism. Phase matching promises scalability to microJoule pulse energies.

**FM2B.6 • 11:45**

**Combining Attosecond Science with Coincidence Momentum Spectroscopy,** Robert Boge[1], Mazyar Sabbar[1], Sebastian Heuser[1], Claudio Cirelli[1], Lukas Gallmann[1,2], Ursula Keller[1]; [1]*Physics Dept., ETH, Switzerland;* [2]*Inst. of Applied Physics, Universität Bern, Switzerland.* We combine an attosecond beam line with a 3D momentum imaging spectrometer to achieve coincidence pump probe experiments with unprecedented attosecond time-resolution. Besides technical details, first coincidence and pump-probe experiments are presented.

### FM2C • Optics in Random Media I—Continued

**FM2C.4 • 11:15**

**Optical resonances in topological defect structures,** Seng Fatt Liew[1], Yaron Bromberg[1], Hui Cao[1]; [1]*Applied Physics, Yale Univ., USA.* We study numerically optical resonances in 2D topological defect structures with wavelength-scale anisotropic scattering units. Both spatially extended and localized modes exhibit vortex-like energy flow due to breaking of chiral symmetry of the underlying structure.

**FM2C.5 • 11:30** Invited

**Densities of states, dynamics and intensity profiles of transmission eigenchannels of opaque media,** Azriel Z. Genack[1], Matthieu Davy[1,2], Zhou Shi[1], Jing Wang[1], Jongchul Park[1]; [1]*CUNY Queens College, USA;* [2]*Univ. of Rennes 1, France.* We determine the frequency derivative of the composite phase of transmission eigenchannels and relate this to their contribution to the density of states, their dwell time and their intensity profile within the random medium.

### FM2D • Graphene and Novel Phenomena—Continued

**FM2D.3 • 11:15**

**Optical Second-Harmonic Generation Induced by Electric Current in Epitaxial Graphene on Vicinal SiC(0001),** Yong An[1], J. E. Rowe[2], Daniel B. Dougherty[2], Ji Ung Lee[1], Alain C. Diebold[1]; [1]*State Univ. of New York, USA;* [2]*North Carolina State Univ., USA.* We find that surface second-harmonic generation (SHG) from epitaxial graphene on a vicinal SiC(0001) substrate is enhanced ~25% by direct electric current in graphene and that the enhanced SHG varies strongly with the measurement location.

**FM2D.4 • 11:30**

**Observation of the Imbert-Fedorov effect via weak value amplification,** Gaurav Jayaswal[1], Giampaolo Mistura[1], Michele Merano[1]; [1]*Dipartimento di Fisica e Astronomia "G. Galilei", UNIV. OF PADOVA, Italy.* We report the first experimental observation of the Imbert-Fedorov shift via weak value amplification.

**FM2D.5 • 11:45**

**Observation of band gaps in amorphous photonic structures with different temperatures in the near infrared,** serdar kocaman[1], James F. McMillan[1], Di Wang[1], Mikael Rechtsman[2], Chee Wei Wong[1]; [1]*Optical Nanostructures Lab, Columbia Univ., USA;* [2]*Physics Dept. and Solid State Inst., Technion, Israel.* We examine numerically and experimentally photonic band-gaps in liquid-like two dimensional photonic materials. Subwavelength dielectric rods and holes are randomly placed with Monte Carlo simulations, fabricated on silicon-on-insulator chips, and measured in near infrared wavelengths.

## CLEO: Science & Innovations

## SM2E • Spectroscopic Chemical Detection—Continued

**SM2E.3 • 11:15**

**Mid-IR Photothermal Spectroscopy with an Integrated Fiber Probe Laser,** Michelle Y. Sander[1,5], Hui Liu[1,5], Alket Mertiri[2,5], Atcha Totachawattana[1,5], Shyamsunder Erramilli[3,4]; [1]*Electrical and Computer Engineering, Boston Univ., USA;* [2]*Division of Materials Science and Engineering, Boston Univ., USA;* [3]*Physics Dept., Boston Univ., USA;* [4]*Dept. of Biomedical Engineering, Boston Univ., USA;* [5]*Photonics Center, Boston Univ., USA.* We present the first compact, all-fiber probe laser system for mid-IR photothermal spectroscopy. Images of the vibrational CH bands of a liquid crystal sample with high contrast are demonstrated.

**SM2E.4 • 11:30**

**Multi-Color Laser Spectroscopy with a Dual-Wavelength Quantum Cascade Laser,** Jana Jágerská[1], Pierre Jouy[2], Béla Tuzson[1], Herbert Looser[3], Andreas Hugi[2], Markus Mangold[1], Patrik Soltic[1], Lukas Emmenegger[1], Jérôme Faist[2]; [1]*Lab for Air Pollution/Environmental Technology, EMPA, Switzerland;* [2]*Inst. for Quantum Electronics, ETHZ, Switzerland;* [3]*Inst. for Aerosol and Sensor Technology, FHNW, Switzerland.* A new concept of multi-color spectroscopy based on a dual-wavelength QCL is presented. The latter emits at two distinct wavelengths (5.26 and 6.25 µm), featuring simultaneous detection of two different gas species without any beam combining optics.

**SM2E.5 • 11:45**

**Intracavity Quartz-Enhanced Photoacoustic Sensor for Mid-Infrared Trace-Gas Detection,** Simone Borri[1,3], Iacopo Galli[1,3], Davide Mazzotti[1,3], Vincenzo Spagnolo[2,4], Paolo De Natale[1,3], Gaetano Scamarcio[2,4], Giovanni Giusfredi[1,3], Pietro Patimisco[2,4]; [1]*CNR - INO, Italy;* [2]*CNR - IFN, Italy;* [3]*LENS, Italy;* [4]*Università di Bari, Italy.* Quartz-enhanced photoacoustic spectroscopy (QEPAS) and cavity-ehnanced spectroscopy are merged in a novel gas sensor. Thanks to the intracavity power build up, sensitivity is increased by more than a factor 100 with respect to standard QEPAS.

## SM2F • Advanced Solid State Laser Architectures—Continued

**SM2F.4 • 11:15**

**Power-scaling continuous-wave solid-state Raman lasers using intracavity adaptive optics,** Ran Li[1], Mike Griffith[2], Leslie Laycock[2], Walter Lubeigt[1]; [1]*Univ. of Strathclyde, UK;* [2]*BAE Systems Advanced Technology Centre, UK.* Initial investigations to alleviate thermal lensing, a fundamental limitation in Raman lasers performance, are reported. An adaptive-optics feedback loop was incorporated into a Nd:YVO4 self-Raman laser demonstrating a 40% Raman output power increase

**SM2F.5 • 11:30**

**High-efficiency continuous-wave index-antiguided planar waveguide laser with large mode area,** Yuanye Liu[1], Tsing-Hua Her[1], Lee Casperson[2]; [1]*Physics and Optical Science, Univ. of North Carolina Charlotte, USA;* [2]*Dept. of Electrical and Computer Engineering, Univ. of North Carolina at Charlotte, USA.* We demonstrate robust continuous-wave lasing in planar index-antiguided waveguides with a 220-µm Nd:YAG active layer. A pump-limited output of 1.5 W with a slope efficiency of 30% with respect to absorbed pump power is achieved.

**SM2F.6 • 11:45**

**Diode-pumped Tm:KYW 1.9-µm Microchip Laser with 71% Slope Efficiency and 1 W cw Output Power,** Maxim S. Gaponenko[1], Nikolay Kuleshov[2], Thomas Südmeyer[1]; [1]*Laboratoire Temps-Fréquence, Université de Neuchâtel, Switzerland;* [2]*Belarusian National Technical Univ., Belarus.* We report on a diode-pumped Tm:KYW microchip laser generating 1 W TEM00 continuous-wave output power with 71% slope efficiency relative to the absorbed pump power and 42% overall optical efficiency to the incident pump power.

## SM2G • Silicon Photonic Modulators—Continued

**SM2G.4 • 11:15**

**Ultralow Power Consumption of 1.5nW Over Wide Optical Spectrum Range in Silicon Organic Hybrid Modulator,** Xingyu Zhang[1], Amir Hosseini[2], Jongdong Luo[3], Alex Jen[3], Ray Chen[1]; [1]*Dept. of Electrical and Computer Engineering, Univ. of Texas at Austin, USA;* [2]*Omega Optics, Inc., USA;* [3]*Dept. of Materials Science and Engineering, Univ. of Washington, USA.* We demonstrate an ultralow-power, low-dispersion and compact silicon-organic-hybrid photonic crystal waveguide modulator. RF power consumption of 1.5nW, effective in-device r33 of 1190pm/V and Vπ×L of 0.291±0.006V×mm over 8nm optical bandwidth are demonstrated.

**SM2G.5 • 11:30**

**A Lumped Michelson Interferometric Modulator in Silicon,** David Patel[1], Venkat Veerasubramanian[1], Samir Ghosh[1], Alireza Samani[1], Qiuhang Zhong[1], David Plant[1]; [1]*Electrical and Computer Engineering, McGill Univ., Canada.* We demonstrate the operation of a low $V_{\pi}L_{\pi}$, lumped, and compact Michelson modulator fabricated in SOI. The modulator operates up to 25 Gbps with measured error free operation up to 12.5 Gbps.

**SM2G.6 • 11:45** Invited

**16QAM Silicon-Organic Hybrid (SOH) Modulator Operating with 0.6 $V_{pp}$ and 19 fJ/bit at 112 Gbit/s,** Matthias Lauermann[1], Robert Palmer[1], Sebastian Koeber[1,2], Philipp C. Schindler[1], Dietmar Korn[1], Thorsten Wahlbrink[3], Jens Bolten[3], Michael Waldow[3], Delwin L. Elder[4], Larry R. Dalton[4], Juerg Leuthold[1,5], Wolfgang Freude[1,2], Christian G. Koos[1,2]; [1]*Inst. of Photonics and Quantum Electronics, Karlsruhe Inst. of Tech, Germany;* [2]*Inst. of Microstructure Tech, Karlsruhe Inst. of Tech, Germany;* [3]*AMO GmbH, Germany;* [4]*Dept. of Chemistry, Univ. of Washington, USA;* [5]*Electromagnetic Fields Lab, Swiss Federal Inst. of Tech (ETH), Switzerland.* We demonstrate a silicon-based 16QAM modulator with a record-low drive voltage of 0.6$V_{pp}$ and an energy consumption of 19fJ/bit. The device employs silicon slot waveguides with electro-optic organic cladding and enables data transmission at 112Gbit/s.

## SM2H • Novel Approaches for Detection, Sensing and Characterization—Continued

**SM2H.4 • 11:30**

**A New Type of "Black Silicon" Materials with High Infrared Absorption and Annealing-Insensitivity,** Yan Peng[1], Yiming Zhu[1]; [1]*Shanghai Key Lab of Modern Optical System, Univ. of Shanghai for Science and Technology, China.* A new type of "black silicon" materials with high optical absorptance and annealing-insensitivity is designed and fabricated by femtosecond laser pulses. These results have important implications for the fabrication of highly efficient optoelectronic devices.

**SM2H.5 • 11:45**

**Extended Infrared Absorption to 2.2 µm with $Ge_{1-x}Sn_x$ Photodetectors Grown on Silicon,** Benjamin Conley[1], Liang Huang[1], Sayed A. Ghetmiri[1], Aboozar Mosleh[1], Wei Du[1], Greg Sun[2], Richard Soref[2], John Tolle[3], Hameed A. Naseem[1], Shui-Qing Yu[1]; [1]*Electrical Engineering, Univ. of Arkansas, USA;* [2]*Dept. of Physics, Univ. of Massachusetts, USA;* [3]*ASM America Inc., USA.* Thin film $Ge_{1-x}Sn_x$ photodetectors fabricated on Si using a CMOS compatible process had responsivities at 1.55 µm of 6.59, 1.49, 2.63, and 0.84 mA/W for 0.9, 2.57, 3.2, and 7.0 % Sn. Spectral response for a $Ge_{0.93}Sn_{0.07}$ photodetector had extended infrared response out to 2.2 µm.

## Meeting Room 211 B/D

## CLEO: Science & Innovations

### SM2I • Mode-locked OPOs—Continued

**SM2I.4 • 11:30**
**2.09-μm degenerate femtosecond OPO with over 60% conversion efficiency and 0.6-W output,** Kirk A. Ingold[1], Alireza Marandi[1], Charles Rudy[1,2], Robert L. Byer[1]; [1]*Stanford Univ., USA;* [2]*IPG Photonics Silicon Valley Technology Center, USA.* We report a broad frequency comb centered at 2.09μm produced by a degenerate OPO. We achieve 0.6W of 94-fs transform limited pulses at 250MHz and a conversion efficiency of 64%.

**SM2I.5 • 11:45**
**Few-Cycle, Broadband, Mid-Infrared Parametric Oscillator Pumped by a 20-fs Ti:sapphire Laser,** Suddapalli Chaitanya Kumar[1], Adolfo Esteban-Martin[1], Takuro Ideguchi[2], Ming Yan[2,3], Simon Holzner[2], Theodor W. Hänsch[2,3], Nathalie Picqué[2,4], Majid Ebrahim-Zadeh[1,5]; [1]*ICFO -The Inst. of Photonic Sciences, Spain;* [2]*Max-Planck Institut für Quantenoptik, Hans-Kopfermann-Strasse, Germany;* [3]*Ludwig-Maximilians-Universität München, Fakultät fur Physik, Schellingstr, Germany;* [4]*Institut des Sciences Moléculaires d'Orsay, CNRS, Bâtiment 350, Université Paris-Sud, France;* [5]*Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain.* We report a broadband mid-IR femtosecond OPO tunable across 2179-3732 nm, pumped by 20-fs pulses at 790 nm, generating idler pulses of 4.3 optical cycles (33 fs) at 2282 nm, with high stability and beam-quality.

## Meeting Room 212 A/C

### SM2J • Nanostructured LEDs and Photovoltaics—Continued

**SM2J.4 • 11:15**
**Investigation of Purcell Factor and Light Extraction Efficiency in Ag-Coated GaN/InGaN Core-Shell Nanowires,** Mohsen Nami[1], Jeremy Wright[1], Daniel Feezell[1]; [1]*Electrical and Computer Engineering, Univ. of New Mexico, USA.* We calculate the Purcell factor and light extraction efficiency in Ag-coated GaN/InGaN core-shell nanowires using a model that includes the structural features necessary for electrical injection. The nanowires exhibit maximum Purcell factors of ~60 and maximum light extraction efficiencies of ~12%.

**SM2J.5 • 11:30** Invited
**Nanowire-based LEDs and Photovoltaics,** Lars Samuelson[1,2]; [1]*Solid State Physics/the Nanometer Structure Consortium, Lund Univ., Sweden;* [2]*Glo AB & Sol Voltaics AB, Sweden.* I will describe principles and advantages of the growth of semiconductor nanowires, specifically for fabrication of light-emitting diodes for display and solid state lighting applications as well as for the realization of nanowire array solar cells.

## Meeting Room 212 B/D

## CLEO: QELS-Fundamental Science

### FM2K • Plasmonic Nanoantennas—Continued

**FM2K.4 • 11:15**
**Circuit Theory of Optical Antenna Shedding Light on Fundamental Limit of Rate Enhancement,** Michael Eggleston[1], Kevin Messer[1], Eli Yablonovitch[1], Ming Wu[1]; [1]*Electrical Engineering and Computer Science, Univ. of California Berkeley, USA.* A circuit model of a single-element linear optical antenna is presented. It agrees well with FDTD simulations and predicts spreading resistance will ultimately limit the maximum rate enhancement an efficient antenna can achieve to ~10,000.

**FM2K.5 • 11:30**
**Spectral interferometric microscopy reveals absorption by individual optical nano-antennas from extinction phase,** Sylvain D. Gennaro[1], Yannick Sonnefraud[1], Niels Verellen[2], Pol Van Dorpe[3], Victor Moshchalkov[2], Stefan Maier[1], Rupert F. Oulton[1]; [1]*Physics, Imperial College London, UK;* [2]*INPAC, Belgium;* [3]*IMEC, Belgium.* We demonstrate a method to extract absorption and scattering from phase and intensity measurements of extinction from a single optical nano-antenna by developing a novel spectrally resolved interferometer integrated within a confocal microscope.

**FM2K.6 • 11:45**
**Multi-Photon Photoluminescence Spectral Behavior of Single Gold Nanorods,** Vanessa Knittel[1], Marco Fischer[1], Alfred Leitenstorfer[1], Daniele Brida[1]; [1]*Univ. of Konstanz, Germany.* The spectral shape and nonlinear order of optical emission from single gold nanorods is investigated. The results highlight the complex absorption cascade in the out-of-equilibrium electronic distribution after few-cycle excitation by near-infrared pulses.

## Marriott Salon I & II

## CLEO: Applications & Technology

### AM2L • Innovative Laser Sources Detectors and Beam Delivery—Continued

**AM2L.4 • 11:15**
**Optics-free kagome fiber-aided laser micro-machining,** Benoît Debord[1], Meshaal Alharbi[1], Clemens Hoenninger[3], Eric Mottay[3], Frédéric Gérôme[1,2], Fetah Benabid[1,2]; [1]*GPPMM Group, Xlim Research Inst., CNRS UMR 7252, France;* [2]*GLOphotonics S.A.S, France;* [3]*Amplitude Systèmes, France.* We report on focus-optics free laser micro-processing of several materials using up to milli-joule energy-level fs-pulses directly delivered by 10m-long hypocycloid-core kagome HC-PCFs. The ablation rate and depth were studied showing high-precision drilling.

**AM2L.5 • 11:30** Invited ▶
**Ultrafast Beam Modulation and Delivery for Printing and Embossing Applications,** Guido Hennig[1], Baldermann Thomas[1], Christian Nussbaum[1], Beat Neuenschwander[2], Stephan Bruening[3]; [1]*Daetwyler Graphics AG, Switzerland;* [2]*Berner Fachhochschule, Switzerland;* [3]*Schepers GmbH, Germany.* Optimized ps laser processing improves direct laser engraving of embossing rollers and high power fiber laser combined with ultrafast modulation and scanning techniques enable for digital print applications based on laser induced forward transfer (LIFT).

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## CLEO: Science & Innovations

### Marriott Salon III

### SM2M • Novel Platforms for Silicon Photonics—Continued

**SM2M.2 • 11:30**

**Dispersion engineering of silicon microdisk resonators by thermal oxidation,** Wei C. Jiang[1], Nicholas Usechak[2], Qiang Lin[1,3]; [1]*Inst. of Optics, Univ. of Rochester, USA;* [2]*Air Force Research Lab, USA;* [3]*Electrical and Computer Engineering, Univ. of Rochester, USA.* We demonstrate a convenient approach for precise dispersion engineering of silicon microdisk resonators via thermal oxidation. This technique potentially enables efficient correlated photon-pair generation for quantum photonics.

**SM2M.3 • 11:45**

**Multilayer Platform for Low-Power/Passive Configurable Photonic Device,** Majid Sodagar[1], Amir H. Hosseinnia[1], Ali A. Eftekhar[1], Ali Adibi[1]; [1]*ECE, Georgia Inst. of Technology, USA.* We demonstrate the possibility of forming ultra-compact, field-configurable, and low-power resonance-based passive integrated photonic structures based on charge accumulation in a high-quality multilayer material platform comprising Si/SiO2/Si layers prepared through direct bonding of SOI wafers.

### Marriott Salon IV

### SM2N • Modes in Fibers—Continued

**SM2N.4 • 11:30**

**Characterization of Optical Fibers Supporting OAM States using Fiber Bragg Gratings,** lixian wang[1,2], Bora Ung[1], Pravin Vaity[1], Leslie Rusch[1], Younès Messaddeq[1], Sophie LaRochelle[1]; [1]*Centre d'Optique, Photonique et Laser (COPL), Université Laval, Canada;* [2]*Inst. of Semiconductor, Chinese Academy of Sciences, China.* The reflectogram of a fiber grating is used to characterize vector modes of an optical fiber supporting orbital angular momentum states. All modes, with a minimal effective index separation around 10e-4, are successfully measured.

**SM2N.5 • 11:45**

**Selective Excitation of Pure Higher Order Modes in Hollow-Core PCF via Side-Coupling,** Barbara M. Trabold[1], David Novoa[1], Amir Abdolvand[1], Philip St.J. Russell[1]; [1]*Max Planck Inst. for the Science of Light, Germany.* Side-coupling enables the selective excitation of individual higher order modes in hollow-core PCF, permitting the complex near-field modal patterns to be cleanly observed at any wavelength. Modal phase indices and losses can be accurately measured.

## CLEO: Applications & Technology

### Marriott Salon V & VI

### AM2O • Endoscopy & Minimally Invasive Optical Imaging—Continued

**AM2O.3 • 11:15**

**Real-time Epidural Anesthesia Guidance Using Optical Coherence Tomography Needle Probe,** Qinggong Tang[1], Chia-Pin Liang[1], Kyle Wu[2], Anthony Sandler[2], Yu Chen[1]; [1]*Bioengineering, Univ. of Maryland-College Park, USA;* [2]*Sheikh Zayed Inst. for Pediatric Surgical Innovation, Children's National Medical Center, USA.* Epidural anesthesia is one of the most widely used anesthesia methods. We developed a small hand-held OCT forward-imaging needle device for real-time epidural anesthesia surgery guidance and demonstrated its feasibility through ex vivo experiments.

**AM2O.4 • 11:30** Invited

**Methods for enhancing visualization of subsurface tissue structures in real time,** Stavros G. Demos[1]; [1]*Lawrence Livermore National Lab, USA.* Methods and prototype instrumentation suitable for near surface imaging in tissues are presented. These methods are designed to address two main applications: a) vein imaging to assist cannulation and venipuncture of near surface veins; b) noncontact biometric identification using distinguishing traits in the human hand.

### Marriott Willow Glen I-III

### AM2P • Symposium on Advances in Molecular Imaging II—Continued

**AM2P.3 • 11:30**

**Approximating the Concentration of Lipids on the Surface of Virus-Like Particles through Plasmon Coupling,** Amin Feizpour[1], Bjorn M. Reinhard[1]; [1]*Chemistry Dept., Boston Univ., USA.* The superior optical properties of gold nanoparticles were used to estimate the concentration of two crucial lipids on virus surface. This is a novel high-throughput and rapid surface characterization approach for viruses in low-concentration samples.

**AM2P.4 • 11:45**

**A Depth Perturbation Method for Determining Depth of Fluorophore in Tissue,** Tuo Zhou[1], Takehiro Ando[1], Hongen Liao[2], Etsuko Kobayashi[1], Ichiro Sakuma[1]; [1]*Univ. of Tokyo, Japan;* [2]*Tsinghua Univ., China.* Estimating bio-distribution of fluorophore in tissue is challenging. In this paper, we demonstrated that our depth perturbation method can accurately determine depth of fluorophore located in tissue as deep as 5.8 mm by phantom experiments.

## CLEO: QELS-Fundamental Science

### Executive Ballroom 210A

### FM2A • Quantum Logic and Interference—Continued

**FM2A.6 • 12:00**
**Quantum Noise in Large-Scale Photonic Circuits,** Charles M. Santori[1], Jason S. Pelc[1], Raymond G. Beausoleil[1], Nikolas Tezak[2], Ryan Hamerly[2], Hideo Mabuchi[2]; [1]*Hewlett-Packard Labs, USA;* [2]*Edward L. Ginzton Lab, Stanford Univ., USA.* We describe a simulation approach for studying quantum-mechanical noise in large-scale nonlinear optical circuits. We apply this model to predict the behavior of a 4-bit counter circuit containing several hundred optical components.

**FM2A.7 • 12:15**
**Verifying Quantum Complexity in Linear Optical Experiments,** Jacques Carolan[1], Jasmine Meinecke[1], Pete Shadbolt[1], Nicholas J. Russell[1], Nur Ismail[2], Kerstin Worhoff[2], Terry Rudolph[3], Mark Thompson[1], Jeremy L. O'Brien[1], Jonathan Matthews[1], Anthony Laing[1]; [1]*Centre for Quantum Photonics, Univ. of Bristol, UK;* [2]*Integrated Optical Microsystems Group, Univ. of Twente, Netherlands;* [3]*Inst. for Mathematical Sciences, Imperial College London, UK.* We develop techniques to verify the computational complexity of a class of analogue quantum computers known as boson samplers. We demonstrate these techniques with up to 5 photons in two different types of integrated linear optical circuit, observing Hilbert spaces of up to 50,000 dimensions.

### Executive Ballroom 210B

### FM2B • New Trends in Attoscience—Continued

**FM2B.7 • 12:00**
**Ultrafast Relaxation and Photodissociation Dynamics of 1,3-Butadiene Studied by Probing Molecular Orbitals,** Ayumu Makida[1], Takehisa Fujiwara[1], Yu Harabuchi[2], Tetsuya Taketsugu[2], Taro Sekikawa[1]; [1]*Applied Physics, Hokkaido Univ., Japan;* [2]*Chemistry, Hokkaido Univ., Japan.* Femtosecond relaxation and picosecond photodissociation dynamics of 1,3-butadiene were investigated by time-resolved photoelectron spectroscopy with high harmonics pulses, probing the deeper molecular orbitals which are sensitive to the molecular structure.

**FM2B.8 • 12:15**
**THz streaking of attosecond pulse trains,** Fernando Ardana-Lamas[1,2], Andrey Stepanov[1], Christian Erny[1,2], Ishkhan .gorgisya[1,2], Pavle Juranic[1], Christoph P. Hauri[1,2]; [1]*Paul Scherrer Inst., Switzerland;* [2]*École polytechnique fédérale de Lausanne, Switzerland.* We present the first streaking of an attosecond pulse train using an intense THz field. Streaking with THz enables temporal characterization of the full pulse train in a single shot measurement.

### Executive Ballroom 210C

### FM2C • Optics in Random Media I—Continued

**FM2C.6 • 12:00**
**Transmission channels for light in absorbing random media,** Seng Fatt Liew[1], Sebastien Popoff[1], Allard P. Mosk[2], Willem L. Vos[2], Hui Cao[1]; [1]*Applied Physics, Yale Univ., USA;* [2]*Complex Photonic Systems, MESA+ Inst. for Nanotechnology, Univ. of Twente, Netherlands.* We study numerically the effects of optical absorption on highly transmitting channels in strongly scattering media. We observe that they are robust against weak absorption. Surprisingly, in case of strong absorption diffusive transport becomes ballistic-like.

**FM2C.7 • 12:15**
**Momentum-resolved Electron Energy Loss Spectroscopy (q-EELS) for Quantum Plasmonics and Metamaterials,** Prashant Shekhar[1], Vaibhav Gaind[3], Marek Malac[2,1], Ray Egerton[2,1], Zubin Jacob[1]; [1]*Univ. of Alberta, Canada;* [2]*National Inst. of Nanotechnology, Canada;* [3]*KLA Tencore, USA.* We report on experimental and theoretical results on EELS from 12nm single-crystal gold films. Our results show that momentum resolution of the electrons gives insight into signatures of non-locality and quantum nature of the excitations.

### Executive Ballroom 210D

### FM2D • Graphene and Novel Phenomena—Continued

**FM2D.6 • 12:00**
**Terahertz Induced Transparency in Single-Layer Graphene,** Michael Paul[1], Byounghwak Lee[1], Jenna Wardini[1], Zack Thompson[1], Andrew Stickel[1], Ali Mousavian[1], Ethan Minot[1], Yun-Shik Lee[1]; [1]*Physics, Oregon State Univ., USA.* We demonstrate THz-induced transparency in two types of single-layer CVD graphene samples utilizing high-field THz pulses. The nonlinear THz transmission depends on the local conductivity of the samples and dynamically varies in the time domain.

**FM2D.7 • 12:15**
**Graphene coated ZnO nanowire optical waveguides,** Bigeng Chen[1], Limin Tong[1]; [1]*Dept. of Optical Engineering, State Key Lab of Modern Optical Instrumentation, China.* Using a tape-assist-transfer method and micromanipulation, we have fabricated graphene coated ZnO nanowire (GZN) optical waveguides. The GZNs exhibit significant saturable absorption (differential transmission of 15% at 1064nm), which can be employed for optical modulation.

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**12:30–13:30 Lunch Break** *(on your own)*

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NOTES

## CLEO: Science & Innovations

### Executive Ballroom 210E

### SM2E • Spectroscopic Chemical Detection—Continued

**SM2E.6 • 12:00**
**Phase Locked System for Dual Comb Molecular Spectroscopy at 2-6 µm Based on Tm-fiber Laser,** Viktor O. Smolski[1], Kevin F. Lee[2], Christian Mohr[2], Jie Jiang[2], Ingmar Hartl[3], Martin Fermann[2], Konstantin L. Vodopyanov[1]; [1]*CREOL, Univ. of Central Florida, USA;* [2]*IMRA America, inc, USA;* [3]*Deutsches Elektronen-Synchrotron (DESY), Germany.* We demonstrate phase-coherent, frequency-stabilized dual-comb system at 2µm, extendable to mid-IR via phase-coherent frequency conversion in a doubly-resonant GaAs OPO. Results of dual-comb molecular spectroscopy with ~1M spectral points taken in ~1ms will be presented.

**SM2E.7 • 12:15**
**Tunable Diode Laser Absorption Spectrometer for Detection of Hydrogen Fluoride Gas at Ambient Pressure,** Ian M. Craig[1], Matthew S. Taubman[1], Bruce E. Bernacki[1], Robert D. Stahl[1], John T. Schiffern[1], Tanya L. Myers[1], Bret D. Cannon[1], Mark C. Phillips[1]; [1]*Pacific Northwest National Lab, USA.* We present a tunable diode laser absorption spectrometer (TDLAS) sensor for hydrogen fluoride (HF) detection at ambient pressure operating around the fundamental R(1) transition at 2.476 µm. We achieve 38 ppt sensitivity for 1-s integration time.

### Executive Ballroom 210F

### SM2F • Advanced Solid State Laser Architectures—Continued

**SM2F.7 • 12:00**
**Generation of 300 ps laser pulse with 1.2 J energy at 532 nm by stimulated Brillouin scattering in water,** Chengyong Feng[1], Xiaozhen Xu[1], Jean-Claude M. Diels[1]; [1]*Univ. of New Mexico, USA.* We experimentally demonstrate SBS pulse compression in water from 10 ns, 2.3 J to 300 ps, 1.2 J. To our best knowledge, this is the highest compressible energy that has been achieved at 532 nm.

**SM2F.8 • 12:15**
**A Linear Phase-Conjugation Imaging System,** Seung-Whan Bahk[1], Jake Bromage[1], Jonathan D. Zuegel[1]; [1]*Univ. of Rochester, USA.* An imaging system based on phase conjugation is demonstrated for application in long-working-distance imaging. A liquid crystal device is adaptively controlled using a near-field feedback to achieve the conjugation of the incident phase.

### Executive Ballroom 210G

### SM2G • Silicon Photonic Modulators—Continued

**SM2G.7 • 12:15**
**A Silicon Photonic Chip-Scale AWGR Switch for High Performance Computing Systems,** Runxiang Yu[1], Stanley Cheung[1], Roberto Proietti[1], Yuliang Li[1], Katsunari Okamoto[2], S. J. Ben Yoo[1]; [1]*Univ. of California Davis, USA;* [2]*AiDi Corporation, Japan.* This paper demonstrates a silicon-photonic AWGR-based optical switch for HPC systems. Simulations show high throughput and low latency even at high input load. A fabricated silicon-photonic AWGR switch with 32 Tx/Rx pairs showed error-free performance.

### Executive Ballroom 210H

### SM2H • Novel Approaches for Detection, Sensing and Characterization—Continued

**SM2H.6 • 12:00**
**Ultra-broad Bandwidth Ultrasound Detector Using Imprinted Polymer Microring Resonator,** Cheng Zhang[1], Tao Ling[1], Sung-Liang Chen[1], L. Jay Guo[1]; [1]*Electrical Engineering and Computer Science, Univ. of Michigan, USA.* A novel ultra-broad bandwidth ultrasound detector is demonstrated using imprinted polymer microring, with flat frequency response up to ~350 MHz at -3dB. A record high sub-3µm axial resolution in ultrasound/photoacoustic imaging applications is demonstrated.

**SM2H.7 • 12:15**
**Modeling and Optimization of Magnesiothermically-formed Porous Silicon in Silicon-on-insulator Microresonator Sensors,** Zhixuan Xia[1], Ali A. Eftekhar[1], Qing Li[1], Ali Adibi[1], Stan C. Davis[2], Ari S. Gordin[2], Kenneth H. Sandhage[2]; [1]*School of Electrical and Computer Engineering, Georgia Inst. of Technology, USA;* [2]*School of Materials Science and Engineering, Georgia Inst. of Technology, USA.* We develop a model for silicon-on-insulator microresonators with magnesiothermically-formed porous silicon cladding possessing three-dimensional interconnected pores. Investigation of waveguide design and geometrical parameters indicates an optimized areal mass sensitivity of ~ 0.2 pm/(pg/$mm^2$).

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**12:30–13:30 Lunch Break** *(on your own)*

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NOTES

## CLEO: Science & Innovations

**Meeting Room 211 B/D**

### SM2I • Mode-locked OPOs—Continued

**SM2I.6 • 12:00**
**Pulse-To-Pulse Spectra of a Picosecond Optical Parametric Oscillator Based on Chirped Quasi-Phase Matching,** Delphine Descloux[1], Cédric Laporte[1], Jean-Baptiste Dherbecourt[1], Jean-Michel Melkonian[1], Myriam Raybaut[1], Cyril Drag[2], Antoine Godard[1]; [1]*ONERA - The French Aerospace Lab, France;* [2]*Laboratoire Aimé-Cotton, France.* The pulse-to-pulse evolution of the spectrum emitted by a synchronously-pumped optical parametric oscillator based on chirped quasi-phase matching is measured, enabling to study the spectro-temporal dynamics upon the buildup of the oscillation.

**SM2I.7 • 12:15**
**Yb-Fiber-Laser-Pumped, High-Power, High-repetition-rate Dual-Wavelength Picosecond Optical Parametric Oscillator,** Venkata Ramaiah Badarla[1], Suddapalli Chaitanya Kumar[1], Majid Ebrahim-Zadeh[1,2]; [1]*ICFO -The Inst. of Photonic Sciences, Spain;* [2]*Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain.* We report a stable, high-power, Yb-fiber-pumped, dual-wavelength picosecond OPO at 160 MHz, generating signal-idler wavelength pairs that are independently tunable across near-to-mid-IR, with no coherent coupling even at degeneracy, providing watt-level output power in excellent beam quality.

**Meeting Room 212 A/C**

### SM2J • Nanostructured LEDs and Photovoltaics—Continued

**SM2J.6 • 12:00**
**Solar Cells based on Atomically Thin Crystals,** Marco Mercurio Furchi’[1], Andreas Pospischil[1], Thomas Mueller[1]; [1]*Technische Universität Wien, Austria.* We report photovoltaic energy conversion in atomically thin crystals. We present two device concepts: (i) a lateral p-n junction diode, based on a WSe2 atomic monolayer. (ii) a MoS2/WSe2 van der Waals heterostructure.

**SM2J.7 • 12:15**
**Surface Antireflection Studies of GaN Nanostructures with Various Effective Refractive Index Profiles,** Lu Han[1], Hongping Zhao[1]; [1]*Case Western Reserve Univ., USA.* GaN nanostructures with various effective refractive index profiles were numerically studied as broadband omnidirectional antireflection structures for concentrator photovoltaics, as compared to that of the conventional GaN with flat surface.

## CLEO: QELS-Fundamental Science

**Meeting Room 212 B/D**

### FM2K • Plasmonic Nanoantennas—Continued

**FM2K.7 • 12:00**
**Electron Tunneling and Acceleration at Gold Nanostructures Driven by Ultrashort Mid-Infrared Pulses,** Katharina E. Echternkamp[2], Fumiya Kusa[1], Georg Herink[2], Satoshi Ashihara[1], Claus Ropers[2]; [1]*Applied Physics, Tokyo Univ of Agriculture and Technology, Japan;* [2]*IV. Physikalisches Institut, Univ. of Goettingen, Germany.* Strong-field photoemission from resonant and non-resonant gold nanostructures is studied using ultrashort mid-infrared pulses. The photoelectron yield and kinetic energy spectra are governed by both antenna resonances and optical near-field distributions.

**FM2K.8 • 12:15**
**Detection, Amplification and Control of Free-Electron Nearfields,** Jin-Kyu So[1], Kevin F. MacDonald[1], Nikolay I. Zheludev[1,2]; [1]*Optoelectronics Research Centre & Centre for Photonic Metamaterials, Univ. of Southampton, UK;* [2]*Centre for Disruptive Photonic Technologies, Nanyanag Technological Univ., Singapore.* We use SNOM-like optical fiber tips functionalized with plasmonic and metamaterial nanostructures to detect, amplify and control the near-field of free electrons in the spectral range from 450 to 850 THz.

## CLEO: Applications & Technology

**Marriott Salon I & II**

### AM2L • Innovative Laser Sources Detectors and Beam Delivery—Continued

**AM2L.6 • 12:00** ▶
**Terahertz Detector Based on a p-n Junction Film of Aligned Carbon Nanotubes,** Xiaowei He[1], Naoki Fujimura[2], Kristopher Erickson[3], A. Alec Talin[3], Zhang Qi[1], Weilu Gao[1], Yukio Kawano[2], Robert H Hauge[4], Francois Leonard[3], Junichiro Kono[1,5]; [1]*Electric and computer Engineering, Rice Univ., USA;* [2]*Quantum Nano-electronics Research Center, Dept. of Physical Electronics, Tokyo Inst. of Technology, Japan;* [3]*Sandia Naotional Labs, USA;* [4]*Chemistry, Rice Univ., USA;* [5]*Physics and Astronomy, Materials Science and NanoEngineering, Rice Univ., USA.* We have developed a room temperature, broadband, and polarization-sensitive terahertz detector based on a p-n junction film of highly aligned and ultralong carbon nanotubes. Direct thermoelectric measurements demonstrate the photothermoelectirc nature of the detection mechanism.

**AM2L.7 • 12:15** ▶
**Free-running Single Photon Detector Based on an InGaAs Negative Feedback Avalanche Photodiode with an Extremely Low Dark Count Rate,** Boris A. Korzh[1], Matthieu Legre[2], Nino Walenta[3], Tommaso Lunghi[1], Hugo Zbinden[1], Bruno Sanguinetti[1]; [1]*Univ. of Geneva, Switzerland;* [2]*ID Quantique, Switzerland;* [3]*Battelle UK, Switzerland.* We demonstrate high performance operation of a single photon detection module based on an InGaAs avalanche photodiode in free-running mode. A dark count rate of 1 cps is measured for an efficiency value of 10%.

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**12:30–13:30 Lunch Break** *(on your own)*

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## CLEO: Science & Innovations

### Marriott
### Salon III

### SM2M • Novel Platforms for Silicon Photonics—Continued

**SM2M.4 • 12:00**
**Integrated Crystalline Silicon and Silicon Nitride Photonic Devices on Plastic Substrates,** Yu Chen[1], Mo Li[1]; [1]*Univ. of Minnesota Twin Cities, USA.* Fully integrated photonic devices based on single-crystal silicon and silicon nitride including ring resonators and grating couplers have been successfully transferred to flexible plastic substrate with one hundred percent yield and uncompromised performance.

**SM2M.5 • 12:15**
**Wideband Electromagnetic Wave Sensing Using Electro-optic Polymer Infiltrated Silicon Slot Photonic Crystal Waveguide,** Xingyu Zhang[1], Amir Hosseini[2], Harish Subbaraman[2], Shiyi Wang[3], Qiwen Zhan[3], Jongdong Luo[4], Alex K. Jen[4], Ray Chen[1,2]; [1]*Dept. of Electrical and Computer Engineering, Univ. of Texas at Austin, USA;* [2]*Omega Optics, Inc., USA;* [3]*Dept. of Electrical and Computer Engineering, Univ. of Dayton, USA;* [4]*Dept. of Materials Science and Engineering, Univ. of Washington, USA.* We demonstrate an integrated photonic electromagnetic field sensor based on an electro-optic polymer refilled slot photonic crystal waveguide modulator driven by a bowtie-antenna. The minimum detectable electric field is measured to be 2.5V/m at 8.4GHz.

### Marriott
### Salon IV

### SM2N • Modes in Fibers—Continued

**SM2N.6 • 12:00**
**High numerical aperture imaging by using multimode fibers with micro-fabricated optics,** Silvio Bianchi[1], Vijayakumar P. Rajamanickam[2], Lorenzo Ferrara[2], Enzo Mario Di Fabrizio[3,4], Roberto Di Leonardo[1,5], Carlo Liberale[2]; [1]*Dipartimento di Fisica, Universita` di Roma Sapienza, Italy;* [2]*Nanostructures, Istituto Italiano di Tecnologia, Italy;* [3]*PSE and BESE divisions, King Abdullah Univ. of Science and Technology (KAUST), Saudi Arabia;* [4]*Dipartimento di Medicina Sperimentale e Clinica, Universita` Magna Graecia di Catanzaro, Italy;* [5]*PCF UOS Roma, National Research Council of Italy, Italy.* Controlling light propagation into multimode optical fibers through spatial light modulators provides highly miniaturized endoscopes and optical micromanipulation probes. We increase the numerical aperture up to nearly 1 by micro-optics fabricated on the fiber-end.

**SM2N.7 • 12:15**
**High Temperature Sensor based on Supermode Interference in Multicore Fiber,** Amy Van Newkirk[1], Zeinab Sanjabi Eznaveh[1], Enrique Antonio-Lopez[1], Guillermo Salceda-Delgado[1], Axel Schulzgen[1], Rodrigo Amezcua-Correa[1]; [1]*CREOL, the College of Optics and Photonics, Univ. of Central Florida, USA.* A high temperature fiber optic sensor based on multicore fiber is presented. Experimental results show the sensor operating stably at temperatures up to 1000°C with the capability to multiplex sensors in a single chain.

## CLEO: Applications & Technology

### Marriott
### Salon V & VI

### AM2O • Endoscopy & Minimally Invasive Optical Imaging—Continued

**AM2O.5 • 12:00**
**Simultaneous Fingerprint and High-Wavenumber Confocal Raman Spectroscopy Enables Real-time In Vivo Diagnosis of Colonic Cancer at Endoscopy,** Zhiwei Huang[1]; [1]*Biomedical Engineering, National Univ. of Singapore, Singapore.* We report the implementation of a novel simultaneous fingerprint and high wavenumber confocal Raman technique developed for enhancing real-time in vivo diagnosis of colonic cancer during colonoscopic examination.

**AM2O.6 • 12:15**
**In-Vivo Urodynamic Pressure Measurement with Fiber-Optic EFPI Pressure Probes,** Sven Poeggel[1], Daniele Tosi[1], Ferdinando Fusco[2], Vincenzo Mirone[2], Simone Sannino[2], Laura Lupoli[2], Juliet Ippolito[2], Gabriel Leen[1], Elfed Lewis[1]; [1]*Optical Fibre Sensors Research Centre, Univ. of Limerick, Ireland;* [2]*Urologic Clinic, Federico II Univ. of Naples, Italy.* Urodynamic analysis carried out with biocompatible catheterized fiber-optic probes, for dual measurement of pressure in bladder and in rectum, is presented. Medical tests have been performed in-vivo on seven patients; main highlights are reported.

### Marriott
### Willow Glen I-III

### AM2P • Symposium on Advances in Molecular Imaging II—Continued

**AM2P.5 • 12:00** Invited
**Molecular Imaging for Early Cancer Diagnosis, Surgery and Therapy,** Quyen Nguyen[1]; [1]*UC San Diego Health System, USA.* This presentation will provide an overview of surgical molecular navigation using fluorescence imaging to visualize key normal structures and diseased tissue in real time.

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**12:30–13:30 Lunch Break** *(on your own)*

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## CLEO: QELS-Fundamental Science

### Executive Ballroom 210A

**13:30–15:30**
**FM3A • Quantum Detection**
*Presider: Sae Woo Nam; NIST, USA*

**FM3A.1 • 13:30**
**An Improved Method for Photon-Number Discrimination for Transition-Edge Sensors,** Boris L. Glebov[1], Jingyun Fan[1], Alan L. Migdall[1], Adriana Lita[1], Sae Woo Nam[1], Thomas Gerrits[1]; [1]*NIST, USA.* Proposed discrimination of photon numbers is based on sum-squared error between detector response curve and a calibration suite of response templates. Templates for higher numbers are extrapolated from fits describing incremental differences between low-number templates.

**FM3A.2 • 13:45**
**GHz gated single-photon detection based on harmonic spectral balancing techniques,** Yan Liang[1], Haibin Du[1], Heping Zeng[1,2]; [1]*State Key Lab of Precision Spectroscopy, East China Normal Univ., China;* [2]*Shanghai Key Lab of Modern Optical System, Engineering Research Center of Optical Instrument and System, Ministry of Education, School of Optical-Electrical and Computer Engineering, Univ. of Shanghai for Science and Technology, China.* We demonstrated GHz-gated InGaAs/InP single-photon detection with ultrashort pulses using harmonic spectral differencing, attaining avalanche signals by subtracting spike noise from mimic signals composed of sinusoidal waves of multi-frequencies and reducing the error counts robustly.

**FM3A.3 • 14:00**
**Asymmetric Multi-Quantum Well Infrared Photodetector with a Bound State in the Continuum,** Germano Maioli Penello[1], Arvind Pawan Ravikumar[1], Deborah L. Sivco[1], Claire F. Gmachl[1]; [1]*Electrical Engineering, Princeton Univ., USA.* By carefully designing a multi-quantum well infrared photodetector (QWIP) heterostructure, we present an asymmetric QWIP with a localized state in the continuum. A narrow photocurrent spectrum confirms the electron confinement above the barrier.

### Executive Ballroom 210B

**13:30–15:30**
**FM3B • Quantum Fluids and Gases in Solids**
*Presider: Junichiro Kono; Rice Univ., USA*

**FM3B.1 • 13:30** Tutorial
**Quantum fluids of light,** Cristiano Ciuti[1]; [1]*Université Paris Diderot, France.* This tutorial reviews recent advances in the fundamental understanding and active control of quantum fluids of light in nonlinear optical media. Perspectives in the direction of strongly correlated photon systems are outlined.

Cristiano Ciuti graduated from Scuola Normale Superiore, Pisa in 1997 and received his PhD at EPFL, Lausanne in 2001. After a postdoc at the University of California, San Diego, in 2003 he became a lecturer at Ecole Normale Supérieure, Paris. Since 2006 he has been a professor at Université Paris Diderot.

### Executive Ballroom 210C

**13:30–15:30**
**FM3C • Optics in Random Media II**
*Presider: Azriel Genack; CUNY Queens College, USA*

**FM3C.1 • 13:30** Invited
**Coherent Control of Total Transmission of Light through Disordered Media,** Sebastien Popoff[1], Seng Fatt Liew[1], Arthur Goetschy[1], A. Douglas Stone[1], Hui Cao[1,2]; [1]*Applied Physics, Yale Univ., USA;* [2]*Physics, Yale Univ., USA.* We used wavefront shaping to enhance/suppress the transmission of coherent light through open highly scattering media. The total transmission was varied by one order of magnitude as a result of mesoscopic correlations of coherent transport.

**FM3C.2 • 14:00**
**Enhanced evanescent transport and Goos-Hanchen localization in a disordered dielectric multilayer,** Hanan Herzig Sheinfux[1], Mordechai Segev[1]; [1]*Technion Israel Inst. of Technology, Israel.* We show that disorder in dielectric structures made of multiple layers of deep subwavelength thickness can induce extremely short-ranged localization. Additionally the disorder can convert evanescent waves into bulk localized modes, enhancing transport dramatically (*10,000).

### Executive Ballroom 210D

**13:30–15:30**
**FM3D • Nonconventional Beams and Applications**
*Presider: Dragomir Neshev; Australian National Univ., Australia*

**FM3D.1 • 13:30**
**Diffraction-resisting Vortex Bessel beams with arbitrary trajectories,** Ioannis D. Chremmos[1,2], Juanying Zhao[3], Demetrios N. Christodoulides[4], Zhigang Chen[3,5], Nikolaos K. Efremidis[1]; [1]*Dept. of Mathematics and Applied Mathematics, Univ. of Crete, Greece;* [2]*Max Planck Inst. for the Science of Light, Germany;* [3]*Dept. of Physics and Astronomy, San Francisco State Univ., USA;* [4]*CREOL/College of Optics, Univ. of Central Florida, USA;* [5]*Teda Applied Physics Inst., Nankai Univ., China.* We theoretically show that it is possible to generate diffraction-resisting higher order Bessel beams with vortex profiles that follow arbitrary trajectories. Our theoretical results are supported by numerical simulations and agree well with experimental observations.

**FM3D.2 • 13:45**
**Temporal tweezing of light,** Jae K. Jang[1], Miro J. Erkintalo[1], Stuart G. Murdoch[1], Stephane Coen[1]; [1]*Univ. of Auckland, New Zealand.* We experimentally demonstrate temporal tweezing of picosecond optical pulses, extending the concept of optical tweezers to the time-domain. By adjusting the phase profile of the driving beam, we can trap and manipulate temporal cavity solitons.

**FM3D.3 • 14:00**
**Spiral Phase Matching,** Thomas Roger[1], Julius Heitz[1], Joesph Lowney[2], Ewan M. Wright[2], Daniele Faccio[1]; [1]*Inst. of Photonics and Quantum Sciences, Heriot-Watt Univ., UK;* [2]*College of Optical Sciences, Univ. of Arizona, USA.* We study the nonlinear interaction between two non-collinear light beams that carry orbital angular momentum (OAM). Theory and experiments highlight the presence of new phase matching conditions in the presence of OAM.

## CLEO: Science & Innovations

### Executive Ballroom 210E

13:30–15:15

### SM3E • Nano-, Micro-, and Waveguide-sensing

*Presider: Yosuke Tanaka; Tokyo Univ of Agriculture and Technology, Japan*

**SM3E.1 • 13:30**

**Mid-infrared Noninvasive in vivo Glucose Detection in Healthy Human Subjects,** Sabbir Liakat[1], Kevin A. Bors[1], Laura Xu[1], Callie M. Woods[1], Jessica Doyle[2,1], Claire F. Gmachl[1]; *[1]Princeton Univ., USA; [2]Hunterdon Regional Central High School, USA.* A novel hollow-core fiber based mid-infrared noninvasive in vivo sensor, capable of clinically accurate predictions of glucose concentrations ranging from 80 - 160 mg/dL in healthy humans, is presented.

**SM3E.2 • 13:45**

**Improved Signal Processing for Distributed Sensing Network based on Chirped Laser Dispersion Spectroscopy,** Genevieve Plant[1], Yue Tian[1,2], Ting Wang[2], Gerard Wysocki[1]; *[1]Princeton Univ., USA; [2]NEC Labs America, USA.* Centralized detection in a network of Chirped Laser Dispersion Spectroscopy (CLaDS) sensors requires efficient signal processing. The optimization of CLaDS processing and development of a custom digital signal processing unit in place of restricting conventional bench-top instruments is discussed.

**SM3E.3 • 14:00**

**A novel method to acquire ring-down interferograms using a double-looped mach-zehnder interferometer,** Jin Hwan Kim[1], Won Sik Kwon[1], Hyub Lee[1], Kyung-Soo Kim[1], Soohyun Kim[1]; *[1]Division of Mechanical Engineering, Korea Advanced Inst. of Science and Technology, Korea.* We present a novel, simple and cost-effective method to acquire ring-down interferograms based on a double-looped mach-zehnder interferometer requiring only a few millimeters of scanning range. Internal loss characterization of two loops is demonstrated.

### Executive Ballroom 210F

13:30–15:30

### SM3F • Advanced Laser Materials

*Presider: Martin Richardson, Univ. of Central Florida, CREOL, USA*

**SM3F.1 • 13:30**

**The role played on the Yb:LuAG laser performance by high doping levels and high ion excitation density,** Angela Pirri[1], Guido Toci[2], Martin Nikl[3], Vladimir Babin[3], Matteo Vannini[2]; *[1]Istituto di Fisica Applicata "Nello Carrara", IFAC, National Research Council, CNR, Italy; [2]Istituto Nazionale di Ottica, INO, National Research Council, CNR, Italy; [3]Inst. of Physics, Academy of Sciences, Czech Republic.* We present the laser performance achieved by 15 at.% Yb:LuAG crystal. Experimental evidences of a non-linear loss mechanism which occurs at high ion excitation density is observed and characterized.

**SM3F.2 • 13:45**

**Spectroscopic Properties and Laser Operation of Sm,Mg:SrAl$_{12}$O$_{19}$,** Daniel-Timo Marzahl[1], Fabian Reichert[1], Benedikt Stumpf[1], Philip W. Metz[1], Christian Kraenkel[1,2], Günter Huber[1,2]; *[1]Inst. of Laser-Physics, Germany; [2]The Hamburg Centre for Ultrafast Imaging, Germany.* We realized the first visible Sm$^{3+}$-doped oxide laser. In Sm(6.7at.\%):SrAl$_{12}$O$_{19}$ 28mW of self-pulsed average output power at 703.0nm were achieved with 8% slope efficiency under 2ω-OPSL-pumping at 479.6nm. Furthermore, detailed spectroscopic investigations were performed.

**SM3F.3 • 14:00**

**anti-B18H22: A brand-new laser material,** Luis Cerdán[1], Jakub Braborec[2], Inmaculada Garcia-Moreno[1], Angel Costela[1], Michael G. S. Londesborough[2]; *[1]Inst. of Physical Chemistry (CSIC), Spain; [2]Inst. of Inorganic Chemistry (AS-CR), Czech Republic.* The first laser borane, anti-B18H22, exhibits blue laser emission at 406nm with an efficiency of 9.5 % and a photostability superior to that of commercial laser dyes, providing a new solution to an old problem.

### Executive Ballroom 210G

13:30–15:30

### SM3G • Micro-Resonators

*Presider: Hideki Yagi; Sumitomo Electric Industries Ltd, Japan*

**SM3G.1 • 13:30** Invited

**Breaking the Conventional Limitations of Microrings,** Joyce K. Poon[1], Wesley D. Sacher[1], Jared C. Mikkelsen[1], Solomon Assefa[2], Douglas M. Gill[2], Tymon Barwicz[2], Huapu Pan[2], Steven M. Shank[3], Yurii Vlasov[2], William M. Green[2]; *[1]Electrical and Computer Engineering, Univ. of Toronto, Canada; [2]IBM T. J. Watson Research Center, USA; [3]Microelectronics Division, IBM Systems Technology Group, USA.* We demonstrate microring resonators with full tunability, modulation bandwidths exceeding the linewidth limit, and improved tolerance to wafer-scale variations. Novel device architectures and designs enable microrings to become more practical for integrated photonics.

**SM3G.2 • 14:00**

**Wideband-Tunable Optical Resonators on Double-Layer SOI Platforms using Electrostatic Actuation,** Razi Dehghannasiri[1], Ali Asghar Eftekhar[1], Majid Sodagar[1], Ali Adibi[1]; *[1]School of Electrical and Computer Engineering, Georgia Inst. of Technology, USA.* We present mechanically-tunable microdisk resonators using electrostatic actuation in double-layer-SOI material platform. The possibility of achieving resonance wavelength shifts as-high-as 5.5 nm/volt and 1.35 nm/nm over a wavelength tuning range of 35 nm is demonstrated.

### Executive Ballroom 210H

13:30–15:30

### SM3H • 2D and Other Novel Materials

*Presider: Jacob Khurgin; Johns Hopkins Univ., USA*

**SM3H.1 • 13:30**

**Adaptive Photonic Meta-surfaces Exploiting Interfacial Phase Change in Elemental Gallium,** Robin F. Waters[1], Kevin F. MacDonald[1], Peter A. Hobson[2], Nikolay I. Zheludev[1,3]; *[1]Optoelectronics Research Centre & Centre for Photonic Metamaterials, Univ. of Southampton, UK; [2]QinetiQ Ltd., UK; [3]Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore.* Surface-driven metallization in a nanoscale layer of elemental gallium forming the backplane of a photonic metamaterial absorber provides a mechanism for reversible all-optical and thermo-optical tuning of resonant response.

**SM3H.2 • 13:45**

**Extracting the complex optical conductivity of true two-dimensional layers by ellipsometry,** You-Chia Chang[1,2], Chang-Hua Liu[3], Zhaohui Zhong[3], Theodore Norris[1,3]; *[1]Center for Ultrafast Optical Science, Univ. of Michigan, USA; [2]Applied Physics Program, Univ. of Michigan, USA; [3]Dept. of Electrical Engineering and Computer Science, Univ. of Michigan, USA.* A simple and robust technique to extract the complex optical conductivity of truly two-dimensional materials is developed. Applying the method to chemical-vapor-deposited graphene, we extract the complex conductivity, including Fermi level and scattering time.

**SM3H.3 • 14:00**

**Graphene Stacks as the Darkest Material},** Kevin J. Webb[1], Sunny Chugh[1], Mengren Man[1], Zhihong Chen[1]; *[1]Purdue Univ., USA.* We present the fabrication and characterization of a graphene stack that can function as the darkest material and serve as the basis for a new class of sensitive, high-speed photodetectors.

## Meeting Room
## 211 B/D

## CLEO: Science & Innovations

**13:30–15:30**
**SM3I • Few-Cycle-Pulse Nonlinear Optical Technologies**
*Presider: Jeffrey Moses; MIT, USA*

**SM3I.1 • 13:30** Invited
**Sources and Diagnostics for Attosecond Science,** Cord L. Arnold[1], Christoph Heyl[1], Samuel Bengtsson[1], Johan Mauritsson[1], Per Johnsson[1], Anne L'Huillier[1]; *[1]Dept. of Physics, Lund Univ., Sweden.* We present a novel scheme to generate trains of angularly separated single attosecond pulses by driving high-order harmonic generation with two identical, but temporally delayed, laser pulses, which are noncollinearly overlapped in the generation medium.

**SM3I.2 • 14:00**
**High Gain Frequency domain Optical Parametric Amplifier (FOPA) preserves ps Pulse Contrast,** Philippe Lassonde[1], Maxime Boivin[1], Ladan Arissian[2], Légaré Légaré[1], Bruno E. Schmidt[1,3]; *[1]Institut National de la Recherche Sci., Canada; [2]Electrical and Computer Engineering, Univ. of New Mexico, USA; [3]few-cycle Inc., Canada.* 800nm, nJ level pulses are amplified >2.000 times in a single 2mm BBO crystal, pumped by picosecond 400nm pulses. Experiments evidence that the picosecond pulse contrast within the pump window remains unchanged upon amplification.

## Meeting Room
## 212 A/C

**13:30–15:30**
**SM3J • Spatial Multiplexing**
*Presider: David Caplan; MIT Lincoln Lab, USA*

**SM3J.1 • 13:30**
**Experimental Demonstration of an Apodized Aperture for Receiving a Data-Carrying Orbital-Angular-Momentum Beam,** Nisar Ahmed[1], Guodong Xie[1], Yongxiong Ren[1], Long Li[1], Hao Huang[1], Yan Yan[1], Alan Willner[1]; *[1]Univ. of Southern California, USA.* We experimentally demonstrate an apodized aperture for receiving OAM beams carrying 50-Gbaud QPSK channels. The performance in terms of power in desired mode and leakage to neighboring modes is compared with a hard aperture.

**SM3J.2 • 13:45**
**Experimental Comparison of Single and Double Partial Receiver Apertures for Recovering Signals Transmitted using Orbital-Angular-Momentum,** Guodong Xie[1], Yongxiong Ren[1], Hao Huang[1], Nisar Ahmed[1], Long Li[1], Yan Yan[1], Martin P. Lavery[2], Miles Padgett[2], Moshe Tur[3], Samuel Dolinar[4], Alan Willner[1]; *[1]Dept. of Electrical Engineering, Univ. of Southern California, USA; [2]School of Physics and Astronomy, Univ. of Glasgow, UK; [3]School of Electrical Engineering, Tel Aviv Univ., Israel; [4]Jet Propulsion Lab, California Inst. of Technology, USA.* We compared power spreading of a partially captured orbital-angular-momentum (OAM) beam by using single and double apertures. Double apertures could help reducing crosstalk from OAM l to OAM l+m by ~10 dB, where l is an integer and m is an odd number.

**SM3J.3 • 14:00**
**Evaluation of channel capacity of the OAM-based FSO links with a precise assessment of turbulence impact,** Ming Li[1,2], Milorad Cvijetic[1], Yuzuru Takashima[1], Zhongyuan Yu[2]; *[1]College of Optical Sciences, Univ. of Arizona, USA; [2]State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China.* The channel capacity of FSO links based on modulation of inconsecutive OAM-modes is evaluated by using modified Von Karman model. The results show significant reduces in crosstalk with channel capacity converging to an ideal case.

## Meeting Room
## 212 B/D

## CLEO: QELS-Fundamental Science

**13:30–15:30**
**FM3K • Plasmonic Biochemical Sensors and Systems**
*Presider: Hatice Altug; Boston Univ., USA*

**FM3K.1 • 13:30** Invited
**Plasmonic Biosensors and Their Analytical Applications,** Jiri Homola[1]; *[1]Inst. of Photonics and Electronics, Czech Republic.* Advances in the field of optical biosensors based on surface plasmons are reviewed and examples of applications of plasmonic biosensors for detection of chemical and biological substances are given.

**FM3K.2 • 14:00**
**Hand-Held Plasmonic Biosensor for High-Throughput Sensing for Point-of-Care Applications,** Arif E. Cetin[1,2], Ahmet F. Coskun[3,4], Betty C. Galarreta[1], Min Huang[1], David Herman[3], Aydogan Ozcan[3,5], Hatice Altug[2,1]; *[1]Electrical and Computer Engineering, Boston Univ., USA; [2]Bioengineering Dept., EPFL, Switzerland; [3]Electrical Engineering, UCLA, USA; [4]Chemistry and Chemical Engineering, California Inst. of Technology, USA; [5]California NanoSystems Inst., UCLA, USA.* We introduce a hand-held biosensor based on large-area plasmonic microarrays coupled with a lens-free computational imaging system for high-throughput biosensing. Our light-weight device, 60 g and 7.5 cm, is highly suitable for point-of-care applications for field-settings.

## Marriott
## Salon I & II

## CLEO: Applications & Technology

**13:30–15:30**
**AM3L • Symposium on Enabling Photonics Technologies for Miniaturization I** ▶
*Presider: Saulius Juodkazis; Swinburne Univ. of Technology, Australia*

**AM3L.1 • 13:30** Invited ▶
**Mapping (slow) Light at the Nanoscale - Don't Forget the Magnetic Field,** L (Kobus) Kuipers[1]; *[1]FOM Inst. AMOLF, Netherlands.* We present local investigations of the spectral evolution of ultrashort slow pulses as they propagate. We also show that nanoscale electrical and magnetic fields can be detected simultaneously.

**AM3L.2 • 14:00** Invited ▶
**Management of the photon orbital angular momentum at small scale,** Etienne Brasselet[1]; *[1]Univ. of Bordeaux, CNRS, France.* The elaboration of photonic devices enabling the control of the optical orbital angular momentum at small spatial scales remains a contemporary challenge that needs to be addressed. We will discuss recent progresses in that direction.

## CLEO: Science & Innovations

### Marriott
### Salon III

**13:30–15:30**
**SM3M • Nanophotonic Structures for Quantum Optics ▶**
*Presider: Kartik Srinivasan; NIST, USA*

**SM3M.1 • 13:30** Invited ▶
**Nonlinear optics and quantum networks based on single atoms coupled to a photonic crystal cavity,** Mikhail Lukin[1], Jeff Thompson[1], Tobias Tiecke[1], Vladan Vuletic[1], Nathalie de Leon[1], Lee Liu[1]; [1]*Harvard Univ., USA.* We present an experimental demonstration of an optical switch operating in the quantum regime, consisting of a single trapped atom near a nanoscale photonic crystal cavity.

**SM3M.2 • 14:00** ▶
**Composite Photonic Crystal Cavity on a Nanofiber,** Mark Sadgrove[1], Ramachandrarao Yalla[1], Kali P. Nayak[1], Kohzo Hakuta[1]; [1]*Center for Photonic Innovations, Univ. of Electro-communications, Japan.* We realize a photonic crystal cavity by mounting an optical nanofiber on a nanostructured grating which includes a designed defect. The device has a Q-factor of ~1000 and excellent coupling to the nanofiber fundamental mode.

### Marriott
### Salon IV

**13:30–15:30**
**SM3N • Gas-Filled Hollow Fibers**
*Presider: Poul Kristensen; OFS Fitel Denmark I/S, Denmark*

**SM3N.1 • 13:30** Invited
**Tunable sources from the visible to vacuum-UV based on gas-filled hollow-core photonic crystal fibers,** John C. Travers[1], Ka Fai Mak[1], Alexey Ermolov[1], Francesco Tani[1], Philipp Hoelzer[1], Nicolas Joly[2,1], Philip St.J. Russell[1,2]; [1]*Russell Division, Max Planck Inst. for the Science of Light, Germany;* [2]*Dept. of Physics, Univ. of Erlangen-Nuremberg, Germany.* High-energy, single-mode, coherent, ultrafast pulses of light - tunable from the vacuum-UV to the visible spectral region - can be generated in gas-filled hollow-core photonic-crystal fibers through a simple experimental scheme.

**SM3N.2 • 14:00**
**Generation of Raman comb over two octaves with picosecond pulse laser in hydrogen-filled Kagome HC-PCF,** Aurélien Benoit[1,2], Benoit Beaudou[3], Meeshal Alharbi[1], Benoît Debord[1], Frederic Gerome[1,3], François Salin[2], Fetah Benabid[1,3]; [1]*GPPMM Group, Xlim Research Inst. UMR CNRS/Univ. of Limoges n°7252, France;* [2]*Eolite Systems, France;* [3]*Glophotonics, France.* We report on 33 W picosecond pulse laser pumped Raman comb generation with fifty spectral lines over two frequency octaves from the visible to the near infrared range obtained in hydrogen-filled hypocycloid-core Kagome HC-PCF.

### Marriott
### Salon V & VI

**13:30–15:30**
**SM3O • Symposium on Large-Scale Silicon Photonic Integration I ▶**
*Presider: Xuezhe Zheng, Oracle Corp., USA*

**SM3O.1 • 13:30** Invited ▶
**Ge-on-Si Integrated Photonics,** Jifeng Liu[1]; [1]*Thayer School of Engineering, Dartmouth College, USA.* We present the latest progress in epitaxial Ge-on-Si lasers, electroabsorption modulators, and photodetectors for integrated photonics. We also discuss an emerging monolithic 3D photonic integration scheme based on high crystallinity GeSn directly grown on SiO2.

**SM3O.2 • 14:00** Invited
**Heterogeneous Integration on Silicon,** Alexander Fang[1], Brian R. Koch[1], Erik J. Norberg[1], Jonathon Roth[1], Byungchae Kim[1], Anand Ramaswamy[1], John Hutchinson[1], Jae-Hyuk Shin[1], Gregory Fish[1]; [1]*Aurrion, Inc., USA.* Aurrion's heterogeneous integration process enables high performance active components such as lasers, modulators, and photodetectors to be elegantly integrated on a silicon photonics platform with high performance passive components.

### Marriott
### Willow Glen I-III

**13:30–15:30**
**SM3P • Bioimaging I ▶**
*Presider: Audrey Ellerbee; Stanford Univ., USA*

**SM3P.1 • 13:30** ▶
**Three-Dimensional Cell Culture on Microscaffolds with Spatially Resolved Surface Chemistry,** Benjamin Richter[1], Thomas Pauloehrl[2], Johannes Kaschke[3], Joachim Fischer[3], Alexandra M. Greiner[1], Martin Wegener[3], Guillaume Delaittre[2,4], Christopher Barner-Kowollik[2], Martin Bastmeyer[1]; [1]*Cell- and Neurobiology, Karlsruhe Inst. of Technology, Germany;* [2]*Preparative Macromolecular Chemistry, Karlsruhe Inst. of Technology, Germany;* [3]*Inst. of Applied Physics, Karlsruhe Inst. of Technology, Germany;* [4]*Inst. for Toxicology and Genetics, Karlsruhe Inst. of Technology, Germany.* To spatially control protein-binding and cell-attachment in three dimensions (3D) we employ a two-photon-triggered cycloaddition of functional (e.g. biotinylated) dienophiles on the surface of 3D microscaffolds, which have been silanized with photoactivatable diens (photoenol).

**SM3P.2 • 13:45**
**Microfluidic Flow Cytometer for Multiparameter Screening of Fluorophore Photophysics,** Kevin M. Dean[1], Lloyd M. Davis[2], Jennifer L. Lubbeck[3], Premashis Manna[3], Amy E. Palmer[1], Ralph Jimenez[3]; [1]*BioFrontiers Inst., Univ. of Colorado at Boulder, USA;* [2]*Dept. of Physics and Center for Laser Applications, Univ. of Tennessee Space Inst., USA;* [3]*JILA, NIST and Univ. of Colorado, USA.* We present a microfluidic cytometer that sorts mammalian or yeast cells by laser force deflection following real-time multibeam, multiparameter fluorescence measurements, including photobleaching, lifetime and expression level, of the intrinsic fluorophores within each cell.

**SM3P.3 • 14:00** ▶
**Hyperspectral Stimulated Raman Microscopy with Fiber-based, Rapidly Wavelength Swept cw-Lasers,** Sebastian Karpf[1], Matthias Eibl[1], Thomas Klein[1], Wolfgang Wieser[1], Robert Huber[2,1]; [1]*LMU Munich, Germany;* [2]*BMO Luebeck, Germany.* A hyperspectral stimulated Raman microscopy system using rapidly wavelength swept lasers is presented. Imaging of biological samples with shot noise limited detection is demonstrated with the fiber based setup.

**Executive Ballroom 210A** | **Executive Ballroom 210B** | **Executive Ballroom 210C** | **Executive Ballroom 210D**

## CLEO: QELS-Fundamental Science

### FM3A • Quantum Detection—Continued

**FM3A.4 • 14:15**
**A New Picture of Inhomogeneities in Nanowire Superconducting Single Photon Detectors,** Rosalinda Gaudio[1], Koen op 't Hoog[1], Zili Zhou[1], Dondu Sahin[1], Andrea Fiore[1]; [1]*COBRA Research Inst., Netherlands.* We introduced, characterized and modeled a simple nanodetector to investigate the efficiency and yield limitations of NbN superconducting single photon detectors. These crucial issues are related to the detectors strongly inhomogeneous nature at the nanoscale.

**FM3A.5 • 14:30**
**Experimental realization of a photon-number-resolving homodyne detector,** Duan Huang[1], Erhu Han[1], Weiqi Liu[1], Dakai Lin[1], Chao Wang[1], Peng Huang[1], Guihua Zeng[1]; [1]*State Key Lab of Advanced Optical Communication Systems and Networks, Dept. of Electronic Engineering Shanghai Jiao Tong Univ., State Key Lab of Advanced Optical Communication Systems and Networks,Shanghai Jiaotong Univ., China.* We demonstrate a photon-number-resolving homodyne detector based on InGaAs PIN photodiodes with active phase compensation. Our detector preserves the capable of detecting single photon and allows 20 photons to be precisely discriminated.

**FM3A.6 • 14:45**
**QPSK Receiver outperforming the Standard Quantum Limit for any Signal Power,** Christian R. Müller[1,2], Gerd Leuchs[1,2], Christoph Marquardt[1,2]; [1]*Max Planck Inst. for the Science of Light, Germany;* [2]*Dept. of Physics, Univ. of Erlangen-Nuremberg, Germany.* We present a quantum receiver for the discrimination of quadrature phase-shift keyed signals that approaches the Helstrom bound for any signal power. The discrimination is performed via adaptive displacements prior to a single photon detector.

### FM3B • Quantum Fluids and Gases in Solids—Continued

**FM3B.2 • 14:30**
**Quantum Electron-Hole Droplets in GaAs Quantum Wells,** Andrew E. Hunter[1,2], Hebin Li[1], Steven T. Cundiff[1,2], Martin Mootz[3], Mackillo Kira[3], Stephan W. Koch[3]; [1]*JILA, Univ. of Colorado, USA;* [2]*Physics, Univ. of Colorado, Boulder, USA;* [3]*Physics, Philipps-Univ. Marburg, Germany.* We present evidence from transient-absorption spectra for quantum electron-hole droplets in GaAs quantum wells. Quantum droplets have a two-particle correlation function characteristic of a liquid, but, unlike macroscopic droplets, have quantized binding energy.

**FM3B.3 • 14:45**
**Build-up dynamics of degenerate excitons luminescence at sub-K temperature in a trap in cuprous oxide,** Hirosuke Suzuki[1], Yusuke Morita[1], Kosuke Yoshioka[1], Makoto Kuwata-Gonokami[1,2]; [1]*Physics, The Univ. of Tokyo, Japan;* [2]*Photon Science Center, The Univ. of Tokyo, Japan.* We demonstrate time- and space- resolved luminescence measurements of quantum degenerate paraexcitons in cuprous oxide. We report dynamics of ultracold excitons such as the drift in a trap potential, cooling process, and lifetime of exctions.

### FM3C • Optics in Random Media II—Continued

**FM3C.3 • 14:15**
**Photon transport and localization in optical superlattices,** PIN-CHUN HSIEH[1], Chung-Jen Chung[2], James F. McMillan[1], Ming Lu[3], Nicolae Panoiu[4], Chee Wei Wong[1]; [1]*Mechanical Engineering, Columbia Univ., USA;* [2]*Center for Micor/Nano Science and Technology, National Cheng Kung Univ., Taiwan;* [3]*Center for Functional Nanomaterials, Brookhaven National Lab, USA;* [4]*Dept. of Electronic and Electrical Engineering, Univ. College London, UK.* Here we examine the photon transport and collimation in optical superlattices, involving transverse guided resonances and disorder-induced localization. With increasing structural disorder, we observe the crossover from cascaded guided resonances into transverse localization modes.

**FM3C.4 • 14:30**
**Effective temperature of optically-controlled active media,** Colin Constant[1], Sergey Sukhov[1], Aristide Dogariu[1]; [1]*Univ. of Central Florida, CREOL, USA.* The interaction between light and matter allows for selective excitation into nonequilibrium states. Using spatially and temporally-varying potentials in active colloidal systems we demonstrate control of diffusion and effective temperatures for particles at thermodynamic equilibrium.

**FM3C.5 • 14:45**
**Active control of the emission of a 2D optofluidic random laser,** nicolas bachelard[1], Xavier Noblin[2], Patrick Sebbah[1]; [1]*Institut Langevin, CNRS, France;* [2]*LPMC, CNRS, France.* We present an optofluidic 2D random laser where multiple scattering replaces the optical cavity. Spatial emission, which is isotropic for uniform transverse optical pumping, is forced in any given direction by iteratively shaping the optical pump profile.

### FM3D • Nonconventional Beams and Applications—Continued

**FM3D.4 • 14:15**
**Non-Paraxial Acceleration and Rotation in Curved Surfaces,** Rivka Bekenstein[1], Yonatan Sharabi[1], Jonathan Nemirovsky[1], Ido Kaminer[1], Tal Carmon[1], Mordechai Segev[1]; [1]*Physics Dept., Technion, Israel.* We present non-paraxial shape-preserving accelerating electromagnetic wavepackets propagating in micro-sized curved surfaces, revealing exotic trajectories and polarization rotation dynamics caused by the interplay of interference effects and the curvature of space.

**FM3D.5 • 14:30**
**Dynamics of Microparticles Trapped in a Perfect Vortex Beam,** Mingzhou Chen[1], Michael Mazilu[1], Yoshihiko Arita[1], Ewan M. Wright[2,1], Kishan Dholakia[1,2]; [1]*Univ. of St Andrews, UK;* [2]*The Univ. of Arizona, USA.* We trap and rotate particles using a perfect vortex beam with integer or fractional topological charges. A linear relationship is observed between the rotation speed and orbital angular momentum content of the beam.

**FM3D.6 • 14:45**
**Cherenkov Radiation From Electron Vortex Beams,** Ido Kaminer[1,2], Maor Mutzafi[2], Gal Harari[2], Hanan Herzig Sheinfux[2], Jonathan Nemirovsky[2], Mordechai Segev[2]; [1]*Dept. of Physics, MIT, USA;* [2]*Physics Dept. and Solid State Inst., Technion Israel Inst. of Technology, Israel.* We find the Cherenkov radiation emitted by vortex electrons, and show that a properly designed photonic waveguide can increase the angular momentum of the electrons. We calculate the selection rules in a relativistic quantum formalism.

## CLEO: Science & Innovations

### Executive Ballroom 210E

### SM3E • Nano-, Micro-, and Waveguide-sensing—Continued

**SM3E.4 • 14:15**
**A Novel Nanoslotted Quadrabeam Photonic Crystal Cavity Sensor with High Sensitivity and High Q-factor,** Daquan Yang[1,2], Shota Kita[2], Cheng Wang[2], Qimin Quan[2], Marko Loncar[2], Huiping Tian[1], Yuefeng Ji[1]; [1]*State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China;* [2]*School of Engineering and Applied Sciences, Harvard Univ., USA.* We experimentally demonstrate a sensor based on a novel nanoslotted quadrabeam photonic-crystal cavity (NQPC). The NQPC possesses both high-sensitivity and high-Q factor. We achieved sensitivity of 451nm/RIU and Q-factor >7000 in water at telecom-wavelength range.

**SM3E.5 • 14:30**
**Nanobeam Photonic Crystal Cavity Based Multifunctional Gas-Phase Chemical Sensor,** Yu Chen[1], William S. Fegadolli[2], Axel Scherer[2,3], Mo Li[1]; [1]*Univ. of Minnesota Twin Cities, USA;* [2]*Physics, California Inst. of Technology, USA;* [3]*Electrical Engineering, California Inst. of Technology, USA.* By applying chemical functionalization to a nanobeam photonic crystal cavity, an ultrasensitive gas-phase chemical sensor was demonstrated. Its nonlinear thermo-optical bi-stability is utilized to realize a novel threshold detector for cumulative chemical exposure.

**SM3E.6 • 14:45**
**Polymeric Whispering Gallery Mode Resonators for Biosensing Applications,** Sarah Wiegele[1], Torsten Beck[1], Tobias Grossmann[1], Raphael Schmager[1], Jan Fischer[1], Martin Mai[1], Tobias Wienhold[2], Uwe Bog[2], Christian Friedmann[3], Timo Mappes[2,4], Heinz Kalt[1]; [1]*Inst. of Applied Physics, Karlsruhe Inst. of Technology, Germany;* [2]*Inst. of Microstructure Technology, Karlsruhe Inst. of Technology, Germany;* [3]*Inst. of Functional Interfaces, Karlsruhe Inst. of Technology, Germany;* [4]*Carl Zeiss AG, Corporate Research and Technology, Germany.* We report on polymeric high-Q microresonators and a method for spatially selective functionalization. Furthermore we present coupled resonators exhibiting a higher bulk refractive index sensitivity than single resonators making them promising candidates for high-sensitivity sensing.

### Executive Ballroom 210F

### SM3F • Advanced Laser Materials—Continued

**SM3F.4 • 14:15**
**Updating of temperature coefficients of refractive index in Nd:GdVO$_4$ and Nd:YVO$_4$,** Yoichi Sato[1], Takunori Taira[1]; [1]*Inst. for Molecular Science, Japan.* Experimental errors in the interferometric evaluation for temperature coefficient of refractive index (dn/dT) were studied. We updated dn/dT of Nd:vanadates with the reduction of experimental errors from 7.8% to 1.5% compared to our previous report.

**SM3F.5 • 14:30**
**High-Power, Continuous-Wave Cr:Colquiriite Lasers Pumped by Multi-Mode Diodes,** Umit Demirbas[1], Ilyes Baali[1], Durmus Alp Emre Acar[1], Alfred Leitenstorfer[2]; [1]*Laser Technology Lab, Antalya International Univ., Turkey;* [2]*Dept. of Physics and Center for Applied Photonics, Univ. of Konstanz, Germany.* We report multi-mode diode pumped, continuous-wave Cr:Colquiriite lasers with up to 2.54-W of near infrared (800-850 nm) and 0.9-W of blue (400 nm) output power, with optical-to-optical conversion efficiencies as high as 33%.

**SM3F.6 • 14:45**
**Efficient diode-pumped Tm,Ho:KLuW laser,** Xavier Mateos[1,2], Fabrizio Di Trapani[2,3], Valentin Petrov[3], Uwe Griebner[3], Magdalena Aguiló[1], Díaz Francesc[1]; [1]*Universitat Rovira i Virgili, Spain;* [2]*Università di Pavia, Italy;* [3]*Max-Born Inst., Germany.* Output powers exceeding 1 W are achieved with a diode-pumped Tm,Ho:KLu(WO4)2 laser at 2078 nm at slope efficiency of ~30% with respect to the absorbed power. Continuous tuning is possible over ~180 nm.

### Executive Ballroom 210G

### SM3G • Micro-Resonators—Continued

**SM3G.3 • 14:15**
**Demonstration of compact high-Q silicon microring resonators suspended in air,** Wei C. Jiang[1], Jidong Zhang[2], Qiang Lin[1,2]; [1]*Inst. of Optics, Univ. of Rochester, USA;* [2]*Electrical and Computer Engineering, Univ. of Rochester, USA.* We demonstrate compact silicon microring resonators suspended in air with ultra-high optical quality, achieving an intrinsic quality factor of 9.2×10$^5$ in the telecom band for the resonator with a radius of 9 µm.

**SM3G.4 • 14:30**
**A Multi-Channel Thermally Reconfigurable SiN Spectral Shaper,** Jian Wang[1], Yi Xuan[1], Andrew J. Metcalf[1], Pei-Hsun Wang[1], Xiaoxiao Xue[1], Daniel E. Leaird[1], Andrew M. Weiner[1], Minghao Qi[1]; [1]*Purdue Univ., USA.* We demonstrate a 4-channel SiN spectral shaper capable of $2\pi$-phase tuning and 30dB-amplitude control in each frequency channel. The phase tuning efficiency of 410mW/$2\pi$ is measured using both optical intensity autocorrelation and RF beat notes.

**SM3G.5 • 14:45**
**On-chip Electrical Modulation of Phase Shift between Optical Vortices with Opposite Topological Charge,** Huanlu Li[1], Michael Strain[3,4], Laura Meriggi[4], Lifeng Chen[1], Jiangbo Zhu[1], Kenan Cicek[1], Xinlun Cai[1,2], Jianwei Wang[2], Marc Sorel[4], Mark Thompson[2], Siyuan Yu[1]; [1]*Electrical and Electronics Engineering, Univ. of Bristol, UK;* [2]*Centre for Quantum Photonics, Univ. of Bristol, UK;* [3]*Inst. of Photonics, Univ. of Strathclyde, UK;* [4]*School of Engineering, Univ. of Glasgow, UK.* On-chip electrical modulation of relative phase between pairs of optical vortices with opposite signs has been demonstrated, enabling useful functions in lab-on-chip, communications and sensing applications.

### Executive Ballroom 210H

### SM3H • 2D and Other Novel Materials—Continued

**SM3H.4 • 14:15**
**Q factor variation in graphene-loaded silicon ring resonators,** Rai Kou[1,2], Tai Tsuchizawa[1,2], Kaori Warabi[3], Tsuyoshi Yamamoto[2], Hiroki Hibino[4], Hirochika Nakajima[3], Koji Yamada[1,2]; [1]*NTT Nanophotonics Center, Japan;* [2]*NTT Microsystem Integration Labs, Japan;* [3]*Graduate School of Advanced Science and Engineering, Waseda Univ., Japan;* [4]*NTT Basic Research Labs, Japan.* A drastic Q factor variation from 7900 to 1200 is observed in a silicon ring resonator loaded by micrometer-scale graphene with various lengths. The significant decay of the Q factor agrees with a numerical analysis.

**SM3H.5 • 14:30**
**Probing Electron-Phonon Interactions at the Saddle Point in Graphene,** Adam T. Roberts[1,2], Rolf Binder[1], Nai H. Kwong[1], Dheeraj Golla[1], Daniel Cormode[1], Brian J. LeRoy[1], Henry O. Everitt[2], Arvinder Sandhu[1]; [1]*Univ. of Arizona, USA;* [2]*US Army, USA.* High frequency differential transmission spectroscopy of graphene, probing near the M-point, is performed and analyzed theoretically. Electron-phonon coupling is identified as the chief mechanism for renormalization with an effective acoustic deformation potential of approximately 5eV.

**SM3H.6 • 14:45**
**Q-switched Fiber Laser with MoS2 Saturable Absorber,** Robert I. Woodward[1], Edmund J. Kelleher[1], T. H. Runcorn[1], Sergei V. Popov[1], Felice Torrisi[2], Rc T. Howe[2], Tawfique Hasan[2]; [1]*Femtosecond Optics Group, Imperial College London, UK;* [2]*Cambridge Graphene Centre, Univ. of Cambridge, UK.* A MoS2-based saturable absorber is fabricated using wet chemistry techniques. We use it to passively Q-switch a fiber laser at 1068 nm.

## Meeting Room
## 211 B/D

## CLEO: Science & Innovations

### SM3I • Few-Cycle-Pulse Nonlinear Optical Technologies—Continued

**SM3I.3 • 14:15**
**Generation and optical parametric amplification of near-IR, few-cycle light pulses,** Alexander Kessel[1], Christoph Skrobol[1,2], Sandro Klingebiel[1], Christoph Wandt[1], Izhar Ahmad[1], Sergei A. Trushin[1], Zsuzsanna Major[1,2], Ferenc Krausz[1,2], Stefan Karsch[1,2]; *[1]Max-Planck-Institut für Quantenoptik, Germany; [2]Physics, Ludwig-Maximilians-Universität München, Germany.* We present different schemes for the generation of few-cycle multi-mJ light pulses in the range of 700-1400 nm together with the amplification of these pulses to several mJ in two ps-pumped optical parametric amplification stages.

**SM3I.4 • 14:30**
**Generation of 17-μJ mid-infrared ultrafast laser pulses by SiC crystal based noncollinear optical parametric amplifier,** Haitao Fan[1], Chunhua Xu[1], Zhaohua Wang[1], Gang Wang[1], Xiaolong Chen[1], Zhiyi Wei[1]; *[1]Inst. of Physics, CAS, China.* A femtosecond OPA system for mid-infrared ultrafast laser is established. Pulse energy of 17-μJ is obtained from SiC crystal at central wavelength of 3.75-μm, which proves SiC an ideal nonlinear crystal for mid-infrared pulse generation.

**SM3I.5 • 14:45**
**Tunable and Near-Fourier-limited Few-Cycle Mid-IR Pulses via an Adiabatically Chirped Difference Frequency Grating,** Peter Krogen[1], Haim Suchowski[2], Gregory J. Stein[1], Franz Kärtner[3], Jeffrey Moses[1]; *[1]Dept. of Electrical Engineering and Computer Science and Research Lab of Electronics, MIT, USA; [2]NSF Nanoscale Science and Engineering Center, Univ. of California, USA; [3]Center for Free-Electron Laser Science, DESY and Physics Dept. Univ. of Hamburg, Germany.* A μJ-level source of few-cycle, mid-IR pulses tunable over 2-4 microns is demonstrated based on adiabatic difference frequency generation. This opens up the possibility for single-cycle mid-IR pulses controllable by a near-IR phase shaper.

## Meeting Room
## 212 A/C

### SM3J • Spatial Multiplexing—Continued

**SM3J.4 • 14:15**
**Method for Bi-directional Conversion between Fundamental Gaussian Beams and Spatially Polarized Beams using a Spatial Light Modulator,** Zhe Zhao[1], Yongxiong Ren[1], Hao Huang[1], Guodong Xie[1], Yan Yan[1], Nisar Ahmed[1], Changjing Bao[1], Long Li[1], Yinwen Cao[1], Alan Willner[1]; *[1]Dept. of Electrical Engineering, Univ. of Southern California, USA.* We describe a method for bi-directional conversion between fundamental Gaussian beams and spatially polarized beams using a spatial light modulator with angular sliced phase pattern.

**SM3J.5 • 14:30**
**Power-Controllable Multicasting of a Single Gaussian Mode to Multiple Orbital Angular Momentum (OAM) Modes,** Shuhui Li[1], Jun Liu[1], Chao Li[2], Chengcheng Gui[1], Long Zhu[1], Qi Yang[2], Jian Wang[1]; *[1]Wuhan National Lab for Optoelectronics, China; [2]State Key Lab of Optical Comm. Technologies and Networks, China.* We experimentally demonstrate power-controllable multicasting of OFDM 64-QAM signal from single Gaussian mode to multiple OAM modes using a single phase-only spatial light modulator assisted by a feedback control. The precision of power control is less than 1 dB.

**SM3J.6 • 14:45**
**Experimental Demonstration of Orbital-Angular-Momentum Demultiplexing using an Optical FFT in the Spatial Domain,** Hao Huang[1], Guodong Xie[1], Nisar Ahmed[1], Yongxiong Ren[1], Yan Yan[1], Martin P. Lavery[2], Miles Padgett[2], Samuel Dolinar[3], Alan Willner[1]; *[1]Univ. of Southern California, USA; [2]Glasgow Univ., UK; [3]Jet Propulsion Lab, USA.* we demonstrate orbital angular momentum modes separation using a geometrical transform-based mode sorter combined with a spatial Fast Fourier Transform. The observed crosstalk between the adjacent modes is <-11.8 dB. A lower crosstalk of <-18.6 dB is anticipated by simulation results.

## Meeting Room
## 212 B/D

## CLEO: QELS-Fundamental Science

### FM3K • Plasmonic Biochemical Sensors and Systems—Continued

**FM3K.3 • 14:15**
**On-chip Plasmonic Interferometer Array for Portable Multiplexed Biosensing System,** Xie Zeng[1], Yongkang Gao[2], Dengxin Ji[1], Nan Zhang[1], Haomin Song[1], Qiaoqiang Gan[1], Filbert Bartoli[2]; *[1]Dept. of Electrical Engineering, The State Univ. of New York at Buffalo, USA; [2]Electrical and Computer Engineering Dept., Lehigh Univ., USA.* We report a multiplexed intensity-modulated sensing platform using a plasmonic interferometer array with the resolution of $1.6\times10^{-5}$ RIU. This sensing mechanism is then integrated with a smartphone imaging system to demonstrate a portable biosensing device.

**FM3K.4 • 14:30**
**Colorimetric Sensors using Plasmonics Grating on a Metallic Mirror,** Mohammadreza Khorasaninejad[1], Mohsen Raeis-Zadeh Mohsen Raeis-Zadeh[2], Navid Abedzadeh[1,2], Hadi Amarloo[2], Safieddin Safavi-Naeini[2], Simarjeet S. Saini[2]; *[1]School of Engineering and Applied Sciences, Harvard Univ., USA; [2]Electrical and Computer Engineering, Univ. of Waterloo, Canada.* We experimentally demonstrate a low-cost colorimetric sensor in which the change in surrounding refractive index is measured using simple image processing. This sensor consists of two-dimensional gold nanopatch grating on a highly reflective mirror.

**FM3K.5 • 14:45**
**Ultra-Sensitive Refractive Index Sensor Utilizing Plasmonic Resonance Splitting,** Yuval Yifat[1], Michal Eitan[1], Zeev Iluz[1], Jacob Scheuer[1]; *[1]Dept. of Physical Electronics, Tel-Aviv Univ., Israel.* We demonstrate experimentally an ultra-sensitive RI sensor based on plasmonic slot nano-antenna arrays utilizing a novel resonance splitting phenomenon observed at small incidence angles. Sensitivities exceeding 1000nm/RIU and high FOM exceeding 50 are demonstrated.

## Marriott
## Salon I & II

## CLEO: Applications & Technology

### AM3L • Symposium on Enabling Photonics Technologies for Miniaturization I—Continued

**AM3L.3 • 14:30** Invited ▶
**Recent advances in ultrafast laser nanostructuring: S-waveplate and eternal data storage,** Peter G. Kazansky[1], Jingyu Zhang[1], Mindaugas Gecevičius[1], Martynas Beresna[1]; *[1]Univ. of Southampton, UK.* Ultrashort light pulses create self-assembled sub-wavelength structures in the bulk of silica glass. Recent progress in applications of this phenomenon ranging from polarization and vortex converters to 5D optical data storage is reviewed.

## SM3M • Nanophotonic Structures for Quantum Optics—Continued

**SM3M.3 • 14:15**

**Coupling of quantum dots with a photon cage,** Rémy Artinyan[1], Aziz Benamrouche[1], Cherif Belacel[1,2], Alice Berthelot[2], Pedro Rojo-Romeo[1], Romain Peretti[1], Bastian Gonzalez-Alcevedo[1], Guillaume Beaudin[3], Vincent Aimez[3], Jean Louis Leclercq[1], Xavier Letartre[1], Segolene Callard[1]; [1]*INL Lyon, France;* [2]*ILM Lyon, France;* [3]*3IT, Canada.* We report on the investigation of the coupling between the high-Q mode of a tri-dimensional hollow silicon-based micro-resonator and PbS quantum dots in the near-infrared range, using near-field scanning optical microscopy and far-field spectroscopy.

**SM3M.4 • 14:30** Invited

**Cavity Quantum Electrodynamics in Quantum Dot-Photonic Crystal Nanocavity Coupled System with Large $g/\kappa$,** Satoshi Iwamoto[1], Yasutomo Ota[1], Hiroyuki Takagi[1], Daisaku Takamiya[1], Yasuhiko Arakawa[1]; [1]*Inst. of Industrial Science and Inst. for Nano Quantum Information Electronics, Univ. of Tokyo, Japan.* We report experimental progresses in cavity quantum electrodynamics using H1 and H0-type photonic crystal nanoacvities embedding single quantum dots. Strong coupling and enhanced optical Stark effect in these systems with large $g/\kappa$ will be discussed.

## SM3N • Gas-Filled Hollow Fibers—Continued

**SM3N.3 • 14:15**

**CW Hollow Core Optically Pumped Fiber Gas Laser,** Vasudevan A. Nampoothiri[1], Wolfgang Rudolph[1], Benoît Debord[2], M. M. Alharbi[2], Frédéric Gérôme[2], Fetah Benabid[2]; [1]*Physics and Astronomy, Univ. of New Mexico, USA;* [2]*Xlim Research Inst., Université de Limoges, France.* CW lasing in the 1280-1340 nm region is demonstrated from molecular iodine gas contained in a hollow-core kagome structured photonic crystal fiber when optically pumped at 532 nm.

**SM3N.4 • 14:30**

**Highly efficient wavelength conversion in CF4-filled hollow-core photonic bandgap fibers,** Lior Ben Yehud[1,2], Amiel Ishaaya[1]; [1]*Electrical and Computer Engineering, Ben-Gurion Univ. of the Negev, Israel;* [2]*Electro-optics Unit, Ben-Gurion Univ. of the Negev, Israel.* We investigate Raman wavelength conversion in CF4-filled hollow-core photonic bandgap fibers. We obtain a record of more than 35% conversion efficiency in a 35cm-long, weakly pressurized, fiber at a peak power of only 2.6kW.

**SM3N.5 • 14:45**

**Dual strong picoseconds laser emissions at 1.8 and 2 µm,** Aurélien Benoit[1,2], Benoit Beaudou[3], Meeshal Alharbi[1], Benoît Debord[1], Frederic Gerome[1,3], François Salin[2], Fetah Benabid[1,3]; [1]*GPPMM group, Xlim Research Inst., CNRS UMR 7252, France;* [2]*Eolite Systems, France;* [3]*Glophotonics, France.* We report on generation of two strong ps-laser emissions at 1.8 µm and 2 µm through hydrogen-filled Kagome HC-PCF. Each line exhibits tens of kW of peak power and operates in a single mode fashion.

## SM3O • Symposium on Large-Scale Silicon Photonic Integration I—Continued

**SM3O.3 • 14:30** Invited

**Silicon-Organic Hybrid - A Compact and Energy Efficient CMOS Compatible Active Silicon Photonic Solution,** Juerg Leuthold[1]; [1]*ETH Zurich, Switzerland.* Organic materials combined with silicon waveguides offer a path to highly efficient electro-optical devices. Modulators based on this technology have already shown frequency responses up to 100 GHz, switching with as little as 0.6 fJ/bit, and operation up to 160 Gbit/s.

## SM3P • Bioimaging I—Continued

**SM3P.4 • 14:15**

**Microwave assisted nanosecond CARS multiplex system,** Dominique Pagnoux[1], Farid El Bassri[1,2], Christophe Louot[1], Vincent Couderc[1]; [1]*Xlim Institut, Limoges Univ., CNRS, France;* [2]*CILAS, France.* Experimental measurements on microwave assisted Multiplex Coherent Anti-Stokes Raman Spectroscopy (M-CARS) in liquids are presented. Nanosecond electric field applied on samples allows M-CARS signal enhancement and offers potentialities to remove non resonant background.

**SM3P.5 • 14:30** Invited

**Fluorescence Lifetime Imaging for Biomedicine,** Paul M. French[1]; [1]*Physics, Imperial College London, UK.* I will review our development and application of fluorescence lifetime imaging implemented in microscopy, tomography and endoscopy to provide molecular readouts across the scales from super-resolved microscopy through imaging of disease models to clinical applications.

## CLEO: QELS-Fundamental Science

### Executive Ballroom 210A

### FM3A • Quantum Detection—Continued

**FM3A.7 • 15:00**
**High-efficiency superconducting nanowire single photon detectors based on amorphous Mo0.75Ge0.25,** Varun Verma[1], Adriana Lita[1], Michael R. Vissers[1], Francesco Marsili[1], David P. Pappas[1], Richard P. Mirin[1], Sae Woo Nam[1]; [1]*NIST, USA.* We measure a saturation of the internal quantum efficiency of superconducting nanowire single-photon detectors based on a Mo0.75Ge0.25 alloy with peak system detection efficiency of 30%.

**FM3A.8 • 15:15**
**Scalable single-photon detection on a photonic chip,** Faraz Najafi[1], Jacob C. Mower[1], Nicholas C. Harris[1], Francesco Bellei[1], Andrew Dane[1], Catherine Lee[1], Solomon Assefa[2], Karl K. Berggren[1], Dirk Englund[1]; [1]*Dept. of Electrical Engineering and Computer Science, MIT, USA;* [2]*IBM TJ Watson Research Center, USA.* We developed a scalable method for integrating sub-70-ps-timing-jitter superconducting nanowire single-photon detectors with photonic integrated circuits. We assembled a photonic chip with four integrated detectors and performed the first on-chip $g^{(2)}(\tau)$-measurements of an entangled-photon source.

### Executive Ballroom 210B

### FM3B • Quantum Fluids and Gases in Solids—Continued

**FM3B.4 • 15:00**
**Mid-infrared absorption imaging of trapped paraexcitons in cuprous oxide,** Kosuke Yoshioka[1], Makoto Kuwata-Gonokami[1,2]; [1]*Dept. of Physics, Univ. of Tokyo, Japan;* [2]*Photon Science Center, Univ. of Tokyo, Japan.* Absorption imaging of trapped dark excitons in a bulk semiconductor is realized. 1s-2p transition in the mid-infrared is used to detect 1s paraexcitons. This technique is crucial to observe the Bose-Einstein condensate of excitons directly.

**FM3B.5 • 15:15**
**Spin Currents and Polarization Textures in Optically Created Indirect Excitons,** Yuliya Y. Kuznetsova[1], Eric V. Calman[1], Jason Leonard[1], Leonid Butov[1], Kenneth Campman[2], Arthur Gossard[2]; [1]*Dept. of Physics, Univ. of California at San Diego, USA;* [2]*Materials Dept., Univ. of California at Santa Barbara, USA.* We report the observation of spin currents and spin polarization textures in optically generated indirect excitons. The textures are observed in linear and circular polarizations and are controlled by magnetic fields.

### Executive Ballroom 210C

### FM3C • Optics in Random Media II—Continued

**FM3C.6 • 15:00**
**Optical Anderson localized modes switched electronically,** Shayan Mookherjea[1], Junrong Ong[1], Xianshu Luo[2], Guo-Qiang Lo[2]; [1]*Electrical and Computer Engineering, Univ. of California San Diego, USA;* [2]*Inst. of Microelectronics, A*STAR, Singapore.* Electronic on-off switching control over optical Anderson localized modes is demonstrated for the first time, using a lithographically-fabricated CMOS-compatible silicon photonic waveguide infiltrated by about 100 sub-micron-scale p-n junction diodes.

**FM3C.7 • 15:15**
**Coherent Backscattering in Multimode Optical Fibers,** Yaron Bromberg[1], Sebastien Popoff[1], Brandon Redding[1], Hui Cao[1]; [1]*Applied Physics, Yale Univ., USA.* We investigate experimentally two counter-propagating beams that travel through multimode fibers with strong mode coupling. The interferences between waves going through time-reversed paths can enhance, and surprisingly sometimes suppress, coherent backscattering to the input mode.

### Executive Ballroom 210D

### FM3D • Nonconventional Beams and Applications—Continued

**FM3D.7 • 15:00**
**Non-Linear Shape Preserving Electron-Beams,** Maor Mutzafi[1], Ido Kaminer[1], Gal Harari[1], Mordechai Segev[1]; [1]*Physics, Technion, Israel.* We show that shaping the initial wavefunction of a multi-electron system can lead to electron beams displaying shape-preserving propagation in spite of the inherent repulsion among electrons. This idea suggests applications in microscopy and lithography.

**FM3D.8 • 15:15**
**Nonparaxial Bessel-like beams following curved trajectories,** Nikolaos K. Efremidis[1], Ioannis D. Chremmos[1,2]; [1]*Mathematics and Applied Mathematics, Univ. of Crete, Greece;* [2]*Max Planck Inst. for the Science of Light, Germany.* We introduce a new class of nonparaxial optical beams with a Bessel-like profile that are capable to laterally shift along fairly arbitrary trajectories during propagation in free space. Numerical simulations confirm our theoretical predictions.

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**15:30–16:00 Coffee Break,** *Concourse Level*

NOTES

## CLEO: Science & Innovations

### Executive Ballroom 210E

### SM3E • Nano-, Micro-, and Waveguide-sensing—Continued

**SM3E.7 • 15:00**
**Surface-Enhanced Infrared Spectroscopy using ultra-compact indium tin oxide (ITO) sensor arrays,** Yudong Wang[1,2], Martina Abb[2], Nikitas Papasimakis[3], Cornelis Hendrik de Groot[1], Otto L. Muskens[2]; [1]*Nano Group, ECS, Univ. of Southampton, UK;* [2]*Physics & Astronomy, Univ. of Southampton, UK;* [3]*Optoelectronics Research Centre and Centre for Photonic Metamaterials, Univ. of Southampton, UK.* Reduced cross section and strong plasmon confinement allows ITO antennas to be integrated at extremely high densities with no loss in performance due to long-range transverse interactions and to hold promise for extremely sub-wavelength SEIRS.

### Executive Ballroom 210F

### SM3F • Advanced Laser Materials—Continued

**SM3F.7 • 15:00**
**Intracavity Second Harmonic Generation of Passively Q-switch Mode Locked $Pr^{3+}$-doped Fluoride Lasers using $Cr^{4+}$:YAG Saturable Absorber,** Hiroki Tanaka[1], Ryosuke Kariyama[1], Junichiro Kojou[1], Fumihiko Kannari[1]; [1]*Keio Univ., Japan.* We demonstrate passive Q-switching and Q-switched mode locking of $Pr^{3+}$-doped fluoride lasers in the visible region using a $Cr^{4+}$:YAG saturable absorber. Intracavity frequency doubling generates deep ultra-violet from the $Pr^{3+}$:YLF laser.

**SM3F.8 • 15:15**
**Passive Q-switching of a Diode-pumped Tm,Ho:YLF Laser Using Cr:ZnSe Saturable Absorber,** Bozhidar Oreshkov[1,2], Antonio Gianfrate[1,3], Stefano Veronesi[3], Valentin Petrov[1], Uwe Griebner[1], Haohai Yu[1], Ivan Buchvarov[2], Daniela Parisi[3], Mauro Tonelli[3]; [1]*Max Born Inst. for Nonlinear Optics and Short Pulse Spectroscopy, Germany;* [2]*Physics, Sofia Univ. St. Kliment Ohridski, Bulgaria;* [3]*Dipartimento di Fisica dell'Università di Pisa, Italy.* We report on passive Q-switching of a Tm,Ho:LiYF4 laser with Cr:ZnSe saturable absorber achieving for the first time short (~50 ns) pulse durations and high (~640 W) peak power from such a diode-pumped Ho-laser.

### Executive Ballroom 210G

### SM3G • Micro-Resonators—Continued

**SM3G.6 • 15:00**
**Fast Switching of Optical Vortex Beam Mode Orders Generated Using a Fully Integrated SOI Device,** Michael J. Strain[1,2], Xinlun Cai[3,4], Jianwei Wang[3], Jiangbo Zhu[4,5], Lifeng Chen[5], Martin Lopez-Garcia[5], Mark Thompson[3], Marc Sorel[2], Siyuan Yu[4,5]; [1]*Inst. of Photonics, Univ. of Strathclyde, UK;* [2]*School of Engineering, Univ. of Glasgow, UK;* [3]*Centre for Quantum Photonics, Univ. of Bristol, UK;* [4]*State Key Lab of Optoelectronic Materials and Technologies and School of Physics and Engineering, Sun Yatsen Univ., China;* [5]*Merchant Venturers School of Engineering, Univ. of Bristol, UK.* Fast tuning of the Optical Angular Momentum (OAM) order of a vortex beam is demonstrated with 20µs switching times using a compact silicon photonic device.

**SM3G.7 • 15:15**
**Realization of a 4th-order pseudo-elliptic microring filter with negative coupling on SOI,** Daniel Bachman[1], Alan Tsay[1], Vien Van[1]; [1]*Electrical and Computer Engineering, Univ. of Alberta, Canada.* We report the design and realization of a 4th-order pseudo-elliptic microring filter with negative coupling in SOI. Measured filter response showed the effect of coupling phase dispersion and sharp skirt roll-off due to negative coupling.

### Executive Ballroom 210H

### SM3H • 2D and Other Novel Materials—Continued

**SM3H.7 • 15:00**
**Nonlinear Optical Properties of a Graphene-based DNA composite,** Saima Husaini[1,2], Robert G. Bedford[1], Emily M. Heckman[1], Alyssa C. Lesko[3]; [1]*Sensors Directorate, Air Force Research Lab, USA;* [2]*Wyle, USA;* [3]*Dept. of Biological Sciences, Univ. of Notre Dame, USA.* A graphene-based biopolymer is developed which exhibits saturable absorption and optical limiting behavior in the femtosecond and nanosecond regime respectively. Further this composite film when irradiated with nanosecond pulses indicates a damage threshold >50 $J/cm^2$.

**SM3H.8 • 15:15**
**Graphene Plasmonic Photodetector for Planar-Type Photonic Integrated Circuits,** Jin Tae Kim[1], Kwang Hyo Chung[1], Young-Jun Yu[1], Hongkyw Choi[1], Choon-Gi Choi[1]; [1]*CRC for Graphene Electronics, Electronics and Telecommunications Research Inst. (ETRI), Korea.* Based on graphene plasmonic waveguides, we developed a graphene plasmonic photodetector to detect horizontally incident light signal. The photocurrent is the maximum at the graphene-metal interface and the time constant is less than 39.7 ms.

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**15:30–16:00 Coffee Break,** *Concourse Level*

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## Meeting Room 211 B/D

## CLEO: Science & Innovations

### SM3I • Few-Cycle-Pulse Nonlinear Optical Technologies—Continued

**SM3I.6 • 15:00**
**OPCPA Systems Based on Chirped Quasi-Phase-Matching Gratings: Physics and Design Constraints,** Christopher R. Phillips[1,2], Benedikt W. Mayer[1], Lukas Gallmann[1,3], Martin M. Fejer[2], Ursula Keller[1]; [1]*ETH Zurich, Switzerland;* [2]*Stanford Univ., USA;* [3]*Univ. of Bern, Switzerland.* We present a comprehensive study of the physics and design of OPCPA based on chirped quasi-phase-matching, identifying subtle parametric processes occurring in these devices, and how they were addressed in our latest mid-IR OPCPA result.

**SM3I.7 • 15:15**
**Broad-bandwidth, high-efficiency adiabatic second-harmonic generation in chirped quasi-phase-matching gratings,** Yu-Wei Lin[1], Christopher R. Phillips[2], Martin M. Fejer[1]; [1]*Edward L. Ginzton Lab, Stanford Univ., USA;* [2]*Dept. of Physics, Inst. of Quantum Electronics, ETH Zurich, Switzerland.* Second-harmonic generation of ultrashort pulses in the sufficiently chirped quasi-phase-matching (QPM) gratings is shown to obtain conversion efficiency approaching 100% with increasing pump intensities, and the wide bandwidth of the pulses is also preserved.

## Meeting Room 212 A/C

### SM3J • Spatial Multiplexing—Continued

**SM3J.7 • 15:00** Invited
**Novel Fibers and Devices for Space-Division Multiplexed Transmission,** Guifang Li[1,2], Cen Xia[1], Neng Bai[1], Ningbo Zhao[2]; [1]*CREOL, The College of Optics & Photonics, Univ. of Central Florida, USA;* [2]*College of Precision Instrument and Opto-Electronic Engineering, Tianjin Univ., China.* Space-division multiplexing (SDM) promises orders of magnitude increase in single-fiber transmission capacity. This paper presents fiber solutions to manage modal dispersion and simplify DSP for modal crosstalk and fiber-based (de)multiplexers that are fundamentally lossless.

## Meeting Room 212 B/D

## CLEO: QELS-Fundamental Science

### FM3K • Plasmonic Biochemical Sensors and Systems—Continued

**FM3K.6 • 15:00**
**High-Sensitivity Chiral Molecular Sensing with Optical Metasurfaces,** Yang Zhao[1,2], AmirNader Askarpour[1], Liuyang Sun[3], Jinwei Shi[4], Xiaoqin Li[3], Andrea Alu[1]; [1]*Electrical and Computer Engineering, The Univ. of Texas at Austin, USA;* [2]*Materials Science and Engineering, Stanford Univ., USA;* [3]*Physics, The Univ. of Texas at Austin, USA;* [4]*Physics, Beijing Normal Univ., China.* We provide theoretical analysis and experimental demonstrations of high sensitivity to zepto moles of chiral molecules with optical metasurfaces. By introducing a figure of merit, our results experimentally show opposite signs to detect molecular handedness.

**FM3K.7 • 15:15**
**Active Surface Plasmon Sensor,** Renmin Ma[1], Sadao Ota[1], Yimin Li[1], Sui Yang[1], Xiang Zhang[1]; [1]*Univ. of California Berkeley, USA.* we have experimentally demonstrated an active plasmon sensor with sub-p.p.b. level explosive molecules detection. Loss compensation by gain in surface plasmon cavity enhanced the sensitivity significantly.

## Marriott Salon I & II

## CLEO: Applications & Technology

### AM3L • Symposium on Enabling Photonics Technologies for Miniaturization I—Continued

**AM3L.4 • 15:00** Invited
**Light-guided Nano-Torchs in Mesoscopia,** Jesper Gluckstad[1]; [1]*Danmarks Tekniske Universitet, Denmark.* Contemporary microscopy demands functionalities, not only for observing micro- and nanoscopic phenomena, but also for reaching into and manipulating mesoscopic constituents. This invited paper is two-fold describing the newest uses of proprietary strongholds we currently are establishing at DTU on new means of sculpting of both light and matter for probing at the smallest scales.

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**15:30–16:00 Coffee Break,** *Concourse Level*

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NOTES

## CLEO: Science & Innovations

Marriott
Salon III

### SM3M • Nanophotonic Structures for Quantum Optics—Continued

**SM3M.5 • 15:00** ▶
**Experimentally controlling the quantum spectrum generated by a silicon nanophotonic chip,** Ranjeet Kumar[1], Junrong Ong[1], Marc Savanier[1], John Recchio[1], Shayan Mookherjea[1]; [1]*Univ. of California San Diego, USA.* To demonstrate control over the quantum spectrum of light, we tune the joint spectral intensity of photon pairs generated at telecommunications wavelengths using a low-power diode-pumped compact CMOS-compatible silicon chip at room temperature.

**SM3M.6 • 15:15**
**1-to-32 H-tree Optical Distribution on Adhesively Bonded Silicon Nanomembrane,** Yang Zhang[1], Xiaochuan Xu[1], David Kwong[1], John Covey[1], Amir Hosseini[2], Ray Chen[1]; [1]*Electrical and Computer Engineering, The Univ. of Texas at Austin, USA;* [2]*Omega Optics, Inc, USA.* We developed an adhesive bonding process to integrate silicon nanomembranes onto silicon chips. A grating-coupled 1-to-32 H-tree optical distribution is experimentally demonstrated with an excess loss of 2.2 dB and a uniformity of 0.72 dB.

Marriott
Salon IV

### SM3N • Gas-Filled Hollow Fibers—Continued

**SM3N.6 • 15:00**
**Generation of three-octave-spanning transient Raman frequency comb in hydrogen-filled hollow-core PCF,** Francesco Tani[1], Federico Belli[1], Amir Abdolvand[1], John C. Travers[1], Philip St.J. Russell[1,2]; [1]*Division III, Max-Planck-Inst Physik des Lichts, Germany;* [2]*Dept. of Physics, Univ. of Erlangen-Nuremberg, Germany.* A noise-seeded transient Raman frequency comb spanning three octaves from 180 to 2400 nm is generated by pumping a hydrogen-filled hollow-core photonic crystal with 300 fs pulses of energy 26 µJ and wavelength 800 nm.

**SM3N.7 • 15:15**
**Single-mode hollow-core fiber for portable acetylene sub-Doppler frequency reference,** Chenchen Wang[1], Shun Wu[1], Brian Mangan[2], Linli Meng[2], John M. Fini[2], Robert S. Windeler[2], Eric M. Monberg[2], Anthony Desantolo[2], Kazunori Mukasa[2], Jeffrey W. Nicholson[2], David DiGiovanni[2], Brian R. Washburn[1], Kristan L. Corwin[1]; [1]*Kansas State Univ., USA;* [2]*OFS Labs, USA.* A newly-developed, single-mode hollow-core fiber is employed for saturated absorption spectroscopy in a molecular gas. Lack of surface modes, ease of angle splicing, and single-modedness make it promising for portable frequency references.

Marriott
Salon V & VI

### SM3O • Symposium on Large-Scale Silicon Photonic Integration I—Continued

**SM3O.4 • 15:00** Invited
**CMOS Integrated Silicon Photonics - Does it Make Sense?,** Wilfried Haensch[1], Douglas M. Gill[1], Jason S. Orcutt[1]; [1]*IBM, USA.* CMOS integrated Silicon Photonics offers a compact solution for a fully functional optical engine. The interdependence of optical and electrical components is discussed and arguments for a co-optimization of these components are given

Marriott
Willow Glen I-III

### SM3P • Bioimaging I—Continued

**SM3P.6 • 15:00** ▶
**Optical Thermophoresis for the Manipulation and Detection of Biomolecules,** Li-Hsien Yu[1], Yih-Fan Chen[2,1]; [1]*Dept. of Biomedical Engineering, National Cheng Kung Univ., Taiwan;* [2]*Inst. of Biophotonics, National Yang-Ming Univ., Taiwan.* We use thermophoresis to accumulate and quantify biomolecules under a laser-induced temperature gradient. As biomolecules accumulate at the heated region, the concentration of the molecules can be determined based on the level of accumulation.

**SM3P.7 • 15:15** ▶
**THG microscopy imaging of blood using sub-50fs Yb fiber laser,** Ilyas Saytashev[1], Bai Nie[2], Marcos Dantus[1,2]; [1]*Dept. of Chemistry, Michigan State Univ., USA;* [2]*Dept. of Physics and Astronomy, Michigan State Univ., USA.* We report on multimodal imaging of blood using sub-50 fs pulses centered at 1060 nm wavelength. We find that red blood cells appear dark on SHG images while on THG images of blood provide bright signal and good contrast.

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**15:30–16:00 Coffee Break,** *Concourse Level*

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NOTES

## CLEO: QELS-Fundamental Science

### Executive Ballroom 210A

**16:00–18:00**
**FM4A • Quantum Key Distribution**
*Presider: Paul Toliver; Applied Communication Sciences, USA*

**FM4A.1 • 16:00**
**Experimental demonstration of the coexistence of continuous-variable quantum key distribution with an intense DWDM classical channel,** Rupesh Kumar[1], Hao Qin[1], Romain Alléaume[1]; [1]*Telecom ParisTech, France.* We have experimentally performed continuous variable quantum key distribution over up to 50 km, in coexistence with a dense-wavelength-multiplexed channel of several dBms. This opens new perspectives for QKD integration over existing optical network architectures.

**FM4A.2 • 16:15**
**Continuous-Variable Measurement-Device-Independent Quantum Key Distribution with Imperfect Detectors,** Zhengyu Li[1], Xiang Peng[1], Hong Guo[1]; [1]*Peking Univ., China.* We show that the performance of continuous-variable measurement-device-independent quantum key distribution will decline dramatically when considering detector's imperfections. However, it can be improved by using phase sensitive optical amplifiers.

**FM4A.3 • 16:30**
**High-dimensional time-energy entanglement-based quantum key distribution using dispersive optics,** Catherine Lee[1,2], Zheshen Zhang[1], Jacob C. Mower[1], Greg Steinbrecher[1], Hongchao Zhou[1], Ligong Wang[1], Robert Horansky[3], Varun B. Verma[3], Michael Allman[3], Adriana Lita[3], Richard P. Mirin[3], Francesco Marsili[4], Andrew D. Beyer[4], Matthew Shaw[4], Sae Woo Nam[3], Gregory Wornell[1], Franco Wong[1], Jeffrey H. Shapiro[1], Dirk Englund[1]; [1]*MIT, USA;* [2]*Dept. of Physics, Columbia Univ., USA;* [3]*National Inst. of Standards and Technology, USA;* [4]*NASA Jet Propulsion Lab, USA.* We implement a high-dimensional quantum key distribution protocol secure against collective attacks. We transform between conjugate measurement bases using group velocity dispersion. We obtain > 3 secure bits per photon coincidence.

### Executive Ballroom 210B

**16:00–18:00**
**FM4B • Dynamics in Strongly Correlated Materials**
*Presider: Matthias Hoffmann; SLAC National Accelerator Lab, USA*

**FM4B.1 • 16:00**
**Femtosecond Magneto-optics of FePt nanocrystals for Heat Assisted Magnetic Recording,** Jean-Yves Bigot[1], Mircea Vomir[1], Jiwan Kim[1], Oleksandr Mosendz[2], Shikha Jain[2], Dieter Weller[2]; [1]*Université de Strasbourg, CNRS, France;* [2]*HGST a Western Digital Company, USA.* We report about the magnetization dynamics in $L1_0$ FePt discs, designed for Heat Assisted Magnetic Recording. We also determine the different nonlinear behaviors of the coercive field and saturation magnetization with increasing laser pulse energy.

**FM4B.2 • 16:15**
**Ultrafast Exchange-Coupling Strengthening in FeNi/FePt Film Induced by Femtosecond Laser,** Zhifeng Chen[1], Shufa Li[2], Bingzhi Zhang[1], Feipeng Pi[1]; [1]*School of Physics and Electronic Engineering, Guangzou Univ., China;* [2]*State-Key Lab of Optoelectronic Materials and Technologies, Sun Yat-Sen Univ., China.* We study laser-induced evolution of exchange coupling in FeNi/$L1_0$-FePt film using pump-probe polar Kerr spectroscopy. Ultrafast coupling-strengthening with significant reduction of hard coercivity is observed. The mechanism is discussed.

**FM4B.3 • 16:30**
**Terahertz Cherenkov Radiation from Ultrafast Magnetization in Terbium Gallium Garnet,** Sergei Gorelov[1], Eugene Mashkovich[1], Maxim Tsarev[1], Michael Bakunov[1]; [1]*Univ. of Nizhny Novgorod, Russia.* Terahertz Cherenkov radiation from a moving pulse of ultrafast magnetization optically induced in terbium gallium garnet is experimentally observed and analyzed for the characterization of the ultrafast inverse Faraday effect.

### Executive Ballroom 210C

**16:00–18:00**
**FM4C • Novel Optics I**
*Presider: Xiang Zhang; Univ. of California Berkeley, USA*

**FM4C.1 • 16:00**
**Gate-controlled Electromagnetically Induced Transparency Analogue in Graphene Metamaterials,** Teun-Teun Kim[1]; [1]*School of Physics and Astronomy, Univ. of Birmingham, UK.* We show an electric control of metamaterial-induced transparency through active tuning of the dark mode. By hybridizing gated graphene with diatomic metamaterials, the transparency window switching is obtained at a frequency of 0.85 THz.

**FM4C.2 • 16:15**
**Tunable Pulse-Shaping with Gated Graphene Nanoribbons,** Ludmila J. Prokopeva[1], Naresh K. Emani[1], Alexandra Boltasseva[1,2], Alexander Kildishev[1]; [1]*Birck Nanotechnology Center, Purdue Univ., USA;* [2]*Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark.* We propose a pulse-shaper made of gated graphene nanoribbons. Simulations demonstrate tunable control over the shapes of transmitted and reflected pulses using the gating bias. Initial fabrication and characterization of graphene elements is also discussed.

**FM4C.3 • 16:30**
**Lorentz Force Metamaterial with Giant Optical Magnetoelectric Response,** João A. Valente[1], Jun-Yu Ou[1], Eric Plum[1], Ian J. Youngs[2], Nikolay I. Zheludev[1,3]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK;* [2]*Physical Sciences Dept., DSTL, UK;* [3]*Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore.* We demonstrate the first reconfigurable photonic metamaterial controlled by electrical currents and magnetic fields, providing first practically useful solutions for sub-megahertz and high contrast modulation of metamaterial optical properties.

### Executive Ballroom 210D

**16:00–18:00**
**FM4D • Accelerating Beams**
*Presider: Roberto Morandotti; INRS-Energie Mat & Tele Site Varennes, Canada*

**FM4D.1 • 16:00** Tutorial
**Self Accelerating Beams of Photons and Electrons,** Ady Arie[1]; [1]*Tel-Aviv Univ., Israel.* The properties of optical, electron and plasmon beams that preserve their shape, while propagating along curved trajectories in free-space or on a surface are discussed. Methods to generate these beams and potential applications are presented.

Ady Arie is a Professor of Electrical Engineering and the Head of the School of Electrical Engineering at Tel-Aviv University, Israel. He is a Fellow of The Optical Society and a topical editor of Optics Letters. His current research is in the areas of nonlinear optics, plasmonics and electron microscopy.

## CLEO: Science & Innovations

**Executive Ballroom 210E**

**16:00–18:00**

### SM4E • Remote and Stand-off Optical Detection

*Presider: David Sonnenfroh; Physical Sciences Inc., USA*

**SM4E.1 • 16:00**

**Active Coherent Laser Spectrometer (ACLaS) for Standoff Detection of Chemicals,** Neil Macleod[1], Damien Weidmann[1]; [1]*Space Science and Technology Dept., Rutherford Appleton Lab, UK.* An active spectrometer has been developed based on diffuse backscattering by solid targets combined with coherent detection and mid-infrared quantum cascade lasers. High selectivity and sensitivity have been shown at standoff distances of 40 m.

**SM4E.2 • 16:15**

**Stand-Off Spectroscopy and Chemical Sensing using a Femtosecond Optical Parametric Oscillator,** Zhaowei Zhang[1], Rhea J. Clewes[2], Christopher R. Howle[2], Derryck T. Reid[1]; [1]*Scottish Universities Physics Alliance (SUPA), Inst. of Photonics and Quantum Sciences, Heriot-Watt Univ., UK;* [2]*Defence Science and Technology Lab, UK.* Fourier-transform spectroscopy using a femtosecond optical parametric oscillator is demonstrated. Specifically, this system is used to detect a thiodiglycol droplet from concrete and aluminum surfaces and atmospheric water vapor at a 2-m stand-off distance.

**SM4E.3 • 16:30**

**Remote Spectroscopy at Kilometer-Scale Distances via Random Raman Lasing,** Brett H. Hokr[1], Joel N. Bixler[1], Vladislav V. Yakovlev[1], Marlan O. Scully[1,2]; [1]*Texas A&M Univ., USA;* [2]*Princeton Univ., USA.* The single-shot remote identification of chemicals at kilometer-scale distances is experimentally demonstrated utilizing random Raman lasing.

**Executive Ballroom 210F**

**16:00–18:00**

### SM4F • Diode Pumped Mode-locked Oscillators and Amplifiers

*Presider: Todd Clatterbuck; Raytheon SAS, USA*

**SM4F.1 • 16:00**

**Diode-pumped 73-fs Kerr-lens mode-locked Yb:YCa4O(BO3)3 laser,** Ziye Gao[1], Jiangfeng Zhu[1], Wenlong Tian[1], Junli Wang[1], Xiaodong Zeng[1], Zhaohua Wang[2], Zhiguo Zhang[2], Zhiyi Wei[2], Huaijin Zhang[3]; [1]*School of Physics and Optoelectronic Engineering, Xidian Univ., China;* [2]*Beijing National Lab for Condensed Matter Physics, Inst. of Physics, Chinese Academy of Sciences, China;* [3]*State Key Lab of Crystal Material and Inst. for Crystal Material, Shandong Univ., China.* Pulses as short as 73-fs were generated from a Kerr-lens mode-locked Yb:YCa4O(BO3)3 laser at 1043 nm. To the best of our knowledge, this is the first demonstration of a Kerr-lens mode-locked Yb:YCa4O(BO3)3 laser.

**SM4F.2 • 16:15**

**A Mode-Locked Ti:sapphire Laser Pumped Directly with a Green Diode Laser,** Shota Sawai[1], Aruto Hosaka[1], Kenichi Hirosawa[1], Fumihiko Kannari[1]; [1]*Keio Univ., Japan.* We report a mode-locked Ti:Sapphire laser pumped directly with a 1-W InGaN diode laser emitting at 518 nm. Pulse durations as short as 62 fs and average output powers of up to 23.5 mW are obtained.

**SM4F.3 • 16:30**

**$\chi^{(2)}$-Lens Mode-Locking of a High Average Power Nd:$YVO_4$ Laser,** Veselin Aleksandrov[1], Teodora Grigorova[1], Hristo Iliev[2], Anton Trifonov[1], Ivan C. Buchvarov[1]; [1]*Sofia Univ. St. Kliment Ohridski, Bulgaria;* [2]*Binovation Ltd., Bulgaria.* We report 20 W, 6 ps, 170 MHz, passive mode-locking of a Nd:$YVO_4$ laser using $\chi^{(2)}$-lens formation in a LBO frequency doubling crystal. The laser is pumped at 808 nm with optical efficiency of 38%.

**Executive Ballroom 210G**

**16:00–18:00**

### SM4G • Integrated Photonic Devices and Circuits

*Presider: Dominic Siriani, MIT Lincoln Lab, USA*

**SM4G.1 • 16:00**

**Cascaded Performance of a Monolithic MZI-SOA Hybrid Switch,** Qixiang Cheng[1], Adrian Wonfor[1], Jinlong Wei[1], Richard V. Penty[1], Ian H. White[1]; [1]*Engineering Dept., Univ. of Cambridge, UK.* We demonstrate for the first time the feasibility of a 32×32 MZI-SOA hybrid switch by means of a re-circulating loop. A power penalty of less than 2.9dB at a data rate of 10Gb/s is obtained.

**SM4G.2 • 16:15**

**50-dB Extinction-Ratio in 2×2 Silicon Optical Switch with Variable Splitter,** Keijiro Suzuki[1], Guangwei Cong[1], Ken Tanizawa[1], Sang-Hun Kim[1], Shu Namiki[1], Hitoshi Kawashima[1]; [1]*AIST, Japan.* We demonstrate that record-high extinction-ratio of 50 dB is achievable in a 2×2 Si optical switch by making use of a variable splitter. The proposed switch will enable such high extinction-ratio even in volume production.

**SM4G.3 • 16:30**

**Faraday Polarisation Rotation in Semiconductor Waveguides Incorporating Periodic Garnet Claddings,** Cui Zhang[1], Barry Holmes[1], David C. Hutchings[1], Prabesh Dulal[2], Andrew D. Block[2], Sang-Yeob Sung[2], Bethanie Stadler[2]; [1]*School of Engineering, Univ. of Glasgow, UK;* [2]*Univ. of Minnesota, USA.* Nonreciprocal polarisation mode conversion is demonstrated in semiconductor waveguides with an alternating periodic upper cladding incorporating a segmented magneto-optic iron garnet fabricated with a novel lift-off process and crystallised by rapid thermal annealing

**Executive Ballroom 210H**

**16:00–18:00**

### SM4H • Light Emitting Materials and Devices

*Presider: Uriel Levy; Hebrew Univ. of Jerusalem, Israel*

**SM4H.1 • 16:00** Tutorial

**Light Emission from Silicon Photonic Crystals,** Thomas F. Krauss[1]; [1]*Univ. of York, UK.* We review some of the most promising methods for generating light in the silicon photonics context; nonlinear effects, defects, dopants and germanium alloying have all shown promise and can be enhanced using photonic crystals.

Thomas Krauss is Professor of Photonics at the University of York. His work on fundamental and applied concepts in photonic crystals has been pivotal for transforming photonic crystals from a scientific curiosity to the essential building block in photonics that they are today.

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### Meeting Room 211 B/D

## CLEO: Science & Innovations

### 16:00–18:00
### SM4I • Advanced QPM Devices

*Presider: Antoine Godard; ONERA - the French Aerospace Lab, France*

**SM4I.1 • 16:00**
**Complex-Transfer-Function Analysis of Optical-Frequency Converters,** Derek Chang[1,2], Carsten Langrock[1], Corey Bennett[2], Martin M. Fejer[1]; [1]*Stanford Univ., USA;* [2]*Lawrence Livermore National Lab, USA.* We measure the complex transfer function (CTF) of aperiodically poled lithium niobate waveguide devices and investigate the sources of CTF distortions, which are related to variations in the spatial distribution of the nonlinear coefficient and phase-mismatch profile.

**SM4I.2 • 16:15**
**Polarization-entangled photons from domain-engineered, periodically poled $LiNbO_3$,** Paulina S. Kuo[1], Jason Pelc[2], Oliver Slattery[1], Lijun Ma[1], Xiao Tang[1]; [1]*Information Technology Lab, NIST, USA;* [2]*Hewlett-Packard Labs, USA.* Using a domain-engineered, periodically poled $LiNbO_3$ grating, we investigate polarization-entangled photon-pair generation near 1550 nm wavelength using type-II spontaneous parametric down-conversion.

**SM4I.3 • 16:30**
**Single-photon-compatible spectral broadening and shaping via nonlinear mixing and phase modulation,** Imad Agha[1,2], Serkan Ates[2,3], Luca Sapienza[2,3], Kartik Srinivasan[2]; [1]*Physics and Electro-Optics Graduate Program, Univ. of Dayton, USA;* [2]*Center for Nanoscale Science and Technology, National Inst. of Standards and Technology, USA;* [3]*Maryland Nanocenter, Univ. of Maryland, USA.* We experimentally demonstrate spectral broadening and shaping of weak mono-exponentially decaying pulses via nonlinear mixing and phase modulation. This method is compatible with single photons wavepackets generated by quantum emitters.

### Meeting Room 212 A/C

### 16:00–18:00
### SM4J • Free Space Laser Communications

*Presider: Michael Dennis; JHU Applied Physics Lab, USA*

**SM4J.1 • 16:00** Invited
**Overview and On-orbit Performance of the Lunar Laser Communication Demonstration Uplink,** Mark L. Stevens[1], David O. Caplan[1], Robert T. Schulein[1], John J. Carney[1], Robert E. Lafon[2,1], Bryan S. Robinson[1], Don M. Boroson[1], Laura E. Elgin[1], Steven Constantine[1], Joseph A. Greco[1]; [1]*Massachusetts Inst of Tech Lincoln Lab, USA;* [2]*NASA, Goddard Space Flight Center, USA.* We present an implementation overview and demonstrated error-free coded performance over the 400,000-km link between an Earth-based laser communication terminal and the LADEE satellite orbiting the moon at 9.72-Mbps and 19.44-Mbps uplink rates.

**SM4J.2 • 16:30**
**A Receiver for the Lunar Laser Communication Demonstration Using the Optical Communications Telescope Lab,** Matthew Shaw[1], Kevin Birnbaum[1], Michael Cheng[1], Meera Srinivasan[1], Kevin Quirk[1], Joseph Kovalik[1], Abhijit Biswas[1], Andrew D. Beyer[1], Francesco Marsili[1], Varun Verma[2], Richard P. Mirin[2], Sae Woo Nam[2], Jeffrey A. Stern[1], William H. Farr[1]; [1]*Jet Propulsion Lab, USA;* [2]*National Inst. of Standards and Technology, USA.* We discuss the implementation of a receiver for the Lunar Laser Communication Demonstration based on a 12-pixel array of WSi SNSPDs. The receiver was used to close a communication link from lunar orbit at 39 and 79 Mbps.

### Meeting Room 212 B/D

## CLEO: QELS-Fundamental Science

### 16:00–18:00
### FM4K • Localized Plasmon Enhanced Sensing: SERS, SEIRA

*Presider: Jiri Homola; Inst. of Photonics and Electronics, Czech Republic*

**FM4K.1 • 16:00** Invited
**Plasmonics: Quantum on the Angstrom Scale, as Observed by Surface-enhanced Raman Scattering,** Wenqi Zhu[1], Kenneth B. Crozier[1]; [1]*School of Engineering and Applied Sciences, Harvard Univ., USA.* We fabricate plasmonic dimers consisting of two metallic nanostructures spaced by a few angstroms using lithographic methods, and show that quantum mechanical tunneling across the gaps limits the enhancement in surface-enhanced Raman scattering.

**FM4K.2 • 16:30**
**Ultra-sensitive time-resolved infrared spectroscopy of biomolecule interactions with plasmonic nanoantennas,** Ronen Adato[1], Hatice Altug[2,1]; [1]*Boston Univ., USA;* [2]*Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland.* We demonstrate a plasmonically enhanced infrared spectroscopy technology that enables in-situ and real-time measurements of protein and nano particle interactions at ultra-high sensitivity by overcoming fundamental water absorption limitations.

### Marriott Salon I & II

## CLEO: Applications & Technology

### 16:00–18:00
### AM4L • Symposium on Enabling Photonics Technologies for Miniaturization II ▶

*Presider: Yves Bellouard; Eindhoven Univ. of Technology, Netherlands*

**AM4L.1 • 16:00** Invited ▶
**Fabrication of subwavelngth optics using glass imprint process,** Junji Nishii[1]; [1]*Hokkaido Univ., Japan.* Glass imprint process was developed for the fabrication of micro- and nano-structures on the surface of glasses. Application of DC voltage to the mold was effective to suppress the imprint temperature and pressure.

**AM4L.2 • 16:30** Invited ▶
**Micro-Optics Technology Supply Chain as Key-enabler for Applied Research and Industrial Innovation,** Hugo Thienpont[1], Jürgen Van Erps[1]; [1]*Brussels Photonics Team, Vrije Universiteit Brussel, Belgium.* We present our polymer micro-optics technology supply chain and its key constituents. We show how it is a key-enabler for frontier applied research and demonstrate how it paves the way towards efficient technology take-up and effective industrial innovation.

## Marriott
## Salon III

### 16:00–18:00
### SM4M • Photonic Crystals ▶
*Presider: Paul Barclay, Univ. of Calgary, Canada*

**SM4M.1 • 16:00** ▶
**Buried-Heterostructure L3 Nanocavity All-Optical Memory with 2.3-nW Power Consumption,** Eiichi Kuramochi[1,2], Kengo Nozaki[1,2], Akihiko Shinya[1,2], Hideaki Taniyama[1,2], Koji Takeda[1,3], Tomonari Sato[1,3], Shinji Matsuo[1,3], Masaya Notomi[1,2]; *[1]NTT Nanophotonics Center, NTT Corporation, Japan; [2]NTT Basic Research Labs, NTT Corporation, Japan; [3]NTT Photonics Labs, NTT Corporation, Japan.* A tuned L3 design with an enhanced Q factor and a small mode volume enabled 2.3-nW bias power for a buried-heterostructure InGaAsP/InP nanocavity optical memory that was 1/10 of the previous record (30 nW).

**SM4M.2 • 16:15** ▶
**L3 Photonic Crystal Nanocavities with Measured Q-factor Exceeding One Million,** Yiming Lai[1], Stefano Pirotta[2], Giulia Urbinati[2], Dario Gerace[2], Matteo Galli[2], Momchil Minkov[3], Vincenzo Savona[3], Antonio Badolato[1]; *[1]Physics and Astronomy, Univ. of Rochester, USA; [2]Physics, Università di Pavia, Italy; [3]Lab of Theoretical Physics of Nanosystems, Ecole Polytechnique Federale de Lausanne EPFL, Switzerland.* We experimentally demonstrate ultra-high quality factors (Q = 1.45×10^6) in evolutionary optimized 2D L3 photonic crystal nanocavities fabricated in Si slabs. Together with ultra-small effective mode volumes ~ 0.96(λ/n)^3, such a nanocavity offers a new platform in future integrated nanophotonics.

**SM4M.3 • 16:30** Invited ▶
**High-Q Optical Nanocavities in Bulk Single-crystal Diamond,** Michael Burek[1], Yiwen Chu[2], Madelaine Liddy[3], Parth Patel[3], Jake Rochman[3], Mikhail Lukin[2], Marko Loncar[1]; *[1]School of Engineering and Applied Sciences, Harvard Univ., USA; [2]Dept. of Physics, Harvard Univ., USA; [3]Univ. of Waterloo, Canada.* Optical nanocavities (racetrack resonators and photonic crystal cavities) are fabricated in bulk single-crystal diamond via angled-etching. Devices operating in the telecom band exhibited Q-factors exceeding 10^5, while devices in the visible yielded Q-factors approaching 10^4.

## Marriott
## Salon IV

### 16:00–18:00
### SM4N • Nonlinear Optical Effects in Fibers
*Presider: Axel Schulzgen; Univ. of Central Florida, USA*

**SM4N.1 • 16:00**
**Visible Light Stimulated Brillouin Scattering in Small-Core Photonic Crystal Fibers,** Robert I. Woodward[1], Edmund J. Kelleher[1], Sergei V. Popov[1], James R. Taylor[1]; *[1]Femtosecond Optics Group, Imperial College London, UK.* A reduced stimulated Brillouin scattering threshold power in small-core PCFs is achieved using visible wavelength excitation. We explain this in the context of acousto-optic interactions at length-scales relative to the fiber geometry.

**SM4N.2 • 16:15**
**Operation of regenerative sources based on alternating SPM and SSFS,** Thibault North[1], Alaa Al-kadry[1], Martin Rochette[1]; *[1]Electrical and Computer Engineering, McGill Univ., Canada.* We report on the operation of regenerative sources based on self-phase modulation (SPM) and soliton self-frequency shift (SSFS). Such stochastic sources generate a wide continuum spreading over 450 nm.

**SM4N.3 • 16:30**
**Thulium Assisted Parametric Conversion from Near to Short Wave Infrared,** Adrien Billat[1], Steevy Cordette[1], Yu-Pei Tseng[1], Camille-Sophie Brès[1]; *[1]Photonic Systems Lab, EPFL, Switzerland.* We report an all-fiber continuous wave source, tunable between 1935-1980nm, based on parametric conversion combined with thulium amplification. More than 150mW of power and 30dB optical signal-to-noise ratio is obtained over the entire range.

## Marriott
## Salon V & VI

### 16:00–18:00
### SM4O • Symposium on Large-Scale Silicon Photonic Integration II ▶
*Presider: Christian Malouin; Juniper Networks Inc., USA*

**SM4O.1 • 16:00** Invited ▶
**Highly Integrated Silicon Photonic Integrated Circuits for Telecommunications,** Christopher R. Doerr[1]; *[1]Acacia Communications, Inc., USA.* We discuss silicon photonic integrated circuits for telecommunications that integrate many elements. We include transmitters, receivers, transceivers, and add-drop filters. Advanced modulation formats and coherent systems are especially investigated.

**SM4O.2 • 16:30** Invited ▶
**Silicon photonics transmitters and receivers for 4x25 Gb/s interconnects,** Mehdi Asghari[1], Dazeng Feng[1], Jonathan Luff[1], Shashank Jatar[1], Roshanak Shafiiha[1], Pegah Seddighian[1], Saeed Fathololoumi[1], Bhavin Bijlani[1], Daniel C. Lee[1], Zhi Li[1], Joe Zhou[1], Jacob Levy[1], Wei Qian[1], Hong Liang[1], Yann Malinge[1], Chris Keller[1]; *[1]Mellanox, USA.* In this talk, we will review the latest progress of the highly integrated Silicon photonics devices for 4x25 Gb/s active optical cables and transceivers. This includes hybrid lasers, WDM multiplexers, electro-absorption modulators, and germanium detectors.

## Marriott
## Willow Glen I-III

### 16:00–18:00
### SM4P • Bioimaging II: Thermal, Speciral and Nanoparticles ▶
*Presider: Chulmin Joo; Yonsei Univ., Korea*

**SM4P.1 • 16:00** ▶
**Subdiffraction-Limited Quantum Imaging of a Living Cell,** Michael Taylor[1], Jiri Janousek[2], Vincent Daria[2], Joachim Knittel[1], Boris Hage[2], Hans Bachor[2], Warwick P. Bowen[1]; *[1]Univ. of Queensland, Australia; [2]Australian National Univ., Australia.* Spatial variations in the thermal motion of a nanoparticle are mapped with quantum enhanced precision over an extended region of a cell. This enables both subdiffraction-limited quantum metrology and quantum enhanced spatial resolution in biology.

**SM4P.2 • 16:15** ▶
**3-D Imaging of Malaria-infected Human Red Blood Cells Using Optical Diffraction Tomography,** Kyoohyun Kim[1], HyeOk Yoon[1,2], YongKeun Park[1]; *[1]Dept. of Physics, KAIST, Korea; [2]Dept. of Applied Physics, Stanford Univ., USA.* We measure 3-D refractive index distributions of malaria-infected red blood cells (RBCs) using optical diffraction tomography. Optical diffraction tomography reveals high resolution details of morphological changes in RBCs during the intraerythrocytic cycles of malaria parasites.

**SM4P.3 • 16:30** ▶
**in vivo Photothermal Optical Coherence Tomography of Targeted Mouse Brain Tumors using Gold Nanostars,** Jung Heo[1], Eunji Jang[2], Seungjoo Haam[2], Seung Jae Oh[3], Yong-Min Huh[3], Jin-Suck Suh[3], Euiheon Chung[4], Chulmin Joo[1]; *[1]Mechanical Engineering, Yonsei Univ., Korea; [2]Chemical and Biomolecular Engineering, Yonsei Univ., Korea; [3]YUHS-KRIBB Medical Convergence Research Inst., Korea; [4]Medical System Engineering & Mechatronics, GIST, Korea.* We present structural and molecular-contrast imaging of mouse brain tumors using photothermal optical coherence tomography (PT-OCT) in vivo. Based on strong PT response of gold nanostars, we demonstrate clear visualization of brain cancer margins.

## CLEO: QELS-Fundamental Science

### Executive Ballroom 210A

### FM4A • Quantum Key Distribution—Continued

**FM4A.4 • 16:45**
**Squeezed-State Measurement-Device-Independent Quantum Key Distribution,** Yi-Chen Zhang[1], Song Yu[1], Wanyi Gu[1]; [1]*Beijing Univ. of Posts and Telecommunications, China.* We report a squeezed-state measurement-device-independent quantum key distribution protocol, which could greatly increase the maximum transmission distance and enhance the robustness to channel noise than the coherent-state based protocol.

**FM4A.5 • 17:00**
**Nonlocal Interferometry Using Macroscopic States and State Discrimination,** Brian T. Kirby[1], James D. Franson[1]; [1]*Univ. of Maryland Baltimore County, USA.* A nonlocal interferometer that can violate Bell's inequality using macroscopic phase-entangled coherent states is described. An operating range of 400 km in optical fiber can be achieved using state discrimination techniques.

**FM4A.6 • 17:15**
**Direct Counterfactual Communication with Single Photons,** Yuan Cao[1,2], Yu-Huai Li[1,2], Zhu Cao[3], Juan Yin[1,2], Yuao Chen[1,2], Xiongfeng Ma[3], Cheng-Zhi Peng[1,2], Jian-Wei Pan[1,2]; [1]*Shanghai Branch, Hefei National Lab for Physical Sciences at Microscale and Dept. of Modern Physics, Univ. of Science and Technology of China, China;* [2]*Synergetic Innovation Center of Quantum Information & Quantum Physics, Univ. of Science and Technology of China, China;* [3]*Center for Quantum Information, Inst. for Interdisciplinary Information Sciences, Tsinghua Univ., China.* Using a single photon source, we experimentally demonstrate counterfactual communication and successfully transfer a monochrome bitmap from one location to another by employing a nested version of the quantum Zeno effect.

### Executive Ballroom 210B

### FM4B • Dynamics in Strongly Correlated Materials—Continued

**FM4B.4 • 16:45**
**Probing Giant Magnetoresistance with THz Spectroscopy,** Zuanming Jin[1], Alexander Tkach[2], Frederick Casper[2], Victor Spetter[3], Hubert Grimm[3], Mathias Kläui[2], Mischa Bonn[1], Dmitry Turchinovich[1,4]; [1]*Max Planck Inst. for Polymer Research, Germany;* [2]*Institut für Physik, Johannes Gutenberg-Universität Mainz, Germany;* [3]*Sensitec GmbH, Germany;* [4]*DTU Fotonik, Technical Univ. of Denmark, Denmark.* We observe a giant magnetoresistance effect in CoFe/Cu-based multistack using THz time-domain spectroscopy. The magnetic field-dependent dc conductivity, electron scattering time, as well as spin-asymmetry parameter of the structure are successfully determined.

**FM4B.5 • 17:00**
**Ultrafast optical manipulation of interfacial magnetoelectric coupling,** Yu-Miin Sheu[1], Stuart A. Trugman[1], Li Yan[1], Quanxi Jia[1], Antoinette Taylor[1], Rohit P. Prasankumar[1]; [1]*Los Alamos National Lab, USA.* We demonstrate a new paradigm for all-optical detection and control of interfacial magnetoelectric coupling on ultrafast timescales, achieved by using time-resolved second harmonic generation (SHG) in a ferroelectric/ferromagnet oxide heterostructure.

**FM4B.6 • 17:15**
**Studying Correlated Electron Systems With a New Tunable (<25 eV) Tabletop XUV Source,** Arthur K. Mills[1], Sergey Zhdanovich[1], Elia Rampi[1], Riccardo Comin[1], Giorgio Levy[1,2], Andrea Damascelli[1,2], David J. Jones[1]; [1]*Physics and Astronomy, Univ. of British Columbia, Canada;* [2]*Quantum Materials Inst., Univ. of British Columbia, Canada.* We characterize a new table-top, tunable XUV source spanning 8 to 25 eV based on a femtosecond enhancement cavity. This source is designed to investigate correlated electron systems with angle and time resolved photoemission spectroscopy.

### Executive Ballroom 210C

### FM4C • Novel Optics I—Continued

**FM4C.4 • 16:45**
**Quasi-PT Symmetry in Waveguide Optical Directional Couplers,** Marco Ornigotti[1], Alexander Szameit[1], Toni Eichelkraut[1]; [1]*Institut für Angewandte Physik, Friedrich-Schiller Universität, Germany.* A comparison between light dynamics in PT-symmetric and passive optical coupler is presented. We show that, apart from an overall damping factor, the dymanics in the passive coupler fully reproduce the PT-symmetric ones.

**FM4C.5 • 17:00**
**High-temperature plasmonic thermal emitter for thermo-photovotaics,** Jingjing Liu[1], Urcan Guler[1], Wei Li[1,2], Alexander Kildishev[1], Alexandra Boltasseva[1,3], Vladimir M. Shalaev[1]; [1]*Purdue Univ., USA;* [2]*Wuhan Univ. of Technology, China;* [3]*Technical Univ. of Denmark, Denmark.* We use titanium nitride (TiN) to demonstrate an ultra-thin plasmonic thermal emitter operating at high temperatures (830 K). The spectrally selective emitter exhibits a large emittance at around 2.5 µm and below, and suppresses emission at longer wavelengths.

**FM4C.6 • 17:15**
**Tunable hyperbolic metamaterials using metal-insulator transition in VO2,** Harish Krishnamoorthy[1,2], You Zhou[3], Shriram Ramanathan[3], Evgenii Narimanov[4], Vinod M. Menon[1,2]; [1]*Physics, CUNY Queens College, USA;* [2]*Physics, Graduate Center of CUNY, USA;* [3]*School of Engineering and Applied Science, Harvard Univ., USA;* [4]*Electrical and Computer Engineering, Purdue Univ., USA.* We present a tunable hyperbolic metamaterial by exploiting the metal-insulator phase transition in vanadium oxide and demonstrate the transition of its in-plane dielectric constant from positive to negative value by temperature control.

### Executive Ballroom 210D

### FM4D • Accelerating Beams—Continued

**FM4D.2 • 17:00**
**Incoherent Nonparaxial Accelerating Beams,** Yaakov Lumer[1], Ran Schley[1], Ido Kaminer[1], Elad Greenfield[1], Mordechai Segev[1]; [1]*Technion Israel Inst. of Technology, Israel.* Accelerating beams completely rely on interference: coherent superposition of waves. In spite of that fundamental feature, we demonstrate, experimentally and theoretically, partially-spatially-incoherent nonparaxial accelerating beams.

**FM4D.3 • 17:15**
**Radially Self-Accelerating Beams,** Christian Vetter[1], Toni Eichelkraut[1], Marco Ornigotti[1], Alexander Szameit[1]; [1]*Inst. of Applied Physics, Friedrich-Schiller-Universität, Germany.* We report on optical non-paraxial beams that exhibit a self-accelerating behavior in radial direction. Hence, the intensity profile evolves on a spiraling trajectory. The beam parameters have been optimized for high contrast and rotation rate.

## SM4E • Remote and Stand-off Optical Detection—Continued

**SM4E.4 • 16:45**
**Towards remote magnetic anomaly detection using Radar REMPI,** Arthur Dogariu[1], Tat Loon Chng[1], Richard Miles[1]; [1]*Princeton Univ., USA.* We demonstrate remote trace detection of Xe in air using microwave scattering off plasma induced by resonant laser ionization. For the purpose of magnetic detection we propose using isotopic Xe rotationally polarized via double resonant three photon pumping.

**SM4E.5 • 17:00**
**Electrical, parametric down-conversion methodology for high-speed, low-noise, and narrow-bandwidth photodetection,** Andreas Hangauer[1], Gerard Wysocki[1]; [1]*Electrical Engineering Dept., Princeton Univ., USA.* We investigate methods to modulate the photodiode responsivity for high-speed photodetection, i.e., parametric down-conversion. Electrical modulation is preferred over optical modulation and gives near optimum efficiency of ~20%. Applications are near- and mid-infrared spectroscopy methods.

**SM4E.6 • 17:15**
**Sensitivity in Synthetic Aperture Ladar Imaging,** Jason Dahl[1], Zeb W. Barber[1]; [1]*The Spectrum Lab, Montana State Univ., USA.* Synthetic Aperture Ladar (SAL) imaging experiments show that cross-range compression, including image based phase error correction, can be performed at very low return light levels. This includes images where the precompression shot-noise-limited signal-to-noise ratio is much less than unity.

## SM4F • Diode Pumped Mode-locked Oscillators and Amplifiers—Continued

**SM4F.4 • 16:45**
**Mode-locked Nd3+,Y3+:SrF2 laser with 181 fs pulse duration,** Long Wei[1,2], Wenlong Tian[1,2], Jiaxing Liu[1], Zheng Zhu[1], Hainian Han[1], Zhiyi Wei[1], Liangbi Su[3], Jun Xu[3]; [1]*Inst. of Physics, Chinese Academy of Sciences, China;* [2]*Xidian Univ., China;* [3]*Key Lab of Transparent and Opto-functional Inorganic Materials, Shanghai Inst. of Ceramics, CAS, China.* We demonstrate a mode-locked Nd3+,Y3+:SrF2 laser for the first time. Pumped with 1.5W continuous Ti:sapphire laser, average output power of 280mW was obtained with pulse duration of 181fs at central wavelength of 1057 nm.

**SM4F.5 • 17:00**
**Generation of 61fs pulse from a diode-pumped Yb:LYSO laser with SESAM for mode-locking,** Wenlong Tian[1,2], Zhaohua Wang[1], Zhiyi Wei[1], Jiangfeng Zhu[2], Lihe Zheng[3], Jun Xu[3]; [1]*Beijing National Lab for Condensed Matter Physics, Inst. of Physics, Chinese Academy of Sciences, China;* [2]*School of Physics and Optoelectronic Engineering, Xidian Univ., China;* [3]*Key Lab of Transparent and Opto-functional Inorganic Materials, Shanghai Inst. of Ceramics, China.* We report a diode-pumped Yb:LYSO laser with a SESAM for mode-locking. Pulse with duration as short as 61 fs was obtained at repetition rate of 113 MHz. The average output power was 40 mW.

**SM4F.6 • 17:15**
**Gigahertz diode-pumped Yb:CALGO laser with 60-fs pulses and an average output power of 3.5 W,** Alexander Klenner[1], Matthias Golling[1], Ursula Keller[1]; [1]*Eidgenossische Technische Hochschule Zurich, Switzerland.* We present a SESAM modelocked diode-pumped Yb:CaGdAlO4 laser with a 1.8 GHz repetition-rate, a 3.5 W average output power and a 60-fs pulse duration, which results in a record high peak power of 28.9 kW.

## SM4G • Integrated Photonic Devices and Circuits—Continued

**SM4G.4 • 16:45**
**Reconfigurable Thermo-Optic Polymer Switch Based True-Time-Delay Network Utilizing Imprinting and Inkjet Printing,** Zeyu Pan[1], Harish Subbaraman[2], Xiaohui Lin[1], Qiaochu Li[3], Cheng Zhang[3], Tao Ling[3], L. Jay Guo[3], Ray Chen[1]; [1]*Dept. of Electrical and Computer Engineering, The Univ. of Texas at Austin, USA;* [2]*Omega Optics, Inc, USA;* [3]*Dept. of Electrical Engineering & Computer Science, The Univ. of Michigan, USA.* Reconfigurable true-time-delay lines, comprising of 2x2 thermo-optic polymer switches and rib waveguides are fabricated utilizing a combination of roll-to-roll (R2R) compatible UV imprinting and ink-jet printing, which promises high throughput and low cost photonic devices.

**SM4G.5 • 17:00**
**Integrated Al2O3:Er3+ DFB Laser for Temperature Control Free Operation with Silicon Nitride Ring Filter,** Purnawirman Purnawirman[1], Ehsan S. Hosseini[1], Michele Moresco[1], Zhan Su[1], Erman Timurdogan[1], Anna Baldycheva[1], Jie Sun[1], Michael R. Watts[1], Thomas Adam[2], Gerald Leake[2], Douglas Coolbaugh[2]; [1]*MIT, USA;* [2]*CNSE, Univ. of Albany, USA.* We demonstrate almost synchronized temperature dependent wavelength shift of Al2O3:Er3+ DFB laser (2.57 GHz/oC) and Si3N4 ring filter (2.47 GHz/oC), which makes it possible for on-chip transceiver operation without temperature control.

**SM4G.6 • 17:15**
**Wavelength-Tracking Tunable Photodetector,** Stephen Adair Gerke[1], Weijian Yang[1], Connie J. Chang-Hasnain[1]; [1]*U.C. Berkeley, USA.* We report on a 1550 nm tunable high-speed photodetector configured to exhibit self-wavelength-tracking behavior. This enables a low-cost WDM system showing resilience to wavelength drift.

## SM4H • Light Emitting Materials and Devices—Continued

**SM4H.2 • 17:00**
**Spontaneous emission control of InGaN/GaN pyramidal structure by localized surface plasmonic modes,** Su-Hyun Gong[1], Je-Hyung Kim[1], Yong-Ho Ko[1], Yong-Hoon Cho[1]; [1]*KAIST, Korea.* To improve poor emissions from quantum wires and dots in GaN pyramidal structure, we introduced silver film on pyramid structure. Due to the pyramidal geometry, we could successfully control the spontaneous emission of these structures.

**SM4H.3 • 17:15**
**Tensile-strained, Heavily N-doped Germanium-On-Insulator for Light Emitting Devices on Silicon,** Xuejun Xu[1], Keisuke Nishida[1], Kentarou Sawano[1], Takuya Maruizumi[1], Yasuhiro Shiraki[1]; [1]*Tokyo City Univ., Japan.* Strong direct gap light emission is obtained from germanium-on-insulator (GOI) with tensile strain of 0.16% and ultra-high n-type doping concentration up to 1.0×10^20 cm^−3. Microdisk resonators are also fabricated on GOI and show modulated emission spectra.

**Thank you for attending CLEO: 2014.**

**Look for your post-conference survey via email and let us know your thoughts on the program.**

## Meeting Room 211 B/D

## CLEO: Science & Innovations

### SM4I • Advanced QPM Devices—Continued

**SM4I.4 • 16:45**
**Double-Prism Domain PPLN as Simultaneously a Laser Q-Switch and an Optical Parametric Down Converter in a Nd:YVO4 Laser,** Yen-Hung Chen[1], Wei-Kun Chang[1], Hung-Ping Chung[1], Jin-feng Huang[1], Shang-Sheng Huang[1], Jui-Wen Chang[1]; [1]*Dept. of Optics and Photonics, National Central Univ., Taiwan.* We report a tunable pulsed optical parametric oscillator using a double-prism domain PPLN as simultaneously an electro-optic Q-switch and a parametric generator in a Nd:YVO4 laser. >2.3-kW peak-power eye-safe light was obtained with this system.

**SM4I.5 • 17:00**
**Thermal Management in High-Power Continuous-Wave Second Harmonic Generation,** Suddapalli Chaitanya Kumar[1], Saeed Ghavami Sabouri[2], A. Khorsandi[2], Majid Ebrahim-Zadeh[1,3]; [1]*ICFO -The Inst. of Photonic Sciences, Spain;* [2]*Univ. of Isfahan, Islamic Republic of Iran;* [3]*Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain.* We report a systematic study of thermal effects in high-power single-pass SHG in the presence of absorption, and propose an optimum heating configuration for the crystal to minimize thermal lensing at various fundamental power levels.

**SM4I.6 • 17:15**
**Monolithic Fan-out PPMgSLT device for cascaded 355nm generation,** Junji Hirohashi[1], Tetsuo Taniuchi[2], Satoshi Makio[1], Koichi Imai[1], Masami Hatori[1], Hiroshi Motegi[1], Yasuhiro Tomihari[1], Masayuki Hoshi[1], Yasunori Furukawa[1]; [1]*Oxide Corporation, Japan;* [2]*FRIS, Tohoku Univ., Japan.* Monolithic Fan-out PPMgSLT device is demonstrated to generate third harmonic generation from 1064nm laser. By integrating single and fan-out QPM structures into one device, 100mW of third harmonic was obtained without any critical tunings.

## Meeting Room 212 A/C

### SM4J • Free Space Laser Communications—Continued

**SM4J.3 • 16:45**
**Simulating Atmospheric Turbulence Using a Spatial Light Modulator based on Fourier Transform,** Xu Tong[1]; [1]*BUPT, China.* We present an atmospheric turbulence simulator based on a spatial light modulator, using phase screens generated by Fourier Transform method. The effects of different atmospheric turbulence on laser beam are successfully demonstrated.

**SM4J.4 • 17:00**
**A Multimode Fiber-coupled Photon-counting Optical Receiver for the Lunar Laser Communication Demonstration,** Matthew E. Grein[1], Oleg Shatrovoy[1], Daniel Murphy[1], Bryan S. Robinson[1], Don M. Boroson[1]; [1]*Massachusetts Inst of Tech Lincoln Lab, USA.* We designed and successfully demonstrated a multimode fiber-coupled photon-counting optical receiver at 1550 nm for the Lunar Laser Communications Demonstration that achieves low coupling loss through atmospheric turbulence without requiring adaptive optics.

**SM4J.5 • 17:15**
**A fiber-coupled photon-counting optical receiver based on NbN superconducting nanowires for the Lunar Laser Communication Demonstration,** Matthew E. Grein[1], Matthew Willis[1], Andreew Kerman[1], Eric Dauler[1], Barry Romkey[1], Danna Rosenberg[1], Jung Yoon[1], Richard Molnar[1], Bryan S. Robinson[1], Daniel Murphy[1], Don M. Boroson[1]; [1]*Massachusetts Inst of Tech Lincoln Lab, USA.* We have designed and demonstrated a multimode fiber-coupled optical receiver based on NbN superconducting nanowires for the Lunar Laser Communications Demonstration and achieved error-free operation at 622 Mb/s over the ~400,000 km link.

## Meeting Room 212 B/D

## CLEO: QELS-Fundamental Science

### FM4K • Localized Plasmon Enhanced Sensing: SERS, SEIRA—Continued

**FM4K.3 • 16:45**
**Optimizing the Surface Enhanced Raman Signal for Accurate Identification of DNA Base Pairs,** Lindsay Freeman[1], Lin Pang[1], Yeshaiahu Fainman[1]; [1]*Univ. of California, San Diego, USA.* DNA sequencing currently lacks optical based techniques such as Raman spectroscopy. We have identified previous issues that prevented sequencing with Raman measurements and proposed a solution for base pair identification via surface enhanced Raman spectroscopy.

**FM4K.4 • 17:00**
**10^10 Electromagnetic SERS enhancement in a nanosphere-plane junction under radially polarized focused excitation,** Jing Long[1], Hui Yi[1], Hongquan Li[1], Xiaolong He[1], Tian Yang[1]; [1]*UM-SJTU Joint Inst., Shanghai Jiao Tong Univ., China.* A monolayer of MGITC molecules in a gold nanosphere-plane junction is excited by focusing a radially polarized laser beam. A record electromagnetic enhancement factor of 10^10 for deterministic SERS experiments has been obtained.

**FM4K.5 • 17:15**
**3D plasmonic nanostructures as building blocks for ultrasensitive Raman spectroscopy,** Andrea Toma[1], Manohar Chirumamilla[1], Anisha Gopalakrishnan[1], Gobind Das[1], Remo Proietti Zaccaria[1], Roman Krahne[1], Eliana Rondanina[1], Marco Leoncini[1], Carlo Liberale[1], Francesco De Angelis[1], Enzo Mario Di Fabrizio[2,3]; [1]*Italian Inst. of Technology, Italy;* [2]*PSE and BESE divisions, King Abdullah Univ. of Science and Technology, Saudi Arabia;* [3]*Dipartimento di Medicina Sperimentale e Clinica, Università Magna Graecia di Catanzaro, Italy.* The fabrication of complex 3D plasmonic nanostructures opens new scenarios towards the realization of high electric field confinement and enhancement. We exploit the unique properties of these nanostructures for performing Raman spectroscopy in the single/few molecules detection limit.

## Marriott Salon I & II

## CLEO: Applications & Technology

### AM4L • Symposium on Enabling Photonics Technologies for Miniaturization II—Continued

**AM4L.3 • 17:00** Invited ▶
**Optically driven microfluidic devices produced by two-photon microfabrication,** Shoji Maruo[1]; [1]*Yokohama National Univ., Japan.* Optically driven microfluidic devices such as micropumps have been developed by two-photon microfabrication. We also developed metalized micromachines driven by an ultralow power laser beam by the combination of two-photon microfabrication and electroless plating.

## CLEO: Science & Innovations

### Marriott Salon III

### SM4M • Photonic Crystals—Continued

**SM4M.4 • 17:00** ▶
**Photonic Crystal Cavities in Cubic Silicon Carbide,** Marina Radulaski[1], Sonia Buckley[1], Linda Zhang[1], Armand Rundquist[1], Thomas Babinec[1], J. Provine[2], Kassem AlAssaad[3], Gabriel Ferro[3], Jelena Vuckovic[1]; [1]*E. L. Ginzton Lab, Stanford Univ., USA;* [2]*Dept. of Electrical Engineering, Stanford Univ., USA;* [3]*Laboratorie des Multimateriaux et Interfaces, Universite de Lyon, France.* We present high quality factor (Q ~ 1,000) photonic crystal cavities in cubic silicon carbide (3C-SiC) films grown directly on silicon. We show results in shifted-L3 and nanobeam cavity geometries for applications in nonlinear and quantum photonics.

**SM4M.5 • 17:15** ▶
**Fabrication and optimization for waveguides in sub-micron scale hyperuniform disordered photonic bandgap materials,** Sam Tsitrin[1], Marian Florescu[2], Milan Miloševč[3], Geev Nahal[1], Ruth A. Mullen[3], Paul Steinvurzel[4], Sal Torquato[4], Paul Chaikin[5], Weining Man[1]; [1]*San Francisco State Univ., USA;* [2]*Advanced Technology Inst.,, Univ. of Surrey, UK;* [3]*Etaphase, Inc.,, USA;* [4]*Princeton Univ., USA;* [5]*New York Univ., USA.* We report experimental and simulation results for low-loss wave-guiding in Si-based hyperuniform disordered photonic bandgap materials at infrared wavelengths. These results pave the way for deploying disordered photonic solids in integrated photonic circuits.

### Marriott Salon IV

### SM4N • Nonlinear Optical Effects in Fibers—Continued

**SM4N.4 • 16:45**
**Four-Wave Mixing and Bragg Scattering in Resonant Seed Modulation Instability in Optical Fiber,** Duc Minh NGUYEN[1,2], Yang Di[3,4], Cesare Soci[2], Xuan Quyen Dinh[1,5], Ming Tang[4], Ping Perry Shum[1,3]; [1]*CINTRA CNRS/NTU/THALES, UMI 3288, Nanyang Technological Univ., Singapore;* [2]*Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore;* [3]*OPTIMUS, Photonics Centre of Excellence, Nanyang Technological Univ., Singapore;* [4]*NGIA, Huazhong Univ. of Science and Technology, China;* [5]*R&T Centre, Thales Solutions Asia Pte. Ltd., Singapore.* We interpret physically the dynamics of resonant seed modulation instability of quasi-continuous picosecond pulses in terms of cascaded four-wave mixing and Bragg scattering. We also report a critical condition to excite the resonant seeding effect.

**SM4N.5 • 17:00**
**Experimental Observation Tunable Second-harmonic Generation in a Chalcogenide-tellurite Hybrid Optical Fiber,** Tonglei Cheng[1], Weiqing Gao[1], Hiroyasu Kawashima[1], Dinghuan Deng[1], Meisong Liao[1], Morio Matsumoto[2], Takashi Misumi[2], Takenobu Suzuki[1], Yasutake Ohishi[1]; [1]*ofmlab, Japan;* [2]*Furukawa Denshi Co., Ltd., Japan.* When the chalcogenide-tellurite hybrid optical fiber is pumped by an optical parametric oscillator with the pump wavelength from 1700 to 3000 nm, widely tunable second-harmonic generation (SHG) from 850 nm to 1502 nm is obtained.

**SM4N.6 • 17:15**
**Improvement of Optical Signal-to-Noise Ratio of a High-Power Pump by Stimulated Brillouin Scattering in an Optical Fiber,** Michel E. Marhic[1], Noran A. Cholan[2]; [1]*Swansea Univ., UK;* [2]*Universiti Putra Malaysia, Malaysia.* We propose and demonstrate improvement of optical signal-to-noise ratio of a high-power pump by saturated stimulated Brillouin amplification of a backward seed in a fiber. A 27-dB improvement was obtained for a 1-W pump.

### Marriott Salon V & VI

### SM4O • Symposium on Large-Scale Silicon Photonic Integration II—Continued

**SM4O.3 • 17:00** Invited ▶
**A WDM CMOS Photonic Platform for Chip-to-Chip Optical Interconnects,** Xuezhe Zheng[1], Ashok V. Krishnamoorthy[1]; [1]*Oracle Corporation, USA.* Optical interconnects play a continually-increasing role in the interconnect hierarchy of high-speed digital systems. We present our vision for photonically-interconnected many-chip modules and progress toward an ultra-dense, low-power silicon photonic technology that supports this vision.

### Marriott Willow Glen I-III

### SM4P • Bioimaging II: Thermal, Speciral and Nanoparticles—Continued

**SM4P.4 • 16:45** ▶
**Ultrahigh-resolution optical coherence tomography using supercontinuum source in 1.9 µm wavelength region,** Hiroyuki Kawagoe[1], Norihiko Nishizawa[1]; [1]*Electrical Engineering and Computer Science, Nagoya Univ., Japan.* Ultrahigh-resolution OCT in 1.9 µm wavelength region was demonstrated using fiber laser supercontinuum. The wavelength dependence of imaging was investigated, and the decrement in attenuation coefficient in longer-wavelength was confirmed for tooth sample.

**SM4P.5 • 17:00** ▶
**Deep tissue imaging using Nd-doped upconverting nanoparticles,** Haichun Liu[1], Can T Xu[1], Hugo Söderlund[1], Monirehalsadat Mousavi[1], Stefan Andersson-Engels[1]; [1]*Physics, Lund Univ., Sweden.* Deep tissue excitation of upconverting nanoparticles is limited for biomedical applications by water absorption. By modifying the nanoparticles to shift the excitation wavelength, we demonstrate better depth sensitivity.

**SM4P.6 • 17:15** ▶
**Detection of Single Nanoparticles Using Photonic Crystal Enhanced Microscopy,** Yue Zhuo[1], Huan Hu[2], Weili Chen[2], Meng Lu[2], Limei Tian[3], Hojeong Yu[2], Kenneth D. Long[1], Edmond Chow[4], William P. King[5,6], Srikanth Singamaneni[3], Brian T. Cunningham[1,2]; [1]*Bioengineering, Univ. of Illinois at Urbana-Champaign, USA;* [2]*Electrical and Computer Engineering, Univ. of Illinois at Urbana-Champaign, USA;* [3]*Mechanical Engineering and Materials Science, Washington Univ. in St. Louis, USA;* [4]*Micro and Nanotechnology Lab, Univ. of Illinois at Urbana-Champaign, USA;* [5]*Mechanical Science and Engineering, Univ. of Illinois at Urbana-Champaign, USA;* [6]*Materials Science and Engineering, Univ. of Illinois at Urbana-Champaign, USA.* We demonstrate a label-free biosensor imaging approach that utilizes a photonic-crystal surface to detect attachment of individual nanoparticles down to 65x30x30nm$^3$.Matching nanoparticle plasmon resonant-frequency to the photonic-crystal resonance substantially increases sensitivity of the approach.

## CLEO: QELS-Fundamental Science

### Executive Ballroom 210A

### FM4A • Quantum Key Distribution—Continued

**FM4A.7 • 17:30**
**Experimental heralded amplification of time-bin qubits,** Natalia Bruno[1], Anthony Martin[1], Nicolas Sangouard[1], Hugo Zbinden[1], Nicolas Gisin[1], Rob Thew[1]; [1]*Group of Applied Physics, Switzerland.* We present an experimental realisation of heralded amplification of time-bin qubits for quantum communication, based on a source of separable photons at telecom wavelengths, with Hong-Ou-Mandel visibility > 90% without any filtering and high coupling efficiency.

**FM4A.8 • 17:45**
**Mapping Qubit Protocols to Coherent-State Protocols in Quantum Communication,** Juan Miguel Arrazola[1], Norbert Lutkenhaus[1]; [1]*Physics, Inst. for Quantum Computing, Univ. of Waterloo, Canada.* We introduce a general mapping for encoding quantum communication protocols involving pure states of multiple qubits, into another set of protocols that employ coherent states of light, linear optics transformations and measurements with single-photon threshold detectors.

### Executive Ballroom 210B

### FM4B • Dynamics in Strongly Correlated Materials—Continued

**FM4B.7 • 17:30**
**Hotspot Dynamics in Current Carrying WSi Superconducting Nanowires,** Francesco Marsili[1], Martin J. Stevens[2], Alexander Kozorezov[3], Varun B. Verma[2], Colin Lambert[3], Jeffrey A. Stern[1], Robert Horansky[2], Shellee D. Dyer[2], Matthew D. Shaw[1], Richard P. Mirin[2], Sae Woo Nam[2]; [1]*Instrument Electronics and Sensors, Jet Propulsion Lab, USA;* [2]*National Inst. of Standards and Technology, USA;* [3]*Dept. of Physics, Lancaster Univ., UK.* We measured the temporal dynamics of optically excited hotspots in current carrying WSi superconducting nanowires as a function of bias current, temperature and excitation wavelength, observing an unexpected effect: hotspot relaxation depends strongly on bias current.

**FM4B.8 • 17:45**
**Current-Controlled Optical Modulation in Thin VO2 Wires,** Arash Joushaghani[1], Junho Jeong[1], Suzanne Paradis[2], David Alain[2], J. Stewart Aitchison[1], Joyce K. Poon[1]; [1]*Electrical and Computer Engineering, Univ. of Toronto, Canada;* [2]*Defence Research and Development Canada - Valcartier, Canada.* We imaged VO2 wires with IR light and monitored the optical properties at the metal-insulator phase transition. Depending on the geometry of the wires, the phase transition either had an electrical or thermal character.

### Executive Ballroom 210C

### FM4C • Novel Optics I—Continued

**FM4C.7 • 17:30**
**Plasmonic Properties and Photoinduced Reflectance of Topological Insulator,** Zilong Wang[1,2], Jun Yin[2], Giorgio Adamo[1], Azat Sulaev[2], Lan Wang[2], Nikolay I. Zheludev[1,3], Cesare Soci[1,2]; [1]*Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore;* [2]*School of Physical and Mathematical Sciences, Nanyang Technological Univ., Singapore;* [3]*Optoelectronics Research Centre, Univ. of Southampton, UK.* We report on linear and nonlinear infrared and plasmonic properties of chalcogenide crystal of the Bi-Sb-Te-Se family that was recently identified as a prospective platform for switchable broadband plasmonic devices.

**FM4C.8 • 17:45**
**Titanium Nitride as a Refractory Plasmonic Material for High Temperature Applications,** Urcan Guler[1], Wei Li[1,2], Alexandra Boltasseva[1,3], Alexander Kildishev[1], Vladimir M. Shalaev[1]; [1]*School of Electrical & Computer Engineering and Birck Nanotechnology Center, Purdue Univ., USA;* [2]*State Key Lab of Advanced Technology for Materials Synthesis and Processing, Wuhan Univ. of Technology, China;* [3]*Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark.* The use of titanium nitride as a plasmonic material for high temperature applications such as solar/thermophotovoltaics is studied numerically and experimentally. Performance of titanium nitride is compared with widely used materials in each field.

### Executive Ballroom 210D

### FM4D • Accelerating Beams—Continued

**FM4D.4 • 17:30**
**Electromagnetic Fields Produced by Self-Accelerating Shape-Preserving Electrons in Free-Space,** Ido Kaminer[1,2], Jonathan Nemirovsky[2], Mikael Rechtsman[2], Rivka Bekenstein[2], Mordechai Segev[2]; [1]*Dept. of Physics, MIT, USA;* [2]*Physics Dept. and Solid State Inst., Technion, Israel.* A recent experiment confirmed the 35 years old prediction of Airy-shaped electron beams that accelerate in the absence of any potential. Yet their most intriguing property remained unclear: will such electrons emit radiation in free-space?

**FM4D.5 • 17:45**
**Dynamical Two-Dimensional Accelerating Beams and Enhancement of Their Peak Intensities,** domenico bongiovanni[1], Yi Hu[1,2], Raúl Amaury Robles[3], Gregorio Mendoza Gonzalez[3], Erwin Martí-Panameño[3], Chen Zhigang[2,4], Roberto Morandotti[1]; [1]*INRS-EMT, INRS, Canada;* [2]*The MOE Key Lab of Weak-Light Nonlinear Photonics, TEDA Applied Physics Inst. and School of Physics, Nankai Univ., China;* [3]*Benemérita Universidad Autónoma de Puebla, Mexico;* [4]*Dept. of Physics & Astronomy, San Francisco State Univ., USA.* We analytically study the propagation dynamics of two-dimensional accelerating beams in a generalized way and propose an optimized method to enhance their peak intensities. Our theoretical analysis is confirmed by experimental results.

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**18:30–20:30 Special Symposium in Memory of James P. Gordon,** *Grand Ballroom* ▶

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## CLEO: Science & Innovations

### Executive Ballroom 210E

### SM4E • Remote and Stand-off Optical Detection—Continued

**SM4E.7 • 17:30**
**Distance Measurement Using Serrodyne Modulation and Two-Photon Absorption Process in Si-APD,** Yosuke Tanaka[1], Seiji Tominaka[1], Takashi Kurokawa[1]; [1]*Division of Advanced Electrical and Electronic Engineering, Graduate School of Engineering, Tokyo Univ. of Agriculture and Technology, Japan.* A laser distance measurement using two-photon absorption (TPA) process in a Si-APD is reported. A newly developed configuration introducing serrodyne modulation suppresses the coherent interference noise, enhances TPA detection sensitivity, and reduces the system components.

**SM4E.8 • 17:45**
**Time-of-flight Depth Imaging at 1550 nm Wavelength at Kilometer-range Distances Using an InGaAs/InP Single-Photon Avalanche Diode Detector,** Ximing Ren[1], Aongus McCarthy[1], Adriano Della Frera[2], Nathan R. Gemmell[1], Nils J. Krichel[1,3], Carmelo Scarcella[2], Alessandro Ruggeri[2], Alberto Tosi[2], Gerald S. Buller[1]; [1]*Inst. of Photonics and Quantum Sciences, and Scottish Universities Physics Alliance (SUPA), School of Engineering and Physical Sciences, Heriot-Watt Univ., UK;* [2]*Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano, Italy;* [3]*Helia Photonics Ltd, UK.* We report a photon-counting depth imager with sub-centimeter resolution of low-signature targets at kilometer range. The system exploited a Peltier-cooled InGaAs/InP single-photon detector module and a 1550 nm wavelength pulsed laser with sub-milliwatt average powers.

### Executive Ballroom 210F

### SM4F • Diode Pumped Mode-locked Oscillators and Amplifiers—Continued

**SM4F.7 • 17:30**
**Power-scaling a Kerr-lens mode-locked Yb:YAG thin-disk oscillator via enlarging the cavity mode in the Kerr-medium,** Jonathan Brons[1], Vladimir Pervak[2], Elena Fedulova[1], Marcus Seidel[1], Dominik Bauer[3], Dirk Sutter[3], Vladimir Kalashnikov[4], Alexander Apolonski[1,2], Oleg Pronin[2], Ferenc Krausz[1,2]; [1]*Max-Planck-Institut für Quantenoptik, Germany;* [2]*Ludwig-Maximilians-Universität München, Germany;* [3]*TRUMPF-Laser GmbH + Co. KG, Germany;* [4]*Institut für Photonik, TU Wien, Austria.* We report on a purely hard-aperture Kerr-lens mode-locked Yb:YAG thin-disk oscillator delivering 230-W, 11.5-µJ, 330-fs (30 MW) in air. To our knowledge this is the highest average power achieved from KLM oscillators so far.

**SM4F.8 • 17:45**
**Generation of sub-100-fs pulses in an Yb:CaGdAlO4 regenerative amplifier by tailored control of linear and nonlinear phase,** Julien Pouysegur[1,2], Martin Delaigue[2], Yoann Zaouter[2], Robert Braunschweig[2], Clemens Hoenninger[2], Eric Mottay[2], Anaël Jaffrès[3], Pascal Loiseau[3], Bruno Viana[3], Patrick Georges[1], Frederic Druon[1]; [1]*Amplitude Systemes, France;* [2]*Institut d, France;* [3]*Laboratoire de Chimie de la Matière Condensée de Paris, France.* Generation of sub 100 fs pulse has been obtained in an Yb:CALGO regenerative amplifier using nonlinear effects. It exhibits 97fs pulses at 1047nm with up to 24µJ energy with a spectral bandwidth of 19nm.

### Executive Ballroom 210G

### SM4G • Integrated Photonic Devices and Circuits—Continued

**SM4G.7 • 17:30**
**Improvement of photodiode responsivity using the InAs quantum dot family for monolithic integration,** Toshimasa Umezawa[1], Kouichi Akahane[1], Atsushi Kanno[1], Tetsuya Kawanishi[1]; [1]*National Inst of Information & Comm Tech, Japan.* We report a photodiode (PD) hybrid sub-system using a 1.5um quantum dot (QD) semiconductor optical amplifier (SOA) and a QD-PD for a high-speed and high-sensitivity photoreceiver, and we characterize its responsivity.

**SM4G.8 • 17:45**
**Pulse Compression by Dynamic Control of Slow Light in Dispersion-Tunable Photonic Crystal Waveguide,** Keisuke Kondo[1], Ishikura Norihiro[1], Takuya Tamura[1], Toshihiko Baba[1]; [1]*Dept. of Electrical and Computer Engineering, Yokohama National Univ., Japan.* We demonstrate optical pulse compression by using two slow light in Si photonic crystal waveguide. Enhanced nonlinearity by slow light and tunable dispersion by integrated heaters achieved the compression from 8.6 to 2.6 ps.

### Executive Ballroom 210H

### SM4H • Light Emitting Materials and Devices—Continued

**SM4H.4 • 17:30**
**Demonstration of Net Gain in an Erbium Chloride Silicate Single Nanowire Waveguide,** Zhicheng Liu[1], Gejian Zhao[1,2], Leijun Yin[1,2], Cun Zheng Ning[1]; [1]*School of Electrical, Computer, and Energy Engineering, Arizona State Univ., USA;* [2]*Dept. of Physics, Arizona State Univ., USA.* Absorption coefficient of erbium chloride silicate nanowire is studied by monitoring the decay of upconversion emission from a single nanowire waveguide. 30 dB/cm low bound for the net gain is demonstrated for erbium chloride silicate.

**SM4H.5 • 17:45**
**A Solid-State Incandescent Device for Single-Chip White-Light Emission,** Yue Kuo[1], Chi-Chou Lin[1]; [1]*Texas A&M Univ., USA.* Single-chip, white-light emitting devices made of sub 10 nm thick metal oxide dielectric films have been investigated for optical properties, operation principles, and reliability. Key elements for the light emission, lifetime, and efficiency are discussed.

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**18:30–20:30 Special Symposium in Memory of James P. Gordon,** *Grand Ballroom* ▶

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NOTES

## Meeting Room
## 211 B/D

## CLEO: Science & Innovations

### SM4I • Advanced QPM Devices—Continued

**SM4I.7 • 17:30**
**355nm generation by Fan-out PP-LBGO device,** Junji Hirohashi[1], Masami Hatori[1], Mitsuyoshi Sakairi[1], Shintaro Miyazawa[1,2], Shunji Takekawa[1], Tetsuo Taniuchi[3], Yasunori Furukawa[1]; [1]*Oxide Corporation, Japan;* [2]*Zaiken, Waseda Univ., Japan;* [3]*FRIS, Tohoku Univ., Japan.* 355 nm generation was confirmed by using a novel ferroelectric QPM device, PP-LBGO with Fan-out structure as a third harmonic of 1064 nm light. More than 100 mW was generated without any walk-off.

**SM4I.8 • 17:45**
**Monolithically integrated optical parametric up/down frequency converter using arrayed PPLN waveguides,** Takushi Kazama[1], Takeshi Umeki[1], Masaki Asobe[1], Hirokazu Takenouchi[1]; [1]*NTT Photonics Labs, Japan.* We propose a novel structure for two monolithically-integrated PPLN waveguides with a reflective wavelength-division multiplexer consisting of two MMIs and a dichroic mirror. Frequency conversion through two-stage SHG/DFG processes is demonstrated using the integrated device.

## Meeting Room
## 212 A/C

### SM4J • Free Space Laser Communications—Continued

**SM4J.6 • 17:30**
**Power-efficient Noise-insensitive Optical Modulation for High-sensitivity Laser Communications,** David O. Caplan[1], John Carney[1]; [1]*MIT Lincoln Lab, USA.* We demonstrate optical waveform generation from directly modulated lasers combined with periodic time-frequency windowing. Real-time experiments with direct FPGA-driven lasers achieve near-theoretical performance at Gbit/s rates using flexible and scalable transceiver designs.

**SM4J.7 • 17:45**
**Free-Space 120 Gb/s Reconfigurable Card-to-Card Optical Wireless Interconnects with 16-CAP Modulation,** Ke Wang[1,2], Ampalavanapillai Nirmalathas[1,2], Christina Lim[2], Efstratios Skafidas[1,2], Kamal Alameh[3]; [1]*National ICT Australia - Victoria Research Lab, Australia;* [2]*Dept. of Electrical and Electronic Engineering, Univ. of Melbourne, Australia;* [3]*Electron Science Research Inst., Edith Cowan Univ., Australia.* In this paper, we propose and experimentally demonstrate reconfigurable card-to-card optical wireless interconnects architecture with 16-Carrierless-Amplitude/Phase modulation. Results show that 3×40 Gb/s interconnection is achieved with 2 mW transmission power.

## Meeting Room
## 212 B/D

## CLEO: QELS-Fundamental Science

### FM4K • Localized Plasmon Enhanced Sensing: SERS, SEIRA—Continued

**FM4K.6 • 17:30**
**Application of Lattice Plasmon Waves in a Bilayer Plasmonic Nanoantenna Array for Surface Enhanced Raman Spectroscopy,** Hamed Shams Mousavi[1], Farshid Ghasemi[1], Ali Asghar Eftekhar[1], Ali Adibi[1]; [1]*Electrical and computer engineering, Georgia Inst. of Technology, USA.* We present a novel bilayer plasmonic nanoantenna array, utilizing lattice plasmon waves to increase the sensitivity in SERS process. Using this nanostructure, we performed SERS measurements of proteins in a very low concentration.

**FM4K.7 • 17:45**
**Scaling rules for Surface Enhanced Raman Scattering,** Yoshiaki Nishijima[1], Jacob Khurgin[2], Lorenzo Rosa[3,4], Saulius Juodkazis[3,4]; [1]*Dept. of Electrical and Computer Engineering, Yokohama National Univ., Japan;* [2]*Dept. of Electrical and Computer Engineering, Johns Hopkins Univ., USA;* [3]*Centre for Micro-Photonics, Faculty of Engineering and Industrial Sciences,, Swinburne Univ. of Technology, Australia;* [4]*The Australian National Fabrication Facility -ANFF, Victoria node, Faculty of Engineering and Industrial Sciences,, Swinburne Univ. of Technology, Australia.* An intricate relationship between the intensity of surface-enhanced Raman scattering (SERS) and the optical extinction are revealed. The observed unusual trend of SERS intensity decrease with the increase of extinction is explained analytically and numerically.

## Marriott
## Salon I & II

## CLEO: Applications & Technology

### AM4L • Symposium on Enabling Photonics Technologies for Miniaturization II—Continued

**AM4L.4 • 17:30** Invited ▶
**Microfabricated Optically-Pumped Magnetometers,** Svenja Knappe[1]; [1]*NIST, USA.* The miniaturization of atomic devices with methods lent from microelectromechanical systems (MEMS) has enabled small, low-power high-performance sensors. Pioneered by the development of the chip-scale atomic clock, the technology has advanced to gyroscopes and optically-pumped magnetometers. MEMS fabrication can open the door for low-cost fabrication in large quantities and make atomic sensors manufacturable with lithographically-defined precision.

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**18:30–20:30 Special Symposium in Memory of James P. Gordon,** *Grand Ballroom* ▶

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NOTES

## CLEO: Science & Innovations

**Marriott**
**Salon III**

### SM4M • Photonic Crystals—Continued

**SM4M.6 • 17:30** ▶
**Holographic Design of Light in the Volume of Photonic Crystals,** Jonathan Nemirovsky[1], Ido Kaminer[1], Rivka Bekenstein[1], Mordechai Segev[1]; [1]*Technion, Israel.* We develop holographic methods to generate arbitrarily-shaped light intensity distributions inside photonic crystals slabs, through shaping the electromagnetic field launched at the facets of the crystal. The technique can be generalized to any photonic structure.

**SM4M.7 • 17:45** ▶
**2D-material Based Nano-photonics,** Arka Majumdar[1,2], Sanfeng Wu[2], Sonia Buckley[3], Aaron M. Jones[2], Jason S. Ross[4], Nirmal J. Ghimire[5,6], Jiaqiang Yan[6,7], David J. Mundros[7], Wang Yao[8], Fariba Hatami[9], Jelena Vuckovic[3], Xiadong Xu[2,4]; [1]*Electrical Engineering, Univ. of Washington, USA;* [2]*Physics, Univ. of Washington, USA;* [3]*E L Ginzton Lab, Stanford Univ., USA;* [4]*Dept. of Material Science and Engineering, Univ. of Washington, USA;* [5]*Dept. of Physics and Astronomy, Univ. of Tennessee, USA;* [6]*Materials Science and Technology Division, Oak Ridge National Lab, USA;* [7]*Dept. of Materials Science and Engineering, Univ. of Tennessee, USA;* [8]*Dept. of Physics and Center of Theoretical and Computational Physics, Univ. of Hong Kong, China;* [9]*Dept. of Physics, Humboldt Univ., Germany.* We demonstrate a nanophotonic platform based on 2D materials coupled to photonic crystal cavities. We show strong enhancement (~60 times) of light emission due to the photonic crystal.

**Marriott**
**Salon IV**

### SM4N • Nonlinear Optical Effects in Fibers—Continued

**SM4N.7 • 17:30**
**Relative intensity noise of Raman solitons: which one is more noisy?,** Wei Liu[1], Gengji Zhou[1], Jinkang Lim[2], Hung-Wen Chen[2], Franz Kärtner[1,2], Guoqing Chang[1,2]; [1]*Center for Free-Electron Laser Science, DESY, Germany;* [2]*Research Lab of Electronics, MIT, USA.* We experimentally study the relative intensity noise of Raman solitons and find that earlier ejected Raman soliton exhibits lower noise. We also observe the bound soliton pair existing in a large range of excitation power.

**SM4N.8 • 17:45**
**Experimental Demonstration of Soliton Cascade in Higher-Order-Mode Fibers,** Kriti Charan[1], Martin Pedersen[2], Ke Wang[3], Lars Grüner-Nielsen[4], Dan Jakobsen[4], Chris Xu[1]; [1]*Cornell Univ., USA;* [2]*NKT Photonics, Denmark;* [3]*Shenzhen Univ., China;* [4]*OFS Fitel, Denmark.* Concatenation of two different higher-order-mode fibers (HOMFs) was used to extend the soliton wavelength shift beyond the mode-crossing wavelengths of the fibers. A 3.5 nJ, 55 fs soliton was obtained at 1170 nm.

**Marriott**
**Salon V & VI**

### SM4O • Symposium on Large-Scale Silicon Photonic Integration II—Continued

**SM4O.4 • 17:30** Invited ▶
**Very Large Scale Silicon Photonics Integration,** Michael R. Watts[1], Erman Timurdogan[1], Jie Sun[1], Ehsan S. Hosseini[1], Cheryl Sorace-Agaskar[1], Ami Yaacobi[1], Zhan Su[1], Michele Moresco[1], Purnawirman Purnawirman[1], Jonathan Bradley[1], Gerald Leake[2], Thomas Adam[2], Douglas Coolbaugh[2]; [1]*Research Lab of Electronics, MIT, USA;* [2]*College of Nanoscale Science and Engineering, SUNY, USA.* We present on the demonstration of a number of critical device technologies including record low power modulators, tunable filters, and integrated lasers, along with the world's largest silicon photonic circuit, integrated on a 300mm platform.

**Marriott**
**Willow Glen I-III**

### SM4P • Bioimaging II: Thermal, Speciral and Nanoparticles—Continued

**SM4P.7 • 17:30** ▶
**Mid-IR Laser Tissue Ablation with Little Collateral Damage Using a Laser Tunable in the Water Absorption Peak,** Danail V. Chuchumishev[1,2], Elizabeth Nagel[1], Alexandra Nierlich[1], Stanislav Philipov[3], Tsvetin Genadiev[3], Torsten Fiebig[1], Ivan C. Buchvarov[1,2], Claus-Peter Richter[1,4]; [1]*Deptartment of Otolaryngology, Northwestern Univ., USA;* [2]*Dept. of Physics, Sofia Univ., Bulgaria;* [3]*Dept. of Medicine, Sofia Univ., Bulgaria;* [4]*Dept. of Biomedical Engineering, Northwestern Univ., USA.* An experimental study of tissue ablation across the water absorption peak is presented. A novel all-solid-state table-top mid-IR laser has been used for observation of wavelength-dependent effects on the ablation of hard and soft tissue.

**SM4P.8 • 17:45** ▶
**Nanoscale precision subcellular chemical identification using quantitative IR nanoimage analysis based on multiple-IR laser illumination,** Eamonn Kennedy[1], Rasoul Al-Majmaie[1,3], Dominic Zerulla[1], Mohamed Al-Rubeai[2], James H. Rice[1]; [1]*School of Physics, Univ. College Dublin, Ireland;* [2]*School of Chemical and Bioprocess Engineering, Univ. College Dublin, Ireland;* [3]*Inst. of laser for postgraduate studies, Univ. of Baghdad, Iraq.* Recent advances in infrared (IR) nanoimaging as a non-invasive and robust method for chemically detecting subcellular features and intracellular exogenous agents without the use of labels at nanoscale resolutions are discussed.

**18:30–20:30 Special Symposium in Memory of James P. Gordon,** *Grand Ballroom* ▶

NOTES

## CLEO: QELS-Fundamental Science

**08:00–10:00 Plenary and Awards Session I,** *Grand Ballroom* ▶

**10:00–17:00 Exhibition Open,** *Exhibit Halls 1 & 2*

**10:00–11:00 Coffee Break (10:00-10:30) and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2*

**10:30–12:30 Market Focus Session I:**
**Emerging Mid-Infrared Market Opportunities: Air Quality Monitoring Related to Energy Extraction,** *Exhibit Hall Theater*

### 11:00–13:00
### FTu1A • Symposium on Quantum Repeaters I
*Presider: Jungsang Kim; Duke Univ., USA*

**FTu1A.1 • 11:00** Invited

**Ultrafast Quantum Repeaters for Long Distance Quantum Communication,** Liang-Xing Jiang[1]; [1]*School of Metallurgical Science and Engineering, Central South Univ., China.* We investigate and optimize three generations of quantum repeater protocols for long distance quantum communication, which can overcome the major challenges of photon loss and operational imperfections.

### 11:00–13:00
### FTu1B • Dynamics in Semiconductor Quantum Wells
*Presider: Robert Kaindl; Lawrence Berkeley National Lab, USA*

**FTu1B.1 • 11:00**

**Multidimensional coherent optical photocurrent spectroscopy of a semiconductor quantum well,** Travis Autry[1,2], Gael Nardin[1], Kevin Silverman[3], Steven T. Cundiff[1,2]; [1]*JILA, Univ. of Colorado, USA;* [2]*Physics, Univ. of Colorado, USA;* [3]*National Inst. of Standards and Technology, USA.* We present a new technique for Multi-Dimensional Coherent spectroscopy of nano-structures. We measure the Four-Wave Mixing (FWM) amplitude and phase via photocurrent detection. The measurement is suitable for any nano-structures that can be electrically contacted.

**FTu1B.2 • 11:15**

**Superradiant Decay of Coherent Cyclotron Resonance in Ultrahigh-Mobility Two-Dimensional Electron Gases,** Qi Zhang[1], Takashi Arikawa[1], Michael A. Zudov[2], John L. Reno[3], Wei Pan[3], John D. Watson[4], Michael J. Manfra[4], Junichiro Kono[1]; [1]*Electrical and computer engineering, Rice Univ., USA;* [2]*Physics, Univ. of MInnesota, USA;* [3]*Sandia National Labs, USA;* [4]*Physics, Purdue Univ., USA.* We study the coherent dynamics of cyclotron resonance in ultrahigh-mobility two-dimensional electron gases via time-domain terahertz magneto-spectroscopy. We show that superradiant damping is the dominant decoherence mechanism at low temperatures.

### 11:00–13:00
### FTu1C • Novel Optics II
*Presider: Jean-Jacques Greffet; Institut d'Optique, France*

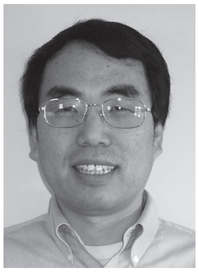
**FTu1C.1 • 11:00** Invited

**Planar Superconducting Toroidal Metamaterial: A Source for Oscillating Vector-Potential?,** Vassili Savinov[1], Kaveh Delfanazari[1], Vassili A. Fedotov[1], Nikolay I. Zheludev[1,2]; [1]*Optoelectronics Research Centre and Centre for Photonic Metamaterials, Univ. of Southampton, UK;* [2]*Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore.* We demonstrate the first superconducting metamaterial that can exhibit a profound toroidal dipolar resonance. Quantum behaviour of the superconductor and toroidal excitation of the metamaterial are both necessary prerequisites for observing the time-dependent Aharonov-Bohm effect.

### 11:00–13:00
### FTu1D • Strong-Field Physics
*Presider: Tenio Popmintchev; JILA, Univ. of Colorado at Boulder, USA*

**FTu1D.1 • 11:00** Tutorial

**Approaching the Atomic Unit of Time with Isolated Attosecond Pulses,** Zenghu Chang[1]; [1]*Univ. of Central Florida, CREOL, USA.* Isolated attosecond pulses are powerful tools for studying electron dynamics in atoms, molecules and condensed matter. The shortest pulses achieved so far are 67 as. Challenges and approaches for further shortening such pulses are introduced.



Zenghu Chang is a Distinguished Professor of Physics and Optics at the University of Central Florida, where he directs the Institute for the Frontier of Attosecond Science and Technology. He is a fellow of The Optical Society and the APS. Chang is the author of the book "Fundamentals of Attosecond Optics."

**Executive Ballroom 210E**

**Executive Ballroom 210F**

**Executive Ballroom 210G**

**Executive Ballroom 210H**

## CLEO: Science & Innovations

**08:00–10:00 Plenary and Awards Session I,** *Grand Ballroom* ▶

**10:00–17:00 Exhibition Open,** *Exhibit Halls 1 & 2*

**10:00–11:00 Coffee Break (10:00-10:30) and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2*

**10:30–12:30 Market Focus Session I:**
**Emerging Mid-Infrared Market Opportunities: Air Quality Monitoring Related to Energy Extraction,** *Exhibit Hall Theater*

### 11:00–13:00
### STu1E • Applications of fs Lasers

*Presider: Andy Kung; National Tsing Hua Univ., Taiwan*

**STu1E.1 • 11:00** Tutorial

**Femtosecond Laser Processing of Materials,** Eric Mazur[1]; [1]*Harvard Univ., USA.* We review recent work involving the interaction of femtosecond laser pulses with materials. We discuss the fundamental processes involved and applications, classifying the work into the interaction with transparent materials and with absorbing materials.

Eric Mazur is the Balkanski Professor of Physics and Applied Physics at Harvard University and Dean of Applied Physics. He is a prominent physicist known for his contributions in nanophotonics, an internationally recognized educational innovator, a sought-after lecturer, and successful entrepreneur. Mazur received the Esther Hoffman Beller award from The Optical Society and the Millikan Medal from the American Association of Physics Teachers.

### 11:00–13:00
### STu1F • Manipulation & Detection of THz Radiation

*Presider: Daniel Mittleman; Rice Univ., USA*

**STu1F.1 • 11:00**

**Terahertz Field Induced Second Harmonic Coherent Detection Scheme based on a Biased Nonlinear Micro-slit,** Anna V. Mazhorova[1], Sze Phing Ho[1,2], Matteo Clerici[1,3], Marco Peccianti[4], Alessia Pasquazi[4], Luca Razzari[1], Jalil Ali[2], Roberto Morandotti[1]; [1]*Energy Materials Telecommunications Research Centre, Institut National de la Recherche Scientifique, Canada;* [2]*Nanophotonics Research Alliance, Universiti Teknologi Malaysia, Malaysia;* [3]*School of Engineering and Physical Sciences, Heriot-Watt Univ., UK;* [4]*Dept of Physics and Astronomy, Univ. of Sussex, UK.* We demonstrated coherent Terahertz characterization based on Terahertz Field Induced Second Harmonic effect in a Silica samples, operated with 10-100 V sources. Our sample is an infinitely long 30 μm slit written in gold. Our results pave the way to a novel approach towards broadband THz detection.

**STu1F.2 • 11:15**

**Active modulation of terahertz wave front,** Yan Zhang[1]; [1]*Capital Normal Univ., China.* A novel method is proposed to dynamically modulate the THz wave front with photo-generated carriers. Some special wave fronts are generated using this method. This new method is structure free, high resolution, and broadband.

### 11:00–13:00
### STu1G • Integrated Components for Optical Communications

*Presider: Leif Johansson; Freedom Photonics, LLC, USA*

**STu1G.1 • 11:00**

**Ultra-Low Voltage Wide Bandwidth Electro-optic Modulators,** Selim Dogru[1], Nadir Dagli[1]; [1]*Univ. of California Santa Barbara, USA.* Wide bandwidth, ultra-low voltage modulators based on substrate removal technology and loaded line traveling wave electrodes are presented. Drive voltage product is 0.06 V-cm and 2 mm long devices have electrical-to-electrical bandwidths exceeding 80 GHz.

**STu1G.2 • 11:15**

**Error-Free Optical Data Generation Using Quantum Dot Electro-Optic Modulator with Semiconductor Optical Amplifier in Ultra-Broad Optical Frequency Bandwidth,** Naokatsu Yamamoto[1], Kouichi Akahane[1], Toshimasa Umezawa[1], Tetsuya Kawanishi[1]; [1]*National Inst. of Information and Communications Technology, Japan.* Error-free Gbps-order high-speed optical data signal generation in a > 5.5-THz ultra-broad optical frequency bandwidth of the O-band was successfully demonstrated using a newly developed quantum dot electro-optic modulator integrated with a semiconductor optical amplifier.

### 11:00–13:00
### STu1H • Plasmonic Devices

*Presider: Zhaowei Liu; Univ. of California San Diego, USA*

**STu1H.1 • 11:00**

**AFM-Based Pick-and-Place Handling of Individual Nanoparticles inside an SEM for the Fabrication of Plasmonic Nano-Patterns,** Uwe Mick[1,2], Peter Banzer[1,2], Silke Christiansen[1,3], Gerd Leuchs[1,2]; [1]*Max Planck Inst. for the Science of Light, Germany;* [2]*Inst. of Optics, Information and Photonics, Friedrich-Alexander-Univ. Erlangen-Nuremberg, Germany;* [3]*Inst. for Nanoarchitectures for Energy Conversion, Helmholz Zentrum Berlin, Germany.* Integrating AFM technology into an SEM enables the interactive assembling of individual nanoparticles by in-situ pick-and-place handling. We present a hardware setup and introduce examples for the nanofabrication of plasmonic patterns.

**STu1H.2 • 11:15**

**High Excitation Efficiency of Channel Plasmon Polaritons in Tailored, UV-Lithography-Defined V-Grooves,** Cameron L. Smith[1], Anil H. Thilsted[1], Cesar E. Garcia-Ortiz[2], Ilya P. Radko[2], Rodolphe Marie[1], Claus Jeppesen[3], Christoph Vannahme[1], Sergey I. Bozhevolnyi[2], Anders Kristensen[1]; [1]*Dept of Micro- and Nanotechnology, Technical Univ. of Denmark, Denmark;* [2]*Inst. of Technology and Innovation, Univ. of Southern Denmark, Denmark;* [3]*Dept of Photonics Engineering, Technical Univ. of Denmark, Denmark.* We demonstrate >50% conversion of light to V-groove channel plasmon-polaritons (CPPs) via compact waveguide-termination mirrors. Devices are fabricated using UV-lithography and crystallographic silicon etching. The V-shape is tailored by thermal oxidation to support confined CPPs.

**Meeting Room**
**211 B/D**

**Meeting Room**
**212 A/C**

**CLEO: Science & Innovations**

**Meeting Room**
**212 B/D**

**CLEO: QELS-Fundamental Science**

**Marriott**
**Salon I & II**

**CLEO: Science & Innovations**

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**08:00–10:00 Plenary and Awards Session I,** *Grand Ballroom* ▶

**10:00–17:00 Exhibition Open,** *Exhibit Halls 1 & 2*

**10:00–11:00 Coffee Break (10:00-10:30) and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2*

**10:30–12:30 Market Focus Session I:**
**Emerging Mid-Infrared Market Opportunities: Air Quality Monitoring Related to Energy Extraction,** *Exhibit Hall Theater*

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### 11:00–13:00
### STu1I • Nonlinear Optical Materials

*Presider: Valentin Petrov; Max Born Inst., Germany*

**STu1I.1 • 11:00**
**Optical nonlinearity in silicon at mid-infrared wavelengths,** Ting Wang[1], Nalla Venkatram[2,3], Wei Ji[2], Dawn Tan[1]; [1]*Engineering Product Development, Singapore Univ. of Technology and Design, Singapore;* [2]*Dept of Physics, National Univ. of Singapore, Singapore;* [3]*Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore.* We report the wavelength dependency of third-order nonlinearity and multiphoton absorption of silicon in the spectral range from 1.6 μm to 6 μm, including the nonlinear figure of merit.

**STu1I.2 • 11:15**
**Synchronously coupled fiber lasers and sum frequency generation using graphene composites,** MENG ZHANG[1], Edmund J. Kelleher[1], T. H. Runcorn[1], Daniel Popa[2], Felice Torrisi[2], Andrea C. Ferrari[2], Sergei V. Popov[1], James R. Taylor[1]; [1]*Dept of Physics, Imperial College London, UK;* [2]*Cambridge Graphene Centre, Univ. of Cambridge, UK.* Graphene mode-locked and self-synchronized fiber lasers are used for sum-frequency mixing in a graphene-polymer composite.

### 11:00–13:00
### STu1J • Short Reach Communications

*Presider: Ivan Djordjevic; Univ. of Arizona, USA*

**STu1J.1 • 11:00**
**Millimeter-wave Radio-over-Fiber Access Architecture for Implementing Real-time Cloud Computing Service,** Feng Lu[1], Jing Wang[1], Lin Cheng[1], Mu Xu[1], Ming Zhu[1], Gee-Kung Chang[1]; [1]*School of Electrical and Computer Engineering, Georgia Inst. of Technology, USA.* A cloud computing access network architecture based on millimeter-wave radio-over-fiber technologies has been proposed and demonstrated. Real-time communication between centralized computing resources and mobile wireless users are provided by bidirectional millimeter-wave over fiber links.

**STu1J.2 • 11:15**
**Energy-efficient, digitally-driven "fat pipe" silicon photonic circuit switch in the UCSD MORDIA data-center network,** Ryan Aguinaldo[1], Alex Forencich[1], Christopher DeRose[2], Anthony L. Lentine[2], Douglas C. Trotter[2], Andrew Starbuck[2], Yeshaiahu Fainman[1], George Porter[1], George Papen[1], Shayan Mookherjea[1]; [1]*Univ. of California San Diego, USA;* [2]*Applied Microphotonic Systems, Sandia National Lab, USA.* Using a compact (0.03 mm^2) silicon photonic thermo-optic switch with five cascaded thermo-topic phase-shifters, we demonstrate low insertion loss, low power, microsecond-scale cross-bar switching of twenty wavelength channels, each carrying 10 Gbit/second data concurrently.

### 11:00–13:00
### FTu1K • Near-field Imaging with Photons, Plasmons and Electrons

*Presider: Rashid Zia; Brown Univ., USA*

**FTu1K.1 • 11:00**
**Sub-diffraction Imaging via Surface Plasmon Decompression,** Alessandro Salandrino[1], Hu Cang[2], Yuan Wang[1], Xiang Zhang[1,3]; [1]*NSF Nanoscale Science and Engineering Center (NSEC), Univ. of California Berkeley, USA;* [2]*Waitt Advanced Biophotonics Center, Salk Inst. for Biological Studies, USA;* [3]*Materials Sciences Division, Lawrence Berkeley National Lab, USA.* We theoretically propose a novel scheme for sub-diffraction imaging based on a process of adiabatic decompression of the local wavelength of a surface plasmon polariton supported by two adjoining curved metal surfaces.

**FTu1K.2 • 11:15**
**Sub-diffraction limited imaging with a spatially dispersive slab,** Avner Yanai[1], Uriel Levy[1]; [1]*Hebrew Univ. of Jerusalem, Israel.* We obtain sub-diffraction limited imaging at $\omega>\omega p$ using a flat silver slab. Unlike Superlenses, the formation of subdiffraction imaging is attributed to high-k longitudinal modes that are supported by the non-local response of the media.

### 11:00–13:00
### STu1L • Mid-infrared Fiber Lasers ▶

*Presider: Shibin Jiang; AdValue Photonics, Inc., USA*

**STu1L.1 • 11:00** Invited ▶
**Robust Multimaterial Tellurium-based Chalcogenide Glass Infrared Fibers,** Guangming Tao[1], Soroush Shabahang[1], He Ren[2,1], Farnood Khalilzadeh-Rezaie[3], Robert E. Peale[3], Zhiyong Yang[4], Xunsi Wang[5,1], Ayman F. Abouraddy[1]; [1]*CREOL, The College of Optics & Photonics, Univ. of Central Florida, USA;* [2]*School of Physics and Electronic Engineering, Jiangsu Normal Univ., China;* [3]*Dept of Physics, Univ. of Central Florida, USA;* [4]*Laser Physics Centre, Research School of Physics and Engineering, The Australian National Univ., Australia;* [5]*Lab of Infrared Material and Devices, Ningbo Univ., China.* We demonstrate the scalable production of the first robust tellurium-based chalcogenide glass fibers provided with a built-in polymer jacket and transmit mid-wave and long-wave infrared light across the 3 - 12 micron window.

**08:00–10:00 Plenary and Awards Session I,** *Grand Ballroom*

**10:00–17:00 Exhibition Open,** *Exhibit Halls 1 & 2*

**10:00–11:00 Coffee Break (10:00-10:30) and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2*

**10:30–12:30 Market Focus Session I:**
**Emerging Mid-Infrared Market Opportunities: Air Quality Monitoring Related to Energy Extraction,** *Exhibit Hall Theater*

### 11:00–13:00
### STu1M • Applied Plasmonics

*Presider: Jon Schuller; Univ. of California Santa Barbara, USA*

**STu1M.1 • 11:00**
**Low-Loss Plasmonic Titanium Nitride Strip Waveguides,** Nathaniel Kinsey[1], Marcello Ferrera[1], Gururaj Naik[1], Alexander Kildishev[1], Vladimir M. Shalaev[1], Alexandra Boltasseva[1]; [1]*ECE, Purdue Univ., USA.* In this work we report low-loss insulator-metal-insulator plasmonic interconnects using the CMOS-compatible material titanium nitride. The mode profile shows the characteristic exponential decay of the plasmonic regime, with propagation losses as low as 0.79 dB/mm.

**STu1M.2 • 11:15**
**Plasmonic Photomixers for Increased Terahertz Radiation Powers at 1550 nm Optical Pump Wavelength,** Christopher W. Berry[1], Mohammed R. Hashemi[1,2], Sascha Preu[3], Hong Lu[4], Arthur Gossard[4], Mona Jarrahi[1,2]; [1]*Electrical Engineering and Computer Science, Univ. of Michigan Ann Arbor, USA;* [2]*Electrical Engineering, Univ. of California Los Angeles, USA;* [3]*Inst. for Microwave Engineering and Photonics, Technical Univ. Darmstadt, Germany;* [4]*Materials Dept, Univ. of California Santa Barbara, USA.* We experimentally demonstrate an order of magnitude higher radiated power from a 1550 nm photomixer with plasmonic contact electrodes in comparison with an analogous photomixer without plasmonic contact electrodes in the 0.25-2.5 THz frequency range.

### 11:00–13:00
### STu1N • Mode-locked Fiber Lasers

*Presider: Ingmar Hartl; DESY, Germany*

**STu1N.1 • 11:00**
**Soliton mode-locked fiber laser using a modulator-based saturable absorber,** Ruixin Wang[1], Yitang Dai[1], Ziping Zhang[1], Hao Chen[1], Haijie Yu[1], Feifei Yin[1], Kun Xu[1], Jianqiang Li[1], Jintong Lin[1]; [1]*Beijing Univ of Posts & Telecom, China.* We demonstrate a novel saturable absorber based on a dual-drive modulator with a feed-forward path for soliton pulse shaping. The fundamentally mode-locked laser produces 16.7-MHz repetition rate pulse train with 1.4-ps pulse width.

**STu1N.2 • 11:15**
**Pulse dynamics in a mode-locked fiber laser and its quantum limited comb linewidth,** Chengying Bao[1,2], Andrew Funk[2], Changxi Yang[1], Steven T. Cundiff[2]; [1]*Tsinghua Univ., China;* [2]*JILA, Univ. of Colorado & National Inst. of Standards and Technology, USA.* We fully characterized the pulse dynamics in a mode-locked Er fiber laser experimentally by measuring its response to gain modulation. The measurement allows us to evaluate quantum-limited comb linewidth and phase noise spectrum.

### 11:00–13:00
### STu1O • High Average Power Lasers for Industrial Applications

*Presider: Constantin Haefner; Lawrence Livermore National Lab, USA*

**STu1O.1 • 11:00** Tutorial
**Laser Additive Manufacturing LAM - Fundamentals of Selective Laser Melting SLM and Laser Material Deposition LMD,** Reinhart Poprawe[1], Ingomar Kelbassa[2], Yves-Christian Hagedorn[1]; [1]*Fraunhofer Institut, Germany;* [2]*RWTH-Aachen Univ., Germany.* With Additive Manufacturing AM, parts can be manufactured for design instead of being designed for manufacture. This tutorial introduces the two laser based AM processes, Selective Laser Melting SLM and Laser Material Deposition LMD.

### 11:00–13:00
### ATu1P • Applications of Optical Microscopy and Imaging

*Presider: Yu Chen; Univ. of Maryland at College Park, USA*

**ATu1P.1 • 11:00** Invited
**Increasing the Diagnostic Yield and Accuracy of Bronchial Biopsy for the Assessment of Lung Cancer,** Melissa J. Suter[1], Lida P. Hariri[1], Alyssa J. Miller[1], David C. Adams[1], Michael Lanuti[1], Mari Mino-Kenudson[1]; [1]*Harvard Medical School, Mass General Hos, USA.* Low-risk bronchoscopy techniques for retrieving biopsy samples for the diagnosis of lung cancer are hampered by low diagnostic yields, and trans-thoracic and surgical approaches carry higher intrinsic risk of complications. We are investigating the use of optical coherence tomography to increase the diagnostic yield and accuracy of bronchial biopsy.

# CLEO: QELS-Fundamental Science

## Executive Ballroom 210A

### FTu1A • Symposium on Quantum Repeaters I—Continued

**FTu1A.2 • 11:30**
**Memory-based Quantum Repeaters with NV Centers,** Kae Nemoto[1], Simon Devitt[1], Michael Trupke[2], Ashley Stephens[1], Mark Everitt[1], Kathrin Buczak[2], Tobias Noebauer[2], Jorg Schmiedmayer[2], William Munro[3,1]; [1]*National Inst. of Informatics, Japan;* [2]*Vienna Center for Quantum Science and Technology, Tu-Wien, Austria;* [3]*NTT BRL, Japan.* We present a simple design of a quantum repeater design build from single NV- centers embedded in an optical cavity. We compare different quantum networks from a simple linear chain to a fully fault-tolerant quantum internet.

**FTu1A.3 • 11:45**
**Trapped Ion Implementation of Memory-Assisted Extended Quantum Key Distribution,** Kai Hudek[1], Geert Vrijsen[1], Louis Isabella[1], Dan Gaultney[1], Jungsang Kim[1], Liang Jiang[3], Norbert Lutkenhaus[2]; [1]*Electrical and Computer Engineering, Duke Univ., USA;* [2]*Inst. for Quantum Computing, Univ. of Waterloo, Canada;* [3]*Applied Physics, Yale Univ., USA.* We discuss a practical scheme to implement memory-assisted measurement-device- independent quantum key distribution protocol using trapped ion systems with the potential to extend the range of conventional QKD by a factor of 2.

**FTu1A.4 • 12:00** Invited
**Quantum Repeater Approach based on Diamond Spin Qubit,** Hideo Kosaka[1,2]; [1]*Research Inst. of Electrical Communication, Tohoku Univ., Japan;* [2]*Graduate School of Engineering, Yokohama National Univ., Japan.* Challenges for building a quantum repeater system using a nitrogen vacancy center in diamond are overviewed and our approach for quantum repeater network with NV-based entanglement detection for entanglement swapping will be presented.

## Executive Ballroom 210B

### FTu1B • Dynamics in Semiconductor Quantum Wells—Continued

**FTu1B.3 • 11:30**
**Spatiotemporal coherence of GaN excitons excited by an optical vortex with multiple orbital angular momentum,** Kyohhei Shigematsu[1], Keisaku Yamane[1,2], Ryuji Morita[1,2], Yasunori Toda[1,2]; [1]*Hokkaido Univ., Japan;* [2]*JST CREST, Japan.* The spatiotemporal coherence of excitons is investigated by degenerate four-wave-mixing using optical vortices with multiple orbital angular momentum (OAM). The OAM-resolved signal indicates that the topological phase with large OAM is robust against spatial decoherence.

**FTu1B.4 • 11:45**
**Electroluminescence from a GaAs/AlGaAs Heterostructure at High Electric Fields: Evidence for Real- & k-Space Transfer,** Weilu Gao[1], Xuan Wang[1], Rui Chen[2], Gottfried Strasser[3], Jonathan Bird[2,4], Junichiro Kono[1,5]; [1]*ECE, Rice Univ., USA;* [2]*EE, Univ. of Buffalo, the State Univ. of New York, USA;* [3]*Center for Micro and Nanostructures and Inst. for Solid State Electronics, Vienna Univ. of Technology, Austria;* [4]*Graduate School of Advanced Integration Science, Chiba Univ., Japan;* [5]*Physics and Astronomy, Rice Univ., USA.* We study impact-ionization-induced electroluminescence (EL) from a GaAs/AlGaAs heterostructure under high bias. In addition to k-space transfer (the Gunn effect), EL spectra indicate real-space (GaAs-to-AlGaAs) transfer. Microscopy shows strong EL near the anode.

**FTu1B.5 • 12:00**
**Optically Controlled Excitonic Transistor,** Peristera Andreakou[1,2], Sergey Poltavtsev[1,3], Jason Leonard[1], Eric V. Calman[1], Mikas Remeika[1], Yuliya Y. Kuznetsova[1], Leonid Butov[1], Joe Wilkes[4], Micah Hanson[5], Arthur Gossard[5], Matthew Hasling[1]; [1]*Dept of Physics, Univ. of California at San Diego, USA;* [2]*Laboratoire Charles Coulomb, Universite Montpellier, France;* [3]*Spin Optics Lab, St. Petersburg State Univ., Russia;* [4]*Dept of Physics and Astronomy, Cardiff Univ., UK;* [5]*Materials Dept, Univ. of California at Santa Barbara, USA.* We present experimental proof of principle for all-optical excitonic routers and all-optical excitonic transistors with a high ratio between the excitonic signal at the optical drain and the excitonic signal due to the optical gate.

## Executive Ballroom 210C

### FTu1C • Novel Optics II—Continued

**FTu1C.2 • 11:30**
**Is There a Metamaterial Route to High Temperature Superconductivity?,** Igor Smolyaninov[1], Vera Smolyaninova[2]; [1]*Univ. of Maryland, USA;* [2]*Towson Univ., USA.* We argue that the metamaterial approach to dielectric response engineering may considerably increase the critical superconducting temperature of a composite superconductor-dielectric metamaterial.

**FTu1C.3 • 11:45**
**Mid-infrared Plasmonic Inductors,** Víctor Torres[1], Rubén Ortuño[1], Pablo Rodríguez-Ulibarri[1], Amadeu Griol[2], Alejandro Martínez[2], Miguel Navarro-Cia[3], Miguel Beruete[1], Mario Sorolla[1]; [1]*Universidad Pública de Navarra, Spain;* [2]*Universitat Politècnica de València, Spain;* [3]*Imperial College London, UK.* Expanding ideas from microwaves, we demonstrate experimentally a terahertz inductor by using meander-lines in a canonical extraordinary transmission (ET) hole array leading to a strong resonance's redshift and an unprecedented enlargement of the operation bandwidth.

**FTu1C.4 • 12:00**
**Ultrafast and ultra-Low Power All-Optical Tunable Plasmon-Induced-Transparency in Gold/Graphene Trimers,** Cuicui Lu[1], Xiaoyong Hu[1], Hong Yang[1], Qihuang Gong[1]; [1]*Physics Dept, Peking Univ., China.* We proposed a novel meta-structure of gold/graphene trimers and realized ultrafast and ultra-low power all-optical tunable plasmon-induced transparency around 1150 nm. The nonlinear susceptibility of graphene/ITO film was up to 2.90×10-5 esu.

## Executive Ballroom 210D

### FTu1D • Strong-Field Physics—Continued

**FTu1D.2 • 12:00**
**Experimental Observation of Light Induced Conical Intersections in a Diatomic Molecule,** Adi Natan[1,2], Matthew R. Ware[1,2], Philip H. Bucksbaum[1,2]; [1]*Stanford PULSE Inst., SLAC National Accelerator Lab, USA;* [2]*Physics, Stanford Univ., USA.* We observe quantum interferences in the angular distributions of H2+ photodissociation arising from the geometric singularity induced by strong laser fields. This is the first experimental observation of light induced conical intersections in diatomic molecules.

## CLEO: Science & Innovations

### Executive Ballroom 210E

### STu1E • Applications of fs Lasers—Continued

**STu1E.2 • 12:00**
**Graphene Supercapacitor as a Voltage Controlled Saturable Absorber for Femtosecond Pulse Generation,** Isinsu Baylam[1,2], Melissa N. Cizmeciyan[1,2], Sarper Ozharar[3], Emre O. Polat[4], Coskun Kocabas[4], Alphan Sennaroglu[1,2]; [1]*Physics and Electrical-Electronics, Koc Univ., Turkey;* [2]*Surface Science and Tecnhology Center, Koc Univ., Turkey;* [3]*College of Arts and Sciences, Bahcesehir Univ., Turkey;* [4]*Physics, Bilkent Univ., Turkey.* For the first time to our knowledge, we employed a graphene supercapacitor as a voltage controlled saturable absorber at bias voltages of 0.5-1V to generate 84-fs pulses from a solid-state laser near 1255 nm.

### Executive Ballroom 210F

### STu1F • Manipulation & Detection of THz Radiation—Continued

**STu1F.3 • 11:30** Invited
**Silicon-based Sources and Detectors for Terahertz Applications,** Ullrich Pfeiffer[1], Janusz Grzyb[1], Richard Al Hadi[1]; [1]*IHCT, Bergische Universität Wuppertal, Germany.* Todays terahertz instrumentation lacks cost-effective sources and detectors compatible with standard microelectronics to drive down the system cost. This paper presents recent developments based on silicon process technologies and discusses the challenges in implementing source and detectors. It presents a 530GHz source array with up to 1mW radiated power, a 1024-pixel CMOS camera, and a heterodyne 830GHz imaging chip-sets.

**STu1F.4 • 12:00**
**Real-Time Absolute Frequency Measurement of CW-THz Wave Based on Dual THz Combs,** Kenta Hayashi[1], Hajime Inaba[2,3], Kaoru Minoshima[2,4], Takeshi Yasui[1,3]; [1]*The Univ. of Tokushima, Japan;* [2]*National Inst. of Advanced Industrial Science and Technology, Japan;* [3]*ERATO Intelligent Optical Synthesizer Project, Japan;* [4]*The Univ. of Electro-Communications, Japan.* We demonstrated a frequency measurement of CW-THz wave referring to dual THz frequency comb in real time. The absolute frequency of the CW-THz wave is measured with an accuracy of 3.5*10^-11 10ms each.

### Executive Ballroom 210G

### STu1G • Integrated Components for Optical Communications—Continued

**STu1G.3 • 11:30** Invited
**InP-Based 100 Gb/s Coherent Receiver Technologies,** Hideki Yagi[1], Yoshihiro Yoneda[1], Masaru Takechi[1], Hajime Shoji[1]; [1]*Sumitomo Electric Industries Ltd, Japan.* We review and discuss InP-based monolithic integration technologies and their application to compact 100 Gb/s coherent receivers.

**STu1G.4 • 12:00**
**A silicon photonic channelized spectrum monitor for UCSD's multi-wavelength ring network,** Ryan Aguinaldo[1], Peter O. Weigel[1], Hannah R. Grant[1], Christopher DeRose[2], Anthony L. Lentine[2], Andrew T. Pomerene[2], Andrew Starbuck[2], Andre Tkacenko[3], Shayan Mookherjea[1]; [1]*Univ. of California San Diego, USA;* [2]*Applied Microphotonic Systems, Sandia National Lab, USA;* [3]*Signal Processing Research Group, NASA Jet Propulsion Lab, USA.* A compact silicon photonic channelized optical spectrum monitor is designed and realized, which can replace a large rack-mounted OSA's channel power monitoring functionality, and the signal processing algorithm underlying its operation is described.

### Executive Ballroom 210H

### STu1H • Plasmonic Devices—Continued

**STu1H.3 • 11:30** Invited
**Semiconductor Plasmonic Devices for Interconnects,** Meir Orenstein[1]; [1]*Technion Israel Inst. of Technology, Israel.* Plasmonic assisted nanodetectors and LEDs may be the only solution for power efficient onchip optical communications - the holy grail of integrated photonics. Localized plasmons in novel detectors and fast LEDs will be described in detail.

**STu1H.4 • 12:00**
**Optically Readable Resistive Random Access Memory in Silicon Plasmonics Platform,** Alexandros Emboras[1], Boris Desiatov[1], Ilya Goykhman[1], Noa Mazurski[1], Liron Stern[1], Joseph Shappir[1], Uriel Levy[1]; [1]*Hebrew Univ. of Jerusalem, Israel.* We experimentally demonstrate resistive random access memory device integrated with a silicon plasmonic waveguide, and relying on the formation of nanoscale metallic needles. The measured electrical and optical response show distinct bistability with well-defined hysteresis.

## Meeting Room 211 B/D

## Meeting Room 212 A/C

## CLEO: Science & Innovations

### STu1I • Nonlinear Optical Materials—Continued

**STu1I.3 • 11:30** Invited

**Room-temperature Bonding and its Applications to Solid-state Lasers and Wavelength-conversion Devices,** Ichiro Shoji[1]; [1]*Chuo Univ., Japan.* We develop composite solid-state lasers and nonlinear wavelength-conversion devices by room-temperature bonding. The room-temperature-bonding technique has a potential of realizing new high-power and highly efficient laser devices over a wide wavelength range.

**STu1I.4 • 12:00**

**> 0.5 MW Peak Power, kHz Repetition Rate at 266 nm Using [100]-Cut Nd:YAG Microchip Laser,** Rakesh Bhandari[1], Takunori Taira[1]; [1]*Inst. for Molecular Science, Japan.* We report the use of [100]-cut YAG/Nd:YAG composite in a microchip laser to reduce depolarization at high average power. Consequently, we achieve FHG giving > 0.5 MW peak power, 1 kHz at 266 nm.

### STu1J • Short Reach Communications—Continued

**STu1J.3 • 11:30**

**A Carrier Centralized Hybrid Long Reach PON with DDO-OFDM Downstream and Nyquist-WDM Upstream,** You-Wei Chen[1], Jhih-Heng Yan[1], Kuo-Ping Huang[2], Kai-Ming Feng[1,2]; [1]*Inst. of Photonics Technologies, National Tsing Hua Univ., Taiwan;* [2]*Inst. of Communications Engineering, National Tsing Hua Univ., Taiwan.* A carrier centralized bi-directional 150/60 Gbps hybrid DDO-OFDM/Nyquist-WDM Long Reach PON is experimentally demonstrated. Uniform performance, high spectral efficiency, asynchronous upstream manipulation, and 1:1024 splitting ratio are achieved.

**STu1J.4 • 11:45**

**Colorless Self-Seeded Fiber Cavity Laser Transmitter for WDM-PON,** Simon Arega Gebrewold[1], Lucia Marazzi[2], Paola Parolari[2], Marco Brunero[2], Romain Brenot[3], David Hillerkuss[1], Christian Hafner[1], Juerg Leuthold[1]; [1]*ETH Zurich, Switzerland;* [2]*Politecnico di Milano, Italy;* [3]*III-V Labs, France.* Colorless, self-seeded km-long fiber cavity RSOA lasers embedded in an access network are investigated for the optimum operation conditions. Theoretical predictions on the proper configuration and the impact of dispersion are supported by experiments.

**STu1J.5 • 12:00**

**Mitigating Rayleigh Backscattering Noise in WDM-PON by Using Cascaded SOAs and Microwave Photonic Filter,** Hanlin Feng[1,2], Jia Ge[2], Shilin Xiao[1], Mable Fok[2]; [1]*The State Key Lab of Advanced Optical Communication Systems and Networks, Shanghai Jiao Tong Univ., China;* [2]*College of Engineering, Univ. of Georgia, Georgia.* We present a Rayleigh backscattering noise mitigation scheme for 10-Gb/s loop-back WDM-PON with cascaded SOAs. OSRNR is reduced to 16.5 dB and BER is improved by 6 dB with the incorporation of microwave photonic filter.

## Meeting Room 212 B/D

## CLEO: QELS-Fundamental Science

### FTu1K • Near-field Imaging with Photons, Plasmons and Electrons—Continued

**FTu1K.3 • 11:30**

**Direct Reconstruction of Transversally Spinning Electric Fields in Tightly Focused Vector Beams,** Martin Neugebauer[1,2], Thomas Bauer[1,2], Gerd Leuchs[1,2], Peter Banzer[1,2]; [1]*Max Planck Inst. for the Science of Light, Germany;* [2]*Inst. of Optics, Information and Photonics, Univ. Erlangen-Nuremberg, Germany.* We demonstrate a simple measurement technique for the direct reconstruction of local transversally spinning electric fields in tightly focused vector beams. Our scheme is based on an easy-to-implement difference measurement of intensities in k-space.

**FTu1K.4 • 11:45**

**Fluorescent Scanning Near-Field Probe Maps the Radiative and Non-Radiative Local Density of Optical States at the Nanometer Scale,** Valentina KRACHMALNICOFF[1], Da Cao[1], Alexandre Cazé[1], Michele Calabrese[1], Romain Pierrat[1], Nathalie Bardou[2], Stéphane Collin[2], Rémi Carminati[1], Yannick De Wilde[1]; [1]*Institut Langevin - ESPCI CNRS, France;* [2]*Laboratoire de Photonique et Nanostructures (LPN-CNRS), France.* We present a novel approach for mapping the radiative and non-radiative local density of states in the near-field of a nanostructure by using a fluorescent near-field probe. Experiments are in quantitative agreement with numerical simulations.

**FTu1K.5 • 12:00**

**Apertureless Optical Near-Field Imaging of Localized Modes of Silicon Nanodisks,** Terefe G. Habteyes[1], Isabelle Staude[2], Katie E. Chong[2], Jason Dominguez[3], Manuel Decker[2], Andrey Miroshnichenko[2], Yuri S. Kivshar[2], Igal Brener[3]; [1]*Dept of Chemistry and Chemical Biology, and Center for High Technology Materials, Univ. of New Mexico, USA;* [2]*Nonlinear Physics Centre, Australian National Univ., Australia;* [3]*Center for Integrated Nanotechnologies, Sandia National Lab, USA.* We measure near-field distributions of Mie-type optical modes of silicon nanodisks using apertureless near-field optical microscopy. Excellent agreement with numerical predictions is obtained, further enabling multipole analysis of the observed modes.

## Marriott Salon I & II

## CLEO: Science & Innovations

### STu1L • Mid-infrared Fiber Lasers—Continued

**STu1L.2 • 11:30**

**Wavelength-Swept Tm-doped Fiber Lasers,** Masaki Tokurakawa[1,3], Jae M. Daniel[1], Chi Shing Cheung[2], Haida Liang[2], W. A. Clarkson[1]; [1]*Optoelectronics Research Centre,Univ. of Southampton, UK;* [2]*Nottingham Trent Univ., School of Science & Technology, UK;* [3]*Inst. of Laser Science, Univ. of Electro-Communications, Japan.* Wavelength-swept operation of cladding-pumped and core-pumped thulium-doped fiber lasers using a novel intracavity rotating disk wavelength-scanning arrangement is reported. Scanning ranges from 1905-2049nm (for cladding pumping) and 1768-1956nm (for core pumping) were obtained.

**STu1L.3 • 11:45** ▶

**3.4 W Ho3+, Pr3+ Co-Doped Fluoride Fibre Laser,** Stephanie Crawford[1], Darren D. Hudson[1], Stuart Jackson[1]; [1]*School of Physics, Univ. of Sydney, Australia.* A maximum output power of 3.4 W, generated at 20.9 % efficiency, was obtained from a Ho3+, Pr3+-co-doped ZBLAN fibre laser pumped at 1150 nm by a Raman fibre laser and pumped by a tunable Yb3+ fibre laser.

**STu1L.4 • 12:00** ▶

**Mid-infrared passively mode-locked fiber ring laser,** Tomonori Hu[1], Darren D. Hudson[1], Stuart Jackson[1]; [1]*Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS), Univ. of Sydney, Australia.* Stable and self-starting passively mode-locked pulses of 6 ps, 465 W peak power, are produced from a holmium-praseodymium co-doped ring fiber laser at 2.9 µm, with a repetition rate of 24.8 MHz.

## CLEO: Science & Innovations

### Marriott
### Salon III

### STu1M • Applied Plasmonics—Continued

**STu1M.3 • 11:30** ▶
**Enhanced Spontaneous Emission Rate of InP using an Optical Antenna,** Kevin Messer[1], Michael Eggleston[1], Ming Wu[1], Eli Yablonovitch[1]; [1]*EECS, Univ. of California - Berkeley, USA.* Experimental evidence of enhanced spontaneous emission from InP coupled to an optical antenna is presented. Photoluminescence measurements show a 120x increase in light emission from antenna-coupled devices over bare InP emitters.

**STu1M.4 • 11:45** ▶
**Electrically-driven surface plasmonic nano-circuits,** Min-Kyo Seo[1,2], Kevin C. Huang[2,3], Tomas Sarmiento[3], Yijie Huo[3], James S. Harris[3], Mark Brongersma[2]; [1]*Physics, KAIST, Republic of Korea;* [2]*Geballe Lab for Advanced Materials, Stanford Univ., USA;* [3]*Electrical Engineering, Stanford Univ., USA.* We realized electrically-driven sub-λ surface plasmonic nano-circuits integrating gap-plasmon emitting nano-LEDs and slot-waveguides with a cross-section of ~0.016λ^2. Gap plasmons are efficiently extracted by the Purcell effect and routed to slot-waveguides, T-splitters, and directional couplers.

**STu1M.5 • 12:00** ▶
**Compact Broadband 50:50 Hybrid Plasmonic Coupler for Silicon Photonics,** Jan Niklas Caspers[1], Mo Mojahedi[1]; [1]*The Edward S. Rogers Sr. Dept of Electrical and Computer Engineering, Univ. of Toronto, Canada.* A compact hybrid plasmonic 50:50 directional coupler for the next generation of silicon photonics integrated circuit was fabricated and measured. Our device has a small footprint of only 21.2 μm by 1.1 μm, a bandwidth of more than 100 nm around 1.55 μm and an insertion loss of less than 1dB.

### Marriott
### Salon IV

### STu1N • Mode-locked Fiber Lasers—Continued

**STu1N.3 • 11:30**
**Development of Femtosecond Thulium-Doped ZBLAN Fiber Laser Oscillators,** Yutaka Nomura[1], Masatoshi Nishio[2], Sakae Kawato[2,3], Takao Fuji[1]; [1]*Inst. for Molecular Science, Japan;* [2]*Graduate School of Engineering, Univ. of Fukui, Japan;* [3]*Research and Education Program for Life Science, Univ. of Fukui, Japan.* We demonstrate a mode-locked fiber laser system using thulium-doped ZBLAN fibers. Very low dispersion of ZBLAN glass fibers enabled generation of pulses with the duration of 45 fs at 1900 nm.

**STu1N.4 • 11:45**
**300 GHz Bound Pulse Generation in a Filter-Assisted Harmonic Mode-Locked Er-doped Fiber Laser with 20 GHz Phase Modulation,** Sheng-Min Wang[1], Siao-Shan Jyu[1], Yinchieh Lai[1]; [1]*Dept of Photonic and Inst. of Electro-Optical Engineering, National Chiao Tung Univ., Taiwan.* By inserting a section of PM fiber for birefringence interference filtering with 100 GHz spacing, stable 300GHz bound pulses have been successfully generated in a harmonic mode-locked Er-doped fiber laser with 20GHz phase modulation frequency.

**STu1N.5 • 12:00**
**Low-temperature PECVD grown carbon-rich silicon carbide saturable absorber for sub-picosecond passively mode-locked fiber lasers,** Chih-Hsien Cheng[1], Gong-Ru Lin[1]; [1]*Graduate Inst. of Photonics and Optoelectronics and Dept of Electrical Engineering, National Taiwan Univ., Taiwan.* The low-temperature PECVD grown carbon-rich silicon carbide film with thickness of 200 nm is employed to passively mode-lock the fiber laser with pulsewidth of 510 fs and linewidth of 5.46 nm.

### Marriott
### Salon V & VI

### STu1O • High Average Power Lasers for Industrial Applications—Continued

**YSTu1O.2 • 12:00**
**1.3 kW average output power Yb:YAG thin-disk multipass amplifier for multi-mJ picosecond laser pulses,** Jan-Philipp Negel[1], Andreas Voss[1], Marwan Abdou Ahmed[1], Dominik Bauer[2], Dirk Sutter[2], Alexander Killi[2], Thomas Graf[1]; [1]*Institut fuer Strahlwerkzeuge (IFSW), Univ. of Stuttgart, Germany;* [2]*TRUMPF Laser GmbH+Co. KG, Germany.* An Yb:YAG thin-disk multipass amplifier delivering sub-8 ps laser pulses with an average output power of 1.3 kW at a repetition rate of 300 kHz, corresponding to a pulse energy of 4.4 mJ is presented.

## CLEO: Applications & Technology

### Marriott
### Willow Glen I-III

### ATu1P • Applications of Optical Microscopy and Imaging—Continued

**ATu1P.2 • 11:30** ▶
**Hand-held RCM/OCT Probe for Assessing Skin Burns,** Ernest Chang[1], Ankit Patel[1], William Fox[2], Milind Rajadhyaksha[3], Mircea Mujat[1], Daniel Ferguson[1], Nicusor Iftimia[1]; [1]*Physical Sciences Inc., USA;* [2]*Lucid, Inc, USA;* [3]*Memmorial Sloan Kettering Cancer Center, USA.* We report a hand-held probe combining high-resolution reflectance confocal microscopy (RCM) and optical coherence tomography (OCT) within the same optical path. Probe development and preliminary testing is being discussed.

**ATu1P.3 • 11:45** Invited ▶
**In vivo Imaging of Nanoparticle Delivery and Tumor Microvasculature with Multimodal Optical Coherence Tomography,** Melissa Skala[1]; [1]*Biomedical Engineering, Vanderbilt Univ., USA.* Photothermal OCT is used to monitor gold nanoparticle delivery in tumors with co-registered speckle variance OCT of vascular morphology. This work demonstrates multimodal OCT as a tool to optimize in vivo drug delivery platforms.

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## CLEO: QELS-Fundamental Science

### Executive Ballroom 210A

### FTu1A • Symposium on Quantum Repeaters I—Continued

**FTu1A.5 • 12:30**
**Long range quantum key distribution using frequency multiplexing in broadband solid state memories,** Hari Krovi[1], Zachary Dutton[1], Saikat Guha[1], Chris Fuchs[1], wolfgang tittel[2], Christoph Simon[2], Joshua A. Slater[2], Khabat Heshami[2], Morgan P. Hedges[2], Gregory S. Kanter[3], Yu-Ping Huang[3], Charles Thiel[4]; *[1]Raytheon BBN Technologies, USA; [2]Univ. of Calgary, Canada; [3]Northwestern Univ., USA; [4]Montana State Univ., USA.* We present simulations of rates for a quantum key distribution scheme using a frequency multiplexed repeater architecture with broadband solid-state quantum memories. We find that key can be generated over 1000 km with eight elementary links.

**FTu1A.6 • 12:45**
**Quantum Repeater for Spectrally Entangled Photons,** Warren P. Grice[1], Raphael Pooser[1], Brian P. Williams[2]; *[1]Oak Ridge National Lab, USA; [2]Univ. of Tennessee, USA.* We describe a quantum repeater architecture for spectrally entangled photons based on sum frequency. The repeater, which does not require a conventional quantum memory, includes a novel scheme for re-using unconverted photons.

### Executive Ballroom 210B

### FTu1B • Dynamics in Semiconductor Quantum Wells—Continued

**FTu1B.6 • 12:15**
**Observation and manipulation of dipole-forbidden exciton transitions in semiconductors,** Lukas Schneebeli[1], Christoph N. Boettge[1], Benjamin Breddermann[1], Mackillo Kira[1], Stephan W. Koch[1], William D. Rice[2,3], Junichiro Kono[2,3], Sabine Zybell[4,5], Stephan Winnerl[4], Jayeeta Bhattacharyya[4], Faina Esser[4,5], Harald Schneider[4], Manfred Helm[4,5], Benjamin Ewers[1], Alexej Chernikov[1], Martin Koch[1], Sangam Chatterjee[1], Galina Khitrova[6], Hyatt Gibbs[6], Aaron M. Andrews[7], Gottfried Strasser[7]; *[1]Dept of Physics and Material Sciences Center, Philipps-Univ., Germany; [2]Dept of Electrical and Computer Engineering, Rice Univ., USA; [3]Dept of Physics and Astronomy, Rice Univ., USA; [4]Helmholtz-Zentrum Dresden-Rossendorf, Germany; [5]Technische Universitaet Dresden, Germany; [6]College of Optical Science, Univ. of Arizona, USA; [7]Inst. of Solid State Electronics, Technische Universitaet Wien, Austria.* We discuss recent experimental and theoretical results that report on the observation of dipole-forbidden intra-exciton transitions in semiconductors via terahertz excitation. Additional manipulation capabilities are gained through the application of a magnetic field.

**FTu1B.7 • 12:30**
**Indirect Excitons in High Magnetic Fields,** Yuliya Y. Kuznetsova[1], Eric V. Calman[1], Leonid Butov[1], Kenneth Campman[2], Arthur Gossard[2]; *[1]Dept of Physics, Univ. of California at San Diego, USA; [2]Materials Dept, Univ. of California at Santa Barbara, USA.* Transport, relaxation, and correlation effects are observed for indirect excitons in high magnetic fields.

**FTu1B.8 • 12:45**
**Terahertz Time-Domain Magnetospectroscopy Using a Table-Top Repetitive Pulsed Magnet,** Gary T. Noe II[1], Qi Zhang[1], Joseph Lee[1], Eiji Kato[2], Hiroyuki Nojiri[3], Gary Woods[1], Junichiro Kono[1]; *[1]Electrical and Computer Engineering, Rice Univ., USA; [2]Advantest America, Inc., USA; [3]Inst. for Materials Research, Tohoku Univ., Japan.* We have observed coherent cyclotron resonance oscillations from a two-dimensional electron gas by combining a rapid scanning terahertz time-domain spectrometer with a table-top mini-coil pulsed magnet.

### Executive Ballroom 210C

### FTu1C • Novel Optics II—Continued

**FTu1C.5 • 12:15**
**UV &Visible Plasmonic Metamaterials Made of Topological Insulator,** Jun-Yu Ou[1], Jin-Kyu So[1], Giorgio Adamo[2], Azat Sulaev[3], Lan Wang[3], Nikolay I. Zheludev[1,2]; *[1]Optoelectronics Research Centre & Centre for Photonic Metamaterials, Univ. of Southampton, UK; [2]Centre for Disruptive Photonic Technologies, Nanyanag Technological Univ., Singapore; [3]School of Physical and Mathematical Sciences, Nanyanag Technological Univ., Singapore.* Plasmonic resonances are observed in metamaterials made of a topological insulator, Bi$_{1.5}$Sb$_{0.5}$Te$_{1.8}$Se$_{1.2}$, at the UV and visible frequencies due to the material's interband transition and nontrivial surface conducting state.

**FTu1C.6 • 12:30**
**Electrically Tunable Mid-Infrared Metamaterials Based on Strong Light-Matter Coupling,** Alexander Benz[1,2], Ines Montano[2], John F. Klem[2], Igal Brener[1,2]; *[1]Center for Integrated Nanotechnologies (CINT), Sandia National Labs, USA; [2]Sandia National Labs, USA.* We present an actively tunable mid-infrared metamaterial operating in the strong light-matter coupling regime. We can tune the upper polariton branch continuously over 8% of the center frequency by applying 5 V.

**FTu1C.7 • 12:45**
**Dielectric meta-atoms coupled by non-resonant metallic antennas: high-quality resonances,** Aditya Jain[1], Philippe Tassin[2,1], Thomas Koschny[1], Costas Soukoulis[1,3]; *[1]Ames Lab-U.S. DOE and Dept of Physics, Iowa State Univ., USA; [2]Dept of Applied Physics, Chalmers Univ., Sweden; [3]Inst. of Electronic Structure and Lasers, FORTH, Greece.* We demonstrate a new class of metamaterials with dielectric meta-atoms coupled to the incident waves by nonresonant metallic antennas. The storage of energy in the dielectric enables high-quality resonances in negative-permittivity and negative-permeability sheet metamaterials.

### Executive Ballroom 210D

### FTu1D • Strong-Field Physics—Continued

**FTu1D.3 • 12:15**
**Two Color Interferences and Quantum Phase Shifts in Above Threshold Ionization,** Lucas Zipp[1,2], Adi Natan[1,2], Philip H. Bucksbaum[1,2]; *[1]Pulse Inst., Stanford/SLAC, USA; [2]Physics, Stanford, USA.* The two color (ω+2ω) above threshold ionization spectrum of argon is measured at different intensity ratios and relative optical phase. We observe quantum phase shifts between interfering ionization pathways, indicating electron dispersion in strong-field ionization.

**FTu1D.4 • 12:30**
**Extraction of Elastic Scattering Cross Sections from Half-Cycle Cutoffs in Photoelectron Spectra,** Henning Geiseler[1], Nobuhisa Ishii[1], Keisuke Kaneshima[1], Kenta Kitano[1], Teruto Kanai[1], Jiro Itatani[1]; *[1]Inst. for Solid State Physics, Univ. of Tokyo, Japan.* We observe half-cycle cutoffs in above-threshold ionization spectra using carrier-envelope phase-stabilized, sub-two-cycle infrared pulses. The waveform-dependent photoelectron spectra allow the retrieval of a resonance-like structure in the cross section for elastic backscattering from Xe$^+$.

**FTu1D.5 • 12:45**
**Carrier-envelope phase sensitive strong-field photoemission from plasmonic nanoparticles,** William Putnam[1], Richard Hobbs[1], Yujia Yang[1], Karl K. Berggren[1], Franz Kärtner[1,2]; *[1]Electrical Engineering and Computer Science and Research Lab of Electronics, MIT, USA; [2]Center for Free-Electron Laser Science, DESY and Univ. of Hamburg, Germany.* Strong-field photoemission from plasmonic nanoparticles is demonstrated on the surface of a chip under ambient conditions. The photoemission shows a carrier-envelope phase-sensitive component with a 27 dB signal-to-noise ratio at a 0.78 Hz resolution bandwidth.

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**13:00–14:00 Lunch and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2 (concessions available)*

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**14:00–16:00 Market Focus Session II:**
**The Solid-State Lighting Revolution: How LEDs are Transforming the $75 Billion Lighting Market,** *Exhibit Hall Theater*

## CLEO: Science & Innovations

### STu1E • Applications of fs Lasers—Continued

**STu1E.3 • 12:15**
**Nanometer-Scale Structuring of Gold Thin-Films and Graphene by Femtosecond Laser Bessel Beams,** Ramazan Sahin[1], Ergun Simsek[2], Selcuk Akturk[1]; [1]*Dept of Physics, Istanbul Technical Univ., Turkey;* [2]*Dept of Electrical and Computer Engineering, George Washington Univ., USA.* We report nanometer-size patterning of various thin films by femtosecond pulsed Bessel beams. Nanoslit arrays fabricated on gold films exhibit excitation of surface plasmon polaritons. We extend the approach to single-atomic-layer systems such as graphene.

**STu1E.4 • 12:30**
**Efficient Femtosecond Mid-infrared Pulse Generation by Dispersive Wave Radiation in Bulk Lithium Niobate Crystal,** Binbin Zhou[1], Hairun Guo[1], Morten Bache[1]; [1]*Danmarks Tekniske Universitet, Denmark.* We experimentally demonstrate efficient mid-infrared pulse generation by dispersive wave radiation in bulk lithium niobate crystal. Femtosecond Mid-IR pulses centering from 2.8-2.92 μm are generated using the single pump wavelengths from 1.25-1.45 μm.

**STu1E.5 • 12:45**
**All-optical ultrafast control of SOI waveguide elements employing localized absorption,** Roman Bruck[1], Otto L. Muskens[1]; [1]*Faculty of Physical Sciences and Engineering, Univ. of Southampton, UK.* An on-chip technique for all-optical ultrafast control of silicon photonic elements was demonstrated by controlling transmission of SOI multimode interference-devices. Localized absorption by free carriers generated by ultraviolet pump pulses was used for achieving control.

### STu1F • Manipulation & Detection of THz Radiation—Continued

**STu1F.5 • 12:15**
**Measured THz pulse propagation between buildings,** Eom-Bae Moon[1], Tae In Jeon[1], Daniel R. Grischkowsky[2]; [1]*Electrical and Electronics Engineering, Korea Maritime and Ocean Univ., Republic of Korea;* [2]*Electrical and Computer Engineering, Oklahoma State Univeristy, USA.* We measured atmospheric propagation of broad-band THz ps pulses between two buildings separated by 79.3 m, using a mode-locked laser as an optical clock. Measurements with a precision of ± 0.1 ps were made in different weather conditions.

**STu1F.6 • 12:30**
**Spectrally resolved measurements of the terahertz beam profile generated from a two-color air plasma,** Pernille K. Pedersen[1], Maksim Zalkovskij[1], Andrew C. Strikwerda[1], Peter U. Jepsen[1]; [1]*DTU Fotonik, Technical Univ. of Denmark, Denmark.* Using a THz camera and THz bandpass filters, we measure the frequency-resolved beam profile emitted from a two-color air plasma. We observe a frequency-independent emission angle from the plasma.

**STu1F.7 • 12:45**
**Concentration of broadband terahertz radiation using a periodic array of conically tapered apertures,** Shuchang Liu[1], Z. Valy Vardeny[2], Ajay Nahata[1]; [1]*Dept of Electrical and Computer Engineering, Univ. of Utah, USA;* [2]*Dept of Physics and Astronomy, Univ. of Utah, USA.* We describe the optical concentration properties of periodic arrays of conically tapered metallic apertures. We also discuss possible future transmission enhancement that utilize cascaded structures by tilting the apertures towards the array center.

### STu1G • Integrated Components for Optical Communications—Continued

**STu1G.5 • 12:15**
**Polarization-Diversified, Multichannel Orbital Angular Momentum (OAM) Coherent Communication Link Demonstration using 2D-3D Hybrid Integrated Devices for Free-Space OAM Multiplexing and Demultiplexing,** Binbin Guan[1], Chuan Qin[1], Ryan P. Scott[1], Nicolas K. Fontaine[2], Tiehui Su[1], Roberto Proietti[1], S. J. Ben Yoo[1]; [1]*Univ. of California Davis, USA;* [2]*Bell Labs, Alcatel-Lucent, USA.* We present dual-polarization QPSK link transmission performance below the FEC limit with simultaneous transmission of three OAM states carrying 14×10 GBd WDM channels using silica 2D-3D hybrid integrated devices for OAM state multiplexing/demultiplexing capacity of 1.68 Tb/s.

**STu1G.6 • 12:30**
**Latch-to-Latch CMOS-Driven Optical Link at 28 Gb/s,** Benjamin G. Lee[1], Seongwon Kim[1], Yoon Ho Daniel Lee[2,1], Jonathan E. Proesel[1], Christian W. Baks[1], Alexander V. Rylyakov[1], Clint L. Schow[1]; [1]*IBM TJ Watson Research Center, USA;* [2]*School of Electrical and Computer Engineering, Cornell Univ., USA.* We demonstrate a 3.4-pJ/bit CMOS-driven VCSEL link incorporating latched half-rate inputs and outputs operating error-free at 28 Gb/s over a few meters of multimode fiber.

**STu1G.7 • 12:45**
**25 Gb/s Data Transmission over a 1.4 m Long Multimode Polymer Spiral Waveguide,** Nikos Bamiedakis[1], Richard V. Penty[1], Ian H. White[1], Petter Westbergh[2], Anders Larsson[2]; [1]*Engineering Dept, Univ. of Cambridge, UK;* [2]*Dept of Microtechnology and Nanoscience, Chalmers Univ. of Technology, Sweden.* Data transmission studies of a 1.4m long multimode polymer spiral waveguide using an 850nm VCSEL are presented. Error-free 25 Gb/s data transmission is demonstrated over that waveguide length, achieving a record bandwidth-length product of 21GHz×m.

### STu1H • Plasmonic Devices—Continued

**STu1H.5 • 12:15**
**Plasmonic Heating and Temperature-Sensing in the Terahertz Regime - Thermometry and Imaging,** Rafik Naccache[1], Anna Mazhorova[1], Matteo Clerici[1,2], Luca Razzari[1], Fiorenzo Vetrone[1], Roberto Morandotti[1]; [1]*Institut National de la Recherche Scientifique - Centre EMT, Canada;* [2]*School of Engineering and Physical Sciences, Heriot-Watt Univ., UK.* Resonant near-infrared excitation induces localized heating of colloidal gold nanorod dispersions. We show that detection and imaging are possible using Terahertz (THz) waves, which possess absorption and refractive indices sensitive to water temperature change.

**STu1H.6 • 12:30**
**Giant Kerr Rotation Enhancement in Magneto-plasmonic Metamaterials,** Evangelos Atmatzakis[1], Nikitas Papasimakis[1], Vassili A. Fedotov[1], Nikolay I. Zheludev[1,2]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK;* [2]*Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore.* We report for the first time an order of magnitude enhancement of Kerr rotation in hybrid plasmonic/ferromagnetic metamaterial resonators. Our results pave the way towards magnetically controlled metamaterials and integrated magneto-plasmonics.

**STu1H.7 • 12:45**
**Optical Exceptional Points at Nano and Macro Scales,** Liang Feng[1,2], Xiang Zhang[2]; [1]*Electrical Engineering, The State Univ. of New York at Buffalo, USA;* [2]*UC Berkeley, USA.* Here, we exploit implementation of optical losses to develop innovative optical phenomena and devices, for example, mimicking exceptional points and their unique transport characteristics in optics at both nano and macro scales.

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**13:00–14:00 Lunch and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2 (concessions available)*

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**14:00–16:00 Market Focus Session II:**
**The Solid-State Lighting Revolution: How LEDs are Transforming the $75 Billion Lighting Market,** *Exhibit Hall Theater*

### Meeting Room 211 B/D

## CLEO: Science & Innovations

### STu1I • Nonlinear Optical Materials—Continued

**STu1I.5 • 12:15**
**Fabrication of large-aperture PPMgLN device using X-axis Czochralski-grown crystal,** Hideki Ishizuki[1], Takunori Taira[1]; *[1]Inst. for Molecular Science, Japan.* New PPMgLN arrangement fabricated from X-axis Czochralski-grown crystal was proposed to improve a laser-beam distortion problem after passing the PPMgLN device. Availability of periodic poling in the new arrangement could be confirmed in 5-mm-thick MgLN.

**STu1I.6 • 12:30**
**Growth of device quality orientation-patterned gallium phosphide (OPGaP) by improved hydride vapour phase epitaxy,** Peter G. Schunemann[1], Lee Mohnkern[1], Alice Vera[1], Xiaoping S. Yang[1], Angie C. Lin[2], James S. Harris[2], Vladimir Tassev[3], Michael R. Snure[3]; *[1]BAE Systems Inc, USA; [2]Stanford Univ., USA; [3]Sensors Directorate (AFRL/RYDH), Air Force Research Lab, USA.* Substantial increases in substrate temperature, super-saturation, and V/III ratio have dramatically improved vertical domain propagation during hydride vapour phase epitaxy of orientation-patterned gallium phosphide, leading to device-quality quasi-phasematched layer thicknesses exceeding 400 μm.

**STu1I.7 • 12:45**
**Mid-Infrared Difference-Frequency Generation in Suspended GaAs Waveguides,** Todd H. Stievater[1], Rita Mahon[1], Doewon Park[1], William Rabinovich[1], Marcel Pruessner[1], Jacob Khurgin[3], Christopher J. K. Richardson[2]; *[1]US Naval Research Lab, USA; [2]Lab for Physical Sciences, USA; [3]Johns Hopkins Univ., USA.* We experimentally demonstrate mid-infrared difference frequency generation in suspended 181-nm thick GaAs waveguides. The extreme form-birefringence in the nanoslab waveguide enables phase-matching between the CW signal (1550 nm), pump (1025 nm), and idler (3000 nm).

### Meeting Room 212 A/C

### STu1J • Short Reach Communications—Continued

**STu1J.6 • 12:15**
**Avalanche Photodiode (APD)-based PAM-16 4 Gb/s LED-POF Link,** Xin Li[1], Nikos Bamiedakis[1], Jinlong Wei[1], Richard V. Penty[1], Ian H. White[1]; *[1]Engineering Dept, Univ. of Cambridge, UK.* The use of an APD-based receiver in a PAM-16 4 Gb/s LED-POF link is shown to provide 10 dB greater link power budget over a PIN photodiode link. Error-free transmission is achieved over 25m SI-POF.

**STu1J.7 • 12:30**
**Experimental Demonstration of a High-Dimension Quasi-Passive Reconfigurable (QPAR) Node,** Yingying Bi[1], Jing Jin[1], Ahmad Dhaini[1], Leonid G. Kazovsky[1]; *[1]Electrical Engineering, Stanford Univ., USA.* Quasi-PAssive Reconfigurable (QPAR) devices can provide flexible power/wavelength distribution in next generation optical access networks. We experimentally demonstrate and analyze a high-dimension QPAR with one wavelength, four power levels and four output ports.

**STu1J.8 • 12:45**
**Optical SSB Modulation Scheme Based on Phase-Modulator and Vertical-Cavity-Surface-Emitting Laser,** Ching-Hung Chang[1], Jui-Hsuan Chang[1]; *[1]Electrical Engineering, National Chiayi Univ., Taiwan.* A novel optical single sideband (OSSB) modulation scheme is proposed based on a phase-modulator (PM) and a tunable optical band pass filter (TOBPF) composed by a vertical-cavity surface-emitting laser (VCSEL) and an optical circulator (OC).

### Meeting Room 212 B/D

## CLEO: QELS-Fundamental Science

### FTu1K • Near-field Imaging with Photons, Plasmons and Electrons—Continued

**FTu1K.6 • 12:15**
**Evidence of random Surface Plasmon modes in fractal metal films,** Arthur Losquin[1], Sophie Camelio[2], David Rossouw[3], Mondher Besbes[4], Frédéric Pailloux[2], David Babonneau[2], Gianluigi A. Botton[3], Jean-Jacques Greffet[4], Odile Stéphan[1], Mathieu Kociak[1]; *[1]Laboratoire de Physique des Solides, Université Paris-Sud, CNRS, France; [2]Institut P', Université de Poitiers, CNRS, France; [3]Dept of Materials Science and Engineering, McMaster Univ., Canada; [4]Laboratoire Charles Fabry, Institut d'Optique, Université Paris-Sud, CNRS, France.* The extraordinary character of Surface Plasmon modes of disordered metallic systems has been predicted theoretically. We here demonstrate through Electron Energy Loss Spectroscopy that percolating fractal metal films sustain numerous strongly confined Surface Plasmon modes.

**FTu1K.7 • 12:30**
**Electron energy-loss spectroscopy of surface plasmon modes in silver nanowires: reconciling experiment and theory,** Xiuli Zhou[1], Andrew Herzing[2], Anton Hörl[3], Andreas Trügler[3], Ulrich Hohenester[3], Theodore Norris[1]; *[1]Center for Ultrafast Optical Science, Univ. of Michigan, USA; [2]Material Measurement Labortary, National Inst. of Standards and Technology, USA; [3]Institut für Physk, Karl-Franzens-Univ. Graz, Austria.* Spectral shifts due to the excitation of higher-order modes occurred when an electric beam is directed near the silver nanowires. Three different theoretical approaches predict the main features of the observed spectra very well.

**FTu1K.8 • 12:45**
**Spatially resolved characterization of gas - metallic nanoparticle interaction by energy loss spectroscopy in an environmental transmission electron microscope,** John Kohoutek[1,2], Pin Ann Lin[1,2], Jonathan Winterstein[1], Henri J. Lezec[1], Renu Sharma[1]; *[1]CNST, NIST, USA; [2]IREAP, Univ. of Maryland, USA.* We use an environmental transmission electron microscope to identify gas adsorption sites for various concentrations of hydrogen and carbon monoxide on Au nanoparticles by collecting electron energy-loss spectra. Experimental results are consistent with simulation.

### Marriott Salon I & II

## CLEO: Science & Innovations

### STu1L • Mid-infrared Fiber Lasers—Continued

**STu1L.5 • 12:15** ▶
**Graphene enabled 3 μm pulsed fiber lasers,** Xiushan Zhu[1], Fengqiu Wang[2], Gongwen Zhu[1], Chen Wei[1], Yuanda Liu[2], Yongbing Xu[2], Kaushik Balakrishnan[1], Robert A. Norwood[1], Nasser Peyghambarian[1]; *[1]Univ. of Arizona, USA; [2]Nanjing Univ., China.* Graphene has emerged as innovative and effective saturable absorber for mid-infrared lasers. Pulsed erbium- and holmium-doped ZBLAN fiber lasers in the 3 μm region based on graphene saturable absorbers are reported.

**STu1L.6 • 12:30** ▶
**Superluminescent Fiber Laser Source in the Mid-Infrared via Dual-Pumping,** Darren D. Hudson[1], Nikolas Iwanus[1], Tomonori Hu[1], Stuart Jackson[1]; *[1]Univ. of Sydney, Australia.* By dual pumping the upper and lower laser level of the 5I6 → 5I7 transition (2.9 μm) of Ho3+ we demonstrate a power-scalable fiber laser that can be modulated between continuous wave lasing and superluminesence.

**STu1L.7 • 12:45** ▶
**Mid-infrared Er:ZBLAN fiber lasers at 3.5μm using dual wavelength pumping,** Ori Henderson-Sapir[1], David J. Ottaway[1], Jesper Munch[1]; *[1]Dept of Physics and Inst. for Photonics and Advanced Sensing (IPAS), Univ. of Adelaide, Australia.* An erbium doped ZBLAN glass fiber laser operating at 3.5μm with an output power of 260mW at room temperature is reported. Substantial efficiency improvement is achieved by employing a novel dual wavelength pumping scheme.

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**13:00–14:00 Lunch and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2 (concessions available)*

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**14:00–16:00 Market Focus Session II:**
**The Solid-State Lighting Revolution: How LEDs are Transforming the $75 Billion Lighting Market,** *Exhibit Hall Theater*

## Marriott Salon III

## CLEO: Science & Innovations

### STu1M • Applied Plasmonics—Continued

**STu1M.6 • 12:15**

**Ultrathin Nanostructured Metals for Highly Transmissive Plasmonic Subtractive Color Filters,** Beibei Zeng[1], Yongkang Gao[1], Filbert Bartoli[1]; [1]*Lehigh Univ., USA.* We present a systematic investigation of the counter-intuitive phenomenon of Extraordinary Low Transmission through ultrathin nanostructured metals, and present results on novel plasmonic subtractive color filters, exhibiting both record-high transmission efficiency and spatial resolution.

**STu1M.7 • 12:30**

**Plasmonic sub-wavelength phase-gradient meta-surfaces for real time dispersive imaging,** Yuewang Huang[1], Qiancheng Zhao[1], Salih K. Kalyoncu[1], Rasul Torun[1], Yumeng Lu[1], Filippo Capolino[1], Ozdal Boyraz[1]; [1]*Univ. of California Irvine, USA.* We have designed and fabricated a sub-wavelength plasmonic deflector based on phase-gradient meta-surfaces for dispersion imaging at 1.55um. We demonstrate dispersive imaging with <300μm resolution and 75.6% power efficiency by incorporating the fabricated plasmonic deflectors.

**STu1M.8 • 12:45**

**Strong Purcell enhancement of Er atoms embedded in a gold nano-trench,** Jung-Hwan Song[1], Hoon Jang[1], Yong-Hee Lee[1]; [1]*Physics, Korea Advanced Inst. of Science and Technology, Republic of Korea.* We demonstrate large enhancement of spontaneous emission (Fp>70) from Er atoms embedded in gold nano-trench structures. This is confirmed by clear correlation between increased decay rate and enhanced photoluminescence as a function of resonant wavelength.

## Marriott Salon IV

### STu1N • Mode-locked Fiber Lasers—Continued

**STu1N.6 • 12:15**

**A 380 fs, 40 GHz Mode-Locked Erbium Fiber Laser with an MQW Nonlinear PM/AM Modulator Using the Pockels Effect and the QCSE,** Masataka Nakazawa[1], Masato Yoshida[1], Ken Tsuzuki[2]; [1]*Tohoku Univ., Japan;* [2]*NTT Photonics Labs, Japan.* We have successfully generated a 380 fs pulse train at 40 GHz from an actively mode-locked erbium fiber laser with an InGaAlAs/InAlAs MQW nonlinear PM/AM modulator using the Pockels effect and the quantum confined Stark effect.

**STu1N.7 • 12:30**

**Cladding-pumped mode-locked fiber laser with a chirped fiber Bragg grating,** Yi-Jing You[1], Alexey Zaytsev[2], Chih-Hsuan Lin[1], Ci-Ling Pan[1,2]; [1]*Inst. of Photonics Technologies, National Tsing Hua Univ., Taiwan;* [2]*Dept of Physics, National Tsing Hua Univ., Taiwan.* A mode-locked cladding-pumped Yb-doped fiber laser using a saturable Bragg reflector and a chirped fiber Bragg grating at 1064 nm wavelength can generate 170 mW of average power and 34 nJ of pulse energy.

**STu1N.8 • 12:45**

**Sub-50 fs compressed pulses from a graphene-mode locked fiber laser,** David Purdie[1], Daniel Popa[1], Valentin J. Wittwer[1], Zhe Jiang[1], Felice Torrisi[1], Andrea C. Ferrari[1]; [1]*Cambridge Graphene Centre, Univ. of Cambridge, UK.* We demonstrate a graphene mode-locked fiber laser system generating 42 fs pulses with 53 mW output power, ideal for high temporal resolution applications.

## Marriott Salon V & VI

### STu1O • High Average Power Lasers for Industrial Applications—Continued

**STu1O.3 • 12:15**

**130 MW peak power femtosecond laser pulses in a Kerr lens mode-locked thin-disk ring oscillator,** Abdolreza Amani Eilanlou[1], Yasuo Nabekawa[1], Makoto Kuwata-Gonokami[2,3], Katsumi Midorikawa[1,2]; [1]*Center for Advanced Photonics, RIKEN, Japan;* [2]*Photon Science Center, The Univ. of Tokyo, Japan;* [3]*Graduate School of Science, The Univ. of Tokyo, Japan.* We report generation of 860 W average power, 440 fs pulses in a 15.2 MHz thin-disk ring oscillator by placing a Kerr lens mode-locking setup in a low-pressure chamber.

**STu1O.4 • 12:30**

**High efficiency laser-diode-pumped continuous-wave Yb:YAG laser at room temperature,** Masatoshi Nishio[1], Sakae Kawato[1,2], AKIYUKI MARUKO[1], Naoya Shimojo[1], Hiroaki Okunishi[1], Kento Kato[1], Keisuke Kyomoto[1], Takeshi Yoshida[1]; [1]*Fukui Univ., Japan;* [2]*Univ. of Fukui, Japan.* A high-efficiency continuous-wave laser-diode-pumped Yb:YAG laser has been realized at room temperature by high intensity pumping. The slope efficiency and optical-to-optical conversion efficiency were 77% and 72% for the absorbed pump power, respectively.

**STu1O.5 • 12:45**

**Pulse Energy Scaling of Modelocked Oscillators: Moving from 80 μJ to >100 μJ from SESAM-modelocked Thin Disk Lasers,** Clara J. Saraceno[1,2], Florian Emaury[1], Cinia Schriber[1], Martin Hoffmann[2], Matthias Golling[1], Thomas Südmeyer[2], Ursula Keller[1]; [1]*Dept of Physics, ETH Zurich, Switzerland;* [2]*Dept of Physics - Time and frequency Lab, Univ. of Neuchatel, Switzerland.* An Yb:YAG SESAM-modelocked thin-disk laser delivering 1.07ps pulses with record-high pulse energy of 80μJ at 242W of average power is presented. Improved SESAM designs and nonlinearity limits are explored towards multi-100 μJ modelocked oscillators

## Marriott Willow Glen I-III

## CLEO: Applications & Technology

### ATu1P • Applications of Optical Microscopy and Imaging—Continued

**ATu1P.4 • 12:15**

**Visible light optical coherence tomography to quantify retinal blood oxygenation,** Ji Yi[1], Wenzhong Liu[1], Hao F. Zhang[1]; [1]*Northwestern Univ., USA.* We presented the method of using visible-light optical coherence tomography (vis-OCT) for retinal oximetry. We demonstrated for the first time in vivo OCT measurement of the arterial and venous oxygenation in retinal circulation.

**ATu1P.5 • 12:30** Invited

**Searching for Biomarkers of Glaucoma using Adaptive Optics Scanning Ophthalmoscopy,** Alfredo Dubra[1]; [1]*Medical College of Wisconsin, USA.* This presentation will review the latest linear microscopy techniques applied to imaging the living retina, as well as the normal and pathological retinal structures that can now be visualized non-invasively..

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13:00–14:00 **Lunch and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2 (concessions available)*

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14:00–16:00 **Market Focus Session II:**
**The Solid-State Lighting Revolution: How LEDs are Transforming the $75 Billion Lighting Market,** *Exhibit Hall Theater*

## CLEO: QELS-Fundamental Science

### Executive Ballroom 210A

**14:00–16:00**

### FTu2A • Symposium on Quantum Repeaters II

*Presider: Wolfgang Tittel; Inst. of Quantum Information, Univ. of Calgary, USA*

**FTu2A.1 • 14:00** Invited

**Toward a quantum network based on semiconductor quantum dots,** Olivier Gazzano[1], Anna Kamila Nowak[1], Valérian Giesz[1], Vivien Loo[1], Christophe Arnold[1], Simone L. Portalupi[1], Justin Demory[1], Marcelo P. Almeida[2], Andrew G. White[2], Claudio Dal Savio[3], Pierre-François Braun[3], Khaled Karrai[3], Isabelle Sagnes[1], A. Lemaitre[1], Loic Lanco[1,4], Pascale Senellart[1]; [1]*CNRS-Laboratoire de Photonique et Nanost, France; [2]Centre for Quantum Computer and Communication Technology, School of Mathematics and Physics, Univ. of Queensland, Australia; [3]Attocube systems AG, attocube, Germany; [4]Département de Physique, Université Paris Diderot, France.* Recent advances in quantum dot based quantum technology are presented: scalable fabrication of bright sources of single photons or entangled photon pairs, optical non-linearities at the few photon scales and first implementations of quantum gates.

**FTu2A.2 • 14:30**

**Quantum dot spin-photon interface and teleportation from a photon to a spin,** Weibo Gao[1], Parisa Fallahi[1], Emre Togan[1], Javier Miguel-Sanchez[1], Atac Imamoglu[1]; [1]*Inst. of Quantum Electronics, ETH Zurich, CH-8093, Switzerland.* Particularly in the frame of quantum information, my talk will focus on the optical manipulation of a quantum dot spin; the creation of entanglement between a flying photon and a semiconductor quantum dot spin; and the photon-to-spin teleportation experiment.

### Executive Ballroom 210B

**14:00–16:00**

### FTu2B • Optical Properties of Low-Dimensional Materials

*Presider: Steven T. Cundiff, Univ. of Colorado at Boulder JILA, USA*

**FTu2B.1 • 14:00**

**Cavity Optomechanics with Suspended Carbon Nanotubes,** Mian Zhang[1], Arthur Barnard[2], Paul L. McEuen[2,3], Michal Lipson[1,3]; [1]*Electrical and Computer Engineering, Cornell Univ., USA; [2]Lab of Atomic and Solid State Physics, Cornell Univ., USA; [3]Kavli Inst. at Cornell, Cornell Univ., USA; [4]4Instituto de Fisica Gleb Wataghin, Universidade Estadual de Campinas, Brazil.* We demonstrate large optomechanical coupling between a carbon nanotube and an optical microresonator. We measured a dominantly dissipative optomechanical coupling coefficient of $g_\kappa$ = 1 MHz/nm

**FTu2B.2 • 14:15**

**Observation of rapid carrier relaxation in graphene oxide probed by ultrafast terahertz spectroscopy,** Jaeseok Kim[1], Juyeong Oh[2], Chihun In[1], Yun-Shik Lee[3], Theodore B. Norris[4], Seong Chan Jun[2], Hyunyong Choi[1]; [1]*School of Electrical and Electronic Engineering, Yonsei Univ., Republic of Korea; [2]Dept of Mechanical Engineering, Yonsei Univ., Republic of Korea; [3]Dept of Physics, Oregon State Univ., USA; [4]Dept of Electrical Engineering and Computer Science, Univ. of Michigan, Ann Arbor, USA.* We investigate the carrier relaxation dynamics in graphene oxide (GO) using ultrafast optical-pump terahertz-probe spectroscopy. Unlike graphene, we observe the dynamics of GO show rapid percolation behaviors related to the multi-particle Auger scattering.

**FTu2B.3 • 14:30**

**Characterization of Fast Temporal Photoresponse in a Broadband Graphene Photodetector,** Ryan J. Suess[1], Xinghan Cai[2], Mohamad M. Jadidi[1], Andrei B. Sushkov[2], Gregory S. Jenkins[2], Jun Yan[2,3], Luke O. Nuakiti[4], Rachel L. Myers-Ward[5], D Kurt Gaskill[5], Thomas E. Murphy[1], H Dennis Drew[2], Michael S. Fuhrer[2,6]; [1]*Inst. for Research in Electronics & Applied Physics, Univ. of Maryland, USA; [2]Dept of Physics, Center for Nanophysics & Advanced Materials, Univ. of Maryland, USA; [3]Dept of Physics, Univ. of Massachusetts, USA; [4]Texas A&M Univ., USA; [5]U.S. Naval Research Lab, USA; [6]School of Physics, Monash Univ., Australia.* The temporal response of a broadband, monolayer graphene photodetector based on the photothermoelectric effect is characterized. Pulse-coincidence and impulse response measurements indicate fast photodetection on the timescale of 10 ps.

### Executive Ballroom 210C

**14:00–16:00**

### FTu2C • Novel Anisotropic Structures

*Presider: Jingbo Sun, State University of New York at Buffalo, USA*

**FTu2C.1 • 14:00**

**Photonic Hyper-Crystals,** Evgenii E. Narimanov[1]; [1]*Purdue Univ., USA.* We introduce a new “universality class” of artificial optical media - photonic hyper- crystals. These hyperbolic metamaterials with periodic spatial variation of dielectric permittivity on subwavelength scale, combine the features of optical metamaterials and photonic crystals.

**FTu2C.2 • 14:15**

**Self-Assembled Tunable Photonic Hyper-Crystals,** Vera Smolyaninova[1], Bradley Yost[1], David Lahneman[1], Evgenii Narimanov[2], Igor Smolyaninov[3]; [1]*Towson Univ., USA; [2]Birck Nanotechnology Centre, Purdue Univ., USA; [3]ECE, Univ. of Maryland, USA.* We demonstrate a novel artificial optical material, a ”photonic hyper-crystal”, which combines properties of hyperbolic metamaterials and photonic crystals. It is based on cobalt nanoparticle ferrofluid subjected to magnetic field.

**FTu2C.3 • 14:30**

**Multi-Periodic Photonic Hyper-Crystals: Volume Plasmon Polaritons and the Purcell Effect,** Viktoriia Babicheva[1,2], Ivan Iorsh[2], Alexey Orlov[2], Pavel A. Belov[2], Andrei Lavrinenko[1], Andrei Andryieuski[1], Sergei Zhukovsky[1,2]; [1]*Technical Univ. of Denmark, Denmark; [2]National Research Univ. for Information Technology, Mechanics, and Optics, Russia.* We theoretically demonstrate superior degree of control over volume plasmon polariton propagation and the Purcell effect in multi-period (4-layer unit cell) plasmonic multilayers, which can be viewed as multiscale hyperbolic metamaterials or multiperiodic photonic hyper-crystals.

### Executive Ballroom 210D

**14:00–16:00**

### FTu2D • Novel XUV/X-Ray Sources

*Presider: Oliver Muecke; Deutsches Elektronen Synchrotron, Germany*

**FTu2D.1 • 14:00** Invited

**Lightwave control of plasma mirrors,** Rodrigo B. Lopez-Martens[1]; [1]*Laboratoire d’Optique Appliquée, ENSTA ParisTech, Ecole Polytechnique, CNRS UMR 7639, France.* We show how tailored few-cycle lightwaves with near relativistic intensity (~1018W/cm2) can be used to control the attosecond electron dynamics of plasma mirrors and produce beam manifolds of fully synchronized attosecond EUV light pulses.

**FTu2D.2 • 14:30**

**High Harmonic Generation of Fiber Laser Systems with more than 100 μW Average Power per Harmonic,** Steffen Hädrich[1,2], Jan Rothhardt[1,2], Arno Klenke[1,2], Manuel Krebs[1], Armin Hoffmann[1], Oleg Pronin[3], Vladimir Pervak[3], Jens Limpert[1,2], Andreas Tünnermann[1,4]; [1]*Inst. of Applied Physics, Germany; [2]Helmholtz-Institut Jena, Germany; [3]Ludwig-Maximilian-Universität München, Germany; [4]Fraunhofer Inst. of Applied Optics and Precision Engineering, Germany.* Sub-30 fs pulses at 600 kHz (82 W) repetition rate are utilized for HHG. More than 30 μW average power are obtained for harmonics between H21-H33 and the strongest harmonic is H25 with 143 μW.

## CLEO: Science & Innovations

## Executive Ballroom 210E

### 14:00–16:00
### STu2E • fs - Oscillators
*Presider: Clara Saraceno, ETH Zurich, Switzerland*

**STu2E.1 • 14:00**
**37 fs - 1.5 W Kerr-lens mode-locked Yb:CALGO laser oscillator,** Pierre Sevillano[1], Romain Dubrasquet[1,2], Frederic Druon[3], Patrick Georges[3], Dominique Descamps[1], Eric Cormier[1]; *[1]CELIA, France; [2]Azur light System, France; [3]Laboratoire Charles Fabry, France.* Kerr-lens mode-locking (KLM) in Yb:CALGO has been demonstrated by means of a high-brightness optical pumping with an Yb:fiber laser. Stable 37 fs pulses are produced with an average power of 1.5 W.

**STu2E.2 • 14:15**
**62 fs Pulse Generation from a SESAM Modelocked Yb:CALGO Thin Disk Laser,** Andreas Diebold[1], Florian Emaury[1], Cinia Schriber[1], Matthias Golling[1], Clara J. Saraceno[1,2], Thomas Südmeyer[2], Ursula Keller[1]; *[1]Inst. of Quantum Electronics, ETH Zurich, Switzerland; [2]Laboratoire Temps-Fréquence, Université de Neuchâtel, Switzerland.* We present the shortest pulses of any modelocked thin disk laser (TDL): a SESAM modelocked Yb:CALGO TDL generates 62 fs pulse duration at 5.1 W average power and we present new noise characterization.

**STu2E.3 • 14:30**
**Soliton Modelocking via Cascaded Quadratic Nonlinearities in a SESAM-modelocked Yb:CALGO Laser,** Aline Sophie Mayer[1], Christopher R. Phillips[1], Alexander Klenner[1], Ursula Keller[1]; *[1]ETH Zurich, Switzerland.* We present soliton modelocking based on cascading of quadratic nonlinearities using an LBO crystal in a SESAM-modelocked Yb:CaGdAlO$_4$ laser cavity, enabling pulse formation in the positive GDD-regime, reaching 114-fs pulses at 1.1-W average output power.

## Executive Ballroom 210F

### 14:00–16:00
### STu2F • THz Metamaterials and Plasmonics
*Presider: Marco Rahm; Technische Universität Kaiserslautern, Germany*

**STu2F.1 • 14:00**
**Metamaterial Composite with an Ultra-Broadband Usable Range of over 25 Terahertz,** Andrew C. Strikwerda[1], Maksim Zalkovskij[1], Alexander Krabbe[1], Dennis Lund Lorenzen[1], Andrei Lavrinenko[1], Peter U. Jepsen[1]; *[1]Dept of Photonics Engineering, Technical Univ. of Denmark, Denmark.* Using a metamaterial composite, we demonstrate a bandpass filter that has only a single transmission mode from 0 to >25 THz. This usable bandwidth matches, or exceeds, that of currently used THz sources.

**STu2F.2 • 14:15**
**Orbit Angular Momentum Multiplexing in 0.1-THz Free-space Communication via 3D Printed Spiral Phase Plates,** Xuli Wei[1]; *[1]Wuhan National Lab for Optoelectronics, China.* We present a proof of concept demonstration of THz free-space communication employing orbital angular momentum (OAM) multiplexing .Two different OAM modes are multiplexed and de-multiplexed in experiment via 3D printed spiral phase plates.

**STu2F.3 • 14:30**
**Wavevector selective surface,** Vassili A. Fedotov[1], Jan Wallauer[2], Markus Walther[2], Nikitas Papasimakis[1], Nikolay I. Zheludev[1,3,] Evangelos Atmatzakis[1]; *[1]Optoelectronics Research Centre and Centre for Photonic Metamaterials, Univ. of Southampton, UK; [2]Dept of Molecular and Optical Physics, Univ. of Freiburg, Germany; [3]Centre for Disruptive Photonics Technologies, Nanyang Technological Univ., Singapore.* Frequency selective surfaces are very well known and have been investigated in detail. Here we for the first time introduce the concept of a wavevector selective surface and demonstrate it experimentally.

## Executive Ballroom 210G

### 14:00–16:00
### STu2G • RF Photonics
*Presider: Willie Ng; Univ. of Southern California, USA*

**STu2G.1 • 14:00**
**Master-Slave Locking of Optomechanical Oscillators Over A Long Distance,** Shreyas Y. Shah[1], Mian Zhang[1], Michal Lipson[1,2]; *[1]School of Electrical and Computer Engineering, Cornell Univ., USA; [2]Kavli Inst. at Cornell, Cornell Univ., USA.* We show that two independent mechanical oscillators, placed ~3.2km apart, and separated in frequency by ~80kHz, can be locked in a master-slave configuration, using light. This scheme can be generalised for an arbitrary network configuration.

**STu2G.2 • 14:15**
**Widely Tunable Dual-loop Optoelectronic Oscillator,** Xiaopeng Xie[1], Tao Sun[1], Huanfa Peng[1], Cheng Zhang[1], Peng Guo[1], Lixin Zhu[1], Weiwei Hu[1], Zhangyuan Chen[1]; *[1]Peking Univ., China.* We demonstrate a record widely tunable dual-loop optoelectronic oscillator with tunable band from 3.39 to 57.50 GHz. The single-side band phase noise is below -120 dBc/Hz at 10 kHz offset for all the measurement frequency points.

**STu2G.3 • 14:30**
**On-chip Quasi-THz Bandwidth Microwave Photonic Phase Shifter based on a Waveguide Bragg Grating on Silicon,** Maurizio Burla[1], Luis Romero Cortés[1], Ming Li[2], Xu Wang[3], Lukas Chrostowski[3], José Azaña[1]; *[1]Ultrafast Optical Processing group, Institut National de la Recherche Scientifique, Canada; [2]Inst. of Semiconductors, Chinese Academy of Sciences, China; [3]Dept of Electrical and Computer Engineering, Univ. of British Columbia, Canada.* We experimentally demonstrate a continuously-tunable quasi-THz RF-photonic phase shifter based on a dual-phase-shifted waveguide Bragg grating on silicon. Phase shifts up to ~90° are demonstrated over the 16-20 GHz band, constrained only by instrumentation limitations.

## Executive Ballroom 210H

### 14:00–16:00
### STu2H • Controlling Light in Resonators and Photonic Crystals
*Presider: Avi Zadok; Bar-Ilan Univ., Israel*

**STu2H.1 • 14:00**
**Optical Preparation of Stable Supercooled VO$_2$ Nanocrystals: A Route Towards Reconfigurable Photonic Devices for Telecom Wavelengths,** Thorben Jostmeier[1], Johannes Zimmer[2], Helmut Karl[3], Hubert J. Krenner[2], Markus Betz[1]; *[1]Experimentelle Physik 2, TU Dortmund Univ., Germany; [2]Lehrstuhl für Experimentalphysik I and Augsburg Centre for Innovative Technologies (ACIT), Universität Augsburg, Germany; [3]Lehrstuhl für Experimentalphysik IV, Universität Augsburg, Germany.* Single-domain VO$_2$ nanocrystals in a fused silica matrix exhibit an extremely large thermally and/or optically induced hysteresis around room temperature. We demonstrate optical imprinting of persistent diffraction gratings and repetitive (>10$^4$) cycling through the phase transition.

**STu2H.2 • 14:15**
**Helium-Ion-Induced Radiation Damage in LiNbO$_3$ Thin Film Electro-Optic Modulators,** Hsu-Cheng Huang[1], Jerry I. Dadap[1], Richard M. Osgood[1], Girish Malladi[2], Hassaram Bakhru[2]; *[1]Columbia Univ., USA; [2]SUNY at Albany, USA.* We study He$^+$-induced radiation damage in 10-μm-thick LiNbO$_3$-thin-film modulators. Results show induced-strain, scattering from interstitials, and the degree of overlap between guided modes with damaged region result in degradation of device extinction ratio and V$_\pi$L.

**STu2H.3 • 14:30**
**Scalable High-Frequency Silicon Carbide Optomechanical Microresonators,** Xiyuan Lu[1], Jonathan Yiho Lee[1], Philip X.-L. Feng[2], Qiang Lin[1]; *[1]Univ. of Rochester, USA; [2]Case Western Reserve Univ., USA.* We demonstrate silicon carbide optomechanical microresonators with mechanical frequency up to 1.7GHz, mechanical quality above 5500 and optomechanical coupling around 100GHz/nm. The frequency can match the zero-field splitting of the defect spin in silicon carbide.

## Meeting Room
## 211 B/D

## CLEO: Science & Innovations

**14:00–16:00**
**STu2I • All Optical and Quantum Signal Processing**
*Presider: Paulina Kuo; National Inst. of Standards and Technology, USA*

**STu2I.1 • 14:00** Invited
**New Applications and Devices for Quantum Frequency Conversion,** Kartik Srinivasan[1], Imad Agha[1,2], Serkan Ates[1,2], Marcelo I. Davanco[1], Yuxiang Liu[1,2]; [1]*Center for Nanoscale Science and Technology, NIST, USA;* [2]*Maryland Nanocenter, Univ. of Maryland, USA.* We review recent experiments demonstrating quantum frequency conversion (QFC) of single photon states of light and discuss perspectives for combining QFC with temporal wavepacket shaping. Progress in developing nanophotonic geometries for QFC is also presented.

**STu2I.2 • 14:30**
**Effects of Raman scattering in quantum state-preserving frequency conversion,** Søren M. Friis[1], Lasse Mejling[1], Mario A. Usuga[1], Anders T. Pedersen[1], Colin J. McKinstrie[2], Karsten Rottwitt[1]; [1]*DTU Fotonik, Technical Univ. of Denmark, Denmark;* [2]*Bell Labs, Alcatel-Lucent, USA.* We analyse frequency conversion by Bragg scattering numerically including Raman scattering. The frequency configuration that performs the best under influence of Raman noise results in 95% conversion over a 3.25 THz bandwidth with a 2.5-dB noise figure.

## Meeting Room
## 212 A/C

**14:00–16:00**
**STu2J • Phase Sensitive Amplification and Optical Regeneration**
*Presider: Michael Vasilyev; Univ. of Texas at Arlington, USA*

**STu2J.1 • 14:00** Invited
**Signal Regeneration Techniques for Advanced Modulation Formats,** Francesca Parmigiani[1], Kyle R. Bottrill[1], Graham Hesketh[1], Peter Horak[1], Periklis Petropoulos[1], David J. Richardson[1]; [1]*Univ. of Southampton, UK.* We review recent results on all-optical regeneration of phase encoded signals based on phase sensitive amplification achieved by avoiding phase-to-amplitude conversion in order to facilitate the regeneration of amplitude/phase encoded (QAM) signals.

**STu2J.2 • 14:30**
**Multilevel amplitude regeneration of 256-symbol constellation,** Mariia Sorokina[1]; [1]*Aston Univ., UK.* We propose a novel scheme for multilevel (9 and more) amplitude regeneration based on nonlinear optical loop mirror and demonstrate its efficiency and cascadability on 256-symbol constellation.

## Meeting Room
## 212 B/D

## CLEO: QELS-Fundamental Science

**14:00–16:00**
**FTu2K • Plasmonic Waveguides, Lenses and Circuits**
*Presider: Henri Lezec; NIST, USA*

**FTu2K.1 • 14:00**
**Suspended MIM Optical Waveguides with Optical Nano-Antennas,** Brian E. Edwards[1], Nader Engheta[1]; [1]*Electrical and Systems Engineering, Univ. of Pennsylvania, USA.* In this work we experimentally demonstrate suspended gold-air-gold (MIM) plasmonic waveguides operating at the NIR wavelengths. The waveguide interfaces with the far field using optical nano-antennas with main beams normal to the structure.

**FTu2K.2 • 14:15**
**Plasmonic antennas nanocoupler for telecom range: simulation, fabrication and near-field characterization,** Andrei Andryieuski[1], Vladimir A. Zenin[2], Radu Malureanu[1], Valentyn S. Volkov[2], Sergey I. Bozhevolnyi[2], Andrei Lavrinenko[1]; [1]*DTU Fotonik, Technical Univ. of Denmark, Denmark;* [2]*Inst. of Technology and Innovation, Univ. of Southern Denmark, Denmark.* We report simulation, fabrication and amplitude-phase near-field characterization in telecom range of the compact and efficient plasmonic antenna coupler to slot waveguide. Near-field data allowed measuring propagation losses and effective mode index that agree well with simulation results.

**FTu2K.3 • 14:30**
**Linearly Dichroic Plasmonic Lens and Hetero-Chiral Structures,** Grisha Spektor[1], Asaf David[1], Bergin Gjonaj[1], Lior Gal[1], Meir Orenstein[1]; [1]*Electrical Engineering, Technion, Israel.* We present an experimental study of plasmonic Hetero-Chiral structures, comprised of constituents with opposite chirality. We show selective focusing of orthogonal polarization states, standing plasmonic 'vortex fields' and more.

## Marriott
## Salon I & II

## CLEO: Applications & Technology

**14:00–16:00**
**ATu2L • Symposium on Laser Processing for Consumer Electronics I** ▶
*Presider: Eric Mottay; Amplitude Systemes, France*

**ATu2L.1 • 14:00** Invited ▶
**Ultrafast laser processing and metrology,** Keiji Nomaru[1], Hiroshi Morikazu[1], Kunimitsu Takahashi[1]; [1]*Laser Engineering, DISCO Corportion, Japan.* Precisely controlled blind via-holes were formed in multilayer substrates by an ultrafast laser. A LIBS detector integrated into the laser processing machine realizes the full potential of the ultrafast laser.

**ATu2L.2 • 14:30** Invited ▶
**Opaque Film Metrology using PULSE Technology,** Manjusha Mehendale[1]; [1]*Rudolph Technologies, USA.* PULSE TechnologyTM involves generation and detection of acoustic waves in opaque layers using ultrafast laser pulses. Its application in advanced semiconductor and packaging industry for single and multi-layer thin film metrology is presented. above

## CLEO: Science & Innovations

### Marriott Salon III

**14:00–16:00**

### STu2M • Novel Concepts in Nanophotonics ▶

*Presider: Thomas Mueller, Vienna Univ of Tech., Austria*

**STu2M.1 • 14:00** Invited ▶

**Photonic Topological Insulators,** Mordechai Segev[1], Yonatan Plotnik[1], Mikael Rechtsman[1], Yaakov Lumer[1], Miguel A. Bandres[1], Julia M. Zeuner[2], Alexander Szameit[2]; *[1]Technion Israel Inst. of Technology, Israel; [2]Inst. of Applied Physics, Abbe Center of Photonics, Friedrich-Schiller-Universität Jena, Germany.* We review the recent progress on the first experimental demonstration of photonic topological insulators, along with a variety of new ideas associated with it.

**STu2M.2 • 14:30** ▶

**Topological Edge States in Silicon Photonics,** Sunil Mittal[1], Jingyun Fan[1], Alan L. Migdall[1], Jacob Taylor[1], Mohammad Hafezi[1]; *[1]Joint Quantum Inst., Univ. of Maryland, College Park / National Inst. of Standards and Technology, Gaithersburg, USA.* We demonstrate the robustness of topological edge states in a photonic system of coupled microring resonators. Using direct imaging and transmission analysis, we show that the edge states are robust to lattice disorders.

### Marriott Salon IV

**14:00–16:00**

### STu2N • High Power Pulsed Fiber Lasers

*Presider: Akira Shirakawa; Univ. of Electro-Communications, Japan*

**STu2N.1 • 14:00**

**300W monolithic actively Q-switched fiber laser at 1064 nm,** Wei Shi[1,2], Qiang Fang[2,3], Xueping Tian[3], Jingli Fan[3]; *[1]Tianjin Univ., China; [2]Tianjin Inst. of Modern Laser & Optics Technology, China; [3]Shandong HFB Photonics Co. Ltd., China.* We report a high power monolithic nanosecond pulsed fiber laser at 1064nm in MOPA configuration. More than 300W average power was achieved for 475 ns pulses at repetition rate of 100 kHz.

**STu2N.2 • 14:15**

**700kW peak power monolithic nanosecond pulsed fiber laser,** Wei Shi[1,2], Qiang Fang[2,3], Jingli Fan[3]; *[1]Tianjin Univ., China; [2]Tianjin Inst. of Modern Laser & Optics Technology, China; [3]Shandong HFB Photonics Co. Ltd., China.* We report a high peak power monolithic nanosecond pulsed fiber laser in MOPA configuration. The system can produce ~ 709 kW peak power for 3.3 ns fiber laser pulses at 10 kHz repetition rate.

**STu2N.3 • 14:30**

**High Power Er-doped Yb-free Double-Clad Fiber Amplifiers,** Leonid V. Kotov[1,2], Mikhail E. Likhachev[1], Mikhail M. Bubnov[1], Denis S. Lipatov[3], Mikhail V. Yashkov[3], Aleksei N. Guryanov[3], Sébastien Février[4], Jérôme Lhermite[5], Eric Cormier[5]; *[1]Fiber Optics Research Center RAS, Russia; [2]Moscow Inst. of Physics and Technology, Russia; [3]Inst. of Chemistry of High Purity Substances RAS, Russia; [4]XLIM, UMR 7252 CNRS - Univ. of Limoges, France; [5]CeLIA, Université Bordeaux 1, CNRS UMR 5107, France.* We present simple and efficient laser schemes based on newly developed Er-doped fibers cladding pumped at 976 nm. 103 W CW-power amplifier with 37 % conversion efficiency and 1.5 mJ-pulse energy nanosecond laser were demonstrated.

### Marriott Salon V & VI

**14:00–16:00**

### STu2O • Symposium on Microcavity Exciton-Polaritons, Devices and Applications I ▶

*Presider: Vinod Menon; CUNY Queens College, USA*

**STu2O.1 • 14:00** Invited ▶

**Persistent Current of a Microcavity Polariton Condensate in a Ring Geometry,** David W. Snoke[1], Gangqiang Liu[1], Andrew Daley[2], Loren N. Pfeiffer[3], Kenneth W. West[3]; *[1]Univ. of Pittsburgh, USA; [2]Strathclyde Univ., UK; [3]Princeton Univ., USA.* We have created microcavity polaritons with a lifetime of about 200 ps, which allows them to condense in the ground state of a ring trap. Optical measurements show they have quantized vorticity.

**STu2O.2 • 14:30** ▶

**Stimulated polariton emission from ZnO-nanoparticles based microcavity,** Xiaoze Liu[1,2], Kannatassen Appavoo[3], Matthew Sfeir[3], Stéphane Kéna-Cohen[4], Vinod M. Menon[1,2]; *[1]Dept. of Physics, Graduate School and Univ. Center of the City Univ. of New York, USA; [2]Dept. of Physics, Queens College of the City Univ. of New York, USA; [3]Center for Functional Nanomaterials, Brookhaven National Lab, USA; [4]Dept. of Engineering Physics, École Polytechnique de Montréal, Canada.* We demonstrate stimulated polariton emission at room temperature in a dielectric microcavity embedded with ZnO nanoparticles. The polariton lifetime is also shown to decrease drastically above the stimulated emission threshold.

## CLEO: Applications & Technology

### Marriott Willow Glen I-III

**14:00–16:00**

### ATu2P • Symposium on Novel Light Sources and Photonic Devices in Optical Imaging I ▶

*Presider: Benjamin Vakoc; Harvard Medical School, USA*

**ATu2P.1 • 14:00** Invited

**Advancements in Nanophotonic-Based Optical Coherence Tomography,** Nicholas Sherwood[1], Kyle J. Preston[1], Arthur Nitkowski[1], Nitin Kalra[1], Arsen R. Hajian[2], Bradley S. Schmidt[2]; *[1]Tornado Spectral Systems, USA; [2]Tornado Spectral Systems, Canada.* In 2013, TSS introduced the OCTANE-860, the first chip-based nanophotonic spectrometer for Spectral-Domain OCT. Challenges and benefits have been identified during development and a new strategy for optimizing performance will be discussed.

**ATu2P.2 • 14:30** Invited

**Next Generation Swept-sources for OCT and Other Applications,** Brian Goldberg[1]; *[1]AXSUN Technologies Inc, USA.* We report on recent progress in the design and understanding of next-generation swept sources and systems for optical coherence tomography and discuss methods for tailoring lasers for specific swept source OCT applications.

## CLEO: QELS-Fundamental Science

### Executive Ballroom 210A

### FTu2A • Symposium on Quantum Repeaters II—Continued

**FTu2A.3 • 14:45**
**Spectrally multiplexed solid-state memories for quantum repeaters,** wolfgang tittel[1], Neil Sinclair[1], Erhan Saglamyurek[1], Hassan Mallazahdeh[1], Joshua A. Slater[1], Mathew George[2], Raimund Ricken[2], Morgan P. Hedges[1], Daniel Oblak[1], Wolfgang Sohler[2]; [1]*Physics and Astronomy, Univ. of Calgary, Canada;* [2]*Physics, Univ. of Paderborn, Germany.* We present experimental work that demonstrates frequency-multiplexed quantum state storage in solid-state quantum memories with readout on demand.

**FTu2A.4 • 15:00**
**Quantum teleportation from a telecom-wavelength photon to a solid-state quantum memory,** Felix Bussieres[1], Christoph Clausen[1], Alexey Tiranov[1], Boris A. Korzh[1], Varun B. Verma[2], Sae Woo Nam[2], Francesco Marsili[3], Alban Ferrier[4], Philippe Goldner[4], Harald Herrmann[5], Christine Silberhorn[5], Mikael Afzelius[1], Nicolas Gisin[1]; [1]*Group of Applied Physics, Univ. of Geneva, Switzerland;* [2]*National Inst. of Standards and Technology, USA;* [3]*Jet Propulsion Lab, California Inst. of Technology, USA;* [4]*Chimie ParisTech, CNRS-UMR 7574, UPMC Univ Paris 06, France;* [5]*Applied Physics / Integrated Optics Group, Univ. of Paderborn, Germany.* We demonstrate quantum teleportation of the polarization state of a telecom-wavelength photon onto the state of a solid-state quantum memory. The fidelity exceeds the classical bound with transmission over 25 km of optical fibre.

**FTu2A.5 • 15:15**
**Heralded single photon storage in a room-temperature, broadband quantum memory,** Patrick Michelberger[1], Joshua Nunn[1], Theresa F. Champion[1], Michael R. Sprague[1], Krzysztof Kaczmarek[1], Dylan Saunders[1], William S. Kolthammer[1], Xian-Min Jin[1], Duncan England[2], Ian A. Walmsley[1]; [1]*Physics Dept, Univ. of Oxford, UK;* [2]*National Research Council of Canada, Canada.* We demonstrate storage of heralded single photons in a room-temperature quantum memory, a key step towards scalable quantum networks. We evaluate the photon statistics of the stored photons and discuss limitations from four-wave mixing noise.

### Executive Ballroom 210B

### FTu2B • Optical Properties of Low-Dimensional Materials—Continued

**FTu2B.4 • 14:45** Invited
**Optoelectronics of 2D-Semicondcutors,** Xiadong Xu[1]; [1]*Univ. of Washington, USA.* Newly discovered 2D semiconductors offer a platform to investigate valley excitons at the two dimensional limit. Here, we present optoelectronic control of valley exciton polarization and coherence, and their device applications in monolayer limit.

**FTu2B.5 • 15:15**
**Ultrafast optical microscopy of single monolayer molybdenum disulfide flakes,** Minah Seo[1,2], Hisato Yamaguchi[2], Aditya Mohite[2], Stephane Boubanga-Tombet[2], Antoinette Taylor[2], Rohit P. Prasankumar[2]; [1]*Korea Inst. of Science and Technology, Republic of Korea;* [2]*Los Alamos National Lab, USA.* We use ultrafast optical microscopy to investigate carrier dynamics in single flakes of atomically thin molybdenum disulfide. By tuning the probe wavelength through the bandgap, we reveal the influence of layer thickness on carrier dynamics.

### Executive Ballroom 210C

### FTu2C • Novel Anisotropic Structures—Continued

**FTu2C.4 • 14:45**
**Manipulating Microwave Signals Using Plasma-Based Metamaterial Structures in Air,** Scott Will[1], Zhaxylyk A. Kudyshev[1], Natalia M. Litchinitser[1]; [1]*Electrical Engineering, Univ. at Buffalo, USA.* In this work, we theoretically and numerically demonstrate several new plasma filament-based structures used for increasing the angular and range resolution of microwave radar systems, and show that they can survive in adverse environments.

**FTu2C.5 • 15:00**
**Coherent Control of Birefringence and Optical Activity,** Seyedmohammad A. Mousavi[1], Eric Plum[1], Jinhui Shi[1,2], Nikolay I. Zheludev[1,3]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK;* [2]*College of Science, Harbin Engineering Univ., China;* [3]*Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore.* Control of polarization of light with light is demonstrated in thin slabs of linear material promising ultrafast all-optical data processing at arbitrarily low intensities. In proof-of-principle experiments we access any polarization azimuth and any ellipticity.

**FTu2C.6 • 15:15**
**Polarization-Dependent One-way Surface Wave Propagation,** Fereshteh Abbasi[1], Arthur Davoyan[1], Alexander Schuchinsky[2], Nader Engheta[1]; [1]*Dept of Electrical and Systems Engineering, Univ. of Pennsylvania, USA;* [2]*The Inst. of Electronics, Communications and Information Technology, Queen's Univ., Ireland.* We numerically study nonreciprocal regimes of surface plasmon-polariton at the interface between two gyrotropic media. We predict existence of isolated unidirectional TE and TM surface modes guided by the interface between gyroelectric and gyromagnetic media.

### Executive Ballroom 210D

### FTu2D • Novel XUV/X-Ray Sources—Continued

**FTu2D.3 • 14:45**
**Power-Scalable and Efficient Geometric XUV Output Coupling for Cavity-Enhanced High-Harmonic Generation,** Simon Holzberger[1,2], Maximilian Högner[1,2], Johannes Weitenberg[3], Dominik Esser[4], Tino Eidam[5], Jens Limpert[5], Andreas Tünnermann[5], Ernst Fill[1,2], Ferenc Krausz[1,2], Vladislav S. Yakovlev[1,2], Ioachim Pupeza[1,2]; [1]*Max-Planck-Insitute of Quantum Optics, Germany;* [2]*Ludwig-Maximillians-Universität München, Germany;* [3]*Lehrstuhl für Lasertechnik, RWTH Aachen Univ., Germany;* [4]*Fraunhofer-Institut für Lasertechnik, Germany;* [5]*Inst. of Applied Physics, Friedrich Schiller Univ. Jena, Germany.* We demonstrate cavity-enhanced HHG with a tailored transverse mode simultaneously allowing for efficient conversion to the XUV and for unparalleled output coupling efficiencies. Due to its purely geometric nature, this method is power scalable.

**FTu2D.4 • 15:00**
**Femtosecond Time-and-Angle-Resolved EUV Photoemission Spectroscopy with Mid-IR Pumping,** Cephise M. Cacho[1], Jesse C. Petersen[2,3], Isabella Gierz[3], Haiyun Liu[3], Stefan Kaiser[3], Richard Chapman[1], Edmond Turcu[1], Andrea Cavalleri[2,3], Emma Springate[1]; [1]*Central Laser Facility, STFC Rutherford Appleton Lab, UK;* [2]*Clarendon Lab, Univ. of Oxford, UK;* [3]*Max Planck Inst. for the Structure and Dynamics of Matter, Germany.* Time- and angle-resolved photoemission spectroscopy directly enables observation of electron dynamics in condensed matter. Using EUV high harmonic probe extends the observation window in energy and momentum. Tuneable mid-infrared pumping allows control of excitation mechanisms.

**FTu2D.5 • 15:15**
**Ultra-High Energy Density Relativistic Plasmas and X-ray Generation by Ultrafast Laser Irradiation of Nanowire Arrays,** Michael Purvis[1], Jorge Rocca[1], Reed Hollinger[1], Clayton Bargsten[1], Vyacheslav Shlyaptsev[1], Brad Luther[1], Alexander Pukhov[2], Carmen S. Menoni[1], Yong Wang[1], Liang Yin[1], Amy Prieto[1], Amanda Townsend[1], David Keiss[1]; [1]*Electrical and Computer Engineering, Colorado State Univ., USA;* [2]*Institut fur Theoretische Physik, Heinrich-Heine-Universitat, Germany.* We demonstrate that trapping of femtosecond laser pulses of relativistic intensity deep within nanowire arrays volumetrically heats matter into a new ultra-hot plasma regime with electron densities nearly 100 times critical and multi-keV temperatures.

### STu2E • fs - Oscillators—Continued

**STu2E.4 • 14:45**
**Dual-Gain SESAM Modelocked Thin Disk Laser Combining the Emission Spectra of Yb:Lu2O3 and Yb:Sc2O3 Laser Crystals,** Cinia Schriber[1], Florian Emaury[1], Kolja Beil[2], Matthias Golling[1], Clara J. Saraceno[1,4], Christian Kraenkel[2,3], Thomas Südmeyer[4], Ursula Keller[1]; [1]*Inst. of Quantum Electronics, ETH Zurich, Switzerland;* [2]*Inst. of Laser Physics, Univ. of Hamburg, Germany;* [3]*Hamburg Centre for Ultrafast Imaging, Germany;* [4]*Laboratoire Temps-Frequence, Univ. of Neuchatel, Switzerland.* We present the first dual-gain SESAM-modelocked thin-disk laser. Using Yb-doped sesquioxide crystals with 8 nm shifted emission peaks, we achieve large overall bandwidth from crystals with excellent thermo-mechanical properties and generate 138-fs pulses in proof-of-principle experiments.

**STu2E.5 • 15:00**
**Mode-locking of a diode-pumped Yb:CLNGG laser using single-walled carbon nanotube saturable absorber,** Yuangeng Zhang[1,2], Valentin Petrov[1], Uwe Griebner[1], Xingyu Zhang[2], Sun Y. Choi[3], Ji Yoon Gwak[3], Fabian Rotermund[3], Xavier Mateos[4], Haohai Yu[5], Huaijin Zhang[5], Junhai Liu[6]; [1]*Max-Born-Inst. for Nonlinear Optics and Ultrafast Spectroscopy, Germany;* [2]*School of Information Science and Engineering, and Shandong Provincial Key Lab of Laser Technology and Application, Shandong Univ., China;* [3]*Dept of Physics & Division of Energy Systems Research, Ajou Univ., Republic of Korea;* [4]*Física i Cristal lografia de Materials, Universitat Rovira i Virgili, Spain;* [5]*State Key Lab of Crystal Materials, Shandong Univ., China;* [6]*College of Physics, Qingdao Univ., China.* A diode-pumped Yb:CLNGG laser is mode-locked with a single-walled carbon nanotube saturable absorber achieving pulse durations as short as 90 fs at ~1049 nm and maximum average output power of 90 mW at 83 MHz.

**STu2E.6 • 15:15**
**Kerr-Lens Mode-Locked Femtosecond mid-IR Laser Oscillations in Polycrystalline Cr$^{2+}$:ZnSe and Cr$^{2+}$:ZnS,** Sergey Vasilyev[1], Mike Mirov[1], Valentin Gapontsev[2]; [1]*IPG Photonics Corp., Mid-IR Lasers, USA;* [2]*IPG Photonics Corp., USA.* We demonstrate Kerr-lens mode-locked polycrystalline Cr$^{2+}$:ZnSe and Cr$^{2+}$:ZnS lasers with pulse duration of 125 fs, 160 MHz pulse repetition rate and output power of 60 mW (Cr$^{2+}$:ZnSe) and 30 mW (Cr$^{2+}$:ZnS).

### STu2F • THz Metamaterials and Plasmonics—Continued

**STu2F.4 • 14:45**
**Highly Anisotropic THz Plasmonic Filter created using a K-Space Design Methodology,** Andrew Paulsen[1], Ajay Nahata[1]; [1]*Electrical and Computer Engineering, Univ. of Utah, USA.* We demonstrate a versatile method to filter design in the THz region based on k-space. Using this methodology we show an anisotropic filter where transmittance is varied by 80 percent with rotation in polarization angle.

**STu2F.5 • 15:00**
**Reconfigurable pressure-sensitive terahertz metamaterials using liquid metals,** Jinqi Wang[1], Shuchang Liu[1], Sivaraman Guruswamy[2], Ajay Nahata[1]; [1]*Electrical and Computer Engineering, Univ. of Utah, USA;* [2]*Metallurgical Engineering, Univ. of Utah, USA.* We demonstrate a liquid metal-based reconfigurable terahertz metamaterial device that is not only pressure driven, but also exhibits pressure memory. The discrete response is obtained by injecting eutectic gallium indium into a microfluidic structure.

**STu2F.6 • 15:15**
**Terahertz Optical Modulator Based on Metamaterial Split-ring Resonators and Graphene,** Riccardo Degl'Innocenti[1], David S. Jessop[1], Yash D. Shah[1], Juraj Sibik[2], Axel Zeitler[2], Piran R. Kidambi[3], Stephan Hofmann[3], Harvey E. Beere[1], David A. Ritchie[1]; [1]*Physics, Univ. of Cambridge, UK;* [2]*Chemical Engineering and Biotechnology, Univ. of Cambridge, UK;* [3]*Engineering, Univ. of Cambridge, UK.* We realized an optical modulator working at terahertz frequencies, based on the interplay between split-ring resonators and graphene. A modulation depth of about 18% was achieved with a bias voltage as low as 0.5 V.

### STu2G • RF Photonics—Continued

**STu2G.4 • 14:45**
**Free Space Millimeter Wave-Coupled Electro-Optic High Speed Phase Modulator Based on Nonlinear Optical Polymer In-Plane Waveguide Structure,** Dong Hun Park[1,2], Vincent R. Pagán[1,2], Thomas E. Murphy[2], Jongdong Luo[3], Alex Jen[3], Warren N. Herman[1]; [1]*Lab for Physical Sciences, USA;* [2]*Electrical and Computer Engineering, Univ. of Maryland, USA;* [3]*Materials Science and Engineering, Univ. of Washington, USA.* We report antenna-coupled electro-optic phase modulators operating at Ka-band based on in-plane polymeric waveguides using the nonlinear guest-host polymer SEO125. Design, simulation, fabrication, and experimental results are discussed.

**STu2G.5 • 15:00**
**A 1 Gbps 105.4 GHz Link with a Directly Modulated Photonic Integrated Dual Laser Source,** Zhen Yang[1], Martyn J. Fice[2], Katarzyna Balakier[2], Adrian Wonfor[1], Cyril C. Renaud[2], Guillermo Carpintero[3], Gaël Kervella[4], Frederic Van Dijk[4], Alwyn J. Seeds[2], Richard V. Penty[1], Ian H. White[1]; [1]*Electrical Division, Dept of Engineering, Univ. of Cambridge, UK;* [2]*Dept of Electronic and Electrical Engineering, Univ. College London, UK;* [3]*Universidad Carlos III de Madrid, Spain;* [4]*III-V Lab, a joint lab of Thales Research and Technology, Alcatel-Lucent Bell Labs France, and CEA Leti, France.* A 1 Gbps 105.4 GHz wireless link is demonstrated by directly modulating a photonic integrated dual-laser source. A 50 m link is predicted to achieve error free operation using FEC.

**STu2G.6 • 15:15**
**High Performance Analog Photonic Link Based on Modified Uni-traveling-carrier Photodiode,** Xiaojun Xie[1], Qiugui Zhou[1], Kejia Li[1], Andreas Beling[1], Joe C. Campbell[1]; [1]*Dept of Electrical and Computer Engineering, Univeristy of Virginia, USA.* An analog fiber optic link that employs a high performance photodiode has achieved high gain of 26.4 dB and 26 dB and low noise figure of 6.1 dB and 6.7 dB at 1 GHz and 10 GHz, respectively.

### STu2H • Controlling Light in Resonators and Photonic Crystals—Continued

**STu2H.4 • 14:45**
**Mechanically Flexible Photonic-Crystal Cavities on Strained-Germanium Nanomembranes,** Cicek Boztug[1], Jose Sanchez-Perez[2], Jian Yin[1], Max G. Lagally[2], Roberto Paiella[1]; [1]*Electrical and Computer Engineering, Boston Univ., USA;* [2]*Materials Science and Engineering, Univ. of Wisconsin - Madison, USA.* Photonic-crystal cavities compatible with the highly subwavelength thicknesses and flexibility requirements of mechanically-stressed Ge nanomembranes are developed and used to demonstrate a strong (20×) strain-induced light-emission efficiency enhancement.

**STu2H.5 • 15:00**
**Semiconductor Nanowire Induced Photonic-Crystal Nanocavity with Selectable Resonant Wavelength,** Atsushi Yokoo[1,2], Masato Takiguchi[1,2], Danang Birowosuto[1,2], Guoqiang Zhang[2], Kouta Tateno[2], Eiichi Kuramochi[1,2], Hideaki Taniyama[1,2], Masaya Notomi[1,2]; [1]*NTT Nanophotonics Center, Japan;* [2]*NTT Basic Research Labs, Japan.* A photonic-crystal nanocavity is induced by a III/V nanowire in a line defect in a Si photonic crystal with several serially-connected lattice constants. The resonant wavelength changes by moving the nanowire along the line defect.

**STu2H.6 • 15:15**
**Guided Resonance Manipulation and Degeneracy Removal by Elliptical Nano-Holes in Photonic Crystal Slabs,** Raanan Gad[1,2], Costa Nicholaou[1,2], Soroosh Ahmadi[1,2], Ofer Levi[1,2]; [1]*Electrical and Computer Engineering, Univ. of Toronto, Canada;* [2]*Inst. of Biomaterials and Biomedical Engineering, Univ. of Toronto, Canada.* We demonstrate a method to manipulate the modes and retain high quality factors of 2D photonic crystal slabs with relatively large nano-features over a wide aspect ratio range through structural symmetry breaking within the unit cell by elliptical nano-holes.

## CLEO: Science & Innovations

### Meeting Room 211 B/D

### STu2I • All Optical and Quantum Signal Processing—Continued

**STu2I.3 • 14:45**
**Coherent detection of phase modulated ultrashort optical pulses using time-to-space conversion at 1.55μm,** Dror Shayovitz[1], Harald Herrmann[2], Wolfgang Sohler[2], Raimund Ricken[2], Chrisitine Silberhorn[2], Dan M. Marom[1]; *[1]Hebrew Univ. of Jerusalem, Israel; [2]The Univ. of Paderborn, Germany.* Phase information is preserved and faithfully recovered in a time-to-space conversion process of ultrashort optical pulses for the first time. Spatial interference between the pulse image and a coherent reference is used for phase detection.

**STu2I.4 • 15:00**
**Novel Polarisation-assisted Phase Sensitive Optical Signal Processor Requiring Low Nonlinear Phase Shifts,** Francesca Parmigiani[1], Graham Hesketh[1], Radan Slavik[1], Peter Horak[1], Periklis Petropoulos[1], David J. Richardson[1]; *[1]Univ. of Southampton, UK.* We demonstrate a new scheme to achieve binary step-like phase response and high phase-sensitive extinction ratio at low powers. Phase-sensitive operation is achieved by polarisation filtering phase-locked signal/idler in a degenerate dual-pump vector parametric amplifier.

**STu2I.5 • 15:15**
**Efficient Wavelength Multicasting through Four-Wave Mixing with a Comb Source,** Hong-Fu Ting[1], Ke-Yao Wang[1], Jasper Stroud[1], Amy C. Foster[1], Mark A. Foster[1]; *[1]Johns Hopkins Univ., USA.* We utilize a coherent optical comb generator to accomplish source-efficient wavelength multicasting via four-wave mixing in both a highly-nonlinear fiber and a silicon nanowaveguide. We demonstrate 23 multicast channels with error-free operation at 10-Gb/s.

### Meeting Room 212 A/C

### STu2J • Phase Sensitive Amplification and Optical Regeneration—Continued

**STu2J.3 • 14:45**
**Experimental Demonstration of Optical Regeneration of DP-BPSK/QPSK Using Polarization-Diversity PSA,** Morteza Ziyadi[1], Amirhossein Mohajerin-Ariaei[1], Jeng-yuan Yang[2], Youichi Akasaka[2], Mohammed Chitgarha[1], Salman Khaleghi[1], Ahmed Almaiman[1], Amin Abouzaid[3], Joseph Touch[3], Motoyoshi Sekiya[2]; *[1]Univ. of Southern California, USA; [2]Fujitsu Labs of America, USA; [3]Information Science Inst., Univ. of Southern California, USA.* We experimentally investigate a polarization-diversity phase-sensitive amplifier (PSA) for phase regeneration of 25-Gbaud DP-BPSK and DP-QPSK signals and show effective reduction on phase noise in both polarizations. BER measurements and reduced phase noise are achieved for both polarizations.

**STu2J.4 • 15:00** Tutorial
**Phase-sensitive Amplification in Communications and Signal Processing,** Zhi Tong[1,2], Stojan Radic[1]; *[1]Univ. of California San Diego, USA; [2]Infinera Corp, USA.* Recent progress in low-noise optical amplification and signal processing has raised prospects of practical devices operating below the conventional quantum limit. We review basic principles, practical implementation, and performance of such devices.

Zhi Tong received his B.S. and Ph.D. degrees, both in electrical engineering, from Beijing Jiaotong University, Beijing, China, in 1999 and 2004, respectively. Since 2008, he worked at Chalmers University of Technology and University of California San Diego, focusing on parametric effects and nonlinear optics. In 2013, he joined Infinera Corporation.

### Meeting Room 212 B/D

## CLEO: QELS-Fundamental Science

### FTu2K • Plasmonic Waveguides, Lenses and Circuits—Continued

**FTu2K.4 • 14:45**
**Self-accelerating plasmonic beams having arbitrary caustic trajectories,** Itai Epstein[1], Ady Arie[1]; *[1]Tel Aviv Univ., Israel.* We demonstrate, numerically and experimentally, the generation of self-accelerating surface plasmon beams along arbitrary caustic curvatures by two-dimensional plasmonic phase masks. We examine both paraxial and non-paraxial curvatures accelerating along polynomial and exponential trajectories.

**FTu2K.5 • 15:00**
**Plasmonic Super-oscillations and Sub-Diffraction Focusing,** Guanghui Yuan[1], Edward T. Rogers[2], Tapashree Roy[2], Luping Du[3], Zexiang Shen[1], Nikolay I. Zheludev[1,2]; *[1]Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore; [2]Optoelectronics Research Centre and Centre for Photonic Metamaterials, Univ. of Southampton, UK; [3]School of Electrical and Electronic Engineering, Nanyang Technological Univ., Singapore.* We demonstrate experimental focusing of surface plasmon polaritons beyond the plasmon diffraction limit using a super-oscillatory plasmonic antenna at the wavelength of 785nm, achieving a hot-spot as small as 300nm.

**FTu2K.6 • 15:15**
**Optical Signal Processing using Nanoscale Plasmonic Circuits,** Fatima Eftekhari[1], Daniel E. Gomez[1,2], Ann Roberts[3], Timothy J. Davis[1,2]; *[1]Melbourne Centre for Nanofabrication, Australian National Fabrication Facility, Australia; [2]Materials Science and Engineering, Commonwealth Sci and Indus Res Org, Australia; [3]The Univ. of Melbourne, Australia.* We present a plasmonic circuit architecture for performing linear mathematical operations on optical signals. We demonstrate experimentally how one such nano-scale circuit performs a difference operation giving a measure of subwavelength optical phase differences.

### Marriott Salon I & II

## CLEO: Applications & Technology

### ATu2L • Symposium on Laser Processing for Consumer Electronics I—Continued

**ATu2L.3 • 15:00** Invited
**Laser Micronanostructuing for High-Performance Organic Optoelectronic Devices,** Hong-Bo Sun[1], *[1]Jilin University, China.* We report series of work on multi-beam interference ablation of organic materials, by which problems like extract efficiency and view angle in OLED were solved. The devices are promising for high-efficiency and long-life time display.

## CLEO: Science & Innovations

### Marriott
### Salon III

### STu2M • Novel Concepts in Nanophotonics—Continued

**STu2M.3 • 14:45** Invited ▶
**Observation of an effective magnetic field for light,** Lawrence D. Tzuang[1], Kejie Fang[2], Paulo A. Nussenzveig[1,3], Shanhui Fan[2], Michal Lipson[1,4]; [1]*School of Electrical and Computer Engineering, Cornell Univ., USA;* [2]*Dept of Electrical Engineering, Stanford Univ., USA;* [3]*Instituto de Física, Universidade de São Paulo, Brazil;* [4]*Kavli Inst. at Cornell for Nanoscale Science, Cornell Univ., USA.* We observe an effective magnetic field for photons using an on-chip silicon-based Ramsey-type interferometer. This interferometer generates a direction-dependent phase which corresponds to a magnetic field of 0.2 Gauss in an Aharonov-Bohm configuration for electrons.

**STu2M.4 • 15:15** ▶
**Voltage Controlled Polarization Rotation from Berry's Phase in Silicon Optical Microring Resonators,** Qiang Xu[1], Li Chen[1], Michael Wood[1], Ronald M. Reano[1]; [1]*Ohio State Univ., USA.* We present an on-chip electrically tunable polarization rotator in silicon utilizing topological phase. Optical polarization is dynamically tuned between TE and TM modes with 9 dB polarization extinction ratio and 1.4 dB conversion loss.

### Marriott
### Salon IV

### STu2N • High Power Pulsed Fiber Lasers—Continued

**STu2N.4 • 14:45**
**High Pulse-energy Generation in a Monolithic Yb-doped All-fiber Dual-cavity Oscillator with Fiber-based Passive Q-switcher,** Dongchen Jin[1], Yijian Jiang[1], Ruoyu Sun[1], Huihui Li[1], Jiang Liu[1], Pu Wang[1]; [1]*BJUT, China.* A novel high pulse-energy Yb-doped all-fiber dual-cavity laser with large core-diameter fiber-based passive Q-switcher is reported. The monolithic fiber oscillator generates pulses with peak power of 3.4 kW and single pulse energy of 484 µJ.

**STu2N.5 • 15:00**
**1 mJ narrow-linewidth master oscillator fiber amplifier system continuously tunable from 1010 nm to 1086 nm,** Jérôme Lhermite[1], Romain Royon[1], Eric Cormier[1]; [1]*Centre Lasers Intenses et Applications, France.* We report on a narrow-linewidth master oscillator fiber amplifier system continuously tunable from 1010nm to 1086nm, delivering ns pulses with 1mJ energy over the entire band. Tunable second-harmonic generation in the visible is also presented.

**STu2N.6 • 15:15**
**High Energy Diode-Seeded Nanosecond 2 µm Fiber MOPA Systems Incorporating Active Pulse Shaping,** Zhihong Li[1], Alexander M. Heidt[1], Peh S. Teh[1], Martin Berendt[1], Jayanta K. Sahu[1], Richard Phelan[2], Brian Kelly[2], Shaif-ul Alam[1], David J. Richardson[1]; [1]*Univ. of Southampton, UK;* [2]*Eblana Photonics Ltd, Ireland.* We present the first demonstration of nanosecond-pulsed fiber MOPA systems seeded by semiconductor laser diodes at 2 µm incorporating arbitrary pulse shaping capabilities, achieving up to 1.0 mJ (12.5 kHz, 100 ns) pulse energy.

### Marriott
### Salon V & VI

### STu2O • Symposium on Microcavity Exciton-Polaritons, Devices and Applications I—Continued

**STu2O.3 • 14:45** ▶
**A study of the formation of dark-solitons in semiconductor microcavities,** Pasquale Cilibrizzi[1], Hamid Ohadi[1], Tomas Ostatnicky[2], Alexis Askitopoulos[1], Wolfgang Langbein[3], Pavlos Lagoudakis[1]; [1]*School of Physics and Astronomy, Univ. of Southampton, UK;* [2]*Faculty of Mathematics and Physics, Charles Univ. in Prague, Czech Republic;* [3]*School of Physics and Astronomy, Cardiff Univ., UK.* We demonstrate that the previously reported experimental signatures of dark-solitons and half-solitons in polariton condensates are observed for negligible nonlinearity and are therefore not sufficient to identify such solitons. A Maxwell equation model is shown to reproduce the observations.

**STu2O.4 • 15:00** Invited ▶
**Single-mode Polariton Laser in a Designable Microcavity,** Bo Zhang[1], Zhaorong Wang[1], Seonghoon Kim[1], Sebastian Brodbeck[2], Christian Schneider[2], Martin Kamp[2], Sven Hoefling[2], Hui Deng[1]; [1]*Univ. of Michigan, USA;* [2]*Univ. of Wuerzburg, Germany.* We demonstrate strong coupling and a coherent polariton laser in a microcavity consisting of a sub-wavelength grating in the top mirror. The designable grating mirror allows 3D confinement, polarization selectivity, and dispersion engineering by design.

## CLEO: Applications & Technology

### Marriott
### Willow Glen I-III

### ATu2P • Symposium on Novel Light Sources and Photonic Devices in Optical Imaging I—Continued

**ATu2P.3 • 15:00** ▶
**A 15-MHz wavelength-stepped laser based on intracavity pulse stretching and compression for optical coherence tomography,** Serhat Tozburun[1,2], Meena Siddiqui[3], Benjamin J. Vakoc[1,2]; [1]*Harvard Medical School, USA;* [2]*Wellman Center for Photomedicine, Massachusetts General Hospital, USA;* [3]*Harvard-MIT Division of Health Sciences and Technology, USA.* We introduce a wavelength-stepped laser that uses dispersive fibers in combination with a lithium-niobate modulator and a fixed Fabry-Perot etalon to achieve wavelength selection for optical-domain subsampled OCT. A 15 MHz A-scan rate is demonstrated.

**ATu2P.4 • 15:15** ▶
**Silicon Photonic Optical Coherence Tomography System,** Simon Schneider[1], Matthias Lauermann[1], Claudius Weimann[1], Wolfgang Freude[1,2], Christian G. Koos[1,2]; [1]*Inst. of Photonics and Quantum Electronics (IPQ), Karlsruhe Inst. of Technology (KIT), Germany;* [2]*Inst. of Microstructure Technology (IMT), Karlsruhe Inst. of Technology (KIT), Germany.* A swept-source optical coherence tomography system is realized as a silicon photonic integrated circuit comprising passive components and germanium photo detector. Experiments show uniform sensitivity over 5 mm scanning range, enabling simple imaging demonstrations.

## CLEO: QELS-Fundamental Science

### Executive Ballroom 210A

### FTu2A • Symposium on Quantum Repeaters II—Continued

**FTu2A.6 • 15:30**
**Double-heralded single-photon absorption by a single atom,** jose M. brito[1], Stephan Kucera[1], Pascal Eich[1], Christoph Kurz[1], Michael Schug[1], Philipp Müller[1], Jan Huwer[1], Jürgen Eschner[1]; [1]*Saarland Univ., Germany.* We present a single-photon to single-atom interface, where a heralded single photon generated by Spontaneous Parametric Conversion is absorbed by a single trapped ion, subsequently generating a single Raman-scattered photon that heralds the absorption event.

**FTu2A.7 • 15:45**
**Progress and prospects for high efficiency and gigacount per second detectors for quantum repeaters using superconducting nanowire detectors,** Varun Verma[1], Michael S. Allman[1], Robert Horansky[1], Francesco Marsili[2], Jeffrey A. Stern[2], Andrew D. Beyer[2], Matthew D. Shaw[2], Sae Woo Nam[1], Richard P. Mirin[1]; [1]*NIST, USA;* [2]*Jet Propulsion Lab, USA.* We describe our work on superconducting nanowire detector arrays and how they may be adapted to meet the requirements for implementing a quantum repeater.

### Executive Ballroom 210B

### FTu2B • Optical Properties of Low-Dimensional Materials—Continued

**FTu2B.6 • 15:30**
**Excitons in Atomically Thin Transition-Metal Dichalcogenides,** Alexey Chernikov[1], Timothy C. Berkelbach[2], Heather M. Hill[1], Albert Rigosi[1], Yilei Li[1], Özgur B. Aslan[1], David R. Reichman[2], Mark S. Hybertsen[3], Tony F. Heinz[1]; [1]*Depts of Physics and Electrical Engineering, Columbia Univ., USA;* [2]*Dept of Chemistry, Columbia Univ., USA;* [3]*Center for Functional Nanomaterials, Brookhaven National Lab, USA.* Excitons are studied experimentally and theoretically in atomically thin WS2 layers. We find a binding energy of 0.32eV as well as non-hydrogenic behavior of the exciton states due to the non-uniformity of the dielectric environment.

**FTu2B.7 • 15:45**
**Coherent Electronic Coupling in Transition Metal Dichalcogenide Monolayer,** Akshay Singh[1], Galan Moody[1], Sanfeng Wu[2], Yanwen Wu[1,3], Nirmal J. Ghimire[4,5], Jiaqiang Yan[5,6], David Mandrus[4,5], Xiadong Xu[2,7], Xiaoqin Li[1]; [1]*Physics, Univ. of Texas at Austin, USA;* [2]*Physics, Univ. of Washington, USA;* [3]*Physics and Astronomy, Univ. of South Carolina, USA;* [4]*Physics and Astronomy, Univ. of Tennessee, USA;* [5]*Materials Science and Technology, Oak Ridge National Lab, USA;* [6]*Materials Science and Engineering, Univ. of Tennessee, USA;* [7]*Materials Science and Engineering, Univ. of Washington, USA.* We present two-color pump-probe spectra of excitons and trions in monolayer $MoSe_2$. Isolated spectral cross-peaks reveal coherent exciton-trion coupling due to many-body interactions. Density matrix calculations suggest the formation of a correlated exciton-trion state.

### Executive Ballroom 210C

### FTu2C • Novel Anisotropic Structures—Continued

**FTu2C.7 • 15:30**
**Circular Polarization Converters Based on Pairs of Oppositely-Handed Gold Helices,** Johannes Kaschke[1], Leonard W. Blume[1], Michael Thiel[2], Wu Lin[3], Zhenyu Yang[3], Martin Wegener[1]; [1]*Inst. of Applied Physics, Karlsruhe Inst. of Technology, Germany;* [2]*Nanoscribe GmbH, Germany;* [3]*School of Optical and Electronic Information, Huazhong Univ. of Science and Technology, China.* We introduce a helix-based metamaterial, a circular polarization converter, composed of pairs of oppositely-handed helices on a square array. We compare our theoretical findings to measurements on samples made by laser lithography and electroplating.

**FTu2C.8 • 15:45**
**How to Guide Light Around Sharp Corners: Topologically Protected Surface Waves without Magnetic Field,** Tzuhsuan Ma[1], Alexander B. Khanikaev[3], Hossein S. Mousavi[2], Gennady Shvets[1]; [1]*Physics, Univ. of Texas at Austin, USA;* [2]*Electrical Engineering, Univ. of Texas at Austin, USA;* [3]*Physics, Queens College of The City Univ. of New York, Flushing, USA.* We propose a new design of bi-anisotropic meta-waveguide exhibiting topologically protected edge mode which can be guided around sharp corners without external magnetic field. The geometry is very simple and easy to be experimentally implemented.

### Executive Ballroom 210D

### FTu2D • Novel XUV/X-Ray Sources—Continued

**FTu2D.6 • 15:30**
**Sparsity-based Ankylography: Recovering 3D structures from a single-shot 2D scattered intensity,** Maor Mutzafi[1], Yoav Shechtman[1], Oren Cohen[1], Yonina C. Eldar[2], Mordechai Segev[1]; [1]*Physics, Technion, Israel;* [2]*Electrical Engineering, Technion, Israel.* We present an algorithmic paradigm for deciphering the 3D structure of a molecule from the far-field intensity of scattered x-ray photons before the molecule disintegrates. Our approach enables surpassing current limits on recoverable information capacity.

**FTu2D.7 • 15:45**
**Microscopic Verification of Terahertz Generation Mechanism in Two-Color Laser-Produced Plasma,** Yong Sing You[1], Ki-Yong Kim[1], Dongwen Zhang[1,2]; [1]*Inst. for Research in Electronics and Applied Physics, Univ. of maryland, USA;* [2]*Dept of Physics, National Univ. of Defense Technology, China.* Terahertz radiation from two-color laser-produced plasma is studied with simultaneous measurements of absolute two-color phases, near-field plasma currents, and far-field THz radiation. This verifies the microscopic mechanism of terahertz radiation generation at various laser intensities.

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**16:00–16:30 Coffee Break** (16:00-16:30) **and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2*

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NOTES

## CLEO: Science & Innovations

## Executive Ballroom 210E

### STu2E • fs - Oscillators—Continued

**STu2E.7 • 15:30**
**Ceramic Cr:ZnS Laser Mode-Locked by Graphene,** Nikolai Tolstik[1], Evgeni Sorokin[2], Irina T. Sorokina[1]; [1]*Norwegian Univ. of Science and Technology, Norway;* [2]*Inst. for Photonics, Technical Univ. of Vienna, Austria.* We report a high-power graphene mode-locked ceramic Cr:ZnS-laser, producing 3.9 nJ, 140 fs pulses with 45 nm spectral bandwidth at 270 MHz repetition rate, at output power for the first time exceeding 1 W level.

**STu2E.8 • 15:45**
**Gain-Matched Output Couplers (GMOCs) for Efficient and Robust Kerr-Lens Mode-Locking of Cr:LiSAF lasers,** Can Cihan[1], Ersen Beyatli[1], Ferda Canbaz[1], Li-Jin Chen[2], Bernd Sumpf[3], Götz Erbert[3], Alfred Leitenstorfer[4], Franz Kärtner[2,5], Alphan Sennaroglu[1], Umit Demirbas[6]; [1]*Laser Research Lab, Koç Univ., Turkey;* [2]*Research Lab of Electronics, MIT, USA;* [3]*Ferdinand-Braun-Institut, Leibniz Institut für Höchstfrequenztechnik, Germany;* [4]*Dept of Physics and Center for Applied Photonics, Univ. of Konstanz, Germany;* [5]*Center for Free-Electron Laser Science, DESY and Dept of Physics, Univ. of Hamburg, Germany;* [6]*Laser Technology Lab, Antalya International Univ., Turkey.* We report efficient and robust Kerr-lens mode-locking of single-mode and tapered diode-pumped Cr:LiSAF lasers by using gain-matched output couplers. Sub-15-fs pulses were generated with peak powers above 60-kW and optical-to-optical conversion efficiencies up to 21%.

## Executive Ballroom 210F

### STu2F • THz Metamaterials and Plasmonics—Continued

**STu2F.7 • 15:30**
**Symmetric and asymmetric T-shaped plasmonic waveguides,** Shashank Pandey[1], Barun Gupta[1], Ajay Nahata[1]; [1]*Univ. of Utah, USA.* We fabricate, experimentally characterize and numerically validate the origin of modes on periodically spaced T-shaped structure for Terahertz input. Effect of parameters such as height, periodicity, asymmetry and symmetry of 'T' structure is explained.

**STu2F.8 • 15:45**
**Terahertz Plasmonic Structures Based on a Spatially Varying Conductivity,** Barun Gupta[1], Shashank Pandey[1], Ajay Nahata[1]; [1]*Univ. of Utah, USA.* We demonstrate a new technique for fabricating terahertz plasmonic structures that incorporates a spatial variation into the conductivity of the metallic layer using inkjet printing of a conductive and resistive ink simultaneously.

## Executive Ballroom 210G

### STu2G • RF Photonics—Continued

**STu2G.7 • 15:30**
**Bandwidth Tunable, High Suppression RF Photonic Filter with Improved Insertion Loss,** Mattia Pagani[1], David Marpaung[1], Blair Morrison[1], Benjamin J. Eggleton[1]; [1]*Univ. of Sydney, Australia.* We demonstrate a scheme for minimising the insertion loss of an RF photonic filter, by exploiting the phase response of stimulated Brillouin scattering. We achieve a filter with high suppression, tunable bandwidth and low loss.

**STu2G.8 • 15:45**
**All-optical single-side-band GHz to THz microwave sources via SOA gain engineering,** Fangxin Li[1], Amr S. Helmy[1]; [1]*ECE, Univ. of toronto, Canada.* We propose and demonstrate low noise broadly tunable single side-band microwaves using cascaded semiconductor optical amplifiers using no RF bias. Microwaves between 40GHz and 875GHz with a linewidth ~22 KHz are demonstrated.

## Executive Ballroom 210H

### STu2H • Controlling Light in Resonators and Photonic Crystals—Continued

**STu2H.7 • 15:30**
**Transport in millimeter scale disordered photonic crystals,** PIN-CHUN HSIEH[1], Chung-Jen Chung[2], James F. McMillan[1], Ming Lu[3], Nicolae Panoiu[4], Chee Wei Wong[1]; [1]*Mechanical Engineering, Columbia Univ., USA;* [2]*Center for Micro/Nano Science and Technology, National Cheng Kung Univ., Taiwan;* [3]*Center for Functional Nanomaterials, Brookhaven National Lab, USA;* [4]*Dept of Electronic and Electrical Engineering, Univ. College London, UK.* We examine the influence of disorder over millimeter lengthscales, in the transport of photons. Super-collimation is achieved for varying controlled degrees of disorder in large-scale measurements, supported by physical theory and simulations.

**STu2H.8 • 15:45**
**Artificial Selection for Structural Color on Butterfly Wings and Comparison to Natural Evolution,** Seng Fatt Liew[1], Bethany R. Wasik[2], David Lilien[1], April J. Dinwiddie[2], Heeso Noh[1], Antonia Monteiro[2], Hui Cao[1]; [1]*Applied Physics, Yale Univ., USA;* [2]*Ecology and Evolutionary Biology, Yale Univ., USA.* We evolved violet structural color from brown-colored butterflies over six generations of artificial selection. The mechanism of color generation was identified and found to mimic the natural evolution of violet/blue color in closely related species.

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**16:00–16:30 Coffee Break** (16:00-16:30) **and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2*

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NOTES

## CLEO: Science & Innovations

Meeting Room
211 B/D

### STu2I • All Optical and Quantum Signal Processing—Continued

**STu2I.6 • 15:30**
**Photonic RF-Channelized Receiver based on Wideband Parametric Mixers and Coherent Detection,** Andreas O. Wiberg[1], Daniel J. Esman[1], Lan Liu[1], Evgeny Myslivets[1], Nikola Alic[1], Stojan Radic[1]; [1]*Univ. of California San Diego, USA.* We present a photonic RF-channelized receiver based on parametric multicasting and LO generation. Using frequency locking and coherent detection, contiguous channelization of 12 sub-channels is achieved covering 24-30GHz. System analysis and characterizations are presented.

**STu2I.7 • 15:45**
**Multi-Channel Amplification in a 20-dB Gain Hybrid Optical Parametric Amplifier,** Gordon K. P. Lei[1], Michel E. Marhic[1]; [1]*College of Engineering, Swansea Univ., UK.* We demonstrate amplification of multiple 40 Gb/s channels in a hybrid fiber optical parametric amplifier. Experimental results show that the proposed amplifier has negligible power penalties compared with traditional parametric amplifier, and reduced inter-channel crosstalk.

Meeting Room
212 A/C

### STu2J • Phase Sensitive Amplification and Optical Regeneration—Continued

Meeting Room
212 B/D

## CLEO: QELS-Fundamental Science

### FTu2K • Plasmonic Waveguides, Lenses and Circuits—Continued

**FTu2K.7 • 15:30**
**Near-field Interference in Optics and RF,** Pavel Ginzburg[1], Polina V. Kapitanova[2], Francisco José Rodríguez-Fortuño[3], Daniel O'Connor[1], Dmitry S. Filonov[2], Pavel M. Voroshilov[2], Alexander N. Poddubny[2], Gregory A. Wurtz[1], Pavel A. Belov[2], Yuri S. Kivshar[4], Anatoly V. Zayats[1]; [1]*Physics, King's College London, UK;* [2]*National Research Univ. of Information Technologies, Mechanics and Optics (ITMO), Russia;* [3]*Nanophotonics Technology Center, Universitat Politècnica de València, Spain;* [4]*Nonlinear Physics Center, Research School of Physics and Engineering, Australian National Univ., Australia.* Interference, one of the major physical phenomena, relies on coherent superposition of waves, undertaking different phase lag. Considering vectorial near-fields structure, the fundamental concept was reconsidered, reformulated, and demonstrated at optical and radio frequencies.

**FTu2K.8 • 15:45**
**Subwavelength multilayer dielectrics: ultra-sensitive transmission and breakdown of effective-medium,** Hanan Herzig Sheinfux[1], Ido Kaminer[1], Yonatan Plotnik[1], Guy Bartal[1], Mordechai Segev[1]; [1]*Technion Israel Inst. of Technology, Israel.* We show that a structure of alternating dielectric layers with deep subwavelength thicknesses exhibits novel transmission effects that depend on the order of the layers and on nanometer scale variations of the layer widths.

Marriott
Salon I & II

## CLEO: Applications & Technology

### ATu2L • Symposium on Laser Processing for Consumer Electronics I—Continued

**ATu2L.4 • 15:30** Invited
**Laser Direct Ablation for Patterning Printed Wiring Boards Using Ultrafast Lasers and High Speed Beam Delivery Architectures,** Hisashi Matsumoto[1], Mark Unrath[1], Jan Kleinert[1], Haibin Zhang[1]; [1]*Electro Scientific Industries, Inc., USA.* A vector scanning based system that incorporates Acousto-Optic Deflectors in addition to galvanometers and linear stages enables in conjunction with an ultrafast laser high accuracy, high bandwidth random beam positioning and precise material removal. see above.

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**16:00–16:30 Coffee Break** (16:00-16:30) **and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2*

NOTES

## CLEO: Science & Innovations

### Marriott
### Salon III

### STu2M • Novel Concepts in Nanophotonics—Continued

**STu2M.5 • 15:30**
**Tunable Liquid Crystal-loaded Metasurfaces for IR and THz Applications,** Oleksandr Buchnev[1], Jan Wallauer[2], Markus Walther[2], Nina Podoliak[1], Malgosia Kaczmarek[3], Nikolay I. Zheludev[1,4], Vassili A. Fedotov[1]; [1]*Optoelectronics Research Centre and EPSRC Centre for Photonic Metamaterials, Univ. of Southampton, UK;* [2]*Dept of Molecular and Optical Physics, Univ. of Freiburg, Germany;* [3]*Physics and Astronomy, Univ. of Southampton, UK;* [4]*Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore.* We experimentally demonstrate a family of compact and efficient IR and THz electro-optical modulators based on active planar metamaterials (metasurfaces) hybridised with liquid crystals.

**STu2M.6 • 15:45**
**Shape Optimization of Nanophotonic Devices Using the Adjoint Method,** Christopher Lalau-Keraly[1], Samarth Bhargava[1], Vidya Ganapati[1], Eli Yablonovitch[1]; [1]*UC Berkeley, USA.* We use an adjoint method integrated with a classical Maxwell solver to optimize several nanophotonic devices, providing an adaptable and efficient tool for photonics design.

### Marriott
### Salon IV

### STu2N • High Power Pulsed Fiber Lasers—Continued

**STu2N.7 • 15:30**
**Effect of seed linewidth on few-moded fiber amplifiers,** Jae M. Daniel[1], Nikita Simakov[1,2], Peter C. Shardlow[1], W. A. Clarkson[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK;* [2]*Cyber and Electronic Warfare Division, Defence Science and Technology Organisation, Australia.* Suppression of detrimental modal interference effects within a cladding-pumped multimode thulium fiber amplifier is achieved using variable bandwidth seed source. The amplifier produced pulse energies of 1.1mJ and peak powers over 20kW at 1956nm.

**STu2N.8 • 15:45**
**16μJ-Pulse-Energy, Picosecond, Narrow-linewidth Master Oscillator Power Amplifier Using Direct Amplification,** Ho-Yin Chan[1], Lin Xu[1], James Bateman[1], Shaif-ul Alam[1], David J. Richardson[1], David Shepherd[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK.* We present a gain-switched-diode-seeded 1034.5-nm master oscillator power amplifier, employing direct amplification through standard commercial Yb3+-doped fibres to generate 15.6μJ-pulse-energy, 126kW-peak-power, picosecond pulses with 3dB spectral bandwidth of 0.87nm.

### Marriott
### Salon V & VI

### STu2O • Symposium on Microcavity Exciton-Polaritons, Devices and Applications I—Continued

**STu2O.5 • 15:30**
**Influence of interactions with non-condensed particles on the coherence of a 1D polariton condensate,** Johannes Schmutzler[1], Tomasz Kazimierczuk[1], Ömer Bayraktar[1], Marc Assmann[1], Sebastian Brodbeck[2], Martin Kamp[2], Christian Schneider[2], Sven Höfling[3], Manfred Bayer[1]; [1]*TU Dortmund Univ., Germany;* [2]*Würzburg Univ., Germany;* [3]*Univ. of St Andrews, UK.* We study interactions between background carriers and a polariton condensate. Second order correlation measurements and Young's double-slit experiment demonstrate a detrimental effect on the coherence of a polariton condensate mediated by background carriers.

**STu2O.6 • 15:45**
**Engineering Dispersion Relation of Photons in Vertical Cavity using High-Contrast Gratings,** Zhaorong Wang[1], Hui Deng[1]; [1]*U of Michigan, USA.* We show the dispersion relation of high-contrast grating based vertical cavity can be altered by orders of magnitude by engineering the angular phase response. The results may benefit Purcell enhancement and strong coupling using the cavity.

### Marriott
### Willow Glen I-III

## CLEO: Applications & Technology

### ATu2P • Symposium on Novel Light Sources and Photonic Devices in Optical Imaging I—Continued

**ATu2P.5 • 15:30**
**Micro-fluid Channel Based on Ultralow-loss Silicon Crossing Waveguide for Various Sensing,** Zheng Wang[1,2], Swapnajit Chakravarty[3], Harish Subbaraman[3], Xiaochuan Xu[3], Donglei Fan[1,4], Alan X. Wang[5], Ray Chen[1,2]; [1]*Materials Science and Engineering Program, Texas Materials Inst., The Univ. of Texas at Austin, USA;* [2]*Dept of Electrical and Computer Engineering, The Univ. of Texas at Austin, USA;* [3]*Omega Optics, Inc.., USA;* [4]*Dept of Mechanical Engineering, The Univ. of Texas at Austin, USA;* [5]*School of Electrical Engineering and Computer Science, Oregon State Univ., USA.* We experimentally demonstrate a new type of micro-fluid channel design with crossing optical waveguides that not only block any gaps in the microfluidic channels in one fabrication step but also enable nearly lossless optical propagation in the primary waveguides on a chip

**ATu2P.6 • 15:45**
**Femtosecond laser stimulated nanosystems for neuroscience applications,** Takashi Nakano[1], Catherine Chin[2], David Myint[3], Eng Tan[3], Peter J. Hale[2], John Reynolds[4], Jeff Wickens[1], Keshav M. Dani[2]; [1]*Neurobiology Research Unit, Okinawa Inst. of Sci and Tech, Japan;* [2]*Femtosecond Spectroscopy Unit, Okinawa Inst. of Sci and Tech, Japan;* [3]*Dept of Chemistry, Univ. of Otago, New Zealand;* [4]*Dept of Anatomy and the Brain Health Research Centre, School of Medical Sciences, Univ. of Otago, New Zealand.* The development of fast and robust chemical delivery systems is important step for nanomedicine. We demonstrate on-demand, sub-second, controlled release of a euromodulator by applying femtosecond laser pulse trains to robust, liposome structures

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**16:00–16:30 Coffee Break** (16:00-16:30) **and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2*

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# CLEO: QELS-Fundamental Science

## Executive Ballroom 210A

### 16:30–18:30
### FTu3A • Quantum Repeater Technologies

*Presider: Kae Nemoto; National Inst. of Informatics, Japan*

**FTu3A.1 • 16:30** Invited

**Atoms, Ions and Photons for Quantum Tasks: Strengths and Weaknesses,** Julio T. Barreiro[1]; [1]*Univ. of California, San Diego, USA.* I will describe applications employing ions, photons and neutral atoms for quantum science. This will lead to an insider's comparison of single- and many-particle aspects of the production (ease and time), lifetime, manipulation and measurement of these quantum systems.

**FTu3A.2 • 17:00**

**Frequency Conversion of Narrowband Single Photons from a SPDC Pair Source,** Andreas Lenhard[1], Stephan Kucera[1], Jose Brito[1], Jürgen Eschner[1], Christoph Becher[1]; [1]*Fachrichtung 7.2, Universität des Saarlandes, Germany.* We report on frequency down conversion of single photons from a photon pair source resonant with an atomic transition of Calcium ions. The temporal correlation between the photon pair is preserved in the conversion process.

## Executive Ballroom 210B

### 16:30–18:30
### FTu3B • Advances in High-Harmonic Generation

*Presider: François Légaré; INRS-Energie Mat & Tele Site Varennes, Canada*

**FTu3B.1 • 16:30**

**Magnetic Circular Dichroism Probed with Bright High-order Harmonics,** Ofer Kfir[1], Patrik Grychtol[2], Emrah Turgut[2], Ronny Knut[2,3], Dmitriy Zusin[2], Dimitar Popmintchev[2], Tenio Popmintchev[2], Hans Nembach[3], Justin M. Shaw[3], Avner Fleischer[1,4], Henry Kapteyn[2], Margaret Murnane[2], Oren Cohen[1]; [1]*Solid State Inst. and Physics Dept, Technion - Israel Inst. of Technology, Israel;* [2]*Dept of Physics and JILA, Univ. of Colorado and NIST, USA;* [3]*Electromagnetics Division, National Inst. of Standards and Technology, USA;* [4]*Dept of Physics and Optical Engineering, Ort Braude College, Israel.* We demonstrate the first bright circularly-polarized high-order harmonics. Using this new tabletop light source, we demonstrate magnetic circular dichroism measurements at the M-shell absorption edges of Cobalt.

**FTu3B.2 • 16:45**

**High flux coherent supercontinuum soft X-ray source driven by a single-stage 10 mJ, kHz, Ti:sapphire laser amplifier,** Chengyuan Ding[1], Wei Xiong[1], Tingting Fan[1], Daniel Hickstein[1], Tenio Popmintchev[1], Xiaoshi Zhang[2], Mike Walls[2], Margaret Murnane[1], Henry Kapteyn[1]; [1]*Physics, JILA, Univ. of Colorado at Boulder, USA;* [2]*Kapteyn-Murnane Labs, USA.* We demonstrate the highest flux tabletop coherent soft X-ray source to date, using high harmonics driven by a single-stage Ti:sapphire-pumped OPA at 1.3μm. The spectrum extends to 200eV, with a flux of >106 photons/pulse/1% bandwidth.

**FTu3B.3 • 17:00**

**High flux table-top ultrafast soft X-ray source generated by high harmonic generation,** Nicolas Thiré[1]; [1]*INRS-EMT / ALLS, Canada.* Intense, few-cycle infrared laser pulses centered at 1.8 μm wavelength, coupled to a new gas cell design, are employed to drive high harmonic generation with high flux down to the soft X-ray regime.

## Executive Ballroom 210C

### 16:30–18:30
### FTu3C • Quantum Meta Optics

*Presider: Liang Feng, Univ. of California Berkeley, USA*

**FTu3C.1 • 16:30**

**Stimulated emission of SPPs on top of hyperbolic metamaterials,** John K. Kitur[1], Thejaswi Tumkur[1], Lei Gu[1], Mikhail A. Noginov[1]; [1]*Norfolk State Univ., USA.* We show that the stimulated emission of surface plasmon polaritons on top of lamellar metal/dielectric metamaterial has much lower threshold than on top of silver.

**FTu3C.2 • 16:45**

**Classical and Quantum Opto-mechanics with Plasmonics and Metamaterials,** Pavel Ginzburg[1], Alexey V. Krasavin[1], Alexander S. Shalin[2], Pavel A. Belov[2], Yuri S. Kivshar[3,2], Anatoly V. Zayats[1]; [1]*Physics, King's College London, UK;* [2]*National Research Univ. of Information Technologies, Mechanics and Optics (ITMO), Russia;* [3]*Nonlinear Physics Center, Research School of Physics and Engineering, Australian National Univ., Australia.* Opto-mechanical phenomena on nano-scale change balance between macroscopic forces and introduce novel quantum effects. Manipulation and control over nano-objects dynamics with plasmonics and metamaterials emphasizing radiation reaction recoil and all-optical modulation will be discussed.

**FTu3C.3 • 17:00** Invited

**Thermal emission control with surface waves,** Jean-Jacques Greffet[1], Daniele Costantini[1], Giovanni Brucoli[1], Henri Benisty[1], Francois Marquier[1]; [1]*Institut d'Optique, France.* Cheap infra red (IR) sources are incandescent sources such hot membranes. In this paper, we show how it is possible to overcome their limitations (omnidirectional, broadband, low efficiency, slow modulation rate) by taking advantage of surface waves.

## Executive Ballroom 210D

### 16:30–18:30
### FTu3D • Filamentation and the THz Generation

*Presider: Stephane Barland; Universite de Nice Sophia Antipolis, USA*

**FTu3D.1 • 16:30**

**Enhancing the Gain by Quantum Coherence in Terahertz Quantum Cascade Lasers,** Elodie Strupiechonski[2,1], Romain Blanchard[1], Patrice Genevet[3,1], Yongrui Wang[3], Alexey Belyanin[3], Lianhe Li[4], Edmund Linfield[4], A. G. Davies[4], Federico Capasso[1], Marlan O. Scully[3,2]; [1]*School of Engineering and Applied Sciences, Harvard Univ., USA;* [2]*Baylor Univ., USA;* [3]*Texas A&M Univ., USA;* [4]*School of Electronic and Electrical Engineering, Univ. of Leeds, UK.* We present an experimental study of a GaAs/Al25Ga75As terahertz quantum cascade laser in which a mid-infrared radiation serves as a coherent drive for enhancing terahertz gain.

**FTu3D.2 • 16:45**

**Terahertz-Field-Induced Second Harmonic Generation Through Pockels Effect in Gallium Phosphide Crystal,** Emmanuel Abraham[1,2], Marion Cornet[1,2], Amine Ould Hamouda[1,2], Jérôme Degert[1,2], Eric Freysz[1,2]; [1]*Bordeaux Univ., France;* [2]*LOMA UMR 5798, CNRS, France.* We report the second harmonic generation of a near-infrared pulse in a Gallium Phosphide crystal through the Pockels effect induced by an intense terahertz pulse. This demonstrates cascading second-order nonlinear phenomena in the terahertz range.

**FTu3D.3 • 17:00**

**Terahertz wave guiding by femtosecond laser filament in air,** Jiayu Zhao[1], Yizhu Zhang[2], Zhi Wang[1], Wei Chu[3], Bin Zeng[3], Ya Cheng[3], Zhizhan Xu[3], Weiwei Liu[1]; [1]*Inst. of Modern Optics, Nankai Univ., China;* [2]*Shanghai Advanced Research Inst., Chinese Academy of Sciences, China;* [3]*Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China.* Superluminal propagation of THz pulse has been observed by investigating THz waveform emitted from different length of filaments. Numerical simulation has implied that a THz waveguide-like photonic structure may be formed, leading to this phenomenon.

## CLEO: Science & Innovations

## Executive Ballroom 210E

**16:30–18:30**
**STu3E • Pulse Characterization and Ultrafast Imaging**
*Presider: Jared Wahlstrand; Univ. of Maryland, USA*

**STu3E.1 • 16:30**
**Characterization techniques for aligning spatio-temporal focused ultrafast pulses,** Amanda K. Meier[1], Michael Greco[1], Charles G. Durfee[1]; *[1]Dept of Physics, Colorado School of Mines, USA.* To optimize intensity-localization in spatio-temporally focused ultrafast beams we demonstrate spectral interferometric and spectrally-resolved knife edge scan methods to characterize lateral and angular spatial chirp. A novel dispersion scan yields the focused-pulse spectral phase.

**STu3E.2 • 16:45**
**Angle-multiplexed spatial-spectral interferometry for simultaneous measurement of spectral phase and polarization state,** Ming-wei Lin[1], Abdurahim Rakhman[1], Igor Jovanovic[1]; *[1]Pennsylvania State Univ., USA.* An angle-multiplexed spatial-spectral interferometry between an arbitrary polarized signal pulse and two orthogonal linearly polarized reference pulses is demonstrated to characterize the polarization state and relative spectral phase of a radially polarized laser pulse.

**STu3E.3 • 17:00**
**Anamorphic temporal imaging using a warped time lens,** Mohammad H. Asghari[1], Bahram Jalali[1]; *[1]Univ. of California, Los Angeles, USA.* Anamorphic temporal imaging concept incorporating a warped time lens is introduced. The system is placed in front of spectrometer to enhance its spectral resolution and update rate and minimizes the volume of the generated data.

## Executive Ballroom 210F

**16:30–18:30**
**STu3F • Technologies for High Intensity**
*Presider: Federico Canova; Amplitude Technologies, France*

**STu3F.1 • 16:30** Invited
**High Repetition Rate kJ-class Nanosecond to Femtosecond Lasers,** Todd Ditmire[1,2]; *[1]Dept. of Physics, Univ. of Texas at Austin, USA; [2]National Energetics, USA.* Using novel liquid cooled slab laser amplifier technology we have developed laser systems capable of amplifying nanosecond laser pulses to energy of ~1 kJ at repetition rate up to 0.1 Hz.

**STu3F.2 • 17:00**
**Generation of 0.61 PW, 33.8fs Pulse by CPA and OPCPA Hybrid Laser System,** Xiaoyan Liang[1], Lianghong Yu[1], Lu Xu[1], Yuxi Chu[1], Zhanggui Hu[2], Yi Xu[1], Cheng Wang[1], Xiaoming Lu[1], Yuxin Leng[1], Ruxin Li[1], Zhizhan Xu[1]; *[1]Shanghai Inst. of Optics and Fine Mechanics, China; [2]Key Lab of Functional Crystals and Laser Technology, Technical Inst. of Physics and Chemistry, China.* We reported a hybrid chirped pulse amplification (CPA) and optical parametric chirped pulse amplification (OPCPA) laser system with peak power of 0.61PW. The conversion efficiency of LBO-OPCPA reached 25.38% with output energy of 28.68 J. The compressed pulse width of hybrid laser was 33.8fs.

## Executive Ballroom 210G

**16:30–18:30**
**STu3G • Photodetectors**
*Presider: Michael Grzesik, MIT Lincoln Lab, USA*

**STu3G.1 • 16:30**
**$Zn^+$ Implanted Silicon Waveguide Photodiodes for On-Chip Mid-Infrared Detection,** Richard R. Grote[1], Brian Souhan[1], Noam Ophir[2], Jeffrey Driscoll[1], Hassaram Bakhru[3], Keren Bergman[2], William M. Green[4], Richard M. Osgood[1]; *[1]Microelectronics Sciences Labs, Columbia Univ., USA; [2]Dept of Electrical Engineering, Columbia Univ., USA; [3]College of Nanoscale Science and Engineering, State Univ. of New York at Albany, USA; [4]T. J. Watson Research Center, IBM, USA.* We present the first experimental demonstration of $Zn^+$ implanted Si waveguide photodiodes for 2.2-2.4 µm operation. Preliminary responsivities > 65 mA/W are measured, suggesting suitability for on-chip sensing and communications applications in the mid-infrared.

**STu3G.2 • 16:45**
**Rapid melt grown Germanium p-i-n photodiode wrapped around a Silicon waveguide,** Ryan Going[1], Tae Joon Seok[1], Ming Wu[1]; *[1]Univ. of California, Berkeley, USA.* We report on a compact germanium photodiode design where single crystal germanium wraps around a single mode silicon waveguide. A 32 µm long, 626 aF, p-i-n device has 0.8 A/W responsivity at 1550 nm.

**STu3G.3 • 17:00**
**The Monolithic Heterogeneous Integration of GaAs PIN Photodiode and Si CMOS-based Transimpedance Amplifier,** Eiji Kume[1], Hiroyuki Ishii[1], Taro Itatani[1], Sadanori Yamanaka[2], Tomoyuki Takada[2], Masahiko Hata[2], Takenori Osada[2], Takayuki Inoue[2], Yoshinori Matsumoto[3]; *[1]National Inst. of Advanced Industria, Japan; [2]Sumitomo Chemical Co., LTD, Japan; [3]Keio Univ., Japan.* This article describes a GaAs PIN photodiode was directly grown on a Si substrate in which CMOS-based transimpedance amplifier (TIA) was fabricated using general Si CMOS process. This monolithic integration device was successfully demonstrated.

## Executive Ballroom 210H

**16:30–18:30**
**STu3H • Quantum & Nonlinear Materials & Devices**
*Presider: Amy Foster; Johns Hopkins Univ., USA*

**STu3H.1 • 16:30**
**Recent Advancements of Strained Silicon as an Optically Nonlinear Material,** Matthew W. Puckett[1], Joseph S. Smalley[1], Yeshaiahu Fainman[1]; *[1]Electrical and Computer Engineering, Univ. of California, San Diego, USA.* We present several improvements to the understanding of strained silicon's second-order optical nonlinearity. In addition to incorporating the material into electro-optic modulators and wave-mixers, we analyze the nature of the optical nonlinearity on the nanoscale.

**STu3H.2 • 16:45**
**Three-photon absorption in hydrogenated amorphous silicon at 1.55µm for all-optical processing,** Xin Gai[1], Duk-Yong Choi[1], Barry Luther-Davies[1]; *[1]Laser Physics Centre of ANU, Australia.* Three-photon absorption (3PA) has been observed as the dominant mechanism for nonlinear absorption in wide-bandgap hydrogenated amorphous silicon (a-Si:H) at 1.55µm.

**STu3H.3 • 17:00**
**CW backward second harmonic generation with 720 nm-period domains in a QPM adhered-ridge waveguide,** Masaki Shimizu[1,2], Takuya Utsugida[1,2], Satoshi Horikawa[1,2], Kazufumi Fujii[1], Sunao Kurimura[1,2], Hirochika Nakajima[2]; *[1]National Inst. for Materials Science (NIMS), Japan; [2]Waseda Univ., Japan.* Ultrafine domain structure (720 nm period) achieved first CW backward SHG in Mg:LiNbO3-based adhered-ridge waveguide.

## Meeting Room 211 B/D

## CLEO: Science & Innovations

### 16:30–18:30
### STu3I • Novel Applications of Nonlinear Optics
*Presider: Valdas Pasiskevicius; Royal Inst. of Technology (JORCEP), Sweden*

**STu3I.1 • 16:30**
**Self-Phase Modulation Compensation in a Regenerative Amplifier Using Cascaded Second-Order Nonlinearities,** Christophe Dorrer[1], Rick Roides[1], Jake Bromage[1], Jonathan D. Zuegel[1]; [1]*Univ. of Rochester, USA.* Cascaded nonlinearities are theoretically and experimentally investigated for intracavity nonlinearity compensation in a Nd:YLF regenerative amplifier. Spectral broadening is significantly reduced, in agreement with simulations, allowing for efficient amplification in a Nd:YLF power amplifier.

**STu3I.2 • 16:45**
**Generation of Flat, Rectangular Frequency Combs with Tunable Bandwidth and Frequency Spacing,** Stefan Preussler[1], Norman Wenzel[1], Thomas Schneider[1]; [1]*Hochschule für Telekommunikation Leipzig, Germany.* A method to produce flat, rectangular shaped frequency combs with tunable bandwidth and spacing is shown. It is based on the selection of lines from a mode-locked laser and a following modulation with cascaded modulators.

**STu3I.3 • 17:00**
**A technique to measure the correlation of optical frequencies using four-wave mixing,** Aravind Anthur[1], Regan Watts[2], Tam Huynh[2], Deepa Venkitesh[1], Liam Barry[2]; [1]*Indian Inst. of Technology, Madras, India;* [2]*Dublin City Univ., Ireland.* We propose a novel technique to measure the correlation between two optical frequencies using a FWM scheme. To verify, we measure the evolution of de-correlation as a function of the path length difference between them.

## Meeting Room 212 A/C

### 16:30–18:30
### STu3J • DSP and Coding
*Presider: Christian Malouin; Juniper Networks Inc., USA*

**STu3J.1 • 16:30**
**Efficient FIR Filter Configuration to Joint IQ Imbalance and Carrier-Phase Recovery in 16-QAM Coherent Receivers,** Md Ibrahim Khalil[1], Arshad M. Chowdhury[1,2], Gee-Kung Chang[2]; [1]*Dept of Electrical Engineering and Computer Science, North South Univ., Bangladesh;* [2]*School of Electrical and computer Engineering, Georgia Inst. of Technology, USA.* We propose an efficient configuration of FIR-filter for joint quadrature-imbalance (IQ) compensation and carrier-phase-recovery 16-QAM optical coherent receivers. Through computer simulation we demonstrate proposed scheme can mitigate wide-range of phase-noise and IQ-mismatch of optical front-end.

**STu3J.2 • 16:45**
**Pilot-tone-Aided Two-stage Carrier Phase Recovery in dual-carrier Nyquist m-QAM Transmission System,** Jiachuan Lin[1], Zhaomin Zhang[1], Lixia Xi[1], Xiaoguang Zhang[1]; [1]*BUPT, China.* We propose an optically generated pilot tone aided carrier phase recovery scheme in dual-carrier Nyquist-mQAM systems. Both side channels can be compensated using one pilot, providing a high linewidth tolerance with small complexity.

**STu3J.3 • 17:00**
**Fast Convergence Single-Stage Adaptive Frequency Domain Equalizer in Few Mode Fiber Transmission Systems,** Xuan He[1], Yi Weng[1], Zhongqi Pan[1]; [1]*Dept of Electrical and Computer Engineering, Univ. of Louisiana at Lafayette, USA.* We propose a fast convergence single-stage adaptive frequency domain algorithm for simultaneously compensating CD&DMGD in few-mode fiber system. The proposed algorithm can increase the convergence speed by 51% with 8% complexity increase.

## Meeting Room 212 B/D

## CLEO: QELS-Fundamental Science

### 16:30–18:30
### FTu3K • Active Plasmonic and Nanophotonic Modulators
*Presider: Mikhail Belkin, Univ. of Texas at Austin, USA*

**FTu3K.1 • 16:30**
**Coherent Modulation of Light with Graphene,** Thomas Roger[1], Julius Heitz[1], Niclas Westerberg[1], Genevieve Gariepy[1], Eliot Bolduc[1], John Jeffers[2], Jonathan Leach[1], Daniele Faccio[1]; [1]*Inst. of Photonics and Quantum Sciences, Heriot-Watt Univ., UK;* [2]*Dept of Physics and Applied Physics, Univ. of Strathclyde, UK.* Recent advances in light matter interaction have demonstrated the possibility to coherently absorb and modulate light with sub-wavelength, partially absorbing thin films. We demonstrate an ON-OFF ratio of 90% using graphene as a broadband modulator.

**FTu3K.2 • 16:45**
**Ultrafast voltage-tunable plasmonic metamaterials based on intersubband polaritons,** Jongwon Lee[1], Seungyong Jung[1], Pai-Yen Chen[1], Feng Lu[1], Frederic Demmerle[2], Gerhard Boehm[2], Markus Amann[2], Andrea Alu[1], Mikhail A. Belkin[1]; [1]*Univ. of Texas at Austin, USA;* [2]*Walter Schottky Institut, Germany.* We report ultra-fast voltage-tunable optical response from metamaterials based coupling of plasmonic resonances in metallic nanostructures with intersubband polaritons. Over 310nm of spectral peak tuning around 7μm with 10ns response time was experimentally demonstrated.

**FTu3K.3 • 17:00**
**CMOS Compatible Ultra-Compact Modulator,** Viktoriia Babicheva[1,3], Nathaniel Kinsey[2], Gururaj Naik[2], Marcello Ferrera[2,4], Andrei Lavrinenko[1], Vladimir M. Shalaev[2,5], Alexandra Boltasseva[2,1]; [1]*Technical Univ. of Denmark, Denmark;* [2]*Purdue Univ., USA;* [3]*National Research Univ. for Information Technology, Mechanics, and Optics, Russia;* [4]*Heriot-Watt Univ., UK;* [5]*The Russian Quantum Center, Russia.* A planar layout for an ultra-compact plasmonic modulator is proposed and numerically investigated. Our device utilizes potentially CMOS compatible materials and can achieve 3-dB modulation in just 65nm and insertion loss <1dB at telecommunication wavelengths.

## Marriott Salon I & II

## CLEO: Applications & Technology

### 16:30–18:00
### ATu3L • Symposium on Laser Processing for Consumer Electronics II ▶
*Presider: Michael Mielke; Raydiance Inc, USA*

**ATu3L.1 • 16:30** Invited ▶
**Laser Cutting of Flexible Glass,** Xinghua Li[1], Sean Garner[1]; [1]*Corning Incorporated, USA.* In this invited talk, we review our cutting research on flexible glass substrates using both laser ablation and laser crack propagation methods. The methods are evaluated in terms of cut edge quality, speed and path to manufacturing.

**ATu3L.2 • 17:00** Invited ▶
**High Throughput Laser Processing with Ultra-Short Pulses by High Speed Line-Scanning in Synchronized Mode,** Beat Neuenschwander[1], B. Jäggi[1], M. Zimmermann[1], L. Penning[2], R. de Loor[2]; [1]*Inst. of Applied Laser, Bern Univ. of Applied Sciences, Switzerland;* [2]*Next Scan Technology, Netherlands.* Keeping the high efficiency and machining quality with today high average power ultrafast lasers demands new and fast beam deflecting systems. We will report on our latest results obtained with a fast polygon line scanner synchronized with a picosecond and femtosecond laser.

## CLEO: Science & Innovations

### Marriott
### Salon III

**16:30–18:30**
**STu3M • Microresonators** ▶
*Presider: Michael Watts, MIT, USA*

**STu3M.1 • 16:30** ▶
**Microgrooved Bottle Microresonators,** Mohd Narizee Mohd Nasir[1], Ming Ding[1], Ganapathy Senthil Murugan[1], Michalis N. Zervas[1]; *[1]Optoelectronics Research Centre, Univ. of Southampton, UK.* Spectral cleaning in bottle microresonators is presented by inscribing periodic surface microgrooves. Cleaning down to single strong WGM family is demonstrated, with Qs > 10E5 (similar to original microresonator).

**STu3M.2 • 16:45** ▶
**Fifth Power Scaling of Quality Factor in Silicon Photonic Degenerate Band Edge Resonators,** Justin Burr[1], Michael Wood[1], Ronald M. Reano[1]; *[1]Ohio State Univ., USA.* We observe experimentally a transition of quality factor scaling from third power to fifth power of the number of periods in periodic silicon optical waveguides designed to exhibit a degenerate band edge.

**STu3M.3 • 17:00** ▶
**High-Q Free-standing Silicon Nitride Micordisk Vertically Coupled with On-chip Waveguide,** Weiqiang Xie[1], Dries Van Thourhout[1]; *[1]Photonics Research Group, Belgium.* We designed and fabricated silicon nitride micordisk-waveguide vertical coupling devices processed at a low temperature of 270°. We experimentally demonstrate an intrinsic quality factor of 7.2×104 in the disk with only 15μm radius operating near 1310nm.

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via email and let us
know your thoughts on
the program.

### Marriott
### Salon IV

**16:30–18:30**
**STu3N • Fiber Measurement and Devices**
*Presider: Mike Messerly, Lawrence Livermore National Lab., USA*

**STu3N.1 • 16:30** Invited
**Broadband and Ultrahigh Resolution Optical Spectroscopy using a Tapered Fiber,** Noel Wan[1,2], Fan Meng[1,3], Ren-Jye Shiue[1], Edward Chen[1], Tim Schroeder[1], Dirk Englund[1]; *[1]Electrical Engineering and Computer Science, MIT, USA; [2]Physics, Columbia Univ., USA; [3]State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China.* We introduce a new integrated-optics spectroscopy scheme based on multimode interference, achieving ultra-high resolving powers (Q > 10^5) with linewidths down to 10 pm at 1500 nm, and a broad spectroscopy range from 500 nm to 1600 nm within a monolithic, millimeter-scale device.

**STu3N.2 • 17:00**
**Spatially and temporally resolved imaging of modal content in photonic-bandgap fiber,** Joel A. Carpenter[1], Benjamin J. Eggleton[1], Jochen Schroeder[1]; *[1]Univ. of Sydney, Australia.* The principles of spatially and spectrally resolved imaging are extended to include spectral phase information which yields a measurement which is resolved both spatially and temporally.

### Marriott
### Salon V & VI

**16:30–18:30**
**STu3O • Symposium on Microcavity Exciton-Polaritons, Devices and Applications II** ▶
*Presider: Stephane Kena-Cohen; Imperial College London, UK*

**STu3O.1 • 16:30** Invited
**Polariton Lattices for Quantum Simulation,** Alberto Amo[1]; *[1]Laboratoire de Photonique et Nanostructures, CNRS, France.* Coupled micropillars etched in semiconductor microcavities are an excellent platform to engineer the properties of exciton-polaritons. These microstructures can be used to simulate various solid-state hamiltonians using photons in a non-linear ennvironment.

**STu3O.2 • 17:00** ▶
**Control of Turing Patterns in a Coherent Quantum Fluid,** Y. C. Tse[1], P. Lewandowski[2], V. Ardizzone[3], Nai H. Kwong[1,4], M. H. Luk[1,4], A. Lücke[2], M. Abbarchi[3,5], J. Bloch[5], E. Baudin[3], E. Galopin[5], A. Lemaitre[5], C. Y. Tsang[1], K. P. Chan[1], P. T. Leung[1], Ph. Roussignol[3], Rolf Binder[4], J. Tignon[3], S. Schumacher[2]; *[1]Chinese Univ. of Hong Kong, China; [2]Univ. of Paderborn, Germany; [3]CNRS, France; [4]Univ. of Arizona, USA; [5]CNRS, France.* A generalization of Turing patterns, originally developed for chemical reactions, to patterns in quantum fluids can be realized with microcavity polaritons. Theoretical concepts of formation and control, together with experimental observations, will be presented.

## CLEO: Applications & Technology

### Marriott
### Willow Glen I-III

**16:30–18:30**
**ATu3P • Symposium on Novel Light Sources and Photonic Devices in Optical Imaging II** ▶
*Presider: Benjamin Vakoc; Harvard Medical School, USA*

**ATu3P.1 • 16:30** Invited ▶
**Laser sources for deep tissue multiphoton imaging,** Chris Xu[1]; *[1]Applied and Engineering Physics, Cornell Univ., USA.* Deep tissue multiphoton microscopy (MPM) using solitons generated from optical fibers are reviewed. The main characteristics of the excitation source for deep tissue MPM, such as wavelength, pulse energy, and repetition rate, are discussed.

**ATu3P.2 • 17:00** Invited ▶
**Multiphoton imaging and manipulation of biological systems,** Jeffrey A. Squier[1], Erica Block[1], Michael Greco[1], Michael Young[1], Charles G. Durfee[1], Jens Thomas[3], Jeff Field[2], Randy Bartels[2]; *[1]Colorado School of Mines, USA; [2]Colorado State Univ., USA; [3]Friedrich-Schiller Univ., Germany.* Through the development of simultaneous spatial and temporal focusing, platforms that can ablate tissue with excellent axial precision, and perform high-speed multiphoton imaging are converging. Recent developments in these platforms are presented.

## CLEO: QELS-Fundamental Science

## Executive Ballroom 210A

### FTu3A • Quantum Repeater Technologies—Continued

**FTu3A.3 • 17:15**
**Long-lived dark states in a superconductor diamond hybrid quantum system,** William Munro[1,3], Xiaobo Zhu[1], Yuichiro Matsuzaki[1], Robert Amsuss[1,4], Kosuke Kakuyanagi[1], Takaaki Shimo-Oka[2], Norikazu Mizuochi[2], Kae Nemoto[3], Kouichi Semba[3], Shiro Saito[1]; *[1]NTT Basic Research Labs, Japan; [2]Univ. of Osaka, Graduate school of Engineering Science, Japan; [3]National Inst. for Informatics, Japan; [4]Vienna Center for Quantum Science and Technology, Atominstitut, TU Wien, Austria.* We have observed a sharp resonance in the spectrum of flux qubit NV- diamond hybrid quantum system where its measured line-width is much narrower than that of both the flux-qubit and spin ensemble. This resonance is evidence of a collective & long-lived dark state.

**FTu3A.4 • 17:30**
**Demonstration of a NV spin qubit interacting with a cavity mode in the Purcell regime,** Luozhou Li[1,2], Tim Schroeder[1], Edward Chen[1], Michael Walsh[1], Igal Bayn[1,2], Ophir Gaathon[1], Matthew Trusheim[1], Ming Lu[3], Jacob C. Mower[1], Hassaram Bakhru[4], Matthew Markham[5], Daniel Twitchen[5], Dirk Englund[1]; *[1]Electrical Engineering and Computer Science, MIT, USA; [2]Electrical Engineering, Columbia Univ., USA; [3]Center for Functional Nanomaterials, Brookhaven National Lab, USA; [4]College of Nanoscale Science and Engineering, Univ. at Albany-State Univ. of New York, USA; [5]Element Six Ltd, UK.* We demonstrate an over-80-fold enhancement of an NV's zero-phonon line emission inside cavity in the Purcell regime within a high-purity, electronic-grade diamond substrate. This system is a promising building block for quantum networks.

**FTu3A.5 • 17:45**
**Hybrid Quantum Nanophotonic Devices for Coupling to Rare-Earth Ions,** Evan Miyazono[1], Alex Hartz[1], Tian Zhong[1], Andrei Faraon[1]; *[1]Applied Physics, California Inst. of Technology, USA.* Gallium arsenide photonic crystal resonators are designed and fabricated for evanescent coupling to localized ensembles of rare-earth ions in crystalline hosts. These devices will enable nano-scale on-chip optical quantum memories.

## Executive Ballroom 210B

### FTu3B • Advances in High-Harmonic Generation—Continued

**FTu3B.4 • 17:15**
**Half-cycle Cutoffs up to the Oxygen K-edge: Signatures of Isolated Attosecond Pulses Across the Water Window,** Francisco Silva[1], Stephan M. Teichmann[1], Seth L. Cousin[1], Michael Hemmer[1], Jens Biegert[1,2]; *[1]ICFO - Institut de Ciencies Fotoniques, Spain; [2]ICREA - Institució Catalana de Recerca i Estudis Avançats, Spain.* We produce CEP-dependent X-ray continua up to the oxygen edge (543 eV) through high harmonic generation driven by sub-2-cycle 1.85 µm pulses at 1kHz, supporting isolated attosecond pulses of 45 as in the water window.

**FTu3B.5 • 17:30**
**Generation of Bright Isolated Attosecond Soft X-Ray Pulses Driven by Multi-Cycle Mid-Infrared Lasers,** Christopher A. Mancuso[1], Ming-Chang Chen[1,2], Carlos Hernandez-Garcia[1,3], Franklin Dollar[1], Benjamin Galloway[1], Dimitar Popmintchev[1], Benjamin Langdon[4], Amelie Auger[4], P. C. Huang[2], Barry C. Walker[5], Luis Plaja[3], Agnieszka Jaron-Becker[1], Andreas Becker[1], Margaret Murnane[1], Henry Kapteyn[1], Tenio Popmintchev[1]; *[1]Physics, JILA and Univ. of Colorado at Boulder, USA; [2]Inst. of Photonics Technologies, National Tsing Hua Univ., Taiwan; [3]Grupo de Investigacion en Optica Extrema, Universidad de Salamanca, Spain; [4]Kapteyn-Murnane Labs Inc., USA; [5]Physics, Univ. of Delaware, USA.* By driving the high harmonic generation process with multi-cycle mid-infrared laser pulses, we demonstrate bright isolated, attosecond soft X-ray pulses for the fist time.

**FTu3B.6 • 17:45**
**Dispersion-free monochromator for selecting a single high-order harmonic beam,** Eiji J. Takahashi[1], Masatoshi Hatayama[2], Satoshi Ichimaru[2], Katsumi Midorikawa[1]; *[1]Extreme Photonics Research Group, RIKEN Center for Advanced Photonics, Japan; [2]NTT Advanced Technology Corporation, Japan.* We propose a method to monochromatize high-order harmonics to isolate a single beam of harmonic radiation comprising femtosecond pulses. This novel method uses a multilayer-mirror approach, and has broadband tunability and high reflectivity in the soft-xray region.

## Executive Ballroom 210C

### FTu3C • Quantum Meta Optics—Continued

**FTu3C.4 • 17:30**
**Probing Epsilon Near Zero-related Enhancements in Silver,** Rabia Hussain[1], Mikhail A. Noginov[1], Maxim Durach[2], Natalia Noginova[1]; *[1]Norfolk State Univ., USA; [2]Georgia Southern Univ., USA.* We probe effects of field enhancements in silver-dielectric layers using a highly luminescent organic system with $Eu^{3+}$. Significant enhancement in the excitation spectra is observed at the spectral range corresponding to epsilon-near zero for silver.

**FTu3C.5 • 17:45**
**Shaping Emission Spectra of Quantum Dots by All-dielectric Metasurfaces,** Dragomir N. Neshev[1], Isabelle Staude[1], Nche T. Fofang[2], Sheng Liu[2], Jason Dominguez[2], Manuel Decker[1], Andrey Miroshnichenko[1], Vyacheslav V. Khardikov[3], Ting S. Luk[2], Igal Brener[2], Yuri S. Kivshar[1]; *[1]Australian National Univ., Australia; [2]Sandia National Lab, USA; [3]National Academy of Sciences of Ukraine, Ukraine.* Silicon nanodisks support electric and magnetic resonances, which can be tuned independently via the nanodisk geometry. We utilize such engineered resonances and demonstrate dielectric metasurfaces for efficient shaping of the emission spectra of quantum dots.

## Executive Ballroom 210D

### FTu3D • Filamentation and the THz Generation—Continued

**FTu3D.4 • 17:15**
**Optical heating of femtosecond laser filaments for long-range guidance of electrical discharges in air,** Maik Scheller[1], Norman Born[2], Jerome V. Moloney[1], Pavel G. Polynkin[1]; *[1]Optical Sciences, Univ. of Arizona, USA; [2]Philipps-Universität Marburg, Germany.* We experimentally demonstrate that through conditioning dilute plasma in femtosecond laser filaments in air by an energetic nanosecond laser pulse, we reduce the breakdown voltage along the filament by up to the factor of 40.

**FTu3D.5 • 17:30**
**Study of the interaction between multiple filaments in air,** Guillaume Point[1], Yohann Brelet[1], Aurélien Houard[1], Vytautas Jukna[2], Carles Milian[2], Jérôme Carbonnel[1], Arnaud Couairon[2], André Mysyrowicz[1]; *[1]Laboratoire d'Optique Appliquée, France; [2]Centre de Physique Théorique, France.* Interaction between a large number of conventional infrared filaments in air leads to the emergence over meter long distance of plasma channels one order of magnitude denser than standard filaments. Simulations reproduce well these features.

**FTu3D.6 • 17:45**
**Helical Filaments,** Nicholas Barbieri[1], Zahra Hosseinimakarem[2], Khan Lim[1], Magali Durand[1], Benjamin Webb[1], Joshua Bradford[1], Erik McKee[1], Nathan Bodnar[1], Lawrence Shah[1], Matthieu Baudelet[1], Eric Johnson[2], Martin Richardson[1]; *[1]Univ. of Central Florida, USA; [2]Clemson, USA.* We demonstrate the use of non-diffracting beams to control and organize multiple filamentation in air. Here, a pair of laser filaments which twist about the optical axis during propagation is obtained using a Bessel beam superposition.

**Executive Ballroom 210E**

**Executive Ballroom 210F**

**Executive Ballroom 210G**

**Executive Ballroom 210H**

## CLEO: Science & Innovations

### STu3E • Pulse Characterization and Ultrafast Imaging—Continued

**STu3E.4 • 17:15**
**Spatiotemporal Characterization of Ultrashort Laser Pulses Using Time-Domain Spatially Resolved Interferometry,** Miguel Miranda[1], Marija Kotur[1], Cord L. Arnold[1], Anne L'Huillier[1]; [1]*Atomic Physics, Lund Univ., Sweden*. We present a technique for characterizing ultrashort pulses in the spatiotemporal domain with high spatial resolution, based on a spatially-resolved Fourier-transform spectrometer. Spatiotemporal characterization of a pulse with pulse-front tilt is presented.

**STu3E.5 • 17:30**
**THG of ZnO nanorods for efficient third order interferometric FROG,** Susanta K. Das[4,1], Frank Güell[2], Ciarán Gray[3], Prasanta K. Das[4], Ruediger Grunwald[1], Enda McGlynn[3], Gunter Steinmeyer[1]; [1]*Max Born Inst. for Nonlinear Optics and Short-Pulse Spectroscopy, Germany;* [2]*Departament d'Electrònica, Universitat de Barcelona, Spain;* [3]*School of Physical Sciences, National Centre for Plasma Science and Technology, Dublin City Univ., Ireland;* [4]*School of Applied Sciences, KIIT Univ., India*. Efficient third harmonic generation was found in ZnO nanorod layers grown by phase transport and low temperature chemical bath deposition method. Interferometric frequency- resolved optical gating of few cycle fs pulses was demonstrated.

**STu3E.6 • 17:45**
**Observing the Conditional Decoherence of a Mixed State of Light,** Marc Assmann[1], Mackillo Kira[2], Steven T. Cundiff[1]; [1]*JILA, Univ. of Colorado & National Inst. of Standards and Technology, USA;* [2]*Dept of Physics, Philipps-Univ. Marburg, Germany*. We demonstrate a method to capture the temporal evolution of a light field using continuous-variable conditional two-time Wigner functions. Reference beams with fixed phase relationship to the signal are not required.

### STu3F • Technologies for High Intensity—Continued

**STu3F.3 • 17:15**
**A White-Light-Seeded Front End for Ultra-Intense Optical Parametric Chirped-Pulse Amplification,** Jake Bromage[1], Rick Roides[1], Seung-Whan Bahk[1], Chad Mileham[1], Leva E. McIntire[1], Christophe Dorrer[1], Jonathan D. Zuegel[1]; [1]*Lab for Laser Energetics, Univ. of Rochester, USA*. Ultra-intense optical parametric chirped-pulse amplification (OPCPA) requires a high-performance front end at 910 nm. Progress on developing a white-light-seeded chain of noncollinear optical parametric amplifiers (NOPA's) and a cylindrical Offner stretcher is presented.

**STu3F.4 • 17:30**
**High-contrast, CEP-controlled double-CPA laser,** Aurelie Jullien[1], Aurelien Ricci[1], Frederik Bohle[1], Jean-Philippe Rousseau[1], Stephanie Grabrielle[2], Nicolas Forget[2], Pierre Tournois[2], Rodrigo B. Lopez-Martens[1]; [1]*Laboratoire d'Optique Appliquee, France;* [2]*Fastlite, France*. We present the first CEP stable double-CPA laser system, producing 8 mJ, 22 fs pulses and featuring high temporal contrast (10^11) for performing relativistic intensity laser-plasma interactions at 1 kHz repetition rate.

**STu3F.5 • 17:45**
**Spectral and Temporal Properties of Optical Signals with Multiple Sinusoidal Phase Modulations,** Christophe Dorrer[1]; [1]*Univ. of Rochester, USA*. High-energy laser systems use optical signals with multiple sinusoidal phase modulations for on-target smoothing and stimulated Brillouin scattering suppression. The spectrum and temporal frequency-modulation-to-amplitude-modulation conversion of these signals are analytically studied.

### STu3G • Photodetectors—Continued

**STu3G.4 • 17:15**
**High Detectivity Short Wavelength II-VI Quantum Cascade Detector,** Arvind Pawan Ravikumar[1], Thor A. Garcia[2], Joel De Jesus[3], Maria C. Tamargo[2], Claire F. Gmachl[1]; [1]*Dept of Electrical Engineering, Princeton Univ., USA;* [2]*Dept of Chemistry, The City College of New York of CUNY, USA;* [3]*Dept of Physics, The City College of New York of CUNY, USA*. We demonstrate the first II-VI based short-wave ($\lambda \leq 4$ μm) Quantum Cascade Detector. Peak responsivity and background limited detectivity of 0.1 mA/W and 2.5x10^10 cm√Hz/W, respectively, were measured at 80 K.

**STu3G.5 • 17:30** **Tutorial**
**Single Photon Imagers,** Edoardo Charbon[1]; [1]*Technische Universiteit Delft, Netherlands*. Photon counting has become a key technology in imaging science for biomedicine, physics, and engineering. This tutorial will review the first 10 years of CMOS single-photon imager history and give a perspective for the future.

Edoardo Charbon received the Ph.D. in EECS from Univ. of California Berkeley in 1995. He was with Cadence and Canesta until 2002, when he joined EPFL's faculty. Since 2008 he has been Chair of VLSI design at Delft University of Technology. Charbon has published over 250 articles in journals and proceedings and two books; in addition he holds 14 patents and is the co-recipient of the European Photonics Innovation Award.

### STu3H • Quantum & Nonlinear Materials & Devices—Continued

**STu3H.4 • 17:15**
**Polymethines with Macroscopic Optical Nonlinearities Suitable for All-Optical Signal Processing,** Joel M. Hales[1], Hyeongeu Kim[1], Stephen Barlow[1], Yulia Getmanenko[1], Yadong Zhang[1], Rebecca Giesking[1], Chad Risko[1], Shiva Shahin[2], Khanh Kieu[2], Robert A. Norwood[2], Nasser Peyghambarian[2], Jean-Luc Brédas[1], Seth R. Marder[1], Joseph W. Perry[1]; [1]*School of Chemistry and Biochemistry, Georgia Inst. of Technology, USA;* [2]*College of Optical Sciences, Univ. of Arizona, USA*. By preventing aggregation of polymethine molecules at high number density, we have developed organic materials with large third-order nonlinearities and low nonlinear absorption in the near-infrared thereby enabling demonstration of an all-optical signal processing application.

**STu3H.5 • 17:30** **Invited**
**Si-based Microcavity Devices with Ge Quantum Dots,** Jinsong Xia[1], Cheng Zeng[1], Yong Zhang[1], Yingjie Ma[2], Zuimin Jiang[2], Jinzhong Yu[1,3]; [1]*Huazhong Univ. of Science and Technology, China;* [2]*Fudan Univ., China;* [3]*Inst. of Semiconductors, Chinese Academy of Science, China*. Site-controlled single Ge quantum dot was grown on patterned silicon-on-insulator substrate. The single dot was then precisely embedded into a photonic crystal microcavity. Resonant photoluminescence was observed from the single Ge dot in the cavity.

## Meeting Room 211 B/D

## CLEO: Science & Innovations

### STu3I • Novel Applications of Nonlinear Optics—Continued

**STu3I.4 • 17:15**
**Experimental Demonstration of a Variable Bandwidth, Shape and Center-Frequency RF Photonics Filter using a Continuously Tunable Optical Tapped-Delay-Line and Having an Optical Output,** Morteza Ziyadi[1], Amirhossein Mohajerin-Ariaei[1], Mohammed Chitgarha[1], Salman Khaleghi[1], Ahmed Almaiman[1], Amin Abouzaid[2], Joseph Touch[2], Moshe Tur[3], Loukas Paraschis[4], Carsten Langrock[5], Martin M. Fejer[5], Alan Willner[1]; *[1]Univ. of Southern California, USA; [2]Information Science Inst., Univ. of Southern California, USA; [3]School of Electrical engineering, Tel Aviv Univ., Israel; [4]Cisco Systems, USA; [5]Edward L. Ginzton Lab, Stanford Univ., USA.* We experimentally demonstrate the RF photonics filter using optical tapped delay line based on an optical frequency comb and a PPLN waveguide as the multiplexer. RF filters with variable bandwidth, shape and center-frequency are implemented.

**STu3I.5 • 17:30**
**Coincidence Detection with Graphene Excitable Laser,** Bhavin J. Shastri[1], Alexander N. Tait[1], Mitchell Nahmias[1], Ben Wu[1], Paul Prucnal[1]; *[1]Electrical Engineering, Princeton Univ., USA.* We demonstrate a photonic coincidence detection circuit with a graphene excitable laser. This technology is a potential candidate for applications in novel all-optical devices for information processing and computing.

**STu3I.6 • 17:45**
**Förster Resonance Energy Transfer within a Donor-Acceptor Composite Photochromic Molecule through One- and Two-Photon Absorption,** Peng Zhao[1], Honghua Hu[1], Raz Gvishi[2], Galit Strum[2], Amir Tal[2], Shmuel Grinvald[2], Galit Bar[2], Laura Bekere[3], Vladimir Lokshin[3], Vladimir Khodorkovsky[3], Mark Sigalov[4], David J. Hagan[1], Eric W. Van Stryland[1]; *[1]1CREOL, The College of Optics and Photonics, Univ. of Central Florida, USA; [2]Applied Physics Division, Soreq NRC, Israel; [3]Aix Marseille Université, France; [4]Ben-Gurion Univ. of the Negev, Israel.* FRET within a donor-acceptor composite photochromic molecule was investigated in a dye-doped sol-gel matrix using both 1 and 2-Photon absorption. The energy transfer efficiency was estimated from UV-excitation photokinetic measurements by applying a 2-level model.

## Meeting Room 212 A/C

### STu3J • DSP and Coding—Continued

**STu3J.4 • 17:15**
**A PMD Monitoring Scheme for Direct-Detection Optical OFDM Systems Using Code-Assisted Optical Subcarriers,** Tianwai Bo[1], Shuang Gao[1], Kam-Hon Tse[1], Chun-Kit Chan[1]; *[1]The Chinese Univ. of Hong Kong, Hong Kong.* A PMD monitoring scheme is proposed for direct-detection optical OFDM systems by adding a pair of code-assisted optical subcarriers. Code correlation technique is used to retrieve DGD values over 0-25ps with <2-ps average monitoring error.

**STu3J.5 • 17:30**
**Optimized Vector-Quantization-Based Signal Constellation Design (OVQ-SCD) for Multidimensional Optical Transport,** Ivan B. Djordjevic[1], Aleksandra Jovanovic[2], Zoran Peric[2], Ting Wang[3]; *[1]ECE Dept., Univ. of Arizona, USA; [2]Faculty of Electronic Engineering, Univ. of Nis, Serbia; [3]Optical Networks Dept, NEC Labs, USA.* An optimized-vector-quantization-based signal-constellation-design (OVQ-SCD) suitable for beyond 1Pb/s serial multidimensional-optical-transport is proposed, in which signal-constellation-radii-transformation-function is optimized and near-uniform-distribution of points is achieved.

**STu3J.6 • 17:45**
**Novel BCH Code Design for Mitigation of Phase Noise Induced Cycle Slips in DQPSK Systems,** Miu Yoong Leong[1,2], Knud J. Larsen[3], Gunnar Jacobsen[1,2], Sergei Popov[2], Darko Zibar[3], Sergey Sergeyev[4]; *[1]Acreo Swedish ICT, Sweden; [2]Royal Inst. of Technology (KTH), Sweden; [3]Technical Univ. of Denmark (DTU), Denmark; [4]Aston Univ., UK.* We show that by proper code design, phase noise induced cycle slips causing an error floor can be mitigated for 28 Gbaud DQPSK systems. Performance of BCH codes are investigated in terms of required overhead.

## Meeting Room 212 B/D

## CLEO: QELS-Fundamental Science

### FTu3K • Active Plasmonic and Nanophotonic Modulators—Continued

**FTu3K.4 • 17:15**
**Dynamic Tuning of Surface Plasmon Polaritons via Thermally Controlled Liquid Crystals,** Arif E. Cetin[1,2], Alket Mertiri[3], Min Huang[1], Shyamsunder Erramilli[3,4], Hatice Altug[2,1]; *[1]Electrical and Computer Engineering, Boston Univ., USA; [2]Bioengineering Dept, EPFL, Switzerland; [3]Materials Science and Engineering, Boston Univ., USA; [4]Physics, Boston Univ., USA.* We present a thermally controlled plasmonic substrate in contact with a liquid crystal offering spectral tunings ~18.7 nm within ~18oC at LC nematic phase. Nematic/isotropic transition also enables ~12 nm spectral change only within ~1oC.

**FTu3K.5 • 17:30**
**Active Plasmonics with Surface Acoustic Waves: Dynamic Electro-Mechanical Control over a Surface Plasmon Polariton Launcher,** Claudia Ruppert[1], Frederike Förster[1], Artur Zrenner[2], Jörg B. Kinzel[3,4], Achim Wixforth[3,4], Hubert J. Krenner[3,4], Markus Betz[1]; *[1]Experimentelle Physik 2, Technische Universität Dortmund, Germany; [2]Dept Physik, Universität Paderborn, Germany; [3]Lehrstuhl für Experimentalphysik 1 and Augsburg Centre for Innovative Technologies (ACIT), Universität Augsburg, Germany; [4]Nanosystems Initiative Munich (NIM), Germany.* 500 MHz surface acoustic waves travel across a commensurate plasmonic grating coupler. A stroboscopic optical technique shows that the dynamic surface deformation deliberately modulates the coupler's efficiency by +/-2\% during the ~2ns acoustic cycle

**FTu3K.6 • 17:45**
**Latching Plasmonic Switch with High Extinction Ratio,** Claudia Hoessbacher[1], Yuriy Fedoryshyn[1], Alexandros Emboras[1], David Hillerkuss[1], Argishti Melikyan[2], Manfred Kohl[2], Martin Sommer[2], Christian Hafner[1], Juerg Leuthold[1]; *[1]ETH Zurich, Switzerland; [2]Karlsruhe Inst. of Technology, Germany.* We demonstrate a plasmonic latching switch (5µm long) at 1550nm with a 6dB extinction ratio. It exploits the reversible formation of conducting nanofilaments in a plasmonic waveguide. It maintains its state without any power consumption.

## Marriott Salon I & II

## CLEO: Applications & Technology

### ATu3L • Symposium on Laser Processing for Consumer Electronics II—Continued

**ATu3L.3 • 17:30** Invited
**Laser Processes for Development of Advanced Lithium-Ion Batteries - Increased Capacity and Cycle Life-Time,** Wilhelm Pfleging[1,2]; *[1]Karlsruher Institut für Technologie, Germany; [2]Karlsruhe Nano Micro Facility, Germany.* Laser processing of electrode materials is a new technical approach in manufacturing of 3D batteries with improved electrochemical performance. Furthermore, laser-generated capillary structures transform electrodes to superwicking for liquid electrolytes leading to cost-efficient production. above

## Marriott
## Salon III

## CLEO: Science & Innovations

### STu3M • Microresonators—Continued

**STu3M.4 • 17:15**
**Controlling the Phase Front of Optical Fiber Beams using High Contrast Metastructures,** Amir Arbabi[1], Mahmood Bagheri[2], Alexander J. Ball[1], Yu Horie[1], David Fattal[3], Andrei Faraon[1]; [1]*Applied Physics, California Inst. of Technology, USA;* [2]*Jet Propulsion Lab, California Inst. of Technology, USA;* [3]*Hewlett-Packard Labs, USA.* The phase of optical beams can be modified by high contrast sub-wavelength periodic structures with gradually varying geometrical features. We present design, simulation, fabrication and characterization of planar micro-lenses shaping the beam of optical fibers.

**STu3M.5 • 17:30**
**Planar Retroreflector,** Amir Arbabi[1], Yu Horie[1], Andrei Faraon[1]; [1]*Applied Physics, California Inst. of Technology, USA.* We propose a planar retroreflector composed of two cascaded high contrast periodic structures with slowly varying features. One of the high contrast structures focuses the light while the other reflects it as a concave mirror.

**STu3M.6 • 17:45**
**Coupled-resonator-optical-waveguide (CROW)-based On-chip Sensors with Multi-pixel Detection Using All-silicon Sub-bandgap Photodetectors,** Yu Li[1], Andrew W. Poon[1]; [1]*Hong Kong Univ of Science & Technology, Hong Kong.* We propose a coupled-resonator-optical-waveguide-based sensor with multi-pixel detection using all-silicon sub-bandgap photodetectors at 1550 nm. Our proof-of-concept experiments of a PIN-diode-integrated three-microring CROW demonstrate sensing a minimum effective refractive index change of 2×10-5.

## Marriott
## Salon IV

### STu3N • Fiber Measurement and Devices—Continued

**STu3N.3 • 17:15**
**Near-real-time modal reconstruction using frequency-domain $C^2$ imaging,** Jeffrey Demas[1], Siddharth Ramachandran[1]; [1]*Dept of Electrical Engineering, Boston Univ., USA.* We demonstrate frequency-domain cross-correlated ($C^2$) imaging to reconstruct fiber modes and measure relative weights. Measurements take only 1.5 s, yield sub-ps group delay resolution and 25 dB modal discrimination, facilitating near-real-time monitoring of modal purity.

**STu3N.4 • 17:30**
**Effect of Dispersion Fluctuations on Longitudinal Gain Evolution in Phase-Sensitive Parametric Amplifiers,** fatemeh alishahi[1,2], Armand Vedadi[2], Mohammad Amin Shoaie[2], Marcelo A. Soto[2], Andrey Denisov[2], Khashayar Mehrany[1], Luc Thevenaz[2], Camille-Sophie Brès[2]; [1]*sharif univercity of technology, Islamic Republic of Iran;* [2]*Ecole Polytechnique Federale de Lausanne(EPFL), Switzerland.* A Brillouin probing method is proposed to extract the distribution of signal power along phase-sensitive parametric amplifiers. Operation near the zero-dispersion-wavelength shows enhanced sensitivity to dispersion fluctuations, allowing effective extraction of dispersion map.

**STu3N.5 • 17:45**
**Oxygen sensing using hollow-core fiber based phase-shift cavity ring-down spectroscopy,** Dorit Munzke[1], Marvin Münzberg[1], Michael Böhm[1], Oliver Reich[1]; [1]*Univ. of Potsdam, Germany.* We combine the benefits of phase-shift cavity ring-down spectroscopy and a photonic crystal fiber that acts as a sample cell. Absolute spectroscopic measurements are performed on gaseous samples (here: oxygen) of nanoliter volumes.

## Marriott
## Salon V & VI

### STu3O • Symposium on Microcavity Exciton-Polaritons, Devices and Applications II—Continued

**STu3O.3 • 17:15**
**Ultra-fast spinor switching in polariton condensates,** Alexis Askitopoulos[1], Hamid Ohadi[1], Tim C. Liew[2], Zaharias Hatzopoulos[3,4], Pavlos Savvidis[3,5], Alexey Kavokin[1,6], Pavlos Lagoudakis[1]; [1]*Physics and Astronomy, Univ. of Southampton, UK;* [2]*School of physical and mathematical sciences, Nanyang Technological Univ., Singapore;* [3]*Microelectronics Research Group, IESL-FORTH, Greece;* [4]*Dept of Physics, Univ. of Crete, Greece;* [5]*Dept of Materials Science and Technology, Univ. of Crete, Greece;* [6]*Spin Optics Lab, St Petersburg State Univ., Russia.* We demonstrate a linear to circular polarization conversion mechanism in an optically confined polariton condensate created by an optical potential trap. Application of a non-resonant below threshold femtosecond pulse on the spinor condensate results in an ultrafast reversal of the spin state..

**STu3O.4 • 17:30** Invited
**Spectroscopy of strongly-coupled organic semiconductor microcavities,** David Lidzey[1]; [1]*Univ. of Sheffield, UK.* The strong-coupling regime allows optical and electronic states to be mixed forming cavity polaritons. I describe the basic physics of polaritons created using organic semiconductor and discuss their application in new types of device.

## Marriott
## Willow Glen I-III

## CLEO: Applications & Technology

### ATu3P • Symposium on Novel Light Sources and Photonic Devices in Optical Imaging II—Continued

**ATu3P.3 • 17:30**
**On-Chip Supercontinuum Generation in a Dispersion-Controlled Silicon-Wire Waveguide,** Atsushi Ishizawa[1], Takahiro Goto[1,2], Hidetaka Nishi[3,4], Nobuyuki Matsuda[1,3], Rai Kou[3,4], Kenichi Hitachi[1], Tadashi Nishikawa[2], Koji Yamada[3,4], Tetsuomi Sogawa[1], Hideki Gotoh[1]; [1]*NTT Basic Research Labs, NTT Corporation, Japan;* [2]*Tokyo Denki Univ., Japan;* [3]*NTT Nanophotonics Center, NTT Corporation, Japan;* [4]*NTT Microsystem Integration Labs, NTT Corporation, Japan.* We demonstrate the broadest on-chip supercontinuum generation, spanning more than 2/3-octave (1300-2200 nm) bandwidth, with an 80-fs laser pulse in the 1.5-um band by controlling dispersion in a 0.9-cm-long Si-wire waveguide.

**ATu3P.4 • 17:45**
**Broadband, High Resolution Stimulated Raman Spectroscopy with Rapidly Wavelength Swept cw-Lasers,** Matthias Eibl[1], Sebastian Karpf[1], Wolfgang Wieser[1], Thomas Klein[1], Robert Huber[1,2]; [1]*Institut für BioMolekulare Optik, Univ. of Munich, Germany;* [2]*Institut für Biomedizinische Optik, Univ. of Lübeck, Germany.* A fast all fiber based setup for stimulated Raman spectroscopy with a rapidly wavelength swept cw-laser is presented. It enables flexible acquisition of broadband (750 cm-1 to 3150 cm-1) spectra with high resolution (0.5 cm-1).

## Executive Ballroom 210A

## Executive Ballroom 210B

## Executive Ballroom 210C

## Executive Ballroom 210D

# CLEO: QELS-Fundamental Science

### FTu3A • Quantum Repeater Technologies—Continued

**FTu3A.6 • 18:00**
**Efficient Storage at Telecom Wavelength for Optical Quantum Memory,** Julian Dajczgewand[1], Jean-Louis Le Gouët[1], Anne Louchet-Chauvet[1], Thierry Chanelière[1]; [1]*Laboratoire Aimé Cotton, France.* We report high efficient storage at telecom wavelength using the recently proposed ROSE protocol. The bandwidth is analyzed to increase the multiplexing capacity.

**FTu3A.7 • 18:15**
**The Quantum Memory Stick,** Simon Devitt[1], Ashley Stephens[2], Rodney Van Meter[3]; [1]*QIS, National Inst. of Informatics, Japan;* [2]*National Inst. of informatics, Japan;* [3]*Keio Univ. Shonan Fujisawa Campu, Japan.* We introduce a design a design for a quantum memory stick that uses active quantum error correction to store a qubit of encoded information for months/years.

### FTu3B • Advances in High-Harmonic Generation—Continued

**FTu3B.7 • 18:00**
**Theory of time-gated phase-matching for isolated attosecond soft x-ray pulse generation using mid-infrared lasers,** Carlos Hernandez-Garcia[1,2], Ming-Chang Chen[1,3], Christopher Mancuso[1], Franklin Dollar[1], Benjamin Galloway[1], Dimitar Popmintchev[1], Pei-Chi Huang[3], Barry C. Walker[4], Tenio Popmintchev[1], Margaret Murnane[1], Henry Kapteyn[1], Luis Plaja[2], Agnieszka Jaron-Becker[1], Andreas Becker[1]; [1]*JILA, Univ. of Colorado, USA;* [2]*Grupo de Investigación en Óptica Extrema, Universidad de Salamanca, Spain;* [3]*Inst. of Photonics Technologies, National Tsing Hua Univ., Taiwan;* [4]*Univ. of Delaware, USA.* We model soft x-ray high harmonic generation and propagation driven by mid-infrared lasers. We find that multi-cycle laser pulses are ideal for generating shorter bright isolated attosecond pulses via time-gated phase-matching in high-density extended media.

**FTu3B.8 • 18:15**
**Carrier-Envelope Phase Stabilization of a 10 Hz, 20 TW Laser for High-Flux Attosecond Pulse Generation,** Yi Wu[1], Eric Cunningham[1], Jie Li[1], Michael Chini[1], Zenghu Chang[1]; [1]*CREOL and Dept of Physics, Univ. of Central Florida, USA.* We developed a method to stabilize the carrier-envelope phase of a 20 TW Ti:Sapphire laser operating at 10 Hz. Phase-dependent features were observed in the high-order harmonic spectrum generated using Generalized Double Optical Gating.

### FTu3C • Quantum Meta Optics—Continued

**FTu3C.6 • 18:00**
**Directional emission from quantum dots in a hyperbolic metamaterial,** Tal Galfsky[1,2], Harish Krishnamoorthy[1,2], Ward D. Newman[3], Evgenii Narimanov[4], Zubin Jacob[3], Vinod M. Menon[1,2]; [1]*Physics, Queens College of the City Univ. of New York, USA;* [2]*Physics, Graduate Center of the City Univ. of New York, USA;* [3]*Electrical and Computer Engineering, Univ. of Alberta, Canada;* [4]*School of Computer and Electrical Engineering, Purdue Univ., USA.* Directional light extraction from high-k modes in a hyperbolic metamaterial is demonstrated by direct coupling of resonance cones from quantum dots underneath a metal-dielectric composite to a high index bulls-eye grating structure.

**FTu3C.7 • 18:15**
**Strong Light-Matter Coupling in Mid-Infrared Monolithic Metamaterial Nanocavities,** Alexander Benz[1,2], Salvatore Campione[1,2], Sheng Liu[1,2], Ines Montano[2], John F. Klem[2], Michael B. Sinclair[2], Filippo Capolino[3], Igal Brener[1,2]; [1]*Center for Integrated Nanotechnologies (CINT), Sandia National Labs, USA;* [2]*Sandia National Labs, USA;* [3]*Dept of Electrical Engineering and Computer Science, Univ. of California, Irvine, USA.* We present the design and realization of strong light-matter coupling in monolithic metamaterial nanocavities. We achieve a Rabi frequency of 2.5 THz (corresponding to a polariton splitting of 20%) in a mode volume of $1.34\times10^{-3}(\lambda/n)^3$

### FTu3D • Filamentation and the THz Generation—Continued

**FTu3D.7 • 18:00**
**Enhanced Spectral Broadening and Beam Collimation from Pulse-Sequence Induced Filamentation,** Eric Rosenthal[1], Nihal Jhajj[1], Reuven Birnbaum[1], Howard Milchberg[1]; [1]*Inst. for Research in Electronics and Applied Physics, Univ. of Maryland, USA.* Filaments in air, induced by pulse trains of four ultrashort pulses, each separated by the rotational revival time of nitrogen exhibit an increased degree of spectral broadening and collimation over the single pulse filament case.

**FTu3D.8 • 18:15**
**Electronic switching mechanism in Aperiodic DFB Lasers,** Thomas Folland[1], Md Khairuzzaman[1], Owen Marshall[1], Harvey E. Beere[2], David A. Ritchie[2], Subhasish Chakraborty[1]; [1]*Univ. of Manchester, UK;* [2]*Univ. of Cambridge, UK.* For the first time, we present direct experimental evidence of the presence of spatial hole burning within switchable aperiodic DFB terahertz quantum cascade lasers. This will lead towards the development of quasicontinuous tuneable terahertz lasers.

NOTES

## STu3E • Pulse Characterization and Ultrafast Imaging—Continued

**STu3E.7 • 18:00**
**Single-shot ultrafast imaging using parallax-free alignment with a tilted lenslet array,** Barmak Heshmat[1], Guy Satat[1], Christopher Barsi[1], Ramesh Raskar[1]; [1]*Media Lab, MIT, USA.* We demonstrate single-shot, two-dimensional imaging of ultrafast phenomena using a streak camera and a tilted lenslet array. We derive conditions for parallax-free imaging and experimentally verify the geometry by observing scattering of femtosecond pulses.

**STu3E.8 • 18:15**
**Time-resolved photoelectron imaging with 90-nm pump pulses,** Shunsuke Adachi[1,2], Motoki Sato[1], Yoshi-ichi Suzuki[1], Toshinori Suzuki[1,2]; [1]*Dept of chemistry, Graduate school of Science, Kyoto Univ., Japan;* [2]*Advanced Science Inst., RIKEN, Japan.* Time-resolved photoelectron imaging was performed with 90-nm pump pulses. Quantum beat by coherent excitation of multiple Rydberg states in Kr, and photodissociation of CO2 within a few ps from initially excited Rydberg state(s) were observed.

## STu3F • Technologies for High Intensity—Continued

**STu3F.6 • 18:00**
**Sub-fs precision measurement of relative x-ray arrival time for FELs,** Nick Hartmann[1,2], Wolfram Helml[1,3], Mina R. Bionta[4], Andreas Galler[5], Jan Grünert[5], Serguei Molodtsov[5,6], Kenneth R. Ferguson[1], Sebastian Schorb[1], Michele Swiggers[1], Sebastian Carron[1], Christoph Bostedt[1], Jean-Charles Castagna[1], John D. Bozek[1], James M. Glownia[1], Daniel J. Kane[7], Alan Fry[1], William E. White[1], Christoph P. Hauri[8,9], Thomas Feurer[2], Ryan N. Coffee[1]; [1]*LCLS, SLAC National Accelerator Lab, USA;* [2]*Inst. of Applied Physics, Univ. of Bern, Switzerland;* [3]*Technische Universität München, Germany;* [4]*LCAR-UMR, Universite Paul Sabatier Toulouse III-CNRS, France;* [5]*European XFEL GmbH, Germany;* [6]*Inst. of Experimental Physics, Univ. of Technology Bergakademie Freiberg, Germany;* [7]*Mesa Photonics, LLC, USA;* [8]*Paul Scherrer Inst., Switzerland;* [9]*Physics Dept, Ecole Polytechnique Federale de Lausanne, Switzerland.* We present a spectrogram-based timing technique for x-ray free electron lasers (XFELs) that reports x-ray/optical delay below 1 fs RMS error to correct for timing jitter.

**STu3F.7 • 18:15**
**Contrast enhancements to petawatt lasers using picosecond optical parametric amplification and frequency doubling,** David I. Hillier[1], Colin Danson[1], David Egan[1], Stephern Elsmere[1], Mark Girling[1], Ewan Harvey[1], Nicholas Hopps[1], Michael Norman[1], Stefan Parker[1], Paul Treadwell[1], David Winter[1], Thomas Bett[1]; [1]*Atomic Weapons Establishment, UK.* Nanosecond contrast of the Orion CPA beamlines is enhanced from 10^-8 to 10^-10 by inserting a picosecond OPA prior to the stretcher. In conjunction with frequency doubling post-compression this will increase the contrast to ~10^-18.

## STu3G • Photodetectors—Continued

## STu3H • Quantum & Nonlinear Materials & Devices—Continued

**STu3H.6 • 18:00**
**Controlling Quantum Dot Energies Using Submonolayer Bandstructure Engineering,** Lan Yu[1], Stephanie Law[1], Daehwan Jung[2], Minjoo Larry Lee[2], Dan Wasserman[1]; [1]*Electrical and Computer Engineering, Univ. of Illinois, USA;* [2]*Electrical Engineering, Yale Univ., USA.* We demonstrate control of energy states in epitaxially-grown sub-monolayer quantum dots by engineering of the internal bandstructure of the dots. We show shifts of the quantum dot ground state energy from 1.38eV to 1.68eV.

**STu3H.7 • 18:15**
**Helium ion microscope generated nitrogen-vacancy centres in type Ib diamond,** David McCloskey[1], Danny Fox[1], Neal O'Hara[1], V. Usov[1], Declan Scanlan[1], Niall McEvoy[1], Georg Duesberg[1], Graham Cross[1], Hongzhou Zhang[1], John F. Donegan[1]; [1]*School of Physics, CRANN and AMBER, Trinity College Dublin, Ireland.* We report on position and density control of nitrogen-vacancy (NV) centres created in type Ib diamond using localised exposure from a helium ion microscope and subsequent annealing. Spatial control to <380 nm has been achieved.

Tuesday, 10 June

NOTES

### Meeting Room 211 B/D

## CLEO: Science & Innovations

### STu3I • Novel Applications of Nonlinear Optics—Continued

**STu3I.7 • 18:00**
**Single-shot Coherent Raman Multiplex Planar Imaging,** Alexis Bohlin[1], Christopher Kliewer[1]; [1]*Combustion Chemistry, Sandia National Labs, USA.* We develop a coherent Raman technique for simultaneous planar imaging and multiplex spectroscopy provided in a single-laser-shot. Spatially correlated spectra from multiple species in a two-dimensional field are presented and possible gas-phase applications are discussed.

**STu3I.8 • 18:15**
**Intracavity Raman lasers at 990 nm and 976 nm based on a three-level Nd:YLF fundamental laser,** Dimitri Geskus[1], Jonas Jakutis Neto[1], Saara-Maarit Reijn[1], Helen M. Pask[2], Niklaus Wetter[1]; [1]*Centro de Lasers e Aplicações, IPEN/SP, Brazil;* [2]*MQ Photonics, Dept of Physics, Macquarie Univ., Australia.* This is the first time that significant Stokes output power of 0.88 W at 990 nm has been achieved using a three-level fundamental transition (quasi-cw Nd:YLF laser) with stimulated Raman scattering in a KGW crystal.

### Meeting Room 212 A/C

### STu3J • DSP and Coding—Continued

**STu3J.7 • 18:00**
**Optimal Signal Constellation Design for Ultra-High-Speed Optical Transport in the Presence of Phase Noise,** Tao Liu[1], Ivan B. Djordjevic[1], Ting Wang[2]; [1]*Univ. of Arizona, USA;* [2]*NEC Labs America, USA.* An optimal signal constellation design algorithm suitable for the phase noise channels is proposed, in which the cumulative log-likelihood-function is used as the optimization criterion. The signal constellations obtained by this algorithm significantly outperform conventional QAM.

**STu3J.8 • 18:15**
**On the Generalized LDPC Codes from Multiple Component Codes Suitable for High-Speed Optical Transport,** Ivan B. Djordjevic[1], Ting Wang[2]; [1]*ECE, Univ. of Arizona, USA;* [2]*Optical Networks, NEC Labs, USA.* A class of GLDPC-codes is proposed consisting of multiple local-codes suitable for code-rate-adaptation in high-speed optical-transport-networks, providing excellent coding-gains. GLDPC-decoder for proposed codes is more suitable for parallelization in FPGA/ASIC-hardware compared to LDPC-decoder.

### Meeting Room 212 B/D

## CLEO: QELS-Fundamental Science

### FTu3K • Active Plasmonic and Nanophotonic Modulators—Continued

**FTu3K.7 • 18:00**
**Compact multisection cavity switches in metal-dielectric-metal plasmonic waveguides,** Pouya Dastmalchi[1], Georgios Veronis[1]; [1]*Louisiana State Univ., USA.* We introduce a compact absorption switch consisting of a plasmonic metal-dielectric-metal waveguide coupled to a multisection cavity. The optimized multisection cavity switch leads to greatly enhanced modulation depth compared to an optimized Fabry-Perot cavity switch.

**FTu3K.8 • 18:15**
**Single-Nanoparticle Study of Switchable Exciton-Plasmon Coupling,** Mingsong Wang[1,2], Yuebing Zheng[1,2]; [1]*Mechanical Engineering, The Univ. of Texas at Austin, USA;* [2]*Materials Science and Engineering, The Univ. of Texas at Austin, USA.* We report the single-nanoparticle study of switchable exciton-plasmon coupling. The wavelength-dependent peak shifts in localized surface plasmon resonances (LSPRs) of metal nanoparticle-spiropyran hybrids depend on the combined effects of material dispersion and sensitivity of LSPRs.

### Marriott Salon I & II

## CLEO: Applications & Technology

NOTES

## Marriott
## Salon III

## CLEO: Science & Innovations

### STu3M • Microresonators—Continued

**STu3M.7 • 18:00** ▶

**An On-chip All Silicon Passive Optical Diode Based on Photonic crystal L3 Cavities,** Jinsong Xia[1], Yong Zhang[1], Danping Li[1], Zengzhi Huang[1], Jinzhong Yu[2,1], Cheng Zeng[1]; [1]*Wuhan National Lab for Optoelectronics, China;* [2]*Inst. of Semiconductors, Chinese Academy of Sciences, China.* An all-silicon passive optical diode based on cascaded photonic crystal L3 cavities is demonstrated. Nonreciprocal transmission ratio of 30.8 dB and insertion loss of 8.3 dB are realized in the device.

**STu3M.8 • 18:15** ▶

**Selective Mode Splitting in High-Q Microresonator for Dispersion Engineering,** Xiyuan Lu[1], Wei C. Jiang[1], Qiang Lin[1]; [1]*Univ. of Rochester, USA.* We demonstrate selective mode splitting (SMS) in microresonators. SMS can split one selected optical mode up to 1.25 nm with other modes unperturbed. This opens a new gate for phasematching in parametric oscillations in microresonators.

## Marriott
## Salon IV

### STu3N • Fiber Measurement and Devices—Continued

**STu3N.6 • 18:00**

**Management of slow light dispersion and delay time characteristics with SNAP bottle resonators,** Misha Sumetsky[1]; [1]*Aston Univ., UK.* The nanoscale radius variation of a bottle microresonator with the required dispersion characteristics is determined theoretically. Experimentally, a microresonator with the footprint 0.08 mm$^2$ exhibiting 20 ns/nm dispersion compensation of 100 ps pulses is demonstrated.

**STu3N.7 • 18:15**

**High-fidelity optical buffer based on temporal cavity solitons,** Jae K. Jang[1], Miro J. Erkintalo[1], Jochen Schroeder[2], Benjamin J. Eggleton[2], Stuart G. Murdoch[1], Stephane Coen[1]; [1]*Univ. of Auckland, New Zealand;* [2]*Univ. of Sydney, Australia.* We demonstrate an all-optical data buffer implemented using temporal cavity solitons in a fiber ring. The ring can hold 4736 bits, encoded as cavity solitons, at 10 Gb/s for over one minute with 100% fidelity.

## Marriott
## Salon V & VI

### STu3O • Symposium on Microcavity Exciton-Polaritons, Devices and Applications II—Continued

**STu3O.5 • 18:00** ▶

**Nonlinear interactions in an organic polariton condensate,** Konstantinos Daskalakis[1], Stefan Maier[1], Ray Murray[1], Stéphane Kéna-Cohen[1,2]; [1]*Dept of Physics and Centre for Plastic Electronics, Imperial College London, UK;* [2]*Dept of Engineering Physics, École Polytechnique de Montréal, Canada.* We demonstrate an organic polariton condensate that exhibits nonlinear interactions at room-temperature. Upon reaching threshold, we observe a superlinear power dependence, a power-dependent blueshift and the emergence of long-range spatial coherence resulting from polariton interactions.

**STu3O.6 • 18:15** ▶

**Room Temperature Bloch Surface Wave Polaritons,** Stefano Pirotta[1], Maddalena Patrini[1], Marco Liscidini[1], Matteo Galli[1], Giacomo Dacarro[1], Giancarlo Canazza[2], Giorgio Guizzetti[1], Davide Comoretto[2], Daniele Bajoni[3]; [1]*Physics, Università degli Studi di Pavia, Italy;* [2]*Chemistry, Università degli Studi di Genova, Italy;* [3]*Engineering, Università degli Studi di Pavia, Italy.* We demonstrate strong coupling between Bloch surface waves in a Ta2O5/SiO2 multilayer and J-aggregate excitons. The measured Rabi splitting is 290 meV. The mode dispersion curves are investigated by means of attenuated-total-reflection and photoluminescence experiments.

## Marriott
## Willow Glen I-III

## CLEO: Applications & Technology

### ATu3P • Symposium on Novel Light Sources and Photonic Devices in Optical Imaging II—Continued

**ATu3P.5 • 18:00** ▶

**Narrowband Guided Fano Resonators for Mid-Infrared Spectroscopy and Imaging,** Jui-Nung Liu[1], Matthew V. Schulmerich[1], Rohit Bhargava[1], Brian T. Cunningham[1]; [1]*Univ. of Illinois at Urbana-Champaign, USA.* We report the demonstration of an array of high-performance one-layer narrowband mid-IR guided Fano resonators (GFRs) in the C-H stretching region (2700-3200 cm-1) for high-quality microspectroscopic mid-IR imaging.

**ATu3P.6 • 18:15** ▶

**Optical time-stretch microscopy using Bessel spectral shower illumination,** Yiqing Xu[1], Xiaoming Wei[1], Antony C. Chan[1], Edmund Y. Lam[1], Kenneth Wong[1], Kevin Tsia[1]; [1]*Dept of Electrical and Electronic Engineering, The Univ. of Hong Kong, Hong Kong.* We experimentally demonstrate optical time-stretch microscopy with one dimensional Bessel spectral shower illumination for ultrafast extended depth-of-field imaging at a single-shot scan rate of 26.3 MHz.

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## 18:30–20:30
## JTu4A • Poster Session 1

**JTu4A.1**
**Studying Momentum Distributions in all Aspects Reveals Important Insight,** Cornelia Hofmann[1], Alexandra S. Landsman[1], Robert Boge[1], Sebastian Heuser[1], Claudio Cirelli[1], Matthias Weger[1], André Ludwig[1], Jochen Maurer[1], Lukas Gallmann[1,2], Ursula Keller[1]; *[1]Physics Dept, ETH Zurich, Switzerland; [2]Inst. of Applied Physics, Univ. of Bern, Switzerland.* Strong field ionization momentum distribution contains much information. The angular distribution indicates real tunneling delay time, the center shows ellipticity dependent Coulomb effects, and the longitudinal momentum spread challenges the assumption of zero initial momentum.

**JTu4A.2**
**An improved attosecond-pulse characterization based on the FROG-CRAB technique,** Siddharth Bhardwaj[1], Phillip D. Keathley[1], Jeffrey Moses[1], Guillaume Laurent[1], Franz Kärtner[1,2]; *[1]Dept of Electrical Engineering and Computer Science, MIT, USA; [2]Center for Free Electron Laser, Deutsches Elektronen-Synchrotron, Germany.* The FROG-CRAB method was improved to account for the photoionization process, significantly improving its accuracy for low-photon-energy EUV pulses. A method for accounting for the photoionization step while using the conventional retrieval algorithm was also demonstrated.

**JTu4A.3**
**Carrier-envelope phase stabilization via acoustic frequency combs,** Fabian Lücking[1], Bastian Borchers[2], Gunter Steinmeyer[2]; *[1]Femtolasers Produktions GmbH, Austria; [2]Max Born Inst. for Nonlinear Optics, Germany.* We demonstrate a novel scheme for improved feed-forward CEP stabilization of laser amplifiers. Synthesized acoustic few-cycle transients are used to stabilize the CEP of an optical pulse train at the amplifier repetition rate.

**JTu4A.4**
**Anomalous light bending with high efficiency by plasmonic phase-discontinuous air-slit array,** Cheng-Hsuin Lin[1], Br-Shu Wu[1], Chen-Bin Huang[1]; *[1]National Tsing Hua Univ., Taiwan.* V-shaped air slits inscribed in a metallic thin film is used to achieve cross-polarized anomalous refraction with high efficiency. The experimental refraction angles are in excellent agreements with theoretical values.

**JTu4A.5**
**A Novel Hybrid Plasmonic Rod-dimer/Ring Nanostructure for Sensing and Trapping,** Jia Yu Lin[1], Chia-Yang Tsai[1], Pin-Tso Lin[1], Tse-En Hsu[1], Po-Tsung Lee[1]; *[1]National Chiao Tung Univ., Taiwan.* We propose and investigate a novel hybrid plasmonic rod-dimer/ring (RDR) nanostructure with significantly enhanced near-field at the gap region for its potential on sensing and trapping applications.

**JTu4A.6**
**Chip-Integrated Plasmon-Induced Transparency via Plasmonic Waveguides Side-coupled of a Single Composite Nanocavity,** zhen chai[1,2]; *[1]Dept of Physics, Peking Univ., China; [2]State Key Lab for Mesoscopic Physics, Peking Univ., China.* We experimentally reported a chip-integrated plasmon-induced transparency (PIT) by a planar plasmonic composite nanocavity. A shift of 490 nm of the transparency window and dual PIT like effect are achieved through coating the PMMA layer.

**JTu4A.7**
**Single Nanoparticle Detection and Sizing by Using a Nanoscale Optical Fiber,** Xiao-Chong Yu[1], Bei-Bei Li[1], Pan Wang[2], Limin Tong[2], Qihuang Gong[1], Yun-Feng Xiao[1]; *[1]Peking Univ., China; [2]Zhejiang Univ., China.* We demonstrate the detection and sizing of single nanoparticles in aqueous environment by real-time monitoring the step changes in the nanofiber transmission.

**JTu4A.8**
**Nano-patterning based on Two-Surface-Plasmon-Polariton-Absorption using 400nm Femtosecond Laser,** yunxiang Li[1], Fang Liu[1], Weisi Meng[1], Yidong Huang[1]; *[1]Electronic Engineering, Tsinghua Univ., China.* Nano-patterning with linewidth of ~55 nm is demonstrated utilizing two-surface-plasmon-polariton-absorption (TSPPA) at the wavelength of 400 nm. The SPP field generated by plasmonic mircolens is recorded by the TSPPA showing a new way for recording the SPP field in micro/nano structures.

**JTu4A.9**
**Low-Temperature Raman G-mode of Plasmonic-Graphene Hybrid Platform,** Long Xiao[1], Fang Liu[1], Yidong Huang[1]; *[1]Dept of Electronic Engineering, Tsinghua Univ., China.* The unusual properties of Raman G-mode of plasmonic-graphene hybrid platform has been studied at varying temperatures, which provides important evidences to understand the optoelectronic characteristics of the hybrid platform.

**JTu4A.10**
**Topological Shaping of Light using Vortex Transmutation,** Nan Gao[1], Lina Shi[1], Changqing Xie[1]; *[1]Key Lab of Nano-Fabrication and Novel Devices Integrated Technology, Inst. of Microelectronics, Chinese Academy of Sciences, China.* We show that vortex transmutation prevents the generation of high order central vortices in the topological shaping of light with nanoslits, and propose a solution to this problem utilizing the modular transmutation rule.

**JTu4A.11**
**Super resolution phase-contrast imaging of transparent nano-objects by a plasmonic lens,** Xiangang Luo[1]; *[1]CAS Inst. of Optics and Electronics, China.* We propose a specially designed plasmonic lens for imaging transparent nano objects with small refraction index difference from surrounding medium. The spatial resolution down to 64 nm and minimum distinguishable refraction index difference down to 0.05 are numerically demonstrated.

**JTu4A.12**
**Fabrication and Characterization of Template-Stripped Plasmonic Substrates for High-Resolution Chemical Imaging,** Sarah Elliott[1], Mark Turner[1], Isabel Rich[1], Nathan Lindquist[1]; *[1]Physics Dept, Bethel Univ., USA.* Template-stripped plasmonic nanoholes are used as high-resolution chemical imaging substrates via surface-enhanced Raman spectroscopy. Chemical patterns created with microcontact printing show these surfaces to provide large and uniform enhancements suitable for imaging.

**JTu4A.13**
**Quantized surface-plasmon-polariton excitation and propagation on graphene,** George Hanson[1], Changhyoup Lee[2], Dimitris Angelakis[2], Mark Tame[3]; *[1]Electrical Engineering, Univ. of Wisconsin Milwaukee, USA; [2]Centre for Quantum Technologies, National Univ. of Singapore, Singapore; [3]School of Chemistry and Physics, Univ. of KwaZulu-Natal, South Africa.* A quantum-mechanical description of the excitation of surface-plasmon polaritons (SPPs) on graphene is presented, as well as photon to quantized SPP state transfer and decoherence. The tunability of graphene allows for the control of quantized SPPs.

**JTu4A.14**
**Experiments on Cascaded Quadratic Soliton Compression in Unpoled LN Waveguide,** Hairun Guo[1], Binbin Zhou[1], Xianglong Zeng[2], Morten Bache[1]; *[1]Dept of Photonics Engineering, Technical Univ. of Denmark, Denmark; [2]Key Lab of Special Fiber Optics and Optical Access Networks, Shanghai Univ., China.* Experiments on cascaded quadratic soliton compression in unpoled phase-mismatched lithium niobate waveguides are presented. Pulse self-phase modulation dominated by an overall self-defocusing nonlinearity is observed, with an variation of pump wavelength and waveguide core width.

**JTu4A.15**
**Generation and Propagation of Optical Accelerating Regular Triple-Cusp Beams,** Zhijun Ren[1,2], Ping Yu[2]; *[1]Key Lab of Optical Information Detecting and Display Technology, Zhejiang Normal Univ., China; [2]Dept of Physics and Astronomy, Univ. of Missouri, USA.* Optical accelerating triple-cusp beams are generated by imposing a phase grey-scale map on a phase modulation element. We give the mechanism of controlling ballistic trajectory of main lobes of regular triple-cusp beams.

**JTu4A.16**
**Femtosecond Supercontinuum Generation in a Silicon Wire Waveguide at Telecom Wavelengths,** François Leo[1,2], Simon-Pierre Gorza[3], Jassem Safioui[3], Pascal Kockaert[3], Stephane Coen[4], Utsav Dave[1,2], Bart Kuyken[1,2], Gunther Roelkens[1,2]; *[1]Photonics Research Group, Dept of Information Technology, Ghent Univ., Belgium; [2]Center for Nano- and biophotonics (NB-photonics), Ghent Univ., Belgium; [3]OPERA-Photonique, Universite Libre de Bruxelles, Belgium; [4]Physics Dept, Univ. of Auckland, New Zealand.* We demonstrate femtosecond supercontinuum generation in a silicon waveguide. Despite the strong nonlinear absorption inherent to silicon at telecom wavelengths, we experimentally demonstrate that the compression and subsequent splitting of higher order solitons remains possible.

**JTu4A.17**
**Coherent control of Snell's law,** Jin-hui Shi[1,2], Xu Fang[2], Nikolay I. Zheludev[2,3]; *[1]Harbin Engineering Univ., China; [2]Univ. of Southampton, UK; [3]Nanyang Technological Univ., Singapore.* We demonstrate coherent control of the generalized Snell's law in ultrathin gradient metasurfaces constructed by an array of V-shaped slot nanoantennas.

**JTu4A.18**
**Measurement of Nonlinear Refraction Dynamics of $CS_2$,** Matthew Reichert[1], Honghua Hu[1], Manuel R. Ferdinandus[1], Marcus Seidel[1], Peng Zhao[1], Jennifer M. Reed[1], Dmitry A. Fishman[1], Scott Webster[1], David J. Hagan[1], Eric W. Van Stryland[1]; *[1]CREOL, The College of Optics and Photonics, Univ. of Central Florida, USA.* Nonlinear refractive dynamics of $CS_2$ are measured with the beam deflection technique. A response function model is fit, from which the pulse width dependent $n_{2,eff}$ is calculated and compared to Z-scan measurements.

**JTu4A.19**
**Enhanced random lasing emission under plasma atmosphere in Nd3+ doped (Pb,La)(Zr,Ti)O3 disordered ceramics,** Long Xu[1], Jingwen Zhang[1], Hua Zhao[1], Yi Zhang[2]; *[1]Dept of Physics, Harbin Inst. of Technology, China; [2]Science and Technology on Special System Simulation Lab, Beijing Simulation Center, China.* Great enhancement of random lasing emission in Nd3+ doped (Pb,La)(Zr,Ti)O3 ceramics were investigated upon exposing to plasma atmosphere. The diffusion of light, optical energy storage and increased scatterers play vital roles in the experimental results.

**JTu4A.20**
**Pump-probe study of plasma generated with linear and circularly polarized filaments in nitrogen,** Amin rasoulof[1], Brian Kamer[1], Jean-Claude M. Diels[1], Ladan Arissian[1]; *[1]Center for high technology materials, Univ. of New Mexico, USA.* We study the dynamics of the plasma generated with 800nm filaments of 60fs in a pump-probe system in nitrogen cell. We see the effect of molecular revival and plasma dynamics on beam profile and spectrum.

## JTu4A • Poster Session 1—Continued

**JTu4A.21**
**Imaging the structure of van der Waals Complexes with Laser-driven Coulomb Explosion,** Chengyin Wu[1]; [1]*Dept of Physics, Peking Univ., China*. Geometric structures of some van der Waals Complexes were determined by precisely measuring three-dimensional momentum vectors of correlated atomic ions produced in the laser-driven Coulomb explosion of these van der Waals complexes.

**JTu4A.22**
**Anomalous transient amplification in lossy waveguides,** Konstantinos Makris[1], Li Ge[2,1], Hakan E. Tureci[1]; [1]*Princeton Univ., USA;* [2]*College of Staten Island, CUNY, USA.* In a medium that is on average lossy, we show that under appropriate initial conditions the power can be amplified by several orders of magnitude. This robust phenomenon can be quantitatively explained by pseudospectra analysis.

**JTu4A.23**
**Interaction of Flying Electromagnetic Doughnut with Nanostructures,** Tim Raybould[1], Nikitas Papasimakis[1], Vassili A. Fedotov[1], Ian J. Youngs[3], Nikolay I. Zheludev[1,2]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK;* [2]*Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore;* [3]*DSTL, UK.* We report on the electromagnetic properties of the single-cycle "flying doughnut" electromagnetic permutations in the context of their interactions with nanoscale objects, such as dielectric and plasmonic nanoparticles.

**JTu4A.24**
**Octave-Spanning Mid-IR Supercontinuum Generation with Ultrafast Cascaded Nonlinearities,** Binbin Zhou[1], Hairun Guo[1], Xing Liu[1], Morten Bache[1]; [1]*Danmarks Tekniske Universitet, Denmark.* An octave-spanning mid-IR supercontinuum is observed experimentally using ultrafast cascaded nonlinearities in an LiInS2 quadratic nonlinear crystal pumped with 70 fs energetic mid-IR pulses and cut for strongly phase-mismatched second-harmonic generation.

**JTu4A.25**
**Relation Between Interband Dipole and Momentum Matrix Elements in Semiconductors,** Baijie Gu[1], Nai H. Kwong[1], Rolf Binder[1]; [1]*Univ. of Arizona, USA.* The relation between dipole and momentum matrix elements in crystals, treated with periodic boundary conditions, is revisited. A correction term to standard expressions is found to be large for bulk GaAs, small for THz transitions.

**JTu4A.26**
**Quantum coherence in bulk GaAs studied by interference between electron-phonon coupled states,** Kazutaka Nakamura[1,2], Shingo Hayashi[1,2], Keigo Kato[1,2], Katsura Norimatsu[1,2], Yosuke Kayanuma[1,2]; [1]*Tohoku Inst. of Technology, Japan;* [2]*CREST-JST, Japan.* Both electronic and phonon coherence in bulk GaAs is studied using an interference experiment of electron-phonon coupled states induced by two phase-locked femtosecond pulses. Full coherence remains within ~ 45 fs at room temperature.

**JTu4A.27**
**High Spatial Resolution Manipulation of the Nitrogen Vacancy Center Charge State in Diamond,** Xiangdong Chen[1], Fang-Wen Sun[1], Chang-Ling Zou[1]; [1]*Univ. of Science and Technology of, China.* We showed the high resolution charge state manipulation of NV center with optical method. The result was used to detect the spin state dynamics of NV- with sub wavelength spatial resolution.

**JTu4A.28**
**Spectral Diffusion of Excitons in Disordered GaAs Quantum Wells,** Rohan Singh[1,2], Galan Moody[3], Mark E. Siemens[4], Hebin Li[5], Steven T. Cundiff[1,2]; [1]*JILA, Univ. of Colorado/NIST, USA;* [2]*Physics, Univ. of Colorado, USA;* [3]*National Inst. of Standards and Technology, USA;* [4]*Physics and Astronomy, Univ. of Denver, USA;* [5]*Physics, Florida International Univ., USA.* We have studied spectral diffusion of excitons in GaAs quantum wells using two-dimensional coherent spectroscopy. Localized and delocalized excitons exhibit distinct spectral diffusion characteristics. These results cannot be explained in the strong redistribution approximation.

**JTu4A.29**
**Generic Diffusion of Phase Singularities,** Xiaojun Cheng[1,2], Yitzchak Lockerman[1], Azriel Z. Genack[1,2]; [1]*CUNY Queens College, USA;* [2]*Graduate Center, City Univ. of New York, USA.* We find generic diffusion of phase singularities in microwave speckle patterns as the frequency is scanned and in numerical simulations in the time domain. These results give the photon diffusion coefficient through the random medium.

**JTu4A.30**
**Ultralow-power all-optical tunable dual Fano resonances in nonlinear metamaterials,** Fan Zhang[1,2]; [1]*Peking Univ., China;* [2]*Physical college, Peking Univ., China.* Dual Fano resonances are realized in a nonlinear photonic metamaterial consisting of periodicarrays of asymmetrical meta-molecules etched in a gold film coated with azobenzene polymerlayer and a large tunability is maintained simultaneously.

**JTu4A.31**
**Time-resolved Imaging of Propagation of THz Wave in SRR Metamaterials,** Bin Zhang[1], Qiang Wu[1], Shibiao Wang[1], Ming Yang[1], Yiping Zuo[1], Jingjun Xu[1]; [1]*Nankai Univ., China.* We studied the time-resolved imaging of THz wave propagating in the double-split-ring resonator (SRR) metamaterial fabricated on LiNbO3 substrate. Distinct swerving wave-front behavior of THz wave has been observed when it interacts with SRR by phase contrast imaging method.

**JTu4A.32**
**Ultralow-power and ultrafast all-optical tunable PIT in metamaterials at optical communication range,** Zhu Yu[1,2]; [1]*shcool of physics, PeKing Univ., China;* [2]*State Key Lab for Mesoscopic Physics, China.* ultralow-power and ultrafast all-optical tunable plasmon-induced transparency have been realized in metamaterials coated on polycrystalline indium-tin oxide layer at the optical communication range.

**JTu4A.33**
**Broadband Epsilon-Near-Zero Metamaterials with Step-like Metal-Dielectric Multilayer Structures with Gain Media,** Lei Sun[1], Xiaodong Yang[1], Jie Gao[1]; [1]*Dept of Mechanical and Aerospace Engineering, Missouri Univ. of Science and Technology, USA.* The broadband epsilon-near-zero metamaterials consisting of step-like metal-dielectric multilayer structures with gain media is proposed. Low-loss functional optical devices including prisms for broadband directional emission and S-shaped lenses for phase front shaping are demonstrated.

**JTu4A.34**
**Metasurface-on-Fiber enabled Orbital Angular Momentum Modes in Conventional Optical Fibers,** Xi Wang[1], Jinwei Zeng[1], Jingbo Sun[1], Vahid Foroughi Nezhad[1], Alexander N. Cartwright[1], Natalia M. Litchinitser[1]; [1]*Electrical Engineering, Univ. at Buffalo, The State Univ. of New York, USA.* We demonstrate generation and propagation of an optical vortex using a metasurface fabricated directly on a cross-section of a few-mode optical fiber at visible wavelengths. The experimental results are in good agreement with numerical simulations.

**JTu4A.35**
**Four-Photon Joint Spectral Probability Distribution of a High Spectral-Purity Photon Source,** Thomas Gerrits[1], Francesco Marsili[2], Matthew D. Shaw[2], Tim J. Bartley[3], Sae Woo Nam[1]; [1]*NIST, USA;* [2]*Jet Propulsion Lab, USA;* [3]*Univ. of Oxford, UK.* We show that the first Schmidt mode of double pair emission equals the square of the first single pair emission Schmidt mode from a spectrally factorizable type-II parametric downconversion process.

**JTu4A.36**
**High-Order Single-Photon W-states for Random Number Generation,** Markus Graefe[1], René Heilmann[1], Armando Perez-Leija[1], Robert Keil[1], Felix Dreisow[1], Matthias Heinrich[2], Stefan Nolte[1], Demetrios N. Christodoulides[2], Alexander Szameit[1]; [1]*Inst. of Applied Physics, Abbe Center of Photonics, Friedrich-Schiller-Univ., Germany;* [2]*REOL, The College of Optics & Photonics, Univ. of Central Florida, USA.* We experimentally realize the generation of high-order photon encoded W-states involving up to 16 optical modes. Furthermore, we exploit the inherent probabilistic properties of these multipartite entangled W-states for generating genuine random numbers.

**JTu4A.37**
**Active Stabilization and Continuous Phase Control of Time-bin Entanglement Interferometers,** Paul Toliver[1], James M. Dailey[1], Anjali Agarwal[1], Nicholas A. Peters[2]; [1]*Applied Communication Sciences, USA;* [2]*Applied Communication Sciences, USA.* We introduce a technique for stabilizing and enabling continuous phase control of fiber-based time-bin entanglement interferometers. This technique reuses the pair creation pump, which coexists with and co-propagates with the entangled photons.

**JTu4A.38**
**Single-photon source based on NV center in nanodiamond coupled to TiN-based hyperbolic metamaterial,** Mikhail Y. Shalaginov[1,2], Vadim Vorobyov[3,4], Jing Liu[1,2], Marcello Ferrera[1,7], Alexey Akimov[4,6], Alexei Lagutchev[2], Andrey N. Smolyaninov[3], Vasiliy V. Klimov[3,8], Joseph Irudayaraj[5], Alexander Kildishev[1,2], Alexandra Boltasseva[1,2], Vladimir M. Shalaev[1,2]; [1]*School of Electrical and Computer Engineering, Purdue Univ., USA;* [2]*Birck Nanotechnology Center, Purdue Univ., USA;* [3]*Photonic Nano-Meta Technologies, Russia;* [4]*Moscow Inst. of Physics and Technology, Russia;* [5]*Agricultural and Biological Engineering, Purdue Univ., USA;* [6]*Russian Quantum Center, Russia;* [7]*School of Engineering and Physical Sciences, Heriot-Watt Univ., UK;* [8]*Lebedev Physical Inst. RAS, Russia.* We experimentally demonstrate both the lifetime reduction and the enhancement of single-photon emission from nitrogen-vacancies in nanodiamonds coupled to a TiN/Al0.6Sc0.4N superlattice. Our results pave the way towards future CMOS-compatible integrated quantum sources.

**JTu4A.39**
**Phase-controlled heralding of photon-number entangled states,** Young-Sik Ra[1], Hyang-Tag Lim[1], JOO-EON OH[1], Yoon-Ho Kim[1]; [1]*Physics, Pohang Univ. of Science and Technology, Republic of Korea.* We report the generation of a photon-number entangled state in which detection of ancillary photons heralds the generation of the entangled state as well as its phase. Our scheme can operate with separable input states.

**JTu4A.40**
**Optimal Quantum Control by Composite Pulses,** Elica Kyoseva[1,2], Nikolay Vitanov[3]; [1]*Engineering Product Development, Singapore Univ. of Technology and Design, Singapore;* [2]*Dept of Nuclear Science and Engineering, MIT, USA;* [3]*Dept of Physics, Sofia Univ., Bulgaria.* We present a novel design of high-fidelity composite pulse sequences for dynamical suppression of amplitude noise with applications to NMR and QIP. We derive exact analytic formulas for the composite phases.

**JTu4A.41**
**Experimental generation of triple quantum correlated beams from cascaded four-wave mixing processes,** Jietai Jing[1], Zhongzhong Qin[1], Leiming Cao[1], Hailong Wang[1], Alberto Marino[2], Weiping Zhang[1]; [1]*East China Normal Univ., China;* [2]*The Univ. of Oklahoma, USA.* We report on our recent experimental results of generating triple quantum correlated beams by using cascaded four-wave mixing processes in hot rubidium vapor. The intensity-difference noise power of the triple beams is 6.5±0.3 dB below the shot noise level (SNL).

## JTu4A • Poster Session 1—Continued

**JTu4A.42**
**Optimized Microwave Near-Field Control in a Planar Ion Trap,** Martina Carsjens[1,2], Matthias Kohnen[1,2], Timko Dubielzig[2], Christian Ospelkaus[2,1]; *[1]Physikalisch-Technische Bundesanstalt, Germany; [2]Institut für Quantenoptik, Leibniz Universität Hannover, Germany.* We describe a microfabricated planar ion trap with integrated microwave conductors. Using numerical simulations, it has been optimized for multi-qubit operations driven by microwave near-fields and represents a considerable experimental simplification.

**JTu4A.43**
**Demonstration of a Characterisation Protocol for Two-qubit Hamiltonians on a Photonic Quantum Simulator,** Alex Nevile[1], Simon Devitt[2], Alberto Peruzzo[3], Jeremy L. O'Brien[1], Pete Shadbolt[1], Laura Thackray[1]; *[1]Univ. of Bristol, UK; [2]National Inst. of Informatics, Japan; [3]Univ. of Sydney, Australia.* We demonstrate an entanglement mapping based characterisation protocol for coupled-qubit Hamiltonians. This is achieved by generating and measuring time-evolved states relevant to an NV-diamond system, using a reconfigurable integrated optical device.

**JTu4A.44**
**The Rydberg-assisted Light-shift Blockade for Ensemble Quantum Computing,** May Kim[1], Yanfei Tu[2], Selim M. Shahriar[2,1]; *[1]Physics and Astronomy, Northwestern Univ., USA; [2]Electrical Engineering and Computer Science, Northwestern Univ., USA.* We show, with numerical verification, how an ensemble of Rubidium atoms can be made to behave like a single particle with only two energy levels, i.e., a quantum bit, by using Rydberg-interaction assisted light-shift blockade.

**JTu4A.45**
**Observation of phase memory in higher-order interference in atomic vapor cells by Raman process,** Liqing Chen[1], Kai Zhang[1], Zhe-Yu Jeff Ou[1,2], Weiping Zhang[1]; *[1]Quantum Inst. for Light and Atoms, Dept of Physics, East China Normal Univ., China; [2]Dept of Physics, Indiana Univ.-Purdue Univ. Indianapolis, USA.* We demonstrate experimentally and theoretically controlled storage and retrieval of the optical phase information. This scheme is a kind of new random phase encoding with 2nd order holographic storage.

**JTu4A.46**
**Optical Nonlinearities Using Tapered Optical Fibers in Rubidium Vapor,** Daniel E. Jones[1], James D. Franson[1], Todd B. Pittman[1]; *[1]Physics, Univ. of Maryland Baltimore County, USA.* Sub-wavelength diameter tapered optical fibers suspended in rubidium vapor can allow ultralow-power nonlinearities that may have applications in photonic quantum information processing. Here we experimentally investigate saturation of the relevant atomic transitions with ultralow-power fields.

**JTu4A.47**
**Phosphor-saving, Excellent Color-Rendering Index Candlelight LEDs Containing Composite Photonic Crystals,** Chun-Feng Lai[1], Chia-Jung Wu[1]; *[1]Dept of Photonics, Feng Chia Univ., Taiwan.* In this study, a technique that saved phosphor use was applied to warm white light-emitting diodes containing 3D photonic crystals to develop the candlelight that exhibits a high luminous flux and an excellent color-rendering index.

**JTu4A.48**
**Low Efficiency Droop Green Nano-Pyramid {10 -11} InGaN/GaN Multiple Quantum Well LED,** Yuh-Jen Cheng[1,2], Shih-Pang Chang[2,3], Da-Wei Lin[2], Hao-chung Kuo[2], Kang-lin Xiong[3]; *[1]Research Center for Applied Sciences, Academia Sinica, Taiwan; [2]Dept of Electro-Optical Engineering, National Chiao Tung Univ., Taiwan; [3]Yale Univ., USA.* We report a low efficiency droop 520 nm green nano-pyramid InGaN/GaN multiple quantum well (MQW) LED. MQWs were grown on the semipolar {10 1} nano-pyramid facets. The device physics will be discussed in details.

**JTu4A.49**
**Third Harmonic Frequency Stabilization to Acetylene Saturated Absorption in a Hollow-core Photonic Crystal Fiber,** Liang-Yu Wei[1], Che-Chung Chou[1]; *[1]Feng Chia Univ., Taiwan.* We demonstrated a hollow-core photonic crystal fiber as an absorption cell to observe the third harmonic derivative signal for laser frequency stabilization to P(9) line of the acetylene v1+ v3 overtone band.

**JTu4A.50**
**RLS Filter-Based Interrogation of Fiber-Optic Extrinsic Fabry-Perot Interferometry Sensors,** Daniele Tosi[1], Sven Poeggel[1], Gabriel Leen[1], Elfed Lewis[1]; *[1]Optical Fibre Sensors Research Centre, Univ. of Limerick, Ireland.* A technique for interrogation of fiber-optic extrinsic Fabry-Perot interferometry sensors, based on adaptive filtering, is reported. This approach achieves 9.6 pm accuracy on Fabry-Perot cavity length (equivalent to 0.045 mmHg pressure) and improved noise resilience.

**JTu4A.51**
**Measurement of Sub-pulse-width Temporal Delays Via Spectral Interference Induced by Weak Value Amplification,** Luis Jose Salazar Serrano[1,2], Davide Janner[1], Nicolas Brunner[3,4], Valerio Pruneri[1,5], Juan P. Torres[1,6]; *[1]ICFO -The Inst. of Photonic Sciences, Spain; [2]Physics Dept, Universidad de los Andes, Colombia; [3]Departement de Physique Theorique, Universite de Genève, Switzerland; [4]H.H. Wills Physics Lab, Univ. of Bristol, UK; [5]ICREA-Institució Catalana de Recerca i Estudis Avançats, Spain; [6]Dept. of Signal Theory and Communications, Universitat Politècnica de Catalunya, Spain.* We present experimental results of a scheme based on the concepts of weak measurements and weak value amplification to measure temporal delays, much smaller than the pulse width, by means of spectral interference.

**JTu4A.52**
**Transmitter for multispecies DIAL sensing of atmospheric water vapor, methane and carbon dioxide in the 2 μm range,** Jessica Barrientos Barria[1], Jean-Baptiste Dherbecourt[1], Myriam Raybaut[1], Domi,ique Mammez[2], Antoine Godard[1], Jean-Michel Melkonian[1], Jacques Pelon[3], Michel Lefebvre[1]; *[1]ONERA, France; [2]CNES, France; [3]Latmos, France.* We describe a tunable transmitter - based on an amplified nanosecond single-frequency optical parametric oscillator - for multi-species monitoring of green-house gases by integrated path DIAL on the CO2-2.05μm, H2O-2.06μm, CH4-2.29 μm absorption lines.

**JTu4A.53**
**Dynamic Displacement Measurement System with Auto Calibration Using Deeply-Phase Modulated Light,** Yosuke Tanaka[1], Naoyuki Miyata[1], Takamasa Ito[1], Takashi Kurokawa[1]; *[1]Tokyo Univ. of Agriculture and Technology, Japan.* We demonstrate dynamic displacement measurement with phase-modulated light. Auto calibration using deep phase modulation makes the measurement independent of driving conditions of the modulator. Displacement of several tens nm for more-than-1-MHz vibration is successfully measured.

**JTu4A.54**
**Mid-infrared Disordered Photonic Crystal Lasers,** Houkun Liang[1], Guozhen Liang[2], Bo Meng[2], Yong Quan Zeng[2], Qijie Wang[2,3], Ying Zhang[1]; *[1]Singapore Inst. of Manufacturing Technology, Singapore; [2]School of Electrical and Electronic Engineering, Nanyang Technological Univ., Singapore; [3]CDPT, Centre for Disruptive Photonic Technology, School of Physical and Mathematical Sciences, Nanyang Technological Univ., Singapore.* Electrically-pumped disordered photonic-crystal lasers in the mid-infrared regime at λ~ 10 μm have been demonstrated for the first time based on quantum cascade lasers. Both the extended and highly-localized lasing modes are generated by adjusting the degree of disorder.

**JTu4A.55**
**Dynamic Strain Measurement at Arbitrary Multiple Points along a Fiber with 500Hz High-Speed Random Accessibility of Brillouin Optical Correlation Domain Analysis,** Chunyu Zhang[1], Masato Kshi[1], Kazuo Hotate[1]; *[1]the Univ. of tokyo, Japan.* In this paper, we demonstrate dynamic strain measurement at arbitrary points by a basic BOCDA system with 500 points/s random access speed. This is the highest speed of the random accessibility reported so far.

**JTu4A.56**
**Optical Quilt Packaging: A New Chip-to-Chip Optical Coupling and Alignment Process for Modular Sensors,** Tahsin Ahmed[1], Aamir A. Khan[1], Genevieve Vigil[1], Jason M. Kulick[2], Gary H. Bernstein[1], Anthony J. Hoffman[1], Scott S. Howard[1]; *[1]Dept of Electrical Engineering, Univ. of Notre Dame, USA; [2]Indiana Integrated Circuits, USA.* A wide-bandwidth, highly efficient method of inter-chip waveguide coupling suitable for on-chip, mid-infrared sensing is discussed. Simulations and preliminary fabrication work on laser-to-waveguide coupling are presented, with losses predicted to be better than 6 dB.

**JTu4A.57**
**A Remote-free Self-feedback Colorless FPLD with FBG Based Single-mode Filter for Multi-channel 2.5 Gbit/s DWDM-PON,** Yu-Chuan Su[1], Yu-Chieh Chi[1], Gong-Ru Lin[1]; *[1]Graduate Inst. of Photonics and Optoelectronics, Dept of Electrical Engineering, National Taiwan Univ., Taiwan.* Remote-free and low Rayleigh-backscattering OOK transmission with a colorless FPLD using FBG reflector based single-mode self-injection-locker is achieved at 2.5 Gbit/s over 25-km SMF in DWDM-PON with receiving power of -29.5 dBm at BER=$10^{-9}$.

**JTu4A.58**
**Performance Demonstration of a Burst-Mode EDFA for Packetized Radio-over-Fiber Signal Transmission,** Masaki Shiraiwa[1], Atsushi Kanno[1], Yoshinari Awaji[1], Naoya Wada[1], Tetsuya Kawanishi[1]; *[1]National Inst. of Information and Communications Technology, Japan.* We investigated the performance of a burst-mode erbium-doped fiber amplifier for packetized radio-over-fiber signals. Low error vector magnitude values were observed over a wide optical power range.

**JTu4A.59**
**Ring-tree TWDM Optical Access Network with Dynamic Wavelength and Bandwidth Allocation,** Xintian Hu[1], Xue Chen[1], Zhiguo Zhang[1], Liqian Wang[1], Chen He[1], Jinsong Bei[2]; *[1]State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China; [2]ZTE Corporation, China.* A novel ring-tree TWDM optical access network architecture using matrix optical switch and OEO wavelength converter is proposed. The architecture owns flexible on-demand wavelength and timeslot provision, OLT energy saving ability and backward compatibility.

**JTu4A.60**
**100-Gb/s All-Optical Wavelength-Preserved 2R Regeneration Using Semiconductor Optical Amplifiers,** Qiang Wang[1], Li Huo[1], Xin Chen[1], Caiyun Lou[1], Bingkun Zhou[1]; *[1]Tsinghua Univ., China.* All-optical wavelength-preserved 2R regeneration with simultaneous wavelength conversion of 100-Gb/s OOK signal is experimentally demonstrated based on cross-gain compression in SOAs. Receiving sensitivity is improved by more than 1.7 dB in the regenerated signal.

## JTu4A • Poster Session 1—Continued

**JTu4A.61**
**Experimental investigation of correlation between multiple side lobes of modulation instability in dispersion oscillating fiber,** Xie Wang[1,2], Damien Bigourd[1], Alexandre Kudlinski[1], Kenneth Wong[2], Marc Douay[1], Laurent Bigot[1], Antoine Lerouge[1], Yves Quiquempois[1], Arnaud Mussot[1]; *[1]CNRS-Université Lille 1, PhLAM/IRCICA USR 3380/UMR 8523, France; [2]Dept of Electrical and Electronic Engineering, Univ. of Hong Kong, Hong Kong.* We experimentally investigate the spectral correlation between multiple modulation instability side lobes in dispersion oscillating fiber by leveraging the dispersive Fourier transformation. We found that parametric processes related to each side lobe pairs act quasi-independently.

**JTu4A.62**
**A Fast Numerical Method to Predict Spectra of High Power CW Yb-Doped Fiber Lasers with Bidirectional Pumping,** Áron Szabó[1], Zoltán Várallyay[2], Andrea Rosales-Garcia[3], Clifford Headley[3]; *[1]Budapest Univ. of Technology and Economics, Hungary; [2]Furukawa Electric Inst. of Technology Ltd., Hungary; [3]OFS Labs, USA.* A fast method is introduced to model high power, continuous wave Yb-doped fiber lasers. Excellent agreement with measurements is obtained for up to 708W output power within 5 minutes of computation on a desktop computer.

**JTu4A.63**
**Intrinsic Temperature Compensation of Interferometric and Polarimetric Fiber-Optic Current Sensors,** Klaus M. Bohnert[1], Georg M. Müller[1], Lin Yang[1], Andreas Frank[1]; *[1]Corporate Research, ABB Ltd, Switzerland.* We theoretically and experimentally demonstrate a method to achieve insensitivity to temperature to within <±0.1% from -40 to 85°C for fiber-optic current sensors with dynamic and static phase biasing and different types of sensing fiber.

**JTu4A.64**
**Control of Saturation Characteristics in a Fiber Optical Parametric Amplifier by Raman Amplification,** Xiaojie Guo[1], Xuelei Fu[1], Chester Shu[1]; *[1]The Chinese Univ. of Hong Kong, Hong Kong.* We report suppression of pump depletion and signal gain reduction in a fiber optical parametric amplifier with a backward Raman pump. The depletion and gain saturation characteristics can be controlled by tuning the Raman gain.

**JTu4A.65**
**Highly Efficient Fast Light Generation in a Single-mode Tellurite Fiber Embedded in a Brillouin Laser Ring Cavity,** Dinghuan Deng[1], Weiqing Gao[1], Tonglei Cheng[1], Edmund E. Samuel[1], Takenobu Suzuki[1], Yasutake Ohishi[1]; *[1]Research Center for Advanced Photon Technology, Toyota Technological Inst., Japan.* Highly efficient fast light propagation at negative group velocity was demonstrated in a 6.2 m long single-mode tellurite fiber embedded in a Brillouin laser ring cavity.

**JTu4A.66**
**Agile tunable Q-switched thulium-doped silica fiber laser,** François GUTTY[1], Arnaud Grisard[1], Christian Larat[1], Dominique Papillon Ruggeri[1], Eric Lallier[1]; *[1]THALES R&T, France.* We demonstrate a Q-switched thulium-doped fiber laser up to 20 kHz with fast tunability over 100 nm without any movable part. Emitted pulses have energies above 10 µJ and peak powers up to 400 W.

**JTu4A.67**
**Graphene saturable absorber power scaling laser,** Zhe Jiang[1], G. E. Bonacchini[1], Daniel Popa[1], Felice Torrisi[1], A. K. Ott[1], Valentin J. Wittwer[1], David Purdie[1], Andrea C. Ferrari[1]; *[1]Cambridge Graphene Centre, Univ. of Cambridge, UK.* A solution-processed graphene-film coated on a fiber-based connector is used for stable, mode-locked femtosecond-duration pulses with 16mW average output power.

**JTu4A.68**
**Radiation-hardened Erbium doped LMA fiber with AlP composition from solution doping process,** Guillaume Canat[1], Jayanta K. Sahu[2], Julien Le Gouët[1], Laurent Lombard[1], Johan Nilsson[2], Sophie Duzellier[1], Boivin Denis[1], William Renard[1]; *[1]Office Natl d'Etudes Rech Aerospatiales, France; [2]Optoelectronic Research Center, Univ. of Southampton, UK.* We report on Erbium doped large-mode-area fibers based on the phosphoalumino-silicates. The radiation induced attenuation are reduced compared to standard highly doped fibers. We measured 22% power conversion efficiency for core pumping at 1532nm.

**JTu4A.69**
**10 GHz Bound Soliton Mode-locking in an Environmentally Stable FM Mode-locked Er-doped Fiber Soliton Laser,** Cheng-Jhih Luo[1], Sheng-Min Wang[1], Yinchieh Lai[1]; *[1]Dept of Photonics and Inst. of Electro-Optical Engineering, National Chiao Tung Univ., Taiwan.* We experimentally demonstrate an environmentally stable 10 GHz FM mode-locked Er-doped fiber soliton laser that can produce stable bound solitons even when there is no equivalent fast saturable absorption mechanism inside the cavity.

**JTu4A.70**
**Optimizing Birefringence of Polarization-Maintaining Photonic Crystal Fiber,** Zhifang Wu[1,2], Xuguang Shao[1], Ping Perry Shum[1,2], Tianye Huang[1,2], Wenbin Ji[1], Nan Zhang[1,2], Ying Cui[1,2], Jie Xue[1,2], Swee Chuan Tjin[1], Xuan Quyen Dinh[2,3]; *[1]School of EEE, Nanyang Technological Univ., Singapore; [2]CINTRA, CNRS International NTU THALES Research Alliance, Singapore; [3]Thales, Thales Solutions Asia Pte Ltd, R&T Dept, Singapore.* We report on a theoretical and experimental investigation to demonstrate that the birefringence of a commercial polarization-maintaining photonic crystal fiber (PMPCF) can be enhanced almost one order of magnitude by scaling its diameter down to ~50um.

**JTu4A.71**
**Low-loss, low return-loss coupling between SMF and single-mode, hollow-core fibers using connectors,** Jeffrey W. Nicholson[1], Brian Mangan[1], Linli Meng[1], Anthony Desantolo[1], Robert S. Windeler[1], John M. Fini[1], Kazunori Mukasa[1], Eric M. Monberg[1], Phouangphet Vannasouk[1], Edward Warych[1], Thierry Taunay[1]; *[1]OFS Labs, USA.* We demonstrate the first low-loss, low-return-loss FC/PC connector for a single-mode, hollow-core fiber. Connector loss of 0.3dB and return loss of -31.3dB was measured, and a 200m HCF jumper with connectors on both ends was fabricated.

**JTu4A.72**
**Numerical Study on Pulse Energy Scaling in an All-Normal-Dispersion Fiber Laser without any Physical Spectral Filters,** Yu Wang[1], Shinji Yamashita[1]; *[1]Research Center of Advanced Science and Technology, The Univ. of Tokyo, Japan.* We investigate high-energy pulse generation in an all-fiber, all-normal-dispersion cavity without any physical spectral filters. Potential of energy scaling is verified numerically by changing the parameters of the gain fiber and the cavity design.

**JTu4A.73**
**On-chip detection of clinical Ebola virus RNA using specific DNA binding technique,** Hong CAI[1], Joshua W. Parks[1], Ricardo Carrion[2], Lynnell Zempoaltecatl[3], Jean P. Patterson[2], Aaron Hawkins[3], Holger Schmidt[1]; *[1]School of Engineering, Univ. of California, Santa Cruz, USA; [2]Virology and Immunology, Texas Biomedical Research Inst., USA; [3]Electrical and Computer Engineering, Brigham Young Univ., USA.* Clinical Ebola RNAs are detected with virus concentration down to 6.25 ×10^4pfu/ml on an optofluidic chip. Longer complementary pull-down DNA sequences provide better isolation and higher signals.

**JTu4A.74**
**Suspended core fiber for propagating vortex LP11 modes,** Hong Ji[1], Yinlan Ruan[1], Shahraam Afshar V.[1], Tanya M. Monro[1]; *[1]School of Chemistry and Physics, The Univ. of Adelaide, Australia.* We have investigated the vortex modes in suspended core fiber with Comsol simulations. The simulation results show that this class of structured fibre is well suited to support stable propagations of the LP11 modes.

**JTu4A.75**
**Optical Phase Imaging Using a Synthetic Aperture Phase Retrieval Technique,** Dennis J. Lee[1], Andrew M. Weiner[1]; *[1]School of Electrical and Computer Engineering, Purdue Univ., USA.* We perform quantitative phase imaging using phase retrieval to implement synthetic aperture imaging. Compared to digital holography, the developed technique is simpler, less expensive, and more stable.

**JTu4A.76**
**Whispering Gallery Mode Biosensing Using Back-Scattered Light,** Joachim Knittel[1], Jon D. Swaim[1], David L. McAuslan[2], Warwick P. Bowen[2], George Brawley[2]; *[1]School of Mathematics and Physics, Univ. of Queensland, Australia; [2]Centre for Engineered Quantum Systems, Univ. of Queensland, Australia.* We present a new technique for whispering gallery mode biosensing involving direct detection of the back-scattered light. This results in suppressing laser frequency noise by 27 dB, and gives an absolute sensitivity of 76 kHz.

**JTu4A.77**
**Patterned Optical Trapping with High Efficiency on a 2D Photonic Crystal Platform,** Peifeng Jing[1], Jingda Wu[1], Lih Lin[1]; *[1]Electrical Engineering, Univ. of Washington, USA.* We demonstrate a method to generate patterned optical trapping on a two-dimensional photonic crystal (2D PC) substrate. Enhanced trapping is achieved with a loosely focused laser beam. The pattern and scale of the optical traps is determined by the 2D PC structure.

**JTu4A.78**
**Giant spatial phase distortion in nonspecularly reflected beams,** Yuhang Wan[1], Weijing Kong[1], Zheng Zheng[1]; *[1]School of Electronic and Information Engineering, Beihang Univ., China.* We demonstrate for the first time that nonspecular reflection could lead to strong spatial phase variation across the beam profile besides the known intensity distortion. This discovery has profound implications for phase-related applications involving sensing.

**JTu4A.79**
**Photonic Crystal Microring Resonator based Sensors,** Stanley M. Lo[1], Shuren Hu[2], Sharon M. Weiss[1,2], Philippe M. Fauchet[1]; *[1]Dept of Electrical Engineering and Computer Science, Vanderbilt Univ., USA; [2]Dept of Physics and Astronomy, Vanderbilt Univ., USA.* Experimental studies on the chemical detection sensitivity of high surface area photonic crystal microring resonators are presented. We report a detection sensitivity of ~170nm/RIU for slow-light resonance modes close to the band edge.

**JTu4A.80**
**Automated Fiber-to-Waveguide Coupling Assisted by a Non-Invasive Integrated Light Monitor,** Marco Carminati[1], Stefano Grillanda[1], Francesco Morichetti[1], Pietro Ciccarella[1], Giorgio Ferrari[1], Marco Sampietro[1], Andrea Melloni[1]; *[1]Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano, Italy.* Automated fiber-to-waveguide coupling is demonstrated in silicon photonics by a ContactLess Integrated Photonic Probe (CLIPP) not requiring an external photodetector. The CLIPP monitors the light-dependent waveguide impedance, providing a feedback signal to the alignment system.

**JTu4A.81**
**Third-Order Distortion Elimination in Phase-Encoded Analog-Photonic Links using a Four-Wave Mixing Comb Source,** Amit Bhatia[1], Hong-fu Ting[1], Mark A. Foster[1]; [1]*Electrical and Computer Engineering, Johns Hopkins Univ., USA.* We present all-optical distortion cancellation in phase-modulated analog-photonic links by combining the phase-encoded signal with lines from an optical comb generated from signal. Experimentally, we fully cancel third-order distortion increasing the link SFDR by >8.3dB.

**JTu4A.82**
**Adjustment of optical path-length difference of nested Mach-Zehnder structure utilizing optical phase shift in waveguide junction,** Akito Chiba[1], Tetsuya Kawanishi[2], Takahide Sakamoto[2], Kaoru Higuma[3], Kazumasa Takada[1], Masayuki Izutsu[4]; [1]*Gunma Univ., Japan;* [2]*National Instuture of Information and Communications Technology, Japan;* [3]*Sumitomo Osaka Cement Co. ltd., Japan;* [4]*Waseda Univ., Japan.* Optical-path length difference of Mach-Zehnder structures embedded on an optical switch can be adjusted within less than 1.6 % of FSR of the structure, without detecting radiation mode of the structure.

**JTu4A.83**
**Waveform-dependent laser spectral compression through pulse propagation in a dispersion-increasing fiber,** Wan-Tien Chao[1], Chi-Cheng Chen[1], Jin-Long Peng[2], Shang-Da Yang[1], Chen-Bin Huang[1]; [1]*Inst. of Photonics Technologies, National Tsing Hua Univ., Taiwan;* [2]*Center for Measurement Standards, Industrial Technology Research Inst., Taiwan.* Waveform dependence of laser spectral compression in a dispersion-increasing fiber is investigated. Experimentally, record-high spectral compression ratios of 35.3 and 41.7 are respectively achieved using a stretch-pulse mode-locked fiber laser and an all-normal dispersion laser.

**JTu4A.84**
**High-sensitivity spectral phase retrieval of 7.2 fs pulse by shaper-assisted modified interferometric field autocorrelation,** Ching-Tze Weng[1], Andy Kung[1], Shang-Da Yang[1]; [1]*Inst. of Photonics Technologies, National Tsing Hua Univ., Taiwan.* We report on spectral phase retrieval of 16 pJ, 7.2 fs pulse and tailored waveforms at 800 nm by shaper-assisted modified interferometric field autocorrelation. Experiment results confirm the high accuracy and reproducibility of this method.

**JTu4A.85**
**Long-term Stabilization of Mode-locked Er-fiber Lasers with 1.2 fs timing jitter,** Shuangyou Zhang[1], Dong Hou[1], Jiutao Wu[1], Jy Zhao[1]; [1]*Peking Univ., China.* We demonstrate a new phase-locking technique for long-term and high-precision stabilization of mode-locked Er-fiber lasers by direct optical-microwave phase detection without high-speed photodiodes and mixers. The excellent locking performance reaches 2.1e-18 at 4000-s averaging time.

**JTu4A.86**
**Broadband Terahertz Generation Approaching Optical Communication Frequency Using Tilted DAST Crystals,** Ikufumi Katayama[1], Michitaka Bito[2], Eiichi Matsubara[2], Masaaki Ashida[2]; [1]*Graduate School of Engineering, Yokohama National Univ., Japan;* [2]*Graduate School of Engineering Science, Osaka Univ., Japan.* To realize ultrabroadband terahertz time-domain spectroscopy reaching near-infrared spectral regions, we investigated the type-I phase matching conditions of the difference frequency generation in DAST crystals. Crystal tilting is found to be efficient for near-infrared generation.

**JTu4A.87**
**Wide repetition rate tunable fetmtosecond laser with a pair of CFBGs,** Young-Jin Kim[1], Jiyong Park[1], Seungman Kim[1], Seung-Woo Kim[1]; [1]*Korea Advanced Inst of Science & Tech, Republic of Korea.* We present an Er-doped fiber femtosecond laser having a wider repetition rate tuning range by introducing a pair of CFBGs which magnifies the cavity length change by 15 times.

**JTu4A.88**
**Ultra-Broadband Non-Collinear Quasi-Phase-Matching in a Hybrid Mid-Infrared OPCPA System,** Benedikt W. Mayer[1], Christopher R. Phillips[1], Lukas Gallmann[1,2], Ursula Keller[1]; [1]*Inst. for Quantum Electronics, ETH Zurich, Switzerland;* [2]*Inst. of Applied Physics, Univ. of Bern, Switzerland.* We present a proof-of-principle of broadband, non-collinear quasi-phase-matching in a hybrid OPCPA system. It employs a combination of quasi-phase-matching and group-velocity-matching in a MgO:PPLN delivering 3.4-µm, 17.2-µJ, 43.1-fs pulses at 50 kHz repetition-rate.

**JTu4A.89**
**Non-invasive Beam Detection in a High Average Power Electron Accelerator,** Joel Williams[1], Jorge Martinez[1], John VanKeuren[1], John Harris[1], Stephen Milton[1], Sandra Biedron[1], Stephen Benson[2], Pavel Evtushenko[2], George Neil[2], Yuhong Zhang[2]; [1]*Colorado State Univ., USA;* [2]*Jefferson National Lab, USA.* Implementation of an electro-optic based beam diagnostic within the Colorado State Univ. and Jefferson Lab beamlines necessitates investigation into how high average power beams affect EO crystals.

**JTu4A.90**
**Dual resonance approach to optical signal processing beyond the carrier relaxation rate,** Mikkel Heuck[1], Philip Trøst Kristensen[1], Jesper Mørk[1]; [1]*Dept of Photonics Engineering, Danmarks Tekniske Universitet, Denmark.* We propose using two optical cavities in a differential control scheme to increase the bandwidth of cavity-based semiconductor optical signal processing devices beyond the limit given by the slowest carrier relaxation rate of the medium.

**JTu4A.91**
**Withdrawn**

**JTu4A.92**
**Design-specific global optimization of a variety of photonic crystal cavities,** Momchil Minkov[1], Vincenzo Savona[1]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland.* We combine the fast guided-mode expansion with a genetic algorithm to perform a global optimization of several widely used photonic crystal cavity designs. The procedure consistently improves their quality factor by more than one order of magnitude, and is in addition highly customizable.

**JTu4A.93**
**Robustness of scalable all-optical logic gates,** Akihiro Fushimi[1], Takasumi Tanabe[1]; [1]*Keio Univ., Japan.* We designed scalable all-optical logic gates that operate at the same input and output wavelength based on microrings. We investigated the influence of input power fluctuations and fabrication errors.

**JTu4A.94**
**Photonic Crystal (PC) Waveguide Based Optical Filters for Dense Integration of High Sensitivity PC Biosensors,** Hai Yan[1], yi zou[1], Chun-Ju Yang[1], Zheng Wang[1], Naimei Tang[2], Swapnajit Chakravarty[2], Ray Chen[1,2]; [1]*The Univ. of Texas at Austin, USA;* [2]*Omega Optics Inc., USA.* A photonic crystal (PC) waveguide based optical filter that enables dense integration of high sensitivity L55 PC microcavities for biosensor microarrays is demonstrated.

**JTu4A.95**
**Spatial Filtering of Light Beams by Axisymmetric Photonic Mictrostructures,** Vytautas Purlys[1], Lina Maigyte[2], Darius Gailevičius[1], Martynas Peckus[1], Roaldas Gadonas[1], Kestutis Staliunas[2,3]; [1]*Laser Research Center, Dept of Quantum Electronics, Vilnius Univeristy, Lithuania;* [2]*Departament de Física i Enginyeria Nuclear, Universitat Politècnica de Catalunya, Spain;* [3]*Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain.* We propose and show experimentally uniform axisymmetric spatial filtering of light beams by three-dimensional axisymmetric photonic microstructures. Such gapless structures (similar to photonic crystals) were recorded in bulk of glass. Angular filtering of 25 mrad is demonstrated experimentally.

**JTu4A.96**
**Exploring Far-field Pattern of Asymmetric Open Microcavities for Sensitive Rotation Detection,** Raktim Sarma[1], Li Ge[2], Jan Wiersig[3], Hui Cao[1]; [1]*Yale Univ., USA;* [2]*Electrical Engineering, Princeton Univ., USA;* [3]*Universitat Magdeburg, Germany.* We propose a novel and ultrasensitive scheme of rotation sensing by measuring farfield intensity from an asymmetric microcavity laser. We optimize the cavity shape and show the farfield sensitivity is enhanced by introducing structural chirality.

**JTu4A.97**
**Semiconductor Single-Photon Emitters with Tunable Polarization Output,** Chu-Hsiang Teng[1], Lei Zhang[2], Tyler Hill[2], Brandon Demory[1], Hui Deng[2], Pei Cheng Ku[1]; [1]*Electrical Engineering, Univ. of Michigan, USA;* [2]*Physics, Univ. of Michigan, USA.* Semiconductor quantum dot based single photon emitters are a critical component for quantum cryptography. In this work, we show a scalable single-photon emitter structure using site-controlled elliptical quantum dots with a controllable and tunable output polarization.

**JTu4A.98**
**Light-assisted Templated Self-Assembly of a Gold Nanoparticle Array,** Ningfeng Huang[1], Luis Javier Martínez Rodríguez[1], Eric Jaquay[1], Camilo A. Mejia[2], Debarghya Sarkar[3], Michelle L. Povinelli[1]; [1]*1. Ming Hsieh Dept of Electrical Engineering, Univ. of Southern California, USA;* [2]*2. Dept of Physics and Astronomy, Univ. of Southern California, USA;* [3]*3. Dept of Electrical Engineering, Jadavpur Univ., India.* We demonstrate for the first time the assembly of an array of gold particles using a guided-resonance mode of a photonic-crystal slab. The 200nm diameter particles form a triangular lattice with spacing of 1140 nm and exhibit high stability.

**JTu4A.100**
**Withdrawn**

**JTu4A.101**
**2.18 µm Mid IR emission from highly transparent Er$^{3+}$ doped tellurite glass ceramic for bio applications,** Roberta Morea[1], Toney Teddy-Fernandez[1], Adrian Miguel[2], Margarita Hernandez[3], Jose Maria Ulloa[4], Joaquin M. Fernandez[2,5], Rolindes Balda[2,5], Javier Solis[1], José Gonzalo[1]; [1]*Inst. of Optics, CSIC, Spain;* [2]*Applied Physics, Universidad del Pais Vasco, Spain;* [3]*Inst. for Structure of Matter, CSIC, Spain;* [4]*Inst. for Systems Based on Optoelectronics and Microtechnology, Universidad Politecnica de Madrid, Spain;* [5]*Materials Physics Center, CSIC-UPV/EHU and Donostia International Physics Center, Spain.* Intense emission peaking at 2.18 µm was successfully obtained from erbium upon rigorous engineering of its glass host. Highly localized crystallization of erbium sites is substantiated by micro Raman and micro-PL along with TEM.

**JTu4A.102**
**Waveguiding in polycrystalline GaP grown on SiO2 by molecular beam deposition,** Michael Gould[1], Nicole K. Thomas[1], Russell Barbour[2], Yuncheng Song[3], Minjoo Larry Lee[3], Kai-Mei C. Fu[1,2]; [1]*Electrical Engineering, Univ. of Washington, USA;* [2]*Physics, Univ. of Washington, USA;* [3]*Electrical Engineering, Yale Univ., USA.* Loss measurements at a wavelength of 632 nm are presented for optical waveguides fabricated in polycrystalline GaP grown directly on SiO2. Devices fabricated in poly-GaP on diamond are also shown.

## JTu4A • Poster Session 1—Continued

**JTu4A.103**
**Electro-optic and converse piezoelectric coefficients of epitaxial thin films: GaN grown on Si, and (Sr,Ba)Nb2O6 (SBN) grown on Pt coated MgO,** Mireille Cuniot-Ponsard[1], Irma Saraswati[2,4], Suk-Min Ko[3], Mathieu Halbwax[2], Yong-Hoon Cho[3], Elhadj Dogheche[2]; [1]*Laboratoire Charles Fabry, IOGS, CNRS, France;* [2]*Optoelectronics Dept, IEMN, France;* [3]*Dept of Physics and Graduate School of Nanoscience and Technology, Korea Advanced Inst. of Science and Technology, Republic of Korea;* [4]*Electrical Engineering, Faculty Engineering Universitas Indonesia, Indonesia.* We report the first measurement of the (r13, r33) Pockels electro-optic coefficients in a SBN thin film and in a GaN thin film grown on silicon. The converse-piezoelectric and electro-absorptive coefficients are simultaneously determined.

**JTu4A.104**
**Formation of Nitrogen vacancy center ensembles in Diamond Nanowires,** Khadijeh Bayat[1], Won Kyu Calvin Sun[2], William Gilpin[3], Mahdi Farrokh Baroughi[4], Marko Loncar[1]; [1]*school of Engineering and Applied Science, Harvard Univ., USA;* [2]*nanotechnology Engineering, Univ. of waterloo, Canada;* [3]*Physics, Princeton Univ., USA;* [4]*Electrical Engineering and Computer Science, South Dakota State Univ., USA.* We have demonstrated incorporation of a thin layer of nitrogen-vacancy (NV) center ensembles at the surface of diamond nanowires. The signature of NV ensembles was confirmed by photoluminescence spectroscopy and electron spin resonance measurements.

**JTu4A.105**
**Experimental Demonstration of On-Chip Silicon Two/Three Mode (De)Multiplexer Using OFDM 64/128/256-QAM Signals,** Chengcheng Gui[1], Jian Wang[1], Zhonglai Zhang[1], Dingshan Gao[1], Chao Li[2], Qi Yang[2]; [1]*Wuhan National Lab for Optoelectr, China;* [2]*State Key Lab of Optical Comm. Technologies and Networks, China.* We fabricate on-chip two/three mode division (de)multiplexing using a tapered asymmetrical directional coupler on SOI platform. System experiments of OFDM 64/128/256-QAM data transmission have been carried out for on-chip two/three mode (de)multiplexing application.

**JTu4A.106**
**SiC Photoconductive Antenna for intense THz generation,** xavier ropagnol[1], Marcel Bouvier[3], Tsuneyuki Ozaki[1], Matt Reid[2]; [1]*physics, INRS, Canada;* [2]*Physics, UNBC, Canada;* [3]*research, Axis photonique, Canada.* We investigate terahertz (THz) radiation from 6H- and 4H-SiC photoconductive (PC) antennas excited at 400 and 800 nm wavelengths. We demonstrate that 6H-SiC large aperture PC antennas have the potential to generate sub-MV/cm THz fields.

**JTu4A.107**
**A Real-Time Terahertz Beam Monitoring Application with a 1024-pixel CMOS Terahertz Camera Module,** Richard Al Hadi[1], Jean-Francois Lampin[2], Ullrich Pfeiffer[1]; [1]*IHCT, Univ. of Wuppertal, Germany;* [2]*IEMN, ISEN, France.* In this paper a terahertz beam monitoring application of an optically pumped molecular terahertz laser with a 1024-pixel CMOS terahertz camera is presented. The terahertz camera has been used to detect variations in real-time of the terahertz source beam around 2.52 THz.

**JTu4A.108**
**Active Terahertz Two-wire Waveguides,** Manoj Kumar Mridha[1], Anna Mazhorova[1], Matteo Clerici[1,2], Ibraheem Al-Naib[3], Maxime Daneau[4], xavier ropagnol[1], Marco Peccianti[5], Christian Reimer[1], Marcello Ferrera[2], Luca Razzari[1], François Vidal[1], Roberto Morandotti[1]; [1]*Energy Materials Telecommunications Research Centre, Institut National de la Recherche Scientifique, Canada;* [2]*School of Engineering and Physical Sciences, Heriot-Watt Univ., UK;* [3]*Dept of Physics, Engineering Physics and Astronomy, Queen's Univ., Canada;* [4]*Univ. of Ottawa, Canada;* [5]*Dept of Physics and Astronomy, Univ. of Sussex, UK.* Increasing coupling of terahertz radiation into a low dispersion, broadband two-wire waveguide is an important issue to address. To resolve this, we demonstrate an active two-wire waveguide with higher performance compared to its passive counterpart.

**JTu4A.109**
**Observation of Change of Moisture Retention of Single Human Hairs using THz Waves,** Kazunori Serita[1], Hironaru Murakami[1], Iwao Kawayama[1], Yoshinori Takahashi[2], Masashi Yoshimura[2], Yusuke Mori[2], Masayoshi Tonouchi[1]; [1]*Institue of Laser Engineering, Osaka Univ., Japan;* [2]*Graduate School of Engineering, Osaka Univ., Japan.* Moisture retention of single human hairs were evaluated using localized generated THz waves. It is found that the cuticles have an important roles for the moisture retention inside the hair.

**JTu4A.110**
**Doubly-resonant mid-infrared AgGaSe2 optical parametric oscillator,** Daniel Maser[1,2], Lora Nugent-Glandorf[1], Gabriel Ycas[1,2], Florian Adler[1], Kevin Knabe[1], Scott A. Diddams[1]; [1]*National Inst. of Standards and Tecn, USA;* [2]*Dept of Physics, Univ. of Colorado, USA.* A doubly-resonant AgGaSe2 mid-infrared optical parametric oscillator (OPO) is synchronously pumped by a hybrid 2 µm Er:fiber/Tm:fiber femtosecond mode-locked laser. The OPO produces spectra ranging from 3-5 µm. Numerical simulations confirm the observed behavior.

**JTu4A.111**
**Surface-Emitting Second-Harmonic Generation: Effective Technique for Evaluating Periodically-Poled Lithium Niobate Waveguide Domains with Nanoscale Resolution,** Da Li[1], Ran Wang[1], Zhaojun Liu[1,2], Lei Wang[1], Yujie J. Ding[1]; [1]*Lehigh Univ., USA;* [2]*Shandong Univ., China.* We demonstrate that surface-emitting second-harmonic generation is an effective technique for evaluating domains of periodically-poled lithium niobate waveguide: domain period, linear taper, and poling depth. Such a method reaches nanoscale spatial resolution of 0.5 nm.

**JTu4A.112**
**Pump-to-Signal Spatial Modulation Transfer in Noncollinear Optical Parametric Amplifiers,** Jake Bromage[1], Christophe Dorrer[1]; [1]*Lab for Laser Energetics, Univ. of Rochester, USA.* Intensity modulation transfer in saturated amplifiers is simulated for different gains and spatial walk-off configurations. Pump-to-signal walk-off in high-gain amplifiers reduces modulation transfer. Increased transfer occurs at low gains, particularly with idler-only walk-off.

**JTu4A.113**
**HgGa2S4-based RISTRA OPO pumped at 1064 nm,** Georgi Marchev[1], Manuel Reza[1,2], Valeriy Badikov[3], Adolfo Esteban-Martin[1,4], Georg Stöppler[5], Marina Starikova[1,6], Dmitrii Badikov[3], Vladimir Panyutin[1,3], Marc Eichhorn[5], Galina Shevyrdyaeva[3], Aleksey Tyazhev[1], Svetlana Sheina[3], Antonio Agnesi[2], Anna Fintisova[3], Valentin Petrov[1]; [1]*Max Born Inst., Germany;* [2]*Università di Pavia, Italy;* [3]*Kuban State Univ., Russia;* [4]*ICFO, Spain;* [5]*ISL, France;* [6]*Special Technologies, Russia.* Idler beam quality at 6.3 µm from HgGa2S4 OPO is compared for linear, planar ring and RISTRA cavities. The last one produces smooth, circular profile and much higher focal fluence.

**JTu4A.114**
**Infrared Signal Detection by Upconversion Technique,** Teh-Hwa Wong[1], Jirong Yu[2], Yingxin Bai[1], William Johnson[3]; [1]*Science systems and Application Inc.., USA;* [2]*NASA Langley Research Center, USA;* [3]*Physics, Montana State Univ., USA.* We demonstrated up-conversion assisted detection of a 2.05-µm signal by using a bulk periodically poled Lithium niobate crystal. The 94% intrinsic up-conversion efficiency and 22.58% overall detection efficiency at pW level of 2.05-µm was achieved.

**JTu4A.115**
**Mid Infrared Sources Based on Widely Tunable DFG in Monolithic Semiconductor Waveguides,** Dylan Logan[1], Alain Villeneuve[2], Mathieu Giguere[2], Amr S. Helmy[1]; [1]*Univ. of Toronto, Canada;* [2]*Genia Photonics Inc, Canada.* Difference frequency generation in monolithic semiconductor waveguides using $\chi(2)$ nonlinearities produced mid IR radiation between 7700 - 8300 nm in a single waveguide element via 20 nm tuning of a 1550 nm fiber laser pump.

**JTu4A.116**
**Fabrication of selective periodic electrodes in up or down domains for electro-optic control of SHG in PPLN,** Adrian J. Torregrosa[1], Haroldo Maestre[1], Juan Carlos Ferrer[1], Susana Fernández de Ávila[1], Juan Capmany[1]; [1]*Miguel Hernandez Univ., Spain.* We present a simple technique for selective deposition of a periodic electrode in one kind of up or down ferroelectric domains alone in a periodically poled lithium niobate crystal for electro-optic control of second harmonic generation.

**JTu4A.117**
**Theoretical and experimental characterization of finite-beam Bragg diffraction in PPLN electro-optic grating,** Yen-Hung Chen[1], Hung-Ping Chung[1], Jui-Wen Chang[1], Wei-Kun Chang[1]; [1]*Dept of Optics and Photonics, National Central Univ., Taiwan.* We report, for the first time, a finite-beam diffraction model built for a PPLN electro-optic Bragg device. Via the fits to experimental results, the diffraction behavior of a finite beam in the device is modeled.

**JTu4A.118**
**Directional-Emission III-V-on-Silicon Microspiral and Double-Notch Microdisk Lasers for Optical Interconnects,** Yu ZHANG[1], Yue-De Yang[2], Yong-Zhen Huang[2], Andrew W. Poon[1]; [1]*Electronic and Computer Engineering, Hong Kong Univ. of Science and Technology, Hong Kong;* [2]*State KeyLab on Integrated Optoelectronics, Inst. of Semiconductor, Chinese Academy of Science, China.* We demonstrate directional-emission III-V-on-silicon microspiral and double-notch microdisk lasers with gaplessly coupled waveguides using wafer-bonding. We observe room-temperature pulsed-injection lasing with a threshold of 33 mA and a side-mode-suppression-ratio of 20 dB at 50 mA.

**JTu4A.119**
**High Performance Excited-State Nanostructure Lasers—Modulation Response, Frequency Chirp and Linewidth Enhancement Factor,** Cheng WANG[1,2], Benjamin Lingnau[3], Eckehard Schöll[3], Kathy Ludge[3], Jacky Even[1], Frederic Grillot[2]; [1]*INSA-Rennes, France;* [2]*Telecom Paristech, France;* [3]*Technische Universität Berlin, Germany.* Excited-state lasing in quantum dot lasers is theoretically demonstrated to exhibit a broader modulation response, lower chirp-to-power ratio, and smaller linewidth enhancement factor in comparison with the conventional lasing in the ground state.

**JTu4A.120**
**Femtosecond mode-locked VECSEL from widely cw-tunable gain chips,** Christopher R. Head[1], Alexander Hein[2], Edward A. Shaw[1], Andrew P. Turnbull[1], Peter Unger[2], Anne C. Tropper[1]; [1]*Univ. of Southampton, UK;* [2]*Inst. of Optoelectronics, Ulm Univ., Germany.* We describe passively mode-locking of an InGaAs quantum well laser, comparing different dielectric coatings applied to the same gain wafer. A 7-fold variation in pulse duration down to 817 fs was observed.

**JTu4A.121**
**Passively Harmonically Self-Mode-Locked Vertical- External-Cavity Surface-Emitting Laser (VECSEL),** Mahmoud Gaafar[1], Christoph Möller[1], Matthias Wichmann[1], Bernd Heinen[1], Bernardette Kunert[2], Arash Rahimi-Iman[1], Wolfgang Stolz[1], Martin Koch[1]; *[1]Faculty of Physics and Material Sciences Center, Philipps-Universität Marburg, Germany; [2]NAsP III/V GmbH, Germany.* We demonstrate a harmonically self-mode-locked optically pumped semiconductor disk laser up to the third harmonic with a central wavelength of 1014 nm. Pulse durations penetrating the femtosecond regime at 500 MHz repetition rate are achieved.

**JTu4A.122**
**GaAsBi Laser Diodes with Low Temperature Dependence of Lasing Wavelength,** Takuma Fuyuki[1], Ryo Yoshioka[1], Kenji Yoshida[1], Masahiro Yoshimoto[1]; *[1]Dept. Electronics, Kyoto Inst. of Technology, Japan.* $GaAs_{1-x}Bi_x$ laser diodes (LDs) with low temperature dependence of the oscillation wavelength ($d\lambda/dT$) are demonstrated. The value $d\lambda/dT$ for a $GaAs_{0.97}Bi_{0.03}$ LD was as low as 0.16 nm/K. This reduction is attributed to a reduction in the temperature coefficient of the band gap.

**JTu4A.123**
**High-Power 1230-nm Quantum-Dot Tapered External Cavity Laser, with 100 nm Tunability,** Stephanie E. Haggett[1], Michel Krakowski[2], Ivo Montrosset[3], Maria Ana Cataluna[1]; *[1]Univ. of Dundee, UK; [2]III-V Lab, France; [3]Politecnico di Torino, Italy.* A quantum-dot tapered waveguide external cavity laser is presented, with 100nm tunability. At 1230nm, a maximum power of 0.62W was achieved, representing a 16-fold increase compared with equivalent narrow-ridge lasers at the same current density.

**JTu4A.124**
**Power Scaling a Cr:ZnSe Thin Disk Laser by Increasing Pump Diameter,** Ronald Stites[1], Gary Cook[1], Patrick Berry[1], Kenneth Schepler[1]; *[1]Air Force Research Labs, USA.* A 500 μm Cr:ZnSe thin disk gain element was pumped at five different pump diameters. Laser output versus pump power was measured. Slope efficiency, threshold, and maximum power versus pump spot size were then extracted.

**JTu4A.125**
**Adaptive Beam Cleanup of a 1.3kW Pulsed Slab Amplifier,** ping yang[1], Shuai Wang[1,2], Lizhi Dong[1], Wenjin Liu[1,2], Mingwu Ao[3]; *[1]Lab on Adaptive Optics, Inst. of Optics and Electronics, Chinese Academy of Sciences, China; [2]Univ. of Chinese Academy of Sciences, China; [3]Univ. of Electronic Science and Technology of China, China.* We present closed-loop adaptive phase compensation of a 1.3 kW solid-state slab laser system. Experimental results demonstrated the beam quality is greatly improved with the proposed adaptive optics system.

**JTu4A.126**
**High Power Continuous-Wave Alexandrite Laser with Green Pump,** Shirin Ghanbari[1], Arkady Major[1]; *[1]Univ. of Manitoba, Canada.* High power operation of a continuous-wave Alexandrite laser is reported. Output power of 2.6 W at 755 nm and tunability of 85 nm were achieved using 11 W of pump at 532 nm.

**JTu4A.127**
**Passive Mode Locking of a Diode Pumped $Nd:Sc_{0.2}Y_{0.8}SiO_5$ Laser,** Veselin Aleksandrov[1], Hristo Iliev[1], Anton Trifonov[1], Lihe Zheng[2], Jun Xu[2], Liangbi Su[2], Ivan C. Buchvarov[1]; *[1]Sofia Univ. St. Kliment Ohridski, Bulgaria; [2]Shanghai Inst. of Ceramics, Chinese Academy of Sciences, China.* We demonstrate passive mode-locking of a $Nd:Sc_{0.2}Y_{0.8}SiO_5$ laser using a semiconductor saturable absorber mirror. The pulse train shows output power of 0.5 W and pulse duration of 3.5 ps at repetition rate of 118 MHz.

**JTu4A.128**
**Graphene-based passive Q-switching of a Tm3+:ZBLAN short-infrared waveguide laser,** Ju Han Lee[2], Simon Gross[4], Ben V. Cunning[3], Chris Brown[3], David Kielpinski[3], Tanya M. Monro[1], David G. Lancaster[1]; *[1]Univ. of Adelaide, Australia; [2]Univ. of Seoul, Republic of Korea; [3]Griffith Univ., Australia; [4]Macquarie Univ., Australia.* We report a passively Q-switched 1.9 μm Tm:ZBLAN waveguide laser based on an extended cavity containing a flake-graphene saturable absorber film. The 790nm diode-laser-pumped laser produces up to 6 mW with ~1.4 μs pulses at ~25 kHz.

**JTu4A.129**
**Chiral polymeric relief structures fabricated by using optical vortices,** Guzhaliayi Juman[1], Mizuki Watabe[1], Katsuhiko Miyamoto[1], Takashige Omatsu[1,2]; *[1]Chiba Univ., Japan; [2]CREST, Japan.* We present a chiral single-arm relief on a micro-meter scale formed in an azo-polymer film by the irradiation of a green optical vortex. A 2-dimensional chiral relief array was also fabricated in the azo-polymer film.

**JTu4A.130**
**Feasibility of Breast Surgical Margins Analysis with Fluorescence-guided Optical Coherence Tomography Imaging,** Dan Savastru[1], Sorin Miclos[1], Ernest Chang[2], Dorin Preda[2], Nicusor Iftimia[2]; *[1]National Inst. of Optoelectronics INOE 2000, Romania; [2]Physical Sciences, Inc., USA.* We demonstrate the feasibility of a surgery guidance approach based on fluorescence-guided optical coherence tomography (OCT) imaging. Surgical margins are assessed for cancer presence using automated analysis of OCT images, only on areas indicated by fluorescence imaging as being cancer suspicious.

**JTu4A.131**
**Photo-addressable multi-stable optical switch,** Tsung-Hsien Lin[1], Chun-Ta Wang[1], Yueh-Chi Wu[1]; *[1]Dept of Photonics, Taiwan.* This work demonstrates an optically switchable tristable optical switch. Tristable attenuation, scattering, and transparent states can be achieved using the dichroic dye doped fingerprint, focal conic, and homeotropic textures, respectively.

**JTu4A.132**
**Localization of Epidural Space in Piglets by Catheter-based Swept Source Optical Coherence Tomography,** Kao Meng-Chun[1]; *[1]Inst. of Biophotonics, National Yang-Ming Univ., Taiwan.* In this study, we designed and built a needle-fiber based Fourier domain swept source optical coherence tomography (SSOCT) system, that used to localize epidural space.

**JTu4A.133**
**Functional optical imaging of neurovascular activation in the rat cerebral cortex,** Kuo Yue-Ming[1]; *[1]National Yang-Ming Univ., Taiwan.* FD-OCT system used to acquire the cross-sectional tissue structure through the cranial window at rat cortex. The intensity of cortex and flow changes during forepaw electrical stimulation. Results show that localized swelling and scattering decreases in the activation region.

**JTu4A.134**
**Optical-Low-Coherence-Reflectometry-Assisted Non-Contact Tonometry,** Tuan-Shu Ho[1], Chien-Chung Tsai[1], Kuang-Yu Hsu[1], Sheng-Lung Huang[1,2]; *[1]Graduate Inst. of Photonics and Optoelectronics, National Taiwan Univ., Taiwan; [2]Dept of Electrical Engineering, National Taiwan Univ., Taiwan.* A multifunctional system incorporating air-puff module and optical low-coherence reflectometry is demonstrated to measure the corneal thickness and intraocular pressure. Properties related to corneal rigidity are determined with the interferogram observed during the air-puffing process.

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## NOTES

**Executive Ballroom 210A** | **Executive Ballroom 210B** | **Executive Ballroom 210C** | **Executive Ballroom 210D**

## CLEO: QELS-Fundamental Science

**08:30–10:00 Plenary and Awards Session II,** *Grand Ballroom*

**10:00–17:00 Exhibition Open,** *Exhibit Halls 1 & 2*

**10:00–10:30 Coffee Break and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2*

**10:30–12:30 Market Focus Session III: Operational Strategies for the Laser and Photonics Industry,** *Exhibit Hall Theater*

### 10:30–12:30
### FW1A • Fundamental Quantum Science
*Presider: Todd Pittman; Univ. of Maryland Baltimore County, USA*

**FW1A.1 • 10:30**
**Measuring Bohm Trajectories of Entangled Photons,** Dylan Mahler[1,2], Lee Rozema[1,2], Kent Fisher[3], Lydia Vermeyden[3], Kevin Resch[3], Boris Braverman[4], Howard Wiseman[5,6], Aephraim M. Steinberg[1,2]; [1]*Center for Quantum Information and Quantum Control and Inst. for Optical Sciences, Canada;* [2]*Univ. of Toronto, Canada;* [3]*Inst. for Quantum Computing and Dept. of Physics & Astronomy, Univ. of Waterloo, Canada;* [4]*MIT-Harvard Center for Ultracold Atoms, and Research Lab of Electronics, MIT, USA;* [5]*Centre for Quantum Computation and Communication Tech. (Australian Research Council), Australia;* [6]*Centre for Quantum Dynamics, Griffith Univ., Australia.* We measure, using weak measurement, the Bohmian trajectories of one photon that is part of an entangled pair. Our results shed light on the nonlocality of the Bohm model, as well as its so-called "surrealism."

**FW1A.2 • 10:45**
**Two-Photon Discrete Speckle in Anderson-Disordered Lattices,** Lane Martin[1], Gianni di Giuseppe[1,2], Armando Perez-Leija[3], Robert Keil[3], Alexander Szameit[3], Ayman F. Abouraddy[1], Demetrios N. Christodoulides[1], Bahaa E. Saleh[1]; [1]*CREOL, The College of Optics and Photonics, Univ. of Central Florida, USA;* [2]*School of Science and Technology, Physics Division, Univ. of Camerino, Italy;* [3]*Inst. of Applied Physics, Friedrich-Schiller-Universität, Germany.* Two photons in an entangled, spatially correlated (anti-correlated) state transmitted through an Anderson disordered lattice maintain their correlation (anti-correlation) but exhibit coincidence-map speckle in the Fourier plane.

### 10:30–12:30
### FW1B • Spin Coherence in Color Centers in Diamond
*Presider: Duncan England; National Research Council, Canada*

**FW1B.1 • 10:30**
**Optical signatures of spin in silicon-vacancy centre in diamond,** Benjamin Pingault[1], Tina Muller[1], Christian Hepp[2], Elke Neu[2], Christoph Becher[2], Mete Atature[1]; [1]*Univ. of Cambridge, UK;* [2]*Universitat des Saarlandes, Germany.* The spin state of the silicon-vacancy centre in diamond and its optical accessibility have so far remained elusive. We here evidence spin-tagged fluorescence through resonant optical access to the electronic spin 1/2 of the centre.

**FW1B.2 • 10:45**
**Observing bulk spin coherence in high-purity nanodiamonds,** Helena S. Knowles[1], Dhiren M. Kara[1], Mete Atature[1]; [1]*Univ. of Cambridge, UK.* Nitrogen-vacancy centres in nanodiamond allow nano-resolution magnetometry. However, their use has been limited by poor quantum state coherence times. Using high purity nanodiamonds we achieve spin coherence comparable to that in bulk.

### 10:30–12:30
### FW1C • Symposium on Science and Applications of Structured Light in Complex Media I ▶
*Presider: Natalia Litchinitser; State Univ. of New York at Buffalo, USA*

**FW1C.1 • 10:30** Invited ▶
**Quantum Electromechanical Processes in Plasmonic Nanostructures,** Nicholas Fang[1]; [1]*MIT, USA.* In this invited talk I will present an quantum electromechanical analysis on enhanced angular momentum transfer observed in different metallic nanostructures. Direct applications include plasmonic angular momentum mode converters for quantum computing and optical manipulation of mechanical torque. We will also discuss our recent effort on quantum jellium model applied to the excitation of metallic interfaces that are just a few nanometer thick.

### 10:30–12:30
### FW1D • Wavelength Conversion in Micro-Structures
*Presider: J. Stewart Aitchison; Univ. of Toronto, Canada*

**FW1D.1 • 10:30** Invited
**Vacuum UV to IR supercontinuum generation by impulsive Raman self-scattering in hydrogen-filled PCF,** Federico Belli[1], Amir Abdolvand[1], Wonkeun Chang[1], John C. Travers[1], Philip St.J. Russell[1,2]; [1]*Max Planck Inst. for the science of light, Germany;* [2]*Dept. of Physics, Univ. of Erlangen-Nuremberg, Germany.* A supercontinuum extending from 125nm to 1200nm is generated in hydrogen-filled kagomé-PCF by means of impulsive Raman self-scattering of few-μJ ultrashort pulses at 805nm. The source shows no optical damage and is stable over time.

| Executive Ballroom 210E | Executive Ballroom 210F | Executive Ballroom 210G | Executive Ballroom 210H |
|---|---|---|---|
| CLEO: Science & Innovations | | | CLEO: Applications & Technology |

**08:30–10:00 Plenary and Awards Session II,** *Grand Ballroom*

**10:00–17:00 Exhibition Open,** *Exhibit Halls 1 & 2*

**10:00–10:30 Coffee Break and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2*

**10:30–12:30 Market Focus Session III: Operational Strategies for the Laser and Photonics Industry,** *Exhibit Hall Theater*

### 10:30–12:30
### SW1E • Pulse Compression
*Presider: Gunter Steinmeyer; Max Born Inst., Germany*

**SW1E.1 • 10:30**
**CEP-stable, multi-mJ, 4.3 fs pulses from long stretched flexible hollow fibers,** Frederik Böhle[1], Martin Kretschmar[2], Aurelie Jullien[1], Peter Simon[3], Rodrigo B. Lopez-Martens[1], Tamas Nagy[2,3]; [1]*Laboratoire d'Optique Appliquée, Ecole Nationale Superieur de Techniques Avancées-Paristech, Ecole Polytechnique, CNRS, France;* [2]*Institut für Quantenoptik, Leibniz Universität Hannover, Germany;* [3]*Laser-Laboratorium Göttingen e.V., Germany.* CEP-stable 4.3fs pulses of 3mJ energy were generated by spectral broadening of circularly polarized 8mJ pulses in a differentially pumped 2-m-long hollow fiber. The pulses were characterized by a single-shot SHG FROG.

**SW1E.2 • 10:45**
**Direct Measurement of Nonlinear Carrier-Envelope Phase Changes in Hollow Fiber Compression,** Fabian Lücking[1], Andrea Trabattoni[2], Sunilkumar Anumula[2], Giuseppe Sansone[2], Francesca Calegari[2], Mauro Nisoli[2], Thomas Oksenhendler[3], Gabriel Tempea[1]; [1]*Femtolasers Produktions GmbH, Austria;* [2]*Politecnico di Milano, Dept. of Physics, Inst. of Photonics and Nanotechnologies,CNR-IFN, Italy;* [3]*Fastlite, France.* We present a single-shot, in-situ interferometric method for measuring phase changes experienced by laser pulses upon nonlinear propagation. With this method we characterized the intensity-dependent phase fluctuations emerging in hollow fiber compressors.

### 10:30–12:30
### SW1F • Nonlinear THz Science and Technology
*Presider: Peter Jepsen; Danmarks Tekniske Universitet, Denmark*

**SW1F.1 • 10:30** Invited
**Colliding Quasiparticles with Intense Terahertz Fields,** Mark S. Sherwin[1]; [1]*Univ. of California Santa Barbara, USA.* Strong quasi-cw terahertz fields accelerate and recollide electron-hole pairs injected by a near-ir laser into GaAs quantum wells. A frequency comb is emitted, with up to 18 teeth separated by twice the terahertz frequency.

### 10:30–12:30
### SW1G • Emerging Trends in Semiconductor Lasers ▶
*Presider: Amr Helmy; Univ. of Toronto, Canada*

**SW1G.1 • 10:30** Invited ▶
**Electrically Driven Exciton-Polariton Lasers,** Sven Höfling[1,2], Christian Schneider[1], Arash Rahimi-Iman[1], Na Young Kim[3,4], Matthias Amthor[1], Matthias Lermer[1], Ivan Savenko[5,6], Ivan Shelykh[5,6], Vladimir Kulakovskii[7], Lukas Worschech[1], Martin Kamp[1], Stephan Reitzenstein[8], Misha Durnev[9], Alexey Kavokin[9,10], Alfred Forchel[1], Yoshihisa Yamamoto[3,11]; [1]*Technische Physik, Wuerzburg Univ., Germany;* [2]*SUPA, Univ. of St Andrews, UK;* [3]*Ginzton Lab, Stanford Univ., USA;* [4]*Inst. of Industrial Science, Univ. of Tokyo, Japan;* [5]*Science Inst., Univ. of Iceland, Iceland;* [6]*Division of Physics and Applied Physics, Nanyang Technological Univ., Singapore;* [7]*Inst. of Solid State Physics, Russian Academy of Science, Russia;* [8]*Institut für Festkörperphysik, Technische Universität Berlin, Germany;* [9]*Spin Optics Lab, St-Petersburg State Univ., Russia;* [10]*Physics and Astronomy School, Univ. of Southampton, UK;* [11]*National Inst. of Informatics, Japan.* We report exciton-polariton laser operation under electrical pumping. The hybrid light-matter nature of this lasing system is probed by measuring the exciton-polariton Zeeman-splitting, which clearly reveals that this laser remains in the strong coupling regime.

### 10:30–12:30
### AW1H • Material Structuration for Next Generation Sensors and Components
*Presider: Yasuhiko Shimotsuma; Kyoto Univ., Japan*

**AW1H.1 • 10:30**
**Generation of second and third order optical dispersion using nonlinearly chirped silicon waveguide gratings,** George Feng Rong Chen[1], Ting Wang[1], Christine Donnelly[2], D. T. H. Tan[1]; [1]*Engineering Product Development, Singapore Univ. of Technology and Design, Singapore;* [2]*Stanford Univ., USA.* The simultaneous generation of second and third order dispersion is demonstrated using nonlinearly chirped silicon waveguide gratings. Second order dispersion of -2.3x106 ps/nm/km and third order dispersion of 1.2x105 ps/nm2/km were demonstrated at 1.55µm.

**AW1H.2 • 10:45**
**Photoluminescence from GeSn/Ge Heterostructure Microdisks with 6% Sn Grown on Si via CVD,** Seyed Amir Ghetmiri[1,2], Benjamin Conley[1,2], Aboozar Mosleh[1,2], Liang Huang[1,2], Wei Du[2], Amjad Nazzal[3], Greg Sun[4], Richard Soref[4], John Tolle[5], Hameed A. Naseem[2], Shui-Qing Yu[2]; [1]*Microelectronics-Photonics graduate program, Univ. of Arkansas, USA;* [2]*Electrical Engineering, Univ. of Arkansas, USA;* [3]*Engineering and Physics, Wilkes Univ., USA;* [4]*Physics, Univ. of Massachusetts, USA;* [5]*ASM Company, USA.* GeSn/Ge heterostructure microdisks integrated on Si were fabricated. The quality of material grown by CVD was investigated and the photoluminescence spectrum was measured using a Ti:Sapphire laser as an excitation source under variable pump powers.

**08:30–10:00 Plenary and Awards Session II,** *Grand Ballroom*

**10:00–17:00 Exhibition Open,** *Exhibit Halls 1 & 2*

**10:00–10:30 Coffee Break and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2*

**10:30–12:30 Market Focus Session III: Operational Strategies for the Laser and Photonics Industry,** *Exhibit Hall Theater*

### 10:30–12:30
### SW1I • Solitons and Nonlinear Propagation ▶

*Presider: Antoine Godard, ONERA - The French Aerospace Lab, France*

**SW1I.1 • 10:30** Tutorial ▶
**Supercontinuum and solitons, what's up?,** Goëry Genty[1], John M. Dudley[2]; [1]*Tampere Univ. of Technology, Finland;* [2]*Université de Franche Comté, France.* This tutorial provides an overview of the basic physical mechanisms of supercontinuum generation. Progress in the field and novel physics linked to recently discovered soliton dynamics including optical rogue waves will be reviewed.

Goëry Genty graduated from the Institute of Optics, France and obtained his PhD from the Aalto University, Finland in 2004. He is currently a Professor at the Tampere University of Technology in Finland, where he leads a research group on ultra-fast pulse propagation dynamics.

### 10:30–12:30
### SW1J • Bandwidth Efficient Signaling

*Presider: David Hillerkuss; ETH Zurich, Switzerland*

**SW1J.1 • 10:30**
**Generation of Nyquist Pulses Using a Dual Parallel Mach-Zehnder Modulator,** Jizhao Zang[1], Jian Wu[1], Yan Li[1], Xinhui Nie[1], Jifang Qiu[1], Jintong Lin[1]; [1]*Beijing Univ. of Posts and Telecommunications, China.* We demonstrated the generation of Nyquist pulses using a dual parallel Mach-Zehnder modulator. 10 GHz to 40 GHz Nyquist pulses with timing-jitter below 258 fs and signal-to-noise ratio more than 30 dB are experimentally generated.

**SW1J.2 • 10:45**
**Experimental Investigation of Sampling Phase Sensitivity in Baud-Rate Sampled Coherent Receiver for Nyquist Pulse-Shaped High-Order QAM Signals,** Guo-Wei Lu[1], Takahide Sakamoto[1], Tetsuya Kawanishi[1]; [1]*Natl. Inst. of Info. & and Comm. Tech., Japan.* We experimentally investigate the sampling phase dependence of baud-rate sampled and equalized coherent receiver for Nyquist Pulse-shaped high-order QAM signals on the modulation format and roll-off factors.

### 10:30–12:30
### FW1K • Metasurfaces and Plasmonic Metamaterials ▶

*Presider: Nanfang Yu; Columbia Univ., USA*

**FW1K.1 • 10:30** Tutorial
**Optical Properties on Demand: Reconfigurable and Coherently Controlled Metamaterials,** Nikolay I. Zheludev[1,2]; [1]*Centre for Photonic Metamaterials and Optoelectronics Research Centre, Univ. of Southampton, UK;* [2]*Centre for Disruptive Photonic Technologies, NTU, Singapore.* Transmission and reflection properties, anisotropy, chirality, optical non-linearity and luminescent of metamaterials can be controlled at will using dynamic nanostructures reconfigurable with electromagnetic forces and by exploiting structured illumination with coherent light.

Nikolay Zheludev directs the Centre for Photonics Metamaterials at the ORC, Southampton University and the Centre for Disruptive Photonic Technologies at NTU, Singapore. His awards include Senior Professorships of the UK Research Council and the Leverhulme Trust and the Royal Society Wolfson Fellowship. He was awarded PhD and DSc from Moscow State University.

### 10:30–12:30
### AW1L • Imaging and Sensing

*Presider: Hao Zhang; Northwestern Univ., USA*

**AW1L.1 • 10:30** Tutorial
**Multimode Optical Bioimaging, from the Lab to the Clinic: A Translational Story,** Daniel L. Farkas[1]; [1]*Dept. of Biomedical Engineering, Univ. of Southern California r, USA.* Focus will be where light and patient meet, and improvements yielding better outcomes, by detecting, characterizing and monitoring very small entities (molecules, cells) within the human body, quantitatively, dynamically, and preferably without contrast agents.

Daniel L. Farkas previously directed the National Science & Technology Center at Carnegie Mellon that won the Smithsonian Award. In addition he has been Professor of Bioengineering at the Univ. of Pittsburg and Professor of Surgery at Cedars-Sinai. He has chaired 26 international conferences, is on 10 editorial boards, and (co)founded 12 startups. His research attracted $75M, yielding 200 publications. He was a Fulbright scholar.

| Marriott Salon III | Marriott Salon IV | Marriott Salon V & VI | Marriott Willow Glen I-III |
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**08:30–10:00 Plenary and Awards Session II,** *Grand Ballroom*

**10:00–17:00 Exhibition Open,** *Exhibit Halls 1 & 2*

**10:00–10:30 Coffee Break and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2*

**10:30–12:30 Market Focus Session III: Operational Strategies for the Laser and Photonics Industry,** *Exhibit Hall Theater*

### 10:30–12:30
### SW1M • Micro and Nanophotnic Devices

*Presider: Douglas Gill, IBM, USA*

**SW1M.1 • 10:30** Invited

**Nano-Optical Scan Probes: Opening Doors to Previously-Inaccessible Parameter Spaces,** James Schuck[1]; *[1]Lawrence Berkeley National Lab, USA.* I will discuss recent progress on new near-field probe geometries, including the "campanile" geometry, which has been used in recent hyperspectral imaging experiments, providing nanoscale spectral information distinct from what is obtained with other methods.

### 10:30–12:30
### SW1N • Novel Fiber Laser Designs

*Presider: Shenping Li; Corning Incorporated, USA*

**SW1N.1 • 10:30** Invited

**Ultra-long Fibre-based Random Lasers,** Sergei K. Turitsyn[1,2]; *[1]Aston Inst. of Photonic Technologies, Aston Univ., UK; [2]Novosibirsk State Univ., Russia.* The emerging science and applications of ultra-long random fibre lasers will be overviewed. The lasers with cavity length up to several hundred km exploit random distributed feedback provided by Rayleigh scattering amplified through Raman effect.

### 10:30–12:30
### SW1O • Laser Frequency Combs

*Presider: Axel Ruehl; Deutsches Elektronen Synchrotron, Germany*

**SW1O.1 • 10:30**

**Direct Comb Stabilization to a 12C2H2-filled Hollow-core Fiber via Single Tooth Saturated Absorption Spectroscopy,** Shun Wu[1], Chenchen Wang[1], Coralie Fourcade Dutin[2,3], Brian R. Washburn[1], Fetah Benabid[2,3], Kristan L. Corwin[1]; *[1]Dept. of Physics, Kansas State Univ., USA; [2]GPPMM group, Xlim Research Inst., France; [3]Physics Dept., Univ. of Bath, UK.* Toward an all-fiber system, an erbium fiber laser-based comb is directly stabilized to a 12C2H2 transition at 1539.4 nm. The comb fractional instability at 1532.8 nm is 6×10-12 at 100 ms gate time.

**SW1O.2 • 10:45**

**A frequency comb that maintains optical coherence under significant vibrations,** Laura C. Sinclair[1], Ian Coddington[1], William C. Swann[1], Lindsay Sonderhouse[1], Greg B. Rieker[1,2], Archita Hati[1], Kana Iwakuni[3], Nathan R. Newbury[1]; *[1]NIST, USA; [2]Mechanical Engineering, Univ. of Colorado, USA; [3]Dept. of Physics, Keio Univ., Japan.* We discuss the design and performance of an all polarization-maintaining self-referenced frequency comb that can maintain optical coherence with an optical reference laser under strong vibrations from a shaker table and a moving vehicle.

### 10:30–12:30
### AW1P • Spectroscopy and Imaging Applications

*Presider: M Krishnamurthy, Tata Inst. of Fundamental Research, India*

**AW1P.1 • 10:30**

**Rapid, wideband cavity ringdown spectroscopy for the detection of explosives,** Toby K. Boyson[1], Dylan R. Rittman[2], Thomas G. Spence[3], Paul Kirkbride[4], David S. Moore[2], Charles C. Harb[1]; *[1]School of Engineering and Information Technology, UNSW Australia, Australia; [2]Shock and Detonation Physics Group, Los Alamos National Lab, USA; [3]Dept. of Chemistry, Loyola Univ. New Orleans, USA; [4]School of Chemical and Physical Sciences, Flinders Univ., Australia.* We present results from a variant of CRDS that allows large spectral bandwidths to be analysed in real time. We have applied the technique to the analysis and detection of explosives and related compounds.

**AW1P.2 • 10:45**

**Silicon on Sapphire Chip Based Mid-Infrared Optical Spectroscopy for Detection of Chemical Warfare Simulant Triethyl phosphate,** parker wray[1], yi zou[1], Swapnajit Chakravarty[2], Ray Chen[1]; *[1]Electrical Engineering, Univ. of Texas at Austin, USA; [2]Omega Optics Inc., USA.* Triethyl phosphate (TEP), a chemical warfare simulant, has absorption peaks in the mid-infrared. Using a single mode slot wave guide we were able to detect TEP, with a detection limit down to 75 ppm. This provides enhanced sensitivity while simultaneously achieving device miniaturization.

## FW1A • Fundamental Quantum Science—Continued

**FW1A.3 • 11:00**
**Classical Realization of Dispersion Cancellation by Using Transform-limited Pulses,** Kazuhisa Ogawa[1], Shuhei Tamate[2], Toshihiro Nakanishi[1], Hirokazu Kobayashi[3], Masao Kitano[1]; [1]*Dept. of Electronic Science and Engineering, Kyoto Univ., Japan;* [2]*Center for Emergent Matter Science, RIKEN, Japan;* [3]*Dept. of Electronic and Photonic System Engineering, Kochi Univ. of Technology, Japan.* We report classical optical interferometry reproducing dispersion-insensitive Hong-Ou-Mandel interferograms. Our scheme is based on the time-reversal symmetry of quantum dynamics. We achieved high-visibility Hong-Ou-Mandel interferograms owing to simplicity of our setup.

**FW1A.4 • 11:15**
**Quantum Correlations Beyond Tsirelson's Bound,** Martin Ringbauer[2], Alessandro Fedrizzi[2], Dominic W. Berry[1], Andrew G. White[2]; [1]*Dept. of Physics and Astronomy, Macquarie Univ., Australia;* [2]*School of Mathematics and Physics, The Univ. of Queensland, Australia.* We optically demonstrate violation of the CHSH-Bell inequality and Tsirelson's bound via loss and postselection. This enables us to more easily distinguish between entangled and unentangled states, and violates information causality with the postselected data.

**FW1A.5 • 11:30**
**Entanglement Transmission through a Distributed Phase Sensitive Amplifier,** James M. Dailey[1], Anjali Agarwal[1], Paul Toliver[1], Nicholas A. Peters[2]; [1]*Applied Communication Sciences, USA;* [2]*Applied Communication Sciences, USA.* We demonstrate transmission of entangled photons through a χ(3)-based 5-km distributed optical amplifier operated in the low-gain limit to offset loss. No measurable degradation in entanglement quality is observed after the amplifier.

**FW1A.6 • 11:45**
**Single-photon frequency conversion using cross-phase modulation,** Nobuyuki Matsuda[1,2]; [1]*NTT Basic Research Labs, NTT Corporation, Japan;* [2]*Nanophotonics Center, NTT Corporation, Japan.* The frequency conversion of single photon wave packets was demonstrated using cross-phase modulation in a dispersion-managed photonic crystal fiber. The frequencies of single photons were successfully modulated without a significant photon loss.

## FW1B • Spin Coherence in Color Centers in Diamond—Continued

**FW1B.3 • 11:00**
**Suppression of Spin Dephasing in Diamond NV Centers with Microwave-Dressed Spin States,** David Golter[1], Thomas K. Baldwin[1], Hailin Wang[1]; [1]*Physics, Univ. of Oregon, USA.* We demonstrate a spectral domain technique for suppressing the nuclear-spin-bath induced dephasing of diamond nitrogen vacancy centers by employing microwave-dressed spin states. Reduction in spin dephasing by more than 10-fold is observed.

**FW1B.4 • 11:15**
**High Precision Wide-Field Sensing with Individual Nitrogen-Vacancy Centers in Diamond,** Matthew E. Trusheim[1], Dirk Englund[1]; [1]*MIT, USA.* We demonstrate a microscopy technique for precision sensing across a wide field of view with high spatial precision through pulsed electron spin resonance of nitrogen vacancy centers in diamond.

**FW1B.5 • 11:30** Invited
**Quantum Information and Networks with Spins in Diamond,** Tim H. Taminiau[1]; [1]*Technische Universiteit Delft, Netherlands.* The nitrogen-vacancy center in diamond is a promising candidate to realize quantum networks. We create multi-qubit nodes of nuclear spins in the environment and couple these nodes together by entangling remote nitrogen-vacancy centers through photons.

## FW1C • Symposium on Science and Applications of Structured Light in Complex Media I—Continued

**FW1C.2 • 11:00**
**Nanopatterned Multilayer Hyperbolic Metamaterials for Enhancing Spontaneous Light Emission,** Dylan Lu[1], Lorenzo Ferrari[2], Jimmy J. Kan[3], Eric E. Fullerton[1,3], Zhaowei Liu[1,2]; [1]*Electrical and Computer Engineering, Univ. of California San Diego, USA;* [2]*Materials Science and Engineering, Univ. of California San Diego, USA;* [3]*Center for Magnetic Recording Research, Univ. of California San Diego, USA.* We show that nanopatterned hyperbolic metamaterials made of Ag-Si multilayers enhance the spontaneous emission rate of dye molecules by 76-fold at tunable frequencies and the emission intensity by ~80 fold compared to metamaterials without nanostructuring.

**FW1C.3 • 11:15**
**Tunable plasmonic platform for giant fluorescence enhancement,** Maiken H. Mikkelsen[1,2], Alec Rose[1], Thang B. Hoang[1,2], Felicia McGuire[1], Jack J. Mock[1], Cristian Ciraci[1], David R. Smith[1]; [1]*Center for Metamaterials and Integrated Plasmonics, Dept. of Electrical and Computer Engineering, Duke Univ., USA;* [2]*Dept. of Physics, Duke Univ., USA.* We demonstrate a colloidally synthesized plasmonic platform for giant fluorescence enhancement and increased spontaneous emission rate of embedded fluorophores. A transition between fluorescence enhancement and quenching is revealed depending on the plasmonic resonance.

**FW1C.4 • 11:30** Invited
**Graphene Metadevices and Metamaterials for Linear and Nonlinear THz Applications,** Hyeondon Kim[1], Woo Young Kim[1], Hyun Joo Choi[1], In-Hyung Baek[2], Bong Ju Kang[2], Teun-Teun Kim[1], Kanghee Lee[1], Young Uk Jeong[3], Fabian Rotermund[2], Bumki Min[1]; [1]*Korea Advanced Inst of Science & Tech, Korea;* [2]*Ajou Univ., Korea;* [3]*Korea Atomic Energy Research Inst., Korea.* Graphene metadevices and metamaterials are promising especially for the control of THz waves. Among various possible functional devices and materials, THz graphene memory metadevices and THz graphene metamaterial saturable absorbers are introduced as illustrative examples.

## FW1D • Wavelength Conversion in Micro-Structures—Continued

**FW1D.2 • 11:00**
**Investigation of Mode Interaction in Optical Microresonators for Kerr Frequency Comb Generation,** Yang Liu[1], Yi Xuan[1,2], Xiaoxiao Xue[1], Pei-Hsun Wang[1], Andrew J. Metcalf[1], Steven Chen[1], Minghao Qi[1,2], Andrew M. Weiner[1,2]; [1]*School of Electrical and Computer Engineering, Purdue Univ., USA;* [2]*Birck Nanotechnology Center, Purdue Univ., USA.* Mode interaction in silicon nitride micro-resonators is investigated. We provide clear experimental evidence of mode interaction between two families of transverse modes and demonstrate a link between such interactions and initiation of comb generation in resonators with normal dispersion.

**FW1D.3 • 11:15**
**Broadband Microresonator-Based Parametric Frequency Comb near Visible Wavelengths,** Kevin Luke[1], Yoshitomo Okawachi[2], Daniel O. Carvalho[1], Michael R. Lamont[1,2], Alexander L. Gaeta[2,3], Michal Lipson[1,3]; [1]*School of Electrical and Computer Engineering, Cornell Univ., USA;* [2]*School of Applied and Engineering Physics, Cornell Univ., USA;* [3]*Kavli Inst. at Cornell for Nanoscale Science, Cornell Univ., USA.* We demonstrate broadband frequency comb generation spanning over 700 nm from 830 to 1540 nm in a dispersion-engineered Si3N4 microresonator. To our knowledge, this is the broadest parametric comb generated near the visible wavelength range.

**FW1D.4 • 11:30**
**Synchronization Phenomena in Mode-locked Parametric Frequency Combs,** Yanan H. Wen[1], Michael R. Lamont[1,2], Isabel M. Kloumann[4], Steven H. Strogatz[4], Alexander L. Gaeta[1,3]; [1]*Applied & Engineering Physics, Cornell Univ., USA;* [2]*Electrical & Computer Engineering, Cornell Univ., USA;* [3]*Kavli Inst. at Cornell for Nanoscale Science, Cornell Univ., USA;* [4]*Center for Applied Mathematics, Cornell Univ., USA.* We show that the mode-locking dynamics in parametric frequency combs is equivalent to synchronization phenomena that occur in many physical systems as described by the Kuramoto model for coupled oscillators.

**FW1D.5 • 11:45**
**Local fluorescent dye excitation with guided second-harmonic in lithium niobate nanowires,** Anton Sergeyev[1], Reinhard Geiss[1], Alexander S. Solntsev[2], Ernst-Bernhard Kley[1], Thomas Pertsch[1], Rachel Grange[1]; [1]*Inst. of Applied Physics, Abbe Center of Photonics, Friedrich Schiller Univ., Germany;* [2]*Nonlinear Physics Center, Research School of Physics and Engineering, Australian National Univ., Australia.* We generate second-harmonic light in $LiNbO_3$ nanowires to excite fluorescent dye. We measure a 63pW second-harmonic threshold power to excite typical dye concentration for bioimaging. We calculate that 40x60nm$^2$ cross-sections nanowires can generate this power.

Wednesday, 11 June

## Executive Ballroom
## 210E

## CLEO: Science & Innovations

### SW1E • Pulse Compression—Continued

**SW1E.3 • 11:00** Invited

**Self-Compression to Sub-Cycle Regime in Kagome Hollow-Core Photonic Crystal Fiber,** Frédéric Gérôme[1], Tadas Balciunas[2], Coralie Fourcade-Dutin[1], Fan Guangyu[2], Tobias Witting[3], Alexander A. Voronin[4], Aleksei Zheltikov[4,5], G.g Paulus[6], Andrius Baltuska[2], Fetah Benabid[1]; [1]*GPPMM group, Xlim Research Inst., CNRS UMR 7252, France;* [2]*Vienna Univ. of Technology, Austria;* [3]*Imperial College London, UK;* [4]*M.V. Lomonosov Moscow State Univ., Russia;* [5]*Dept. of Physics and Astronomy, Texas A&M Univ., USA;* [6]*Inst. of Optics and Quantum Electronics, Germany.* We demonstrate sub-cycle gigawatt peak power pulses self-compressed by optical shock waves in a simple manner based on gas-filled kagome hollow-core photonic crystal fiber.

**SW1E.4 • 11:30**

**Low-energy Self-defocusing Soliton Compression at Optical Communication Wavelengths in Unpoled Lithium Niobate Ridge Waveguide,** Hairun Guo[1], Xianglong Zeng[2], Binbin Zhou[1], Morten Bache[1]; [1]*Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark;* [2]*Key Lab of Special Fiber Optics and Optical Access Networks, Shanghai Univ., China.* Self-defocusing soliton compression supported by the cascaded phase-mismatched second-harmonic generation process is numerically demonstrated in unpoled lithium niobate ridge waveguides where nano-joule pulses are operated and quasi-phase-matching is unnecessary. The soliton range is 1100-1800 nm.

**SW1E.5 • 11:45**

**Tunable single-cycle pulse compression at the group-velocity horizon,** Ayhan Demircan[1], Shalva Amiranashvili[2], Carsten Bree[2], Uwe Morgner[1], Gunter Steinmeyer[3]; [1]*Leibniz Univ. Hannover, Germany;* [2]*Weierstrass Inst. for Applied Analysis and Stochastics, Germany;* [3]*Max-Born-Institut, Germany.* An adjustable adiabatic soliton compression scheme is presented, enabling pulse generation in the single-cycle regime. The compression comes without external dispersion compensation and is naturally stimulated by two-pulse collisions in an optical event horizon.

## Executive Ballroom
## 210F

### SW1F • Nonlinear THz Science and Technology—Continued

**SW1F.2 • 11:00**

**Extreme Terahertz Nonlinearities in Undoped GaAs Driven by Ultrahigh Near-Fields in Metamaterials,** Christoph Lange[1], Thomas Maag[1], Matthias Hohenleutner[1], Sebastian Baierl[1], Eric Edwards[2], Dominique Bougeard[1], Georg Woltersdorf[2], Rupert Huber[1]; [1]*Dept. of Physics, Univ. of Regensburg, Germany;* [2]*Dept. of Physics, Univ. of Halle, Germany.* Local terahertz fields of multiple 10 MV/cm tailored in gold metamaterials drive electronic interband transitions in intrinsic GaAs. The bandgap exceeds the THz photon energy 400-fold. Photoluminescence microscopy maps the THz near-field distribution.

**SW1F.3 • 11:15**

**Nonlinear THz conductivity in graphene,** Zoltan Mics[1], Soren Jensen[1], Khaled Parvez[1], Ivan Ivanov[1], Klaas-Jan Tielrooij[2], Frank Koppens[2], XinLiang Feng[1], Klaus Müllen[1], Mischa Bonn[1], Dmitry Turchinovich[1,3]; [1]*Max Planck Inst. f. Polymer Research, Germany;* [2]*The Inst. of Photonic Sciences, Spain;* [3]*DTU Fotonik, Technical Univ. of Denmark, Denmark.* We report the nonlinear THz conductivity of graphene. The heating of charge carriers by strong THz pulses results in a reduction of the high-frequency conductivity of graphene, in spite of reduced scattering for high-energy carriers.

**SW1F.4 • 11:30**

**Scaling up of intense terahertz pulses pumped with 800 nm light pulse,** François Blanchard[1], Hadi Razavipour[1], Hassan Hafez[2], xavier ropagnol[2], Martin Bolduc[3], Roberto Morandotti[2], Tsuneyuki Ozaki[2], David G. Cooke[1]; [1]*Physics, McGill Univ., Canada;* [2]*Institut national de la recherche scientifique, Canada;* [3]*Institut national d'Optique, Canada.* We investigate the terahertz generation efficiency dependence as function of the pulse width durations at 800 nm. Our results confirmed conversion efficiency of 0.35% with saturation at 240 fs of pulse width duration.

**SW1F.5 • 11:45**

**Efficient Generation of THz Pulses with 0.4 mJ Energy,** József A. Fülöp[1,3], Zoltán Ollmann[2], Csaba Lombosi[2], Christoph Skrobol[4,5], Sandro Klingebiel[4], László Pálfalvi[2], Ferenc Krausz[4,5], Stefan Karsch[4,5], János Hebling[1,2]; [1]*MTA-PTE High-Field Terahertz Research Group, Hungary;* [2]*Univ. of Pécs, Hungary;* [3]*ELI-Hu Nkft., Hungary;* [4]*Max-Planck-Institut für Quantenoptik, Germany;* [5]*Ludwig-Maximilians-Universität, Germany.* THz pulses above 0.4 mJ energy were generated with 0.77% efficiency by optical rectification of 785-fs laser pulses in LiNbO3 using tilted-pulse-front pumping. The spectral peak is at about 0.2 THz, suitable for charged-particle manipulation.

## Executive Ballroom
## 210G

### SW1G • Emerging Trends in Semiconductor Lasers—Continued

**SW1G.2 • 11:00** ▶

**Measurement of the Second Order Coherence of a Nanolaser Through Its Intra-cavity Second Harmonic Generation,** Yasutomo Ota[1], Katsuyuki Watanabe[2], Satoshi Iwamoto[1,2], Yasuhiko Arakawa[1,2]; [1]*Nanoquine, Univ. of Tokyo, Japan;* [2]*IIS, Univ. of Tokyo, Japan.* We measured the second order coherence of a photonic crystal nanolaser through measuring frequency doubling occurring within the laser nanocavity. This method enables investigation of the intensity noise properties even far below the lasing threshold.

**SW1G.3 • 11:15** ▶

**Gallium Nitride Nanotube Lasers,** Changyi Li[1], Antonio Hurtado[2], Jeremy B. Wright[1,3], Huiwen Xu[1], Sheng Liu[3,4], Ting S. Luk[3,4], Igal Brener[3,4], Steven R. Brueck[1], George T. Wang[3]; [1]*Center for High Technology Materials, Univ. of New Mexico, USA;* [2]*School of Computer Science and Electronic Engineering, Univ. of Essex, UK;* [3]*Sandia National Labs, USA;* [4]*Center for Integrated Nanotechnology, Sandia National Labs, USA.* Lasing is demonstrated from gallium nitride nanotubes fabricated using a two-step top-down technique. By optically pumping, we observed characteristics of lasing: a clear threshold, a narrow spectral, and guided emission from the nanotubes.

**SW1G.4 • 11:30** Tutorial ▶

**Dealing with Loss in Plasmonics and Metamaterials,** Jacob Khurgin[1]; [1]*Johns Hopkins Univ., USA.* Loss in the metal is the main factor restricting practicality of plasmonic and metamaterial devices. In this tutorial the inevitability of the loss, its physical origins and the means to mitigate it will be considered.

Jacob B Khurgin has been a Professor of electrical and computer engineering at Johns Hopkins University for 26 years. Prior to John Hopkins Univ. he was a researcher at Philips Laboratories. His areas of interest include semiconductor devices, nonlinear optics, integrated optics, condensed matter physics and communications. He has authored of 300 journal articles and holds 30 patents.

## Executive Ballroom
## 210H

## CLEO: Applications & Technology

### AW1H • Material Structuration for Next Generation Sensors and Components—Continued

**AW1H.3 • 11:00**

**Femtosecond laser modification of Li(NiCoMn)O2 electrodes for lithium-ion batteries,** Peter Smyrek[1], Johannes Proell[1], Wilhelm Pfleging[1,2]; [1]*IAM-AWP, Karlsruhe Inst. of Technology, Germany;* [2]*LMP, Karlsruhe Nano Micro Facility, Germany.* Ultrafast laser micromachining processes for modification and formation of three-dimensional architectures in cathode materials were developed. The electrochemical properties were investigated applying cell test with current densities in the range of (0.05-28.79) mA/cm2.

**AW1H.4 • 11:30** Invited

**Ultrafast Laser Writing of Advanced Guided Wave Communications Components,** Nicholas Psaila[1]; [1]*Heriot-Watt Univ., UK.* The use of ultrafast laser writing for fabricating advanced 3D waveguide components is presented and demonstrated. Couplers for space division multiplexing allowing beyond Shannon limit spectral efficiency, and 3D hybrid integration capabilities are discussed.

## Meeting Room 211 B/D

## CLEO: Science & Innovations

### SW1I • Solitons and Nonlinear Propagation—Continued

**SW1I.2 • 11:30** ▶

**Spectrally resolved shot-to-shot nonlinear dynamics of a passive PCF ring cavity,** Michael J. Schmidberger[1,2], Pooria Hosseini[2,1], David Novoa[1], Alessio Stefani[1], Philip St.J. Russell[1,2], Nicolas Joly[2,1]; [1]*Russell, Max-Planck-Inst. for the Science of Light, Germany;* [2]*Dept. of Physics, Univ. of Erlangen-Nuremberg, Germany.* The global experimental bifurcation diagram of a passively pumped PCF ring cavity is analyzed. We observe unequal shot-to-shot evolution of different spectral regions of the cavity pulse, and confirm this using two independent measurement techniques.

**SW1I.3 • 11:45** ▶

**Experimental Measurement of Supercontinuum Second Order Coherence,** Mikko Närhi[1], Minna Korhonen[2], Jari Turunen[2], Ari Friberg[2], Goëry Genty[1]; [1]*Physics, Tampere Univ. of Technology, Finland;* [2]*Physics and Mathematics, Univ. of Eastern Finland, Finland.* We report the first experimental measurements of second-order coherence functions of supercontinuum light. The method is based on measuring separately the quasi-coherent and quasi-stationary contributions using a combination of interferometric and nonlinear gating techniques.

## Meeting Room 212 A/C

### SW1J • Bandwidth Efficient Signaling—Continued

**SW1J.3 • 11:00**

**Flexible Terabit/s Nyquist-WDM Superchannels with net SE > 7bit/s/Hz using a Gain-Switched Comb Source,** Vidak Vujicic[1], Joerg Pfeifle[2], Regan Watts[1], Philipp C. Schindler[2], Claudius Weimann[2], Rui Zhou[1], Wolfgang Freude[2,3], Christian G. Koos[2,3], Liam Barry[1]; [1]*School Of Electronic Engineering, Dublin City Univ., Ireland;* [2]*Inst. of Photonics and Quantum Electronics, Karlsruhe Inst. of Technology, Germany;* [3]*Inst. of Microstructure Technology, Karlsruhe Inst. of Technology, Germany.* We demonstrate two 1Tbit/s superchannel architectures using a compact, FSR-tunable gain-switched comb source. SSMF transmission of 18GBaud Nyquist-WDM shaped PDM-QPSK and PDM-16QAM modulation is reported, with a capacity up to 1.296Tbit/s and SE of 7.2bit/s/Hz.

**SW1J.4 • 11:15**

**All-optical demultiplexing of Nyquist OTDM using a Nyquist gate,** Jasper R. Stroud[1], Mark A. Foster[1]; [1]*Johns Hopkins Univ., USA.* We present an approach to all-optical demultiplexing of ultrafast Nyquist OTDM signals using four-wave mixing with a Nyquist gate. Our design does not suffer from the tradeoff between SNR and ISI of existing approaches.

**SW1J.5 • 11:30**

**Transmitter Sensitivity to High PAPR in Coherent Optical OFDM Systems,** Siamak Amiralizadeh[1], Leslie Rusch[1]; [1]*Center for Optics, Photonics and Lasers (COPL), Universite Laval, Canada.* We investigate degradation of QPSK CO-OFDM system due to components most susceptible to high PAPR. We vary transmitter design parameters and uncover appropriate working conditions and clipping effectiveness regions.

**SW1J.6 • 11:45**

**Generation of SSB Optical Signals with Dual-EML Modulated with Wideband OFDM,** Mohamed Essghair Chaibi[1], Didier Erasme[1], Thomas Anfray[2], Christelle Aupetit-Berthelemot[2], Christophe Kazmierski[3]; [1]*MINES-TELECOM, TELECOM ParisTech, CNRS LTCI, France;* [2]*XLIM-CNRS, France;* [3]*III-V Lab-Common Lab of "Alcatel-Lucent Bell Labs France","Thales Research and Technology" and "CEA Leti", France.* The generation of optical SSB signals by a Dual-EML is generalized for wideband modulating signals. The feasibility of the proposed technique is demonstrated by transmitting 5.3 GHz baseband OFDM signal in an optical SSB context.

## Meeting Room 212 B/D

## CLEO: QELS-Fundamental Science

### FW1K • Metasurfaces and Plasmonic Metamaterials—Continued

**FW1K.2 • 11:30** ▶

**Far field characterization of light propagation in hyperbolic metamaterial with multi metal-dielectric layers,** Xiangang Luo[1]; [1]*CAS Inst. of Optics and Electronics, China.* Far field characterization of light propagation in metamaterial with multi metal-dielectric layers is performed by introducing rough surface and nano grating structures. Light directional imaging and evanescent wave moiré fringes are observed in experiments.

**FW1K.3 • 11:45** ▶

**Angle-independent Salisbury screens based on nonlocal nanowire metamaterials,** Brian Wells[1], Christopher Roberts[1], Viktor A. Podolskiy[1]; [1]*Physics and Applied Physics, Univ Massachusets Lowell, USA.* We demonstrate that nonlocal nanowire metamaterials can help to alleviate one of the main limitations of Salisbury screens, their dependence on the incident angle.

## Marriott Salon I & II

## CLEO: Applications & Technology

### AW1L • Imaging and Sensing—Continued

**AW1L.2 • 11:30**

**Photophysical Properties of Novel Ru-complex Probes for Two-photon Dissolved Oxygen Imaging,** Aamir A. Khan[1], Tahsin Ahmed[1], Genevieve Vigil[1], Susan K. Fullerton-Shirey[1], Scott S. Howard[1]; [1]*Dept. of Electrical Engineering, Univ. of Notre Dame, USA.* Oxygen-sensitive hydrophobic indicators encapsulated in poloxamer nanomicelles are quantitatively demonstrated to preserve the oxygen-sensitivity and the two-photon induced phosphorescence in a ruthenium-complex indicator, thus providing for economical dissolved oxygen imaging probes.

**AW1L.3 • 11:45**

**Lab-on-chip Silicon Nitride Microring Sensor at Visible Wavelength Using Glycoprotein Receptors,** Farshid Ghasemi[1], Ali A. Eftekhar[1], Hamed Shams Mousavi[1], Reza Abbaspour[1], Hesam Moradinejad[1], Ali Adibi[1]; [1]*Electrical and Computer Engineering, Georgia Inst. of Technology, USA.* A full biosensor system based on referenced and spectrally multiplexed arrays of silicon nitride microrings with glycoprotein receptors is demonstrated. Underlying system design guidelines and fundamental noise limits of the device are discussed.

## Marriott
## Salon III

## CLEO: Science & Innovations

### SW1M • Micro and Nanophotnic Devices—Continued

**SW1M.2 • 11:00**
**Observation of visible-wavelength electric and magnetic resonances on silicon nanorods,** Wuzhou Song[1], Kenneth B. Crozier[1]; [1]*Havard Univ., USA.* We fabricated silicon nanorods on silica substrates, and show that they support electric and magnetic resonances by simulation and experiment. Due to these resonances, the nanorods appear vivid colors when observed by optical microscopy.

**SW1M.3 • 11:15**
**Photonic Crystal Enhanced Photoacoustic Detection,** Yunfei Zhao[1], Kaiyang Liu[1], John F. McClelland[2,4], Meng Lu[1,3]; [1]*Dept. of Electrical and Computer Engineering, Iowa State Univ., USA;* [2]*Ames Lab-USDOE, USA;* [3]*Dept. of Mechanical Engineering, Iowa State Univ., USA;* [4]*Dept. of Biochemistry, Biophysics, and Molecular Biology, Iowa State Univ., USA.* A photonic crystal sensor has been demonstrated to enhance photoacoustic signal from light absorbing molecules. The developed system was applied to detect an absorbing dye and gold nanoparticles and exhibited signal enhancement over 40 times.

**SW1M.4 • 11:30**
**Narrowband Four Wave Mixing in InGaP Photonic Crystal Waveguides,** Amnon Willinger[1], Gadi Eisenstein[1], Sylvain Combrie[2], Alfredo De Rossi[2]; [1]*Electrical Enginnering, Technion - Israel Inst. of Technology, Israel;* [2]*Thales Research and Technology, France.* Abstract We demonstrate the first narrowband parametric interaction in a semiconductor (GaInP) photonic crystal waveguide. A pulsed pump, propagating in the normal dispersion regime yields a conversion efficiency of -10dB with a moderate peak pump power of 650mW .

**SW1M.5 • 11:45**
**Heterogeneously Integrated MIR Silicon Photonics,** Yu Chen[1], Hongtao Lin[2], Juejun Hu[2], Mo Li[1]; [1]*Univ. of Minnesota Twin Cities, USA;* [2]*Material Science and Engineering, Univ. of Delaware, USA.* By utilizing heterogeneous integration method, integrated silicon photonics on mid-IR compatible substrate has been fabricated and on-chip cavity-enhanced mid-IR spectroscopic analysis of organic chemicals has been demonstrated.

## Marriott
## Salon IV

### SW1N • Novel Fiber Laser Designs—Continued

**SW1N.2 • 11:00**
**Ultra-short wavelength operation of a two-micron thulium fiber laser,** Jae M. Daniel[1], Nikita Simakov[1,2], Masaki Tokurakawa[1,3], Morten Ibsen[1], W. A. Clarkson[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK;* [2]*Cyber and Electronic Warfare Division, Defence Science and Technology Organisation, Australia;* [3]*Inst. for Laser Science, Univ. of Electro-Communications, Japan.* The short wavelength limit of a thulium fiber laser is investigated. Wavelength tuning from 1720nm to 1660nm was demonstrated and fixed wavelength operation up to 12.6W at 1726nm with slope efficiency of 67% was achieved.

**SW1N.3 • 11:15**
**Watt-level fluoride fiber lasers and amplifiers in the 1.2 μm region,** Xiushan Zhu[1,2], Jie Zong[1], Kort Wiersma[1], Robert A. Norwood[2], Narasimha S. Prasad[3], Michael D. Obland[3], Arturo Chavez-Pirson[1], Nasser Peyghambarian[2]; [1]*NP Photonics, USA;* [2]*Univ. of Arizona, USA;* [3]*NASA Langley Research Center, USA.* Holmium-doped ZBLAN fiber has proven to be an efficient high gain material in the 1.2 μm region. In this paper, single-mode fiber lasers and amplifiers at 1178 nm, 1190 nm, and 1200 nm are reported. Over 2 watts of continuous wave output power was achieved with a 10-cm long gain fiber.

**SW1N.4 • 11:30**
**A 160 mW Output, 5 kHz Linewidth Frequency-Stabilized Erbium Silica Fiber Laser with a Short Cavity Configuration,** Keisuke Kasai[1], Akira Fujisaki[1], Masato Yoshida[1], Toshihiko Hirooka[1], Masataka Nakazawa[1], Shin Masuda[2]; [1]*Research Inst. of Electrical Communication, Tohoku Univ., Japan;* [2]*Advantest Labs, Ltd., Japan.* We demonstrate a 160 mW output, $^{13}C_2H_2$ frequency-stabilized erbium silica fiber laser. The frequency stability reached $8.8\times10^{-12}$ for $\tau$=100s. Furthermore, a linewidth of 5 kHz and a RIN of -130 dB/Hz were simultaneously achieved.

**SW1N.5 • 11:45**
**Ultra-narrow linewidth fiber laser with self-injection feedback based on Rayleigh backscattering,** leilei shi[1], Tao Zhu[1], Shihong Huang[1]; [1]*Chongqing Univ., China.* We propose a single longitudinal mode fiber laser with ultra-narrow linewidth of ~130 Hz by combining self-injection feedback and Rayleigh backscattering, in which Rayleigh backscattering collected by self-injection feedback is utilized as linewidth compressor.

## Marriott
## Salon V & VI

### SW1O • Laser Frequency Combs—Continued

**SW1O.3 • 11:00**
**Carrier-Envelope-Offset Frequency Stabilization and Noise Analysis of a SESAM-Modelocked Thin Disk Laser,** Florian Emaury[1], Alexander Klenner[1], Andreas Diebold[1], Cinia Schriber[1], Clara J. Saraceno[1,2], Stephane Schilt[2], Ursula Keller[1], Thomas Südmeyer[2]; [1]*ETH Zurich, Switzerland;* [2]*Université de Neuchâtel, Switzerland.* We present the first phase stabilization of the carrier envelope offset frequency of a SESAM-modelocked thin disk laser (<120 mrad at 1 Hz-1 MHz) and measure the influence of different noise sources such as multi-transverse-mode high-power diode-pumping.

**SW1O.4 • 11:15**
**Compact and ultra-high-resolution spectrograph with multi-GHz optical frequency comb,** Mamoru Endo[1,2], Takashi Sukegawa[3], Alissa Silva[1,2], Yohei Kobayashi[1,2]; [1]*The Inst. for Solid State Physics, The Univ. of Tokyo, Japan;* [2]*Exploratory Research for Advanced Technology (ERATO), JST, Japan;* [3]*Corporate R&D Headquarters, Canon Inc., Japan.* A 4-GHz optical frequency comb with a laser-diode pumped Yb:$Y_2O_3$ ceramic oscillator is demonstrated. Each comb tooth was resolved by a home-made, sub-gigahertz frequency resolution grating spectrograph, which would be useful for many small observatories.

**SW1O.5 • 11:30**
**500 MHz Yb:fiber laser frequency comb,** Guizhong Wang[1], Fei Meng[2], Chen Li[1], Tongxiao Jiang[1], Yizhou Liu[1], Aimin Wang[1], Zhanjun Fang[2], Zhigang Zhang[1]; [1]*Peking Univ., China;* [2]*National Inst. of Metrology, China.* We report direct generation of 500MHz Yb:fiber laser frequency comb. The offset frequency was stabilized more than 6 hours in an open air environment. The stabilized repetition rate has an in-loop tracking stability of 4.46*10-13/s.

**SW1O.6 • 11:45**
**Opto-Optical Modulation of an Intra-Cavity SESAM for Low-Noise CEO Stabilization of a Femtosecond Laser,** Martin Hoffmann[1], Stephane Schilt[1], Thomas Südmeyer[1]; [1]*Universite de Neuchatel, Switzerland.* We present a CEO-stabilization technique based on optical feedback to an intra-cavity SESAM with significantly improved bandwidth compared to standard pump current control, enabling a CEO-locked Er:Yb:glass laser with ten times lower residual phase noise.

## Marriott
## Willow Glen I-III

## CLEO: Applications & Technology

### AW1P • Spectroscopy and Imaging Applications—Continued

**AW1P.3 • 11:00** **Invited**
**Ultrafast X-ray Absorption Spectroscopy using Superconducting Microcalorimeter Sensors,** Joel Ullom[1], Marla Dowell[1], Joseph Fowler[1], Luis Miaja[1], Galen O'Neil[1], Kevin Silverman[1], Daniel Swetz[1], Dodderi Sagar[2], Zin Yoon[2], Ralph Jimenez[2], Jens Uhlig[3], Wilfred Fullagar[3], Dharmalingam Kurunthu[3], Ujjwal Mandal[3], Villy Sundstrom[3]; [1]*NIST, USA;* [2]*JILA, USA;* [3]*Dept. of Chemical Physics, Lund Univ., Sweden.* We are developing a table-top system for ultrafast x-ray spectroscopy based on a sub-picosecond x-ray source. We perform high-resolution spectroscopy of the x-rays after they interact with a sample using an array of superconducting microcalorimeters.

**AW1P.4 • 11:30**
**Single-mode, high repetition rate, compact Ho:YLF laser for space-borne lidar applications,** Yingxin Bai[1], Jirong Yu[2], Tehhwa Wong[1], Songsheng Chen[2], Mulugeta Petros[2], Robert Menzies[3], Upendra Singh[2]; [1]*Science Systems & Applications Inc, USA;* [2]*Active remote sensing, NASA Langley Research Center, USA;* [3]*NASA Jet Propulsion Lab, USA.* A single transverse/longitudinal mode, compact Q-switched Ho:YLF laser has been designed and demonstrated for space-borne lidar applications. The pulse energy is between 34-40 mJ for 100-200 Hz operation. The corresponding peak power is >1 MW.

**AW1P.5 • 11:45**
**Beyond 10 Km Range wind-speed measurement with a 1.5 μm all-fiber laser source,** William Renard[1], Didier Goular[1], Matthieu Valla[1], Christophe Planchat[1], Beatrice Augere[1], Agnes Dolfi-Bouteyre[1], Claudine Besson[1], Guillaume Canat[1]; [1]*Theroretical and Applied Optics Dept., Onera - The French Aerospace Lab., France.* We report the development of a high power single-frequency all-fiber laser for long-range wind speed measurement. The laser source has been integrated in a Lidar architecture and we report wind-speed measurement beyond 10 km.

## CLEO: QELS-Fundamental Science

### Executive Ballroom 210A

### FW1A • Fundamental Quantum Science—Continued

**FW1A.7 • 12:00**
**Observation of Topological Structures in Photonic Quantum Walks,** Graciana Puentes[1,2], Ilja Gerhardt[2], Fabian Katzschmann[3], Chrisitine Silberhorn[3], Jörg Wrachtrup[2], Maciej Lewenstein[1]; [1]*ICFO -The Inst. of Photonic Sciences, Spain;* [2]*3 Physik. Insitut, Universität Stuttgart, Germany;* [3]*Applied Physics, Universität Paderborn, Germany.* We present an experimental observation of topological structure in 1D photonic discrete-time quantum walks. We probe the full topological landscape demonstrating emergence of localized bound states, and existence of extremely (de)localized non-Gaussian quantum states.

**FW1A.8 • 12:15**
**Entanglement discloses Time as an emergent phenomenon,** marco gramegna[1]; [1]*Quantum Optics, INRIM, Italy.* Page and Wootters' mechanism of "static" time is experimentally implemented by a toy universe consisting of a polarization entangled photon pair, one of which serves as a clock to gauge the evolution of the second.

### Executive Ballroom 210B

### FW1B • Spin Coherence in Color Centers in Diamond—Continued

**FW1B.6 • 12:00**
**Targeted creation and Purcell enhancement of NV centers within photonic crystal cavities in single-crystal diamond,** Tim Schroder[1], Edward Chen[1], Luozhou Li[1,2], Michael Walsh[1], Matthew E. Trusheim[1], Igal Bayn[1], Dirk Englund[1]; [1]*MIT, USA;* [2]*Columbia Univ., USA.* We demonstrate Purcell enhancement of single NV centers in L3 photonic crystal cavities made from high-purity single-crystal diamond. Furthermore, NV centers were created using an implantation mask in the cavity high field region.

**FW1B.7 • 12:15**
**Efficient Integration of High-Purity Diamond Nanostructures into Silicon Nitride Photonic Circuits,** Sara L. Mouradian[1], Tim Schroeder[1], Carl Poitras[3], Luozhou Li[2], Jaime Cardenas[3], Jordan Goldstein[1], Rishi Patel[1], Edward Chen[1], Matthew E. Trusheim[1], Igal Bayn[1,2], Michal Lipson[3], Dirk Englund[1]; [1]*MIT, USA;* [2]*Columbia Univ., USA;* [3]*Cornell Univ., USA.* A high purity diamond nanowire with implanted nitrogen-vacancy centers (NVs) is integrated into a low-loss silicon nitride photonic circuit. NV fluorescence is coupled into and collected from the waveguide system, paving the way for on-chip read out and manipulation of qubits.

### Executive Ballroom 210C

### FW1C • Symposium on Science and Applications of Structured Light in Complex Media I—Continued

**FW1C.5 • 12:00**
**Switching of Mid-Infrared Light Using Plasmonic Fano-Resonant Meta-Surfaces Integrated with Graphene,** Nima Dabidian[1], Iskandar Kholmanov[2], Alexander B. Khanikaev[1,3], Kaya Tatar[1], Simeon Trendafilov[1], Hossein S. Mousavi[1,4], Carl Magnunson[2], Rodney Ruoff[2], Gennady Shvets[1]; [1]*physics, Univ. of Texas at Austin, USA;* [2]*Mechanical engineering, Univ. of Texas at Austin, USA;* [3]*physics, Queens College of The City Univ. of New York, USA;* [4]*Electrical engineering, Univ. of Texas at Austin, USA.* We experimentally demonstrate that graphene can strongly modulate the scattered light from Fano-resonant plasmonic metasurfaces. The Modulation depth of 1000% is achieved at around 7μm as the graphene carrier concentration changes.

**FW1C.6 • 12:15**
**Scattering super-lens: subwavelength light focusing and imaging via wavefront shaping in complex media,** Jung-Hoon Park[1], Chunghyun Park[1], Yong-Hoon Cho[1], YongKeun Park[1]; [1]*Korea Advanced Inst. of Science and Technology, Korea.* We present a novel optical method exploiting multiple scattering to achieve sub-wavelength focusing and imaging using visible light. The evanescent near-field information are controlled by or transferred into far-field components by scattering from disordered nanoparticles.

### Executive Ballroom 210D

### FW1D • Wavelength Conversion in Micro-Structures—Continued

**FW1D.6 • 12:00**
**Phase-Locking in Multi-Frequency Brillouin Oscillator via Four-Wave Mixing,** Thomas Buettner[1], Irina V. Kabakova[1], Darren D. Hudson[1], Ravi Pant[1], Christopher G. Poulton[2,1], Alexander C. Judge[1], Benjamin J. Eggleton[1]; [1]*CUDOS, School of Physics, Univ. of Sydney, Australia;* [2]*CUDOS, School of Mathematical Sciences, Univ. of Technology, Australia.* We report the experimental demonstration and numerical modeling of phase-locking cascaded Stokes waves generated by Stimulated Brillouin Scattering via Kerr nonlinear four-wave mixing in a short, chalcogenide fiber resonator, producing phase-locked trains of picosecond pulses.

**FW1D.7 • 12:15**
**Supercontinuum Generation in Hydrogenated Amorphous Silicon Waveguides in the Femtosecond Regime,** Simon-Pierre Gorza[1], François Leo[3], Bart Kuyken[3], Shankar Kumar Selvaraja[3], Gunther Roelkens[3], Roel Baets[3], Philippe Emplit[1], Serge Massar[2], Jassem Safioui[1]; [1]*Service OPERA-photonique, Université Libre de Bruxelles, Belgium;* [2]*Laboratoire d'Information Quantique, Université libre de Bruxelles, Belgium;* [3]*INTEC Dept., Ghent Univ.-IMEC, Belgium.* Supercontinuum generation in CMOS compatible hydrogenated amorphous silicon waveguides with femtosecond pulses at telecommunication wavelengths is experimentally studied. It is shown that stable 540 nm broad supercontinua can be obtained in 1 cm-long waveguides.

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**12:00–13:30 VIP Industry Leaders Networking Event,** *Exhibit Hall 3*
*(lunch provided, registration required)*

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**12:30–13:30 Lunch and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2 (concessions available)*

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NOTES

## CLEO: Science & Innovations

### Executive Ballroom 210E

### SW1E • Pulse Compression—Continued

**SW1E.6 • 12:00**
**Tilted Transmission Grisms for Pulse Compression with Dispersion Control Up to the Fourth Order,** Stéphanie Grabielle[1], Nicolas Forget[1], Pierre Tournois[1]; [1]*FASTLITE, France.* We demonstrate a grism compressor designed to compensate the second, third and fourth order dispersions of a 1.5m SF57 stretcher at 800nm.

**SW1E.7 • 12:15**
**High-energy pulse compressor using self-defocusing spectral broadening in anomalously dispersive media,** Morten Bache[1], Binbin Zhou[1]; [1]*Danmarks Tekniske Universitet, Denmark.* A new high-energy pulse compressor uses self-defocusing spectral broadening in anomalously dispersive quadratic nonlinear crystals, followed by positive group-delay-dispersion compensation. Compression to sub-50 fs is possible from Joule-class 1.03 μm femtosecond amplifiers in large-aperture KDP.

### Executive Ballroom 210F

### SW1F • Nonlinear THz Science and Technology—Continued

**SW1F.6 • 12:00**
**Terahertz Conversion Efficiency Scaling by Optical Rectification in the 800 nm Pump-Wavelength Range,** Sergio Carbajo[1,2], Xiaojun Wu[1,2], Frederike Ahr[1], Franz Kärtner[1,3]; [1]*Center for Free Electron Laser Science, Germany;* [2]*The Hamburg Center for Ultrafast Imaging, Germany;* [3]*Research Laborartory of Electronics, MIT, USA.* We report on a record 800 nm-to-terahertz energy conversion efficiency of 0.13% at room temperature in LiNbO3 by tilting the pulse intensity front and experimentally studying optimal pumping conditions.

**SW1F.7 • 12:15**
**MV/cm Terahertz transients in the THz gap (1-20 THz) from organic crystals,** Carlo Vicario[1], Balazs Monoszlai[1], Christoph P. Hauri[1,2]; [1]*Paul Scherrer Institut, Switzerland;* [2]*Ecole Polytechnique Federale de Lausanne, Switzerland.* We demonstrate highly efficient Terahertz production and absolute phase control in the hardly accessible THz frequency gap by optical rectification in organic crystals leading to single-cycle field oscillations beyond 150 MV/m and 0.5 Tesla.

### Executive Ballroom 210G

### SW1G • Emerging Trends in Semiconductor Lasers—Continued

### Executive Ballroom 210H

## CLEO: Applications & Technology

### AW1H • Material Structuration for Next Generation Sensors and Components—Continued

**AW1H.5 • 12:00**
**Monolithic Three Dimensional Dielectrophoretic Actuator for Positioning Optics Fabricated by Femtosecond Laser,** Tao Yang[1], Yves Bellouard[1]; [1]*Eindhoven Univ. of Technology, Netherlands.* We report a monolithic three dimensional dielectrophoretic micro-actuator fabricated by femtosecond laser in fused silica. Such actuators are useful for fine positioning of optical fibers and for introducing optomechanical coupling in waveguides.

**AW1H.6 • 12:15**
**A monolithic micro-tensile tester for investigating silica micromechanics, fabricated *and* fully operated using a femtosecond laser,** Christos-Edward Athanasiou[1], Ben McMillen[1], Yves Bellouard[1]; [1]*TU/e, Netherlands.* We report on the use of femtosecond laser for fabricating, loading *and* in-situ measuring using third-harmonic signal generation a micro-tensile tester for characterizing silica and its polymorphic phases.

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12:00–13:30 **VIP Industry Leaders Networking Event,** *Exhibit Hall 3*
*(lunch provided, registration required)*

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12:30–13:30 **Lunch and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2 (concessions available)*

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**Meeting Room 211 B/D**

## CLEO: Science & Innovations

### SW1I • Solitons and Nonlinear Propagation—Continued

**SW1I.4 • 12:00**
**Vacuum-UV Dispersive Wave Emission Using Gas-Filled Hollow-Core PCF,** Alexey Ermolov[1], Ka Fai Mak[1], Philipp Hoelzer[1], John C. Travers[1], Philip St.J. Russell[1,2]; [1]*Max Planck Inst. for the Science, Germany;* [2]*Univ. of Erlangen-Nuremberg, Germany.* Vacuum-UV radiation between 145-155 nm is generated from 40 fs, 800 nm 6.8 μJ pump pulses in a 34 μm core-diameter kagomé-PCF filled with 20-25 bar neon. Simulations confirm the mechanism as resonant dispersive-wave emission.

**SW1I.5 • 12:15**
**Efficiency of dispersive wave generation by cascaded four-wave mixing,** Karen E. Webb[1], Miro J. Erkintalo[1], Yiqing Xu[1,2], Goëry Genty[3], John M. Dudley[4], Stuart G. Murdoch[1]; [1]*Univ. of Auckland, New Zealand;* [2]*Univ. of Hong Kong, Hong Kong;* [3]*Tampere Univ. of Technology, Finland;* [4]*Universite de Franche-Comte, France.* We experimentally show that the pump frequency detuning strongly affects the efficiency of dispersive wave generation by cascaded four-wave mixing. We explain our results in terms of higher-order soliton compression of the input beat signal.

**Meeting Room 212 A/C**

### SW1J • Bandwidth Efficient Signaling—Continued

**SW1J.7 • 12:00**
**ASE Noise Suppressed Optical Multi-carrier Generation using Optical FIR Filter in Frequency Shifter Loop,** Jiachuan Lin[1], Xiaoguang Zhang[1], Jianrui Li[1], Lixia Xi[1], Xia Zhang[1,2]; [1]*State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China;* [2]*The Key Lab of Optical Communications Science & Technology in Shandong Province, Liaocheng Univ., China.* A low noise multi-carrier generation scheme using optical FIR filter for ASE noise suppressing is proposed. 50 and 69 low noise carriers are generated experimentally, having much higher carrier-to-noise-ratio values of 22.5dB and 19.1dB.

**SW1J.8 • 12:15**
**Improving Broad-band Mid-span Spectral Inversion Performance for Fiber Nonlinearity Compensation,** Mohammad M. Morshed[1,2], Bill Corcoran[1,2], Arthur Lowery[1,2]; [1]*Electrical and Computer Systems Engineering, Monash Univ., Australia;* [2]*Center for Ultrahigh bandwidth Devices for Optical Systems (CUDOS), Monash Univ., Australia.* We investigate design approaches for improving the performance of broad-band mid-span spectral inversion. Simulations show at least 0.7 dB peak Q improvement of a 160-GHz wide 16-QAM OFDM super channel after 800 km transmission.

**Meeting Room 212 B/D**

## CLEO: QELS-Fundamental Science

### FW1K • Metasurfaces and Plasmonic Metamaterials—Continued

**FW1K.4 • 12:00**
**GZO/ZnO Multilayered nanodisk metasurface to engineer the plasma frequency,** Jongbum Kim[1], Babak Memarzadeh[2], Aveek Dutta[1], Sajid M. Choudhury[1], Alexander Kildishev[1], Hossein Mosallaei[2], Alexandra Boltasseva[1]; [1]*Purdue Univ., USA;* [2]*Northeastern Univ., USA.* We demonstrate that a multilayered nanodisk metasurface based on semiconductor materials offers the design flexibility for tuning the plasmonic resonance by controlling the ratio between the metal and dielectric layers.

**FW1K.5 • 12:15**
**Silicon on sapphire mid-IR wave-front engineering by using sub-wavelength gratings,** Yuewang Huang[1], Qiancheng Zhao[1], Salih K. Kalyoncu[1], Rasul Torun[1], Yumeng Lu[1], Ozdal Boyraz[1]; [1]*Univ. of California Irvine, USA.* We propose a methodology to manipulate reflected field for the design of wavefront engineered device in mid-IR range using sub-wavelength silicon gratings on sapphire substrate. High reflectivity mirror, blazed grating and focusing reflector are designed.

**Marriott Salon I & II**

## CLEO: Applications & Technology

### AW1L • Imaging and Sensing—Continued

**AW1L.4 • 12:00**
**Fiber-Optic EFPI/FBG Dual Sensor for Monitoring of Radiofrequency Thermal Ablation of Liver Tumors,** Daniele Tosi[1], Edoardo G. Macchi[2], Mario Gallati[2], Giovanni Braschi[2], Alfredo Cigada[3], Sandro Rossi[4], Sven Poeggel[1], Gabriel Leen[1], Elfed Lewis[1]; [1]*Optical Fibre Sensors Research Centre, Univ. of Limerick, Ireland;* [2]*Dipartimento di Ingegneria Civile ed Architettura, Universita, Italy;* [3]*Dipartimento di Meccanica, Politecnico di Milano, Italy;* [4]*VI Dept. of Internal Medicine, IRCCS Policlinico San Matteo Foundation, Italy.* A dual EFPI/FBG pressure and temperature sensing architecture, biocompatible and with minimum cross-sensitivity, is presented. The system performs online monitoring of radiofrequency thermal ablation in liver tumor, detecting the physical phenomena; ex-vivo experiments are reported.

**AW1L.5 • 12:15**
**High Repetition-Rate, Pulse-Burst Assisted Desorption, Electrospray Post-Ionization Mass Spectrometry,** Paul Flanigan[1], Fengjian Shi[1], Jieutonne Archer[1], Andrew Mills[2], Martin Fermann[2], Robert Levis[1]; [1]*Chemistry, Temple Univ., USA;* [2]*IMRA America, Inc, USA.* We demonstrate electrospray post-ionization mass spectrometry with an Yb fiber laser producing 500 fs, 50 μJ pulse-bursts, enabling protein, peptide and lipid identification and imaging for the pharmaceutical and biomedical realm.

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**12:00–13:30 VIP Industry Leaders Networking Event,** *Exhibit Hall 3*
*(lunch provided, registration required)*

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**12:30–13:30 Lunch and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2 (concessions available)*

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## CLEO: Science & Innovations

### Marriott Salon III

### SW1M • Micro and Nanophotnic Devices—Continued

**SW1M.6 • 12:00**
**Flexible Crystalline Silicon Nanomembrane Photonic Crystal Microcavity,** Xiaochuan Xu[1,2], Harish Subbaraman[2], Amir Hosseini[2], Swapnajit Chakravarty[2], Ray Chen[1]; [1]*Univ. of Texas at Austin, USA;* [2]*Omega Optics, Inc., USA.* We for the first time demonstrated a flexible crystalline silicon nanomembrane photonic crystal microcavity, which shows a quality factor of 22000 and could be bent to a radius of 5 mm.

**SW1M.7 • 12:15**
**Beam focalization by chirped mirrors,** Yu-Chieh Cheng[1], Martynas Peckus[2], Simonas Kicas[2], Josep Trull[1], Crina Cojocaru[1], Ramon Vilaseca[1], Ramutis Drazdys[2], Kestutis Staliunas[1,3]; [1]*Departament de Física i Enginyeria Nuclear, Universitat Politècnica de Catalunya, Spain;* [2]*State Research Inst. for Physical Sciences and Technology, Lithuania;* [3]*Institució Catalana de Reserca i Estudis Avançats (ICREA), Spain.* A novel application of chirped dielectric mirrors for narrow beam focalization is proposed and demonstrated numerically and experimentally. Analogy to temporal dispersion compensation by chirped dielectric mirrors is discussed.

### Marriott Salon IV

### SW1N • Novel Fiber Laser Designs—Continued

**SW1N.6 • 12:00**
**Analysis of Dynamic Properties of Dispersion-Tuned Lasers,** Yuta Hasegawa[1], Shinji Yamashita[1]; [1]*Univ. of Tokyo, Japan.* We numerically investigate spectral changes due to sweep in dispersion-tuned lasers. We found that the sweep can be fast without spectral spread when the wavelength shifts to longer with anomalous dispersion and high modulation frequency.

**SW1N.7 • 12:15**
**MW peak power infrared source for tunable visible light generation by Four-Wave Mixing,** Romain Royon[1], Jérôme Lhermite[1], Eric Cormier[1]; [1]*CELIA, CNRS, France.* We report on a continuously tunable fiber laser emitting between 1020 nm and 1070 nm with peak power in excess of 4 MW. This source is optimally adapted for frequency conversion in the visible by means of Four wave mixing.

### Marriott Salon V & VI

### SW1O • Laser Frequency Combs—Continued

**SW1O.7 • 12:00**
**Toward an all-fiber based optically referenced frequency comb,** Chenchen Wang[1], Shun Wu[1], Coralie Fourcade Dutin[2,3], Brian R. Washburn[1], Fetah Benabid[2,3], Kristan L. Corwin[1]; [1]*Physics, Kansas State Univ., USA;* [2]*GPPMM group, Xlim Research Inst., France;* [3]*Physics, Univ. of Bath, UK.* A potentially portable optical metrology system is demonstrated by using an acetylene-filled optical fiber frequency reference as an optical reference to a fiber-laser based frequency comb without an intracavity EOM.

**SW1O.8 • 12:15**
**Enhancement cavity based high harmonics generation with post-compressed 10-MHz high power fiber CPA laser system,** Zhigang Zhao[1], Akira Ozawa[1,2], Makoto Kuwata-Gonokami[3,4], Yohei Kobayashi[1,2]; [1]*The Inst. for Solid State Physics, The Univ. of Tokyo, Japan;* [2]*Core Research for Evolutional Science and Technology (CREST), JST, Japan;* [3]*Dept. of Physics, The Univ. of Tokyo, Japan;* [4]*Photon Science Center, The Univ. of Tokyo, Japan.* High harmonics are generated inside an enhancement cavity with nonlinear compressed 10-MHz high power 70-fs laser as seed. Stable operation lasting over half an hour with more than 0.1 mW at 147 nm is demonstrated with low finesse cavity.

### Marriott Willow Glen I-III

## CLEO: Applications & Technology

### AW1P • Spectroscopy and Imaging Applications—Continued

**AW1P.6 • 12:00** **Invited**
**Infrared Digital Holography as New 3D Imaging Tool for First Responders and Firefighters: Recent Achievements and Perspectives,** Pietro Ferraro[1]; [1]*Istituto Nazionale di Ottica, Italy.* We demonstrate a novel concept for imaging live humans through smoke and flames. We make use of lens-less Digital Holography at far Infrared Radiation (IRDH) thus overcoming the limits of current IR sensors.

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**12:00–13:30 VIP Industry Leaders Networking Event,** *Exhibit Hall 3*
*(lunch provided, registration required)*

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**12:30–13:30 Lunch and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2 (concessions available)*

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## 13:30–15:00
## JW2A • Poster Session 2

**JW2A.1**
**Interdigitated Back-contact Solar Cells Implemented with Foundry CMOS Processes,** Yung-Jr Hung[1], Tsung-Yen Chuang[2], Chung-Lin Chun[1], Li-Chi Yang[2], San-Liang Lee[2]; [1]*Dept. of Photonics, National Sun Yat-sen Univ., Taiwan;* [2]*Dept. of Electronic Engineering, National Taiwan Univ of Science & Tech, Taiwan.* Interdigitated back-contact solar cells with two-dimensional doping design are realized by foundry CMOS processes. Experimental results indicate superior diode performance and a 4.6% conversion efficiency that could be further boosted by thinning down the substrate.

**JW2A.2**
**Microsphere Based Photolithography to Make Micro-OLEDs,** Getachew Tilahun Ayenew[1], Alexis P. A. Fischer[1,2], Chia-Hua Chan[3], Chii-Chang Chen[4], Mahmoud Chakaroun[1], Jeanne Solard[1,2], Azzedine Boudrioua[1]; [1]*Université Paris 13, Sorbonne Cité, Laboratoire de Physique de Lasers CNRS UMR 7538, France;* [2]*Université Paris 13, Sorbonne Cité, Centrale de Proximité en nanotechnologies de Paris Nord, IUT de Villetaneuse, France;* [3]*Graduate Inst. of Energy Engineering, National Central Univ., Taiwan;* [4]*Departement of Optics and Photonics, National Central Univ., Taiwan.* A simple photolithography process using monolayer of microspheres was used to pattern photoresist on ITO coated glass substrate. Organic materials and aluminum were deposited on the patterned photoresist to have completed OLED structure resulting micro-OLEDs.

**JW2A.3**
**Colored hybrid photovoltaics with angle invariance,** Kyu-Tae Lee[1], Jae Yong Lee[1], Sungyong Seo[1], L. Jay Guo[1]; [1]*Electrical Engineering and Computer Science, Univ. of Michigan, USA.* We present hybrid photovoltaic cells with distinct and angle-insensitive colors based on efficient photon manipulation. Up to 3% of power conversion efficiency is achieved by using tens of nm thick amorphous silicon active layer.

**JW2A.4**
**Frequency Comb Calibrated Diode Laser Interferometry for Absolute Distance Measurement,** Xuejian Wu[1], Haoyun Wei[1], Honglei Yang[1], Hongyuan Zhang[1], Yan Li[1]; [1]*Dept. of Precision Instruments, Tsinghua Univ., China.* Real-time frequency-sweeping interferometer for arbitrary distance determination is demonstrated, which is consisted by a homodyne interferometer and a diode calibrated by an optical frequency comb. For arbitrary distance of ~73 mm, the deviation is 0.91 µm.

**JW2A.5**
**Sagnac Based Polarimetric Analysis of EBC: Experimental Relationship to Blood Glucose,** Hiroshi Kajioka[1], Tatsuya Kumagai[2], Yuto Yamashita[3], Mikio Kataoka[4]; [1]*Global Fiberoptics, Ltd., Japan;* [2]*Optoquesto, Co., Ltd., Japan;* [3]*Kitanihon Electric Cable, Co., Ltd.., Japan;* [4]*Okayama Univ., Japan.* We have developed a novel polarimeter based on fiberoptic gyroscope. We have discovered that there is a good correlation between optical rotation of EBC (exhaled breath condensate) and blood glucose levels using this polarimeter.

**JW2A.6**
**Integrated Yb:fiber laser frequency comb with three photonic crystal fibers,** Tongxiao Jiang[1], Aimin Wang[1], Wei Zhang[1], Fuzeng Niu[1], Guizhong Wang[1], Chen Li[1], Zhigang Zhang[1]; [1]*Peking Univ., China.* We demonstrated a near all-fiber femtosecond Yb:laser frequency comb incorporated with three different photonic crystal fibers. The comb removes most of free-space components so that it is more compact and stable.

**JW2A.7**
**Simultaneous Detection of Multiple Gases by Raman Spectroscopy with Hollow-Core Fibers,** David Bomse[1], Marwood N. Ediger[1]; [1]*Mesa Photonics, USA.* Raman spectroscopy of gas flowing through a hollow-core photonic crystal fiber (HC-PCF) provides simultaneous detection of N2, O2, CO2, and CH4, with detection limits between 300 and 1000 ppm for 30 s of signal averaging.

**JW2A.8**
**Photonic Crystal Nanobeam Air-mode Cavity for High-Q and High Sensitivity Refractive Index Sensing,** Daquan Yang[1,2], Huiping Tian[1], Yuefeng Ji[1]; [1]*State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China;* [2]*School of Engineering and Applied Sciences, Harvard Univ., USA.* We demonstrate a novel photonic-crystal nanobeam air-mode cavity with high-Q and high-sensitivity for refractive-index sensing. For the air-mode, the light is strongly localized inside the air-region. The high-Q ~5.0×106 and high-sensitivity of 537.8nm/RIU are achieved.

**JW2A.9**
**Withdrawn**

**JW2A.10**
**Large-area bi-functional nano-mushroom plasmonic sensor for colorimetry and surface-enhanced Raman spectroscopy,** Zhida Xu[1], Ibrahim M. Khan[1], Kevin Han[1], Jing Jiang[1], Gang L. Liu[1]; [1]*Dept. of Electrical and Computer Engineering, Univ. of Illinois at Urbana-Champaign, USA.* Wafer-scale nano-mushroom sensor was demonstrated with the refractive index sensitivity of 373 nm/RIU, resulting in significant color shift detectable by eye. It also works for surface-enhanced Raman spectroscopy with the enhancement factor of 10^7.

**JW2A.11**
**Sub-Rayleigh Imaging via Speckle Illumination and Correlation Measurement,** JOO-EON OH[1], Young-Wook Cho[1], Giuliano Scarcelli[2], Yoon-Ho Kim[1]; [1]*Physics, POSTECH, Korea;* [2]*Harvard Medical School and Wellman Center for Photomedicine, Massachusetts General Hospital, USA.* We demonstrate a sub-Rayleigh imaging technique based on speckle illumination and the second-order correlation measurement. The image resolution is related to the speckle size or the lateral coherence length of the pseudothermal light.

**JW2A.12**
**Visibility and Contrast Enhancement with Polarization Difference Ghost Imaging,** Yongchao Zhu[1], Jianhong Shi[1], Hu Li[1], Guihua Zeng[1]; [1]*State Key Lab of Advanced Optical Communication Systems and Networks, Key Lab on Navigation and Location-based Service, Dept. of Electronic Engineering, Shanghai Jiao Tong Univ., China.* We experimentally demonstrate that polarization difference ghost imaging can provide the visibility and contrast enhancement, especially when the target is under predominately reflecting objects, complex background or turbid media. It facilitates the practical applications of ghost imaging.

**JW2A.13**
**Nonlinear-optical-loop-mirror-based, phase-preserving 2R regeneration of a high-duty-cycle RZ-DPSK signal,** Lu Li[1], Michael Vasilyev[1], Taras I. Lakoba[2]; [1]*Dept. of Electrical Engineering, Univ. of Texas at Arlington, USA;* [2]*Dept. of Mathematics and Statistics, Univ. of Vermont, USA.* We use a NOLM with a directional attenuator for regeneration of 50% duty-cycle RZ-DPSK signal and demonstrate eye-opening improvement of 1.5 dB for a signal degraded by a combination of ASE noise and amplitude jitter.

**JW2A.14**
**All-Optical Phase-Preserving Amplitude Regeneration Using Coherent Nonlinear Wave Mixing,** Zahra Bakhtiari[1]; [1]*, USA.* We propose and demonstrate an all-optical tunable phase-preserving scheme for amplitude regeneration of amplitude modulated signals and phase modulated signals based on coherent optical nonlinear wave mixing using HNLF.

**JW2A.15**
**Generation of Wideband Radio Frequency Signals Carrying Orbital Angular Momentum Based on Microwave Photonics Phase Shifter,** Fengkai Bian[1], Shangyuan Li[1], Yunlong Song[1], Qi Yu[1], Xinlu Gao[2], Xiaoping Zheng[1], Hanyi Zhang[1], Bingkun Zhou[1]; [1]*Dept. of Electronic Engineering, Tsinghua Univ., China;* [2]*Dept. of Physics, Beijing Normal Univ., China.* A novel way to generate the wideband radio frequency (RF) signals carrying orbital angular momentum (OAM) by phase shifting using optical spectrum processor is proposed. Stable RF-OAM signals with topological charge l=1 have been generated.

**JW2A.16**
**Optical Beat Noise Suppression in OFDMA PON Uplink Transmission by Using RF Clipping Tone,** Sang-Min Jung[1], Sun-Young Jung[1], Seung-Min Yang[1], Sang-Kook Han[1]; [1]*Yonsei Univ., Korea.* A technique of suppressing optical beat interference (OBI) noise in OFDMA PON is proposed and verified experimentally by applying RF clipping tone. We achieve reliable 8Gbit/s 20km uplink transmission with spectral efficiency 2.7bit/s/Hz.

**JW2A.17**
**High power and high efficiency Tm-doped fiber laser pumped by a 1173 nm Raman fiber laser,** Xiong Wang[1], Hanwei Zhang[1], Pu Zhou[1], Xiaolin Wang[1], Hu Xiao[1], Zejin Liu[1]; [1]*College of Optoelectronic Science and Engineering, National Univ. of Defense Technology, China.* We report a high power Tm-doped fiber laser pumped by a 1173 nm Raman fiber laser. The slope efficiency is 47%, the maximum output power is 46 W and can be scaled to higher power.

**JW2A.18**
**Green-enhanced super-continuum generation in a tapered photonic crystal fiber for efficient fceo detection,** Fuzeng Niu[1], Tongxiao Jiang[1], Guizhong Wang[1], Chen Li[1], Aimin Wang[1], Zhigang Zhang[1]; [1]*Inst. of Quantum Electronics, School of Electronics Engineering and Computer Science, Peking Univ., China.* We report the green-enhanced (530 nm) super-continuum generation in a tapered photonic crystal fiber by 280 pJ pulses from a mode-locked Yb:fiber laser. This system offers a technique for efficient fceo beating signal detection.

**JW2A.19**
**Divergence Angle as a Quality Parameter for Fiber Modes,** Stine Møller Israelsen[1], Karsten Rottwitt[1]; [1]*DTU Fotonik, Technical Univ. of Denmark, Denmark.* We suggest using divergence angle as a quality parameter for pure fiber modes. We demonstrate a measurement of the divergence angle of an LP11-mode and obtain agreement with numerical predictions with 2-digit precision.

**JW2A.20**
**A femtosecond thulium holmium co-doped fiber laser based on graphene oxide evanescent filed interaction,** Minwan Jung[1,2], Joonhoi Koo[1], Jaehyun Park[3], Yong Won Song[3], Kwanil Lee[2], Sang Bae Lee[2], Ju Han Lee[1]; [1]*School of Electrical and Computer Engineering, Univ. of Seoul, Korea;* [2]*Inst. for Multidisciplinary Convergence of Matter, Korea Inst. of Science and Technology, Korea;* [3]*Future Convergence Research Division, Korea Inst. of Science and Technology, Korea.* We demonstrate an all fiberized, passively mode-locked thulium holmium co-doped fiber laser operating at a wavelength of ~1.95 µm using the graphene-oxide evanescent field interaction.

## JW2A • Poster Session 2—Continued

**JW2A.21**
**Continuous-Wave Two-pump Fiber Optical Parametric Amplifier with 60 dB Gain,** Mehdi Jamshidifar[1], Armand Vedadi[1], Michel E. Marhic[1]; [1]*Swansea Univ., UK.* We have obtained record gain of 60 dB with a continuous-wave two-pump fiber optical parametric amplifier, over a 5.5-nm bandwidth. We used a 500-m long fiber, and 1.5 W of pump power.

**JW2A.22**
**Direct generation of radially-polarized output from an Yb-doped fiber laser,** Di Lin[1], Jae M. Daniel[1], Mindaugas Gecevičius[1], Martynas Beresna[1], Peter G. Kazansky[1], W. A. Clarkson[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK.* A simple technique for directly generating a radially-polarized output beam from an ytterbium-doped fiber laser using an intracavity S-waveplate is reported. The laser yielded 7W of output with a corresponding slope efficiency of 67%.

**JW2A.23**
**Stimulated Brillouin scattering threshold variations due to bend-induced birefringence in a non-polarization-maintaining fiber amplifier,** Cyril L. Guintrand[1]; [1]*Nufern, USA.* We report on the SBS threshold variations due to the coiling-induced birefringence in a non-polarization-maintaining fiber high power amplifier. We demonstrate that a control of the output polarization can permit higher SBS threshold operation.

**JW2A.24**
**Radiofrequency Spectroscopy of the Active Fiber Heating under Condition of High-Power Lasing Generation,** Renat Shaidullin[1,2], Ilya Zaytsev[2], Oleg A. Ryabushkin[1,2]; [1]*Moscow Inst. of Physics and Technology, Russia;* [2]*Kotelnikov Inst. of Radio Engineering and Electronics of RAS, Russia.* A novel precise method for measurement of active fiber temperature in high-power fiber lasers and amplifiers is proposed. This method allows determination of the temperature distribution along the active fiber.

**JW2A.25**
**31 nJ sub-200 fs pulse generation from an Erbium-doped fiber amplifier similariton oscillator,** Chia-lun Tsai[1], Kuan-Chen Chu[1], Shang-Da Yang[1]; [1]*Inst. of Photonics Technologies, National Tsing Hua Univ., Taiwan.* We demonstrated the highest femtosecond pulse energy from Erbium-doped fiber similariton or dissipative soliton oscillators (to our best knowledge). The output spectrum can be manipulated by waveplates and filter to support 86 fs transform-limited pulse.

**JW2A.26**
**Soliton trapping in a Tm fiber laser,** Luming Zhao[1,2], Yong Wang[1,2], Siming Wang[1,2], Jiaolin Luo[1,2], Yanqi Ge[1,2], Lei Li[1,2], Dingyuan Tang[1,2], Deyuan Shen[1,3], Shumin Zhang[4], Frank W. Wise[5]; [1]*Jiangsu Key Lab of Advanced Laser Materials and Devices, Jiangsu Normal Univ., China;* [2]*School of Physics and Electronic Engineering, Jiangsu Normal Univ., China, China;* [3]*Dept. of Optical Science and Engineering, Fudan Univ., China;* [4]*College of Physics Science and Information Engineering, Hebei Advanced Thin Films Lab, Hebei Normal Univ., China;* [5]*Dept. of Applied Physics, Cornell Univ., USA.* Soliton trapping is demonstrated in an all-fiber Tm fiber laser. The central wavelength shift between the two orthogonal polarized components of the vector soliton is determined by the cavity birefringence.

**JW2A.27**
**Frequency-comb-referenced stable multi-channel fiber laser,** Byungjae Chun[1], Sangwon Hyun[1], Seungman Kim[1], Seung-Woo Kim[1], Young-Jin Kim[1]; [1]*Korea Advanced Inst. of Science and Technology, Korea.* We demonstrate an all-fiber-based multi-channel fiber laser referenced to the frequency comb. Three sample optical frequencies were generated within telecommunication band with a frequency stability of 2.24×10-12 and a linewidth less than 30 kHz.

**JW2A.28**
**Time-to-frequency Conversion Based on Nonlinear Pulse Shaping,** Dong Wang[1], Li Huo[1], Qiang Wang[1], Xin Chen[1], Caiyun Lou[1]; [1]*Electronic Engineering, Tsinghua Univ., China.* A precise time-to-frequency conversion based on nonlinear pulse shaping is demonstrated. Simulation results also show the scheme can be applied to arbitrary waveform.

**JW2A.29**
**Gain dynamics in Er:Yb co-doped fiber amplifiers,** Michael Steinke[1,2], Dietmar Kracht[1,2], Jörg Neumann[1,2], Peter Wessels[1,2]; [1]*Laser Zentrum Hannover e.V., Germany;* [2]*Centre for Quantum Engineering and Space-Time Research - QUEST, Germany.* Gain dynamics of Er:Yb fiber amplifiers were studied analytically and corresponding transfer functions were measured, showing good agreement with the theoretical treatment. In addition, numerical investigations have been carried out to get deeper insight.

**JW2A.30**
**Realization of Multiphoton Photoacoustic Microscopy via a Loss Modulation Technique,** Szu-Yu Lee[1], Yu-Hung Lai[1,2], Kai-Chih Huang[1], Yu-Cheng Chen[4], Chi-Kuang Sun[1,3]; [1]*Dept. of Electrical Engineering and Graduate Inst. of Photonics and Optoelectronics, National Taiwan Univ., Taiwan;* [2]*Applied Physics Option, California Inst. of Technology, USA;* [3]*Inst. of Physics and Research Center for Applied Sciences, Academia Sinica, Taiwan;* [4]*Molecular Imaging Center, National Taiwan Univ., Taiwan.* Trade-off between resolution and penetration restricts performances of microscopes. We realize a hybrid modality of multiphoton fluorescence and photoacoustic microscopy via an optical modulation technique. The new modality features both high-resolution and deep-penetration.

**JW2A.31**
**Demonstration of Mueller polarimetry through an optical fiber for endoscopic applications,** Jérémy VIZET[1], Sandeep Manhas[1], Stanislas Deby[2], Jean-Charles Vanel[2], Antonello De Martino[2], Dominique Pagnoux[1]; [1]*XLIM, Photonics Dept., Université de Limoges, CNRS, France;* [2]*LPICM, Ecole Polytechnique, CNRS, France.* Mueller polarimetry through an optical fiber is demonstrated for the first time, opening the way to endoscopic applications. Proof of principle is demonstrated by measuring with accuracy linear retardance, diattenuation and depolarization of known sample.

**JW2A.32**
**Chalcogenide Microfiber Photonic Synapses,** Behrad Gholipour[1], Paul Bastock[2], Khouler Khan[2], Chris Craig[2], Dan Hewak[2], Nikolay I. Zheludev[1,2], Cesare Soci[1]; [1]*Centre for disruptive photonic technologies (CDPT), Nanyang technological Univ., Singapore;* [2]*Optoelectronics research centre (ORC), Univ. of Southampton, UK.* Optical axons and photonic synapses implemented using chalcogenide microfibers allow the generation and propagation of photonic action potentials which give rise to the demonstration of various neuromorphic concepts.

**JW2A.33**
**Studying Membrane Tubes with Positive and Negative Curvatures in Giant Vesicles,** Raktim Dasgupta[1], Reinhard Lipowsky[1], Rumiana Dimova[1]; [1]*Dept. of Theory and Bio-Systems, Max Planck Inst. of Colloids and Int, Germany.* Membrane tubes could be extruded both externally and internally from giant lipid vesicles using membrane-attached beads manipulated via optical trapping and controlled hydrodynamic flow. The technique has potential use for studying different membrane tubulation mechanisms.

**JW2A.34**
**3D hollow nanostructures for multifunctional plasmonics,** Mario Malerba[1], Ermanno Miele[1], Andrea Toma[1], Francesco De Angelis[1]; [1]*Istituto Italiano di Tecnologia, Italy.* A novel top-down technique allows precise 3D nanofabrication; we exploit fully its potential by manufacturing plasmonic devices, to be employed in optoelectronics, microfluidics and advanced biosensing.

**JW2A.35**
**Fiber torsion sensor with directional discrimination based on twist-induced circular birefringence in unbalanced Mach-Zehnder interferometer,** Nan-Kuang Chen[1,2], Jheng-Jyun Wang[1], Gia-Ling Cheng[3], Wood-Hi Cheng[3], Ping Perry Shum[4]; [1]*Dept. of Electro-Optical Engineering, National United Univ., Taiwan;* [2]*Optoelectronics Research Center, National United Univ., Taiwan;* [3]*Dept. of Photonics, National Sun Yat-sen Univ., Taiwan;* [4]*Network Technology Research Centre, Nanyang Technological Univ., Singapore.* We demonstrate fiber torsion sensor based on twist-induced circular birefringence in unbalanced Mach-Zehnder interferometer with two dissimilar abrupt tapers in a short (~1.4cm) highly Er/Yb co-doped fiber for simultaneous measurements of twisting angle and direction.

**JW2A.36**
**Intermodulation distortion elimination for analog photonics link based on integrated dual-parallel Mach-Zehnder modulator,** Jian Li[1], Yi-Chen Zhang[1], Song Yu[1], Tianwei Jiang[1], Xie Qian[1], Wanyi Gu[1]; [1]*Beijing Univ. of Posts and Telecommunications, China.* We report a total third-order intermodulation distortion elimination method for analog photonics link based on integrated dual-parallel Mach-Zehnder modulator. Theoretical analysis and experiment verification of 33.57 dB suppression are both carried out.

**JW2A.37**
**Compact Athermal Electro-optic Modulator Design Based on SOI Off-axis Microring Resonator,** Raktim Haldar[1], Abhik Datta Banik[1], Sanathanan M.S[1], Shailendra K. Varshney[1]; [1]*Indian Inst. of Technology Kharagpur, India.* In this work, we propose efficient electro-optic modulation using compact SOI off-axis microring resonator. We show that adding an extra off-axis inner-ring in conventional microring structure provides control to compensate thermal effects on electro-optic modulator.

**JW2A.38**
**A novel InP-based 1.31/1.55-μm wavelength demultiplexer with side-port multimode interference coupler,** Shile Wei[1,2], Jian Wu[1], Lingjuan Zhao[2], Ruikang Zhang[2], Jifang Qiu[1], Zuoshan Yin[1], Ye Tian[1]; [1]*Beijing Univ of Posts & Telecom, China;* [2]*Inst. of Semiconductors, Chinese Academy of Science, China.* A novel ultrashort InP-based 1.31/1.55-μm wavelength demutiplexer, whose MMI section is only one beat length of the two guided modes, is demonstrated. The measured extinction ratios for 1.3/1.55-μm bands exceed 20/15 dB, respectively.

**JW2A.39**
**Mapping molecular rotational dynamics on the time-dependent spectral minimum,** meiyan qin[1], Xiaosong Zhu[1], Peixiang Lu[1]; [1]*School of Physics, Huazhong Univ of Science and Technology, China.* We investigate the time-dependent harmonic emissions from nonadiabatically aligned molecules. It is shown that the spectral minimum position depends linearly on $1/<\cos^2\theta>$. This relation indicates the possibility of tracing molecular rotational dynamics by measuring the spectral minima.

**JW2A.40**
**Ultrashort pulse generation using supercontinuum generated by Er-doped fiber laser with carbon nanotube,** Atsushi Okamura[1], Youichi Sakakibara[2], Emiko Omoda[2], Hiromichi Kataura[2], Norihiko Nishizawa[1]; [1]*Nagoya Univ., Japan;* [2]*AIST, Japan.* Ultrashort pulse generation was demonstrated by dispersion compensation of coherent high quality supercontinuum generated by ultrashort pulse fiber laser with carbon nanotube and fiber amplifier system. A 22 fs ultrashort pulse was observed by X-FROG.

## JW2A • Poster Session 2—Continued

**JW2A.41**
**High-power sub-50 fs, Kerr-lens mode-locked Yb:CaF2 oscillator pumped by high-brightness fiber- laser,** pierre sevillano[1], Guillaume Machinet[1], Romain Dubrasquet[1,2], Patrice Camy[3], Jean Louis Doualan[3], Richard Moncorgé[3], Patrick Georges[4], Frederic Druon[4], Dominique Descamps[1], Eric Cormier[1]; *[1]CELIA, France; [2]Azur light System, France; [3]Centre de recherhce sur les Ions, France; [4]Laboratoire Charles Fabry, France.* We investigated the influence of the spatial pump beam quality on the generation of ultra-short pulses in high-brightness Yb:fiber laser-pumped pure Kerr-lens mode-locked Yb:CaF2 oscillators. We report pulse duration as short as 48 fs with an average output power of 2.7 W.

**JW2A.42**
**Ultrafast Arbitrary (Non-Minimum-Phase) Optical Pulse Processors Based On Bragg Gratings in Transmission,** María R. Fernández-Ruiz[1], Alejandro Carballar[2], José Azaña[1]; *[1]INRS - EMT, Canada; [2]Ingeniería Electrónica, Universidad de Sevilla, Spain.* A new approach to implement arbitrary (non-minimum phase) time-windowed linear optical pulse processors using minimum-phase filters is proposed and demonstrated through the design of a Terahertz-bandwidth Hilbert transformer based on a transmissive fiber Bragg grating.

**JW2A.43**
**2.5 D photonic crystal quantum cascade detector,** Peter Reininger[1], Benedikt Schwarz[1], Andreas Harrer[1], Tobias Zederbauer[1], Hermann Detz[1], Aaron Maxwell Andrews[1], Roman Gansch[1], Werner Schrenk[1], Gottfried Strasser[1]; *[1]Inst. for Solid State Electronics and Center for Micro- and Nanostructures, Vienna Univ. of Technology, Austria.* Quantum cascade detectors are intersubband photodetectors that offer a vast design freedom. By combining it with a novel photonic crystal cavitiy, a significant improvement of the detectors performance could be achieved.

**JW2A.44**
**Simple Single-Shot Technique for Measuring the Complete Spatiotemporal Intensity and Phase of a Complex Ultrashort Pulse,** Zhe Guang[1], Michelle Rhodes[1], Rick Trebino[1]; *[1]School of Physics, Georgia Inst. of Technology, USA.* Our simple device measures the complete spatiotemporal field of an arbitrary ultrashort pulse complex in both space and time (x,y,t). We also demonstrate a method for displaying the resulting dual plots of complex four-dimensional data.

**JW2A.45**
**Saturation broadening effect in an InP photonic-crystal nanocavity switch,** Yi Yu[1], Evarist Palushani[1], Mikkel Heuck[1], Dragana Vukovic[1], Christophe Peucheret[1], Leif K. Oxenlowe[1], Kresten Yvind[1], Jesper Mørk[1]; *[1]Dept. of Photonics Engineering, Danmarks Tekniske Universitet, Denmark.* Pump-probe measurements on InP photonic-crystal nanocavities show large-contrast fast switching at low pulse energy. For large pulse energies, large resonance shifts passing across the probe lead to switching contrast saturation and switching time-window broadening.

**JW2A.46**
**High Efficient Vertical Binary Blazed Grating Coupler for Chip Level Optical Interconnections,** Li Yu[1], Lu Liu[1], Zhiping Zhou[1], Xingjun Wang[1]; *[1]Peking Univ., China.* A high-efficiency vertical binary blazed grating coupler is proposed. An 83% of efficiency and 65nm 3dB bandwidth are demonstrated. The tolerance of the incident angle is 11.5°.

**JW2A.47**
**A novel polarization and dichroic dual-functional splitter with ultra-high splitting ratios,** Kun Li[1], Fan Lu[1], Dalin Liu[1], Zhijun He[1], Anshi Xu[1]; *[1]Peking Univ., China.* A novel polarization and dichroic dual-functional splitter is proposed, with ultra-high polarization splitting ratios >33dB and >36dB for TE- and TM-polarized modes, respectively; and with high wavelength splitting ratios >26dB and >33dB for 650nm and 850nm, respectively.

**JW2A.48**
**Effect of Quantum Confinement in Si-QD on Free-Carrier Modulation Bandwidth and Cross-Section of the SiOx:Si-QD Waveguide,** Chung-Lun Wu[1], Sheng-Pin Su[1], Gong-Ru Lin[1]; *[1]Graduate Inst. of Photonics and Optoelectronics, Dept. of Electrical Engineering, National Taiwan Univ., Taiwan.* The free-carrier cross-section of Si-QD is decreased from 5.5×10-17 to 9×10-18 cm2 with shortened lifetime from 10 to 0.48 µs when shrinking Si-QD size from 4.3 to 1.7 nm due to the quantum confinement effect.

**JW2A.49**
**A novel polarization converter and filter based on MMI couplers in silicon-on-insulator,** Wei Yang[1], Tiantian Li[1], Zhijuan Tu[1], Yanping Li[1], Xingjun Wang[1], Ziyu Wang[1]; *[1]School of Electronics Engineering and Computer Science, Peking Univ., China.* A novel polarization converter and filter based on silicon multimode interference couplers (MMI) has been demonstrated. The measured transmission spectra of the proposed device for the light with arbitrary polarization exhibit a good performance.

**JW2A.50**
**Disorder-induced resonance shifts and mode edge broadening in photonic crystal waveguides,** Nishan S. Mann[1], Alisa Javadi[2], Pedro David Garcia[2], Mark Patterson[1], Peter Lodahl[2], Stephen Hughes[1]; *[1]Physics, Queen's Univ., Canada; [2]Niels Bohr Inst., Denmark.* We present theory and measurements for systematically disordered slow-light photonic crystal waveguides and find a pronounced disorder-induced blueshift and broadening of the photon density of states.

**JW2A.51**
**Double Heterostructure AlGaAs/GaAs W-shaped Waveguide Mach-Zehnder Intensity Modulator for 780 nm Lasers,** Bassem Arar[1], Harendra N. J. Fernando[2], Olaf Brox[1], Andre Maassdorf[1], Andreas Wicht[1], Achim Peters[3], Markus Weyers[1], Götz Erbert[1], Günther Tränkle[1]; *[1]Ferdinand-Braun-Institut FBH, Germany; [2]Leibniz-Institut für Astrophysik Potsdam, Germany; [3]Humboldt-Universität zu Berlin, Germany.* An integrated Mach-Zehnder intensity modulator for laser radiation at the wavelength 780 nm is demonstrated for the first time. The device features a double heterostructure GaAs/AlGaAs electro-optic phase modulator. The estimated insertion loss is less than 2.5 dB and the extinction ratio is 3.3 dB.

**JW2A.52**
**Brillouin Scattering in Silicon Slot Waveguides,** Yovanny A. Espinel[1], Thiago Pedro M. Alegre[1], Gustavo S. Wiederhecker[1]; *[1]"Gleb Wataghin" Physics iInst., Univ. of Campinas, Brazil.* Here we numerically investigate Brillouin scattering (BS) in a silicon slot waveguide. We show that BS is strongly influenced by the boundary effects, instead of the photoelastic effect, leading to the interaction with novell mechanical modes.

**JW2A.53**
**Silicon Waveguide to Hybrid Plasmonic Waveguide Polarization Rotator and Coupler,** Sangsik Kim[1], Minghao Qi[1]; *[1]School of Electrical and Computer Engineering and Birck Nanotechnology Center, Purdue Univ., USA.* We present a polarization rotator and coupler that rotates the $TE_0$ mode in a silicon waveguide and couples to the hybrid plasmonic ($HP_0$) mode. Coupling factor of ~60% and polarization conversion efficiency of ~90% is achieved.

**JW2A.54**
**Athermal microring resonator based on the resonance splitting of dual-ring structure,** Qingzhong Deng[1], Xinbai Li[1], Zhiping Zhou[1]; *[1]State Key Lab of Advanced Optical Communication Systems and Networks, Peking Univ., China.* A novel athermal scheme based on resonance splitting of dual-ring structure is proposed and proved. An athermal resonator based on this scheme is demonstrated, achieving athermal transmission over a temperature range of at least 40K.

**JW2A.55**
**Dynamical behave of optomechanically induced transparency in a silica microresonator,** Chun-Hua Dong[1], Zhen Shen[1], Guang-Can Guo[1]; *[1]Key Lab of Quantum Information, USTC, China.* We report an experimental study of transient optomechanically induced transparency (OMIT) using a silica microresonator. The transient OMIT behaviors are observed in good agreement with theoretical calculations based on the coupled-oscillator model.

**JW2A.56**
**Optical transition between Stark levels in (ErSc)2O3 epitaxitial films,** Takehiko Tawara[1,2], Hiroo Omi[1,2], Adel Najar[1], Reina Kaji[3], Satoru Adachi[3], Hideki Gotoh[1]; *[1]NTT Basic Research Labs, Japan; [2]NTT Nanophotonics Center, Japan; [3]Hokkaido Univ., Japan.* Toward quantum information applications, we control the interactions between Er ions by alloying epitaxial Er2O3 with scandium and suppress energy transfer and inhomogeneous broadening of Stark levels in the intra-4f band of Er ions.

**JW2A.57**
**Investigation of Photoluminescence from Ge1-xSnx: A CMOS-Compatible Material Grown on Si via CVD,** Wei Du[1], Sayed A. Ghetmiri[1], Aboozar Mosleh[1], Benjamin Conley[1], Liang Huang[1], Amjad Nazzal[2], Richard Soref[3], Greg Sun[3], John Tolle[4], Hameed A. Naseem[1], Shui-Qing Yu[1]; *[1]Electrical Engineering, Univ. of Arkansas, USA; [2]Engineering and Physics, Wilkes Univ., USA; [3]Physics, Univ. of Massachusetts Boston, USA; [4]ASM America, USA.* Photoluminescence (PL) from Ge1-xSnx grown on Si by CVD was investigated for Sn composition of 0.9, 3.2, 6, and 7%, respectively. The direct and indirect band transitions were analyzed at different temperatures.

**JW2A.58**
**Opto-Mechanically Tunable Polymeric Microlasers,** Assegid Mengistu Flatae[1,2], Matteo Buresi[2], Hao Zeng[2], Sara Nocentini[2], Sarah Wiegele[1], Diederik Wiersma[2], Heinz Kalt[1]; *[1]Inst. of Applied Physics, Karlsruhe Inst. of Technology, Germany; [2]Optics of complex system, European Lab for Nonlinear Spectroscopy, Italy.* Opto-mechanically controlled liquid crystalline elastomer (LCE) integrated tunable polymeric microgoblet lasers are fabricated on a silicon chip. Symmetrical deformation of uniaxially aligned LCE microcylinders enables expansion of the microgoblet resonators for tuning the lasing modes.

**JW2A.59**
**Intense Photoluminescence from Er Doped Chalcogenide Thin Films Fabricated by Cothermal Evaporation,** Kunlun Yan[1], Khu Vu[1], Steve Madden[1]; *[1]Australian National Univ., Australia.* Erbium doped chalcogenide films were fabricated by cothermal evaporation and demonstrated propagation losses and lifetimes suitable for waveguide amplifiers. The 1490nm pumped Photoluminescence yield is up to ~10x higher than the prior best film material, Er:TeO2.

**JW2A.60**
**Optical properties of Er-doped fluoride glasses for solar-pumped laser applications,** Takenobu Suzuki[1], Yasuyuki Iwata[1], Yasutake Ohishi[1]; *[1]Toyota Technological Inst., Japan.* Optical properties required for the design of a solar pumped fiber laser were evaluated for Er3+-fluoride glass. The quantum efficiency of the emission band at 1530nm was about 35%. The product of the stimulated emission cross-section and the emission lifetime was about 46×10−24 cm2s.

## JW2A • Poster Session 2—Continued

**JW2A.61**
**Structural characterization and luminescence properties of ErxSc2-xSi2O7 prepared by RF sputtering,** Adel Najar[1], Takehiko Tawara[2,1], Hiroo Omi[1,2]; [1]*NTT Basic Research Labs, NTT Corporation, Japan;* [2]*NTT Nanophotonics Center, NTT Corporation, Japan.* Polycrystalline ErxSc2-xSi2O7 compounds were fabricated using RF-sputtering by alternating Er2O3, Sc2O3 layers separated by SiO2 layer. This new compounds presents excitation cross section at 980nm around 1.39x10-21cm2 with lifetime of 38 µs.

**JW2A.62**
**Carrier Dynamics of a Bismuth Thin Film Accelerated via Intense Terahertz Field,** Yasuo Minami[1], Kotaro Araki[1], Thang D. Dao[2,3], Tadaaki Nagao[2,3], Jun Takeda[1], Masahiro Kitajima[4,5], Ikufumi Katayama[1]; [1]*Yokohama National Univ., Japan;* [2]*International Center for Materials Nanoarchitectonics, National Inst. for Materials Science, Japan;* [3]*CREST, Japan Science and Technology Agency, Japan;* [4]*LxRay Co. Ltd., Japan;* [5]*Dept. of Applied Physics, National Defense Academy, Japan.* THz pump-THz probe spectroscopy is performed to study carrier dynamics in Bi film. Transmittance of Bi film increases since effective masses of carriers increases by acceleration. After the illumination, transmittance decreases due to carrier increases.

**JW2A.63**
**High-Power Terahertz Generation via Two-Color Laser Filamentation and Real-Time Terahertz Imaging,** Taek Il Oh[1], Yung Jun Yoo[1], Yong Sing You[1], Ki-Yong Kim[1]; [1]*Univ. of Maryland, USA.* We generate terahertz radiation via two-color laser filamentation with average output power of 1.4 mW and peak fields of 4.4 MV/cm. We also introduce a real-time, uncooled, cost-effective microbolometer camera for terahertz profiling and imaging.

**JW2A.64**
**Narrowband Terahertz Emission from Beta-Barium Borate,** David A. Valverde-Chavez[1], David G. Cooke[1]; [1]*Physics, McGill Univ., Canada.* We observed narrowband terahertz emission from beta-barium borate crystal at a center frequency of 10.7 THz. The field emission is linear with incident pump power consistent with an optical rectification process.

**JW2A.65**
**Mechanisms of THz trapping devices based on plasmonic grating,** Baoshan Guo[1], Wei Shi[1], Jianquan Yao[1]; [1]*Tianjin Univ., China.* The mechanisms of plasmonic THz wave trapping devices is attributed to the transformation from surface modes to cavity modes which have a saturated state. An ultraslow THz waveguide is realized by controlling the modes transformation.

**JW2A.66**
**Terahertz surface plasmon polaritons on freestanding multi-walled carbon nanotube aerogel sheets,** Shuchang Liu[1], Tho D. Nguyen[2], Marcio D. Lima[3], Shaoli Fang[3], Ray H. Baughman[3], Ajay Nahata[1], Z. Valy Vardeny[2]; [1]*Dept. of Electrical and Computer Engineering, Univ. of Utah, USA;* [2]*Dept. of Physics and Astronomy, Univ. of Utah, USA;* [3]*Alan G. MacDiarmid NanoTech Inst., Univ. of Texas at Dallas, USA.* We demonstrate that multi-walled carbon nanotubes exhibit highly anisotropic terahertz polarization behavior. We accomplish this by measuring the complex index of refraction of planar and periodically perforated carbon nanotube sheets for two orthogonal nanotube orientations.

**JW2A.67**
**Modeling and Design of a Soliton Modelocked Yb:CaGdAlO$_4$ Laser in the Normal Dispersion Regime,** Christopher R. Phillips[1], Aline Sophie Mayer[1], Alexander Klenner[1], Ursula Keller[1]; [1]*ETH Zurich, Switzerland.* We consider SESAM soliton-modelocking via cascaded quadratic nonlinearities in the normal dispersion regime. We explain the theory, perform a design study for our experimental implementation in LiB$_3$O$_5$/Yb:CaGdAlO$_4$, and present detailed numerical simulations of this laser.

**JW2A.68**
**18.7-fs DUV Pulses Generated by Using Chirped-pulse Four-wave Mixing in Bulk Material,** JinPing He[1,2], Takayoshi Kobayashi[1,2]; [1]*Univ. of Electro-Communications, Japan;* [2]*JST, CREST, Japan.* Sub-20fs, wavelength tunable, uJ-level DUV pulses were generated by using nondegenerate, chirped-pulse four-wave mixing in CaF2 crystal. The DUV spectrum can be tuned from 257nm to 277nm with widest spectral width of 16.8nm.

**JW2A.69**
**Nonlinear Fourier-transform spectroscopy using ultrabroadband pulses for measurement of photobleaching spectra of fluorescent proteins,** Akira Suda[1]; [1]*Tokyo Univ. of Science, Japan.* We present the measurement of photobleaching spectra of fluorescent proteins with nonlinear Fourier-transform spectroscopy using ultrabroadband femtosecond pulses. Photobleaching of two-photon excited fluorescent molecules occurs through one-photon excited-state absorption.

**JW2A.70**
**Frequency Doubling at 7J of a High Energy, High Repetition Rate DPSSL System,** Jonathan Phillips[1], Saumyabrata Banerjee[1], Paul D. Mason[1], Jodie M. Smith[1], Magdalena Sawicka[2], Martin Divoky[2], Klaus Ertel[1], Thomas J. Butcher[1], Mariastefania de Vido[1], Tristan R. Davenne[1], Michael D. Fitton[1], Oleg Chekhlov[1], Justin Greenhalgh[1], Waseem Shaikh[1], Ophelie Wagner[3], Cristina Hernandez-Gomez[1], John L. Collier[1]; [1]*Central Laser Facility, STFC Rutherford Appleton Lab, UK;* [2]*HiLASE Project, Na Slovance 2, Czech Republic;* [3]*Cristal Laser, Parc d, France.* We present calculations and results for frequency doubling on DiPOLE, a 7J 10 Hz Yb:YAG DPSSL, using DKDP, YCOB and LBO. The LBO crystal achieved the highest conversion efficiency of 65%.

**JW2A.71**
**Two new blue laser emission lines from an intracavity Raman laser,** Dimitri Geskus[1], Jonas Jakutis Neto[1], Helen M. Pask[2], Niklaus Wetter[1]; [1]*Centro de Lasers e Aplicações, IPEN/SP, Brazil;* [2]*MQ Photonics, Dept. of Physics, Macquarie Univ., Australia.* Here we report quasi-CW operation of intracavity Raman laser generating three blue laser emission lines at 454 nm, 473 nm and 495 nm with a maximum output power of 230 mW.

**JW2A.72**
**Broadband and Ultra-flat Optical Comb Generation Using an EO Comb Source and a Programmable Pulse Shaper,** Hyoung-Jun Kim[1], Andrew J. Metcalf[1], Oscar E. Sandoval[1], Daniel E. Leaird[1], Andrew M. Weiner[1]; [1]*School of Electrical and Computer Engineering, Purdue Univ., USA.* Optical frequency comb generation using an advanced electro-optic comb source, a programmable pulse shaper, and a highly nonlinear fiber is demonstrated. The generated 18 GHz comb has 2 dB power variation within a 24 nm bandwidth.

**JW2A.73**
**Tailoring of Saturation in Fiber Optical Parametric Amplifier by SBS-Induced Nonlinear Phase,** Chaoran Huang[1], Xiaojie Guo[1], Xuelei Fu[1], Liang Wang[1], Chester Shu[1]; [1]*Dept. of Electronic Engineering, The Chinese Univ. of Hong Kong, Hong Kong.* We use gain-transparent SBS to defer/expedite the saturation of a fiber optical parametric amplifier by dynamically control the phase mismatch. The input signal power at saturation can be raised or reduced by ~6 dB.

**JW2A.74**
**CW Pumped, Generation of Narrow Linewidth Non-Resonant Mid-IR Radiations in Liquid Filled Single Capillary Assisted Chalcogenide Optical Fibers,** Satya Pratap Singh[1], Viswatosh Mishra[1], Shailendra K. Varshney[1]; [1]*Indian Inst. of Technology Kharagpur, India.* We report the generation of the non-resonant radiations (<100 GHz FWHM) ranging from near-IR to mid-IR in capillary-assisted chalcogenide optical fibers with three zero dispersion wavelengths owing to the temperature dependent phase-matching topologies.

**JW2A.75**
**Defect Mode Lasing in metal-coated GaN Grating Structure at Room Temperature,** Kuo-Ju Chen[1], Wan-Hai Hsu[1], Wei-Chun Liao[1], Min-Hsiung Shih[1,2], Hao-chung Kuo[1]; [1]*Dept. of Photonics, Inst. of Electro-Optical Engineering, National Chiao Tung Univ., Taiwan;* [2]*Research Center for Applied Sciences, Academia Sinica, Taiwan.* The lasing action from a metal-coated GaN with defect grating structure was observed and the wavelength is approximately 365 nm with the quality factor of 480 at room temperature.

**JW2A.76**
**Gain compression in a quantum cascade laser: Connection between high frequency tuning and bending of LI curve,** Andreas Hangauer[1], Gerard Wysocki[1]; [1]*Electrical Engineering Dept., Princeton Univ., USA.* This paper studies relation between high-frequency chirping of a quantum-cascade laser and the curvature of its light-current characteristic. Assuming negligible thermal backfilling and a photon lifetime of 9ps, a gain-compression effect explains both experimental observations.

**JW2A.77**
**31nm Quasi-Continuous Tuning Single Mode Laser Array Based on Slots,** Qiaoyin Lu[1], Weihua Guo[2], Azat Abdullaev[1], Marta Nawrocka[1], James O'Callaghan[3], John F. Donegan[1]; [1]*Univ. of Dublin Trinity College, Ireland;* [2]*Univ. of California Santa Barbara, USA;* [3]*Tyndall National Inst., Ireland.* We present a 10-channel slotted single-mode laser array with effective-cavity-length ~300µm which exhibits quasi-continuous tuning range ~31nm over 42°C with side-mode suppression-ratio >35dB. The linewidth is about 2MHz for all channels at 150mA at 20°C.

**JW2A.78**
**Experimental Analysis of Laterally-Coupled MQW-DFB Lasers in Optical Feedback,** Ramón Maldonado-Basilio[1], Vahid Eslamdoost[1], Julie E. Nkanta[1], Trevor J. Hall[1]; [1]*Univ. of Ottawa, Canada.* Characterization of third-order grating LC-MQW-DFB lasers in free-running and feedback is reported for various operation conditions. Relative to free-running, line-width reduction of >15 times is measured in optical feedback, obtaining a minimum of 10 kHz.

**JW2A.79**
**High-brightness single-mode tapered laser diodes with laterally coupled high-order surface grating,** Wan-hua Zheng[1], Lei Liu[1], Hongwei Qu[1], Yun Liu[1], Qi Aiyi[1], Chuanlong Ma[1], Siriguleng Zhang[1], Yejin Zhang[1]; [1]*Chinese Acad Sci Inst of Semiconductor, China.* 913 nm tapered diode lasers with 23th order laterally coupled grating is fabricated. Power of over 560 mW/facet and lateral divergence angle of 2.1° are achieved. Measured side mode suppression ratio is about 27 dB.

**JW2A.80**
**Continuum seeded OPCPA system driven by tandem fs Yb:KGW and ps Nd:YAG lasers,** Tomas Stanislauskas[1,3], Rimantas Budriunas[1], Roman Antipenkov[1], Audrius Zaukevicius[2], Jonas Adamonis[2], Andrejus Michailovas[2], Linas Giniunas[3], Romualdas Danielius[3], Arunas Varanavicius[1]; [1]*Vilnius Univ., Lithuania;* [2]*Ekspla Ltd., Lithuania;* [3]*Light Conversion Ltd., Lithuania.* We present a compact TW-class continuum seeded multistage OPCPA system operated at 800 nm and pumped by femtosecond and picosecond pulses. 35 mJ pulse energies and compression to 9 fs are demonstarated.

## JW2A • Poster Session 2—Continued

**JW2A.81**
**Cryogenic laser performance of Yb:YAG diode-pumped at 940 nm and 969 nm for high power lasers,** Venkatesan Jambunathan[1], Lucie Těsnohlídková[1], Taisuke Miura[1], Antonio Lucianetti[1], Tomas Mocek[1]; *[1]Dept. of Diode pumped lasers, Fyzikální ústav AV CR, v.v.i., Czech Republic.* We demonstrated the laser performance of Yb:YAG for different cryogenic temperatures pumped by fibre coupled diode laser emitting at 940 and 969 nm. Laser diode bandwidth, absorption bandwidth of laser material plays a crucial role.

**JW2A.82**
**Dual-Wavelength CW Operations at 1064.1 & 1073.1 nm and 1064.1 & 1085.3 nm of Nd:YVO4 Laser,** Tanant Waritanant[1], Arkady Major[1]; *[1]Electrical & Computer Engineering, Univ. of Manitoba, Canada.* Two dual-wavelength operations of diode-pumped Nd:YVO4 laser were demonstrated at 1064.1 & 1073.1 and 1064.1 & 1085.3 nm with two intracavity birefringent plates. The output power ratio of the dual-wavelength output could be freely adjusted.

**JW2A.83**
**Selectable dual-wavelength actively Q-switched laser by monolithic electro-optic periodically poled lithium niobate Bragg modulator,** Shang-Yu Hsu[1], Yen-Yin Lin[2], Yuan-Yao Lin[2], Shou-Tai Lin[1]; *[1]Feng Chia Univ., Taiwan; [2]National Tsing Hua Univ., Taiwan.* A novel dual-wavelength actively Q-switched laser was demonstrated. When applying 20 W diode power, the output wavelength can be selected between 1063 and 1342 nm with the peak power of 27.6 and 1.6 kW, respectively.

**JW2A.84**
**52-mJ, kHz-Nd:YAG Laser with Diffraction Limited Output,** Bozhidar Oreshkov[1], Danail Chuchumishev[1], Hristo Iliev[2], Anton Trifonov[1], Torsten Fiebig[3], Claus-Peter Richter[3], Ivan Buchvarov[1,3]; *[1]Physics, Sofia Univ. St. Kliment Ohridski, Bulgaria; [2]Binovation Ltd., Bulgaria; [3]Otolaryngology, Northwestern Univ., USA.* We present Nd:YAG, diode pumped amplifier system emitting up to 52-mJ pulse energy with 1.6-ns pulse duration and near diffraction limited beam, operating at 0.75-kHz repetition rate.

**JW2A.85**
**Ultrahigh frequency surface acoustic wave modulation of optical resonators,** Semere Tadesse[1], Mo Li[2]; *[1]School of Physics and Astronomy, Univ. of MInnesota, USA; [2]Dept. of Electrical and Computer Engineering, Univ. of MInnesota, USA.* A piezoelectric aluminum nitride film on oxidized silicon wafer is used to realize high frequency surface acoustic wave devices. Optical ring resonator is integrated with the surface acoustic wave device to demonstrate a high speed acousto-optic modulation.

**JW2A.86**
**Full determination of coupling rate of light emitter to surface plasmon polaritons in frequency- and momentum-space,** Zhaolong Cao[1], H C. Ong[1]; *[1]Physics, The Chinese Univ. of Hong Kong, Hong Kong.* The spectrally- and momentum-resolved coupling rate between light emitters and surface plasmon polaritons has been studied. We find the coupling rate depends strongly on the interplay between the absorption and radiative decay rates of SPPs.

**JW2A.87**
**Modulated Plasma Waveguides Generated by Intense Bessel Beams Patterned with a Spatial Light Modulator,** George Hine[1], Andy Goers[1], Sung Yoon[1], Jennifer Elle[1], Howard Milchberg[1]; *[1]Univ. of Maryland, USA.* Plasma guiding structures are generated with programmable axial density modulations using a Spatial Light Modulator (SLM). A coherent beam-combining scheme enables the sculpting of high power beams with modest energy passing through the SLM.

**JW2A.88**
**Relevance of the transversal phase-matching in high-order harmonic generation,** Carlos Hernandez-Garcia[1,2], Íñigo J. Sola[1], Luis Plaja[1]; *[1]Grupo de Investigación en Óptica Extrema, Universidad de Salamanca, Spain; [2]JILA, Univ. of Colorado, USA.* We demonstrate theoretically and experimentally the relevance of the transversal coherence length in high-order harmonic generation (HHG). We present results in which transversal phase matching plays the leading role in the macroscopic HHG.

**JW2A.89**
**Exploring characteristics of strong-field ionization dynamics in the mid-infrared regime,** André Ludwig[1], Jochen Maurer[1], Benedikt W. Mayer[1], Christopher R. Phillips[1], Lukas Gallmann[1,2], Ursula Keller[1]; *[1]ETH Zurich, Switzerland; [2]Univ. of Bern, Switzerland.* We present a study of features in photoelectron momentum distributions from strong-field ionization of noble gases for few-cycle pulses in the mid-infrared regime and assign characteristics to their classical and quantum mechanical origin.

**JW2A.90**
**Capsule-Shaped Metallic-Cavity Laser with Reduced Plasmonic Loss,** Baifu Zhang[1], Takuya Okimoto[1], Takuo Tanemura[1], Yoshiaki Nakano[1]; *[1]The Univ. of Tokyo, Japan.* We propose novel 1.55-µm capsule-shaped metallic-cavity lasers with curved facets to reduce plasmonic losses. Significant reduction of threshold current from 291 µA to 60 µA is demonstrated with effective modal volume of 0.45 µm$^3$.

**JW2A.91**
**Graphene as a tunable reservoir for shaping the incoherent spectrum of a quantum dot via plasmonic effects,** George Hanson[1], Ebrahim Forati[1], Stephen Hughes[2]; *[1]Electrical Engineering, Univ. of Wisconsin-Milwaukee, USA; [2]Physics, Engineering Physics and Astronomy, Queen, Canada.* Using a realistic quantum master equation we show that the Mollow triplet of a quantum dot can be tuned by adjusting its local density of states via biasing of a graphene monolayer.

**JW2A.92**
**Superfocusing properties of disorder-enhanced plasmonic nanolenses,** Juan Sebastian Totero Gongora[1], Maria Laura Coluccio[2], Remo Proietti Zaccaria[2], Enzo Mario Di Fabrizio[2,3], Andrea Fratalocchi[1]; *[1]PRIMALIGHT, Faculty of Electrical Engineering; Applied, Mathematics and Computational Science, King Abdullah Univ. of Science and Technology (KAUST), Saudi Arabia; [2]Dept. of Nanostructrures, Istituto Italiano di Tecnologia (IIT), Italy; [3]PSE and BESE Divisions, King Abdullah Univ. of Science and Technology (KAUST), Saudi Arabia.* We investigated a disordered plasmonic nanolens using an extensive campaign of FDTD simulations. Our results show that surface roughness plays a crucial role in the enhancement of the electromagnetic energy with respect to regular structures.

**JW2A.93**
**Experimental observation of surface plasmon vortices with arbitrarily synthesized intensity patterns,** Chen-Da Ku[1], Chen-Bin Huang[1]; *[1]National Tsing Hua Univ., Taiwan.* Surface plasmon vortices with arbitrary pattern are synthesized via geometrical designs. The resulting vortex intensity patterns are experimentally measured using a near-field scanning optical microscope and are in good agreements as compared to numerical results.

**JW2A.94**
**Enhancing Refractive Index Sensing Capability with Infrared Plasmonic Perfect Absorbers,** Fei Cheng[1], Xiaodong Yang[1], Jie Gao[1]; *[1]Dept. of Mechanical and Aerospace Engineering, Missouri Univ of Science and Technology, USA.* We experimentally demonstrate an infrared refractive index sensor based on plasmonic perfect absorbers for glucose concentration sensing, with the figure of merit (FOM*) around 55 and a bulk wavelength sensitivity around 600nm/RIU.

**JW2A.95**
**Two-photon Photoluminescence Investigation of Transverse Plasmonic Mode of Single-crystalline Gold Nanoantennas,** Wei-Liang Chen[1], Yu-Yang Lee[1], Feng-Chieh Li[1], Fan-Cheng Lin[2], Jer-Shing Huang[2], Yu-Ming Chang[1]; *[1]Center for Condensed Matter Sciences, National Taiwan Univ., Taiwan; [2]Chemistry, National Tsing Hua Univ., Taiwan.* Polarization-dependent spectra of two-photon photoluminescence (TPPL) from three series of single-crystalline gold nanoantennas were studied. The peak position in transverse TPPL spectra was found to shift with the arm width, revealing the depolarization nature of nanoantenna-mediated radiation.

**JW2A.96**
**Near-field investigation of a periodic plasmonic metasurface,** Sabine Dobmann[1,2], Arian Kriesch[1,2], Daniel Ploss[1,2], Ulf Peschel[1,2]; *[1]Inst. of Optics, Information and Photonics, Friedrich-Alexander-Univ. Erlangen-Nuremberg (FAU), Germany; [2]Erlangen Graduate School in Advanced Optical Technologies (SAOT) and Cluster of Excellence, Engineering of Advanced Materials (EAM), Germany.* Using a near-field scanning optical microscope we investigate the optical response of a plasmonic metasurface consisting of a subwavelength periodic pattern in an ultrathin (10nm) silver film, which shows extraordinarily suppressed transmission in the visible.

**JW2A.97**
**Anisotropically Etched Silicon Surfaces for Planar Plasmonic Terahertz Guided Wave Devices,** Gagan Kumar[1,2], Shanshan Li[2], Mohamad M. Jadidi[3], Thomas E. Murphy[4]; *[1]Dept. of Physics, Indian Inst. of Technology Guwahati, India; [2]Inst. for Research in Electronics and Applied Physics, Univ. of Maryland, USA; [3]Inst. for Research in Electronics and Applied Physics, Univ. of Maryland, USA; [4]Inst. for Research in Electronics and Applied Physics, Univ. of Maryland, USA.* We report a terahertz waveguide fabricated from doped crystalline silicon. Anisotropic chemically etching is used to produce a periodic array of concave pyramidal troughs in the silicon that provide confinement in both transverse directions.

**JW2A.98**
**Dual-resonant-band enhanced optical transmission through star shape bull's eye,** Tavakol Nazari[1], Woohyun Jung[1], Reza Khazaeinezhad[1], Sahar Hosseinzadeh Kassani[1], Boram Joo[1], Byung-Joo Kong[1], Kyunghwan Oh[1]; *[1]Yonsei Univ., Korea.* Two resonant bands in enhanced optical transmission were predicted in a star shape bull's eye plasmonic structure. Fundamental and its second harmonic resonance were analyzed parametrically to find optimal conditions for linear and nonlinear responses.

**JW2A.99**
**Hybrid Plasmonic Strip and Slot Waveguides for Deep Subwavelength Nanofocusing of TE and TM Modes,** Lucas Lafone[1], Themistoklis Sidiropoulos[1], Rupert F. Oulton[1]; *[1]Dept. of Physics, Imperial College London, UK.* We identify a hybrid plasmonic slot waveguide capable of millimetre range transport and deep subwavelength nanofocusing by varying slot width. Convenient integration with the SOI platform provides an important bridge between plasmonics and silicon photonics.

**JW2A.100**

**Unidirectional Scattering and Emission of Light Mediated by a Single-Element Nanoantenna,** Niels Verellen[1,2], Dries Vercruysse[2,1], Yannick Sonnefraud[3], Xuezhi Zheng[4], Giuliana Di Martino[3], Guy A. Vandenbosch[4], Liesbet Lagae[2,1], Victor Moshchalkov[1], Stefan Maier[3], Pol Van Dorpe[2,1]; [1]*Physics and Astronomy, KU Leuven, Belgium;* [2]*imec, Belgium;* [3]*Physics, Imperial College, UK;* [4]*ESAT-TELEMIC, KU Leuven, Belgium.* We experimentally and by means of FDTD simulations and eigenmode analysis demonstrate unidirectional side scattering of a plane wave and unidirectional emission from photo luminescent molecules mediated by a V-shaped single-element metallic nanoantenna.

**JW2A.101**

**Analysis of Single Photon Micropillar Optical Switch using Semi-Analytical Model,** Stewart Carswell[1], Chegyong Hu[1], Andrew Young[1], Ruth Oulton[1], Christian Schneider[2], Sven Höfling[2,3], Martin Kamp[2], John Rarity[1]; [1]*Univ. of Bristol, UK;* [2]*Univ. of Wuerzburg, Germany;* [3]*Univ. of St Andrews, UK.* We have developed an optical switch with a quantum dot in a high Q-factor microcavity. Experimental reflectivity spectroscopy fitted by a semi-analytical model estimates the intracavity photon number required to switch the device as 0.13.

**JW2A.102**

**Non-cylindrical optical vortices,** Anderson M. Amaral[1], Edilson L. Falcão-Filho[1], Cid B. de Araújo[1]; [1]*Physics Dept., Universidade Federal de Pernambuco, Brazil.* Abstract The spatial intensity profile of vortex beams may be shaped by spatially arranging topological charges on a phase mask. In our experiments, we produced and characterized vortex beams shaped as straight lines, corners and triangles.

**JW2A.103**

**Enhanced Forward and Backward Anti-Stokes Raman Signals in Lithium Niobate Waveguides,** Da Li[1], Pengda Hong[1], Zhaojun Liu[1,2], Yujie J. Ding[1], Lei Wang[2]; [1]*Lehigh Univ., USA;* [2]*Shandong Univ., China.* We have observed enhancements of forward and backward anti-Stokes Raman signals generated in lithium niobate waveguides by one order of magnitude. Forward and backward exhibit different spectral features, unique for two configurations.

**JW2A.104**

**Coherent Attosecond Beams Carrying Orbital Angular Momentum,** Carlos Hernandez-Garcia[1,2], Antonio Picón[3], Julio San Román[2], Luis Plaja[2]; [1]*JILA, Univ. of Colorado, USA;* [2]*Grupo de Investigación en Óptica Extrema, Univ. of Salamanca, Spain;* [3]*Argonne National Lab, USA.* We present a theoretical study of high-order harmonic generation and propagation driven by an infrared field carrying orbital angular momentum (OAM). We show that extreme-ultraviolet high-OAM vortices with helical attosecond pulse structure are generated.

**JW2A.105**

**Experimental Bifurcation Diagram and Terminal Voltage Change of an External-cavity Semiconductor Laser,** Byungchil Kim[2,1], Nianqiang Li[3,2], Aakash Sahai[2,1], Alexandre Locquet[1,2], David Citrin[2,1]; [1]*Electrical and Computer Engineering, Georgia Tech Lorraine, France;* [2]*Electrical and Computer Engineering, Georgia Inst. of Technology, USA;* [3]*Center for information photonics and communications, Southwest Jiaotong Univ., China.* We present for the first time experimental bifurcation diagrams of an external-cavity semiconductor laser using the photodetected optical intensity and the laser diode terminal voltage and interpret them on the basis of the Lang and Kobayashi model.

**JW2A.106**

**A collinear 2*f*-to-3*f* self-referencing interferometer with a dual-pitch PPLN ridge waveguide,** Kenichi Hitachi[1], Atsushi Ishizawa[1], Tadashi Nishikawa[2], Hiroki Mashiko[1], Osamu Tadanaga[3], Masaki Asobe[3], Tetsuomi Sogawa[1], Hideki Gotoh[1]; [1]*NTT Basic Research Labs, Japan;* [2]*Tokyo Denki Univ., Japan;* [3]*NTT Photonics Labs, Japan.* We report carrier-envelope offset beat detection (52-dB signal-to-noise ratio at 100-kHz resolution bandwidth) with a common-path 2*f*-to-3*f* self-referencing interferometer with a dual-pitch periodically poled lithium niobate ridge waveguide.

**JW2A.107**

**Ultra-Fast Motion of Optically Driven Metallic Nanoparticles,** Sergey Sukhov[1], Alexander S. Shalin[2], Aristide Dogariu[1]; [1]*Univ. of Central Florida, CREOL, USA;* [2]*National Univ. for Information Technology, Mechanics and Optics (ITMO), Russia.* The temperature of absorbing particles changes under external illumination. In turn, this temperature distribution modifies the viscosity properties of the surrounding fluid leading to nonstationary dynamics and to ultra-fast optically induced motion of particles.

**JW2A.108**

**Accelerating beam propagation in refractive index potentials,** Nikolaos K. Efremidis[1]; [1]*Dept. of Mathematics and Applied Mathematics, Univ. of Crete, Greece.* We study the dynamics of accelerating beams impinging on different classes of index potentials. The analytic expressions for the reflected and transmitted waves show that the Airy-wave parabolic trajectory is modified with some particular exceptions.

**JW2A.109**

**Hexagonal pattern motion induced by spin dynamics of exciton-polaritons,** Oleg Egorov[1], Albrecht Werner[1], Falk Lederer[1]; [1]*Friedrich-Schiller-Universität Jena, Germany.* We report on a spin-induced collective motion of exciton-polaritons in microresonators driven coherently by a linearly polarized pump. Hexagonal patterns start a uniform motion provided that the TE-TM mode splitting is taken into account.

**JW2A.110**

**Biological Source of Correlated Photon Pairs,** Abu Thomas[1]; [1]*Northwestern, USA.* Photon pairs sources based on nonlinear optical techniques are essential components in modern quantum optical systems. We present here a naturally occurring biological source of photon pairs—Green Fluorescent Protein (GFP)—obtained by a non-degenerate four-wave mixing (FWM). © 2014 Optic

**JW2A.111**

**Determination of multidimensional hyper potential surface configuration in polyacetylene derivative,** Takayoshi Kobayashi[1,3], Tsugumasa Iiyama[1], Kotaro Okamura[1], Juan Du[2,4], Toshio Masuda[5]; [1]*Univ. of Electro-Communications, Japan;* [2]*JST, CREST, Japan;* [3]*National Chiao-Tung Univ., Taiwan;* [4]*Shanghai Inst. of Optics and Fine Mechanics, China;* [5]*Fukui Univ. of Technology, Japan.* We have for the first time obtained multi-dimensional Huang Rhys factors, which determine the potential hypersurface structures in complex polymeric system by observing the transition-energy modulations separately among many modes induced by impulsive excitation.

**JW2A.112**

**Space Charge Effects in Strong-Field Emission From a Nanostructured Si Cathode,** Phillip D. Keathley[1], Michael E. Swanwick[2], Arya Fallahi[3], Luis F. Velasquez-Garcia[1], Franz Kärtner[3,4]; [1]*Electrical Engineering and Computer Science, MIT, USA;* [2]*Microsystems Technology Labs, MIT, USA;* [3]*Center for Free-Electron Laser Science, Deutsches Elektronen Synchrotron, Germany;* [4]*Physics Dept. and the Hamburg Center for Ultrafast Imaging, Univ. of Hamburg, Germany.* Ultrafast photoemission from a nanostructured Si-cathode array comprised of nano-sharp tips (~5 nm radius of curvature) was studied. Total current yield and electron spectra indicate a transition from multiphoton to strong-field emission followed by virtual cathode formation.

**JW2A.113**

**Photoinduced Absorption with Ultrafast Decay Constants in a Large Single Crystal of BiFeO3,** Takeshi Mochizuki[1], Eiichi Matsubara[1], Masaya Nagai[1], Toshimitsu Ito[2], Masaaki Ashida[1]; [1]*Osaka Univ., Japan;* [2]*National Inst. of Advanced Industrial Science and Technology (AIST), Japan.* Using near-infrared pump probe technique, we demonstrate ultrafast photoinduced absorption with a decay constant as short as 100 fs in a large single crystal of bismuth ferrite with high quality grown by floating zone method.

**JW2A.114**

**Exciton dynamics in conducting polymer polyaniline using ultrafast spin-polarized spectroscopy,** Soonyoung Cha[1], Yoochan Hong[2], Jaemoon Yang[3], Inhee Maeng[1], Seung Jae Oh[3], Kiyoung Jeong[3], Jin-Suck Suh[3], Seungjoo Haam[4], Yong-Min Huh[3], Hyunyong Choi[1]; [1]*School of Electrical and Electronic Engineering, Yonsei Univ., Korea;* [2]*Dept. of Biomedical Engineering, Yonsei Univ., Korea;* [3]*Dept. of Radiology, YUMS-KRIBB Medical Convergence Center, College of Medicine, Yonsei Univ., Korea;* [4]*Dept. of Chemical and Biomolecular Engineering, Yonsei Univ., Korea.* The non-equilibrium charge dynamics in conducting polymer polyaniline (PANI) have been barely understood. Utilizing ultrafast spin-resolved spectroscopy, we show that the charge dynamics in PANI is dominated by the excitonic photoresponse.

**JW2A.115**

**Ring breathing mode (RBMs) coupled with exciton in semiconducting single-walled carbon nanotubes,** Takayoshi Kobayashi[1,3], Zhaogang Nie[1,2], Xue Bing[1,2], Juan Du[1,4]; [1]*Univ. of Electro-Communications, Japan;* [2]*JST, CREST, Japan;* [3]*National Chiao-Tung Univrsity, Taiwan;* [4]*Shanghai Inst. of Optics and Fine Mechanics, China.* The probe photon energy dependent amplitude of RBMs is explained in terms of the real and imaginary parts of third-order susceptibility showing that the previous explanation by frequency modulation due to radius change is incorrect.

**JW2A.116**

**Compact Subwavelength Cavities Using Reflecting Metasurfaces,** Amr Shaltout[1,2], Alexander Kildishev[1,2], Vladimir M. Shalaev[1,2]; [1]*Electrical and Computer Engineering, Purdue Univ., USA;* [2]*Birck Nanotechnology Center, Purdue Univ., USA.* Subwavelength cavities are obtained by replacing conventional mirrors with reflecting metasurfaces that introduce arbitrary phase-shifts compensating for reduced accumulated phase through the ultra-small cavity. 100-nm cavities showed resonance in the range (0.6 - 1.1μm).

**JW2A.117**

**Withdrawn**

**JW2A.118**

**Planar broadband terahertz metamaterial absorber using single nested resonator,** Yongzheng Wen[1], Wei Ma[1], Joe Bailey[2,3], Guy Matmon[2], Xiaomei Yu[1], Gabriel Aeppli[2]; [1]*Inst. of Microelectronics, Peking Univ., China;* [2]*London Centre for Nanotechnology and Dept. of Physics and Astronomy, Univ. College London, UK;* [3]*Centre for Mathematics and Physics in the Life Sciences and Experimental Biology, Univ. College London, UK.* We report a broadband terahertz metamaterial absorber with two nested back-to-back split-ring resonators constituting a single planar resonator. Bandwidths of 0.66THz and 0.98THz with the absorptivity above 0.8 and 0.6 were experimentally obtained respectively.

**JW2A.119**

**Complex Wavefront Control for Enhancing Penetration Depth in 2-D Optical Coherence Tomography,** Hyeonseung Yu[1], Jaeduck Jang[2], Jaeguyn Lim[3], Jung-Hoon Park[1], Wooyounh Jang[3], Ji-Yeun Kim[2], Yong-Keun Park[1]; *[1]Physics, Korea Advanced Inst of Science & Tech, Korea; [2]Samsung Advanced Inst. of Technology, Korea; [3]Saumsung Electronics, Korea.* We report the enhancement of signal and penetration depth in 2-D imaging in optical coherence tomography by suppressing multiple scattering via complex wavefront shaping. Up to 92% enhancements of the penetration depth were observed for a highly scattering sample.

**JW2A.120**

**Experimental Demonstration of Near-Infrared Epsilon-Near-Zero Multilayer Metamaterial Slabs,** Changyu Hu[1], Huixu Deng[1], Daniel Rosenmann[2], David A. Czaplewski[2], Xiaodong Yang[1], Jie Gao[1]; *[1]Dept. of Mechanical and Aerospace Engineering, Missouri Univ of Science and Technology, USA; [2]Center for Nanoscale Materials, Argonne National Lab, USA.* Near-infrared epsilon-near-zero metamaterial slabs based on Ag-Ge multilayers are experimentally demonstrated and numerically analyzed. A post-annealing process and multilayer grating structures are introduced to reduce the optical loss and also tune the epsilon-near-zero wavelength.

**JW2A.121**

**Unidirectional Surface Plasmon Polariton Coupler in the Visible Using Metasurfaces,** FEI DING[1,2], Nathaniel Kinsey[1], Jingjing Liu[1], Zhuoxian Wang[1], Vladimir M. Shalaev[1], Alexander Kildishev[1]; *[1]Birck Nanotechnology Center, School of Electrical &Computer Engineering, Purdue Univ., USA; [2]Centre for Optical and Electromagnetic Research, State Key Lab of Modern Optical Instrumentations, Zhejiang Univ., China.* We have theoretically investigated a metasurface as a unidirectional surface plasmon polariton (SPP) coupler. The structure can work over a broad bandwidth in the visible region.

**JW2A.122**

**Laser-Written Microstructures for Enhanced Single-Photon Collection Efficiency,** Andreas W. Schell[1], Tanja Neumer[1], Qiang Shi[2], Johannes Kaschke[2], Joachim Fischer[2], Martin Wegener[2], Oliver Benson[1]; *[1]Nano-Optics, Humboldt-Universität zu Berlin, Germany; [2]Inst. of Applied Phyics, Karlsruhe Inst. of Technology (KIT), Germany.* Highly efficient single-photon collection from solid-state single-photon emitters is an important task in quantum optics. Here, we will introduce two approaches based on three-dimensional laser-written microstructures to enhance collection efficiency as well as directivity.

**JW2A.123**

**Nonlocal polarization interferometer for entanglement detection,** Brian P. Williams[1], Warren P. Grice[2], Travis S. Humble[2]; *[1]Physics and Astronomy, Univ. of Tennessee Knoxville, USA; [2]Quantum Information Science, Oak Ridge National Lab, USA.* We report an interferometer consisting of two spatially separated balanced Mach-Zehnder interferometers sharing a polarization entangled source. Nonlocal correlation statistics enable entanglement detection, Bell state identification, and fidelity bounding.

**JW2A.124**

**Quantum Secret Sharing with Phase-Encoded Photons,** Warren P. Grice[1], Philip Evans[1], Benjamin Lawrie[1], Matthieu Legre[3], Pavel Lougovski[1], Bing Qi[1], William Ray[1], Matthew Smith[2]; *[1]Oak Ridge National Lab, USA; [2]Univ. of Tennessee, USA; [3]ID Quantique, Switzerland.* We demonstrate single-qubit quantum secret sharing using phase-encoded photons. The intermediate node is designed to be inserted directly between Alice and Bob, with no need for additional compensation schemes.

**JW2A.125**

**Separable Schmidt modes of an entangled state,** marco gramegna[1]; *[1]INRIM, Italy.* Two-Photon Spectral Amplitude of entangled states is engineered to produce a losslessly decomposition in non-overlapping single Schmidt modes. The method relies on spontaneous parametric down-conversion pumped by a comb-like spectrum radiation.

**JW2A.126**

**Broadband quasiphasematching for large-scale entanglement in quantum optical frequency combs,** Wenjiang Fan[1], Pei Wang[1], Olivier Pfister[1]; *[1]Physics, Univ. of Virginia, USA.* We observed a remarkably broad sum frequency generation quasi-phasematching bandwidth in periodically poled KTiOPO4, consistent with theory. This is key to large-size quantum computing registers by generating continuous-variable cluster states in quantum optical frequency combs.

**JW2A.127**

**Progress Towards On-chip Single Photon Sources Based on Colloidal Quantum Dots in Silicon Nitride Devices,** Suzanne Bisschop[1,2], Yunpeng Zhu[2,3], Weiqiang Xie[2,3], Antoine Guille[1,3], Zeger Hens[1,3], Dries Van Thourhout[2,3], Edouard Brainis[1,3]; *[1]Physics and Chemistry of Nanostructures, Ghent Univ., Belgium; [2]Photonics Research Group, INTEC, Ghent Univ., Belgium; [3]Center for Nano and Biophotonics, Ghent Univ., Belgium.* New results on integration of colloidal quantum dots (QDs) into SiN microstructures are reported, including QD positioning with nanometric accuracy and the efficient coupling of their emission to waveguides and cavities. The results are relevant to on-chip quantum optics and information processing.

**JW2A.128**

**Adaptive Optics for Single-Photon Fiber Coupling of Ions,** Alexander Hill[1], Joseph Nash[1], Martin Graham[1], David Hervas[1], Paul Kwiat[1]; *[1]Physics, Univ. of Illinois at Urbana-Champaign, USA.* We present a new adaptive-optics technique for the optimization of photon collection from a simulated ion. Our technique uses a genetic algorithm to correct wavefront aberrations via deformable mirror before coupling into a single-mode fiber.

**JW2A.129**

**Quantum nano optics of defect centers in diamond and h-BN with nano-cathodoluminescence,** Sophie Meuret[1], Luiz H. Tizei[1], Jean-Denis Blazit[1], Romain Bourrellier[1], Marcel Tencé[1], Alberto Zobelli[1], Mathieu Kociak[1]; *[1]Laboratoire de Physique des Solides, France.* We have developed a cathodoluminescence-based single photon emitter detection scheme with deep subwavelength resolution. Application to NV0 centers in diamond and a new type of emitter in hexagonal Boron Nitride is presented.

**JW2A.130**

**Uniform and large volume microwave magnetic coupling to NV centers in diamond using split ring resonators,** Khadijeh Bayat[1], Jennifer Choy[1], Anna V. Shneidman[2], Srujan Meesala[1], Mahdi Farrokh Baroughi[3], Marko Loncar[1]; *[1]school of Engineering and Applied Science, Harvard Univ., USA; [2]Dept. of Chemistry and Chemical Biology, Harvard Univ., USA; [3]Electrical Engineering and Computer Science, South Dakota State Univ., USA.* A microwave resonator for uniform coupling of microwave magnetic field into NV centers in diamond over a mm3 volume with an average Rabi frequency of 16 MHz with a 5% variance for 0.5 W microwave power is reported.

**JW2A.131**

**The optimized probe light frequency detuning for Faraday-rotation cesium atomic magnetometer,** Wenhao Li[1], Pingwei Lin[2], Xiang Peng[1], Hong Guo[1]; *[1]Peking Univ., China; [2]National Inst. of Metrology (NIM), China.* We experimentally demonstrate that the sensitivity of all-optical Faraday-rotation magnetometer can be improved by tuning probe light frequency to the edge of wings of Doppler profile with cesium atoms, which coincides with the theoretical analysis.

**JW2A.132**

**Vacuum Rabi oscillation in coupled highly-dissipative cavity quantum electrodynamics,** Yong-Chun Liu[1,2], Xingsheng Luan[2], Hao-Kun Li[1], Qihuang Gong[1], Chee Wei Wong[2], Yun-Feng Xiao[1]; *[1]Peking Univ., China; [2]Columbia Univ., USA.* We demonstrate strong anharmonicity of the polariton dressed states in a highly dissipative cavity quantum electrodynamics system via dark state resonances. Vacuum Rabi oscillation and photon blockade occur even for decay-to-interaction rate ratio exceeding 100.

**JW2A.133**

**Measurement of the autocorrelation function of a cathodoluminescence signal : characteristics and applications in nanosecond time resolved and nanometer spatially resolved experiment,** Sophie Meuret[1], Luiz H. Tizei[1], Jean-Denis Blazit[1], Marcel Tencé[1], Thomas Auzelle[4], Karine Hestroffer[4], Huan-Cheng Chang[2], Bruno Daudin[4], François Treussart[3], Mathieu Kociak[1]; *[1]Laboratoire de Physique des Solides, Université Paris-Sud, CNRS-UMR 8502, France; [2]Inst. of Atomic and Molecular Sciences, Academia Sinica, Taiwan; [3]Laboratoire Aimé Cotton, Université Paris Sud and ENS Cachan, France; [4]Nanophysique et Semiconducteurs, CEA-CNRS Group, France.* In this presentation we show that the autocorrelation function of the cathodo- luminescence signal (CL−g(2)(τ)) can be different from the photoluminescence PL−g(2)(τ) showing a huge nanosecond bunching effect g(2)(0) > 1, allowing to retrieve emitters lifetime at nanometer scale.

**JW2A.134**

**Quantum noise limit of the White-Light-Cavity assisted LIGO interferometer sensitivity,** Minchuan Zhou[2], Selim M. Shahriar[1,2]; *[1]Dept. of EECS, Northwestern Univ., USA; [2]Dept. of Physics and Astronomy, Northwestern Univ., USA.* We present the quantum noise limited sensitivity curves for the LIGO interferometer incorporating the white light cavity, which shows broadening effect and dips of opto-mechanical resonances for different values of reflectivities of the auxiliary mirror.

**JW2A.135**

**Withdrawn**

**JW2A.136**

**Laser scribing of CIGS based thin films solar cells,** Michele Sozzi[1], Daniele Menossi[2], Alessio Bosio[2], Annamaria Cucinotta[1], Nicola Romeo[2], Stefano Selleri[1]; *[1]Information engineering, Univ. of Parma, Italy; [2]Physics and Earth Sciences, Univeristy of Parma, Italy.* Laser scribing tests on CIGS based thin films solar cells have been performed. The obtained high quality incisions show that laser scribing is a valuable tool for producing low-cost photovoltaic modules.

**JW2A.137**

**Solar tracking system for lighting fiber,** Kim Sung-Hyun[1], Lee MinHwan[1], Park Jaesik[1], Lee Kyung-Goo[2], Hwang InKag[1]; *[1]Chonnam National Univ., Korea; [2]Taihan Fiberoptics company, Korea.* We demonstrate a simple and effective solar tracking system for collection of sunlight in an optical fiber. The system incorporates a mirror whose axes were controlled based on the known equation of solar motion.

**JW2A.138**

**The Ability of Laser to Perforate and Analyze Rocks in Oil and Gas Wells,** Mohamed Shahin[1]; *[1]Petroleum Engineering, Faculty of Petroleum and Mining Engineering, Suez Univ., Egypt.* Lab investigations were carried out using 1 KW Nd:YAG laser to study the thermal effects on several rock samples, removal mechanisms and the feasibility of real time downhole analysis of the perforated/drilled formations.

## JW2A • Poster Session 2—Continued

**JW2A.139**
**Enhancement of Solar Energy Conversion by Internal Light Randomization in Subwavelength Active Layer,** Avi Niv[1,3], Guy Bartal[1], Avner Rothchiled[2]; [1]*Eelectrical Engineering, Technion, Israel;* [2]*Material Science and Engineering, Technion, Israel;* [3]*Environmental Physics, Ben Gurion Univ. of the Negev, Israel.* Light randomization in subwavelength active layers beyond the eligibility of rays is investigated. None-the-less more than 30% current enhancement in less than 50nm thick oxide layers is observed indicating a potentially game-changing approach.

**JW2A.140**
**Dynamic Monitoring Instrument for Fluidic Water Quality,** Ruey-Ching Twu[1], Guan-Min Chen[1], Hsiao-Ying Tu[1]; [1]*Electro-Optical Engineering, Southern Taiwan Univ. of Science and Technology, Taiwan.* An optic sensing instrument is developed and demonstrated successfully for the dynamic measurements of fluidic water quality.

**JW2A.141**
**The Coupled Electrical-Optical Simulation of Solar Cell J-V Degradation with Grating Heights,** Yu Chiun Lin[1], Yan-Kai Zhong[1], Sze Ming Fu[1], Chi Wei Tseng[1], Shih-Yun Lai[1], Wei-Ming Lai[1], Sheng Lun Yan[1], Nyan-Ping Ju[1], Po-Yu Chen[1], Chi-Chung Tsai[1], Albert Lin[1]; [1]*National Chiao Tung Univ., Taiwan.* Solar cell with grating structure is used frequently for increased optical absorption, but it can lead to electrical degradation. Here coupled simulation is conducted to clarify the physical reason causing this J-V degradation.

**JW2A.142**
**Withdrawn**

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**14:00–16:00 Market Focus Session IV: The Future of "Enabling" Photonics Innovation,** *Exhibit Hall Theater*

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**15:00–16:30 Coffee Break** (15:00-15:30) **and Unopposed Exhibit Only Time,** *Exhibit Halls 1 & 2*

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NOTES

## CLEO: QELS-Fundamental Science

### Executive Ballroom 210A

**16:30–18:30**
**FW3A • Single Photon and Photon Pair Sources**
*Presider: Hiroki Takesue; NTT Basic Research Labs, Japan*

**FW3A.1 • 16:30**
**Efficient Heralding of Passively Spatial-Multiplexed O-Band Photons for Noise-Tolerant Quantum Key Distribution,** Mao Tong Liu[1], Han Chuen Lim[1,2]; [1]*School of Electrical and Electronic Engineering, Nanyang Technological Univ., Singapore;* [2]*Emerging Systems Division, DSO National Labs, Singapore.* We demonstrate an O-band passively spatial-multiplexed heralded photon source with 74.5% heralding efficiency for noise-tolerant quantum key distribution. Relation between QBER and noise-degraded g(2)(0) of heralded photons transmitted over a 10-km-long fiber is observed.

**FW3A.2 • 16:45**
**Widely-Detuned All-Fiber Photon Pair Source in Standard Telecom Fiber,** Shellee D. Dyer[1], Laura Wadleigh[2], Varun Verma[1], Sae Woo Nam[1]; [1]*NIST, USA;* [2]*Physics, Carleton College, USA.* We demonstrate photon pair generation in the telecom O- and L-bands thru spontaneous four-wave mixing in fiber. These wavelengths have low loss in fiber and are widely detuned from the pump, which simplifies filtering and reduces Raman.

**FW3A.3 • 17:00**
**An integrated source of high purity single photon pairs with narrow bandwidths,** Kai-Hong Luo[1], Harald Herrmann[1], Stephan Krapick[1], Raimund Ricken[1], Viktor Quiring[1], Hubertus Suche[1], Wolfgang Sohler[1], Chrisitine Silberhorn[1]; [1]*Integrated Quantum Optics, Univ. of Paderborn, Germany.* We implemented a compact integrated non-degenerate source which comprises a periodically poled waveguide with highly reflective dielectric mirror coatings to obtain narrowband photon pairs based on type II parametric down-conversion.

### Executive Ballroom 210B

**16:30–18:30**
**FW3B • Advances in Quantum Optics Platforms**
*Presider: Tim Taminiau; Technische Universiteit Delft, Netherlands*

**FW3B.1 • 16:30**
**Enhanced spin-based sensing using light trapping in a bulk diamond system,** Hannah Clevenson[1], Tim Schroder[1], Matthew Trusheim[1], Dirk Englund[1], Danielle Braje[2]; [1]*Electrical Engineering and Computer Science, Research Lab of Electronics, MIT, USA;* [2]*MIT Lincoln Lab, USA.* We introduce a room-temperature diamond magnetometer based on a multi-pass cell design. We estimate that we address ~10^10 nitrogen vacancy centers, achieving a sensitivity of 93 nT/Hz^.5 while predicting a shot-noise-limited sensitivity of 25 fT/Hz^.5.

**FW3B.2 • 16:45**
**Implantation of proximal NV clusters in diamond by lithographically defined silicon masks with 5 nm resolution,** Igal Bayn[1,2], Edward Chen[1], Luozhou Li[1,2], Matthew Trusheim[1,3], Tim Schroeder[1], Ophir Gaathon[1], Ming Lu[4], Aaron Stein[4], Mingzhao Liu[4], Kim Kisslinger[4], Dirk Englund[1]; [1]*Dept. of Electrical Engineering and Computer Science, and Research Lab of Electronics, MIT, USA;* [2]*Dept. of Electrical Engineering, Columbia Univ., USA;* [3]*Dept. of Applied Physics and Applied Mathematics, Columbia Univ., USA;* [4]*Center for Functional Nanomaterials, Brookhaven National Lab, USA.* We present the fabrication of nitrogen-vacancy (NV) spin chains by implantation through a silicon mask on diamond. A minimum implantation aperture width of 5 nm is produced. Super-resolution measurements reveal NV lines 26 nm wide and minimal NV-pitch of 8 nm.

**FW3B.3 • 17:00**
**Statistics of decay dynamics of quantum emitters in disordered photonic-crystal waveguides,** Alisa Javadi[1], Pedro David Garcia[1], Luca Sapienza[1], Sebastian Maibom[1], Henri Thyrrestrup[1], Peter Lodahl[1]; [1]*Niels Bohr Inst., Copenhagen Univ., Denmark.* We present a statistical analysis of the spontaneous emission of quantum dots coupled to Anderson-localized cavities in disordered photonic-crystal waveguides.We observe an average Purcell factor of 5 with a maximum value of 24.

### Executive Ballroom 210C

**16:30–18:30**
**FW3C • Symposium on Science and Applications of Structured Light in Complex Media II ▶**
*Presider: Andrea Alu; Univ. of Texas at Austin, USA*

**FW3C.1 • 16:30** Invited
**Resonating Metasurface Photon and its Spin Manipulation,** Xiaobo Yin[1,2]; [1]*Mechanical Engineering, Univ. of Colorado, USA;* [2]*Mechanical Engineering, Univ. of California, USA.* The ubiquitous spin-orbit interaction destroys the particles' spin rotational symmetry and introduces a universal transverse spin current. Here we show that an anomalous refracting metasurface induces a controllable spin-orbit interaction and a path-dependent polarization rotation.

**FW3C.2 • 17:00** ▶
**Geometrical Management of Optical Vortices by Closed-path Metallic Nanoslits,** Etienne Brasselet[1], Gediminas Gervinskas[2], Gediminas Seniutinas[2], Saulius Juodkazis[2]; [1]*Univ. of Bordeaux, CNRS, France;* [2]*Swinburne Univ. of Technology, Australia.* We propose and experimentally demonstrate a geometrical approach to the controlled generation of optical phase singularities at small scale by using metallic nanostructures, thereby offering a novel strategy towards singular nanophotonics.

### Executive Ballroom 210D

**16:30–18:30**
**FW3D • Spatio-Temporal Dynamics**
*Presider: Anna Peacock, Univ. of Southampton, USA*

**FW3D.1 • 16:30**
**Dark Soliton Attraction and Optical Spatial Shock Waves Observed in M-cresol/Nylon Solutions,** Valton Smith[1], Phillip Cala[1], Zhigang Chen[1], Weining Man[1]; [1]*San Francisco State Univ., USA.* We demonstrate the strongest effect of dark-soliton attraction in a new type of nonlocal thermal self-defocusing nonlinear media (m-cresol/nylon solutions). Formation of spatial shock waves is also observed with only mW power.

**FW3D.2 • 16:45**
**The True Nature of Spatiotemporal Light Bullets at 1.8 μm in Bulk Dielectric Media with Kerr Nonlinearity,** Donatas Majus[1], Gintaras Tamošauskas[1], Ieva Grazuleviciute[1], Nail Garejev[1], Antonio Lotti[2], Daniele Faccio[3], Audrius Dubietis[1]; [1]*Dept. of Quantum Electronics, Vilnius Univ., Lithuania;* [2]*Dipartimento di Scienza e Alta Tecnologia, Università degli Studi dell Insubria, Italy;* [3]*School of Engineering and Physical Sciences, SUPA, Heriot-Watt Univ., UK.* By three-dimensional imaging and measurements of energy density flux, we experimentally demonstrate that light bullets generated by filamentation in bulk dielectric media with anomalous group velocity dispersion are spatio-temporal, polychromatic Bessel pulses.

**FW3D.3 • 17:00**
**Raman rogue waves in a long cavity passively mode-locked fiber laser,** Antoine Runge[1], Claude Aguergaray[1], Neil Broderick[1], Miro J. Erkintalo[1]; [1]*Univ. of Auckland, New Zealand.* Single-shot spectral measurements using the dispersive Fourier transformation reveal sporadic emission of parasitic Raman pulses at the output of an ultrafast Yb-doped, all-normal dispersion fiber laser. A statistical analysis reveals rogue-wave-like extreme energy fluctuations.

## CLEO: Science & Innovations

### Executive Ballroom 210E

**16:30–18:30**
**SW3E • Coherent Combining and fs Fiber Lasers**
*Presider: Jeffrey Nicholson; OFS Labs, USA*

**SW3E.1 • 16:30**
**464 MHz repetition rate erbium doped soliton fiber laser,** Jian Zhang[1], Fuzeng Niu[1], Xing Chen[1], Xiang Gao[2], Yizhou Liu[1], Aimin Wang[1], Zhigang Zhang[1]; [1]*Insitiute of Quantum Electronics,School of Electronics Engineering and Computer Science, Peking Univ., China;* [2]*School of Electronics Engineering and Computer Science, Peking Univ., China.* We demonstrate an Er:fiber ring laser operated at the fundamental repetition rate of 464MHz. The output power is 115mW under the pump power of 1.65W. The pulse width is 123fs.

**SW3E.2 • 16:45**
**1 GHz repetition rate ring cavity femtosecond Yb:fiber laser,** Chen Li[1], Xiang Gao[1], Guizhong Wang[1], Tongxiao Jiang[1], Aimin Wang[1], Zhigang Zhang[1]; [1]*Peking Univ., China.* We demonstrate the first 1 GHz fundamental repetition rate ring cavity ytterbium doped fiber laser. The laser delivers 600 mW, 64fs near transform-limited pulses and supports direct octave-spanning spectrum generation.

**SW3E.3 • 17:00** Invited
**Performance Scaling of Ultrafast Laser Systems by Coherent Addition of Femtosecond Pulses,** Jens Limpert[1]; [1]*Friedrich-Schiller-Universität Jena, Germany.* The approach of coherent combination of ultrashort laser pulses will reviewed. Concept, achievements and perspectives towards compact high peak power and high average power fiber laser systems will be discussed.

### Executive Ballroom 210F

**16:30–18:30**
**SW3F • THz Spectroscopy & Sensing I**
*Presider: David Cooke; McGill Univ., Canada*

**SW3F.1 • 16:30** Tutorial
**Intense terahertz pulses: probing and controlling fundamental motions of electrons, spins and ions,** Tobias Kampfrath[1]; [1]*Fritz Haber Inst./MPG, Germany.* Terahertz radiation permits resonant and sensitive probing of electron transport, spin precession and ion vibration in solids. Recently developed sources of strong-field terahertz pulses even allow one to gain control over these fundamental modes.

Tobias Kampfrath earned is PhD in Physics in 2006 from Free University of Berlin. He was a Postdoc at AMOLF Amsterdam with K. Kuipers. Since 2010 he has been the head of the the THz physics group at the Fritz Haber Institute, Berlin. His Work is on THz spectroscopy of magnetically ordered solids and on ultrafast nanooptics.

### Executive Ballroom 210G

**16:30–18:30**
**SW3G • Micro-and Photonic Crystal Lasers** ▶
*Presider: Anthony Hoffman; Univ. of Notre Dame, USA*

**SW3G.1 • 16:30** Invited ▶
**Asymmetric Heterogeneously Integrated InP Microdisk Lasers on Si for Optical Interconnect and Optical Logic,** Geert I. Morthier[1,2], Pauline Mechet[1,2], Thijs Spuesens[1,2], Dries Van Thourhout[1,2], Gunther Roelkens[1,2]; [1]*Dept. of Information Technology, Ghent Univ., Belgium;* [2]*Center for Nano- and Biophotonics, Ghent Univ., Belgium.* We discuss properties and applications of heterogeneously integrated microdisk lasers coupled to an asymmetrically reflecting bus waveguide, in particular unidirectionality and sensitivity to external feedback. We also discuss the application of such lasers for low power all-optical signal regeneration.

**SW3G.2 • 17:00**
**Electrically Driven Photonic-Crystal Lasers on Silicon Substrates Using Direct Wafer Bonding,** Koji Takeda[1,3], Tomonari Sato[1,3], Takuro Fujii[1,3], Eiichi Kuramochi[2,3], Masaya Notomi[2,3], Koichi Hasebe[1,3], Takaaki Kakitsuka[1,3], Shinji Matsuo[1,3]; [1]*NTT Photonics Labs, NTT Corporation, Japan;* [2]*NTT Basic Research Labs, NTT Corporation, Japan;* [3]*Nanophotonics Center, NTT Corporation, Japan.* We demonstrate the first continuous wave operation of electrically driven photonic-crystal lasers on Si at room temperature. Plasma assisted bonding integrated III-V semiconductor devices on Si. The device exhibited a 33 μA threshold current.

## CLEO: Applications & Technology

### Executive Ballroom 210H

**16:30–17:45**
**AW3H • High Performance Optical Measurement**
*Presider: Hugo Thienpont, B-PHOT, Belgium*

**AW3H.1 • 16:30**
**Ultra-wideband Cueing Receiver based on Spatial-Spectral Holographic Rainbow Spectrometer,** Tia Sharpe[1], Cooper McCann[1], Cal Harrington[1], Zeb W. Barber[1], R. Krishna Mohan[1], Wm. Randall Babbitt[1]; [1]*Montana State Univ., USA.* A spatial-spectral holographic channelizer and cueing receiver capable of operating 1-110 GHz with sub-MHz resolution, high dynamic range, and 1000 variably programmable channels is presented, along with initial test results in the 10-20 GHz band.

**AW3H.2 • 16:45**
**Method for Increasing the Operating Distance of MEMS LIDAR beyond Brownian Noise Limitation,** Behnam Behroozpour[1]; [1]*Univ. of California, Berkeley, USA.* A LIDAR based on a MEMS tunable VCSEL uses resonance tuning to increase the maximum range ten-fold. A novel demodulator reduces the peak electrical beat frequency from 52GHz to 235MHz for compatibility with standard CMOS.

**AW3H.3 • 17:00**
**Lidar Velocity Measurement using a GHz Gated Photon Detector and Locked but Unequal Optical Pulse Rate,** Gregory S. Kanter[1], Daniel Reilly[1]; [1]*NuCrypt, USA.* A lidar system with high tolerance to background light is described. Velocity sensitivity measurements using two different signal processing methods are compared. Sensitivity of -90 dBm is realized for up to 6.9 km/s emulated speeds.

**Meeting Room**
**211 B/D**

## CLEO: Science & Innovations

**16:30–18:30**

### SW3I • Novel Materials for Integrated Nonlinear Optics ▶

*Presider: Benjamin Eggleton; Univ. of Sydney, Australia*

**SW3I.1 • 16:30** ▶

**Mid-IR parametric frequency generation in hybrid As2Se3 microwires using normal dispersion modulation instability,** Thomas Godin[1], Yves Combes[1], Raja Ahmad[2], Martin Rochette[2], Thibaut Sylvestre[1], John M. Dudley[1]; *[1]Institut FEMTO-ST, France; [2]McGill Univ., Canada.* We report the observation of modulation instability in the mid-infrared by pumping chalcogenide-polymer optical microwires in the normal dispersion regime. Modulation instability is allowed via negative fourth-order dispersion and leads to far-detuned parametric frequency conversion.

**SW3I.2 • 16:45** ▶

**Mid-infrared Supercontinuum Generation in Robust Step-Index Chalcogenide Nanotapers Pumped with a Thulium Fiber Laser,** Soroush Shabahang[1], Guangming Tao[1], Kevin F. Lee[2], Viktor Smolski[1], Konstantin L. Vodopyanov[1], Martin Fermann[2], Ayman F. Abouraddy[1]; *[1]Univ. of Central Florida, CREOL, USA; [2]IMRA, USA.* We fabricate highly nonlinear and mechanically robust step-index chalcogenide nanotapers with large core-cladding index contrast. Using femtosecond pulses at 2-micron wavelength from a thulium fiber laser, mid-infrared supercontinuum spanning more than an octave was generated.

**SW3I.3 • 17:00** ▶

**A two-octave broadband quasi-continuous mid-infrared supercontinuum generated in a chalcogenide glass waveguide,** Barry Luther-Davies[1], Yi Yu[1], Pan Ma[1], Zhiyong Yang[1], Duk-Yong Choi[1], Steve Madden[1], Sukanta Dabbarma[1], Xin Gai[1], Rongping Wang[1]; *[1]Australian National Univ., Australia.* We have produced a stable 10mW, mid-infrared supercontinuum spanning the full functional group band from 1750nm to >7000nm spanning using a 1cm long chalcogenide waveguide pumped by a 20MHz train of 320fs pulses at 4µm.

**Meeting Room**
**212 A/C**

**16:30–18:30**

### SW3J • Subsystems for Optical Communications

*Presider: Sophie LaRochelle; Universite Laval, Canada*

**SW3J.1 • 16:30**

**Pump-Linewidth-Tolerant Wavelength Conversion with Coherent Pumps,** Guo-Wei Lu[1], André Albuquerque[2], Benjamin J. Puttnam[1], Takahide Sakamoto[1], Miguel Drummond[2], Rogério Nogueira[2], Atsushi Kanno[1], Satoshi Shinada[1], Naoya Wada[1], Tetsuya Kawanishi[1]; *[1]NICT, Japan, Japan; [2]Instituto de Telecomunicações (IT) - pólo de Aveiro, Portugal.* We propose a pump-linewidth-tolerant wavelength conversion scheme with coherent two-tone pump, and demonstrate high quality wavelength conversion of 64QAM signals with <0.3-dB penalty at BER of 10-3 even using 3.5MHz-linewidth DFB pump source.

**SW3J.2 • 16:45**

**Impact of Laser Resonance Phase Noise on the Wavelength Conversion of DQPSK Signals,** Sean O Duill[1], Aravind Anthur[2], Tam Huynh[1], Deepa Venkitesh[2], Liam Barry[1]; *[1]The Rince Inst., Dublin City Univ., Ireland; [2]Dept. of Electrical Engineering, Indian Inst. of technology, Madras, India.* We show through simulations and with supporting experimental results that the performance of four-wave mixing based wavelength conversion of DQPSK signals is severely limited by resonance enhanced phase noise on the pump source.

**SW3J.3 • 17:00**

**Reconfigurable Optical Sub-harmonic Clock Recovery Based on Inverse Temporal Self-imaging,** Reza Maram[1], Luis Romero Cortés[1], José Azaña[1]; *[1]INRS-Energie Materiaux et Telecom, Canada.* We propose and experimentally demonstrate a novel, simple and efficient sub-harmonic optical clock recovery technique from RZ-OOK data based on temporal self-imaging, involving temporal phase modulation and dispersion, with a reconfigurable rate division factor.

**Meeting Room**
**212 B/D**

## CLEO: QELS-Fundamental Science

**16:30–18:30**

### FW3K • Devices Enabled by Nano-Optics and Plasmonics ▶

*Presider: Nikolay Zheludev; Univ. of Southampton, UK*

**FW3K.1 • 16:30** **Invited** ▶

**Transparent Displays Enabled by Resonant Nanoparticle Scattering,** Chia Wei Hsu[1,2], Bo Zhen[1], Wenjun Qiu[1], Ofer Shapira[1], Brendan DeLacy[3], John Joannopoulos[1], Marin Soljacic[1]; *[1]Physics, MIT, USA; [2]Physics, Harvard Univ., USA; [3]U.S. Army Edgewood Chemical Biological Center, USA.* We create a transparent display by projecting monochromatic images onto a polymer film embedded with nanoparticles that selectively scatter light at the projected wavelength. This approach features simplicity, wide viewing angle, scalability, and low cost.

**FW3K.2 • 17:00** ▶

**Aperiodic single-pixel angle-modulated plasmonic color sorter and angle sensor,** Matthew S. Davis[1], Ting Xu[2], Christopher D. Bohn[2], Henri J. Lezec[2], Amit K. Agrawal[1,2]; *[1]Dept. of Electrical Engineering and Computer Science, Syracuse Univ., USA; [2]Center for Nanoscale Science and Technology, National Inst. of Standards and Technology, USA.* We demonstrate the design, simulation and experimental realization of a single aperiodic slit-groove plasmonic device that exhibits angle-selectable RGB color response at optical frequencies, as well as a high quality factor and optical contrast.

**Marriott**
**Salon I & II**

## CLEO: Applications & Technology

**16:30–18:30**

### AW3L • Microscopy

*Presider: Ernest Chang; Physical Sciences Inc., USA*

**AW3L.1 • 16:30**

**Single Nanoparticle and Virus Detection Using a Smart Phone Based Fluorescence Microscope,** Qingshan Wei[1,2], Hangfei Qi[4], Wei Luo[1], Derek Tseng[1], Laurent A. Bentolila[3,5], Ting-Ting Wu[4], Ren Sun[4,3], Aydogan Ozcan[1,2]; *[1]Electrical Engineering Dept., Univ. of California Los Angeles, USA; [2]Bioengineering Dept., Univ. of California Los Angeles, USA; [3]California NanoSystems Inst. (CNSI), Univ. of California Los Angeles, USA; [4]Dept. of Molecular and Medical Pharmacology, Univ. of California Los Angeles, USA; [5]Dept. of Chemistry and Biochemistry, Univ. of California Los Angeles, USA.* We demonstrate a field-portable fluorescence microscopy platform installed on a smart phone for imaging of single/isolated nanoparticles and fluorescently labeled viruses.

**AW3L.2 • 16:45**

**Hyper-dimensional analysis for label-free high-throughput imaging flow cytometry,** Claire Chen[1,3], Ata Mahjoubfar[1,3], Allen Huang[1,3], Kayvan Niazi[3,4], Shahrooz Rabizadeh[3,4], Bahram Jalali[1,2]; *[1]Dept. of Electrical Engineering, Univ. of California Los Angeles, USA; [2]Dept. of Bioengineering, Univ. of California, Los Angeles, USA; [3]California NanoSystems Inst., USA; [4]NantWorks, LLC, USA.* We present an imaging flow cytometer capable of capturing phase and intensity images of individual unlabeled cells at 36 million frames/second to generate multi-dimensional scatter plots, leading to a considerable enhancement in cell classification sensitivity.

**AW3L.3 • 17:00** **Invited**

**Photoacoustic microscopy: current situation and new ultrasonic detectors,** Biqin Dong[1], Cheng Sun[1], Hao F. Zhang[1]; *[1]Northwestern Univ., USA.* We present the need for new ultrasonic detectors in photoacoustic microscopy and report on the development of a cover-slip type, optically transparent, all-optical ultrasonic detector based on a polymeric micro-ring resonator for various photoacoustic applications.

## CLEO: Science & Innovations

## Marriott Salon III

### 16:30–18:30

### SW3M • Nonlinear Nanophotonics

*Presider: Alexander Gaeta; Cornell Univ., USA*

**SW3M.1 • 16:30**

**Improved four-wave mixing with free-carrier removal in silicon coupled microring waveguides,** Junrong Ong[1], Ranjeet Kumar[1], Xianshu Luo[2], Guo-Qiang Lo[2], Shayan Mookherjea[1]; [1]*Univ. of California San Diego, USA;* [2]*Inst. of Microelectronics, A*STAR, Singapore.* We improve CW wavelength conversion efficiency by 10 dB in an optical waveguide consisting of 51 directly-coupled silicon microrings, based on electronic free-carrier sweepout using two reverse-biased p-n junction diodes on each microring resonator.

**SW3M.2 • 16:45**

**Wide-band On-chip Four-Wave Mixing via Coupled Cavity Dispersion Compensation,** Cale M. Gentry[1], Xiaoge Zeng[1], Miloš A. Popović[1]; [1]*Univ. of Colorado at Boulder, USA.* We demonstrate a dual-cavity resonant structure that employs frequency splitting at one of three resonances to structurally compensate dispersion. We show seeded four-wave mixing across the largest free spectral range to our knowledge of 26nm.

**SW3M.3 • 17:00**

**Four-wave mixing in silicon ``photonic molecule" resonators with port-selective, orthogonal supermode excitation,** Xiaoge Zeng[1], Cale M. Gentry[1], Miloš A. Popović[1]; [1]*Univ. of Colorado at Boulder, USA.* We propose coupled-cavity resonators for four-wave mixing (FWM) that support strong nonlinear interaction between distributed pump, signal and idler modes, yet allow independent coupling of these modes to separate ports. We demonstrate seeded FWM and discuss applications of such orthogonal coupling.

## Marriott Salon IV

### 16:30–18:30

### SW3N • High Power Laser

*Presider: Michalis Zervas; Univ. of Southampton, UK*

**SW3N.1 • 16:30**

**High-power Single-frequency, Single-polarization, Thulium-doped all-fiber MOPA,** Jiang Liu[1], Kun Liu[1], Hongxing Shi[1], Yubin Hou[1], Yijian Jiang[1], Pu Wang[1]; [1]*Beijing Univ. of Technology, China.* We demonstrated a high-power single-frequency, single-polarization, thulium-doped all-fiber MOPA system. The linearly-polarized thulium-doped fiber MOPA yielded 192 W of single-frequency output at central wavelength of 2001 nm with a polarization extinction ratio of >15 dB.

**SW3N.2 • 16:45**

**SBS Mitigation via Phase Modulation and Demodulation,** Henrik Tünnermann[1,4], Philipp Jahn[1,2], Volker Quetschke[3], Jörg Neumann[1,2], Dietmar Kracht[1,2], Peter Wessels[1,2]; [1]*Laser Zentrum Hannover e.V., Germany;* [2]*Centre for Quantum Engineering and Space-Time Research - QUEST, Germany;* [3]*Dept. of Physics and Astronomy, Univ. of Texas at Brownsville, USA;* [4]*Inst. for Laser Science, Univ. of Electro-Communications, Japan.* We present SBS suppression in a single frequency amplifier using frequency sidebands added by an EOM and complete recovery of the single frequency signal after amplification using a custom high power high modulation index EOM.

**SW3N.3 • 17:00**

**High Power, Sub-GHz, Monolithic Fiber Amplifier Based on Phase Modulated Laser Gain Competition,** Angel Flores[1], Iyad Dajani[1]; [1]*US Air Force Research Lab, USA.* SBS suppression in monolithic, Yb-doped fiber amplifiers via phase modulated two-tone laser gain competition (LGC) is reported. The LGC between broad and narrow-linewidth (1036nm/1064nm) signals yielded pump-limited output powers of 600W at a 500MHz modulation-frequency.

## Marriott Salon V & VI

### 16:30–18:30

### SW3O • Optical Clocks & Dissemination

*Presider: Zeb Barber; Montana State Univ. - Spectrum Lab, USA*

**SW3O.1 • 16:30** **Invited**

**Optical Atomic Clocks for a Future New Definition of the Second,** Fritz Riehle[1]; [1]*Physikalisch Technische Bundesanstalt, Germany.* Optical atomic clocks outperform the best caesium atomic clocks which define the second wrt accuracy and stability. As secondary representations of the second they pave the way to a new definition of the time unit.

**SW3O.2 • 17:00**

**650-km Fiber Link in Italy for Optical Frequency Dissemination and Remote Clocks Comparison,** Cecilia Clivati[1], Claudio E. Calosso[1], Matteo Frittelli[1], Aldo Godone[1], Filippo Levi[1], Alberto Mura[1], Massimo Zucco[1], Davide Calonico[1], Denis V. Sutyrin[2], Guglielmo M. Tino[2], Nicola Poli[2], Giovanni A. Costanzo[3]; [1]*Istituto Nazionale di Ricerca Metrologica, Italy;* [2]*Università di Firenze, LENS and INFN, Italy;* [3]*Politecnico di Torino, Italy.* We realized a 650-km optical fiber link in Italy for frequency dissemination and remote clocks comparison. We present its implementation and characterization at the 5e-19 uncertainty level, discussing its future applications.

## CLEO: Applications & Technology

## Marriott Willow Glen I-III

### 16:30–18:30

### AW3P • Novel Optical Devices

*Presider: Richard Sandberg; Los Alamos National Lab, USA*

**AW3P.1 • 16:30** **Invited**

**Nanowire superconducting single photon detectors progress and promise,** Sae Woo Nam[1], Varun Verma[1], Michael Allman[1], Robert Horansky[1], Richard P. Mirin[1], Adriana Lita[1], Francesco Marsili[2], Matthew Shaw[2], Andrew D. Beyer[2], Jeffrey A. Stern[2]; [1]*NIST, USA;* [2]*Jet Propulsion Lab, USA.* Since the first reported detection of a single photon using a superconducting nanowire in 2001, rapid progress has been made in the development and application of superconducting nanowire single photon detectors (SNSPD or SSPD). I will briefly describe use of these detectors in new applications, progress in detector developments, and describe areas of research and their potential impact.

**AW3P.2 • 17:00**

**Ultrafast Quantum Random Number Generation Using Off-the-shelf Components,** Carlos Abellan[1], Waldimar Amaya[1], Marc Jofre[1], Marcos Curty[2], Antonio Acin[1,3], Jose Capmany[4], Valerio Pruneri[1,3], Morgan W. Mitchell[1,3]; [1]*The Inst. of Photonic Sciences, Spain;* [2]*El Telecomunicacion, Dept. of Signal Theory and Communications, Univ. of Vigo, Spain;* [3]*ICREA, Spain;* [4]*ITEAM, Universidad Politecnica de Valencia, Spain.* We demonstrate a 43 Gbps quantum random number generator using DPSK demodulation of pulses from a current-modulated laser diode. The signal is random by quantum phase diffusion, macroscopic, and detectable with off-the-shelf components.

### FW3A • Single Photon and Photon Pair Sources—Continued

**FW3A.4 • 17:15**
**1.5μm degenerate-frequency photon pair generation in silicon micro-ring cavities,** Yuan Guo[1], Wei Zhang[1], Shuai Dong[1], Yidong Huang[1], Jiangde Peng[1]; [1]*Tsinghua Univ., China.* 1.5μm degenerate-frequency photon pairs are generated in a silicon micro-ring cavity by reverse degenerate spontaneous four wave mixing. Their quantum interferences in Mach-Zehnder interferometers are demonstrated, showing their potential in quantum metrology and quantum information.

**FW3A.5 • 17:30**
**Theory of scattering loss during spontaneous parametric downconversion in waveguides,** Lukas G. Helt[1], John E. Sipe[2], Michael J. Steel[1]; [1]*Physics and Astronomy, Macquarie Univ., Australia;* [2]*Physics, Univ. of Toronto, Canada.* We consider simultaneous SPDC and scattering loss in waveguides by coupling waveguide modes to a reservoir. We calculate that a reduction in pair generation efficiency can be accompanied by an increase in heralded photon purity.

**FW3A.6 • 17:45**
**Highly efficient generation of narrow-band single-mode photon pairs from a whispering gallery mode resonator,** Michael J. Foertsch[1,3], Gerhard Schunk[1,3], Josef Fürst[1,2], Florian Sedlmeir[1,2], Dmitry Strekalov[1,2], Harald Schwefel[1,2], Thomas Gerrits[4], Martin J. Stevens[4], Sae Woo Nam[4], Gerd Leuchs[1,2], Christoph Marquardt[1,2]; [1]*Max Planck Insitute for the Science of Light, Germany;* [2]*Inst. for Optics, Information, and Photonics, Germany;* [3]*School in Advanced Optical Technologies, Germany;* [4]*National Inst. of Standards and Technology, USA.* We present a highly efficient narrow-band pair-photon source based on a crystalline whispering gallery mode resonator, which emits photons in exactly one spatiotemporal mode.

### FW3B • Advances in Quantum Optics Platforms—Continued

**FW3B.4 • 17:15**
**Observation of superradiant phase transition in quantum chaos,** Changxu Liu[1], Andrea Di Falco[2], Andrea Fratalocchi[1]; [1]*PRIMALIGHT, Faculty of Electrical Engineering; Applied Mathematics and Computational Science, King Abdullah Univ of Sci & Technology, Saudi Arabia;* [2]*SUPA; School of Physics and Astronomy, Univ. of St. Andrews, UK.* We observed the phase transition of multiple superradiant states in chaotic optical cavities with multiple open decay channels base on photonic crystals.

**FW3B.5 • 17:30**
**Quadratic Measurement and Conditional State Preparation in an Optomechanical System,** George Brawley[1], Michael Vanner[1], Warwick P. Bowen[1], Silvan Schmid[2], Anja Boisen[2]; [1]*School of Mathematics and Physics, The Univ. of Queensland, Australia;* [2]*Dept. of Micro- and Nanotechnology, Technical Univ. of Denmark, Denmark.* We experimentally demonstrate, for the first time, quadratic measurement of Brownian mechanical motion in an optomechanical system. We use this nonlinear measurement to conditionally prepare classical non-Gaussian states of motion of a micro-mechanical oscillator.

**FW3B.6 • 17:45**
**Superfluid Helium Optomechanics,** David L. McAuslan[1], Glen I. Harris[1], Eoin Sheridan[1], Warwick P. Bowen[1]; [1]*Centre for Engineered Quantum Systems, Univ. of Queensland, Australia.* By evanescently coupling a helium film to a high-Q optical resonator we make the first observation of superfluid helium Brownian motion. This new system has applications in quantum optomechanics, and in understanding superfluid helium properties.

### FW3C • Symposium on Science and Applications of Structured Light in Complex Media II—Continued

**FW3C.3 • 17:15** ▶
**Bulk optical measurement of topological numbers in photonic lattices with a non-Hermitian system,** Julia M. Zeuner[1], Mikael Rechtsman[2], Yaakov Lumer[2], Yonatan Plotnik[2], Stefan Nolte[1], Mordechai Segev[2], Alexander Szameit[1]; [1]*Inst. of Applied Physics, Friedrich-Schiller-Universität, Germany;* [2]*Technion Israel Inst. of Technology, Israel.* Topological insulators have been extended to photonics; however, the measurement of their topological invariant has been limited to probing edge states, an indirect measure. Here we optically measure a topological invariant using only bulk information.

**FW3C.4 • 17:30** Invited ▶
**Controlling Light Propagation in Optical Waveguides Using One Dimensional Phased Antenna Arrays,** Nanfang Yu[1], Myoung-Hwan Kim[1], Zhaoyi Li[1]; [1]*Columbia Univ., USA.* We demonstrated using full-wave simulations that phased array antennas patterned on optical waveguides can strongly affect mode coupling and propagation in the waveguides. We designed broadband small-footprint integrated photonic devices based on the concept.

### FW3D • Spatio-Temporal Dynamics—Continued

**FW3D.4 • 17:15**
**Extreme Events in Resonant Radiation from 3-dimensional light bullets,** Thomas Roger[1], Donatas Majus[2], Gintaras Tamošauskas[2], Audrius Dubietis[2], Goëry Genty[3], Miroslav Kolesik[4], Daniele Faccio[1]; [1]*Inst. of Photonics and Quantum Sciences, Heriot-Watt Univ., UK;* [2]*Dept. of Quantum Electronics, Vilnius Univ., Lithuania;* [3]*Dept. of Physics, Tampere Univ. of Technology, Finland;* [4]*College of Optical Sciences, Tucson Univ., USA.* We experimentally demonstrate rogue event statistics of dispersive waves from 3-dimensional spatiotemporal light bullets. Similarities to fibre solitons, with the added complexity related to spatiotemporal dynamics render this system ideal for future rogue wave studies.

**FW3D.5 • 17:30**
**Polarization switching in stretched pulse fiber laser,** Chengbo Mou[1], Sergey Sergeyev[1], Raz Arif[1], Aleksey Rozhin[1], Stanislav Kolpakov[1], Zuxing Zhang[1], Sergei K. Turitsyn[1]; [1]*Aston Univ., UK.* We studied experimentally polarization dynamics in a carbon nanotube mode locked stretched pulse fiber laser. For the first time, polarization locked, regular and irregular polarization switching have been observed at the microsecond time scale.

**FW3D.6 • 17:45**
**Interplay of nonlinear dynamics in silicon photonic crystal waveguides,** Chad A. Husko[1], Andrea Blanco-Redondo[1,2], Daniel Eades[1], Juntao Li[3,4], Thomas F. Krauss[5,3], Benjamin J. Eggleton[1]; [1]*Univ. of Sydney, Australia;* [2]*Tecnalia, Spain;* [3]*Univ. of St. Andrews, UK;* [4]*Sun Yat-sen Univ., China;* [5]*Univ. of York, UK.* We report time-domain measurements of nonlinear dynamics of picosecond pulses in silicon. The dispersion-engineered photonic crystal enables our systematic investigation of dynamic interplay between dispersion, free-carriers, and chi(3) effects for a broad parameter range.

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## CLEO: Science & Innovations

### Executive Ballroom 210E

### SW3E • Coherent Combining and fs Fiber Lasers—Continued

**SW3E.4 • 17:30**
**Soliton Wake Instability in a SESAM Modelocked Fiber Laser,** Shaokang Wang[1], Curtis R. Menyuk[1], Laura Sinclair[2], Ian Coddington[2], Nathan R. Newbury[2]; [1]*Computer Science and Electrical Engineering, Univ. of Maryland Baltimore County, USA;* [2]*National Inst. of Standards and Technology, USA.* We describe the nonlinear evolution profile of the soliton wake instability in a single-polarization SESAM modelocked fiber laser system. We show that it leads to quasi-periodicity.

**SW3E.5 • 17:45**
**Generation of ultra-broadband pulses with axially-symmetric polarization based on coherent beam combining of optical vortices,** Keisaku Yamane[1,2], Yasuyuki Shioda[1], Masato Suzuki[1,2], Yasunori Toda[1,2], Ryuji Morita[1,2]; [1]*Hokkaido Univ., Japan;* [2]*JST CREST, Japan.* We demonstrated the generation of ultra-broadband optical pulses with axially-symmetric polarization, on the basis of a coherent beam combining technique. The high polarization purity (~95 %) ranging from 750 to 880 nm was obtained.

### Executive Ballroom 210F

### SW3F • THz Spectroscopy & Sensing I—Continued

**SW3F.2 • 17:30**
**Numerical Investigation of Ultrafast interaction between THz Fields and Crystalline Materials,** Pernille K. Pedersen[1], Stewart S. Clark[2], Peter U. Jepsen[1]; [1]*DTU Fotonik, Technical Univ. of Denmark, Denmark;* [2]*Dept. of Physics, Univ. of Durham, UK.* We present a quantum-mechanical molecular dynamics investigation of the interaction between strong single-cycle THz pulses and ionic crystals. We find nonlinearities in the response of the CsI crystals at field strengths higher than 10 MV/cm.

**SW3F.3 • 17:45**
**Effects of Depolarization Fields on Transient Terahertz Spectra of Nanostructured Materials,** Hynek Nemec[1], Vít Zajac[1], Petr Kuzel[1]; [1]*Inst. of Physics AS CR, v.v.i, Czech Republic.* Analysis of the relationship between the microscopic conductivity, morphology represented by percolation degree and terahertz transmission spectra allowed us to retrieve microscopic properties of several nanostructured materials from measurements by terahertz spectroscopy.

### Executive Ballroom 210G

### SW3G • Micro-and Photonic Crystal Lasers—Continued

**SW3G.3 • 17:15** ▶
**Demonstration of Watt-class High-power Photonic-Crystal Lasers,** Kazuyoshi Hirose[1,2], Yoshitaka Kurosaka[1,2], Akiyoshi Watanabe[1], Takahiro Sugiyama[1], Yong Liang[2], Susumu Noda[2]; [1]*Hamamatsu Photonics K.K.,, Japan;* [2]*Kyoto Univ., Japan.* We demonstrate watt-class high output power (1.5 W) operation in single-chip photonic-crystal surface-emitting lasers under room-temperature continuous-wave condition. The beam quality factor M2 has been found to be kept at 1.0 up to 0.5 W.

**SW3G.4 • 17:30** ▶
**Room Temperature Operation of Optically Pumped 1.55-µm VCSEL with Polarization-Independent HCG Mirror on SOI,** Yoshihiro Tsunemi[1], Nobuhide Yokota[1], Shota Majima[1], Kazuhiro Ikeda[1], Takeo Katayama[1], Hitoshi Kawaguchi[1]; [1]*Graduate School of Materials Science, Nara Inst. of Science and Technology, Japan.* We fabricated a VCSEL incorporating a polarization-independent HCG mirror on SOI for a novel polarization-bistable functional device. The VCSEL oscillated under an optical short pulse excitation at 300 K.

**SW3G.5 • 17:45** ▶
**Low-threshold photonic-band-edge laser using iron-nail-shaped rod array,** Jae-Hyuck Choi[1], You-Shin No[1], Soon-Hong Kwon[2], Jin-Kyu Yang[3], Hong-Gyu Park[1]; [1]*Physics, Korea Univ., Korea;* [2]*Physics, Chung-Ang Univ., Korea;* [3]*Optical Engineering, Kongju National Univ., Korea.* We report the experimental demonstration of an optically pumped rod-type photonic-crystal band-edge laser. Lasing operation was achieved with a low threshold of ~90 µW and a peak wavelength of 1451.5 nm at room temperature.

## CLEO: Applications & Technology

### Executive Ballroom 210H

### AW3H • High Performance Optical Measurement—Continued

**AW3H.4 • 17:15**
**Terahertz reflectometry of multi-layered paint thicknesses and estimation of particle sizes,** Anis Rahman[1], Aunik Rahman[1]; [1]*Applied Research and Photonics Inc, USA.* A terahertz reflectometer was designed and utilized for measuring paint panels comprised of layers of paint, primer and overcoat. Particle size of the paint additives were estimated by contour plot derived from 3D surface map.

**AW3H.5 • 17:30**
**Femtosecond pulses for 3-D surface measurement of microelectronic step-structures,** Young-Jin Kim[1], Woo-Deok Joo[1], Jiyong Park[1], Seungman Kim[1], Seung-Woo Kim[1]; [1]*Korea Advanced Inst of Science & Tech, Korea.* We present a fast and precise 3-D measurement of microelectronic step-structures over a wide field-of-view by utilizing high spatial coherence, low temporal coherence and repetition rate tunablility of femtosecond laser pulses.

## Meeting Room
## 211 B/D

## CLEO: Science & Innovations

### SW3I • Novel Materials for Integrated Nonlinear Optics—Continued

**SW3I.4 • 17:15**
**Optical Nonlinearities in High Confinement SiC Waveguides,** Jaime Cardenas[1], Mengjie Yu[2], Yoshitomo Okawachi[2], Carl Poitras[1], Ryan K. Lau[2], Alexander L. Gaeta[2,3], Michal Lipson[1,3]; *[1]School of Electrical and Computer Engineering, Cornell Univ., USA; [2]School of Applied and Engineering Physics, Cornell Univ., USA; [3]Kavli Inst. at Cornell for Nanoscale Science, Cornell Univ., USA.* We demonstrate strong nonlinearities of $n_2 = 8 \times 10^{-15}$ cm$^2$ W$^{-1}$ in single crystal silicon carbide at a wavelength of 2360nm. We use a high confinement SiC waveguide fabricated using a modified smart-cut process.

**SW3I.5 • 17:30**
**Enhanced Second-Harmonic Generation in GaP Nanopillars Arrays by Modal Engineering,** Reza Sanatinia[1], Sybren Westendorp[2], Srinivasan Anand[1], Marcin Swillo[2]; *[1]KTH Royal Inst. of Technology, Sweden; [2]KTH Royal Inst. of Technology, Sweden.* Second harmonic generation from GaP nanopillars with optimized mode field overlap is analyzed and experimentally demonstrated. We present dispersion engineering in arrays of nanopillars to satisfy modal phase matching.

**SW3I.6 • 17:45**
**Third Harmonic Generation in Polycrystalline Anatase Titanium Dioxide Nanowaveguides,** Katia Shtyrkova[1], Christopher Evans[2], Orad Reshef[2], Jonathan Bradley[2], Michael G. Moebius[2], Eric Mazur[2], Erich Ippen[1]; *[1]Electrical Engineering and Computer Science, MIT, USA; [2]School of Engineering and Applied Sciences, Harvard Univ., USA.* We experimentally demonstrate third-harmonic generation in polycrystalline anatase titanium dioxide nano-waveguides, using ultrashort optical pulses centered around 1550 nm. Phase matching is achieved using higher order optical modes at the third harmonic wavelength.

## Meeting Room
## 212 A/C

### SW3J • Subsystems for Optical Communications—Continued

**SW3J.4 • 17:15**
**Timing-jitter Reduction by Demultiplexed-Feedback Clock Recovery in a 160Gbaud Serial Data Transmission System,** Siyuan Zhou[1], Deming Kong[1], Yan Li[1], Jizhao Zang[1], Jian Wu[1]; *[1]State Key Lab of Information Photonics and Optical Communications, Beijing Univ. of Posts and Telecommunications, China.* Demultiplexed-feedback clock recovery for ultra-high speed serial data transmission system is proposed and analyzed through numerical simulations. A 4×40 Gbaud proof-of-concept experiment is carried out, achieving 31 fs timing-jitter of the recovered clock.

**SW3J.5 • 17:30**
**Simple all optical modulation format conversion from 4x12.5 Gbps NRZ-OOK to 50 Gbps PDM RZ-QPSK using cross-phase modulation in a bidirectional scheme,** Yu-Hsiang Wen[1], Kai-Ming Feng[1,2]; *[1]National Tsing Hua Univ., Photonics Technologies, Taiwan; [2]National Tsing Hua Univ., Communications Engineering, Taiwan.* We proposed and experimentally demonstrated a low-complexity and cost-effectiveness format converter using XPM in a single HNLF. Four individual 12.5 Gbps NRZ-OOK to one 50 Gbps PDM RZ-QPSK format conversion is successfully achieved.

**SW3J.6 • 17:45**
**IQ Skew Monitoring and Alignment of Optical Quadrature Amplitude Transmitter using Reconfigurable Interference,** Yang Yue[1], Bo Zhang[1], Rob Lofland[1], Jason O'Neil[1], Qiang Wang[1], Jon Anderson[1]; *[1]Juniper Networks, USA.* IQ skew measurement of quadrature amplitude transmitter using reconfigurable interference is demonstrated with >20-dB dynamic range. The scheme is compatible with different modulation formats and patterns. Fast tracking scheme for large skew is discussed.

## Meeting Room
## 212 B/D

## CLEO: QELS-Fundamental Science

### FW3K • Devices Enabled by Nano-Optics and Plasmonics—Continued

**FW3K.3 • 17:15**
**Solid-immersion Super-oscillatory Lens for Heat Assisted Magnetic Recording Technology and Nanoscale Imaging,** Tapashree Roy[1], Guanghui Yuan[2], Edward T. Rogers[1], Nikolay I. Zheludev[1,2]; *[1]Optoelectronics Research Centre and Centre for Photonic Metamaterials, Univ. of Southampton, UK; [2]Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore.* We demonstrate a solid-immersion super-oscillatory planar lens for super-resolution applications with a 102 nm full-width at half maximum focal spot in a low-loss immersion medium.

**FW3K.4 • 17:30**
**Plasmonic Enhanced Near IR Schottky Detectors Based on Internal Photoemission in Nano Pyramids,** Boris Desiatov[1], Ilya Goykhman[1], Noa Mazurski[1], Joseph Shappir[1], Jacob Khurgin[2], Uriel Levy[1]; *[1]Hebrew Univ. of Jerusalem, Israel; [2]Johns Hopkins Univ., USA.* We demonstrate the detection of subband-gap light in silicon nano pyramid using the process of internal photoemission in Schottky diode. The quantum efficiency is enhanced by using metal coated silicon nano pyramids.

**FW3K.5 • 17:45**
**Monolithic Integration of Quantum Emitter with On-chip Beam-splitter for Quantum Information Processing,** Nikola Prtljaga[1], Rikki J. Coles[1], John O'Hara[1], Benjamin Royall[1], Anthony M. Fox[1], Edmund Clarke[2], Maurice S. Skolnick[1]; *[1]Dept. of Physics and Astronomy, Univ. of Sheffield, UK; [2]Dept. of Electronic and Electrical Engineering, Univ. of Sheffield, UK.* We demonstrate the monolithic integration of an on-demand quantum emitter in the form of a single self-assembled InGaAs quantum dot with an air clad, free standing directional coupler acting as a beam-splitter for anti-bunched light.

## Marriott
## Salon I & II

## CLEO: Applications & Technology

### AW3L • Microscopy—Continued

**AW3L.4 • 17:30**
**Novel wedge-based approach for simultaneous multichannel microscopy,** Samuel Chung[1,3], Christopher V. Gabel[1,2]; *[1]Physiology and Biophysics, Boston Univ. School of Medicine, USA; [2]Boston Univ. Photonics Center, USA; [3]Physical Sciences Inc., USA.* We demonstrate a novel device, based on wedge prisms, that enables simultaneous imaging and fluorescence microscopy of multiple color channels and is simpler, more user-friendly, and less expensive than current commercial devices.

**AW3L.5 • 17:45**
**Temporal focusing microscopy with structured illumination for super-resolution deep imaging,** Keisuke Isobe[1,2], Kyohei Mochizuki[1,3], Qiyuan Song[1,4], Akira Suda[3], Fumihiko Kannari[4], Hiroyuki Kawano[5], Akiko Kumagai[5], Atsushi Miyawaki[5,2], Katsumi Midorikawa[1,2]; *[1]Laser Technology Lab, RIKEN, Japan; [2]RIKEN Center for Advanced Photonics, Japan; [3]Tokyo Univ. of Science, Japan; [4]Keio Univ., Japan; [5]RIKEN Brain Science Inst., Japan.* We demonstrate that temporal focusing microscopy with structured illumination provides super-resolution even if wavefront distortion within the sample results in stretching the point spread function of the microscope.

## CLEO: Science & Innovations

**Marriott**
**Salon III**

### SW3M • Nonlinear Nanophotonics—Continued

**SW3M.4 • 17:15**
**Wavelength Conversion in Low Loss Si3N4 Waveguides,** Clemens Krückel[1], Victor Torres-Company[1], Peter Andrekson[1], Jock Bovington[2], Jared Bauters[2], Martijn Heck[2], John E. Bowers[2]; [1]*Dept. of Microtechnology and Nanoscience (MC2), Chalmers Univ. of Technology, Sweden;* [2]*Dept. of Electrical and Computer Engineering, Univ. of California, USA.* We show wavelength conversion in a compact Si3N4 waveguide. Combining low loss, long length, relatively large nonlinear coefficient, high-power handling and absence of two-photon absorption, this platform is promising for integrated nonlinear optics applications.

**SW3M.5 • 17:30**
**40-GHz Analog-to-Digital Converter Based on Sampling Gate of Silicon Waveguide with Ultra-Low Loss and High Conversion Efficiency,** Mu-Han Yang[1], Bill P.P. Kuo[1], Stojan Radic[1], Faezeh Gholami[1], Lan Liu[1]; [1]*UCSD, USA.* An ultra-low loss and high conversion efficiency silicon waveguide is used as sampling gate via four waves mixing, and 5.2 effective number of bits of signal at 40-GHz is achieved by 2-GHz cavity-less pulse source.

**SW3M.6 • 17:45**
**Low-power four-channel wavelength multicasting in embedded microring resonators,** Mario Souza[1], Luis A. M. Barea[1], Felipe Vallini[1], Guilherme F. M. Rezende[1], Gustavo S. Wiederhecker[1], Newton C. Frateschi[1]; [1]*DFA - IFGW, Universidade Estadual de Campinas, Brazil.* We demonstrate four-channel all-optical wavelength multicasting using only 1 mW of pump power and channel spacing of 40-60 GHz. Our device is based on a compact embedded microring design fabricated on a scalable SOI platform.

**Marriott**
**Salon IV**

### SW3N • High Power Laser—Continued

**SW3N.4 • 17:15**
**Yb-doped Rod-type Fiber Amplifier with 2 kW Average Power,** Hans-Jürgen Otto[1], Cesar Jauregui[1], Fabian Stutzki[1], Norbert Modsching[1], Jens Limpert[1,2], Andreas Tünnermann[1,3]; [1]*Inst. of Applied Physics, Germany;* [2]*Helmholtz-Inst. Jena, Germany;* [3]*Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany.* The average output power of rod-type fiber-laser systems can be scaled well beyond the mode instability threshold. A record average output power of 2 kW with 83% slope-efficiency and good beam quality (M2=3) is presented.

**SW3N.5 • 17:30**
**High Power Single Frequency 1014.8 nm Yb-doped Fiber Amplifier and Frequency Quadrupling to 253.7 nm,** Jinmeng Hu[1,2], Lei Zhang[1,2], Hongli Liu[1,3], Kangkang Liu[1,3], Zhen Xu[1,3], Yan Feng[1,2]; [1]*Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China;* [2]*Shanghai Key Lab of Solid State Laser and Application, China;* [3]*Key Lab of Quantum Optics, and Center for Cold Atom Physics, Chinese Academy of Science, China.* A 19 W linearly-polarized single-frequency 1014.8 nm fiber amplifier working at room temperature is developed. Both absorption and saturated absorption spectra of atomic mercury are measured with this radiation after frequency quadrupling to 253.7 nm.

**SW3N.6 • 17:45**
**High power Raman fiber laser based on random Rayleigh distributed feedback,** hanwei zhang[1], Pu Zhou[1], Hu Xiao[1], Xiaojun Xu[1]; [1]*National Univ. of Defense Technology, China.* We demonstrated a high power Raman fiber laser based on randomly Rayleigh distributed feedback. A total power of 73.7W was achieved with an optical efficiency of 74.7%. The spectrums and output power characters are discussed.

**Marriott**
**Salon V & VI**

### SW3O • Optical Clocks & Dissemination—Continued

**SW3O.3 • 17:15**
**Optical Frequency Transfer via 1840 km Fiber Link with superior Stability,** Stefan Droste[1], Filip Ozimek[2], Thomas Udem[1], Katharina Predehl[1], Theodor W. Hänsch[1], Harald Schnatz[2], Gesine Grosche[2], Ronald Holzwarth[1]; [1]*Max-Planck-Institut fur Quantenoptik, Germany;* [2]*Physikalisch-Technische Bundesanstalt, Germany.* We transferred an optical frequency along a 1840km fiber link and achieved an instability of 3x10^-15 at 1s with 4x10^-19 after 100s. The transferred frequency shows no systematic offset within an uncertainty of 3x10^-19. Detailed analysis revealed a τ^-2 response in the modified Allan deviation.

**SW3O.4 • 17:30**
**One-femtosecond, long-term stable remote laser synchronization over a 3.5-km fiber link,** Ming Xin[1], Kemal Safak[1], Michael Peng[2], Patrick Callahan[2], Franz Kärtner[1,2]; [1]*Center for Free-Electron Laser Science, Deutsches Elektronen-Synchrotron, Germany;* [2]*Dept. of Electrical Engineering and Computer Science and Research Lab of Electronics, MIT, USA.* Long-term stable remote laser synchronization over a 3.5 km long polarization maintaining fiber link is demonstrated. The residual rms-timing jitter and drift over 36-hour operation is 0.96 fs integrated from 100 µHz to 1 MHz.

**SW3O.5 • 17:45**
**Characterization of a 450-km-baseline GPS Carrier-Phase Link using an Optical Fiber Link,** Stefan Droste[1], Christian Grebing[2], Julia Leute[2], Sebastian Raupach[2], Andreas Bauch[2], Gesine Grosche[2], Ronald Holzwarth[1]; [1]*Max-Planck-Institut fur Quantenoptik, Germany;* [2]*Physikalisch-Technische Bundesanstalt, Germany.* We characterize a GPS carrier-phase link with 450 km baseline, using a long-distance phase-stabilized optical fiber link. Active hydrogen masers at both ends are compared via both links simultaneously. This allows us to assess the instability and accuracy of the GPS link with sub-10^-15 resolution.

**Marriott**
**Willow Glen I-III**

## CLEO: Applications & Technology

### AW3P • Novel Optical Devices—Continued

**AW3P.3 • 17:15**
**Progress Towards a Near IR Single-Photon Superconducting Nanowire Camera for Free-Space Imaging of Light,** Michael Allman[1], Varun B. Verma[1], Robert Horansky[1], Francesco Marsili[2], Jeffrey A. Stern[2], Matthew D. Shaw[2], Andrew D. Beyer[2], Richard P. Mirin[2], Sae Woo Nam[2]; [1]*NIST, USA;* [2]*Jet Propulsion Lab, USA.* We describe our progress towards building a free-space coupled array of nanowire detectors with a multiplexed readout. The cryogenic, optical, and electronic packaging to readout the array will be discussed.

**AW3P.4 • 17:30** Invited
**Quantum Noise Reduction in the LIGO Gravitational Wave Interferometer with Squeezed States of Light,** Lisa Barsotti[1]; [1]*MIT, USA.* The quantum nature of light imposes a fundamental limit on the sensitivity of ground based gravitational wave detectors. Squeezed states of light, produced via parametric downconversion in a non linear medium, have recently been employed to beat the quantum limit and extend the astrophysical reach of the most sensitive gravitational wave detector ever built.

Wednesday, 11 June

## FW3A • Single Photon and Photon Pair Sources—Continued

**FW3A.7 • 18:00**
**Integrated Source of Multiplexed Photon Pairs,** Lucia Caspani[1], Christian Reimer[1], Matteo Clerici[1,2], Marcello Ferrera[1,2], Marco Peccianti[1,3], Alessia Pasquazi[1,3], Luca Razzari[1], Brent E. Little[4], Sai T. Chu[5], David J. Moss[1,6], Roberto Morandotti[1]; *[1]INRS-EMT, Canada; [2]School of Engineering and Physical Sciences, Heriot-Watt Univ., UK; [3]Dept. of Physics and Astronomy, Univ. of Sussex, UK; [4]HiQ Photonics, USA; [5]Dept. of Physics and Material Science, City Univ. of Hong Kong, China; [6]School of Electrical and Computer Engineering, RMIT Univ., Australia.* We report an integrated, CMOS-compatible source of multiple and independent photon pairs at different wavelengths compatible with standard fiber communication channels and quantum memories. It operates in a self-locked mode with no external pump laser.

**FW3A.8 • 18:15**
**Encoding and decoding of biphoton wavepackets,** Joseph M. Lukens[1], Amir Dezfooliyan[1], Carsten Langrock[2], Martin M. Fejer[2], Daniel E. Leaird[1], Andrew M. Weiner[1]; *[1]Electrical and Computer Engineering, Purdue Univ., USA; [2]Edward L. Ginzton Lab, Stanford Univ., USA.* We demonstrate orthogonal spectral coding of entangled photons for the first time. Applying one code to the signal photon spreads and scrambles the biphoton; only by properly decoding the idler is the original biphoton recovered.

## FW3B • Advances in Quantum Optics Platforms—Continued

**FW3B.7 • 18:00**
**Multimode Correlations in Chip-based Frequency Combs,** Avik Dutt[1], Kevin Luke[1], Alexander L. Gaeta[2], Paulo A. Nussenzveig[3], Michal Lipson[1]; *[1]School of Electrical and Computer Engineering, Cornell Univ., USA; [2]School of Applied and Engineering Physics, Cornell Univ., USA; [3]Instituto de Física, Universidade de São Paulo, Brazil.* We demonstrate correlations between non-twin beams of a frequency comb generated from a silicon nitride ring resonator optical parametric oscillator. The normalized correlation coefficient between these two modes is 0.997, corresponding to near perfect correlations between the two beams.

**FW3B.8 • 18:15**
**Photon lifetime and the linewidth in a superluminal laser,** Jacob Scheuer[1], Selim M. Shahriar[2,3]; *[1]Tel-Aviv Univ., Israel; [2]EECS, Northwestern Univ., USA; [3]Physics, Northwestern Univ., USA.* We present a theoretical analysis of the cavity lifetime of a superluminal laser. In contrast to the naive intuition, the lifetime is only slightly shorter than that of conventional lasers, facilitating ultra-sensitive sensors.

## FW3C • Symposium on Science and Applications of Structured Light in Complex Media II—Continued

**FW3C.5 • 18:00** ▶
**Selective Self-assembly of Symmetry-breaking Nanoplasmonic Structures,** Sui Yang[1,2], Xiaobo Yin[1,2], Boubacar Kante[1], Peng Zhang[1], Jia Zhu[1], Yuan Wang[1], Xiang Zhang[1,2]; *[1]NSF Nano-scale Science and Engineering Center (NSEC), Univ. of California Berkeley, USA; [2]Materials Sciences Division, Lawrence Berkeley National Lab, USA.* Self-assembly approaches to construct plasmonic materials often result in high-symmetry structures within a thermodynamic limit. Here we demonstrate a novel selective self-assembly route for synthesis of a new class of nanoplasmonic structures with symmetry-breaking.

**FW3C.6 • 18:15** ▶
**Molding Surface Plasmons by Spinoptical Rashba Metasurfaces,** Nir Shitrit[1], Igor Yulevich[1], Dekel Veksler[1], Vladimir Kleiner[1], Erez Hasman[1]; *[1]Technion-Israel Inst. of Technology, Israel.* We report on a spin-based surface plasmon directional excitation by spinoptical Rashba metasurfaces. The light-matter interaction control via the geometric design of the metasurface symmetry ushers in a new era of light manipulation.

## FW3D • Spatio-Temporal Dynamics—Continued

**FW3D.7 • 18:00**
**Buffering optical data with topological localized structures,** Bruno Garbin[1], Julien Javaloyes[2], Giovanna Tissoni[1], Stephane Barland[1]; *[1]Institut Non Lineaire de Nice, Universite de Nice - CNRS, France; [2]departamento de fisica, Universidad de la Islas Baleares, Spain.* We demonstrate experimentally that a semiconductor laser based excitable system placed in a linear feedback loop can store optical bits. In the process, we show the existence of topological localized states in optics.

**FW3D.8 • 18:15**
**Back-Action of Continuum on Solitons and the Resulting Energy Oscillations in a Mode-Locked Laser,** Chien-Chung Lee[1], Thomas R. Schibli[1]; *[1]Dept. of Physics, Univ. of Colorado at Boulder, USA.* We describe a resonant phenomenon that exists in all mode-locked lasers with non-negligible anomalous chromatic dispersion and self-phase modulation. Numerical simulation and experiment are also performed, and good agreement with the analytic results was found.

NOTES

## Executive Ballroom 210E

## Executive Ballroom 210F

## Executive Ballroom 210G

## Executive Ballroom 210H

## CLEO: Science & Innovations

## CLEO: Applications & Technology

### SW3E • Coherent Combining and fs Fiber Lasers—Continued

**SW3E.6 • 18:00**

**Sub-femtosecond Envelope Stability of Fiber Comb Lasers Locked to a CW Reference,** Russell wilcox[1], Klaus Hartinger[2], Ronald Holzwarth[2]; [1]*Lawrence Berkeley National Lab, USA;* [2]*Menlo Systems, Germany.* We measured relative envelope jitter of two fiber comb lasers, each with one comb line phase locked to a CW optical phase reference. Integrated jitter is 0.9fs RMS from 10Hz to 2MHz.

**SW3E.7 • 18:15**

**Improved design of environmentally stable all fibre, all normal dispersion Yb doped short pulse lasers,** Neil Broderick[1], Antoine Runge[1], Miro J. Erkintalo[1], Claude Aguergaray[1], Ryan Hawker[1], Richard Provo[2]; [1]*Physics, Univ. of Auckland, New Zealand;* [2]*Southern Photonics Ltd., New Zealand.* We report the improved performance and reliability of all-normal dispersion fibre lasers produced linearly chirped output pulses compressible to 120fs. The effect of the intra- cavity l filter is investigated and demonstrate the reliability of the device.

### SW3F • THz Spectroscopy & Sensing I—Continued

**SW3F.4 • 18:00**

**Nanoantenna Enhanced Terahertz Spectroscopy of a Monolayer of Cadmium Selenide Quantum Dots,** Luca Razzari[1], Andrea Toma[2], Salvatore Tuccio[2], Mirko Prato[2], Francesco De Donato[2], Andrea Perucchi[3], Paola Di Pietro[3], Sergio Marras[2], Carlo Liberale[2], Remo Proietti Zaccaria[2], Francesco De Angelis[2], Liberato Manna[2], Stefano Lupi[4], Enzo Mario Di Fabrizio[5]; [1]*INRS Énergie, Matériaux et Télécommunications, Canada;* [2]*Fondazione Istituto Italiano di Tecnologia, Italy;* [3]*Sincrotrone Trieste, Italy;* [4]*Università di Roma "La Sapienza", Italy;* [5]*King Abdullah Univ. of Science and Technology (KAUST), Saudi Arabia.* Exploiting the localization and enhancement capabilities of terahertz resonant dipole nanoantennas coupled through nanogaps, we present an effective method to perform terahertz spectroscopy on an extremely small number of nano-objects.

**SW3F.5 • 18:15**

**THz Spectroscopy of Self-Assembled ErSb Nanowires,** Sascha Preu[1], Hong Lu[2], Jason K. Kawasaki[2], Daniel G. Ouellette[3], Christopher J. Palmstrom[2], Mark S. Sherwin[3], Arthur Gossard[2]; [1]*Inst. for Microwave Engineering and Photonics, Technical Univ. of Darmstadt, Germany;* [2]*Materials Dept., Univ. of California, Santa Barbara, USA;* [3]*Physics Dept. & Inst. for THz Science and Technology, Univ. of California, Santa Barbara, USA.* We report on self-assembled ErSb nanowires in a GaSb matrix that show a strong polarization-sensitive THz response. The nanowires behave like a polarizer. Their orientation and shape can be engineered by the growth conditions.

### SW3G • Micro-and Photonic Crystal Lasers—Continued

**SW3G.6 • 18:00** ▶

**Control of lasing modes in semiconductor microdisks by shaping pump profile,** Seng Fatt Liew[1], Brandon Redding[1], Glenn S. Solomon[2], Hui Cao[1]; [1]*Applied Physics, Yale Univ., USA;* [2]*Joint Quantum Inst., NIST and Univ. of Maryland, USA.* We demonstrate experimentally that by optimizing the spatial pump profile we can select different modes to lase in a semiconductor microdisk cavity, and suppress lasing in all other modes by increasing their thresholds.

**SW3G.7 • 18:15** ▶

**Low-Threshold Dielectric-Cavity Microlasers,** Guan-Lin Su[1], Pengfei Qiao[1], Chien-Yao Lu[1], Dieter Bimberg[2], Shun Lien Chuang[1]; [1]*Electrical and Computer Engineering, Univ. of Illinois at Urbana-Champaign, USA;* [2]*Institut fur Festkoerperphysik, Technische Universität Berlin, Germany.* We present low-threshold dielectric-cavity surface-emitting microlasers working at room temperature under continuous-wave electrical injection with device diameter down to 2 µm. Size-dependent lasing properties are predicted theoretically and demonstrated experimentally.

NOTES

## CLEO: Science & Innovations

### Meeting Room 211 B/D

### SW3I • Novel Materials for Integrated Nonlinear Optics—Continued

**SW3I.7 • 18:00** ▶

**GHz Near-IR Optical Parametric Amplifier using a Hydrogenated Amorphous Silicon Waveguide,** Ke-Yao Wang[1], Amy C. Foster[1]; [1]*Electrical and Computer Engineering, Johns Hopkins Univ., USA.* We demonstrate for the first time optical parametric amplification operating at a GHz rate in near-IR using hydrogenated amorphous silicon waveguides. The strong gain at this repetition rate shows its potential for telecommunication applications.

**SW3I.8 • 18:15**

**Giant sub-THz Nonlinear Response in Superconducting Metamaterial,** Vassili Savinov[1], Kaveh Delfanazari[1], Vassili A. Fedotov[1], Nikolay I. Zheludev[1,2]; [1]*Optoelectronics Research Centre and Centre for Photonic Metamaterials, Univ. of Southampton, UK;* [2]*Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore.* We present a superconducting metamaterial with ultra-strong nonlinear response in the sub-terahertz range. A change in transmission of more than 10% has been achieved by ramping up the radiation intensity from 100μW/cm$^2$ to just 800μW/cm$^2$.

### Meeting Room 212 A/C

### SW3J • Subsystems for Optical Communications—Continued

**SW3J.7 • 18:00**

**Multi-Mode Spectral Pulse-Shaper with Control of Mode Attenuation and Delay,** Jochen B. Schroeder[1], Joel A. Carpenter[1], Sergio G. Leon-Saval[1], Joel R. Salazar Gil[1], Joss Bland-Hawthorn[1], Glenn Baxter[2], Luje Stewart[2], Steve Frisken[2], Michael A. Roelens[2], Benjamin J. Eggleton[1]; [1]*The School of Physics, Univ. of Sydney, Australia;* [2]*Finisar Australia, Australia.* We present a few-mode spectral pulse-shaper, that offers independent control over the spectral phase and attenuation of different input modes from a multi-mode input, with a similar performance to a single mode device.

**SW3J.8 • 18:15**

**Crosstalk in a ROADM Supporting Spatial Superchannels for Space Division Multiplexing,** Xin Jiang[1], Roey Harel[2], Gil Cohen[3], Dan M. Marom[4], Mark D. Feuer[1]; [1]*Engineering Science & Physics, CUNY College of Staten Island, USA;* [2]*Nistica, Inc., USA;* [3]*independent consultant, USA;* [4]*Applied Physics, Hebrew Univ. of Jerusalem, Israel.* We report crosstalk measurements among spatially-multiplexed subchannels in a ROADM supporting spatial superchannels. Aggregate crosstalk can reach -23dB when express paths are routed on adjacent fibers, but >6dB improvement results when paths are interleaved.

## CLEO: QELS-Fundamental Science

### Meeting Room 212 B/D

### FW3K • Devices Enabled by Nano-Optics and Plasmonics—Continued

**FW3K.6 • 18:00** ▶

**Inverse Design of Optical Antennas for Sub-Wavelength Energy Delivery,** Samarth Bhargava[1], Eli Yablonovitch[1]; [1]*Electrical Engineering and Computer Science, Univ. of California, Berkeley, USA.* We report using Inverse Electromagnetic Design to computationally optimize optical antenna shapes. Optimized antennas deliver 10% of incident power to a 50x40x10 nm3 spot in a practical magnetic recording medium for Heat Assisted Magnetic Recording.

**FW3K.7 • 18:15**

**Large-scale ideal waveguide lenses with complete power concentration in a single waveguide,** Peter B. Catrysse[1], Victor Liu[1], Shanhui Fan[1]; [1]*E. L. Ginzton Lab, Stanford Univ., USA.* We demonstrate ideal waveguide lenses with very large number of waveguides and with complete power concentration in a single waveguide. We also show for the first time an ideal waveguide lens structure.

## CLEO: Applications & Technology

### Marriott Salon I & II

### AW3L • Microscopy—Continued

**AW3L.6 • 18:00**

**Terahertz scanning investigations of human dermal cells,** Anis Rahman[1], Tatsiana Mironava[2], Aunik Rahman[1], Miriam Rafailovich[2]; [1]*Terahertz, Applied Research and Photonics Inc, USA;* [2]*Dept. of Materials Science and Engineering, Stony Brook Univ., USA.* Investigation of cultured skin cells have have been conducted by a terahertz scanning reflectometer. In particular, the dermal fibroblasts alone and the same treated with titanium nano-particles have been examined for their thickness profile.

**AW3L.7 • 18:15**

**Two-photon three-axis digital scanned light-sheet microscopy (2P3A-DSLM),** Weijian Zong[1,2], Xuanyang Chen[1], Jia Zhao[1], Yunfeng Zhang[4], Ming Fan[2], Zhuan Zhou[1], Heping Cheng[1], Yujie Sun[3], Liangyi Chen[1]; [1]*The State Key Lab of Biomembrane and Membrane Biotechnology, Inst. of Molecular Medicine Peking Univ., China;* [2]*China Dept. of Cognitive Sciences, Inst. of Basic Medical Sciences, China;* [3]*Biodynamic Optical Imaging Center, Peking Univ., China;* [4]*School of Electronics Engineering and Computer Science, Peking Univ., China.* We demonstrate a new two-photon scanned light-sheet microscopy with diffraction-limited thickness and tailorable illumination area from 50×50 μm2 to 500×500 μm2, capable of multi-scale live imaging in one setup.

NOTES

## CLEO: Science & Innovations

**Marriott**
**Salon III**

### SW3M • Nonlinear Nanophotonics—Continued

**SW3M.7 • 18:00**
**Nonlinear optical properties of SiGe waveguides in the mid-infrared,** luca carletti[1], Pan Ma[2], Barry Luther-Davies[2], Darren D. Hudson[3], Christelle Monat[1], Steve Madden[2], David J. Moss[4], Mickael Brun[5], Sophie Ortiz[5], Sergio Nicoletti[5], Christian Grillet[1]; [1]*Institut des Nanotechnologies de Lyon, Ecole Centrale de Lyon, France;* [2]*CUDOS, Laser Physics Centre, Australian National Univ., Australia;* [3]*CUDOS, School of Physics, Univ. of Sydney, Australia;* [4]*School of Electrical and Computer Engineering, Royal Melbourne Inst. of Technology, Australia;* [5]*CEA-Leti, MINATEC Campus, France.* We measure the nonlinear response of CMOS-compatible SiGe waveguides in the mid-infrared. Comparing with numerical calculations, we extract the multi-photon absorption coefficients and the induced free-carrier absorptions for wavelengths between 3µm and 5µm.

**SW3M.8 • 18:15**
**Below Bandgap Second Harmonic Generation in GaAs Photonic Crystal Cavites in (111) and (001) Crystal Orientations,** Sonia Buckley[1], Marina Radulaski[1], Jan Petykiewicz[1], Konstantinos Lagoudakis[1], Klaus Biermann[2], Jelena Vuckovic[1]; [1]*Stanford Univ., USA;* [2]*Paul-Drude-Institut für Festkörperelektronik, Germany.* We demonstrate second harmonic generation in photonic crystal cavities in (001)- and (111)-oriented GaAs, with fundamental resonance at 1800nm, leading to second harmonic below the GaAs bandgap. Below bandgap operation minimizes linear and nonlinear absorption.

**Marriott**
**Salon IV**

### SW3N • High Power Laser—Continued

**SW3N.7 • 18:00**
**Over 50 W 589 nm single frequency laser by frequency doubling of single Raman fiber amplifier,** Lei Zhang[1], Huawei Jiang[1], Shuzhen Cui[1], Jinmeng Hu[1], Lingxia Chen[1], Yan Feng[1]; [1]*Shanghai Inst. of Optics and Fine Mechanics, China.* 300W CW linearly-polarized 1120nm laser is achieved with an integrated Yb-Raman fiber amplifier. 86W 1178nm single frequency Raman fiber amplifier is generated and frequency doubled to 589nm with power up to 52.7W.

**SW3N.8 • 18:15**
**Near Diffraction-Limited, 811W, Single-Frequency Photonic Crystal Fiber Amplifier,** Benjamin Pulford[1], Iyad Dajani[1], Craig Robin[1]; [1]*Air Force Research Lab, USA.* An acoustic and gain tailored Yb-doped polarization-maintaining photonic crystal fiber is used to demonstrate 811W single-frequency output power with near diffraction-limited beam quality; the highest power ever reported from a near diffraction-limited single-frequency fiber laser.

**Marriott**
**Salon V & VI**

### SW3O • Optical Clocks & Dissemination—Continued

**SW3O.6 • 18:00**
**A Unidirectional Scheme for High-Fidelity Optical-Carrier Dissemination Using Phase-Modulation, Homodyne Coherent-Detection, and Frequency Entrainment,** Ehsan Sooudi[1,2], Fatima C. Garcia Gunning[1,2], James O'Gorman[3], Stylianos Sygletos[4], Selwan K. Ibrahim[5], Andrew D. Ellis[4], Robert J. Manning[1,2]; [1]*Photonic Systems Group, Tyndall National Inst., Ireland;* [2]*Dept. of Physics, Univ. College Cork (UCC), Ireland;* [3]*Xylophone Optics Ltd, Ireland;* [4]*Aston Inst. of Photonic Technologies, Aston Univ., UK;* [5]*FAZTech Research, Ireland.* We report for the first time an ultra-stable optical-carrier dissemination technique for transmission over a 20km unidirectional fibre link. The optical-linewidth of the recovered carrier matches closely that of the original carrier.

**SW3O.7 • 18:15**
**Stability Characterization of an Optical Injection Phase Locked Loop for Optical Frequency Transfer Applications,** Joonyoung Kim[1], David Wu[1], Giuseppe Marra[2], David J. Richardson[1], Radan Slavik[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK;* [2]*National Physics Lab, UK.* We propose an optical injection phase locked loop (OIPLL) as a high-gain amplifier for precise frequency transfer via optical fibers. The suitability of this approach for international optical clock comparison is evaluated.

## CLEO: Applications & Technology

**Marriott**
**Willow Glen I-III**

### AW3P • Novel Optical Devices—Continued

**AW3P.5 • 18:00**
**Optical Encryption Based on Cancellation of Analog Noise,** Ben Wu[1], Matthew Chang[1], Zhenxing Wang[1], Bhavin Shastri[1], Paul Prucnal[1]; [1]*Electrical Engineering, Princeton Univ., USA.* We propose an optical encryption technique where the data is encrypted with wideband analog noise. Matching both the phase and amplitude of the noise is required, providing a large key space for the encryption process.

**AW3P.6 • 18:15**
**Commercially Packaged Optical True-Time-Delay Devices With Record Delays of Wide Bandwidth Signals,** Paul A. Morton[1], Jacob Khurgin[2], Zemer Mizrahi[3], Steven Morton[1]; [1]*Morton Photonics, USA;* [2]*Electrical and Computer Engineering, Johns Hopkins Univ., USA;* [3]*Aeon Corporation, USA.* Commercially packaged optical true-time-delay devices were developed utilizing ultra-low loss silicon nitride microresonators, achieving record tunable delay of 535ps for a 20GHz wide signal, 632ps for a 10GHz wide signal, with tunable loss of 3dB.

NOTES

## CLEO: QELS-Fundamental Science

### 08:00– 10:00
### FTh1A • Quantum Entanglement
*Presider: Warren Grice; Oak Ridge National Lab, USA*

**FTh1A.1 • 08:00**
**Creation and manipulation of two-dimensional photonic frequency entanglement,** Laurent Olislager[1], Erik Woodhead[1], Kien Phan Huy[2], Jean-Marc Merolla[2], Philippe Emplit[1], Serge Massar[1]; *[1]Universite Libre de Bruxelles, Belgium; [2]FEMTO-ST, France.* We demonstrate, using standard telecommunication components, the creation and manipulation of frequency entangled effective qubits that exhibit nonlocal interferences in the frequency domain, violating the CHSH inequality by more than 40 standard deviations.

**FTh1A.2 • 08:15**
**Demonstration of high-dimensional frequency-bin entanglement,** Zhenda Xie[1], Tian Zhong[2], Xinan Xu[1], Junlin Liang[1], Yanxiao Gong[3], Sajan Shrestha[1], Jeffrey H. Shapiro[2], Franco Wong[2], Chee Wei Wong[1]; *[1]Columbia Univ., USA; [2]MIT, USA; [3]Southeast Univ., China.* We exhibit high-dimensional frequency-bin entanglement from a mode-locked two-photon source via frequency-correlation measurement and Hong-Ou-Mandel interference. Generalized Bell-inequality is tested by Franson interference, showing revival interference fringes, with maximum visibility of 98.6%.

**FTh1A.3 • 08:30**
**Emission of time-energy entangled photon pairs from an integrated silicon ring resonator,** Davide Grassani[1], Stefano Azzini[1], Marco Liscidini[1], Matteo Galli[1], Michael Strain[2,3], Marc Sorel[2], John E. Sipe[4], Daniele Bajoni[5]; *[1]Physics, Universita degli Studi di Pavia, Italy; [2]Univ. of Glasgow, UK; [3]Univ. of Strathclyde, UK; [4]Physics, Univ. of Toronto,, Canada; [5]Engineering, Università degli Studi di Pavia, Italy.* We demonstrate an integrated silicon source of time-energy entangled photons. Entanglement is proved using a Franson type experiment, obtaining visibility exceeding 90% and a violation of the Bell's inequality by more than 10 standard deviations.

### 08:00– 10:00
### FTh1B • Quantum Interconnects
*Presider: Yanhong Xiao; Fudan Univ., China*

**FTh1B.1 • 08:00** Tutorial
**Strong Photon-Photon Interactions,** Vladan Vuletic[1], Mikhail Lukin[2], Kristin Beck[1], Wenlan Chen[1], Thibault Peyronel[1], Ofer Firstenberg[2], Qiyu Liang[1]; *[1]MIT, USA; [2]Physics, Harvard Univ., USA.* Standard nonlinear optical materials exhibit negligible nonlinearity at the level of individual photons. I will discuss two methods to generate strong photon-photon interactions using either atom-cavity coupling, or strong interactions between atoms in Rydberg states.

Vladan Vuletic received his Ph.D. from the University of Munich and has previously worked at the Max Planck Institute for Quantum Optics in Garching, Germany, and at Stanford University. He is now at the Massachusetts Institute of Technology, where his research group studies many-body entanglement, quantum measurements, cavity quantum electrodynamics, and strong photon-photon interactions.

### 08:00– 10:00
### FTh1C • High-Field THz Physics
*Presider: Matthias Hoffmann; SLAC National Accelerator Lab, USA*

**FTh1C.1 • 08:00** Invited
**CEP Control of Dynamical Bloch Oscillations in a Bulk Semiconductor via Ultra-Intense Multi-THz Fields,** Fabian Langer[1], Olaf Schubert[1], Matthias Hohenleutner[1], Benedikt Urbanek[1], Christoph Lange[1], Ulrich Huttner[2], Daniel Golde[2], Torsten Meier[3], Mackillo Kira[2], Stephan W. Koch[2], Rupert Huber[1]; *[1]Univ. of Regensburg, Germany; [2]Univ. of Marburg, Germany; [3]Univ. of Paderborn, Germany.* Dynamical Bloch oscillations and coherent interband polarization in bulk GaSe are controlled by CEP-stable, ultra-intense multi-THz waveforms and result in the emission of phase stable high-order harmonics covering 12.7 optical octaves from THz to VIS regimes.

**FTh1C.2 • 08:30**
**High-field terahertz shift current in lithium niobate,** Michael Woerner[1], Carmine Somma[1], Klaus Reimann[1], Thomas Elsaesser[1], Christos Flytzanis[2]; *[1]Max Born Inst., Germany; [2]Ecole Normale Superieure, France.* We study the nonlinear terahertz response of LiNbO3 using 2D spectroscopy. Dissecting the nonlinear response into different orders in the electric field shows a strong shift current and higher harmonics of the THz fundamental.

### 08:00– 10:00
### FTh1D • Solitons and Temporal Effects
*Presider: Marco Peccianti; Univ. of Sussex, Italy*

**FTh1D.1 • 08:00**
**Temporal Soliton Generation in Chip-based Silicion Nitride Microresonators,** Victor Brasch[1], Tobias Herr[1], Martin Pfeiffer[1], John Jost[1], Tobias Kippenberg[1]; *[1]EPFL, Switzerland.* We demonstrate temporal dissipative soliton generation in silicion nitride microresonators for the first time. Temporal soliton states allow for low-noise RF-generation, smooth frequency comb spectra and produce ultra-short optical pulses on a chip.

**FTh1D.2 • 08:15**
**Observation of dispersive wave emission by temporal cavity solitons,** Jae K. Jang[1], Stuart G. Murdoch[1], Stephane Coen[1], Miro J. Erkintalo[1]; *[1]Univ. of Auckland, New Zealand.* We report the first experimental observation of dispersive wave emission by temporal cavity solitons. Our results could impact on a variety of systems supporting temporal cavity solitons, such as high-Q Kerr microresonators.

**FTh1D.3 • 08:30**
**Self-compression of Millijoule mid-IR Femtosecond Pulses in Transparent Dielectrics,** Audrius Pugzlys[1], Pavel Malevich[1], Skirmantas Alisauskas[1], Alexander A. Voronin[2], Daniil Kartashov[5], Andrius Baltuska[1], Aleksei Zheltikov[2,3], Daniele Faccio[4]; *[1]Photonics Inst., vienna Univ. of technology, Austria; [2]International Laser Center, M.V. Lomonosov Moscow State Univ., Russia; [3]Dept. of Physics and Astronomy, Texas A&M Univ., USA; [4]Inst. of Photonics and Quantum Sciences, Heriot-Watt Univ., UK; [5]Inst. for Optics and Quantum Electronics, Friedrich-Schiller Univ., Germany.* Self-compression of 2.2-mJ, 80-fs mid-IR pulses is achieved using a 1.5-mm-thick CaF2 plate. Femtosecond pulses with peak powers orders of magnitude higher than the self-focusing threshold can undergo self-compression without breaking up into multiple filaments.

## Join the Exhibitors for Pizza

Thursday, 12 June
12:30–14:00
*Exhibit Hall 1 & 2*

## CLEO: Science & Innovations

### Executive Ballroom 210E

**08:00– 10:00**
**STh1E • Filamentation**
*Presider: Pavel Polynkin; Univ. of Arizona, USA*

**STh1E.1 • 08:00**
**Direct observation of pulse dynamics, influencing high-order harmonic emission along a filament,** Martin Kretschmar[1,2], Tamas Nagy[1,3], Ayhan Demircan[1], Carsten Bree[4], Michael Hofmann[4], Heiko Kurz[1,2], Uwe Morgner[1,2], Milutin Kovacev[1]; *[1]Gottfried Wilhelm Leibniz Universität Hannover, Germany; [2]Quest, Centre for Quantum Engineering and Space-Time Research, Germany; [3]Laser-Laboratorium Goettingen e.V., Germany; [4]Weierstrass-Institut für Angewandte Analysis und Stochastik, Germany.* We present in-situ measurements of pulse dynamics along a femtosecond filament. Pulse-splitting has been observed, resulting in self-compression to 5.3 fs, influencing high-order harmonic generation along the filament.

**STh1E.2 • 08:15**
**Direct Interferometric Measurements of the Acoustic Waves from Femtosecond Filaments,** Jared K. Wahlstrand[1], Nihal Jhajj[1], Eric Rosenthal[1], Sina Zahedpour[1], Howard Milchberg[1]; *[1]Univ. of Maryland at College Park, USA.* Interferometric measurements of submicrosecond gas density dynamics following passage of an intense ultrashort pulse are presented for single- and multi-lobed beams at 10 Hz and 1 kHz. Results are in excellent agreement with hydrodynamic simulations.

**STh1E.3 • 08:30**
**Demonstration of long-lived high power optical waveguides in air,** Nihal Jhajj[1], Eric Rosenthal[1], Reuven Birnbaum[1], Jared Wahlstrand[1], Howard Milchberg[1]; *[1]Univ. of Maryland, USA.* We show that femtosecond filament arrays can generate robust, very long-lived optical waveguides in air . These guides have millisecond lifetime and should be suitable for the transmission of high average power beams.

### Executive Ballroom 210F

**08:00– 09:45**
**STh1F • THz Quantum Cascade Lasers**
*Presider: Masayoshi Tonouchi, Osaka Univ., Japan*

**STh1F.1 • 08:00**
**Widely-Tunable Monolithic Terahertz Quantum Cascade Laser Sources Based on Difference-Frequency Generation,** Seungyong Jung[1], Aiting Jiang[1], Yifan Jiang[1], Karun Vijayraghavan[1], Xiaojun Wang[2], Mariano Troccoli[2], Mikhail A. Belkin[1]; *[1]Electrical and Computer Engineering, Univ. of Texas at Austin, USA; [2]Adtech Optics, Inc., USA.* We demonstrate monolithic tunable terahertz quantum cascades laser sources with a tuning range over 580 GHz at room temperature by integrating electrically separated distributed feedback section and distributed Bragg reflector section into a single device.

**STh1F.2 • 08:15**
**In-plane surface plasmonics integrated with THz Quantum cascade lasers for high collimation,** Guozhen Liang[1]; *[1]Nanyang Technological Univ., Singapore.* We report planar integration of tapered Terahertz (THz) quantum cascade lasers (QCLs) with spoof surface plasmon (SSP) structures, which results in a surface-emitting THz beam with a beam divergence of 3.6×9.7 degree.

**STh1F.3 • 08:30**
**Effect of Interface Roughness Scattering on performance of Indirectly Pumped Terahertz Quantum Cascade Lasers,** Seyed Ghasem Razavipour[1], Emmanuel Dupont[2], Zbigniew Wasilewski[1], Dayan Ban[1]; *[1]Univ. of Waterloo, Canada; [2]National Reseach Council Canada, Canada.* The effect of interface roughness scattering on performance of indirectly-pumped terahertz quantum cascade lasers is studied and a dual-barrier structure is proposed to improve its performance in terms of threshold current density and operating temperature.

### Executive Ballroom 210G

**08:00– 10:00**
**STh1G • Semiconductor Lasers for Communication**
*Presider: Kent Choquette; Univ. of Illinois, USA*

**STh1G.1 • 08:00**
**50×100GHz Wavelength Tuning in Rectangular Ring-FP Semiconductor Laser,** Lin Wu[1], Zhipeng Hu[1], Jian-Jun He[1]; *[1]Zhejiang Univ., China.* We report our latest experimental results of the half-wave coupled rectangular ring-FP laser. Wavelength tuning of 50 channels covering L band at 100GHz spacing is achieved, with SMSR up to 41dB. Direct modulation at 2.5Gbps is also demonstrated.

**STh1G.2 • 08:15**
**Error-free 25-Gbit/s direct modulation of lateral-current-injection DFB laser,** Koichi Hasebe[1], Tomonari Sato[1], Koji Takeda[1], Takuro Fujii[1], Takaaki Kakitsuka[1], Shinji Matsuo[1]; *[1]NTT Photonics Labs, NTT Corporation, Japan.* We present a lateral-current-injection InP-based DFB laser consisting of a pn junction fabricated by using Zn thermal diffusion and Si ion implantation. An error-free direct modulation with a bit rate of 25 Gbit/s is achieved.

**STh1G.3 • 08:30**
**High Temperature Athermal Colorless Laser for Low-Cost Backhaul Networks,** Jiannan Zhu[1], Adrian Wonfor[1], Rosie Cush[2], Michael J. Wale[2], Stephan Pachnicke[3], Richard V. Penty[1], Ian H. White[1]; *[1]Unversity of Cambridge, UK; [2]Oclaro Inc., UK; [3]ADVA Optical Networking SE, Germany.* We describe the performance of an optimized high-temperature DS-DBR laser used as an uncooled WDM source. Constant wavelength output with less than 6GHz error without mode-hopping is shown for C-band channels from 70-90 °C.

### Executive Ballroom 210H

**08:00– 10:00**
**STh1H • Advanced Imaging Technologies**
*Presider: Audrey Ellerbee; Stanford Univ., USA*

**STh1H.1 • 08:00**
**Label-Free 3D Imaging for Lab-on-Chip Biomedical Applications,** Lisa Miccio[1], Francesco Merola[1], Pasquale Memmolo[1,2], Pietro Ferraro[1]; *[1]CNR-INO Istituto Nazionale di Ottica, Italy; [2]Istituto Italiano di Tecnologia - Center for Advanced Biomaterials for Health Care IIT@CRIB, Italy.* We demonstrate through a unique and novel approach based on holographic imaging the ability to achieve full morphological 3D analysis and 3D visualization of motile cells and their accurate 3D tracking for Lab-on Chip devices.

**STh1H.2 • 08:15**
**Two-dimensional spectral-encoding for high speed arbitrary patterned illumination,** Antony C. Chan[1], Andy Lau[1], Kenneth Wong[1], Edmund Y. Lam[1], Kevin Tsia[1]; *[1]Dept. of Electrical & Electronic Engineering, Hong Kong.* We propose a new tool for scaling the speed of arbitrary patterned illumination by two-dimensional spectral-encoding. A multi-objective optimization based on genetic algorithm is presented for its utility in different imaging modalities.

**STh1H.3 • 08:30**
**Maximally efficient imaging through multimode fiber,** Joel A. Carpenter[1], Benjamin J. Eggleton[1], Jochen Schroeder[1]; *[1]Univ. of Sydney, Australia.* Polarization diverse images are generated at the end of a multimode fiber using spatial light modulators to completely characterize propagation through the fiber in terms of the eigenmodes.

## CLEO: Science & Innovations

### Meeting Room 211 B/D

**08:00– 10:00**
### STh1I • Nonlinear Optics in Waveguides and Nanophotonics Devices
*Presider: Carl Poitras; Cornell Univ., USA*

**STh1I.1 • 08:00**
**Single nanoparticle detection with mode splitting of the microcavity Raman lasers,** Bei-Bei Li[1], William R. Clements[1], Xiao-Chong Yu[1], Li Wang[1], Qihuang Gong[1], Yun-Feng Xiao[1]; [1]*Peking Univ., China.* We report single nanoparticle detection using mode splitting of the microcavity Raman lasers. Using this method, single polystyrene (PS) nanoparticle down to 20 nm in radius in an aqueous environment is realized.

**STh1I.2 • 08:15**
**Demonstration of Difference Frequency Generation in a Silicon Slot Waveguide,** Aleksandar Nesic[1], Robert Palmer[1], Sebastian Koeber[1,2], Dietmar Korn[1], Swen Koenig[1], Delwin L. Elder[3], Larry R. Dalton[3], Wolfgang Freude[1,2], Christian G. Koos[1,2]; [1]*Inst. of Photonics and Quantum Electronics (IPQ), Karlsruhe Inst. of Technology (KIT), Germany;* [2]*Inst. of Microstructure Technology, Karlsruhe Inst. of Technology, Germany;* [3]*Dept. of Chemistry, Univ. of Washington, USA.* We report on the generation of microwave frequencies of up to 50 GHz by second-order nonlinear mixing of two optical carriers at 1540 nm in a silicon-organic hybrid slot waveguide.

**STh1I.3 • 08:30**
**Supercontinuum Generation in a Silica Spiral Waveguide,** Dongyoon Oh[1], David Sell[1], Hansuek Lee[1], Ki Youl Yang[1], Scott A. Diddams[2], Kerry J. Vahala[1]; [1]*T. J. Watson Lab of Applied Physics, California Inst. of Technology, USA;* [2]*Time and Frequency Division, National Inst. of Standards and Technology, USA.* A low-loss silica spiral waveguide is used for demonstrating on-chip supercontinuum generation. The broadest measured spectrum spans an octave (936 - 1888 nm) at -50 dB from peak when 2.17 nJ pulses are launched.

### Meeting Room 212 A/C

**08:00– 10:00**
### STh1J • Structuring Materials with fs Lasers
*Presider: Wayne Hess; Pacific Northwest National Lab, USA*

**STh1J.1 • 08:00** **Tutorial**
**Femtosecond Laser Materials Processing,** Chunlei Guo[1]; [1]*The Inst. of Optics, Univ. of Rochester, USA.* In this tutorial talk, I will discuss the mechanisms and applications of femtosecond laser-material processing.

Chunlei Guo is a professor in Optics and Physics at University of Rochester. His research is in the area of femtosecond laser-matter interactions at high intensities. He is an elected Fellow for both The Optical Society and American Physical Society.

## CLEO: QELS-Fundamental Science

### Meeting Room 212 B/D

**08:00– 10:00**
### FTh1K • Optomechanics and Optical Manipulation
*Presider: Kenneth Crozier; Harvard Univ., USA*

**FTh1K.1 • 08:00** **Invited**
**3D Optical Manipulation of a single 50 nm particle with a scanning evanescent nano-tweezers,** Johann Berthelot[1], Srdjan Acimovic[1], Mathieu Juan[2,3], Mark Kreuzer[1], Jan Renger[1], Romain Quidant[1,4]; [1]*ICFO, Spain;* [2]*Dept. of Physics & Astronomy, Macquarie Univ., Australia;* [3]*ARC Centre for Engineered Quantum Systems, Macquarie Univ., Australia;* [4]*ICREA, Spain.* Herein,we demonstrate stable optical trapping and accurate 3D manipulation of a single dielectric nanoparticle with a scanning optical near field probe.

**FTh1K.2 • 08:30**
**Photothermal heating enabled by plasmonic nanoantennas for electrokinetic manipulation and sorting of submicron particles,** Justus C. Ndukaife[1,2], Avanish Mishra[1], Urcan Guler[1], Agwu A. Nnanna[1,2], Steven Wereley[1], Alexandra Boltasseva[1]; [1]*Purdue Univ., USA;* [2]*Water Inst., Purdue Univ. Calumet, USA.* The photo-induced collective heating enabled by a plasmonic nanoantenna array is for the first time harnessed for rapid concentration, manipulation and sorting of particles, with high throughput. This work could find application in biosensing, and surface enhanced spectroscopies.

## JOINT

### Marriott Salon I & II

**08:00– 10:00**
### JTh1L • Symposium on Laser-Driven Sources of Particle and X-Ray Beams I ▶
*Presider: Sergei Tochitsky; Univ. of California Los Angeles, USA*

**JTh1L.1 • 08:00** **Invited** ▶
**Laser plasma acceleration using the PW-class BELLA laser,** Wim Leemans[1,2], Anthony J. Gonsalves[1], Kei Nakamura[1], Hann-Shin Mao[1], Csaba Toth[1], Joost Daniels[1,3], Daniel Mittelberger[1,2], Carlo Benedetti[1], Stepan Bulanov[2,1], Cameron Geddes[1], Jean-Luc Vay[1], Carl B. Schroeder[1], Eric H. Esarey[1]; [1]*Lawrence Berkeley National Lab, USA;* [2]*UC, USA;* [3]*TUE, Netherlands.* Multi-GeV electron acceleration of electrons using intense laser pulses that excite multi-gigavolt fields in plasmas will be discussed. Experimental results with the new BELLA PW-class lasers and supporting simulations will be presented as well as a path forward to apply this acceleration method towards practical machines.

**JTh1L.2 • 08:30**
**Tunable Monoenergetic Electron Beams from Staged Ionization Assisted Laser Wakefield Accelerator,** Gregory Golovin[1], Shouyuan Chen[1], Nathan Powers[1], Cheng Liu[1], Sudeep Banerjee[1], Jun Zhang[1], Ming Zeng[2], Zhengming Sheng[2], Donald Umstadter[1]; [1]*Physics and Astronomy, UNL, USA;* [2]*Physics and Astronomy, Shanghai Jiao Tong Univ., China.* By employing a pair of partially overlapped supersonic gas jets, we made a separation of injection and acceleration stages of laser wakefield acceleration and produced stable, quasi-monoenergetic (10-30% FWHM) and tunable (50-300 MeV) electron beams.

## Marriott
## Salon III

## CLEO: Science & Innovations

### 08:00– 10:00
### STh1M • Modulators using Novel Materials ▶

*Presider: Juerg Leuthold; ETH Zurich, Switzerland*

**STh1M.1 • 08:00** ▶

**Electro-optic Modulation of Small Disk Microcavity through Gated Graphene,** Majid Sodagar[1], Hesam Moradinejad[1], Ali A. Eftekhar[1], Ali Adibi[1]; *[1]Georgia Inst. of Technology, USA.* Monolayer graphene sheet has been integrated on top of small disk optical resonator in SOI platform. Electro-optic interaction between graphene and whispering gallery mode of the cavity has been demonstrated and studied for modulation application.

**STh1M.2 • 08:15** ▶

**Hybrid Si3N4-Graphene Nanophotonic Circuits for Electro-Optic Modulation,** Nico Gruhler[1], Christian Benz[1,2], Romain Danneau[1,2], Wolfram Pernice[1]; *[1]Inst. of Nanotechnology, Karlsruhe Inst. of Technology, Germany; [2]Inst. of Physics, Karlsruhe Inst. of Technology, Germany.* We present graphene-based optical modulators integrated with Si3N4 waveguides, which allow for utilizing graphene's broad flat absorption from visible to infrared wavelengths. Tunable attenuation of 0.067dB/µm is measured in Mach-Zehnder and microring resonators.

**STh1M.3 • 08:30** ▶

**Simultaneous optical modulation and detection using graphene integrated on a silicon waveguide,** Nathan Youngblood[1], Yoska Anugrah[1], Rui Ma[1], Steven Koester[1], Mo Li[1]; *[1]Electrical and Computer Engineering, Univ. of Minnesota, USA.* A dual-mode, graphene optical modulator and detector for the near-IR is demonstrated in a single device. Gate dependent photocurrent and optical transmission allow the device to operate in a highly novel mode of simultaneous optical modulation and detection.

## Marriott
## Salon V & VI

## CLEO: Science & Innovations

### 08:00– 10:00
### STh1N • Comb Spectroscopy ▶

*Presider: Brian Washburn; Kansas State Univ., USA*

**STh1N.1 • 08:00**

**Broadband Midinfrared Comb-Resolved Fourier Transform Spectroscopy,** Kevin F. Lee[1], Piotr Maslowski[2], Andrew Mills[1], Christian Mohr[1], Jie Jiang[1], Chien C. Lee[3], Thomas R. Schibli[3,4], Peter G. Schunemann[5], Martin Fermann[1]; *[1]IMRA America, Inc., USA; [2]Inst. of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus Univ., Poland; [3]Dept. of Physics, Univ. of Colorado at Boulder, USA; [4]JILA, National Inst. of Standards and Technology and Univ. of Colorado, USA; [5]BAE Systems, USA.* We combine a Tm-fiber frequency comb, phase-locked doubly-resonant GaAs optical parametric oscillator, multipass cell, and Fourier transform spectrometer to measure comb-resolved spectra at wavelengths of 3.1 to 5.5 micrometers for multiple gases at trace concentrations.

**STh1N.2 • 08:15** ▶

**Spectrally Interleaved, Comb-Mode-Resolved, Dual-Terahertz-Comb Spectroscopy,** Yi-Da Hsieh[1], Yuki Iyonaga[1], Yoshiyuki Sakaguchi[1], Shuko Yokoyama[2], Hajime Inaba[3,4], Kaoru Minoshima[4,5], Francis Hindle[6], Tsutomu Araki[1], Takeshi Yasui[4,7]; *[1]Osaka Univ., Japan; [2]Micro Optics Co., Ltd, Japan; [3]National Inst. of Advanced Industrial Science and Technology, Japan; [4]JST-ERATO Intelligent Optical Synthesizer Project, Japan; [5]The Univ. of Electro-Communications, Japan; [6]Université du Littoral Côte d'Opale, Japan; [7]The Univ. of Tokushima, Japan.* We demonstrated combination of spectrally interleaved terahertz (THz) frequency comb with dual-comb spectroscopy, enabling us to achieve the spectral sampling equal to linewidth of the comb tooth in the low-pressure gas spectroscopy in THz region.

**STh1N.3 • 08:30** ▶

**Sub-kHz-Linewidth Mid-infrared Optical Parametric Oscillator,** Maurizio De Rosa[1], Iolanda Ricciardi[1], Simona Mosca[1], Maria Parisi[1], Pasquale Maddaloni[1], Luigi Santamaria[1], Giovanni Giusfredi[2,3], Paolo De Natale[2,3]; *[1]Istituto Nazionale di Ottica, Consiglio Nazionale delle Ricerche, Italy; [2]Istituto Nazionale di Ottica, Consiglio Nazionale delle Ricerche, Italy; [3]LENS, Italy.* We present a transfer oscillator scheme between the pump and signal modes of a singly resonant optical parametric oscillator, emitting in the reange 2.7-4.2 µ m, demonstrating sub-kHz linewidth of the idler mode.

## Marriott
## Willow Glen I-III

## CLEO: Applications & Technology

### 08:00– 10:00
### ATh1O • OCT-Technology Development & Clinical Applications ▶

*Presider: Nicusor Iftimia; Physical Sciences Inc., USA*

**ATh1O.1 • 08:00** Invited ▶

**Progress on Cellular Resolution Retinal Imaging: Setting the Stage for Translation between Clinical and Basic Science,** Robert J. Zawadzki[1,2]; *[1]Ophthalmology & Vision Science, Univ. of California Davis, USA; [2]Cell Biology and Human Anatomy, Univ. of Califoria Davis, USA.* I will review our progress on developing clinical and animal (mice) cellular resolution in vivo retinal imaging modalities. Example applications of these technologies to in vivo studies of microscopic retinal morphology will be presented.

**ATh1O.2 • 08:30** ▶

**Optical Coherence Imaging of Microvascular Oxygenation and Hemodynamics,** Shau Poh Chong[1], Conrad Merkle[1], Harsha Radhakrishnan[1], Conor Leahy[1], Alfredo Dubra[2,3], Yusufu Sulai[4], Vivek J. Srinivasan[1]; *[1]Biomedical Engineering, Univ. of California Davis, USA; [2]Dept. of Ophthalmology, Medical College of Wisconsin, USA; [3]Dept. of Biophysics, Medical College of Wisconsin, USA; [4]The Inst. of Optics, Univ. of Rochester, USA.* Here, we present high-speed spectral domain OCT in the visible spectral range using a supercontinuum source that performs angiography, oximetry, and speed assessment of red blood cells in individual vessels of the mouse pinna in vivo.

## CLEO: QELS-Fundamental Science

### FTh1A • Quantum Entanglement—Continued

**FTh1A.4 • 08:45**
**High visibility two-photon interference of entangled photons from a quasi-phase-matched AlGaAs waveguide,** Peyman Sarrafi[1], Eric Y. Zhu[1], Barry Holmes[2], David Hutchings[2], J. Stewart Aitchison[1], Li Qian[1]; [1]*ECE, Univ. of Toronto, Canada;* [2]*School of Engineering, Univ. of Glasgow, UK.* We experimentally demonstrate time-frequency entanglement of photon pairs produced in a cw-pumped quasi-phased-matched AlGaAs superlattice waveguide, producing 8E06 pairs/s with 96.0±0.7% visibility without background subtraction, highest known visibility by far in AlGaAs waveguides.

**FTh1A.5 • 09:00**
**Demonstration of high-visibility two-photon interference with a multimode waveguide source,** Michal Jachura[1], Michal Karpinski[2], Czeslaw Radzewicz[1], Konrad Banaszek[1]; [1]*Faculty of Physics, Univ. of Warsaw, Poland;* [2]*Clarendon Lab, Univ. of Oxford, UK.* We verified interferometrically generation of spatially pure photon pairs via spontaneous parametric down-conversion in a multimode nonlinear waveguide in the 800 nm spectral region, obtaining two-photon interference visibility robustly exceeding 90% without any spatial fitering.

**FTh1A.6 • 09:15**
**Entangling color-different photons via time-resolved measurement and active feed-forward,** Tian-Ming Zhao[1,2], Han Zhang[1,2], Jian Yang[1,2], Zi-Ru Sang[1,2], Jiang Xiao[1,2], Xiao-Hui Bao[1,2], Jian-Wei Pan[1,2]; [1]*Hefei National Lab for Physical Sciences at Microscale and Dept. of Modern Physics, Univ. of Science and Technology of China, China;* [2]*Synergetic Innovation Center of Quantum Information and Quantum Physics, Univ. of Science and Technology of China, China.* We report an experiment of entangling independent color-different photons by using time-resolved measurement and active feed-forward. Our work provides an approach to solve the frequency mismatch problem for the interconnection between dissimilar quantum systems in a quantum network.

**FTh1A.7 • 09:30**
**A Time-Bin Qubit Entangler based on Photon Switching,** Hiroki Takesue[1]; [1]*NTT Basic Research Labs, Japan.* I present a simple scheme for entangling two independent time-bin qubits using quantum interference at a high-speed 2x2 optical switch. Non-classical two photon interference fringes were observed experimentally by using the proposed scheme.

### FTh1B • Quantum Interconnects—Continued

**FTh1B.2 • 09:00**
**Realisation of a photonic link between a trapped ion and a semiconductor quantum dot,** Claire Le Gall[1], Robert Stockill[1], Matthias Steiner[1], Hendrik-Marten Meyer[1,2], Clemens Matthiesen[1], Jakob Reichel[3], Edmund Clarke[4], Arne Ludwig[5], Michael Koehl[1,2], Mete Atature[1]; [1]*Cavendish Lab, Univ. Of Cambridge, UK;* [2]*Physikalisches Institut, Univ. of Bonn, Germany;* [3]*Laboratoire Kastler Brossel, France;* [4]*EPSRC National center for III-V nanotechnologies, Univ. of Sheffield, UK;* [5]*Lehrstuhl fur Festkoerperphysic, Ruhr-Universitat Bochum, Germany.* We report on the first photonic link between a quantum dot and a single ion and show that the ion absorption probability per quantum dot photon can reach 1.2%.

**FTh1B.3 • 09:15**
**Observation of High-Purity Single Photons Hopping between Optical Cavities,** Kenzo Makino[1], Jun-ichi Yoshikawa[1], Yosuke Hashimoto[1], Peter van Loock[2], Akira Furusawa[1]; [1]*Applied Physics, Univ. of Tokyo, Japan;* [2]*Physics, Johannes Gutenberg-Universität Mainz, Germany.* We experimentally demonstrate high-purity single photons hopping coherently between coupled optical cavities. The system shows high performance also as a controllable single-photon source, which emits single photons with a negative Wigner function.

**FTh1B.4 • 09:30**
**Certified quantum non-demolition measurement of atomic spins,** Robert Sewell[1], Mario Napolitano[1], Naeimeh Behbood[1], Georgio Colangelo[1], Ferran Martin Ciurana[1], Morgan W. Mitchell[1,2]; [1]*ICFO -The Inst. of Photonic Sciences, Spain;* [2]*ICREA, Spain.* We report certified quantum non-demolition measurement of atomic spins using criteria developed for continuous variable experiments in optics. We observe quantum state preparation and information--damage trade--off beyond classical limits by seven and twelve standard deviations.

### FTh1C • High-Field THz Physics—Continued

**FTh1C.3 • 08:45**
**Selective THz excitation of collective modes in underdoped YBCO,** Georgi L. Dakovski[1], Wei-Sheng Lee[1], Joshua J. Turner[1], Matthias C. Hoffmann[1]; [1]*SLAC National Accelerator Lab, USA.* We use intense broadband THz pulses to excite underdoped YBCO exhibiting competing superconducting and charge density wave ground states. We observe pronounced coherent oscillations at 1.85 and 2.65THz, attributed to renormalized low-energy phonon modes.

**FTh1C.4 • 09:00**
**Femtosecond Insulator-Metal Transition in $VO_2$ Induced by Intense Multi-THz Transients,** Alexander Grupp[1], Bernhard Mayer[1], Christian Schmidt[1], Jannis Oelmann[1], Robert E. Marvel[2], Richard F. Haglund[2], Alfred Leitenstorfer[1], Alexej Pashkin[1]; [1]*Dept. of Physics and Center for Applied Photonics, Univ. of Konstanz, Germany;* [2]*Dept. of Physics and Astronomy, Vanderbilt Univ., USA.* A non-thermal insulator-metal transition in $VO_2$ has been driven by a non-resonant excitation at frequencies around 25 THz. A switching time of 80 fs is found, corresponding to approximately two cycles of the driving field.

**FTh1C.5 • 09:15**
**High Harmonic Generation in Graphene at Terahertz Frequencies,** Ibraheem Al-Naib[1], John E. Sipe[2], Marc M. Dignam[1]; [1]*Dept. of Physics, Engineering Physics and Astronomy, Queen's Univ., Canada;* [2]*Dept. of Physics and Inst. for Optical Sciences, Univ. of Toronto, Canada.* We employ a density-matrix formalism in the length gauge to simulate the nonlinear terahertz response of graphene. The generation of high harmonics is dominated by the strong interplay between intraband and interband dynamics.

**FTh1C.6 • 09:30**
**Terahertz second-order nonlinear optics in a graphene-metamaterial device: difference-frequency generation,** Chihun In[1], Hyeondon Kim[2], Bumki Min[2], Hyunyong Choi[1]; [1]*School of Electrical and Electronic Engineering, Yonsei Univ., Korea;* [2]*Dept. of Mechanical Engineering, Korea Advanced Inst. of Science and Technology (KAIST), Korea.* We show the first experimental demonstration of nonlinear second-order terahertz frequency generation in a graphene-metamaterial device. Characteristic ultrafast nature of graphene and strong metamaterials' nonlinear resonances enables to observe the nonlinear difference frequency generation.

### FTh1D • Solitons and Temporal Effects—Continued

**FTh1D.4 • 08:45**
**Higher-Order Equilibrium States of Temporal Soliton Molecules,** Alexander Hause[1], Fedor Mitschke[1]; [1]*Univ. of Rostock, Germany.* Bound states of fiber-optic dispersion-managed solitons are investigated. When the pulse separation is increased, a sequence of alternatingly stable and unstable equilibria arises; it terminates at a point defined by the radiation background.

**FTh1D.5 • 09:00**
**Generation of a Train of Ultrashort Pulses by Simply Inserting Transparent Plates on the Optical Path,** Kazumichi Yoshii[1], Yoshitaka Nakamura[1], Kohei Hagihara[1], Masayuki Katsuragawa[1]; [1]*Engineering Science, Univ. of Electro-communications, Japan.* We experimentally demonstrate generation of a train of ultrashort pulses with a nearly TL pulse duration of 1.78 fs by simply inserting transparent plates on the optical axis and adjusting their thicknesses precisely.

**FTh1D.6 • 09:15**
**Dissipative Vectorial Solitons in Semiconductor Lasers,** Mathias Marconi[1], Julien Javaloyes[2], Stephane Barland[1], Salvador Balle[3], Massimo Giudici[1]; [1]*Institut Non Linéaire de Nice, Université de Nice Sophia Antipolis - CNRS, France;* [2]*Departamento de Fisica, Universitat de les Illes Baleares, Spain;* [3]*Institut Mediterrani d'Estudis Avançats, CSIC, Spain.* Nonlinear polarization dynamics of VCSELs with a long-delay external cavity lead to vectorial dissipative solitons. The large temporal aspect-ratio enables the observation of multiple -- independent and/or bound -- solitons within the same roundtrip.

**FTh1D.7 • 09:30**
**Temporal dynamics of all-optical switching in Photonic Crystal Cavity,** Pierre Colman[1], Yi Yu[1], Mikkel Heuck[1], Per Lunnemann Hansen[1], Kresten Yvind[1], Jesper Mørk[1]; [1]*DTU Fotonik, Denmark.* The temporal dynamics of all-optical switching has been investigated in a Photonic Crystal Cavity with a 150fs-40aJ/pulse resolution. This allowed observing for the first time effects like pulse reshaping, pulse delay and intra-cavity Four-Wave-Mixing.

## STh1E • Filamentation—Continued

**STh1E.4 • 08:45**

**Observation of free electron density oscillation in filamentation as a function of carrier-envelope phase,** Lifeng Wang[1], Hao Teng[1], Xin Lu[1], Shiyou Chen[1], Xinkui He[1], Peng He[1], Zhiyi Wei[1]; [1]*Inst. of Physics, The Chinese Academ, China.* The free electron density in a 40 mm long filamentation generated by carrier-envelope stabilized few-cycle laser pulses is detected in a circular loop. The oscillation of electron density is observed as a function of CEP.

**STh1E.5 • 09:00**

**Diagnostics of rotational wavepackets of nitrogen molecules by strong-field-ionization induced air lasers,** Jielei Ni[1], Haisu Zhang[1], Wei Chu[1], Bin Zeng[1], Jinping Yao[1], Guihua Li[1], Chenrui Jing[1], Hongqiang Xie[1], Huailiang Xu[2], Ya Cheng[1]; [1]*State Key Lab of High Field Laser Physics, Shanghai Inst. of Optics and Fine Mechanics, China;* [2]*State Key Lab on Integrated Optoelectronics, College of Electronic Science and Engineering, Jilin Univ., China.* We report on diagnostics of rotational wavepackets coherently generated in strong-field-ionized nitrogen molecules with a seed-amplified air lasing scheme, and the first observation on Raman scattering of neutral nitrogen molecules with such an "air laser."

**STh1E.6 • 09:15**

**A new and improved approach to supercontinuum generation in solids,** Chih-Hsuan Lu[1], Yu_Chen Cheng[2], Shang-Da Yang[1], Yuan-Yao Lin[1], Chia-Chen Hsu[3], Andy Kung[1]; [1]*National Tsing Hua Univ., Taiwan;* [2]*Inst. of Atomic and Molecular Sciences, Taiwan;* [3]*National Chung Cheng Univ., Taiwan.* A stable octave-spanning supercontinuum with excellent beam quality is generated by high-intensity spectral broadening in bulk fused silica plates in a cascaded arrangement.

**STh1E.7 • 09:30**

**Study of Filamentation Threshold in Zinc Selenide,** Magali M. Durand[1], Aurelien Houard[2], Khan Lim[1], Anne Durécu[3], Olivier Vasseur[3], Martin Richardson[1]; [1]*Townes Laser Inst., CREOL - Univ. of Central Florida, USA;* [2]*Laboratoire d'Optique Appliquée, ENSTA ParisTech - Ecole Polytechnique, CNRS, France;* [3]*ONERA, France.* Filamentation in different multi-photon absorption regimes was studied using different laser wavelengths in a zinc selenide crystal. The 3-photon ionization/absorption threshold was verified, and the impact of absorption on filament formation was observed.

## STh1F • THz Quantum Cascade Lasers—Continued

**STh1F.4 • 08:45** Invited

**The Development and Applications of Terahertz Quantum Cascade Lasers,** Edmund Linfield[1], Lianhe Li[1], P. Dean[1], A. G. Davies[1]; [1]*Univ. of Leeds, UK.* This paper will review the development of terahertz frequency quantum cascade lasers, including the achievement of >1W output powers. It will also discuss self-mixing imaging, where the laser cavity is used as a coherent detector.

**STh1F.5 • 09:15**

**THz imaging of free carrier density based on quantum cascade lasers under optical feedback,** francesco P. mezzapesa[1,2], Lorenzo L. Columbo[1,3], Massimo Brambilla[1,3], Maurizio Dabbicco[1,2], Harvey E. Beere[4], David A. Ritchie[4], Miriam S. Vitiello[5], Gaetano Scamarcio[1,2]; [1]*Dip. Interuniversitario di Fisica, Università degli Studi e Politecnico di Bari, Italy;* [2]*CNR-IFN, Italy;* [3]*Dipartimento di Scienza ed Alta tecnologia, Università dell'Insubria, Italy;* [4]*Cavendish Lab, Univ. of Cambridge, UK;* [5]*NEST - CNR, Italy.* Detectorless THz imaging based on quantum cascade lasers operating under optical feedback to monitor the spatial distribution of free electron plasma induced onto a semiconductor by photo-excitation with a reconfigurable pattern of NIR laser pump.

**STh1F.6 • 09:30**

**Towards Doppler-Free QCL-based Metrological THz Spectroscopy,** Luigi Consolino[1], Saverio Bartalini[1,2], Annamaria Campa[1], Harvey E. Beere[4], David A. Ritchie[4], Miriam S. Vitiello[3], Pablo Cancio Pastor[1], Davide Mazzotti[1], Paolo De Natale[1,2]; [1]*CNR - INO, Italy;* [2]*LENS, Italy;* [3]*CNR - NEST, Italy;* [4]*Cavendish Lab, UK.* New frontiers for high precision THz spectroscopy are presented. Current limits can be overcome by exploiting saturation effects on molecular transitions and coupling THz QCL radiation to an optical cavity.

## STh1G • Semiconductor Lasers for Communication—Continued

**STh1G.4 • 08:45**

**1.55 µm DFB laser monolithically integrated with power amplifier array,** Lianping Hou[1], Marc Sorel[1], John H. Marsh[1]; [1]*Univ. of Glasgow, UK.* We present a highly efficient laterally-coupled 1.55 µm DFB laser monolithically integrated with multistage MMIs and SOAs, using low bias currents and providing an output power of ~100 mW with a low divergence angle.

**STh1G.5 • 09:00**

**Optical Characteristics of 1.3-µm Dual-Mode Laser Diode with Integrated Semiconductor Optical Amplifier,** Namje Kim[1], Sang-Pil Han[1], Kiwon Moon[1], Il-Min Lee[1], Eui Su Lee[1], Kyung Hyun Park[1]; [1]*THz Photonics Creative Research Center, Electronics and Telecommunications Research Inst., Korea.* A 1.3-µm dual-mode laser diode with an integrated semiconductor optical amplifier with high output power of over 80 mW has been developed as an optical beat source for a continuous wave terahertz system.

**STh1G.6 • 09:15**

**1.3 µm InAs/GaAs Quantum Dot Lasers on SOI Waveguide Structures,** Katsuaki Tanabe[1,2], Yasuhiko Arakawa[2,3]; [1]*Inst. for Nano Quantum Information Electronics, Univ. of Tokyo, Japan;* [2]*Inst. for Photonics-Electronics Convergence System Technology, Japan;* [3]*Inst. of Industrial Science, Univ. of Tokyo, Japan.* A 1.3-µm InAs/GaAs quantum dot laser on a silicon-on-insulator waveguide structure with a threshold current density of 300 A/cm$^2$ and lasing temperatures greater than 100°C is fabricated by direct wafer bonding and layer transfer.

**STh1G.7 • 09:30** Invited

**Quantum Teleportation using Entangled LEDs,** Richard M. Stevenson[1], Jonas Nilsson[1], K. H. A. Chan[1,2], Anthony J. Bennett[1], Joanna Skiba-Szymanska[1], Marco Lucamarini[1], Martin B. Ward[1], Ian Farrer[2], David A. Ritchie[2], Andrew J. Shields[1]; [1]*Toshiba Research Europe Limited, UK;* [2]*Cavendish Lab, Univ. of Cambridge, UK.* : Quantum teleportation can relay quantum information, and enable near-deterministic quantum circuits. Previous linear-optical implementations use optically excited, similar light sources. We show teleportation using electrically excited entangled light, even for dissimilar, laser generated input qubits.

## STh1H • Advanced Imaging Technologies—Continued

**STh1H.4 • 08:45**

**Enhanced Spatial Resolution in Confocal Laser Microscopy by Subtractive Imaging Using Vector Beams,** Susumu Segawa[1], Yuichi Kozawa[1], Shunichi Sato[1]; [1]*Inst. of Multidisciplinary Research for Advanced Materials, Tohoku Univ., Japan.* The enhanced spatial resolution in confocal laser microscopy is demonstrated by subtracting two confocal images acquired by radially and azimuthally polarized beams. The effect of the side-lobe emerging in the subtraction processes is also discussed.

**STh1H.5 • 09:00**

**Real-time Optical Diffraction Tomography for 3-D Visualization of Microscopic Particles,** Kyoohyun Kim[1], Kyung Sang Kim[2], HyunJoo Park[1], JongChul Ye[2], YongKeun Park[1]; [1]*Dept. of Physics, KAIST, Korea;* [2]*Dept. of Bio and Brain Engineering, KAIST, Korea.* We develop a real-time reconstruction technique in optical diffraction tomography for the visualization of 3-D refractive index distribution using sparse angle illumination and graphic processing unit implementation. We apply the method to image dynamics of colloidal dimers and red blood cells.

**STh1H.6 • 09:15** Invited

**Computational Imaging and Sensing for Biophotonics Applications,** Aydogan Ozcan[1]; [1]*Electrical Engineering and Bioengineering Depts., Univ. of California Los Angeles, USA.* We review our recent progress on computational imaging and sensing techniques aiming various bio-photonics applications.

## Meeting Room 211 B/D

## CLEO: Science & Innovations

### STh1I • Nonlinear Optics in Waveguides and Nanophotonics Devices—Continued

**STh1I.4 • 08:45**
**Effects of Multiphoton Absorption on Parametric Comb Generation in Silicon Microresonators,** Ryan K. Lau[1], Yoshitomo Okawachi[1], Michael R. Lamont[1,2], Alexander L. Gaeta[1,2]; *[1]School of Applied and Engineering Physics, Cornell Univ., USA; [2]Kavli Inst. at Cornell for Nanoscale Science, Cornell Univ., USA.* We investigate theoretically parametric frequency comb generation in silicon microresonators for telecom and mid-infrared (MIR) wavelengths in the presence of multiphoton absorption. Parametric oscillation is inhibited at telecom wavelengths but can occur at MIR wavelengths.

**STh1I.5 • 09:00**
**On-chip ultra-broad frequency conversion via simultaneous second and third-order optical nonlinearity,** Steven Miller[1], Kevin Luke[1], Yoshitomo Okawachi[2], Jaime Cardenas[1], Alexander L. Gaeta[2,3], Michal Lipson[1,3]; *[1]School of Electrical and Computer Engineering, Cornell Univ., USA; [2]School of Applied and Engineering Physics, Cornell Univ., USA; [3]Kavli Inst. at Cornell for Nanoscale Science, Cornell Univ., USA.* We demonstrate ultra-broad frequency conversion through simultaneous second and third-order nonlinearities. Using a high-Q resonator, we generate multiple frequency lines in both the near-IR and in the visible range using a single near-IR CW pump.

**STh1I.6 • 09:15**
**Slow-light enhanced Brillouin frequency comb generation on a chip,** Moritz Merklein[1], Irina V. Kabakova[1], Thomas Buettner[1], Steve Madden[2], Barry Luther-Davies[2], Duk-Yong Choi[2], Benjamin J. Eggleton[1]; *[1]Univ. of Sydney, Australia; [2]Australian National Univ., Australia.* We present the experimental observation of the slow-light enhancement effect on the generation of a frequency comb formed by stimulated Brillouin scattering (SBS) in a chip scale $As_2S_3$ rib waveguide.

**STh1I.7 • 09:30**
**All chalcogenide Raman-parametric laser, wavelength converter and broadband source in a single microwire,** Raja Ahmad[1], Martin Rochette[1]; *[1]McGill Univ., Canada.* We present a chalcogenide microwire device that acts as a compact (~11 cm length, ~1 µm diameter) and power efficient (sub-Watt threshold peak power, >2% slope efficiency) Raman-parametric laser, wavelength converter and ultra-broadband supercontinuum generator/amplifier.

## Meeting Room 212 A/C

### STh1J • Structuring Materials with fs Lasers—Continued

**STh1J.2 • 09:00**
**Femtosecond-laser inscription via local modification of the glass composition in phosphate glasses,** Jesus Hoyo[1], Belen Sotillo[2], Jan Siegel[1], Toney T. Fernandez[1], Paloma Fernandez[2], Patricia Haro[3], Daniel Jaque[3], Margarita Hernandez[4], Concepcion Domingo[4], Javier Solis[1]; *[1]Laser Processing Group, Instituto de Optica, CSIC, Spain; [2]Depto. de Física de Materiales, Univ. Complutense, Spain; [3]Fluorescence Imaging Group, Depto. de Física de Materiales, Univ. Autonoma de Madrid, Spain; [4]Instituto de Estructura de la Materia, CSIC, Spain.* Femtosecond laser inscription of high performance active/passive waveguides is demonstrated in phosphate glass via local modification of the glass composition. La-K cross diffusion plays a key role in the performance of the generated structures.

**STh1J.3 • 09:15**
**Polarization-Sensitive Cat`s Eye Structuring of Silicon by Ultrashort Light Pulses,** Jingyu Zhang[1], Rokas Drevinskas[1], Martynas Beresna[1], Mindaugas Gecevičius[1], Peter G. Kazansky[1]; *[1]Optoelectronics Research Centre, Univ. of Southampton, UK.* Sub-wavelength ridge structures are observed on silicon surface after irradiation with two femtosecond pulses. Cat's-eye-shaped structures are aligned perpendicular to polarization of the second pulse and can be used for polarization-sensitive recording.

**STh1J.4 • 09:30**
**In-Situ Measurement of the Intrinsic Polymerization Time During Three-Dimensional Direct Laser Writing,** Jonathan B. Mueller[1], Joachim Fischer[2], Martin Wegener[1,2]; *[1]Inst. of Applied Physics and DFG-Center for Functional Nanostructures, Karlsruhe Inst. of Technology, Germany; [2]Inst. of Nanotechnology, Karlsruher Institut für Technologie, Germany.* We focus a short writing pulse burst into a photo-resist, polymerizing a voxel. The time-resolved transmission of a co-focused second laser probes the voxel formation dynamics. We measure time constants as small as 400 µs.

## Meeting Room 212 B/D

## CLEO: QELS-Fundamental Science

### FTh1K • Optomechanics and Optical Manipulation—Continued

**FTh1K.3 • 08:45**
**New Techniques in Optical Trapping and Sensing,** Lulu Liu[1], Alexander Woolf[1], Federico Capasso[1]; *[1]Harvard Univ., USA.* We demonstrate several new techniques that expand the current capabilities of optical trapping and sensing, and demonstrate the application of a combination of these techniques in the successful measurement of near-field optical and double-layer forces.

**FTh1K.4 • 09:00**
**Optomechanics with photonic crystals slab mirrors and cavities,** Isabelle Robert-Philip[1], Rémy Braive[1], Isabelle Sagnes[1], Izo Abram[1], Alexios Beveratos[1], Thomas Antoni[2], Kevin Makles[2], Aurélien Kuhn[2], Tristan Briant[2], Pierre-François Cohadon[2], Emanuel Gavartin[3], Tobias Kippenberg[3]; *[1]LPN, CNRS, France; [2]LKB, CNRS, France; [3]EPFL, Switzerland.* We investigate optomechanical effects in photonic crystal slab membranes, either including a cavity or acting as an end-mirror in a Fabry-Perot cavity. We in particular demonstrate the non-linear behavior of the membranes fundamental mode.

**FTh1K.5 • 09:15**
**Torsional Cavity Optomechanical Nano-Seesaw System,** Huan Li[1], Mo Li[1]; *[1]Electrical and Computer Engineering, Univ. of Minnesota, USA.* A novel torsional cavity optomechanical system consisting of a nano-seesaw with one photonic crystal cavity on each side has been demonstrated, which exhibits extremely high mechanical sensitivity and can potentially reveal new optomechanical phenomena.

**FTh1K.6 • 09:30**
**Bidimensional nano-optomechanics and topological backaction in a non-conservative radiation force field,** Arnaud Gloppe[1], Pierre Verlot[1], Eva Dupont-Ferrier[1], Aurélien G. Kuhn[1], Alessandro Siria[2], Philippe Poncharal[2], Guillaume Bachelier[1], Pascal Vincent[2], Olivier Arcizet[1]; *[1]Institut Néel, Université Grenoble Alpes - CNRS UPR2940, France; [2]Institut Lumière Matière, UMR5306, CNRS - Université Claude Bernard Lyon 1, France.* We explore the vectorial optomechanical interaction between a nanowire and a focused beam of light. The nanowire is sensitive to the topological variations of the focused laser force field which dramatically modify the phenomenology of the dynamical backaction.

## Marriott Salon I & II

## JOINT

### JTh1L • Symposium on Laser-Driven Sources of Particle and X-Ray Beams I—Continued

**JTh1L.3 • 08:45** ▶
**High Power Guiding and Electron Acceleration in Pure N5+ Plasma Channels,** Andy Goers[1], Sung Yoon[1], George Hine[1], Jennifer Elle[1], Howard Milchberg[1]; *[1]Univ. of Maryland, USA.* We examine the interaction of relativistic laser pulses with plasma channels formed in a nitrogen cluster jet. We observe creation of nearly pure N5+ plasma channels and ionization injected wakefield beams with energies. >100 MeV.

**JTh1L.4 • 09:00** ▶
**Single-shot visualization of evolving plasma bubble accelerators by frequency-domain streak camera,** Zhengyan Li[1], Hai-En Tsai[1], Chih-Hao Pai[1], Rafal Zgadzaj[1], Xiaoming Wang[1], X. Zhang[1], V. Khudik[1], Gennady Shvets[1], Michael C. Downer[1]; *[1]Univ. of Texas at Austin, USA.* We visualize formation, propagation and collapse of laser-driven plasma bubbles using a single-shot frequency domain streak camera, thereby identifying bubble dynamics that optimize electron injection and acceleration.

**JTh1L.5 • 09:15** Invited ▶
**Current Status and Future Prospects of Laser-driven Ion Sources,** Marco Borghesi[1,2]; *[1]Centre for Plasma Physics, The Queen's Univ. of Belfast, UK; [2]ELI Beamlines project, Inst. of Physics of the ASCR, Czech Republic.* Laser-driven ion acceleration is attracting an impressive and steadily increasing research effort. The talk will review the state of the art in this field, focusing on emerging mechanisms which hold high promise for further progress.

## Marriott
## Salon III

## CLEO: Science & Innovations

### STh1M • Modulators using Novel Materials—Continued

**STh1M.4 • 08:45**
**Low Insertion Loss Graphene based Absorption Modulator on SOI Waveguide,** Muhammad Mohsin[1], Daniel Schall[1], Martin Otto[1], Daniel Neumaier[1], Heinrich Kurz[1]; [1]*Advanced Microelectronic Center Aachen (AMICA), AMO GmbH, Germany.* We present a graphene based absorption modulator on SOI waveguide with very low insertion loss. The device showed a modulation of 16 dB and an insertion loss of only 3.3dB, surpassing GeSi based absorption modulators.

**STh1M.5 • 09:00**
**A silicon integrated BaTiO$_3$ electro-optic modulator,** Chi Xiong[1], Wolfram Pernice[1], Joseph Ngai[1], James Reiner[1], Divine Kumah[1], Fred Walker[1], Charles Ahn[1], Hong Tang[1]; [1]*Yale Univ., USA.* A Si-integrated modulator based on epitaxial ferroelectric aTiO$_3$ thin films is demonstrated with gigahertz modulation bandwidth and an effective Pockels coefficient of 213 ± 49 pm/V.

**STh1M.6 • 09:15**
**Silicon on Lithium Niobate: A Hybrid Electro-Optical Platform for Near- and Mid-Infrared Photonics,** Jeff Chiles[1], Sasan Fathpour[1]; [1]*CREOL, The College of Optics and Photonics, Univ. of Central Florida, USA.* A thin layer of silicon is transferred onto a lithium niobate substrate, forming a hybrid electro-optical platform, on which ring resonators are fabricated and characterized at 1550 nm, showing an optical loss of 3.0±0.5 dB/cm.

**STh1M.7 • 09:30**
**Large Photo-Induced Group Delay Variations in Chalcogenide-on-Silicon Mach-Zehnder Interferometers,** Ran Califa[1], Yuri Kaganovskii[2], Dvir Munk[1], Hadar Genish[2], Idan Bakish[1], Michael Rosenbluh[2], Avi Zadok[1]; [1]*Faculty of Engineering, Bar-Ilan Univ., Israel;* [2]*Dept. of Physics, Bar-Ilan Univ., Israel.* The rapid post-fabrication trimming of the group index in hybrid chalcogenide-on-silicon Mach-Zehnder interferometers is demonstrated. Index changes of 0.065 are achieved through photo-induced mass transfer in an As10Se90 layer.

## Technology Transfer Program

Thursday, 12 June
09:30-12:30
*Exhibit Hall Theater*

- Tutorial about Product Licensing and Tech Startups
- Pitch Panel
- Keynote - Becoming an Entrepreneur and Sustaining a Technology Business

## Marriott
## Salon V & VI

## CLEO: Science & Innovations

### STh1N • Comb Spectroscopy—Continued

**STh1N.4 • 08:45**
**High-Coherence Mid-Infrared Frequency Comb Generation and Applications,** Francesco Cappelli[1,2], Iacopo Galli[1,2], Pablo Cancio Pastor[1,2], Giovanni Giusfredi[1,2], Davide Mazzotti[1,2], Saverio Bartalini[1,2], Paolo De Natale[1,2]; [1]*CNR-INO, Italy;* [2]*LENS, Italy.* We report on the generation of a highly-coherent frequency comb around 4330 nm. A quantum cascade laser has been effectively phase-locked to a comb tooth and its frequency noise has been measured.

**STh1N.5 • 09:00**
**Multi-octave Acousto-Optic Spectrum Analyzer for Mid-Infrared Pulsed Sources,** Grégory Gitzinger[1], Vincent Crozatier[1], Raman Maksimenka[1], Stéphanie Grabielle[1], Nicolas Forget[1], Skirmantas Alisauskas[3], Audrius Pug<\#193>zlys[2], Andrius Baltuska[3], Balazs Monoszlai[3], Carlo Vicario[3], Christoph P. Hauri[2,4]; [1]*FASTLITE, France;* [2]*Paul Scherrer Inst., Switzerland;* [3]*Institut für Photonik, Technische Universität Wien, Austria;* [4]*Ecole Polytechnique Federale de Lausanne, Switzerland.* Demonstration of an acousto-optic filter based infrared spectrometer featuring a 5 cm-1 resolution over more than 2 octaves (1 to 5 micron) is reported.

**STh1N.6 • 09:15**
**Ultra-Broadband Near-Infrared Dual-Comb Spectroscopy,** Sho Okubo[1], Kana Iwakuni[1,2], Hajime Inaba[1], Kazumoto Hosaka[1], Atsushi Onae[1], Hiroyuki Sasada[2], Feng-Lei Hong[1]; [1]*National Metrology Inst. of Japan, National Inst. of Advanced Industrial Science and Technology, Japan;* [2]*Faculty of Science and Technology, Keio Univ., Japan.* We extend the spectral bandwidth of dual-comb spectroscopy over a hundred THz using two optical frequency combs with relative linewidth of sub-Hz level. We record the spectrum of the entire vibration band of acetylene.

**STh1N.7 • 09:30**
**Ultra-Long Duration Time-Resolved Spectroscopy with Enhanced Temporal Resolution of High-Q Nano-Optomechanical Modes using Interleaved Asynchronous Optical Sampling (I-ASOPS),** Aleem M. Siddiqui[1], Robert L. Jarecki[1], Andrew Starbuck[1], Jonathan A. Cox[1]; [1]*Sandia National Labs, USA.* Transient responses of high-Q nano-optomechanical modes are characterized with Interleaved-ASOPS, where pump-induced transients are interrogated with multiple probe pulses. Temporal resolution increases with probe-pulse-number beyond conventional ASOPS, achieving sub-ps resolution over µs durations.

## Marriott
## Willow Glen I-III

## CLEO: Applications & Technology

### ATh1O • OCT-Technology Development & Clinical Applications—Continued

**ATh1O.3 • 08:45**
**Automated classification of basal cell carcinoma in mouse skin by polarization sensitive optical coherence tomography,** Lian Duan[1], Tahereh Marvdashti[1], Alex Lee[2], Jean Y. Tang[2], Audrey Ellerbee[1]; [1]*E.L. Ginzton Lab and Dept. of Electrical Engineering, Stanford Univ., USA;* [2]*Dermology Dept., Stanford Univ., USA.* A support-vector-machine classifier was developed to discriminate between basal cell carcinoma and healthy tissue in images of mouse skin obtained by polarization-sensitive optical coherence tomography. The achieved sensitivity and specificity were respectively 98% and 96.9%.

**ATh1O.4 • 09:00**
**Withdrawn**

**ATh1PO5 • 09:15**
**Spatiotemporal optical coherence (STOC) manipulation and its possible applications,** Maciej Nowakowski[1], Dawid Borycki[1], Maciej Wojtkowski[1]; [1]*Optical Biomedical Imaging Group, Inst. of Physics, Nicolaus Copernicus Univ., Poland.* We present a novel method of spatiotemporal optical coherence (STOC) manipulation, in which the effective coherence properties of the optical field are adjusted by modulating the phase of the spectral degree of coherence.

**ATh1O.6 • 09:30**
**Biodynamic 3D Imaging for Personalized Cancer Care,** David D. Nolte[1], Ran An[1], Michael Childress[1], John Turek[1]; [1]*Purdue Univ., USA.* Tumor heterogeneity and differential drug response in 3D tissue is a major obstacle for survival of cancer patients. Biodynamic 3D imaging provides personalized therapy assessment by testing heterogeneous response of tumor biopsies to anti-cancer drugs.

## CLEO: QELS-Fundamental Science

### FTh1A • Quantum Entanglement—Continued

**FTh1A.8 • 09:45**
**Entanglement Creation by Locally Splitting a Discordant State,** Callum Croal[1], Ladislav Mista[2], Vanessa Chille[3], Christian Peuntinger[3], Christoph Marquardt[3], Gerd Leuchs[3], Natalia V. Korolkova[1]; [1]*Univ. of St Andrews, UK;* [2]*Dept. of Optics, Palacky Univ., Czech Republic;* [3]*Max Planck Inst. for the Science of Light, Germany.* We introduce and experimentally implement counter-intuitive entanglement creation by locally splitting a classical mode that is part of a larger discordant state. Possible applications are quantum advantage in information encoding and assisted dense coding.

### FTh1B • Quantum Interconnects—Continued

**FTh1B.5 • 09:45**
**Towards Coupling Rare Earth Ions to a $Y_2SiO_5$ Nanophotonic Resonator,** Tian Zhong[1], Alex Hartz[1], Evan Miyazono[1], Andrei Faraon[1]; [1]*California Inst. of Technology, USA.* An yttrium orthosilicate nanophotonic resonator is fabricated with resonances near the $4I_{9/2}$-$4F_{3/2}$ hyperfine transition of Neodymium ions. Measured absorption by Neodymium embedded in a nanobeam indicates promising prospect for coupling ions to our nano-resonator.

### FTh1C • High-Field THz Physics—Continued

**FTh1C.7 • 09:45**
**Terahertz harmonics in multi-layer graphene in the nonperturbative regime,** Michael Woerner[1], Pamela Bowlan[1], Klaus Reimann[1], Thomas Elsaesser[1]; [1]*Max Born Inst., Germany.* We report the first observation of terahertz higher harmonics in graphene by mapping the nonlinear response with broadband electrooptic sampling. The nonlinear response in the non-perturbative regime is determined by intra- and interband electron motions.

### FTh1D • Solitons and Temporal Effects—Continued

**FTh1D.8 • 09:45**
**Mode Structure and Temporal Solitons in Optical Microresonators,** Tobias Herr[1], Victor Brasch[1], John Jost[1], Ivan Mirgorodskiy[1], Martin Pfeiffer[1], Grigoriy Lihachev[2], Michael Gorodetsky[2,3], Tobias Kippenberg[1]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland;* [2]*M.V. Lomonosov Moscow State Univ., Russia;* [3]*Russian Quantum Center, Russia.* Temporal dissipative solitons in microresonators constitute a novel class of ultra-short optical pulse generators. Here we study the influence of resonator mode-structure, particularly avoided mode crossings, on soliton formation and derive resonator design criteria.

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**09:30–12:30 Technology Transfer Program,** *Exhibit Hall Theater*

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**10:00–15:00 Exhibits Open,** *Exhibit Halls 1 & 2*

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**10:00–11:30 Coffee Break** (10:00-10:30) **and Unopposed Exhibit Only Time,** *Exhibit Hall 1 & 2*

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NOTES

## CLEO: Science & Innovations

### STh1E • Filamentation—Continued

**STh1E.8 • 09:45**
**Propagation of intense femtosecond laser pulse in water and acoustic waves generation,** Aurelien Houard[1], Yohann Brelet[1], Amélie Jarnac[1], Jerome Carbonnel[1], André Mysyrowicz[1], Carles Milian[2], Arnaud Couairon[2], Regine Guillermin[3], Jean-Pierre Sessarego[3]; [1]*LOA, ENSTA-Ecole polytechnique-CNRS, France;* [2]*CPHT, Ecole Polytechnique, France;* [3]*LMA, CNRS, France.* Propagation of femtosecond pulses at 800 and 400 nm is studied in water. Acoustic signals generated with MW to TW laser power are characterized, showing a directed and broadband emission in the band 0-20 MHz.

### STh1F • THz Quantum Cascade Lasers—Continued

### STh1G • Semiconductor Lasers for Communication—Continued

### STh1H • Advanced Imaging Technologies—Continued

**STh1H.7 • 09:45**
**Coherent laser source for optical time-stretched microscopy,** Xiaoming Wei[1], Andy Lau[1], Terence Wong[2], Chi Zhang[1], Kevin Tsia[1], Kenneth Wong[1]; [1]*Dept. of Electrical and Electronic Engineering, The Univ. of Hong Kong, Hong Kong;* [2]*Dept. of Biomedical Engineering,, Washington Univ. in St. Louis, USA.* We demonstrate a coherent picosecond pulsed fiber laser for the high frame-rate optical time-stretched microscopy at 1.0 micron. Real-time flow imaging with a frame rate of 26.25 MHz is achieved based on this source.

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**09:30–12:30 Technology Transfer Program,** *Exhibit Hall Theater*

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**10:00–15:00 Exhibits Open,** *Exhibit Halls 1 & 2*

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**10:00–11:30 Coffee Break** (10:00-10:30) **and Unopposed Exhibit Only Time,** *Exhibit Hall 1 & 2*

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NOTES

## CLEO: Science & Innovations

Meeting Room
211 B/D

### STh1I • Nonlinear Optics in Waveguides and Nanophotonics Devices—Continued

**STh1I.8 • 09:45**
**Low-loss AlGaAs waveguide performance enhancement for continuous-wave four-wave mixing,** Paveen Apiratikul[1,2], Gyorgy Porkolab[1,2], Jeremiah J. Wathen[1,2], Bohan Wang[1], Thomas E. Murphy[1], Christopher J. K. Richardson[2]; [1]*Univ. of Maryland at College Park, USA;* [2]*Lab for Physical Sciences, USA.* Low-loss nonlinear AlGaAs waveguides are fabricated using plasma-assisted photoresist reflow. A 6.8-dB continuous-wave four-wave mixing conversion efficiency in a 1.35-μm-wide waveguide, and a 44-nm half-width 3-dB bandwidth in a 0.65-μm-wide waveguide are demonstrated.

Meeting Room
212 A/C

### STh1J • Structuring Materials with fs Lasers—Continued

**STh1J.5 • 09:45**
**Three-dimensional Nanostructuring in YIG Ferrite with Femtosecond Laser,** Tomo Amemiya[1], Atsushi Ishikawa[2], Yuya Shoji[3], Nam Hai Pham[4], Masaaki Tanaka[4], Tetsuya Mizumoto[3], Takuo Tanaka[2], Shigehisa Arai[1,3]; [1]*Quantum Nanoelectronics Research Center, Tokyo Inst. of Technology, Japan;* [2]*Metamaterials Lab, RIKEN, Japan;* [3]*Dept. of Electrical and Electronic Engineering, Tokyo Inst. of Technology, Japan;* [4]*Dept. of Electrical Engineering and Information Systems, The Univ. of Tokyo, Japan.* We demonstrated forming nanostructures inside a substrate of cerium-substituted yttrium iron garnet by means of direct laser writing. The laser irradiation increases a refractive index by 0.7% and changes magnetic properties from hard to soft.

Meeting Room
212 B/D

## CLEO: QELS-Fundamental Science

### FTh1K • Optomechanics and Optical Manipulation—Continued

**FTh1K.7 • 09:45**
**Shot-noise driven self-oscillations of ultra-low dissipation silicon carbide nanowires,** Pierre Verlot[1], anthony ayari[1], Alessandro Siria[1], Sorin Perisanu[1], Pascal Vincent[1], Philippe Poncharal[1], Stephen Purcell[1]; [1]*Université Lyon 1, France.* We report ultra-low threshold optically induced self-oscillations of a ultra-low dissipation nanowire. We interpret the asymmetrically observed responses as a signature of the laser shot noise drive, consistent with our system's parameters.

Marriott
Salon I & II

## JOINT

### JTh1L • Symposium on Laser-Driven Sources of Particle and X-Ray Beams I—Continued

**JTh1L.6 • 09:45** ▶
**A quasi-directional emission of MeV neutrals from a dense cluster nano plasma,** Krishnamurthy Manchikanti[1]; [1]*Tata Inst. of Fundamental Research, India.* Nanoclusters are strongly ionised at 1016 Wcm-2 to generate even MeV ions. In a dense cluster ensemble a near 100% charge reduction of the ions to form fast neutrals is demonstrated. Neutrals atom emission is quasi-directional and neutralisation is more effective along the laser polarization.

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**09:30–12:30 Technology Transfer Program,** *Exhibit Hall Theater*

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**10:00–15:00 Exhibits Open,** *Exhibit Halls 1 & 2*

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**10:00–11:30 Coffee Break** (10:00-10:30) **and Unopposed Exhibit Only Time,** *Exhibit Hall 1 & 2*

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NOTES

Marriott
Salon III

## CLEO: Science & Innovations

### STh1M • Modulators using Novel Materials—Continued

**STh1M.8 • 09:45** ▶
**Fast and Slow Optical Modulation of Refractive Index in a SiN Microring,** Jian Wang[1], Yi Xuan[1], Andrew M. Weiner[1], Minghao Qi[1]; [1]*Purdue Univ., USA.* We retrieve the thermal dissipation time of $\tau\theta$=0.25μs and investigate the power dependent absorption in a SiN microring resonator. We estimate n2=4.3×10-19m2/W based on clear 1 GHz optical modulation of the refractive index.

Marriott
Salon V & VI

## CLEO: Science & Innovations

### STh1N • Comb Spectroscopy—Continued

**STh1N.8 • 09:45** ▶
**Low-Pressure Gas Spectroscopy Using Terahertz Frequency Synthesizer Traceable to Microwave Frequency Standard via Dual Optical Combs,** Yi-Da Hsieh[1,2], Hiroto Kimura[1], Hajime Inaba[3,4], Kaoru Minoshima[4,5], Tsutomu Araki[2], Takeshi Yasui[1,4]; [1]*The Univ. of Tokushima, Japan;* [2]*Osaka Univ., Japan;* [3]*National Inst. of Advanced Industrial Science and Technology, Japan;* [4]*ERATO Intelligent Optical Synthesizer Project, Japan;* [5]*The Univ. of Electro-Communications, Japan.* An accurate, continuously tunable, terahertz synthesizer was proposed by photomixing of two continuous-wave lasers phase-locked to dual optical combs. This synthesizer enables us to perform the precise THz spectroscopy secured by microwave frequency standard.

Marriott
Willow Glen I-III

## CLEO: Applications & Technology

### ATh1O • OCT-Technology Development & Clinical Applications—Continued

**ATh1O.7 • 09:45** ▶
**A high power directly diode pumped Ti:sapphire laser with synchronized Yb-fiber amplifier for nonlinear optical microscopy and optical coherence tomography,** Aart J. Verhoef[1], Alma Fernandez[1], Tschackad Kamali[2], Anders K. Hansen[3], Ole B. Jensen[3], Peter E. Andersen[3], Bernd Sumpf[4], Götz Erbert[4], Peter M. Petersen[3], Andrius Baltuska[1], Wolfgang Drexler[2], Angelika Unterhuber[2]; [1]*Vienna Univ. of Technology, Austria;* [2]*Medical Univ. Vienna, Austria;* [3]*Technical Univ. of Denmark, Denmark;* [4]*Ferdinand-Braun-Institut, Germany.* A simple scheme of a compact femtosecond Ti:sapphire laser with synchronized Yb-fiber amplifier pumped by a powerful single tapered diode laser implemented in a combined coherent Anti-Stokes Raman and optical coherence tomography platform is presented.

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**09:30–12:30** **Technology Transfer Program,** *Exhibit Hall Theater*

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**10:00–15:00** **Exhibits Open,** *Exhibit Halls 1 & 2*

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**10:00–11:30** **Coffee Break** (10:00-10:30) **and Unopposed Exhibit Only Time,** *Exhibit Hall 1 & 2*

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NOTES

## Exhibit Hall 3

## 11:30– 13:00
## JTh2A • Poster Session 3

**JTh2A.1**

**Short Circuit Current Improvement of Si HIT Solar Cell by Optimal and "Chess Board" Like 1-D Light Trapping Periodical Grating Structure,** Ming-Lun Lee[1], Chun Nien[1], Shih-Hung Lin[2], Hung-Chou Lin[1], Yao-Hong You[1], Vin-Cent Su[1], Po-Hsun Chen[1], Han-Bo Yang[1], Yen-Pu Chen[1], Shen-Han Tsai[1], Chieh-Hsiung Kuan[1]; *[1]Graduate Inst. of Electronics Engineering, National Taiwan Univ., Taiwan; [2]Dept. of Biomedical Engineering, HungKuang Univ., Taiwan.* We experimentally report that the novel "chess board" like 1-D grating structure with optimal period of 800 nm can dramatically increases the JSC from 33.7 mA/cm2 to 38.9 mA/cm2 compared to the reference solar cell.

**JTh2A.2**

**Enhancement on Photovoltaic Properties of Boron-doped Super-high Density Si Quantum Dot Thin Film,** Pin-Ruei Huang[1], You-Jeng Chen[1], Jia-Ruei Chang[1], Kuang-Yang Kuo[1], Po-Tsung Lee[1]; *[1]Dept. of Photonics & Inst. of Electro-Optical Engineering, National Chiao Tung Univ., Taiwan.* Boron-doped super-high density nano-crystalline Si quantum dot thin film is demonstrated by utilizing a gradient Si-rich oxide multilayer structure. The boron doping effect and its significant influence on photovoltaic properties are observed and discussed.

**JTh2A.3**

**Crystal Equivalent Temperature Concept for Laser Calorimetry and Nonlinear Optics,** Aleksey Konyashkin[1,2], Oleg A. Ryabushkin[1,2], Ivan S. Ulyanov[1,2]; *[1]NTO IRE-Polus, Russia; [2]Moscow Inst. of Physics and Technology, Russia.* Concept of equivalent temperature is proposed for temperature measurement of crystals in laser calorimetry and nonlinear optics experiments. Determination of equivalent temperature is based on frequency shift measurement of temperature calibrated acoustic resonance, excited in sample.

**JTh2A.4**

**Dispersion Measurement and Compensation using Optical Frequency Comb,** Mitsutaka Ito[1], Takayuki Miyamoto[1], Masaichi Nakamura[2], Toshiaki Yamazaki[2], Tatsutoshi Shioda[1]; *[1]Electrical and Electric Systems, Saitama Univ., Japan; [2]Electrical Engineering, Nagaoka Univ. of Technology, Japan.* A dispersion spectrum in a 3.2 Tbit/s waveform generation was controlled / compensated by a 200 GHz optical frequency comb synthesizer and optical frequency comb analyzer simultaneously.

**JTh2A.5**

**Detecting micro-particles of explosives at ten meters using selective stimulated Raman scattering,** Marshall T. Bremer[1], Marcos Dantus[1,2]; *[1]Dept. of Physics and Astronomy, Michigan State Univ., USA; [2]Dept. of Chemistry, Michigan State Univ., USA.* We demonstrate standoff detection using stimulated Raman scattering (SRS), simultaneously measuring stimulated Raman gain (SRG) and loss (SRL) within a single laser shot, and detect nanogram quantities of explosives using a 10mW femtosecond laser.

**JTh2A.6**

**Rapid scanning cavity ring-down spectroscopy at the quantum noise limit,** David Long[1], Adam J. Fleisher[1], Szymon Wojtewicz[1], David F. Plusquellic[2], Joseph T. Hodges[1]; *[1]Material Measurement Lab, NIST, USA; [2]Physical Measurement Lab, National Inst. of Standards and Technology, USA.* We present an ultrasensitive cavity-enhanced technique for probing weak molecular absorptions. Recently, we have implemented heterodyne detection, which allowed for quantum-noise-limited detection and noise-equivalent absorption coefficients as low as 6×10-14 cm-1Hz-1/2.

**JTh2A.7**

**Photonics-Assisted Millimeter-Wave Phase Detector for Femto-Second Fiber Delay Variation Sensing,** Qizhuang Cen[1], Feifei Yin[1], Yitang Dai[1], Jianqiang Li[1], Kun Xu[1]; *[1]Beijing Univ. of Posts and Telecommunications, China.* A novel technique to improve the fiber delay variation sensing precision by a photonics-assisted millimeter-wave phase detector is proposed and demonstrated experimentally. The capacity for sensing link delay jitter of sub-10 femtoseconds is achieved.

**JTh2A.8**

**Fiber Strain Sensor using Spectral Linewidth of FBG Reflection through Optical Filter,** Shih-Hsiang Hsu[1], Yung-Chia Yang[1]; *[1]National Taiwan Univ of Science & Tech, Taiwan.* The FBG reflective spectrum was coupled to a optical filter for linewidth monitoring in strain sensing applications. The sensitivity was typically demonstrated as 48-MHz/με and the strain sensing limitation could achieve ~nε with kHz narrow resolution bandwidth.

**JTh2A.9**

**Nonlinear Fluorescence Spectra Unmixing,** Hayato Ikoma[1], Barmak Heshmat[1], Gordon Wetzstein[1], Ramesh Raskar[1]; *[1]Media Lab, MIT, USA.* We have developed a nonlinear spectral unmixing algorithm that separates fluorescence excitation-emission matrix of multiple fluorophores affected by the inner filter effect. We evaluate this technique on simulated data and demonstrate its superior performance experimentally.

**JTh2A.10**

**Open Path Chirped Laser Dispersion Spectroscopy of Methane Plume,** Nart S. Daghestani[1], Richard Brownsword[1], Damien Weidmann[1]; *[1]Science and Technology Dept., Rutherford Appleton Lab, UK.* A molecular detection method based on laser dispersion spectroscopy has been implemented to detect methane concentrations with an open-path configuration and using transitions from the v4 band. Preliminary results on transient seeps are presented.

**JTh2A.11**

**Analysis of 50 Gbaud homodyne coherent receivers relying on line-coding and injection locking in lasers,** Adonis Bogris[1], Constantinos Ressopoulos[1]; *[1]Technological Educational Inst of Athens, Greece.* We present a numerical analysis of 50 Gbaud coherent detection enabled by injection locked lasers and line coding. The impact of the slave laser properties and line coding techniques on the receiver performance is highlighted.

**JTh2A.12**

**Modified CMA Based Blind Carrier-Phase Estimation for 16-QAM Homodyne Digital Coherent Optical Receivers,** Md Ibrahim Khalil[1], Arshad M. Chowdhury[1,2], Gee-Kung Chang[2]; *[1]Dept. of Electrical Engineering and Computer Science, North South Univ., Bangladesh; [2]School of Electrical and computer Engineering, Georgia Inst. of Technology, USA.* We propose modified CMA based blind carrier-phase-estimation methods for 16-QAM homodyne digital coherent optical receivers. Through computer simulation we found proposed scheme has less hardware requirements and comparable performance to decision-directed carrier-recovery algorithms.

**JTh2A.13**

**Passive Digital Algorithmic Stabilization of Optical Phase,** Joseph Touch[1], Morteza Ziyadi[2], Amine Abouzaid[2], Mohammed Chitgarha[2], Salman Khaleghi[2], Amirhossein Mohajerin-Ariaei[2], Youichi Akasaka[3], Jeng-yuan Yang[3], Motoyoshi Sekiya[3]; *[1]Information Sciences Inst., Univ. of Southern California, USA; [2]Electrical Engineering, Univ. of Southern California, USA; [3]Fujitsu Labs of America, USA.* The coherent signal processing of nonlinear wave mixing often creates interferometers that require feedback stabilization. A digital electronic optical phase stabilizer is described that avoids injecting pilot control signals and supports long-duration BER measurements.

**JTh2A.14**

**SSBI Cancellation Based on Time Diversity Reception in SSB-DD-OOFDM Transmission Systems,** Hu Shi[1], Pengfei Yang[1], Cheng Ju[1], Xue Chen[1], Jinsong Bei[2], Rongqing Hui[3]; *[1]Beijing Univ. of Posts and Telecommunications, China; [2]ZTE Corporation, China; [3]Univ. of Kansas, USA.* A novel SSBI cancellation scheme based on time diversity reception is proposed. Experiment shows that the proposed scheme improves ~3.6dB sensitivity compared with baseband optical OFDM scheme in a 5-Gbps SSB-DD-OOFDM system over 100-km SMF.

**JTh2A.15**

**Real-time Demonstration of 3 × 10 Gb/s Uncooled MIMO DWDM System with Adaptive Laser Bias Control,** Jiannan Zhu[1], Jonathan D. Ingham[1], Adrian Wonfor[1], Richard V. Penty[1], Ian H. White[1]; *[1]Unversity of Cambridge, UK.* We demonstrate a 3×10Gb/s uncooled MIMO DWDM system using uncooled DFB lasers with real-time crosstalk cancellation, allowing separate lasers to operate on different temperatures. Adaptive laser bias control is applied to ensure adequate channel separation.

**JTh2A.16**

**Channel-spacing tunable multiwavelength erbium-doped fiber laser based on a microfiber Fabry-Perot filter,** Weihua Jia[1], Qizhen Sun[1], Zhilin Xu[1], Xiaohui Sun[1], Deming Liu[1]; *[1]School of Optical and Electronic Information, National Engineering Lab for Next Generation Internet Access System, Huazhong Univ. of Science and Technology, China.* A tunable multiwavelength fiber laser incorporating a microfiber Fabry-Perot filter with wideband and high extinction ratio is proposed and demonstrated. By adjusting the cavity length of the filter, the channel-spacing can be continuously tuned.

**JTh2A.17**

**Boundaries of Parametric Gain due to Four-wave Mixing in Hybrid Photonic Crystal Fibers,** Sidsel R. Petersen[1], Jesper Lægsgaard[1], Thomas T. Alkeskjold[2]; *[1]DTU Fotonik, Technical Univ. of Denmark, Denmark; [2]NKT Photonics A/S, Denmark.* Parametric gain by four-wave mixing is considered in photonic crystal fibers for an undepleted pump. The mode distributions are wavelength dependent, thus field overlap integrals cannot be simplified, and an extended gain region is observed.

**JTh2A.18**

**Spectra of Raman Scattering in Micro/nano-fibers,** Liang Cui[1], Cheng Guo[1], Xiaoying Li[1], Yu Hang Li[2], Zhong Yang Xu[2], Lijun Wang[2], Wei Fang[3]; *[1]Tianjin Univ., China; [2]Tsinghua Univ., China; [3]Zhejiang Univ., China.* We experimentally demonstrate the spectra of Raman scattering in micro/nano-fibers, which is different from that of traditional optical fibers, not only depends on their diameters, but also depends on their fabricating methods.

**JTh2A.19**

**Coherent combining of SHG converters,** Anne Durécu[1], Guillaume Canat[1], Julien Le Gouët[1], Laurent Lombard[1], Pierre Bourdon[1]; *[1]Onera, France.* Coherent combining of frequency doubled beams at 532 nm is demonstrated. Active phase control of the 1064-nm fundamental waves enables high efficiency combining of the second harmonic beams with λ/30 residual phase error.

**JTh2A.20**

**Polarization multiplexed, dual-frequency ultrashort pulse generation by a birefringent mode-locked fiber laser,** Zheng Gong[1], Xin Zhao[1], Guoqing Hu[1], Jiansheng Liu[1], Zheng Zheng[1]; *[1]School of Electronic and Information Engineering, Beihang Univ., China.* Two orthogonally polarized soliton pulse trains with different repetition rates are stably generated from a passively mode-locked fiber ring cavity with a section of polarization maintaining fiber. The frequency difference can be varied as well.

## JTh2A • Poster Session 3—Continued

**JTh2A.21**
**Highly-efficient Mid-IR Supercontinuum Generation in ZBLAN Fiber Pumped by Thulium-doped Fiber Amplifier,** Jiang Liu[1], Kun Liu[1], Hongxing Shi[1], Fangzhou Tan[1], Yijian Jiang[1], Pu Wang[1]; [1]*Beijing Univ. of Technology, China.* Mid-infrared supercontinuum of 8.1 W with optical-to-optical conversion efficiency of ~76% with respect to the launched pump power at 2 μm wavelength was demonstrated in a ZBLAN fiber pumped by a thulium-doped all-fiber amplifier.

**JTh2A.22**
**Tm-doped Rod-type Photonic Crystal Fibers with Symmetry-Free Cladding,** Enrico Coscelli[1], Carlo Molardi[1], Federica Poli[1], Annamaria Cucinotta[1], Stefano Selleri[1]; [1]*Information Engineering Dept., Universita degli Studi di Parma, Italy.* A new design approach for large mode area Tm-doped photonic crystal fibers, based on the reduction of cladding symmetry, is numerically analyzed to demonstrate the possibility to obtain robust single-mode guiding under severe heat load.

**JTh2A.23**
**Efficient regenerative self-pulsating sources,** Thibault North[1], Martin Rochette[1]; [1]*Electrical and Computer Engineering, McGill Univ., Canada.* We present an improved design of regenerative self-pulsating sources including large filter bandwidths. Pico- and sub-picosecond pulses of energies 20x higher than previously reported are observed in a setup increasing the source efficiency.

**JTh2A.24**
**Line-Plane-Switching Infrared Fiber Imaging Bundle,** huan zhan[1,2], Xingtao Yan[1,2], Zhang Aidong[1], Fu Li[1], Jianfen Yang[1], Aoxiang Lin[1]; [1]*State Key Lab of Transient Optics and Photonics, Xi'an Inst. of Optics and Precision Mechanics, China;* [2]*Graduate School of Chinese Academy of Sciences, China.* Using line-plane-switching infrared fiber imaging bundle made from As2S3 glass fibers with core of 40 μm, clad of 45 μm, and error of 1% in diameter, we demonstrated push-broom infrared sensing imaging.

**JTh2A.25**
**Packet-Based All Optical Wavelength Conversion Using Saw-Tooth Pulse Generated by Optical Pulse Synthesizer,** Ken Kashiwagi[1]; [1]*Tokyo Univ of Agriculture and Technology, Japan.* Packet-based wavelength conversion is demonstrated in cross phase modulation scheme using a saw-tooth pulse generated by an optical pulse synthesizer. Two different patterns of packets with 800 ps guard time were separated in small cross-talk.

**JTh2A.26**
**Polarization Attractors in Harmonic Mode-Locked Fiber Laser With Carbon Nanotubes,** Tatiana Habruseva[1], Sergey Sergeyev[1], Sergei K. Turitsyn[1]; [1]*Aston Univ., UK.* We study polarization dynamics of a harmonic mode-locked erbium-doped fiber laser with carbon nanotubes absorber. New types of vector solitons are shown for multi-pulse and harmonic mode-locked operation with locked, switching and precessing polarization states.

**JTh2A.27**
**Monitoring the frequency detune of harmonically mode-locked Fourier domain mode locked fiber laser using the supermode noise peaks,** Feng Li[1], Aiqin Zhang[2], Xinhuan Feng[2], Ping Kong Alexander Wai[1]; [1]*Dept. of Electronic and Information engineering, The Hong Kong Polytechnic Univ., Hong Kong;* [2]*Inst. of Photonics Technology, Jinan Univ., China.* The intensity of supermode noise peaks of a harmonically mode-locked Fourier domain mode-locked fiber laser will drop significantly with the increase of frequency detune, which can be used to monitor the laser output quality.

**JTh2A.28**
**Active mode-locking and CW regimes operating simultaneously in an Erbium doped fiber laser,** Cláudia B. Santos[1], Farshad Yazdani[2,1], Eunézio A. Sousa[1]; [1]*MackGraphe, Mackenzie Presbiterian Univ., Brazil;* [2]*Eletric Engineering Dept., Universidade Federal de Sergipe, Brazil.* We demonstrated an Erbium-doped fiber laser operating simultaneously in two distinct regimes, CW and active mode-locking at 1.8 GHz with pulses of 38 ps. The lasers wavelengths can be tuned in both regimes.

**JTh2A.29**
**Effective Delivery of Analytes with Optofluidics for Ultrasensitive Biodetection,** Min Huang[1], Betty C. Galarreta[1], Arif E. Cetin[1,2], Hatice Altug[2,1]; [1]*Electrical and Computer Engineering, Boston Univ., USA;* [2]*Bioengineering Dept., EPFL, Switzerland.* We present a plasmonic nanobiosensor offering superior analyte delivery efficiency. Our experiments with virus-like analytes show more than an order of magnitude faster response time, and seven orders-of-magnitude dynamic concentration range for 103-109 particles/mL.

**JTh2A.30**
**Group Delay Compensation of Spectrally-Filtered Picosecond Pulses for Stimulated Raman Microscopy,** Yasuyuki Ozeki[1], Keisuke Nose[2], Kyoya Tokunaga[1]; [1]*The Univ. of Tokyo, Japan;* [2]*Osaka Univ., Japan.* Wavelength-tunable pulses with a constant group delay are successfully generated through spectral filtering of broadband pulses in a modified 4-f configuration. This technique effectively improves the reproducibility of spectral data in stimulated Raman spectral microscopy.

**JTh2A.31**
**Development of a CMOS compatible biophotonics platform based on SiN nanophotonic waveguides,** Pieter Neutens[1,2], Tom Claes[1], Roelof Jansen[1], Ananth Subramanian[3], Mahmud UlHasan[1], Veronique Rochus[1], Finub James Shirley[1], Bert Du bois[1], Philippe Helin[1], Simone Severi[3], Kenny Leyssens[3], Ashim Dhakal[3], Frédéric Peyskens[1], Shankar Selvaraja[3], Paru Deshpande[1,2], Roel Baets[1], Liesbet Lagae[1,2], Xavier Rottenberg[1], Pol Van Dorpe[1]; [1]*imec, Belgium;* [2]*Dept. of Physics, KU Leuven, Belgium;* [3]*Photonics Research Group, Ghent Univ., Belgium.* We report on the development of low-loss photonic components fabricated in SiN for the development of a biophotonics platform. We discuss experimental demonstration of strip waveguides, MMI and evanescent couplers, fractal trees, AWGs and waveguide-integrated resonators.

**JTh2A.32**
**Optical Tweezers with Tunable Orbital Angular Momentum,** Mindaugas Gecevičius[1], Rokas Drevinskas[1], Martynas Beresna[1], Peter G. Kazansky[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK.* We demonstrate a method of optical vortices generation with continuous orbital angular momentum control. The beam generated with an S-waveplate is used as an optical spanner where the rotation speed of trapped particles can be controlled.

**JTh2A.33**
**Biological lasing in liquid microdroplets deposited on a superhydrophobic surface,** Alexandr Jonas[1], Mehdi Aas[2], Yasin Karadag[2], Halil Bayraktar[3], Suman Anand[4], David McGloin[4], Alper Kiraz[2]; [1]*Dept. of Physics, Istanbul Technical Univ., Turkey;* [2]*Dept. of Physics, Koç Univ., Turkey;* [3]*Dept. of Chemistry, Koç Univ., Turkey;* [4]*Electronic Engineering and Physics Division, Univ. of Dundee, UK.* We demonstrate lasing in water/glycerol microdroplets which stand on a superhydrophobic surface and contain purified Venus variant of the yellow fluorescent protein or dilute suspensions of E. Coli bacterial cells expressing stably the Venus protein.

**JTh2A.34**
**Withdrawn**

**JTh2A.35**
**Design and Fabrication of Hybrid SPP Waveguides for Ultrahigh-Bandwidth Low-Penalty 1.8-Tbit/s Data Transmission (161 WDM 11.2-Gbit/s OFDM 16-QAM),** Jing Du[1], Chengcheng Gui[1], Chao Li[2], Qi Yang[2], Jian Wang[1]; [1]*Huazhong Univ. of Sci. and Tech., China;* [2]*State Key Lab of Optical Comm. Technologies and Networks, China.* We design and fabricate a vertical hybrid SPP waveguide. The suitability of ultrahigh-bandwidth data transmission through the proposed waveguide by transmitting 1.8-Tbit/s (161 wavelength 11.2-Gbit/s) WDM OFDM 16-QAM is studied.

**JTh2A.36**
**High power, narrow linewidth, micro-integrated semiconductor laser modules designed for quantum sensors in space,** Anja Kohfeldt[1], Ahmad Bawamia[1], Christian Kuerbis[1], Erdenetsetseg Luvsandamdin[1], Max Schiemangk[1,2], Andreas Wicht[1,2], Götz Erbert[1], Achim Peters[1,2], Günther Tränkle[1]; [1]*Ferdinand-Braun-Institut, Leibniz-Institut fuer Hoechstfrequenztechnik, Germany;* [2]*Humboldt-Universitaet zu Berlin, Germany.* We developed a very robust diode laser module platform for the deployment of cold atom based quantum sensors in space. The micro optical benches, not larger than 80 x 25 mm^2, host MOPA and EDCL modules.

**JTh2A.37**
**Generation of Tunable Optical Frequency Combs with a High Side Mode Suppression Ratio,** Shihu Zhang[1], Juanjuan Yan[1], Zhenya Xia[1], Xiayuan Yao[1], Ming Bai[1], Zheng Zheng[1], Zheng Zheng[1]; [1]*Beihang Univeristy, China.* We demonstrate a new scheme of generating optical frequency combs (OFC) utilizing a single dual parallel Mach-Zehnder modulator. Gaussian-shaped OFC and flat OFC with a tunable spacing, flexible line-number and high side mode suppression ratio are generated.

**JTh2A.38**
**Time-Bandwidth Product Expansion of Microwave Waveforms Using Anamorphic Stretch Transform,** Jianping Yao[1], Jiejun Zhang[1], Mohammad H. Asghari[2], Bahram Jalali[2]; [1]*Univ. of Ottawa, Canada;* [2]*ECE, UCLA, USA.* We show for the first time that a chirped fiber Bragg grating with specially engineered nonlinear group delay profile can be used to significantly increase the time-bandwidth product of a microwave waveform.

**JTh2A.39**
**A Phase Coherent Near-Octave-Spanning Zero-Offset Composite Frequency Comb,** Richard A. McCracken[1], Karolis Balskus[1], Derryck T. Reid[1]; [1]*Heriot Watt Univ., UK.* Using a zero-offset carrier-envelope locking technique, we have demonstrated that multiple pulse sequences of different colors from a femtosecond optical parametric oscillator can be coherently combined to synthesize a near-octave-spanning composite frequency comb.

**JTh2A.40**
**Pulse train based generation of tunable THz comb,** Chao Tian[1], Tao Yang[1]; [1]*Stevens Inst. of Technology, USA.* We present a simple and novel scheme to generate a tunable THz frequency comb using a multi pulse excitation scheme, as well as a comb-like filter in the detection process.

**JTh2A.41**
**Generating ultra-long bound soliton sequences from a mode-locked fiber laser through intracavity spectral shaping,** Ya Liu[1], Xin Zhao[1], Jiansheng Liu[1], Guoqing Hu[1], Zheng Gong[1], Zheng Zheng[1]; [1]*School of Electronic and Information Engineering, Beihang Univ., China.* Extremely long states of bound solitons consisting of up to eleven solitons have been generated from a carbon nanotube passively mode-locked fiber laser with an intracavity pulse shaper.

**JTh2A.42**
**Demonstration and Fabrication of Electro-Optic CaxBa1-xNb2O6 (CBN) Thin-Film Based Rib Waveguide Structure,** Faezeh Fesharaki[1], Nadir Hossain[2], Sebastien Vigne[2], Joelle Margot[3], Ke Wu[1], Mohamed Chaker[2]; [1]*PolyGrames Research Center, Ecole Polytechnique of Montreal, Canada;* [2]*INRS-EMT, Canada;* [3]*Departement de Physique, Universite de Montreal, Canada.* We report on the design, simulation and experimental demonstration of an electro-optic SiO2-CBN-MgO rib waveguide structure. The fabricated waveguides are characterized and results are compared with simulation, where a good agreement validates our design approach.

**JTh2A.43**
**Locating fluorescence lifetimes behind turbid layers non-invasively using sparse, time-resolved inversion,** Guy Satat[1], Christopher Barsi[1], Barmak Heshmat[1], Dan Raviv[1], Ramesh Raskar[1]; [1]*MIT, USA.* We use time-resolved sensing and sparsity-based dictionary learning to recover the locations and lifetimes of fluorescent tags hidden behind a turbid layer. We experimentally demonstrate non-invasive target classification via fluorescence lifetimes.

# JTh2A • Poster Session 3—Continued

**JTh2A.44**

**Ultrabroadband Coherent Infrared Spectroscopy Using Air-Plasma Based Generation and Detection,** Eiichi Matsubara[1], Masaya Nagai[1], Masaaki Ashida[1]; [1]*Osaka Univ., Japan.* We generated ultrabroadband coherent infrared pulses by focusing using hollow-fiber compressed intense 10-fs pulses in air. We also coherently detected the electric-field profiles through the field induced second harmonic generation in air.

**JTh2A.45**

**Serial time-encoded amplified microscopy (STEAM) by fully incoherent noise,** Chi Zhang[1], Yiqing Xu[1], Xiaoming Wei[1], Kevin Tsia[1], Kenneth Wong[1]; [1]*Electrical and Electronic Engineering, Univ. of Hong Kong, Hong Kong.* By introducing a time-lens in the serial time-encoded amplified microscopy (STEAM), its input temporal aperture is greatly enlarged. Therefore, the light source with arbitrary waveform can be applied, especially the amplified spontaneous emission noise.

**JTh2A.46**

**Enhanced mid-to-near-infrared second harmonic generation in silicon-organic hybrid plasmonic microring resonators,** Jihua Zhang[1,2], Eric Cassan[2], Xinliang Zhang[1]; [1]*Wuhan National Lab for Optoelectonics & School of Optical and Electronic Information, Huazhong Univ of Science and Technology, China;* [2]*Institut d'Electronique Fondamentale, Université Paris-Sud, France.* We propose an enhanced mid-to-near-infrared second harmonic generation (SHG) process relying on a silicon plasmonic microring resonator. The SHG efficiency is enhanced by two orders of magnitude compared to previous results.

**JTh2A.47**

**Optomechanical Response Spectrum of a Tapered Fiber Coupled Microsphere Pendulum,** Yong Yang[1], Ramgopal Madugani[1], Jonathan Ward[1], Sile Nic Chormaic[1]; [1]*Light-Matter Interactions Unit, OIST Graduate Univ., Japan.* We study the noise spectrum arising from absorptive and dispersive modulations to the motion of a micropendulum via transmission through the coupling tapered fiber. The observed asymmetrical line shape matches theoretical predictions.

**JTh2A.48**

**Optimal laser cooling limits in the strong coupled cavity optomechanics,** Yong-Chun Liu[1], Yu-Feng Shen[1], Qihuang Gong[1], Yun-Feng Xiao[1]; [1]*Physics, Peking Univ., China.* In the strong coupled cavity optomechanics, we find the island structure in the temporal evolution map of mean phonon number. Analytical results are provided to obtain the optimal cooling limits with the frequency matching condition.

**JTh2A.49**

**Fast and accurate calculation of Q factor of 2D photonic crystal cavity,** Akihiro Fushimi[1,2], Hideaki Taniyama[2], Eiichi Kuramochi[2], Masaya Notomi[2], Takasumi Tanabe[1]; [1]*Keio Univ., Japan;* [2]*NTT Basic Research Labs, Japan.* We developed a method for calculating the Q-factor of a 2D photonic crystal nanocavity directly from the in-plane wavevector distribution of the cavity mode. A high-Q of >10^7 was obtained with high accuracy and speed.

**JTh2A.50**

**Generations of vector beams in photonic crystal cavities,** Xuetao Gan[1]; [1]*Northwestern Polytechnic Univ., China.* We propose the generation of vector beams in planar photonic crystal cavities with multiple missing-hole defects. The characters of the generated vector beams are analyzed from the intensity, phase and polarization distributions.

**JTh2A.51**

**Photothermal Tuning and Spatial Mapping of Toroidal Optical Microcavities,** Kevin Heylman[1], Randall H. Goldsmith[1]; [1]*Univ. Wisconsin, Madison, Chemistry, USA.* A new method for controlling resonance wavelengths of ultrahigh-Q toroidal optical microcavities using a focused free-space laser is presented. Tuning range, rate, and spatial dependence is investigated.

**JTh2A.52**

**Inverted-wedge silica resonators for controlled and stable coupling,** Fang Bo[1,2], Steven H. Huang[1], Sahin Ozdemir[1], Guoquan Zhang[2], Jingjun Xu[2], Lan Yang[1]; [1]*Electrical and Systems Engineering, Washington Univ. in St. Louis, USA;* [2]*The MOE Key Lab of Weak Light Nonlinear Photonics, TEDA Applied Physics Inst. and School of Physics, Nankai Univ., China.* Inverted-wedge silica resonators with Q>1e6 were fabricated using conventional semiconductor methods. Robust and large-extent controllable coupling was demonstrated by horizontally moving a fiber taper on the top surface of the resonator.

**JTh2A.53**

**Field Envelope of High Contrast Gratings with Finite Length,** Hanxing Zhang[1], Chao Peng[1], Weiwei Hu[1]; [1]*Peking Univ., China.* The complex band structure of HCG is solved with revised couple wave theory. Further, we analytically solved the field envelope for the HCG with finite length and investigate the impact on modes' Q factors.

**JTh2A.54**

**Mid-IR flat lens based on parallelogram antennas,** Xia Yu[1]; [1]*SIMTech, Singapore.* By engineering parallelogram antenna on ZnSe substrate, we can control the wavefront of laser beam and design a flat lens at 10µm. The fabricated flat lens has demonstrated focusing effect matching well with simulation.

**JTh2A.55**

**Strong Optomechanical Coupling in a Nanobeam Cavity based on Hetero Optomechanical Crystals,** Zhilei Huang[1], Kaiyu Cui[1], Yongzhuo Li[1], Xue Feng[1], Yidong Huang[1], Fang Liu[1], Wei Zhang[1]; [1]*Electronic Engineering, Tsinghua Univ., China.* A hetero optomechanical crystal nanobeam cavity with high mechanical frequency of 5.88 GHz is proposed. By enhancing the overlap between optical and strain field, an optomechanical coupling rate as high as 1.31 MHz is achieved.

**JTh2A.56**

**Femtosecond-laser Inscribed, Tunable, Waveguide Embedded Bragg Gratings in Lithium Niobate,** Sebastian Kroesen[1], Wolfgang Horn[1], Jörg Imbrock[1], Cornelia Denz[1]; [1]*Inst. of Applied Physics, Univ. of Muenster, Germany.* We demonstrate electro-optical tunable Bragg gratings embedded into complex two-dimensional waveguides in lithium niobate by femtosecond direct laser writing. The structures support both, ordinary and extraordinary guiding and narrowband reflections around $\lambda = 1.55$ µm.

**JTh2A.57**

**Single-Mode GeSn Mid-Infrared Waveguides on Group-IV Substrates,** Xiaodong Yang[1], Fei Cheng[1], Richard Soref[2]; [1]*Dept. of Mechanical and Aerospace Engineering, Missouri Univ. of Science and Technology, USA;* [2]*The Engineering Program, Unviersity of Massachusetts at Boston, USA.* We design low-loss single-mode GeSn mid-infrared waveguides on group-IV substrates including Si substrates and Ge-on-SOI substrates. The waveguide geometries under single mode condition are optimized for different GeSn alloy compositions and polarizations.

**JTh2A.58**

**Large enhancement in photoluminescence of ZnO grown on strain relaxed nanoporous GaN template by pulsed laser deposition,** Jie Tang[1,2], Liyuan Deng[1], Jian Huang[1], Peiyuan Seetoh[1,3], Kwadwo Konadu Ansah-Antwi[1,4], Venky Venkatesan[1,2], Soo Jin Chua[1,2]; [1]*National Univ. of Singapore, Singapore;* [2]*National Univ. of Singapore, Singapore;* [3]*3 Singapore-MIT Alliance, National Univ. of Singapore, Singapore;* [4]*Inst. of Materials and Research Engineering, Agency for Science, Technology and Research, Singapore.* ZnO thin film was grown over nanoporous GaN by PLD. Up to 8-fold PL intensity enhancement has been achieved. This is attributed to relieved misfit stress and reduced defect density.

**JTh2A.59**

**Enhanced spontaneous emission by embedding light emitters inside hyperbolic metamaterials,** Lorenzo Ferrari[1], Dylan Lu[2], Dominic Lepage[2], Zhaowei Liu[2,1]; [1]*Materials Science and Engineering, Univ. of California, San Diego, USA;* [2]*Electrical and Computer Engineering, Univ. of California, San Diego, USA.* The inclusion of an emitter inside a Ag/Si multilayer yields a 3-fold enhancement of the Purcell factor over its outer value. The radiation is outcoupled to the far-field via a triangular and a rectangular grating.

**JTh2A.60**

**Low phonon energy fluorozirconate-based glass ceramics for efficient rare-earth luminescence,** Charlotte Pfau[1], Ulrich Skrzypczak[1], Manuela Miclea[1], Gerhard Seifert[1,2], Bernd Ahrens[3,4], Stefan Schweizer[3,4]; [1]*Centre for Innovation Competence SiLi-nano, Martin Luther Univ. of Halle-Wittenberg, Germany;* [2]*Fraunhofer Center for Silicon Photovoltaics CSP, Germany;* [3]*Dept. of Electrical Engineering, South Westphalia Univ. of Applied Sciences, Germany;* [4]*Fraunhofer Institut for Mechanics of Materials IWM, Germany.* Fluorozirconate-based, highly transparent glass ceramics doped with Nd3+ exhibit very low multiphonon relaxation rates following an exponential energy gap dependence. The resulting high radiative quantum efficiencies show the material's potential for amplifier applications.

**JTh2A.61**

**Rectangular-shaped sub-wavelength terahertz beam profiling via an all-optical knife-edge technique,** Sze Phing Ho[1,2], Anna Mazhorova[1], Mostafa Shalaby[1], Marco Peccianti[3], Matteo Clerici[1,4], Alessia Pasquazi[1], Yavuz Ozturk[1,5], Jalil Ali[2], Roberto Morandotti[1]; [1]*INRS-EMT, Univ. of Quebec, Canada;* [2]*Nanophotonics Research Alliance, Universiti Teknologi Malaysia, Malaysia;* [3]*Inst. for Complex Systems- CNR, Italy;* [4]*School of Engineering and Physical Sciences, Heriot-Watt Univ., UK;* [5]*Ege Univ., Turkey.* An all-optical, sub-wavelength terahertz characterization technique based on an ultra-thin-knife-edge is demonstrated employing ultraviolet-pulse to project the blade image on a ZnTe crystal, where the free carriers excited on a blade-shaped area act as field-shield.

**JTh2A.62**

**Coherent Monochromatic Terahertz-wave Pulse Detection using Nonlinear Parametric Conversion at Room,** Shin'ichiro HAYASHI[1], Koji Nawata[1], Kodo Kawase[2,1], Hiroaki Minamide[1]; [1]*RIKEN, Japan;* [2]*Nagoya Univ., Japan.* We report on a coherent detection of monochromatic terahertz-wave pulses by using a frequency up-conversion in a nonlinear MgO:LiNbO3 crystal at room temperature. We measured the intensity and the phase of the input terahertz-wave.

**JTh2A.63**

**Modulated Beating Signal Generation via Bias Modulations of Micro-Heaters Integrated on Dual-Mode Laser,** Il-Min Lee[1], Namje Kim[1], Kiwon Moon[1], Eui Su Lee[1], Gyeongho Son[1], Kyung Hyun Park[1]; [1]*THz Photonics Creative Research Center, ETRI, Korea.* A simple and compact method of generating modulated beating signals from a dual-mode laser via bias modulation of integrated micro-heaters is proposed and successfully demonstrated. The proposed scheme will enrich the continuous-wave terahertz system applications.

## JTh2A • Poster Session 3—Continued

**JTh2A.64**
**Selective Erasure and Refilling of Liquid Metal Based Terahertz Metamaterials,** Jinqi Wang[1], Shuchang Liu[1], Sivaraman Guruswamy[2], Ajay Nahata[1]; [1]*Electrical and Computer Engineering, Univ. of Utah, USA;* [2]*Metallurgical Engineering, Univ. of Utah, USA.* We demonstrate a technique to selectively erase and refill unit cells of THz metamaterials, which are formed by injecting eutectic gallium indium, a liquid metal at room temperature, into microchannels in a polydimethylsiloxance mold.

**JTh2A.65**
**Transmission bleaching and coupling crossover in a split tapered aperture,** Shuchang Liu[1], Oleg Mitrofanov[2], Ajay Nahata[1]; [1]*Dept. of Electrical and Computer Engineering, Univ. of Utah, USA;* [2]*Dept. of Electronic and Electrical Engineering, Univ. College London, UK.* We investigate the spectral broadening of the transmitted radiation of conically tapered apertures made in a split metallic plate. We further propose a tapered shell structure to realize strong broadband field concentration.

**JTh2A.66**
**Two-Photon Photovoltaic Effect in Gallium Arsenide,** Jichi Ma[1], Jeff Chiles[1], Yagya D. Sharma[2], Sanjay Krishna[2], Sasan Fathpour[1]; [1]*CREOL, The College of Optics and Photonics, Univ. of Central Florida, USA;* [2]*Center for High Technology Material, Univ. of New Mexico, USA.* The two-photon photovoltaic effect is demonstrated in gallium arsenide at 976 and 1550 nm wavelengths. A waveguide photodiode biased in its fourth quadrant is used to harvest electrical power from photons lost to two-photon absorption.

**JTh2A.67**
**Investigation of Multiple Coupled Optical Parametric Oscillators,** Ran Wang[1], Pengda Hong[1], Xingquan Zou[1], Yujie J. Ding[1], Xiaodong Mu[2], Huai-Chuan Lee[2], Stephanie Meissner[2], Helmuth Meissner[2]; [1]*Lehigh Univ., USA;* [2]*Onyx Optics Inc., USA.* We investigated multiple coupled optical parametric oscillators, exhibiting behaviors of strong coupling. Conversion efficiency and slope efficiency stay the same as those for conventional and two coupled optical parametric oscillators whereas linewidths are significantly reduced.

**JTh2A.68**
**Coherence properties of optical frequency combs generated in Kerr microresonators,** Miro J. Erkintalo[1], Stephane Coen[1]; [1]*Physics Dept., The Univ. of Auckland, New Zealand.* We numerically study the stability of microresonator frequency combs in terms of the complex degree of first-order coherence.We identify different regimes of comb coherence, linked to the solutions of the Lugiato-Lefever equation.

**JTh2A.69**
**All-fiber optical parametric amplifier for life-science application,** Xiaoming Wei[1], Andy Lau[1], Yiqing Xu[1], Chi Zhang[1], Arnaud Mussot[2], Alexandre Kudlinski[2], Kevin Tsia[1], Kenneth Wong[1]; [1]*Dept. of Electrical and Electronic Engineering, The Univ. of Hong Kong, Hong Kong;* [2]*PhLAM/IRCICA USR 3380/UMR 8523, 2CNRS-Université Lille 1, France.* We demonstrate an all-fiber optical parametric amplifier for life-science (OPALS) application. Optical amplification of megahertz serial time-encoded amplified microscopy (STEAM) images with a resolution of less than 2 micron is achieved with a 20-dB gain.

**JTh2A.70**
**Periodically Oriented Gallium Nitride: Materials Development,** Jennifer K. Hite[1], Jaime A. Freitas[1], Ramasis Goswami[1], Michael A. Mastro[1], Igor Vurgaftman[1], Jerry R. Meyer[1], Christopher G. Brown[2], Francis J. Kub[1], Steven R. Bowman[1], Charles R. Eddy[1]; [1]*US Naval Research Lab, USA;* [2]*Sotera Defense Solutions, USA.* Methods for growing periodically alternating polarities of GaN on N-polar and Ga-polar GaN substrates have been developed. The resulting periodically oriented samples can be extended to thick growth, allowing their use in non-linear optics.

**JTh2A.71**
**Tunable, Continuous-wave, Single-frequency Ultraviolet Source Based on $BiB_3O_6$,** Kavita Devi[1], Suddapalli Chaitanya Kumar[1], Majid Ebrahim-Zadeh[1,2]; [1]*ICFO -The Inst. of Photonic Sciences, Spain;* [2]*Institucio Catalana de Recerca i Estudis Avancats (ICREA), Spain.* We report a single-frequency cw UV source tunable across 333-345nm using $BiB_3O_6$ as the nonlinear material, generating 21.6mW of UV power at 339.7nm, with >15mW over 64% of the UV tuning range in high-beam quality.

**JTh2A.72**
**Natural Phase Matching in Microdisk Cavities,** Vesselin G. Velev[1], Prem Kumar[1,2], Yu-Ping Huang[2]; [1]*Dept. of Physics and Astronomy, Center for Photonic Communication and Computing, Northwestern Univ., USA;* [2]*Dept. of Electrical Engineering and Computer Science, Center for Photonic Communication and Computing, Northwestern Univ., USA.* We identify new approaches to achieve natural phase matching in microdisk cavities for widely-spaced wavelengths across the visible and telecom bands.

**JTh2A.73**
**Femtosecond Laser-Induced Volume Gratings in Lithium Niobate for Noncollinear Second-Harmonic Generation,** Jörg Imbrock[1], Sebastian Kroesen[1], Christian Dietrich[1], Wolfgang Horn[1], Cornelia Denz[1]; [1]*Inst. of Applied Physics, Univ. of Muenster, Germany.* Noncollinear second-harmonic generation is induced by a volume grating which is directly written into a lithium niobate wafer by femtosecond laser pulses. The efficiency can be increased by Bragg matching of the fundamental wave.

**JTh2A.74**
**Metal-Clad Subwavelength Semiconductor Lasers with Temperature-Insensitive Spontaneous Hyper-Emission,** Joseph S. Smalley[1], Qing Gu[1], Matthew W. Puckett[1], Yeshaiahu Fainman[1]; [1]*Electrical and Computer Engineering, Univ. of California, San Diego, USA.* Accounting for the temperature dependence of the cavity resonances and gain medium, we investigate a metal-clad subwavelength semiconductor laser with a spontaneous emission factor, β, approaching unity for all temperatures.

**JTh2A.75**
**Optical trapping with Bessel beams generated from semiconductor lasers,** Grigorii Sokolovskii[1], Vladislav V. Dudelev[1], Sergey N. Losev[1], Ksenya Soboleva[1], Anton G. Deryagin[1], Evgeny A. Viktorov[2,3], Vladimir I. Kuchinskii[1,4], Wilson Sibbett[5], Edik U. Rafailov[6]; [1]*AF Ioffe Physical-Technical Inst., Russia;* [2]*Univerite libre de Bruxelles, Belgium;* [3]*National Research Univ. of Information Technologies, Mechanics and Optics, Russia;* [4]*St.Petersburg State Electrotechnical Univ. "LETI", Russia;* [5]*Univ. of St Andrews, UK;* [6]*Aston Univ., UK.* In this paper, we demonstrate, for the first time to the best of our knowledge, utilization of Bessel beams generated from a semiconductor laser for optical trapping and manipulation of microscopic particles including living cells.

**JTh2A.76**
**Coherent Spectral Broadening and Compression of a Mode-locked VECSEL,** Adrian H. Quarterman[1], Lucy E. Hooper[2], Peter J. Mosley[2], Keith G. Wilcox[1]; [1]*School of Engineering, Physics and Mathematics, Univ. of Dundee, UK;* [2]*Centre for Photonics and Photonic Materials, Univ. of Bath, UK.* We report the coherent spectral broadening of a mode-locked VECSEL in normal-dispersion photonic crystal fibers. Subsequent compression produced 150 fs pulses at 270 mW average power or 220 fs pulses at 520 mW average power.

**JTh2A.77**
**InGaAs/GaAs quantum well laser with broad spectrum of stimulated emission at 1.06 μm,** Wang Huolei[1], JunPing Mi[1], Laura Meriggi[2], Matthew Steer[2], WeiXi Chen[3], Jiaoqing Pan[1], Ying Ding[2,1]; [1]*Inst. of Semiconductors,CAS, China;* [2]*School of Engineering, Univ. of Glasgow, UK;* [3]*Peking Univ., China.* We report the first demonstration to our knowledge of quantum well laser having a broadband lasing spectrum of 38 nm at a center wavelength of 1.06 μm with a pulsed output power of ~50 mW.

**JTh2A.78**
**"Impact of Absorber Bias Voltage on the Optical Feedback Sensitivity of a Passively Mode-Locked Quantum Dot Laser Operating at Elevated Temperature",** Ravi Raghunathan[1], Frederic Grillot[2], Jesse Mee[3], Luke F. Lester[1]; [1]*Electrical and Computer Engineering, Virginia Polytechnic Inst. and State Univ., USA;* [2]*Telecom Paristech, Ecole Nationale Superieure des Telecommunications, France;* [3]*Air Force Research Lab, Kirtland AFB, USA.* A feedback-sensitivity study of a two-section, passively mode-locked quantum dot laser operating at elevated temperature suggests that the absorber bias voltage is critical in determining the feedback-response of the device, even under the resonant configuration.

**JTh2A.79**
**Phase Retrieval with an Array of Coupled Lasers,** Moti Fridman[1], Oren Raz[2]; [1]*Bar Ilan Univ., Israel;* [2]*Physics of complex systems, Weizmann Inst. of Science, Israel.* We will present how large array of coupled laser can solves complicated mathematical problems, such as phase retrieval of X-ray imaging experiments, in a microsecond instead of days or even weeks in cluster of powerful computers.

**JTh2A.80**
**Thermal Lensing in Nd:YVO4 Laser with In-Band Pumping at 914 nm,** Tanant Waritanant[1], Arkady Major[1]; [1]*Electrical & Computer Engineering, Chulalongkorn Univ., Canada.* Thermal lensing in Nd:YVO4 laser with in-band pumping at 914nm was experimentally characterized. An FEA modeling showed excellent agreement. A comparison with other standard pumping wavelengths was also made, highlighting a factor of 3 difference.

**JTh2A.81**
**Direct Manipulation of Transverse Mode of a Yb:YAG Laser by a Scanning Pump Beam,** Takumi Sato[1], Yuichi Kozawa[1], Shunichi Sato[1]; [1]*Inst. of Multidisciplinary Research for Advanced Materials, Tohoku Univ., Japan.* We demonstrate a novel method for the direct generation of single-transverse, higher-order Hermite-Gaussian and Laguerre-Gaussian mode beams from a Yb:YAG laser pumped by a high-speed scanning beam without any alignment of a laser cavity.

**JTh2A.82**
**45W CW TEM00 mode diode-side-pumped Nd:YAG rod laser with linearly polarized beam,** Regiane S. Pinto[1], Dimitri Geskus[1], Niklaus Wetter[1]; [1]*Centro de Lasers e Aplicações, IPEN/SP, Brazil.* Using a commercial, diode-side pumped Nd:YAG rod laser module, we obtain more than 53% extraction efficiency in fundamental mode with respect to multimode operation in a fully polarized beam.

**JTh2A.83**

**Enhancement of Output Laser Power in High-power Nd/Cr:YAG Ceramic Amplifiers Based on Cross-relaxation Effect under Solar-Pumping,** Takato Nakamachi[1], Naoki Matuoka[1], Taku Saiki[1], Kana Fuzioka[2], Masahiro Nakatsuka[3], Yukio Iida[1]; *[1]kannsai Univ., Japan; [2]Inst. of Laser Engineering, Japan; [3]Inst. for Laser Technology, Japan.* Marked increase in output laser power of a high-power Nd/Cr:YAG ceramic amplifier based on the cross-relaxation effect at high temperature under quasi-solar light pumping was observed. The solar-pumped laser is applicable to renewable energy production.

**JTh2A.84**

**Laser- and Filament-Induced Multi-scale Surface Structures on Solid Target Materials,** Anthony Valenzuela[1], Kristopher Behler[2,1], Chase Munson[1], Andrew Porwitzky[1], Matthew Weidman[3], Martin Richardson[3]; *[1]US Army Research Lab, USA; [2]Bowhead Science and Technology, USA; [3]CREOL, The College of Optics & Photonics, Univ. of Central Florida, USA.* Laser-induced filaments can ablate solid material at distances greater than that practicably achieved through linear optics. We observed multi-scale structures on metals, polymers, and ceramics from filaments and compared to those from short-focused laser pulses.

**JTh2A.85**

**Laser crystallization of silicon on lithium niobate,** Gregorio Martinez[1], Grigorios Zisis[1], Yohann Franz[1], Noel Healy[1], Anna C. Peacock[1], Harold Chong[2], David Grech[2], Sakellaris Mailis[1]; *[1]Optoelectronics Research Centre, Univ. of Southampton, UK; [2]School of Electronics and Computer Science, Univ. of Southampton, UK.* Localized laser heating of amorphous Si deposited on LiNbO3 results in crystallization of the Si over-layer and the formation of a waveguide in the LiNbO3 substrate that supports guided modes in the visible and IR.

**JTh2A.86**

**Quarter-Laser-Cycle Oscillations in Attosecond Transient Absorption for Robust Delay Zero Calibration,** Lukas Gallmann[1,2], Jens Herrmann[1], Matteo Lucchini[1], Shaohao Chen[3], Mengxi Wu[3], André Ludwig[1], Lamia Kasmi[1], Kenneth Schafer[3], Mette Gaarde[3], Ursula Keller[1]; *[1]Dept. of Physics, ETH Zurich, Switzerland; [2]Inst. of Applied Physics, Univ. of Bern, Switzerland; [3]Dept. of Physics and Astronomy, Louisiana State Univ., USA.* We investigated quarter-laser-cycle oscillations in the transient absorption signal of attosecond pulse trains and infrared pulses interacting in helium. We discuss their physical origin and show their usefulness for experimental delay-zero calibration in attosecond science.

**JTh2A.87**

**Time resolved spectroscopy of laser induced graphite plasma relevant to high-order harmonic generation,** Muhammad Ashiq Fareed[1], Yoann Pertot[1], Sudipta Mondal[1], Tsuneyuki Ozaki[1]; *[1]Energie, Matériaux et Telécommunications, INRS-EMT, Canada.* We perform spectroscopic characterization of graphite plasma to study the species responsible for high-order harmonics generation. We observed that visible region contains vibrational transitions of C2 and C3 molecules. Using same conditions, we found shorter delays are favorable for intense HHG.

**JTh2A.88**

**Mapping the fragmentation of acetylene with femtosecond resolution pump probe at LCLS using 2, 3, and 4 particle coincidences,** Chelsea E. Liekhus-Schmaltz[1], Ian Tenney[1], Timur Osipov[2], Philip H. Bucksbaum[1,2], Vladimir Petrovic[1]; *[1]Stanford Univ., USA; [2]SLAC National Accelerator Lab, USA.* A three-layer delay line anode detector has been used in x-ray pump x-ray probe time-resolved measurement at LCLS. We used ~10 fs long pulses to initiate and probe ultrafast dynamics in the dication of acetylene. The dynamics are discerned from the temporal evolution of multi-particle coincidences.

**JTh2A.89**

**Accessing the optical properties of single nanoobjects at the nanometer scale through fast electron based spectroscopies,** Arthur Losquin[1], Luiz F. Zagonel[1], Viktor Myroshnychenko[2], Benito Rodriguez-Gonzalez[3], Marcel Tencé[1], Luis M. Liz-Marzan[3], Javier García de Abajo[2], Odile Stéphan[1], Mathieu Kociak[1]; *[1]Laboratoire de Physique des Solides, Université Paris-Sud, CNRS, France; [2]IQFR, CSIC, Spain; [3]Departamento de Quimica Fisica, Universidade de Vigo, Spain.* Fast electron based spectroscopies are often loosely compared to light scattering. By performing Electron Energy Loss Spectroscopy and Cathodoluminescence on single metallic nanoobjects, we show that these techniques are nanometric probes of extinction and scattering.

**JTh2A.90**

**Experimental demonstration of an efficient unidirectional coupler for surface plasmons with wide-angle efficiency,** Fan Lu[1], Lin Sun[2], Jia Wang[2], Kun Li[1], Anshi Xu[1]; *[1]Peking Univ., China; [2]Tsinghua Univ., China.* We experimentally demonstrated a wide-angle unidirectional excitation of surface plasmons. Employing the plasmonic critical angle and the grating effect, a wide angular full-width-half-maximum (AFWHM = 25deg) with high unidirectionality (extinction ratio>10dB) was realized.

**JTh2A.91**

**Modulated spontaneous emission via the coupling between Fabry-Pérot cavity and surface plasmon polariton modes,** Jianjian Jiang[1], Yubo Xie[1], Zhengyang Liu[1], Xue-jin Zhang[1], Yong-yuan Zhu[1]; *[1]Nanjing Univ., China.* The fluorescence is experimentally controled with bandgap engineering of structured metal surface. Grating duty ratio is optimized as 3/4 and narrow emission spectra are obtained by coupling between Fabry-Pérot cavity and surface plasmon polariton modes.

**JTh2A.92**

**Nanocavity Enhanced Absorption of Ultrathin Films,** Haomin Song[1], Luqing Guo[2], Zhejun Liu[2], Kai Liu[1], Xie Zeng[1], Dengxin Ji[1], Nan Zhang[1], Haifeng Hu[3], Suhua Jiang[2], Qiaoqiang Gan[1]; *[1]Dept. of Electrical Engineering, The State Univ. of New York at Buffalo, USA; [2]Dept. of Materials Science, Fudan Univ., China; [3]College of Information Science and Engineering, Northeastern Univ., China.* We develop a fundemantal strategy to enhance the light-matter interaction of ultra-thin films based on strong interference effect in planar nanocavities, and overcome the limitation between the absorption and film thickness of energy harvesting materials.

**JTh2A.93**

**High-Throughput Optical Biosensing Arrays Detection Using White Light Fourier Transform Method,** Wan-Shao Tsai[1], Yi-Chang Lin[1]; *[1]Dept. of Applied Materials and Optoelectronic Engineering, Natianl Chi Nan Univ., Taiwan.* High-throughput detection of a large-area chip-based gold nanoslit biosensing array was detected using an imaging system based on white light Fourier transform spectrometry, with the detection sensitivity 0.02 in index change and 60nM of anti-BSA.

**JTh2A.94**

**On-chip low-profile nano-horn metal-clad optical cavity with much improved performance,** Zheng Li[1], Hyuck Choo[1]; *[1]Electrical Engineering, California Inst. of Technology, USA.* We propose an on-chip nano-horn metal-clad optical cavity with sloped sidewalls that achieves much improved vertical mode confinement--quality factor of 1000 and effective volume of $0.31(\lambda/n)^3$-- in 0.8µm height of previously reported devices.

**JTh2A.95**

**Gold Nanorod Reshaping using a Continuous Wave Laser,** David Harris-Birtill[1], Mohan Singh[1], Yu Zhou[1], Maria Elena Gallina[1], Tony Cass[1], Daniel S. Elson[1]; *[1]Imperial College London, UK.* Gold nanorods for photothermal therapy are shown, using spectroscopy and electron microscopy, to reshape after irradiation with a $6W/cm^2$ continuous wave laser, affecting their absorption coefficient and thus their clinical efficacy.

**JTh2A.96**

**Reflective plasmonic imaging lithography with deep sub-wavelength resolution and high aspect ratio,** Xiangang Luo[1]; *[1]CAS Inst. of Optics and Electronics, China.* Reflective silver layer is employed toimproveboth resolution andfidelity of sub-diffraction lithography by amplifying evanescent waves and tailoring electric field components.Nano characters patterns with depth~35nm and about 36nm line width are obtained.

**JTh2A.97**

**Bowtie Plasmonic Aperture for Single Quantum Emitter Absorption Measurement,** I-Chun Huang[1], Jennifer Choy[1], Russ Jensen[2], Moungi Bawendi[2], Marko Loncar[1]; *[1]School of Engineering and Applied Sciences, Harvard Univ., USA; [2]Chemistry, MIT, USA.* Bowtie apertures with gap sizes of less than 30nm are fabricated successfully by lift-off process. Simulations show that they have mode area as small as $0.011(\lambda/n)^2$, which is two orders smaller than a conventional tightly focused laser spot.

**JTh2A.98**

**Graphene-based tunable Bragg reflector with a broad bandwidth,** Jin Tao[1,3], XueChao Yu[1], Bin Hu[2], Alexander Dubrovkin[3], Qijie Wang[1,3]; *[1]OPTIMUS, Photonics Centre of Excellence, School of Electrical and Electronic Engineering, Nanyang Technological Univ., Singapore; [2]School of Optoelectronics, Beijing Inst. of Technology, China; [3]CDPT, Centre for Disruptive Photonic Technology, School of Physical and Mathematical Sciences, Nanyang Technological Univ., Singapore.* We show theoretically that Bragg stopband and defect resonance mode can be achieved and dynamically tuned over a wide wavelength range by a small change in Fermi energy level of graphene in graphene plasmonic waveguide structures.

**JTh2A.99**

**Proposal for a single-photon silicon device based on the unconventional photon blockade,** Hugo Flayac[1], Dario Gerace[2], Vincenzo Savona[1]; *[1]Inst. of Theoretical Physics, EPFL, Switzerland; [2]Dipartimento di Fisica, Università di Pavia, Italy.* We demonstrate that the unconventional photon blockade can produce single photons under pulsed excitation at high repetition rates. Our proposal relies on two coupled photonic crystal cavities and on the Kerr nonlinearity of silicon.

**JTh2A.100**

**Using a two-photon dressed state picture to explain Multi-frequency Raman generated spectra,** Hao Yan[1], Donna T. Strickland[1]; *[1]Dept. of Physics and Astronomy, Univ. of Waterloo, Canada.* Observations of multi-frequency Raman generated spectra indicate that at high intensities, the Raman process is better described using a dressed state picture of two-photon Stark shifted Raman levels.

**JTh2A.101**

**Multidimensional Study of Distortions Induced by Cascaded Stimulated Raman Scattering in Potassium Titanyl Phosphate,** Alexis Labruyere[1], Badr Mohamed Ibrahim Shalaby[1,2], Katarzyna Krupa[1], Alessandro Tonello[1], Fabio Baronio[3], Vincent Couderc[1]; *[1]Institut XLIM, UMR 7252, Université de Limoges, France; [2]Physics Dept., Faculty of Science, Tanta Univ., Egypt; [3]CNISM and Dipartimento di Ingegneria dell'Informazione, Università degli Studi di Brescia, Italy.* Stimulated Raman scattering was investigated in potassium titanyl phosphate. A broadband Raman cascade was generated between 1086 nm and 1250 nm. A detailed discussion is given about spatial and temporal distortions of Raman-scattered light.

**JTh2A.102**

**Ultrafast Random Bit Generation Based on the Chaotic Dynamics of a Semiconductor Laser,** Nianqiang Li[3,1], Byungchil Kim[1,4], V. n. Chizhevsky[2], Alexandre Locquet[4,1], Matthieu Bloch[1,4], David Citrin[1,4], Wei Pan[3]; *[1]Georgia Inst. of Technology, School of Electrical and Computer Engineering, USA; [2]B. I. Stepanov Inst. of Physics, National Academy of Science of Belarus, Belarus; [3]Southwest Jiaotong Univ., China; [4]UMI 2958 Georgia Tech-CNRS, Georgia Tech Lorraine, France.* We achieve physical random bit generation (RBG) that does not exceed the limit set by information theory via extracting 4 bits per sample or keep 55 bits per sample, leading to faster physical-based pseudo RBG.

**JTh2A.103**

**Recovery of Image after Distortion by Atmospheric Turbulence Using Phase-Conjugate Beam through Difference Frequency Generation,** Xingquan Zou[1], Pengda Hong[1], Yujie J. Ding[1]; [1]*Lehigh Univ., USA.* Using phase-conjugate beam generated by second-order nonlinear process, blurred images caused by atmospheric turbulence were fully recovered. Due to instantaneous response, it is perhaps the only scheme for efficiently recovering image distorted by atmospheric turbulence.

**JTh2A.104**

**Generation of Coherent Ultraviolet Radiation by Efficient Frequency Conversion Based on Nitride Heterostructures,** Guan Sun[1], Da Li[1], Ruolin Chen[1], Yujie J. Ding[1]; [1]*Lehigh Univ., USA.* We show that waveguides made of GaN/AlGaN heterostructures can be used for efficient parametric up and down conversion under transverse geometry. The conversion efficiency for generation of coherent ultraviolet radiation reaches 1%.

**JTh2A.105**

**Power Enhancement, Noise Reduction, and Linewidth Narrowing of THz Output by Mixing Beams from Coupled Oscillators,** Xingquan Zou[1], Pengda Hong[1], Da Li[1], Yujie J. Ding[1]; [1]*Lehigh Univ., USA.* THz radiation was generated by mixing idler-idler waves from coupled optical parametric oscillators based on stacked KTP plates. Power enhancement, noise reduction, and linewidth narrowing have been attributed to noise reduction between idler waves.

**JTh2A.106**

**Third and Fifth Harmonic Generation in Transparent Solids with Few Optical Cycle Mid-infrared Pulses,** Donatas Majus[1], Nail Garejev[1], Ieva Grazuleviciute[1], Gintaras Tamošauskas[1], Vytautas Jukna[2,3], Arnaud Couairon[2], Audrius Dubietis[1]; [1]*Dept. of Quantum Electronics, Vilnius Univ., Lithuania;* [2]*Centre de Physique Theorique, Ecole Polytechnique, France;* [3]*Laboratoire Hubert Curien, Universite de Lyon, Universite Jean Monnet, France.* We present a detailed investigation of third and fifth harmonics generation with 20 fs pulses at 2 μm in CaF$_2$ crystal, revealing a negligible contribution of higher-order Kerr terms up to intensities of 15 TW/cm$^2$.

**JTh2A.107**

**Complex spatial and spectral evolutions in cascaded second order nonlinear process,** Katarzyna Krupa[1], Alexis Labruyère[1], Badr Mohamed Ibrahim Shalaby[1,2], Alessandro Tonello[1], Fabio Baronio[3], Vincent Couderc[1]; [1]*Département Photonique, Institut Xlim, UMR CNRS 7252, France;* [2]*Physics Dept., Tanta Univ., Egypt;* [3]*Dipartimento di Ingegneria dell, Università di Brescia, Italy.* We experimentally study spatio-temporal nonlinear dynamics in periodically poled lithium niobate crystal. We discuss broadband frequency conversion by modulation instability through cascading second harmonic generation under self-defocusing regime. Measurements agree well with numerical simulations.

**JTh2A.108**

**Withdrawn**

**JTh2A.109**

**Ultrafast Resonant Optical Kerr Response due to Long-Range Coherent Coupling of Light and Multinode-Type Excitons,** Masayoshi Ichimiya[1], Hiroyuki Murata[1], Takayuki Umakoshi[1], Takashi Kinoshita[2], Hajime Ishihara[2], Masaaki Ashida[1]; [1]*Graduate School of Engineering Science, Osaka Univ., Japan;* [2]*Graduate School of Engineering, Osaka Prefecture Univ., Japan.* Resonant optical Kerr effects have been investigated in high-quality CuCl thin films. The peculiar spectral feature and the ultrafast response below 200 fs by a remarkably strong coupling between light and multinode-type excitons are observed.

**JTh2A.110**

**Measuring coherence dynamics of methanol using transient coherent spontaneous Raman scattering,** Seth Meiselman[1], Offir Cohen[2], Matthew F. DeCamp[1], Virginia Lorenz[1]; [1]*Physics and Astronomy, Univ. Of Delaware, USA;* [2]*Joint Quantum Inst., National Inst. of Standards and Technology, USA.* We demonstrate the measurement of vibrational state coherence dynamics in liquid methanol using transient coherent spontaneous Raman scattering. The resulting lifetimes and quantum beat frequency agree with frequency-domain and coherent anti-Stokes Raman scattering measurements.

**JTh2A.111**

**Temperature Dependence of Terahertz Transmission through Photoexcited Graphene,** Hassan Hafez Eid[1], Ibraheem Al-Naib[2], Katsuya Oguri[3], Yoshiaki Sekine[3], Akram Ibrahim[1], Marc Dignam[2], Roberto Morandotti[1], Satoru Tanaka[4], Fumio Komori[5], Hiroki Hibino[3], Tsuneyuki Ozaki[1]; [1]*INRS-EMT, Canada;* [2]*Physics, Engineering Physics and Astronomy,, Queen's Univ., Canada;* [3]*3NTT Basic Research Labs, NTT Corporation, Japan;* [4]*Applied Quantum Physics and Nuclear Engineering, Kyushu Univ., Japan;* [5]*Inst. for Solid State Physics, Univ. of Tokyo, Japan.* We report temperature dependence and thermal hysteresis behavior of terahertz transmission through photoexcited graphene. We vary the temperature between room temperature and 180° C, and use the optical-pump/terahertz-probe differential transmission technique.

**JTh2A.112**

**Two Dimensional Coherent Spectroscopy of CdSe/ZnS Colloidal Quantum Dots,** Bo Sun[1], Rohan Singh[1,2], Lazaro Padilha[3], Wan K. Bae[4], Jeffrey Pietryga[5], Victor Klimov[5], Steven T. Cundiff[1,2]; [1]*JILA/NIST and Univ. of Colorado, USA;* [2]*Dept. of Physics, Univ. of Colorado, USA;* [3]*Instituto de Fisica "Gleb Wataghin", Universidade Estadual de Campinas, Brazil;* [4]*Photo-Electronic Hybrid Research Center, Korea Inst. of Science and Technology, Korea;* [5]*Chemistry Division, Los Alamos National Lab, USA.* We demonstrate 2D coherent spectroscopy of CdSe/ZnS nanocrystals and measure the exciton homogeneous linewidth. The 2D spectra also reveal an off-diagonal peak that oscillates as a function of the waiting time T.

**JTh2A.113**

**Experimental Characterization of Optical Nonlocalities in Metal-Dielectric Multilayer Metamaterials,** Changyu Hu[1], Jie Gao[1], Cherian J. Mathai[2], Shubhra Gangopadhyay[2], Xiaodong Yang[1]; [1]*Dept. of Mechanical and Aerospace Engineering, Missouri Univ. of Science and Technology, USA;* [2]*Dept. of Electrical and Computer Engineering, Univ. of Missouri, USA.* The optical nonlocalities in metal-dielectric multilayer metamaterials are characterized as functions of incident angles for different polarizations. The measured epsilon-near-zero frequency shifts due to nonlocal effects agree with the theoretical analysis developed from transfer-matrix method.

**JTh2A.114**

**Coherent Excitation-Selective Spectroscopy in Planar Metamaterials,** Xu Fang[1], Ming Lun Tseng[2,3], Din Ping Tsai[3,4], Nikolay I. Zheludev[1,5]; [1]*Optoelectronics Research Centre and Centre for Photonic Metamaterials, Univ. of Southampton, UK;* [2]*Graduate Inst. of Applied Physics, National Taiwan Univ., Taiwan;* [3]*Dept. of Physics, National Taiwan Univ., Taiwan;* [4]*Research Center for Applied Sciences, Academia Sinica, Taiwan;* [5]*Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore.* We demonstrated that the electric and magnetic resonances of metamaterials can be separately switches off and on by positioning the metamaterials along a standing wave, while both resonances are present in travelling-wave spectra.

**JTh2A.115**

**Giant Optical Nonlocality near the Dirac Point in Metal-Dielectric Multilayer Metamaterials,** Lei Sun[1], Jie Gao[1], Xiaodong Yang[1]; [1]*Dept. of Mechanical and Aerospace Engineering, Missouri Univ. of Science and Technology, USA.* The giant optical nonlocality near the Dirac point in lossless metal-dielectric multilayer metamaterials is revealed and fully investigated through the band structure analysis of the multilayer stack, iso-frequency contour analysis, and numerical simulation.

**JTh2A.116**

**An Analytical Field Density Function for All Scattering Regimes,** Kevin J. Webb[1], Yulu Chen[1], Jason A. Newman[1]; [1]*Purdue Univ., USA.* We present an analytical density function for field statistics that applies in all scattering regimes, providing a new framework for the study of Anderson localization, and facilitating imaging in random media and random laser design.

**JTh2A.117**

**Ultrathin and smooth Aluminum-doped Silver based Meta-material with Low Loss and Homogeneous Response,** Cheng Zhang[1], Long Chen[1], Xi Chen[1], Yang Yang[1], Dewei Zhao[1], L. Jay Guo[1]; [1]*Electrical Engineering and Computer Science, Univ. of Michigan, USA.* Wetting-layer-free, ultra-thin and smooth Silver film is achieved by doping Aluminum in film deposition. Hyperbolic metamaterial using Al-doped Ag films shows high transmittance and homogeneous response.

**JTh2A.118**

**Sub-wavelength confinement in metamaterial filled-slot waveguide,** Evgeny G. Mironov[1], Liming Liu[1], Haroldo T. Hattori[1], Richard M. De La Rue[2]; [1]*School of Engineering and Information Technology, UNSW Australia, Australia;* [2]*School of Engineering, The Univ. of Glasgow, UK.* We study a metamaterial-based optical waveguide formed by a silica-filled slot in a layered metal-dielectric slab. This geometry results in very strong confinement of a quasi-TE fundamental mode and gives smaller propagation losses than a purely metallic slot waveguide.

**JTh2A.119**

**Photon-Efficient High-Dimensional Quantum Key Distribution,** Tian Zhong[1], Hongchao Zhou[1], Ligong Wang[1], Gregory Wornell[1], Zheshen Zhang[1], Jeffrey H. Shapiro[1], Franco Wong[1], Robert Horansky[2], Varun Verma[2], Adriana Lita[2], Richard P. Mirin[2], Thomas Gerrits[2], Sae Woo Nam[2], Alessandro Restelli[3], Joshua C. Bienfang[3], Francesco Marsili[4], Mathew D. Shaw[4]; [1]*MIT, USA;* [2]*National Inst. of Standards and Technology, USA;* [3]*Joint Quantum Inst., National Inst. of Standards and Technology and Univ. of Maryland, USA;* [4]*Jet Propulsion Lab, California Inst. of Technology, USA.* We demonstrate two high-dimensional QKD protocols — secure against collective Gaussian attacks — yielding up to 8.6 secure bits per photon and 6.7 Mb/s throughput, with 6.9 bits per photon after transmission through 20 km of fiber.

**JTh2A.120**

**Adaptive Binning and On-line Certification of Quantum Random Number Generators Using Bayesian Inference,** Pavel Lougovski[1]; [1]*Oak Ridge National Lab, USA.* Quantum random number generator statistics fluctuates with time due to noise affecting quality of randomness. We use Bayesian inference to monitor the statistics after each measurement and bin data adaptively to mitigate effects of noise.

**JTh2A.121**

**Experimental Passive Decoy-state Quantum Key Distribution,** Qi-Chao Sun[1,3], Wei-Long Wang[2], Yang Liu[1], Fei Zhou[4], Jason Pelc[5], Martin M. Fejer[5], Cheng-Zhi Peng[1], Xian-Feng Chen[3], Xiongfeng Ma[2], Qiang Zhang[1,4], Jian-Wei Pan[1]; [1]*Shanghai Branch, Hefei National Lab for Physical Sciences at Microscale and Dept. of Modern Physics, Univ. of Science and Technology of China, China;* [2]*Center for Quantum Information, Inst. for Interdisciplinary Information Sciences, Tsinghua Univ., China;* [3]*Dept. of Physics, Shanghai Jiao Tong Univ., China;* [4]*Jinan Inst. of Quantum Technology, Shandong Academy of Information and Communication Technology, China;* [5]*E.~L.~Ginzton Lab, Stanford Univ., USA.* By employing low dark count up-conversion single photon detectors, we have experimentally demonstrated the passive decoy-state method over a 50-km-long optical fiber and have obtained a key rate of about 100 bit/s.

## JTh2A • Poster Session 3—Continued

**JTh2A.122**
**Development of Entangled Photon Pair Sources Based on Birefringent Structures,** Alex McMillan[1], Alex Clark[2], Giacomo Corrielli[3], Bryn Bell[1], Will McCutcheon[1], Tian Wu[1], William Wadsworth[4], Roberto Osellame[3], John Rarity[1]; *[1]Univ. of Bristol, UK; [2]Univ. of Sydney, Australia; [3]Politecnico di Milano, Italy; [4]Univ. of Bath, UK.* We describe an in-line source of polarisation entangled photons, based on four-wave mixing in birefringent optical fibre. We also discuss the prospect of implementing this scheme in a birefringent, laser-written waveguide on a chip.

**JTh2A.123**
**Quantum Random Number Generation using Spontaneous Raman Scattering,** Matthew J. Collins[1], Alex Clark[1], ZhiZhong Yan[2], Chunle Xiong[1], Michael J. Steel[2], Benjamin J. Eggleton[1]; *[1]Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS), Inst. of Photonics and Optical Science (IPOS), School of Physics, Univ. of Sydney, Australia; [2]CUDOS, MQ Photonics Research Centre, Dept. of Physics and Astronomy, Macquarie Univ., Australia.* We generate a quantum random bit-string at 650kb/s by frequency binning spontaneous Raman scattered photons from a highly-nonlinear As2S3 glass detected using superconducting single photon detectors. The bit-sequences pass all the NIST statistical randomness tests.

**JTh2A.124**
**High Throughput Photon Timing Electronics For Fluorescence Lifetime And Quantum Optics Applications,** Michael Wahl[1], Tino Röhlicke[1], Hans-Jürgen Rahn[1], Volker Buschmann[1], Uwe Ortmann[1], Gerald Kell[2]; *[1]PicoQuant GmbH, Germany; [2]Fachhochschule Brandenburg, Germany.* New integrated photon timing electronics with three independent input channels provide very short deadtime and very high throughput. We present design features and basic tests as well as application results from fluorescence and luminescence imaging.

**JTh2A.125**
**A delayed choice complementarity experiment using a randmoly switched quantum eraser,** Dirk Puhlmann[1], Axel Heuer[1], Carsten Henkel[1], Ralf Menzel[1]; *[1]Univ. of Potsdam, Inst. of Physics and Astronomy, Germany.* Quantum correlations between photons have applications in cryptography and imaging. We present a setup where Mach-Zehnder interference of the ``signal photon'' is suppressed or revived depending on which measurements are made on the "idler photon".

**JTh2A.126**
**Phase Sensitive Raman Process with Correlated Seeds,** Bing Chen[1], Cheng Qiu[1], Kai Zhang[1], Jinxian Guo[1], Liqing Chen[1], Chun-Hua Yuan[1], Zhe-Yu Jeff Ou[1,2], Weiping Zhang[1]; *[1]Quantum Inst. for Light and Atoms, Dept. of Physics, East China Normal Univ., China; [2]Dept. of Physics, Indiana Univ.-Purdue Univ. Indianapolis, USA.* We experimentally demonstrate a phase sensitive Raman scattering by injecting a Stokes light seed into an atomic ensemble, whose internal state is initially prepared in such a way that it is coherent with the input Stokes seed.

**JTh2A.127**
**Phonon-Mediated Spin-Photon Interface with a Diamond Nanomechanical Oscillator,** Mark Kuzyk[1], Thein Oo[1], Hailin Wang[1]; *[1]Physics, Univ. of Oregon, USA.* We propose the use of diamond nanomechanical oscillator to mediate coupling between electron spins and arbitrary optical modes in a whispering-gallery optical resonator. Fabrication and characterization of the diamond nanomechanical oscillator will also be presented.

**JTh2A.128**
**A polarization-singularity photonic crystal waveguide design to enable quantum dot spin to photon entanglement on-chip,** Andrew Young[1], Arthur Thijssen[1], Daryl Beggs[1], Kobus Kuipers[2], John Rarity[1], Ruth Oulton[1]; *[1]Bristol Univ., UK; [2]FOM Inst. AMOLF, Netherlands.* We show the importance of polarization and phase engineering when designing quantum information devices. Using the example of a photonic-crystal waveguide we demonstrate, for the first time, designs for an integrated quantum dot spin-photon interface.

**JTh2A.129**
**Single-crystalline GaP cavity-waveguide structures on diamond,** Nicole K. Thomas[1], Russell Barbour[2], Yuncheng Song[3], Minjoo Larry Lee[3], Kai-Mei C. Fu[1,2]; *[1]Electrical Engineering, Univ. of Washington, USA; [2]Physics, Univ. of Washington, USA; [3]Electrical Engineering, Yale Univ., USA.* We present coupled GaP resonator-waveguide structures on diamond fabricated from single-crystalline, epitaxially grown material. This progress is critical for the integration of nitrogen-vacancy centers in diamond into optical networks with active, linear electro-optic devices.

**JTh2A.130**
**Tunable Dual-Wavelength Ytterbium Doped Photonic Crystal Fiber Laser Based On A Mach-Zehnder Interferometer,** Daniel Toral-Acosta[1], Arturo Castillo-Guzman[1], Romeo Selvas-Aguilar[1], Juan M. Sierra-Hernandez[2], Valentin Guzman-Ramos[1], Roberto Rojas-Laguna[2]; *[1]UANL-FCFM, Mexico; [2]UG, Mexico.* A tunable dual-wavelength ytterbium doped photonic crystal fiber laser based on a Mach-Zehnder interferometer is presented. The laser tunes from 1026nm to 1034nm by controlling the birefringence with a linewidth of 0.007nm and a contrast of 40dB.

**JTh2A.131**
**Flat-top pulse generation with pulse width continuously tunable using bandpass filter in mode locking fiber laser,** Xiaohui Fang[1]; *[1]Guangzhou Univ., China.* A 10 GHz Flat-top pulse with pulse width continuously and periodically tunable using bandpass filt is generated in active-mode-locking combined nonlinear-polarization-rotation fiber laser. The SMSR is 65 dB and the timing jitter is 92 fs.

**JTh2A.132**
**High speed single-pixel imaging via time domain compressive sampling,** Hongwei Chen[1,2], Zhiliang Weng[1,2], Yunhua Liang[1,2], Cheng Lei[1,2], Fangjian Xing[1,2], Minghua Chen[1,2], Shizhong Xie[1,2]; *[1]Tsinghua National Lab for Information Science and Technology, China; [2]Dept. of Electronic Engineering, Tsinghua Univ., China.* We report a high speed single-pixel microscopic imaging method by compressive sampling accomplished with time-stretch technique. By this method, we demonstrate a single-pixel imaging system with 1000 times faster than the conventional single-pixel cameras.

**JTh2A.133**
**Withdrawn**

**JTh2A.134**
**Advanced High-Efficiency NLW Fiber Raman Lasers,** Ravinder K. Jain[1], Mike Klopfer[1], Leanne Henry[2]; *[1]Univ. of New Mexico, USA; [2]AFRL, USA.* We will describe key design issues and related experimental results for achieving high-efficiency high-power (~ 100 W) < 3 GHz narrow linewidth (NLW) 1178 nm fiber Raman lasers for sodium guidestar applications.

**JTh2A.135**
**Real-time THz-wave spectroscopy via infrared lights detection interacted with evanescent THz waves,** Takuya Akiba[1], Naoya Kaneko[1], Koji Suizu[1], Katsuhiko Miyamoto[2], Takashige Omatsu[2,3]; *[1]Chiba Inst. of Technology, Japan; [2]Chiba Univ., Japan; [3]CREST, Japan.* We report a novel spectroscopy technique that uses an evanescent terahertz wave, without detecting the THz wave directly. It will be possible to measure various material in real-time at the terahertz frequency region.

**JTh2A.136**
**Design of X-ray Differential Phase Contrast Imaging System for High Energy and Wide Spectrum X-ray Applications,** Yuzuru Takashima[1], Jihun Kim[1], Yao-Te Cheng[2], Max Yuen[2], Jeffrey Wilde[2], Lambertus Hesselink[2]; *[1]College of Optical Sciences, The Univ. of Arizona, USA; [2]Stanford Univ., USA.* The optimum design of a grating-based X-ray differential phase contrast imaging system is relatively insensitive to the source spectrum. High energy and wide field of view applications eventually require grating-less sources and detectors.

**JTh2A.137**
**Ultra high sensitivity and precise solute positioning by tailoring surface wettability,** Ermanno Miele[1], Mario Malerba[1], Michele Dipalo[1], Eliana Rondanina[1], Andrea Toma[1], Francesco De Angelis[1]; *[1]Italian Inst. of Technology, Italy.* Hydrophobic and oleophobic surfaces have been used to deliver molecules and nanoparticles in given 2D arrays with spatial control. Effectiveness in sensing and assembly processes is shown, reaching ultra low sensitivity (aM) and precise positioning of colloidal nanocrystals.

**JTh2A.138**
**Silicon Microreflector Created by Single Ultrafast Laser Pulse,** Jingyu Zhang[1], Rokas Drevinskas[1], Martynas Beresna[1], Mindaugas Gecevičius[1], Peter G. Kazansky[1]; *[1]Optoelectronics Research Centre, Univ. of Southampton, UK.* Directly written structure created on the surface of silicon by the single pulse femtosecond laser irradiation are observed to function as microreflector. The smooth surface of the structure is a result of molten material flow.

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**12:30–14:00 Pizza Lunch with Exhibitors,** *Exhibit Hall 1 & 2*

NOTES

## CLEO: QELS-Fundamental Science

### Executive Ballroom 210A

**14:00– 16:00**
**FTh3A • Nonclassical States and Quantim Phenomena**
*Presider: Raphael Pooser; Oak Ridge National Lab, USA*

**FTh3A.1 • 14:00**
**Simulating Quantum Optical Networks with Ultrafast Pulse Shaping,** Jonathan Roslund[1], Yin Cai[1], Claude Fabre[1], Nicolas Treps[1]; [1]*Laboratoire Kastler Brossel, France.* Photonic cluster states are fabricated within the internal structure of a multimode frequency comb. Projective measurements combined with ultrafast pulse shaping allow the creation of arbitrary cluster states with no change in the optical footprint.

**FTh3A.2 • 14:15**
**Weaving quantum optical frequency combs into hypercubic cluster states,** Pei Wang[1], Moran Chen[1], Nicolas C. Menicucci[2], Olivier Pfister[1]; [1]*Physics, Univ. of Virginia, USA;* [2]*School of physics, The Univ. of Sydney, Australia.* We present a simple, scalable, top-down method of entangling the quantum optical frequency comb into hypercubic-lattice continuous-variable cluster states up to a maximum size of about 10000 modes using existing technology.

**FTh3A.3 • 14:30**
**Quantum non-Gaussian and Gaussian States at Multiple Side-band Frequencies,** Katanya Kuntz[1,2], Hongbin Song[1,2], James Webb[1], Trevor Wheatley[1,2], Akira Furusawa[3], Timothy Ralph[2,4], Elanor Huntington[1,2]; [1]*School of Engineering and Information Technology, UNSW Canberra, Australia;* [2]*Center for Quantum Computation and Communication Technology, Australian Research Council, Australia;* [3]*Dept. of Applied Physics, School of Engineering, Univ. of Tokyo, Japan;* [4]*School of Mathematics and Physics, Univ. of Queensland, Australia.* We simultaneously generate photon-subtracted squeezed vacuum and squeezed vacuum at three frequencies from an optical parametric oscillator by utilizing its frequency nondegenerate side-bands. Quantum non-Gaussianity is demonstrated by applying a novel character witness.

### Executive Ballroom 210B

**14:00– 16:00**
**FTh3B • Quantum Optics with Atoms and Ions**
*Presider: Stefan Kröll, Lunds Universitet, Sweden*

**FTh3B.1 • 14:00**
**Nonlinear Optics at Ultra Low Power in a High-Finesse Optical Cavity with Metastable Xenon,** Garrett Hickman[1], Todd B. Pittman[1], James D. Franson[1]; [1]*Physics, Univ. of Maryland, Baltimore County, USA.* We propose metastable xenon gas as a medium for realizing room temperature nonlinear optics experiments in cavity QED. We demonstrate the viability of this scheme by saturating the 6s[3/2]2 to 6p[3/2]2 transition with nanowatt powers.

**FTh3B.2 • 14:15**
**Measuring the Photonic Frequency Qubit Generated by an 171Yb+ Ion in a Surface Trap,** Geert Vrijsen[1], Jungsang Kim[1], Kai Hudek[1], Dan Gaultney[1], Louis Isabella[1]; [1]*Electrical and Computer Engineering, Duke Univ., USA.* We propose a novel qubit state measurement method for photonic frequency qubits using a Mach-Zehnder interferometer with unequal path lengths. A practical implementation for photons generated by 171Yb+ ions in a surface trap is described.

**FTh3B.3 • 14:30** Invited
**Building Quantum Networks with Ions in Optical Cavities,** Tracy Northup[1], Bernardo Casabone[1], Birgit Brandstätter[1], Konstantin Friebe[1], Klemens Schüppert[1], Florian Ong[1], Rainer Blatt[1,2]; [1]*Univ. of Innsbruck, Austria;* [2]*Inst. for Quantum Optics and Quantum Information of the Austrian Academy of Sciences, Austria.* Trapped ions are a key experimental platform for quantum computing, while photons transport information over long distances. Optical cavities provide a coherent link between these two systems, as demonstrated by recent experiments with calcium ions.

### Executive Ballroom 210C

**14:00– 16:00**
**FTh3C • Low Energy Dynamics in Dirac Materials**
*Presider: Yun-Shik Lee, Oregon State Univ., USA*

**FTh3C.1 • 14:00**
**Effect of grain-boundary plasmon on the negative terahertz dynamics conductivity in graphene,** Soonyoung Cha[1], Seong Chu Lim[2], Seung Jin Chae[2], Young Hee Lee[2], Hyunyong Choi[1]; [1]*School of Electrical and Electronic Engineering, Yonsei Univ., Korea;* [2]*Inst. of Basic Science, Center for Integrated Nanostructure Physics, Dept. of Physics, Sungkyunkwan Univ., Korea.* We discuss the origin of negative dynamic terahertz (THz) conductivity in graphene. By performing series of fluence and photon-energy dependent studies, we show that the nonequilibrium THz dynamics is strongly affected by the polycrystalline plasmons.

**FTh3C.2 • 14:15**
**Electronic Cooling in Epitaxial and CVD Graphene,** Momchil T. Mihnev[1,2], Torben Winzer[3], Seunghyun Lee[1], Zhaohui Zhong[1], Claire Berger[4], Walt A. de Heer[4], Ermin Malic[3], Andreas Knorr[3], Theodore B. Norris[1,2]; [1]*Dept. of Electrical Engineering and Computer Science, Univ. of Michigan, USA;* [2]*Center for Ultrafast Optical Science, Univ. of Michigan, USA;* [3]*Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Germany;* [4]*School of Physics, Georgia Inst. of Technology, USA.* Using ultrafast optical-pump terahertz-probe spectroscopy, we study the THz dynamics and electronic cooling in few-layer epitaxial and CVD graphene; a microscopic theory of carrier-carrier and carrier-phonon interactions accounts quantitatively for the observed dynamics.

**FTh3C.3 • 14:30**
**Carrier dynamics in graphene studied by ultra-broadband THz time-domain spectroscopy,** Masatsugu Yamashita[1], Sho Ikeda[1,2], Chiko Otani[1,2]; [1]*Center for Advanced Photonics, RIKEN, Japan;* [2]*Graduate School of Science, Tohoku Univ., Japan.* Carrier dynamics in graphene has been studied by ultrabroadband THz-TDS. We measured the optical conductivity of graphene with and without the photoexcitation. Above $I_{pump}$=200μJ/cm$^2$, the negative conductivity in graphene indicating THz wave amplification are observed.

### Executive Ballroom 210D

**14:00– 16:00**
**FTh3D • Novel Optical Phenomena**
*Presider: Luca Razzari; INRS-Energie Materiaux et Telecom, Canada*

**FTh3D.1 • 14:00**
**Tunable Raman Soliton Self-Frequency Shift via an Asymmetric Airy Pulse,** Yi Hu[1,2], Amirhossein Tehranchi[1,3], Stefan Wabnitz[4], Zhigang Chen[2,5], Raman Kashyap[3], Roberto Morandotti[1]; [1]*INRS-EMT, Canada;* [2]*TEDA Applied Physics Inst. and School of Physics, Nankai Univ., China;* [3]*Dept. of Electrical Engineering and Dept. of Engineering Physics, Ecole Polytechnique, Univ. of Montreal, Canada;* [4]*Dipartimento di Ingegneria dellInformazione, Università di Brescia, Italy;* [5]*Dept. of Physics & Astronomy, San Francisco State Univ., USA.* We study soliton self-frequency shift initiated by an Airy pulse in an optical fiber. The asymmetric features associated with the pulse exhibiting leading or trailing oscillatory tails are revealed through the effect of Raman scattering.

**FTh3D.2 • 14:15**
**Nonlinear optics of fiber event horizons,** Karen E. Webb[1], Miro J. Erkintalo[1], Yiqing Xu[1,2], Neil Broderick[1], John M. Dudley[3], Goëry Genty[4], Stuart G. Murdoch[1]; [1]*Univ. of Auckland, New Zealand;* [2]*The Univ. of Hong Kong, Hong Kong;* [3]*Universite de Franche-Comte, France;* [4]*Tampere Univ. of Technology, Finland.* We theoretically and experimentally show that fiber-optic analogues of event horizons can be explained by cascaded four-wave mixing of monochromatic continuous waves. Experiments performed with pulsed and continuous wave lasers are in excellent agreement.

**FTh3D.3 • 14:30**
**Third-harmonic spectroscopy of all-dielectric oligomers with both electric and magnetic resonances,** Maxim R. Shcherbakov[1], Dragomir N. Neshev[2], Alexander S. Shorokhov[1], Isabelle Staude[2], Elizaveta V. Melik-Gaykazyan[1], Ben Hopkins[2], Jason Dominguez[3], Andrey Miroshnichenko[2], Igal Brener[3], Andrey Fedyanin[1], Yuri S. Kivshar[2]; [1]*Faculty of Physics, Lomonosov Moscow State Univ., Russia;* [2]*Nonlinear Physics Centre, Research School of Physics and Engineering, The Australian National Univ., Australia;* [3]*Center for Integrated Nanotechnologies, Sandia National Lab, USA.* We characterize experimentally the nonlinear optical response of silicon nanodisk oligomers using third-harmonic generation spectroscopy and reveal the contributions of magnetic and electric dipolar resonances, local field enhancement, and nonlinear interference.

## CLEO: Science & Innovations

## Executive Ballroom 210E

### 14:00– 16:00
### STh3E • High Harmonics and Field Synthesis
*Presider: Tamas Nagy; Leibniz Universität Hannover, Germany*

**STh3E.1 • 14:00** Invited

**Synthesizing Optical Fields of Arbitrary Shape,** Andy Kung[1,2], Han-Sung Chan[1], Ahi-Ming Hsieh[3], Chih-Hsuan Lu[2], Br-Shu Wu[1], Yu_Chen Cheng[1], Yuan-Yao Lin[2], Yen-Yin Lin[2], Shang-Da Yang[2], Chia-Chen Hsu[4]; [1]*Inst. of Atomic and Molecular Sciences, Academia Sinica, Taiwan;* [2]*Inst. of Photonics Technologies, National Tsing Hua Univ., Taiwan;* [3]*Physics Dept., Fu Jen Catholic Univ., Taiwan;* [4]*Physics Dept., National Chung Cheng Univ., Taiwan.* Light fields with shapes similar to those produced from RF function generators are realized. Such fields may be used to dictate the microscopic motion of charged particles in atoms and molecules and in matter.

**STh3E.2 • 14:30**

**Arbitrary Carrier-Envelope Phase Control in a 10 kHz, mJ-Class Amplifier,** Fabian Lücking[1], Vincent Crozatier[2], Andreas Assion[1]; [1]*Femtolasers Produktions GmbH, Austria;* [2]*Fastlite, France.* The carrier-envelope phase of every single shot emitted by a 10 kHz, mJ-class amplifier is measured with a fast spectrometer. A novel high-speed actuator allows arbitrary phase control, with closed-loop integrated phase noise on seed oscillator level (98 mrad, 500000 shots, 50 s).

## Executive Ballroom 210F

### 14:00– 16:00
### STh3F • THz Waveguides and Optics
*Presider: Ajay Nahata; Univ. of Utah, USA*

**STh3F.1 • 14:00**

**Optically-induced mode coupling and interference in a terahertz parallel plate waveguide,** Lauren Gingras[1], Marcel Georgin[1], David G. Cooke[1]; [1]*McGill Univ., Canada.* We demonstrate all-optical control of terahertz wave mode coupling in a silicon-filled parallel-plate waveguide. The resulting frequency modulation is widely tunable by moving the control beam illumination in the propagation direction.

**STh3F.2 • 14:15**

**Probing Inside THz Parallel-Plate Waveguides with Resonant Cavities,** Kimberly S. Reichel[1], Krzysztof Iwaszczuk[2], Peter U. Jepsen[2], Rajind Mendis[1], Daniel M. Mittleman[1]; [1]*Electrical and Computer Engineering, Rice Univ., USA;* [2]*DTU Fotonik, Technical Univ. of Denmark, Denmark.* We experimentally observe in situ the resonance due to an integrated resonant cavity inside a parallel-plate waveguide excited by the TE1 mode. We also observe a field enhancement associated with this narrowband resonance.

**STh3F.3 • 14:30**

**Terahertz Absorption Saturation in Intrinsic Silicon Dielectric Ridge Waveguides,** Shanshan Li[1], Gagan Kumar[2], Thomas E. Murphy[1]; [1]*Inst. for Research in Electronics & Applied Physics, Univ. of Maryland, USA;* [2]*Dept. of Physics, Indian Inst. of Technology Guwahati, India.* We measure the transmission of terahertz pulses through an intrinsic silicon waveguide, and observe a decrease in absorption at higher terahertz fields. The effect is enhanced when photocarriers are introduced by top-illuminating the waveguide.

## Executive Ballroom 210G

### 14:00– 15:45
### STh3G • Quantum Cascade Lasers I
*Presider: Dan Wasserman; Univ. of Illinois, USA*

**STh3G.1 • 14:00**

**Low-threshold InGaAs/GaAsSb 'W'-type quantum well laser on InP substrate,** Chia-Hao Chang[1], Zong-Lin Li[1], Hong-Ting Lu[1], Chien-Ping Lee[1], Sheng-Di Lin[1]; [1]*Electronics Engineering, National Chiao Tung Univ., Taiwan.* The mid-infrared electrically-driven laser using InGaAs/GaAsSb 'W'-type QWs is demonstrated at room temperature. The InP-based laser lasing at 2.35 µm with the lowest threshold current density of 1.42 kA/cm2 is presented.

**STh3G.2 • 14:15**

**High-Power CW Operation of 7-Stage Interband Cascade Lasers,** Chadwick L. Canedy[1], Joshua Abell[1], Charles D. Merritt[1], William W. Bewley[1], Chul Soo Kim[1], Igor Vurgaftman[1], Jerry R. Meyer[1], Mijin Kim[2]; [1]*US Naval Research Lab, USA;* [2]*Sotera Defense Solutions, USA.* We report a 7-stage narrow-ridge interband-cascade laser emitting at λ ≈ 3.5 µm that produces up to 592 mW of cw power, with a wallplug efficiency of 10.1% and M2 = 3.7 at T = 25 °C.

**STh3G.3 • 14:30**

**Direct Observation of Non-uniform Electric Field in the Active Regions of an Interband Cascade Laser,** Rudra S. Dhar[1], Chao Xu[1], Dayan Ban[1], Lu Li[2], Hao Ye[2], Rui Yang[2], Matthew B. Johnson[3], Tetsuya D. Mishima[3], Mike Santos[3]; [1]*Electrical & Computer Engineering, Univ. of Waterloo, Canada;* [2]*School of Electrical & Computer Engineering, Univ. of Oklahoma, USA;* [3]*Physics & Astronomy, Univ. of Oklahoma, USA.* The non-uniform electric field in the active regions of an interband cascade laser is directly imaged and characterized for the first time by employing a nanoscopic voltage profiling technique.

## Executive Ballroom 210H

### 14:00– 16:00
### STh3H • Sensing with Optofluidics
*Presider: Timo Mappes; Karlsruher Institut für Technologie, USA*

**STh3H.1 • 14:00** Tutorial

**Optofluidics for Mobile Health, Bioenergy, and Nanoparticle Analysis,** David Erickson[1]; [1]*Sibley School of Mechanical and Aerospace Engineering, Cornell Univ., USA.* In this talk I will review recent progress on Optofluidics at Cornell in three application spaces: mobile and global health, bioenergy, and nanoparticle analysis. Fundamental science will be described as well as routes to commercialization and deployment.

David Erickson is an Associate Professor in the Sibley School of Mechanical and Aerospace Engineering at Cornell University. Prior to joining the faculty in 2005, he was a postdoctoral scholar at the California Institute of Technology and he received his Ph.D. degree from the University of Toronto in 2004. Erickson is the co-founder of Optofluidics, Inc. which is commercializing high-throughput nanoparticle analysis systems, and was named Philadelphia life-sciences start-up of the year in 2012, and VitaMe Technologies which is developing smartphone based point-of-care molecular diagnostics.

## Meeting Room
## 211 B/D

### CLEO: Science & Innovations

**14:00– 16:00**
**STh3I • Photovoltaics Sciences**
*Presider: Arthur J. Fischer; Sandia National Labs, USA*

**STh3I.1 • 14:00** Tutorial
**Flexible, Microscale Inorganic LEDs and Solar Cells,** John Rogers[1]; *[1]Univ of Illinois at Urbana-Champaign, USA.* This tutorial covers recent progress in the design of high-performance light emitting diodes with unusual sizes, shapes and forms. Applications range from large-area, flexible light sources for general illumination to cellular-scale, injectable systems for biomedicine.

John A. Rogers obtained an undergraduate degree from the University of Texas in 1989 and a Ph.D. from MIT in 1995. From 1995 to 1997, he was a Junior Fellow at Harvard University. He spent five years at Bell Labs before joining the faculty at University of Illinois in 2003.

## Meeting Room
## 212 A/C

### JOINT

**14:00– 16:00**
**JTh3J • Symposium on High Performance Optics I**
*Presider: Christopher J. Stolz, Lawrence Livermore National Lab. USA*

**JTh3J.1 • 14:00** Invited
**Defect-driven laser-induced damage in optical coatings,** Xinbin Cheng[2,1], Tao Ding[2,1], Bin Ma[2,1], Hongfei Jiao[2,1], Jinlong Zhang[2,1], Zhengxiang Shen[2,1], Zhanshan Wang[2,1]; *[1]Inst. of Precision Optical Engineering, School of Physics Science and Engineering, Tongji Univ., China; [2]MOE Key Lab of Advanced Micro-Structured Materials, China.* Defect-driven laser-induced damage in sub-surface of substrates and coatings is discussed with emphasis on the techniques for characterizing defects and the solutions to reduce defects. Consideration is also given to laser-induced damage of artificial defects.

**JTh3J.2 • 14:30**
**Optical Damage Performance Assessment of Petawatt Final Optics for the Advanced Radiographic Capability,** David A. Alessi[1], Christopher W. Carr[1], Richard P. Hackel[1], Kenneth Stanion[1], David A. Cross[1], Matthew Fischer[1], James D. Nissen[1], Ronald Luthi[1], Shawn Betts[1], William Gourdin[1], Jerry A. Britten[1], Jim Fair[1], Constantin L. Haefner[1]; *[1]Lawrence Livermore National Lab, USA.* To predict in-vacuum optical damage performance of Advanced Radiographic Capability Petawatt final optics we have developed a ps-damage test station to measure damage density and compare results to R-on-1 tests.

## Meeting Room
## 212 B/D

### CLEO: QELS-Fundamental Science

**14:00– 16:00**
**FTh3K • Plasmonic Lasers and Amplification**
*Presider: Vinod Menon, CUNY Queens College, USA*

**FTh3K.1 • 14:00**
**Injection- Seeded Optoplasmonic Amplifier in the Visible,** Manas Ranjan Gartia[1], Sujin Seo[1], JunHwan Kim[1], Te-Wei Chang[1], Gaurav Bahl[1], Meng Lu[2], J. Gary Eden[1], Gang L. Liu[1]; *[1]Electrical and Computer Engineering, Univ. of Illinois Urbana Champaign, USA; [2]Electrical and Computer Engineering, Iowa State Univ., USA.* An injection-seeded, WGM resonator-based amplifier has been demonstrated. Synergy between the gain medium, WGM spectrum, and the Raman modes of the amplifier constituents is fundamental. The estimated optical gain is ~ 30 dB.

**FTh3K.2 • 14:15**
**Strong coupling of surface plasmons to dye molecules: Tailoring dispersion and beyond,** Thejaswi Tumkur[1], Guohua Zhu[1], Mikhail A. Noginov[1]; *[1]Norfolk State Univ., USA.* In the presence of dye molecules, the dispersion curve of SPPs splits into three branches and demonstrates the avoided crossing characteristic of strong coupling. It is further modified by the optical gain in the system.

**FTh3K.3 • 14:30** Invited
**Highly-directional plasmonic lasing in the visible with subwavelength hole arrays,** Xiangeng Meng[1], Jingjing Liu[1], Alexander Kildishev[1], Vladimir M. Shalaev[1]; *[1]Purdue Univ., USA.* We demonstrate directional plasmonic nanolaser emission using subwavelength hole arrays perforated in metal film as plasmonic nanocavities. The lasing exhibits a single mode in the red wavelength region.

## Marriott
## Salon I & II

### JOINT

**14:00– 16:00**
**JTh3L • Symposium on Laser-Driven Sources of Particle and X-Ray Beams II** ▶
*Presider: Donald Umstadter; Univ. of Nebraska Lincoln, USA*

**JTh3L.1 • 14:00** Invited ▶
**X-ray emission from laser-accelerated electrons and its use as diagnostic of laser-plasma interaction,** Sebastien Corde[1], Cédric Thaury[1], Kim Ta Phuoc[1], Agustin Lifschitz[1], Rémi Lehe[1], Emillien Guillaume[1], Guillaume Lambert[1], Antoine Rousse[1], Victor Malka[1]; *[1]Laboratoire d optique appliquée, France.* X-ray radiation emitted by electrons during their acceleration in a laser-plasma accelerator was used to evidence two distincts self-injection mechanisms (longitudinal and transverse) and to identify one source of angular-momentum growth in laser-plasma accelerators.

**JTh3L.2 • 14:30** ▶
**Angular dependance of betatron x-ray spectra in a laser-wakefield accelerator,** Félicie Albert[1], Bradley Pollock[1], Jessica L. Shaw[2], Ken Marsh[2], Yu-Hsin Chen[1], David Alessi[1], Chris Clayton[2], Joseph Ralph[1], Arthur Pak[1], Siegfried Glenzer[3], Chan Joshi[2]; *[1]NIF and Photon Sciences, Lawrence Livermore National Lab, USA; [2]Electrical Engineering, UCLA, USA; [3]SLAC National Accelerator Lab, USA.* Our experiments produced betatron x-rays up to 80 keV from a laser-wakefield accelerator. Measurements, performed with stacked image plates spectrometers, provide simultaneous information on the beam profile and spectrum at various angles of observation.

## CLEO: Science & Innovations

### Marriott
### Salon III

**14:00– 15:45**

### STh3M • Silicon Photonics ▶

*Presider: To be Determined*

**STh3M.1 • 14:00** ▶

**Efficient Thermally Tunable Linear Photonic Crystal Cavities in a Zero-Change Microelectronics SOI CMOS Process,** Christopher V. Poulton[1], Xiaoge Zeng[1], Mark T. Wade[1], Jeffrey M. Shainline[1], Miloš A. Popović[1]; [1]*Univ. of Colorado at Boulder, USA.* We demonstrate directly-doped Si tunable linear photonic crystal microcavities. Also the first tunable photonic crystals realized in an advanced (45nm) SOI CMOS microelectronics process with no in-foundry process changes, they show 0.63nm/mW tuning efficiency.

**STh3M.2 • 14:15** ▶

**On chip wide angle beam steering Ami,** Ami Yaacobi[1], Jie Sun[1], Michele Moresco[1], Gerald Leake[2], Douglas Coolbaugh[2], Michael R. Watts[1]; [1]*MIT, USA;* [2]*Suny College of Nanoscale Science and Engineering, USA.* We demonstrate an on-chip optical phased array fabricated in a CMOS compatible process with continuous, fast (100 kHz), wide-angle (51o) beam-steering that is suitable for applications such as low-cost lidar systems.

**STh3M.3 • 14:30** ▶

**Non-Invasive Integrated Light Probe,** Stefano Grillanda[1], Francesco Morichetti[1], Marco Carminati[1], Giorgio Ferrari[1], Michael Strain[2], Marc Sorel[3], Marco Sampietro[1], Andrea Melloni[1]; [1]*Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano, Italy;* [2]*Inst. of Photonics, Univ. of Strathclyde, UK;* [3]*School of Engineering, Univ. of Glasgow, UK.* Non-perturbative on-chip light observation is achieved in silicon photonics waveguides by a novel integrated photonic probe. Light intensity monitoring is performed over 40 dB dynamic range, -30 dBm sensitivity, and microsecond scale time response.

### Marriott
### Salon IV

**14:00– 16:00**

### STh3N • Supercontinuum Generation

*Presider: Fetah Benabid; Univ. of Bath, UK*

**STh3N.1 • 14:00**

**Mid-infrared supercontinuum generation in concatenated fluoride and chalcogenide glass fibers covering more than three octaves,** Irnis Kubat[1], Christian Rosenberg Petersen[1], Uffe Møller[1], Angela Seddon[2], Trevor Benson[2], Laurent Brilland[3], David Mechin[3], Peter Moselund[4], Ole Bang[1]; [1]*DTU Fotonik, Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark;* [2]*George Green Inst. for Electromagnetics Research, Faculty of Engineering, Univ. Park, Univ. of Nottingham, UK;* [3]*Perfos, R&D Platform of Photonics Bretagne, France;* [4]*NKT Photonics A/S, Denmark.* Supercontinuum is generated in concatenated ZBLAN and As2Se3 fibers. Initially, a 0.9-4.1µm supercontinuum is obtained by pumping the ZBLAN fiber with a Tm laser, which then continues to broaden to 0.9-9µm in As2Se3 fiber.

**STh3N.2 • 14:15**

**Supercontinuum Generation in As2S3-Silica Double-Nanospike Waveguide,** Shangran Xie[1], Francesco Tani[1], John C. Travers[1], Johann Troles[2], Markus Schmidt[3,1], Philip St.J. Russell[1,4]; [1]*Russell Division, Max Planck Inst. for the Science of Light, Germany;* [2]*Sciences Chimiques de Rennes, Université de Rennes I, France;* [3]*Inst. of Photonic Technology, Germany;* [4]*Dept. of Physics, Univ. of Erlangen-Nuremberg, Germany.* A more than one-octave-wide supercontinuum (0.9 to ~2.1 µm) is generated in a double-nanospike As2S3-silica step-index waveguide. The average supercontinuum spectral intensity is increased by ~20 dB compared to the previously reported single-spike structure.

**STh3N.3 • 14:30**

**Supercontinuum Generation in an As2S5 Chalcogenide Microstructured Optical Fiber,** Weiqing Gao[1,3], Zhongchao Duan[1], Koji Asano[1], Tonglei Cheng[1], Dinghuan Deng[1], Morio Matsumoto[2], Takashi Misumi[2], Takenobu Suzuki[1], Yasutake Ohishi[1]; [1]*Research Center for Advanced Photon Technology, Toyota Technological Inst., Japan;* [2]*Furukawa Denshi Co., Ltd., Japan;* [3]*School of Electronic Science & Applied Physics, Hefei Univ. of Technology, China.* We demonstrate the supercontinuum generation in an As2S5 microstructured optical fiber experimentally. The SC bandwidth of 4280 nm wider than two octaves covering from 1370 to 5650 nm is obtained in 4.8 cm long fiber.

### Marriott
### Salon V & VI

**14:00– 16:00**

### STh3O • Timing and Imaging ▶

*Presider: Franklyn Quinlan; NIST, USA*

**STh3O.1 • 14:00** ▶

**High fidelity, general reflection-mode coherent diffractive imaging with a tabletop EUV source,** daniel adams[1], Bosheng Zhang[1], Matthew Seaberg[1], Dennis Gardner[1], Elisabeth Shanblatt[1], Margaret Murnane[1], Henry Kapteyn[1]; [1]*NIST/JILA/CU, USA.* We demonstrate the most general, highest fidelity, reflection mode coherent diffractive imaging to date. By combining tabletop high harmonics with ptychography and keyhole coherent diffraction techniques, images are reconstructed with < 3 nm axial resolution.

**STh3O.2 • 14:15** ▶

**Impact of Optical Amplification and Pulse Interleaving on Low Phase Noise Photonic Microwave Generation,** Franklyn Quinlan[1], Fred N. Baynes[1], Tara M. Fortier[1], Qiugui Zhou[2], Allen Cross[2], Joe C. Campbell[2], Scott A. Diddams[1]; [1]*NIST, USA;* [2]*Dept. of Computer and Electrical Engineering, Univ. of Virginia, USA.* Using carefully constructed pulse interleavers, we demonstrate ~10 dB reduction in the quantum noise from optical amplification for short pulse detection, resulting in a phase noise floor on a 10 GHz microwave of -175 dBc/Hz.

**STh3O.3 • 14:30** ▶

**Optical frequency comb-based microwave distribution through a 2.3-km fiber link with $7\times10^{-19}$ instability,** Junho Shin[1], Kwangyun Jung[1], Jinho Kang[1], Stephan Hunziker[2], Chang-Ki Min[3], Jungwon Kim[1]; [1]*Korea Advanced Inst. of Science and Technology (KAIST), Korea;* [2]*Paul Scherrer Inst. (PSI), Switzerland;* [3]*Pohang Accelerator Lab (PAL), Korea.* We demonstrate a new time-of-flight stabilization technique based on all-fiber-loop optical-microwave phase detectors. The demonstrated relative frequency instability between 2.856-GHz signals separated by a 2.3-km fiber link is $6.5\times10^{-19}$ at 82500-s averaging time.

## CLEO: Applications & Technology

### Marriott
### Willow Glen I-III

**14:00– 16:00**

### ATh3P • Symposium on Advanced Ultrashort Pulse Laser Technologies in Biophotonics and Nanobiophotonics I ▶

*Presider: Ilko Ilev; U.S. Food and Drug Administration, USA*

**ATh3P.1 • 14:00** Invited ▶

**Advances in Short-Pulse Fiber Lasers for Nonlinear Microscopy,** Frank W. Wise[1]; [1]*Cornell Univ., USA.* Recent advances in the development of fiber lasers for applications in nonlinear bioimaging will be presented.

**ATh3P.2 • 14:30** ▶

**Two-photon Fluorescence Resonance Energy Transfer Stoichiometry in Living Cells,** Amar R. Bhagwat[1], Daniel Flynn[1], Meredith Brenner[1], Marcos Nunez[1], Jennifer Ogilvie[1], Dawen Cai[2], Joel Swanson[2]; [1]*Univ. of Michigan, Ann Arbor, USA;* [2]*Univ. of Michigan Medical School, USA.* Using phase-shaped pulses, we perform, for the first time, a proof-of-principle demonstration of two-photon fluorescence resonance energy transfer (FRET) microscopy for studying the stoichiometry of intermolecular interactions within living cells.

## CLEO: QELS-Fundamental Science

## Executive Ballroom 210A

### FTh3A • Nonclassical States and Quantim Phenomena—Continued

**FTh3A.4 • 14:45**
**Lower Bound on the Speed of Nonlocal Correlations without Locality and Measurement Choice Loopholes,** Juan Yin[1], Yuan Cao[1], Hai-Lin Yong[1], Ji-Gang Ren[1], Hao Liang[1], Sheng-Kai Liao[1], Fei Zhou[1], Chang Liu[1], Yu-Ping Wu[1], Ge-Sheng Pan[1], Li Li[1], Nai-Le Liu[1], Cheng-Zhi Peng[1], Jian-Wei Pan[1]; [1]*Shanghai Branch, National Lab for Physical Sciences at Microscale and Dept. of Modern Physics, Univ. of Science and Technology of China, China.* Here, we strictly closed the loopholes by observing a 12 h continuous violation of the Bell inequality and concluded that the lower bound speed of spooky action was 4 orders of magnitude of the speed of light.

**FTh3A.5 • 15:00**
**Testing randomness using multi-photon interference,** Jonathan Matthews[1], Rebecca Whittaker[1], Jeremy L. O'Brien[1], Peter Turner[1]; [1]*Univ. of Bristol, UK.* We demonstrate pseudorandom optical processes known as t-designs, showing that for t=1(2) they are statistically indistinguishable from random operations for 1(2)-photon quantum interference, and that they fail to mimic randomness for 2(3)-photon interference.

**FTh3A.6 • 15:15**
**Experimental Verification of Quantum Discord and Operational Significance of Discord Consumption,** Sara Hosseini[1], Saleh Rahimi-Keshari[2], Jing Yan Haw[1], Assad M. Syed[1], Helen M. Chrzanowski[1], Jiri Janousek[1], Thomas Symul[1], Timothy Ralph[2], Ping Koy Lam[1], Mile Gu[3], Kavan Modi[4,3], Vlatko Vedral[4,5]; [1]*Quantum Science, Australian National Univ., Australia;* [2]*Mathematics and Physics, Univ. of Queensland, Australia;* [3]*Quantum Technology, National Univ. of Singapore, Singapore;* [4]*Atomic and Laser Physics, Univ. of Oxford, UK;* [5]*Physics, National Univ. of Singapore, Singapore.* We introduce a simple and efficient technique to verify quantum discord in unknown Gaussian states and certain class of non-Gaussian states. We also demonstrate that discord between bipartite systems can be consumed to encode information that can only be accessed by coherent quantum interaction.

## Executive Ballroom 210B

### FTh3B • Quantum Optics with Atoms and Ions—Continued

**FTh3B.4 • 15:00**
**Frequency translation via four-wave mixing Bragg scattering in Rb filled photonic band-gap fibers,** Prathamesh Donvalkar[1], Vivek Venkataraman[1], Stéphane Clemmen[1], Kasturi Saha[1], Alexander L. Gaeta[1]; [1]*School of Applied and Engineering Physics, Cornell Univ., USA.* We demonstrate frequency translation of a weak signal beam with 21% efficiency in Rb vapor confined to a hollow core photonic band-gap fiber via Bragg scattering by four-wave mixing using microwatt level pump beams.

**FTh3B.5 • 15:15**
**Ultra-long lived atomic polarization of Rb confined in hypocycloidal Kagome HC-PCF,** Ekatarina Ilinova[1], Tom Bradley[1,2], Meshaal Alharbi[1,2], John Mac Ferran[1], Benoît Debord[1], Frédéric Gérôme[1], Fetah Benabid[1,2]; [1]*GPPMM Group, Xlim Research Inst., CNRS UMR 7252, France;* [2]*Dept. of Physics, Univ. of Bath, UK.* We measure atomic polarization relaxation-time of Rb-loaded in different hypocycloidal-core Kagome HC-PCFs. The measured relaxation-time is two-orders of magnitude larger than the transit-time limit. We attribute this to slow-atom stronger contribution to the polarization build-up.

## Executive Ballroom 210C

### FTh3C • Low Energy Dynamics in Dirac Materials—Continued

**FTh3C.4 • 14:45**
**Terahertz Carrier Dynamics in Graphene and Graphene Nanostructures,** Soeren Jensen[1,2], Dmitry Turchinovich[1,3], Klaas-Jan Tielrooij[4], Frank Koppens[4], Ronald Ulbricht[2,5], Tobias Hertel[6], Akimitsu Narita[1], XinLiang Feng[1], Klaus Müllen[1], Mischa Bonn[1]; [1]*Max Planck Inst. for Polymer Research, Germany;* [2]*FOM Inst. for Atomic and Molecular Physics, Netherlands;* [3]*DTU Fotonik, Technical Univ. of Denmark, Denmark;* [4]*The Inst. of Photonic Sciences, Spain;* [5]*Hokkaido Univ., Japan;* [6]*Julius-Maximilians Univ., Germany.* Photo-excited charge carriers in 2D graphene and in 1D graphene nanostructures were studied with optical pump-THz probe spectroscopy. We find efficient hot-carrier multiplication in 2D graphene, and predominantly free carrier early-time response in 1D nanostructures.

**FTh3C.5 • 15:00** Invited
**Observation of Floquet-Bloch States on the Surface of a Topological Insulator,** Nuh Gedik[1]; [1]*MIT, USA.* Using time- and angle-resolved photoemission spectroscopy, we show that an intense ultrashort mid-infrared pulse with energy below the bulk band gap hybridizes with the surface Dirac fermions of a topological insulator to form Floquet-Bloch bands.

## Executive Ballroom 210D

### FTh3D • Novel Optical Phenomena—Continued

**FTh3D.4 • 14:45**
**Approaching Single-Photon Detection Level in Communication Band via Frequency Upconversion in GaP,** Da Li[1], Xingquan Zou[1], Yujie J. Ding[1]; [1]*Lehigh Univ., USA.* We have observed frequency upconversion of the incoming photons within the communication band to a visible band in a gallium phosphide crystal. Such a crystal is capable of reaching the single-photon detection level.

**FTh3D.5 • 15:00**
**Ultralow-power nonlinear optics using tapered optical fibers in noble gases,** Todd B. Pittman[1], Daniel E. Jones[1], James D. Franson[1]; [1]*Univ. of Maryland Baltimore County, USA.* We demonstrate ultralow-power optical nonlinearities using a sub-wavelength diameter tapered optical fiber in a gas of metastable xenon atoms. The use of inert noble gases offers advantages over reactive alkali vapors such as rubidium.

**FTh3D.6 • 15:15**
**Investigation of Hot Photons in GaN/AlN High Electron Mobility Transistor Based on Stokes Raman Scattering,** Ruolin Chen[1], Guan Sun[1], Yujie J. Ding[1], Jacob Khurgin[2]; [1]*Lehigh Univ., USA;* [2]*Johns Hopkins Univ., USA.* We investigated hot phonons based on Stokes Raman scattering from a GaN/AlN high electron mobility transistor. Such a simple method is advantageous compared with the method based on Stokes and anti-Stokes Raman scattering.

## CLEO: Science & Innovations

## Executive Ballroom 210E

### STh3E • High Harmonics and Field Synthesis—Continued

**STh3E.3 • 14:45**
**CEP dependent high-order harmonic generation at 200 kHz repetition rate,** Anne Harth[1], Piotr Rudawski[1], Chen Guo[1], Miguel Miranda[1], Eleonora Lorek[1], Esben Witting-Larsen[1], Christoph Heyl[1], Jan Matyschok[2,3], Oliver Prochnow[2], Thomas Binhammer[2], Uwe Morgner[3], Anne L'Huillier[1], Cord L. Arnold[1]; *[1]Atomic Physics, Lund Univ., Sweden; [2]VENTEON Laser Technologies GmbH, Germany; [3]Instiute of Quantum Optics, Leibniz Universität, Germany.* We present the carrier-envelope phase dependent high-order harmonic generation in argon at 200 kHz repetition rate using ultra-short laser pulses from an optical parametric chirped pulse amplifier.

**STh3E.4 • 15:00**
**Single Exposure Wavefront Curvature Estimation of High Harmonic Radiation by Diffraction from a Regular Array,** James S. Feehan[1], Hannah M. Watts[2], Patrick Anderson[1], Thomas J. Butcher[3], Jonathan H. Price[1], Russell S. Minns[2], Peter Horak[1], William S. Brocklesby[1], Jeremy G. Frey[2]; *[1]ORC, Univ. of Southampton, UK; [2]School of Chemistry, Univ. of Southampton, UK; [3]Rutherford Appleton Lab, UK.* We present a novel technique for estimating the radius of curvature from a single exposure of EUV light from a high harmonic source diffracted by a grating of square apertures.

**STh3E.5 • 15:15**
**Non-instantaneous polarization decay in dielectric media,** Michael Hofman[1], Carsten Bree[1], Matthias Hoffmann[2], Ayhan Demircan[2], Tamas Nagy[2], Detelf Ristau[2,3], Uwe Morgner[2,3], Simon Birkholz[4], Susanta Das[4], Martin Bock[4], Rüdiger Grunwald[4], Janne Hyyti[5], Thomas Elsaesser[4], Gunter Steinmeyer[4,5]; *[1]Weierstrass-Institut für Angewandte Analysis und Stochastik, Germany; [2]Laser Zentrum Hannover, Germany; [3]Institut für Quantenoptik, Universität Hannover, Germany; [4]Max Born Inst., Germany; [5]Optoelectronics Research Centre, Tampere Univ. of Technology, Finland.* We demonstrate experimental evidence for non-instantaneous polarization decay in dielectrics. The few-femtosecond relaxation times agree favorable with solutions of the time-dependent Schrödinger equation and relate to resonances of the quantum mechanical dipole.

## Executive Ballroom 210F

### STh3F • THz Waveguides and Optics—Continued

**STh3F.4 • 14:45**
**A Terahertz Leaky-Wave Antenna using a Parallel-Plate Waveguide,** Robert W. McKinney[1], Yasuaki Monnai[2], Rajind Mendis[1], Daniel M. Mittleman[1]; *[1]Electrical and Computer Engineering, Rice Univ., USA; [2]Creative Informatics, Univ. of Tokyo, Japan.* A terahertz leaky-wave antenna was implemented using the TE1 mode of a parallel-plate waveguide with a plate separation of 4 mm. Peak frequencies of leaky wave radiation are shown to be consistent with predicted values.

**STh3F.5 • 15:00**
**THz Tube Waveguides With Low Loss, Low Dispersion, and High Bandwidth,** Hualong Bao[1], Kristian Nielsen[1], Ole Bang[1], Peter U. Jepsen[1]; *[1]DTU Fotonik - Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark.* We propose, model and experimentally characterize a novel class of terahertz hollow-core tube waveguides with high-loss cladding material, resulting in propagation with low loss, low dispersion, and high useful bandwidth.

**STh3F.6 • 15:15**
**Design and Optimization of Air-Doped 3-dB Terahertz Fiber Directional Couplers,** Hualong Bao[1], Kristian Nielsen[1], Henrik K. Rasmussen[2], Peter U. Jepsen[1], Ole Bang[1]; *[1]Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark; [2]Dept. of Mechanical Engineering, Technical Univ. of Denmark, Denmark.* We present a thorough practical design optimization of broadband low loss, terahertz (THz) photonic crystal fiber directional couplers in which the two cores are mechanically down-doped with a triangular array of air holes.

## Executive Ballroom 210G

### STh3G • Quantum Cascade Lasers I—Continued

**STh3G.4 • 14:45**
**Broadly Tunable Single-mode Slot Quantum Cascade Lasers,** Bo Meng[1], Jin Tao[1], Xiao Hui Li[1], Yong Quan Zeng[1], Sheng Wu[2], Jie Q. Wang[1,3]; *[1]School of Electrical and Electronic Engineering, Nanyang Technological Univ., Singapore; [2]Power Energy and Environmental Research Inst. Covina, USA; [3]CDPT, Centre for Disruptive Photonic Technology, School of Physical and Mathematical Sciences, Nanyang Technological Univ., Singapore.* Broadly tunable single-mode quantum cascade laser at ~10 µm with two-section etched slot structure is presented. The device shows 80 cm-1 tuning range, ~20 dB side mode suppression ratio and ~30 to ~100 peak power.

**STh3G.5 • 15:00**
**3 W Near-Diffraction-Limited Power from High-Index-Contrast Photonic-Crystal Quantum Cascade Lasers,** Jeremy D. Kirch[1], Chun-Chieh Chang[1], Colin Boyle[1], Luke J. Mawst[1], Don Lindberg III[2], Thomas Earles[2], Dan Botez[1]; *[1]ECE, Univ. of Wisconsin-Madison, USA; [2]Intraband, LLC, USA.* Phase locking, via resonant leaky-wave coupling, of five 8.36 µm-emitting quantum cascade lasers has provided in-phase-mode operation to 3 W with 1.5 x diffraction limit lobewidth and 2.45 W emitted in the main far-field lobe.

**STh3G.6 • 15:15**
**Surface Emission Quantum Cascade Lasers Combining First and Second Order DFB gratings,** Pierre Jouy[1], Christopher Bonzon[1], Johanna Wolf[1], Mattias Beck[1], Jérôme Faist[1]; *[1]IQE, ETH, Switzerland.* By combining first and second order DFB gratings, a new solution for surface emission QCL is presented. A QWS mode and a buried hetero-structure process allow single mode emission and low dissipation devices.

## Executive Ballroom 210H

### STh3H • Sensing with Optofluidics—Continued

**STh3H.2 • 15:00**
**Mid-Infrared Opto-nanofluidics for Label-free On-Chip Sensing,** Pao T. Lin[1], Sen W. Wai Kwok[2], Hao-Yu Greg Lin[3], Vivek Singh[1], Lionel C. Kimerling[1], George Whitesides[2], Anu Agarwal[1]; *[1]Microphotonics Center, MIT, USA; [2]Dept. of Chemistry and Chemical Biology, Harvard Univ., USA; [3]Center for Nanoscale Systems, Harvard Univ., USA.* A mid-infrared opto-nanofluidics was developed using a Si-liquid-Si slot-waveguide. Through an optical-field enhancement with a direct interaction between the probe light and analyte, the detection sensitivity is increased by 50 times compared to evanescent-wave-sensing.

**STh3H.3 • 15:15**
**Open-access microcavities for optofluidic sensing,** Aurélien Trichet[1], James Foster[2], Dean James[2], Naomi Omori[1], Philip Dolan[1], Gareth Hughes[1], Claire Vallance[2], Jason Smith[1]; *[1]Dept. of Materials, Univ. of Oxford, UK; [2]Dept. of Chemistry, Univ. of Oxford, UK.* Open-access microcavities are an original approach for lab-on-a-chip optofluidic sensing since they offer a direct access to the confined electromagnetic field. This work describes their basic characteristics for refractive index and nanoparticle sensing.

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## Meeting Room 211 B/D

### CLEO: Science & Innovations

### STh3I • Photovoltaics Sciences—Continued

**STh3I.2 • 15:00**
**Absorption enhancement and electrical transport in thin-film solar cells with randomly rough textures,** Piotr Kowalczewski[1], Angelo Bozzola[1], Marco Liscidini[1], Lucio C. Andreani[1]; [1]*Dept. of Physics, Univ. of Pavia, Italy.* With rigorous electro-optical calculations we study randomly rough silicon solar cells approaching the Lambertian Limit of absorption. We determine the efficiency dependence on the absorber thickness and discuss the role of surface recombination.

**STh3I.3 • 15:15**
**Perfect Sunlight Absorption in Iron Oxide Photoanode,** Ken Xingze Wang[1], Zongfu Yu[1], Victor Liu[1], Mark Brongersma[1], Thomas Jaramillo[1], Shanhui Fan[1]; [1]*Stanford Univ., USA.* We design a novel core-shell nanocone structure that allows full absorption of sunlight in an iron oxide photoanode. The photocurrent approaches 12.5mA/cm2 within an iron oxide thickness of 20nm, verified by full-field electromagnetic simulation.

## Meeting Room 212 A/C

### JOINT

### JTh3J • Symposium on High Performance Optics I—Continued

**JTh3J.3 • 14:45**
**Enhanced Laser Damage Behavior of Laser Mirror by Modification of the Top Layer Design,** Drew Schiltz[1], Peter Langston[1], Dinesh Patel[1], Luke Emmert[2], Leandro Acquaroli[1], Cory Baumgarten[1], Brendan A. Reagan[1], Wolfgang Rudolph[2], Ashot Markosyan[3], R. Route[3], Martin M. Fejer[3], Jorge Rocca[1], Carmen S. Menoni[1]; [1]*Electrical and Computer Engineering, Colorado State Univ., USA;* [2]*Physics and Astronomy, Univ. of New Mexico, USA;* [3]*E. L. Ginzton Lab, Stanford Univ., USA.* We show the laser damage resistance of ion beam sputtered Ta2O5/SiO2 for high energy lasers can be increased by 50% when the Ta2O5 in the top few layers of the stack is replaced by HfO2 or Y2O3.

**JTh3J.4 • 15:00**
**Increased Laser Damage Threshold in As2S3 Motheye Antireflective Structures,** Robert J. Weilblen[1], Catalin Florea[2], Lynda Busse[4], Brandon Shaw[4], Curtis R. Menyuk[1], Ishwar Aggarwal[3], Jasbinder Sanghera[4]; [1]*Computer Science and Electrical Engineering, Univ. of Maryland, Baltimore County, USA;* [2]*Avo Photonics, USA;* [3]*Sotera Defense Solutions, USA;* [4]*Naval Research Lab, USA.* We computationally study the irradiance enhancement in As2S3 motheye structures. We show that enhancement in the glass is minimal, matching with experiments showing an increased laser damage threshold for motheye structures versus thin-film AR coatings.

**JTh3J.5 • 15:15** Invited
**Dispersive Mirrors for Short Pulse Lasers,** Vladimir Pervak[1,2]; [1]*Ludwig-Maximillians-Universität Munchen, Germany;* [2]*Ultrafast Innovations GmbH, Germany.* A dispersive-mirror-based laser permits a dramatic simplification of high-power femto- and atto-second systems and affords promise for their further development towards shorter pulse durations, higher peak- and average powers with user-friendly systems.

## Meeting Room 212 B/D

### CLEO: QELS-Fundamental Science

### FTh3K • Plasmonic Lasers and Amplification—Continued

**FTh3K.4 • 15:00**
**Hybrid photon-plasmon nanowire lasers,** Xiaoqin Wu[1], Yao Xiao[1], Cun Zheng Ning[2], Limin Tong[1]; [1]*Optical Engineering, Zhejiang Univ., China;* [2]*Computer and Energy Engineering, Arizona State Univ., USA.* By near-field coupling a high-gain CdSe nanowire (NW) and a 100-nm-diameter Ag NW, we demonstrate a hybrid photon-plasmon laser operating at 723-nm wavelength at room temperature, with a plasmon mode area of 0.008λ2.

**FTh3K.5 • 15:15**
**Ultrafast ZnO nanowire lasers: nanoplasmonic acceleration of gain dynamics at the surface plasmon polariton frequency,** Themistoklis Sidiropoulos[1], Sebastian Geburt[2], Robert Röder[2], Ortwin Hess[1], Stefan Maier[1], Rupert F. Oulton[1], Carsten Ronning[2]; [1]*Physics, Imperial College London, UK;* [2]*Univ. of Jena, Germany.* We report optically pumped hybrid photonic - plasmonic ZnO nanowire lasers operating near the surface plasmon frequency. Here, we use the non-linearity of the laser process itself to reveal the internal ~1 ps dynamics of these plasmonic lasers.

## Marriott Salon I & II

### JOINT

### JTh3L • Symposium on Laser-Driven Sources of Particle and X-Ray Beams II—Continued

**JTh3L.3 • 14:45** ▶
**3rd order harmonic in inverse Compton scattering,** Yusuke Sakai[1], Igor Pogorelsky[2], Mikhail Fedurin[2], Pietro Musumeci[1], Joseph Duris[1], Oliver Williams[1], James Rosenzweig[1]; [1]*Physics, Univ. of California Los Angeles, USA;* [2]*ATF, BNL, USA.* We report observations of strong-field effects in inverse Compton scattering via its X-ray characteristics using K-, L-edge, and attenuation filters. A CO2 laser of a0 ≈ 0.6 is collided by a 65-MeV electron beam.

**JTh3L.4 • 15:00** Invited ▶
**Producing Bright X-rays for Imaging Applications Using a Laser Wakefield Accelerator,** Stuart Mangles[1], Michael S. Bloom[1], Jonathan Bryant[1], Jason M. Cole[1], Andreas Doepp[1], Stefan Kneip[1], Hirotaka Nakamura[1], Kristjan Poder[1], Matthew J. Streeter[1], Jonathan Wood[1], Rodolfo Bendoyro[2], Jason Jiang[2], Nelson C. Lopes[2,1], Carlos Russo[2], Oleg Chekhlov[3], Klaus Ertel[3], Steven J. Hawkes[3], Chris J. Hooker[3], David Neely[3], Peter A. Norreys[3], P. P. Rajeev[3], Dean R. Rusby[3], Robbie Scott[3], Daniel R. Symes[3], James Holloway[4], Matthew Wing[4], John F. Seely[5]; [1]*John Adams Inst. for Accelerator Science, The Blackett Lab, Imperial College London, UK;* [2]*Grupo de Lasers e Plasmas, Instituto de Plasmas e Fusao Nuclear, Instituto Superior Tecnico, Portugal;* [3]*Central Laser Facility, STFC Rutherford Appleton Lab, UK;* [4]*Physics and Astronomy Dept., Univ. College London, UK;* [5]*Artep Inc., USA.* We report on the generation of bright multi-keV betatron X-ray radiation using a GeV laser wakefield accelerator and investigate the use of these X-rays for various imaging applications.

## STh3M • Silicon Photonics—Continued

**STh3M.4 • 14:45** ▶

**Ultra-Efficient and Broadband Dual-Level Si3N4-on-SOI Grating Coupler,** Wesley D. Sacher[1], Ying Huang[2], Liang Ding[2], Benjamin J. Taylor[1], Hasitha Jayatilleka[1], Guo-Qiang Lo[2], Joyce K. Poon[1]; _[1]Univ. of Toronto, Canada; [2]Inst. of Microelectronics, A*STAR (Agency for Science, Technology and Research), Singapore._ A grating coupler with aligned Si3N4 and Si grating teeth is proposed and demonstrated. The measured coupling efficiency is -1.3 dB (competitive with the best Si-only grating couplers), and the 1-dB bandwidth is a record 80 nm.

**STh3M.5 • 15:00** ▶

**Unidirectional chip-to-fiber grating couplers in unmodified 45nm CMOS Technology,** Mark T. Wade[1], Rajesh Kumar[1], Kareem Nammari[1], Cale M. Gentry[1], Jeffrey Shainline[1], Jason S. Orcutt[3], Ananth Tamma[4], Rajeev Ram[3], Vladimir Stojanovic[2], Miloš A. Popović[1]; _[1]Univ. of Colorado at Boulder, USA; [2]Univ. of California, USA; [3]MIT, USA; [4]UC Irvine, USA._ We propose and demonstrate the first asymmetric unidirectional grating couplers fabricated in a 45nm unmodified CMOS process. Measured coupling efficiency from fiber-to-chip is ~40 %.Simulations show >70% efficiency is achievable with same design.

**STh3M.6 • 15:15** ▶

**Silicon Chip Based Near-Infrared and Mid-Infrared Optical Spectroscopy for Volatile Organic Compound Sensing,** yi zou[1], Swapnajit Chakravarty[2], Wei-Cheng Lai[1], Ray Chen[1]; _[1]Univ. of Texas at Austin, USA; [2]Omega Optics Inc, USA._ We compared different on-chip silicon based absorption sensors for the detection of xylene in water in both near-infrared and mid-infrared including strip waveguide, slot waveguide and PC-based chip integrated optical absorption spectroscopy devices.

## STh3N • Supercontinuum Generation—Continued

**STh3N.4 • 14:45**

**Visible Supercontinuum Generation by Dual-Wavelength Pumping in Multimode Rectangular Optical FibersVisible Supercontinuum Generation by Dual-Wavelength Pumping in Multimode Rectangular Optical Fibers,** Badr M. SHALABY[1,2], Alexis Labruyère[1], Katarzyna Krupa[1], Denisa Subtirelu[3], Nelly Rongeat[3], Alessandro Tonello[1], Vincent Couderc[1]; _[1]Xlim-Photonics, Limoges Unversity-CNRS, France; [2]Physics-Faculty of Science, Tanat Unversity, Egypt; [3]Physics, Horiba Medical, France._ We study supercontinuum generation in a multimode microstructured optical fiber by dual-wavelength pumping. We demonstrate significant blue extension of the spectrum in relatively short fiber length by exploiting cross-phase modulation between high order modes.

**STh3N.5 • 15:00**

**Octave spanning coherent supercontinuum generation by 46 fs pedestal free ultrashort pulse using similariton amplifier and Er-doped fiber laser with carbon nanotube,** Yoshitaka Nomura[1], Yuto Nozaki[1], Youichi Sakakibara[2], Emiko Omoda[2], Hiromichi Kataura[2], Norihiko Nishizawa[1]; _[1]Nagoya Univ., Japan; [2]AIST, Japan._ 46 fs, 4.0 nJ pedestal free high power ultrashort pulse was generated using Er-doped similariton amplifier seeded by nanotube fiber laser. An octave spanning coherent supercontinuum was generated in highly nonlinear normal dispersion fiber.

**STh3N.6 • 15:15**

**Coherent All-PM Fiber Frequency Comb Source at 2.03 µm and 100 MHz Emitting Broadband Pulses at up to 290 mW and 128 fs Pulse Duration,** Heinar Hoogland[1], Alexandre Thai[1,2], Daniel Sanchez[2], Seth L. Cousin[2], Michael Hemmer[2], Martin Engelbrecht[1], Jens Biegert[2,4], Ronald Holzwarth[1,3]; _[1]Menlo Systems GmbH, Germany; [2]ICFO-Institut de Ciences Fotoniques, Spain; [3]Max-Planck-Inst. of Quantum Optics, Germany; [4]ICREA - Institucio Catalana de Recerca i Estudis Avançats, Spain._ We report on a compact coherent All-PM fiber laser amplifier system at around 2.03 µm running at 100 MHz delivering broadband pulses at 290 mW average power and pulse duration down to 128 fs.

## STh3O • Timing and Imaging—Continued

**STh3O.4 • 14:45** ▶

**Precise Time Recovery at Arbitrary Point in Fiber-Optic Loop Link with RF Phase Locking Assistance,** Zhongze Jiang[1], Yitang Dai[1], Feifei Yin[1], Jianqiang Li[1], Kun Xu[1]; _[1]BUPT, China._ Precise time recovery on arbitrary point of fiber-optic link with λ-dispersion-induced RF phase locking assistance is proposed. Experiments have demonstrated the time deviation of 8.34ps@1s averaging and 0.592ps@$10^3$s averaging within a 30-km fiber loop.

**STh3O.5 • 15:00** ▶

**Long-Term Stable, Sub-Femtosecond Balanced Optical-Microwave Phase Detector,** Michael Y. Peng[1], Franz Kärtner[1,2]; _[1]Electrical Engineering and Computer Science, MIT, USA; [2]Center for Free-Electron Laser Science, Deutsches Elektronen-Synchrotron, Germany._ We achieved a sub-fs thermal-noise-limited noise floor in a balanced optical-microwave phase detector and demonstrated long-term stable RF extraction with <1 fs RMS drift and <7 fs pk-pk for over 10 hours of continuous operation.

**STh3O.6 • 15:15** ▶

**Timing Jitter Minimization in Soliton Mode-Locked Fiber Lasers by Dispersion Engineering,** Chur Kim[1], Sangho Bae[1], Khanh Kieu[2], Jungwon Kim[1]; _[1]Korea Advanced Inst of Science & Tech, Korea; [2]The Univ. of Arizona, USA._ We searched for the minimal timing jitter condition in an all-fiber, soliton, CNT-mode-locked Er-laser by dispersion engineering. The measured lowest timing jitter is 490-attosecond [10-kHz to 39.4-MHz] at -0.02 ps$^2$ intra-cavity dispersion.

## ATh3P • Symposium on Advanced Ultrashort Pulse Laser Technologies in Biophotonics and Nanobiophotonics I—Continued

**ATh3P.3 • 14:45** ▶

**3D Visualization of Dental Anatomy in Ancient Fossil Vertebrates by Using Third Harmonic Generation Microscopy,** Yu-Cheng Chen[1], Ya-Na Wu[2], Dar-Bin Shieh[2], Chi-Kuang Sun[1,3], Robert R. Reisz[4]; _[1]Molecular Imaging Center, National Taiwan Univ., Taiwan; [2]Inst. of Oral Medicine, National Cheng Kung Univ. College of Medicine and Hospital, Taiwan; [3]Inst. of Physics and Research Center for Applied Sciences, Academia Sinica, Taiwan; [4]Dept. of Biology, Univ. of Toronto Mississauga, Canada._ Clear 3D visualization in fossilized dentinal tissues was first discovered with extremely strong contrast by means of third harmonic generation microscopy, providing a novel approach to study the dental evolution of ancient vertebrates (dinosaurs) noninvasively.

**ATh3P.4 • 15:00** ▶

**Measurements of Two-, Three-, and Four-Photon Excitation Action Cross Sections,** Li-Chung Cheng[1,3], Ke Wang[2], Chris Xu[3]; _[1]Dept. of Photonics, National Cheng Kung Univ., Taiwan; [2]College of Optoelectronic Engineering, Shenzhen Univ., China; [3]School of Applied Engineering and Physics, Cornell Univ., USA._ We report quantitative measurements of two-, three-, and four-photon excitation action cross sections of several commonly used fluorophores and fluorescent proteins at three different excitation wavelengths of 800 nm, 1300 nm, and 1680 nm.

**ATh3P.5 • 15:15** ▶

**Effect of Femtosecond Laser Pulse Energy and Repetition Rate on Laser Induced Second and Third Harmonic Generation in Corneal Tissue,** William Calhoun[1,2], Ilko K. Ilev[1]; _[1]DP/OSEL/CDRH, Food and Drug Administration, USA; [2]Biomedical Engineering, Virginia Commonwealth Univ., USA._ We present a quantitative study on the effect of femtosecond laser pulse energy and repetition rate on the intensity and duration of the laser induced second and third harmonic generation in fresh corneal tissue.

# CLEO: QELS-Fundamental Science

## Executive Ballroom 210A

### FTh3A • Nonclassical States and Quantim Phenomena—Continued

**FTh3A.7 • 15:30**
**Bi-directional Multiplexing of Heralded Single Photon Sources from a Single Silicon Photonic Chip,** Chunle Xiong[1], Trung Vo[1,2], Matthew Collins[1], Alex Clark[1], Juntao Li[3], Michael J. Steel[5], Thomas F. Krauss[3,4], Benjamin J. Eggleton[1]; *[1]Univ. of Sydney, Australia; [2]Defence Science and Technology Organisation, Australia; [3]Univ. of St. Andrews, UK; [4]Univ. of York, UK; [5]Macquarie Univ., Australia.* We demonstrate spatial multiplexing of two heralded single photon sources created by bi-directionally pumping a single 96 µm photonic crystal waveguide. This enhances the source brightness by 51.2±4.0% whilst maintaining the coincidence to accidental ratio.

**FTh3A.8 • 15:45**
**On-Chip Heralded Single Photon Source with Demultiplexing and Pump Filtering,** Nicholas C. Harris[1], Christophe Galland[2], Daniele Bajoni[3], Mihir Pant[1], Davide Grassani[3], Tom Baehr-Jones[4,5], Michael Hochberg[4,5], Dirk Englund[1]; *[1]RLE, MIT, USA; [2]École Polytechnique Fédérale de Lausanne (EPFL), Switzerland; [3]Università di Pavia, Italy; [4]Univ. of Delaware, USA; [5]National Univ. of Singapore, Singapore.* We demonstrate an on-chip source of correlated photons with spatial demultiplex-ing of signal and idler photons via ring resonators and with pump suppression greater than 60 decibels.

## Executive Ballroom 210B

### FTh3B • Quantum Optics with Atoms and Ions—Continued

**FTh3B.6 • 15:30**
**Excitation of Higher-Order Modes of an Optical Nanofiber by Laser-Cooled Rb-87 Atoms,** Ravi Kumar[1,2], Vandna Gokhroo[1], Aili Maimaiti[1,2], Kieran Deasy[1], Síle Nic Chormaic[1]; *[1]OIST Graduate Univ., Japan; [2]Physics Dept., Univ. College Cork, Iceland.* We demonstrate excitation of higher order modes in an optical nanofiber by resonantly-excited Rb-87 atoms. Absorption by laser-cooled atoms is enhanced when probe light propagates in higher order modes compared to the fundamental mode.

**FTh3B.7 • 15:45**
**Spin cooling via incoherent feedback in an ensemble of cold 87Rb atoms,** Naeimeh Behbood[1], Georgio Colangelo[1], Ferran Martin Ciurana[1], Mario Napolitano[1], Robert Sewell[1], Morgan W. Mitchell[1,2]; *[1]ICFO -The Inst. of Photonic Sciences, Spain; [2]ICREA - Institucio Catalana de Recerca i Estudis Avancats,, Spain.* We report an experimental study of a new technique for spin cooling an ensemble of ultracold atoms via quantum non-demolition (QND) measurement and incoherent feedback. We have demonstrated 12db spin noise reduction.

## Executive Ballroom 210C

### FTh3C • Low Energy Dynamics in Dirac Materials—Continued

**FTh3C.6 • 15:30**
**Disorder induced Floquet topological insulators in photonic systems,** Mikael Rechtsman[2], Netanel H. Lindner[2], Paraj T. Bhattacharjee[1], Gil Refael[1]; *[1]Physics Dept., California Inst. of Technology, USA; [2]Physics Dept., Technion Israel Inst. of Technology, Israel.* We propose the photonic topological Anderson insulator, the first realization of this phase in any physical context. In this phase, disorder counterintuitively induces a topological transition that breaks Anderson localization and leads to robust transport.

**FTh3C.7 • 15:45**
**Terahertz dynamics of topological insulator Bi2Se3 : ultrafast photoexcitation suppresses hot-Dirac electron surface scattering,** Sim Sangwan[1], Matthew Brahlek[2], Nikesh Koirala[2], Soonyoung Cha[1], Seongshik Oh[2,3], Hyunyong Choi[1]; *[1]School of Electrical and Electronic Engineering, Yonsei Univ., Korea; [2]Rutgers Center for Emergent Materials and Dept. of Physics and Astronomy, Rutgers the State Univ. of New Jersey, USA; [3]Inst. for Advanced Materials, Devices and Nanotechnology, Rutgers the State Univ. of New Jersey, USA.* We present ultrafast terahertz scattering dynamics in topological insulator Bi2Se3 thin films. Upon photoexcitation, the surface-scattering rate is increased, resulting in decrease of conductance. At high temperature, however, the photo-generated electrons suppress the surface-scattering.

## Executive Ballroom 210D

### FTh3D • Novel Optical Phenomena—Continued

**FTh3D.7 • 15:30**
**Test of Higher-Order Nonlinearity via Low-Order Harmonic Generation Revisited,** Darshana L. Weerawarne[1], Xiaohui Gao[2], Alexander L. Gaeta[2], Bonggu Shim[1]; *[1]Physics, SUNY Binghamton, USA; [2]School of Applied and Engineering Physics, Cornell Univ., USA.* We measure the ratio between fifth- and third-harmonic signals from air as a function of the laser intensity determined by mode measurements. Our results do not support the presence of a higher-order Kerr nonlinearity.

**FTh3D.8 • 15:45**
**A Quasi-Optical Tool for the Demultiplexing of Orbital Angular Momentum Carried at Millimeter-Wave Frequencies,** Martin P. Lavery[1], Yan Yan[2], Guodong Xie[2], Hao Huang[2], Moshe Tur[3], Andreas F. Molisch[2], Miles Padgett[1], Alan Willner[2]; *[1]School of Physics and Astronomy, Univ. of Glasgow, UK; [2]Electrical Engineering, Univ. of Southern California, USA; [3]Electrical Engineering, Tel Aviv Univ., Israel.* We present a quasi-optical component for the simultaneous de-multiplexing of multiple channels by the transformation of OAM into transverse momentum. A communications link comprising 4 independent channels is demonstrated achieving a data rate of 8 Gbit/s.

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16:00–16:30 **Coffee Break,** *Concourse Level*

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NOTES

## STh3E • High Harmonics and Field Synthesis—Continued

**STh3E.6 • 15:30** Invited

**Isolated Attosecond Continua in the Water Window via High Harmonic Generation using a Few-cycle Infrared Light Source,** Nobuhisa Ishii[1], Keisuke Kaneshima[1], Henning Geiseler[1], Teruto Kanai[1], Shuntaro Watanabe[2], Jiro Itatani[1]; *[1]Inst. for Solid State Physics, Japan; [2]Tokyo Univ. of Science, Japan.* A few-cycle infrared light source is applied to generate isolated soft-x-ray continua in the water window via high harmonic generation. The current status of the light source and some strong-field experiments will be discussed.

## STh3F • THz Waveguides and Optics—Continued

**STh3F.7 • 15:30**

**Tunable Terahertz wave plates fabricated with a 3D printer,** Stefan Busch[1], Marcel Weidenbach[1], Benedikt Scherger[1], Martin Koch[1], Maik Scheller[2], Christian Jansen[2], Enrique Castro-Camus[3]; *[1]Faculty of Physics and Material Sciences Center, Philipps-Universitat Marburg, Germany; [2]Lytera UG (haftungsbeschränkt), Germany; [3]Centro de Investigaciones en Óptica A.C., Mexico.* We fabricate wave plates for terahertz waves using a 3D printer. The wave plates base on the physical mechanism of form birefringence. Applying mechanical pressure to the plates allows for continuously tuning of the optical retardance.

**STh3F.8 • 15:45**

**Extraordinary Transmission-inspired Dual-band THz Quarter-wave Plate,** Víctor Torres[1], Nuria Sánchez[2], David Etayo[1], Rubén Ortuño[1], Alejandro Martínez[2], Miguel Navarro-Cia[3,4], Miguel Beruete[1]; *[1]Universidad Pública de Navarra, Spain; [2]Universitat Politècnica de València, Spain; [3]Imperial College London, UK; [4]Univ. College London, UK.* We propose a very compact metasurface that works as a quarter-wave plate at two different frequencies, 1 THz and 2.2 THz. The fractional bandwidth of the first band is remarkably 32.2%, beyond the state-of-the-art.

## STh3G • Quantum Cascade Lasers I—Continued

**STh3G.7 • 15:30**

**A mid-infrared Lab-on-a-Chip: Generating, Guiding and Detecting Light in a Monolithic Device,** Benedikt Schwarz[1], Daniela Ristanic[1], Peter Reininger[1], Hermann Detz[1], Aaron M. Andrews[1], Werner Schrenk[1], Gottfried Strasser[1]; *[1]Inst. for Solid State Electronics and Center for Micro- and Nanostructures, Vienna Univ. of Technology, Austria.* We present a fully integrated mid-infrared sensor. The laser and detector are fabricated from a bi-functional quantum cascade structure, connected through a dielectric-loaded surface plasmon waveguide, which acts as interaction zone and provides high coupling.

## STh3H • Sensing with Optofluidics—Continued

**STh3H.4 • 15:30**

**Miniature droplet-based FRET lasers stabilized by superhydrophobic surfaces,** Ersan Ozelci[1], Mehdi Aas[1], Alexandr Jonas[2], Alper Kiraz[1]; *[1]Dept. of Physics, Koc Universitesi, Turkey; [2]Dept. of Physics, Istanbul Technical Univ., Turkey.* We demonstrate optofluidic microlasers based on liquid microdroplets stabilized by a superhydrophobic surface. Lasing is achieved using highly efficient non-radiative Förster resonance energy transfer between donor and acceptor molecules placed within the droplets.

**STh3H.5 • 15:45**

**On-chip Opto-electrical Discrimination of Single Biological Nanoparticles,** Shuo Liu[1], Yue Zhao[2], Joshua W. Parks[1], Aaron Hawkins[2], Holger Schmidt[1]; *[1]School of Engineering, Univ. of California Santa Cruz, USA; [2]Dept. of Electrical and Computer Engineering, Brigham Young Univ., USA.* Using an opto-fluidic chip with an integrated nanopore, a mixture of nanobeads and influenza viruses were opto-electrically detected. Different types of nanoparticles can be distinguished by different fluorescence wavelengths and fluorescence correlation functions.

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**16:00–16:30 Coffee Break,** *Concourse Level*

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NOTES

## Meeting Room 211 B/D

### CLEO: Science & Innovations

### STh3I • Photovoltaics Sciences—Continued

**STh3I.4 • 15:30**
**Photocurrent enhancement in thin a-Si:H solar cells via plasmonic light trapping,** Seweryn Morawiec[1,2], Manuel J. Mendes[1], Sergej A. Filonovich[3,4], Tiago Mateus[3,4], Salvatore Mirabella[1], Hugo Águas[3,4], Isabel Ferreira[3,4], Francesca Simone[2], Elvira Fortunato[3,4], Rodrigo Martins[3,4], Francesco Priolo[1,2], Isodiana Crupi[1]; [1]*MATIS IMM-CNR, Italy;* [2]*Dipartimento di Fisica e Astronomia, Università di Catania, Italy;* [3]*Departamento de Ciência dos Materiais, CENIMAT/I3N, Portugal;* [4]*Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, CEMOP/UNINOVA, Portugal.* Photocurrent enhancement in thin a-Si:H solar cells due to the plasmonic light trapping is investigated, and correlated with the morphology and the optical properties of the self-assembled silver nanoparticles incorporated in the cells' back reflector.

**STh3I.5 • 15:45**
**Low Cost All-Dielectric Thin-Film Solar Cell Using Diffuse Medium Reflectors,** Chi Wei Tseng[1], Sze Ming Fu[1], Shih-Yun Lai[1], Wei-Ming Lai[1], Sheng Lun Yan[1], Nyan-Ping Ju[1], Po-Yu Chen[1], Chi-Chung Tsai[1], Albert Lin[1]; [1]*National Chiao Tung Univ., Taiwan.* Diffuse reflectors can be beneficial for solar cells, due to no plasmonic loss, higher reflectance, decent light scattering, and low cost. Experimental and theoretical works are presented here to demonstrate its feasibility for photovoltaics.

## Meeting Room 212 A/C

### JOINT

### JTh3J • Symposium on High Performance Optics I—Continued

**JTh3J.6 • 15:45**
**Temperature Dependence of Laser-Induced Damage Thresholds in Dielectric Crystals,** Katsuhiro Mikami[1], Takahisa Jitsuno[1], Azumi Minako[2], Tsuyoshi Sugita[2], Azechi Hiroshi[1]; [1]*Inst. of Laser Engineering, Osaka Univ., Japan;* [2]*Glass Division, NIKON Corporation, Japan.* Laser-induced damage thresholds (LIDT) in dielectric crystals were evaluated at different temperature. The temperature dependence of the LIDTs could be explained with some physical models.

## Meeting Room 212 B/D

### CLEO: QELS-Fundamental Science

### FTh3K • Plasmonic Lasers and Amplification—Continued

**FTh3K.6 • 15:30**
**Novel physics in photonic crystal nanolasers : Dynamics and Coherence,** Isabelle Robert-Philip[1], Armand Lebreton[1], Grégoire Beaudoin[1], Isabelle Sagnes[1], Rémy Braive[1], Alexios Beveratos[1], Izo Abram[1]; [1]*LPN, CNRS, France.* Lasers of diffraction-limited volumes involve the interaction of small numbers of particles (photons and dipoles). We demonstrate that these small populations of discrete particles induce large intensity noise in the output of the laser.

**FTh3K.7 • 15:45**
**Non-linear Fano interactions in plasmonic-vapor system,** Liron Stern[1], Meir Y. Grajower[1], Uriel Levy[1]; [1]*Hebrew Univ. of Jerusalem, Israel.* Linear and non-linear Fano interactions in a hybrid system consisting of surface plasmonic resonance and alkali vapor are presented. Using a pump probe apparatus, Doppler free lineshape and all optical modulation is experimentally demonstrated.

## Marriott Salon I & II

### JOINT

### JTh3L • Symposium on Laser-Driven Sources of Particle and X-Ray Beams II—Continued

**JTh3L.5 • 15:30**
**X-ray Generation by Relativistic Laser-Accelerated Electrons,** Stefan Karsch[1,2], Johannes Wenz[1], Konstantin Khrennikov[1], Matthias Heigoldt[1], Antonia Popp[1], Alexander Buck[2], Jiancai Xu[2], Laszlo Veisz[2], Shao-Wei Chou[2], Andreas Maier[3,1], Nathaniel Kajumba[1], Thorben Seggebrock[1], Florian Grüner[3,1], Alexander Guggenmos[1,2], Ulf Kleineberg[1,2], Simone Schleede[4], Martin Bech[4], Pierre Thibault[4], Franz Pfeiffer[4]; [1]*Ludwig-Maximilians-Universität München, Germany;* [2]*Max-Planck-Institut fur Quantenoptik, Germany;* [3]*Universität Hamburg, Germany;* [4]*Technische Universität München, Germany.* Laser-wakefield-accelerated electrons were used to drive an all-optical undulator source, a 5-keV betatron X-ray source and a tunable quasi-monochromatic Compton-X-ray source. Also, we present a phase-contrast tomogram of a fly obtained with the betatron beam.

**JTh3L.6 • 15:45** ▶
**Quasi Monoenergetic and Tunable X-rays by Laser Compton Scattering from Laser Wakefield e-beam,** Nathan Powers[1], Isaac Ghebregziabher[1], Gregory Golovin[1], Cheng Liu[1], Shouyuan Chen[1], Sudeep Banerjee[1], Jun Zhang[1], Donald P. Umstadter[1]; [1]*Univ. of Nebraska Lincoln, USA.* Quasi monoenergetic and tunable x-ray beams are reported by inverse-Compton scattering from laser wakefield accelerated electrons. The high peak brightness, ultrashort duration, and small size of the source make it uniquely suitable for many applications.

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**16:00–16:30 Coffee Break,** *Concourse Level*

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## CLEO: Science & Innovations

Marriott
Salon III

### STh3M • Silicon Photonics—Continued

**STh3M.7 • 15:30** ▶
**Controlled Coupling of Rolled-Up Microtubes Integrated with Silicon Waveguides,** Qiuhang Zhong[1], Zhaobing Tian[1], Venkat Veerasubramanian, Mohammad Hadi Tavakoli Dastjerdi[1], David Patel[1], Zetian Mi[1], David V. Plant[1]; [1]*Dept. of Electrical and Computer Engineering, McGill Univ., Canada.* We demonstrate, for the first time, the controlled coupling of rolled-up microtubes integrated with silicon waveguides by thermally tuning the coupling gap. Then we realize coupling modulation utilizing the dynamic tuning effect.

Marriott
Salon IV

### STh3N • Supercontinuum Generation—Continued

**STh3N.7 • 15:30**
**Controlling rogue wave statistics,** Ayhan Demircan[1], Shalva Amiranashvili[2], Carsten Bree[2], Ayhan Tajalli[1], Uwe Morgner[1], Gunter Steinmeyer[3]; [1]*Leibniz Univ. Hannover, Germany;* [2]*Weierstrass Intitute for Applied Analysis and Stochastics, Germany;* [3]*Max-Born-Institut, Germany.* We propose a radically new way of rogue wave control, modifying the statistical distribution of events via suitable injection of dispersive waves. This allows reducing the frequency of rogue events rather than only increasing it.

**STh3N.8 • 15:45**
**Nanotube mode-locked, low repetition rate pulse source for fiber-based supercontinuum generation at low average pump power,** Robert I. Woodward[1], Edmund J. Kelleher[1], T. H. Runcorn[1], Daniel Popa[2], Tawfique Hasan[2], Andrea C. Ferrari[2], Sergei V. Popov[1], James R. Taylor[1]; [1]*Femtosecond Optics Group, Imperial College London, UK;* [2]*Cambridge Graphene Centre, Univ. of Cambridge, UK.* We demonstrate a nanotube mode-locked fiber laser with low repetition rate (244 kHz), enabling supercontinuum generation in photonic crystal fiber spanning 600 to 2000 nm, at a low average pump power of 87 mW.

Marriott
Salon V & VI

### STh3O • Timing and Imaging—Continued

**STh3O.7 • 15:30** ▶
**Phase Stabilized Downlink Transmission and Optical Down-Conversion for Wideband Radio Frequency,** Anxu Zhang[1], Yitang Dai[1], Feifei Yin[1], Kun Xu[1], Jianqiang Li[1], Jintong Lin[1]; [1]*Beijing Univ. of Posts and Telecommunications, China.* A novel wideband radio frequency phase stabilized downlink transmission and optical domain down-conversion scheme is proposed. The achieved stability of the intermediate frequency is ~1.8x10-12τ-1/2 after transferring through 30km optical fiber.

**STh3O.8 • 15:45** ▶
**Spectral linewidth reduction of single-mode and mode-locked lasers using a feed-forward heterodyne detection scheme,** Regan Watts[1], Stuart G. Murdoch[2], Liam Barry[1]; [1]*School of Electronic Engineeering, Dublin City Univ., Ireland;* [2]*Dept. of Physics, Univ. of Auckland, New Zealand.* We present a novel feed-forward laser linewidth reduction scheme. The linewidth of a DFB laser is reduced from 9.4MHz to 37.2kHz. Sixteen modes of a mode-locked laser are simultaneously reduced from ~20MHz to below 300kHz.

Marriott
Willow Glen I-III

## CLEO: Applications & Technology

### ATh3P • Symposium on Advanced Ultrashort Pulse Laser Technologies in Biophotonics and Nanobiophotonics I—Continued

**ATh3P.6 • 15:30** ▶
**Electrically-Tunable Multi-Color Ultrafast Cherenkov Fiber Laser,** Ask S. Svane[1], Xiaomin Liu[1], Jesper Lægsgaard[1], Haohua Tu[2], Stephen A. Boppart[2], Dmitry Turchinovich[1,3]; [1]*DTU Fotonik, Technical Univ. of Denmark, Denmark;* [2]*Biophotonics Imaging Lab, Univ. of Illinois, USA;* [3]*Max Planck Inst. for Polymer Research, Germany.* We demonstrate the broadband electrical tunability of ultrafast fiber laser output across the visible range, from the deep blue to the infrared.

**ATh3P.7 • 15:45** ▶
**Femtosecond 905nm-940nm band Nd:fiber laser,** Xiang Gao[1], Weijian Zong[1], Bingying Chen[1], Jian Zhang[1], Chen Li[1], Yizhou Liu[1], Aimin Wang[1], Yangrong Song[2], Zhigang Zhang[1]; [1]*School of Electronics Engineering and Computer Science, Peking Univ., China;* [2]*School of Applied Science, Beijing Univ. of Technology, China.* We demonstrate a passively all-normal dispersion mode-locked Nd-doped fiber laser at 905-940 nm with high optical to optical efficiency. The central wavelengths can be tunable through tuning birefringent filter.

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**16:00–16:30 Coffee Break,** *Concourse Level*

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## Executive Ballroom 210A

### CLEO: QELS-Fundamental Science

### 16:30– 18:30
### FTh4A • Quantum Sensing and Metrology
*Presider: Yuao Chen; Univ of Science and Technology of China, China*

**FTh4A.1 • 16:30**
**High-resolution, stimulated-emission-based measurement of the joint spectral correlations of photon pairs produced in optical fiber,** BIN FANG[1], Offir Cohen[2], Marco Liscidini[3], John E. Sipe[4], Virginia Lorenz[1]; *[1]Dept. of Physics and Astronomy, Univ. of Delaware, USA; [2]Joint Quantum Inst., National Inst. of Standards and Technology & Univ. of Maryland, USA; [3]Dept. of Physics, Univ. of Pavia, Italy; [4]Dept. of Physics and Inst. for Optical Sciences, Univ. of Toronto, Canada.* We demonstrate the measurement of photon-pair joint spectral correlations in optical fiber through stimulated four-wave mixing. This method enables us to study correlations more easily, precisely and quickly than with traditional coincidence counting measurements.

**FTh4A.2 • 16:45**
**High-resolution measurement of the joint spectral density of quantum correlated photon pairs,** Andreas Eckstein[1], Guillaume Boucher[1], A. Lemaitre[2], P. Filloux[1], Giuseppe Leo[1], John E. Sipe[3], Marco Liscidini[4], Sara Ducci[1]; *[1]Université Paris Diderot,, France; [2]Laboratoire de Photonique et de Nanostructures, France; [3]Univ. of Toronto, Canada; [4]Universita degli Studi di Pavia, Italy.* We show that the characterization of the quantum correlations generated by a photon- pair source can be directly performed via a classical measurement leading to an unprecedented spectral resolution and a shorter integration time.

**FTh4A.3 • 17:00**
**Record-efficiency biphoton correlator and observation of high-order dispersion cancellation,** Joseph M. Lukens[1], Amir Dezfooliyan[1], Carsten Langrock[2], Martin M. Fejer[2], Daniel E. Leaird[1], Andrew M. Weiner[1]; *[1]Electrical and Computer Engineering, Purdue Univ., USA; [2]Edward L. Ginzton Lab, Stanford Univ., USA.* We construct an ultrafast biphoton correlator with a record pair conversion efficiency of 1e-5 based on sum-frequency generation in a PPLN waveguide, enabling us to demonstrate high-order dispersion cancellation for the first time.

## Executive Ballroom 210B

### CLEO: Science & Innovations

### 16:30– 18:30
### STh4B • Laser-Driven Dynamics in Materials
*Presider: Richard Haglund; Vanderbilt Univ., USA*

**STh4B.1 • 16:30** Invited
**Ultrafast Electron Dynamics in Photoexcited Semiconductors Studied by Time and Angle-resolved Two Photon Photoelectron Spectroscopy,** Junichi Kanasaki[1]; *[1]Osaka Univ., Japan.* Ultrafast dynamics of photo-excited electrons with non-equilibrium distribution in GaAs has been studied on femtosecond time scale, by means of energy- and angle-resolved two-photon photoelectron spectroscopy. Fundamental scattering processes governing their energy relaxation are elucidated.

**STh4B.2 • 17:00**
**Unusual phenomena with self-organized nanogratings written in silica glass with a femtosecond laser,** Nathaniel Groothoff[1], Audrey Champion[1], Max-Oliver Hongler[2], Yves Bellouard[1]; *[1]Mechanical Engineering, Eindhoven Univ. of Technology, Netherlands; [2]Faculty of Engineering and Technology (STI), Ecole Polytechnique Fédérale de Lausanne, Switzerland.* Femtosecond laser written nanogratings show a random transition from self-organized to disordered structure and vice versa. A reason for the transition is proposed. Overlapping laser scans create nanogratings with apparent self-aligned fringes.

## Executive Ballroom 210C

### CLEO: QELS-Fundamental Science

### 16:30– 18:30
### FTh4C • Carrier Dynamics in 0-D and 1-D Nanostructures
*Presider: Rohit Prasankumar; Los Alamos National Lab, USA*

**FTh4C.1 • 16:30**
**Exciton-Phonon Interactions in an InAs Quantum Dot Ensemble Studied with 2D Coherent Spectroscopy,** Takeshi Suzuki[1], Rohan Singh[1,2], Galan Moody[1,2], Marc Assmann[1,3], Ilya Akimov[3,4], Manfred Bayer[3], Dirk Reuter[5], Andreas Wieck[5], Steven T. Cundiff[1,2]; *[1]JILA, Univ. of Colorado and National Inst. of Standards and Technology, USA; [2]Physics, Univ. of Colorado, USA; [3]Experimentelle Physik 2, Technische Universität Dortmund, Germany; [4]A. F. Ioffe Physical-Technical Inst., Russian Academy of Sciences, Russia; [5]Angewandte Festkörperphysik, Technische Universität Bochum, Germany.* 2D coherent spectroscopy is used to study exciton-phonon interactions in an InAs quantum dot ensemble. Temperature and size dependent properties of the zero-phonon line and the phonon background in the s- and p-shells are revealed.

**FTh4C.2 • 16:45**
**Subpicosecond adiabatic rapid passage in a single InGaAs quantum dot: Role of phonons in dephasing,** Reuble Mathew[1], Eric Dilcher[1], Angela Gamouras[1], Ajan Ramachandran[1], Sabine Freisem[2], Dennis Deppe[2], Kimberley Hall[1]; *[1]Dalhousie Univ., Canada; [2]Univ. of Central Florida, USA.* Robust excitation of an exciton state via adiabatic rapid passage is demonstrated in a single InGaAs quantum dot using subpicosecond optical pulses. A chirp sign dependence of the transfer efficiency indicates dephasing tied to phonons.

**FTh4C.3 • 17:00**
**Investigation of Quantum Dot—Quantum Dot Coupling at High Hydrostatic Pressure,** Sheng Liu[1,2], Binsong Li[1], Hongyou Fan[1], Ting S. Luk[1,2], Michael B. Sinclair[1], Igal Brener[1,2]; *[1]Sandia National Labs, USA; [2]Center for Integrated Nanotechnologies, USA.* We performed photoluminescence and radiative lifetime measurements of quantum dots (QDs) showing different carrier dynamic mechanisms at elevated pressures that could reveal the inter-QD coupling as the QDs spacing decreases with increasing hydrostatic pressure.

## Executive Ballroom 210D

### 16:30– 18:30
### FTh4D • Nonlinear Metamaterials and Cooling
*Presider: Demetrios Christodoulides; Univ. of Central Florida, USA*

**FTh4D.1 • 16:30** Invited
**Inducing Giant Nonreciprocal Effects in Metamolecules, Metasurfaces and Metamaterials,** Andrea Alu[1]; *[1]Univ. of Texas at Austin, USA.* We discuss venues to realize magnetic-free nonreciprocal integrated components based on linear and/or nonlinear metamaterials. These solutions, being based on azimuthal spatio-temporal modulation or nonlinear effects, are ideally suited for newly-developed metasurfaces with giant nonlinearities.

**FTh4D.2 • 17:00** Invited
**Phase Mismatch-Free Nonlinear Propagation in Optical Zero-Index Materials,** Kevin O'Brien[1], Haim Suchowski[1], Zi Jing Wong[1], Alessandro Salandrino[1], Xiaobo Yin[1], Xiang Zhang[1,2]; *[1]NSF Nano-scale Science and Engineering Center (NSEC), UC Berkeley, USA; [2]Materials Sciences Division, Lawrence Berkeley National Lab, USA.* Phase-matching is critical for coherent nonlinear optical processes, allowing nonlinear sources to combine constructively, resulting in more efficient emission. We experimentally demonstrate phase mismatch-free nonlinear propagation in a bulk zero index metamaterial.

## CLEO: Science & Innovations

### Executive Ballroom 210E

**16:30– 18:30**

### STh4E • OPO, OPA and Regenerative Amplifiers

*Presider: Takao Fuji; National Inst.s of Natural Sciences, Japan*

**STh4E.1 • 16:30**

**Regenerative Amplification of Ultrashort Pulses at 2 µm with a Thulium-doped YAP Crystal,** Andreas Wienke[1], Dieter Wandt[1], Uwe Morgner[1,2], Jörg Neumann[1], Dietmar Kracht[1]; [1]*Laser Zentrum Hannover e.V., Germany;* [2]*Institut für Quantenoptik, Leibniz Universität Hannover, Germany.* Seed pulses at nJ-level of a fiber-based pre-amplified Thulium oscillator are amplified to µJ-level at 1 kHz repetition rate in a regenerative amplifier based on a Thulium-doped YAP crystal with 355 fs compressed pulse duration.

**STh4E.2 • 16:45**

**Multi-kHz, High Energy, Femtosecond Diode-Pumped Yb:CaF$_2$ Regenerative Amplifier,** Etienne Caracciolo[1,2], Matthias Kemnitzer[2], Annalisa Guandalini[2], Federico Pirzio[1], Juerg Au der Au[2], Antonio Agnesi[1]; [1]*Universita degli Studi di Pavia, Italy;* [2]*High Q Laser GmbH, Austria.* We report an efficient, high-energy, diode-pumped Yb:CaF$_2$ regenerative amplifier. Energies up to 1.02 mJ at 1045-nm and 5 kHz-repetition rate in 324 fs-long pulses have been obtained with a beam quality factor of $M^2$ =1.1.

**STh4E.3 • 17:00**

**Self-stabilization of an Intracavity Pumped fs Optical Parametric Oscillator,** Xuan Luo[1], Jean-Claude M. Diels[1], Ladan Arissian[1]; [1]*Center for High Technology Materials, Univ. of New Mexico, USA.* It is shown that auto-stabilization of an intracavity pumped Optical Parametric Oscillator can be achieved by exploiting the cascaded nonlinearities that are at the root of phase instabilities of this system.

### Executive Ballroom 210F

**16:30– 18:30**

### STh4F • THz Imaging

*Presider: Hynek Nemec; Inst. of Physics - Academy of Sciences Czech Republic, Czech Republic*

**STh4F.1 • 16:30** Invited

**Sparse Imaging with Metamaterials at Terahertz Frequencies,** Willie J. Padilla[1]; [1]*Boston College, USA.* Metamaterials are composite structures which permit unprecedented control over light matter interactions. Here we show use of metamaterials as spatial light modulators permitting single pixel compressive imaging at terahertz frequencies.

**STh4F.2 • 17:00**

**Zenneck THz Surface Waves-assisted Imaging of Subwavelength Dielectric Particles,** Miguel Navarro-Cia[1,2], Michele Natrella[2], Filip Dominec[3], Jean-Christophe Delagnes[4], Petr Kuzel[3], Patrick Mounaix[4], Chris Graham[2], Cyril C. Renaud[2], Alwyn J. Seeds[2], Oleg Mitrofanov[2]; [1]*Electrical and Electronic Engineering, Imperial College London, UK;* [2]*Electronic & Electrical Engineering, Univ. College London, UK;* [3]*Inst. of Physics, Academy of Sciences of the Czech Republic, Czech Republic;* [4]*LOMA, Bordeaux 1 Univ., France.* Electromagnetic Zenneck THz surface waves propagating on a bow-tie antenna are employed for time-resolved near-field imaging of subwavelength-size SrTiO$_3$ and TiO$_2$ particles. This approach provides high contrast, high-spatial resolution imaging through enhancing the field-particle interaction.

### Executive Ballroom 210G

**16:30– 18:30**

### STh4G • Quantum Cascade Lasers II

*Presider: Michael Wanke; Sandia National Labs, USA*

**STh4G.1 • 16:30**

**Active Frequency-Noise Reduction of a Mid-IR Quantum Cascade Laser without Optical Frequency Reference,** Lionel Tombez[1], Stephane Schilt[1], Thomas Südmeyer[1]; [1]*Univ. of Neuchatel, Switzerland.* Frequency-noise reduction of a 4.55-µm distributed-feedback quantum cascade laser is demonstrated using the voltage fluctuations across its junction as an error signal only. A 10-fold reduction of the frequency-noise power spectral density is achieved.

**STh4G.2 • 16:45**

**A Detailed Experimental Study of Frequency Noise in Mid-Infrared Distributed Feedback Quantum Cascade Lasers,** Stephane Schilt[1], Lionel Tombez[1], Stephane Blaser[2], Romain Terazzi[2], Camille Tardy[2], Richard Maulini[2], Alfredo Bismuto[2], Tobias Gresch[2], Michel Rochat[2], Antoine Muller[2], Thomas Südmeyer[1]; [1]*Laboratoire Temps-Fréquence, Université de Neuchatel, Switzerland;* [2]*Alpes Lasers SA, Switzerland.* Flicker noise was studied in a set of 20 QCLs at 7-8 µm, showing significant differences among the devices and the probable existence of various noise sources. Ridge-waveguide lasers showed lower noise than buried-heterostructures.

**STh4G.3 • 17:00**

**Electron localization in quantum cascade heterostructures due to interface roughness,** Michael Harter[1], Yamac Dikmelik[2], Anthony J. Hoffman[1]; [1]*Electrical Engineering, Univ. of Notre Dame, USA;* [2]*Electrical Engineering, Johns Hopkins Univ., USA.* The localization of electron wavefunctions due to interface roughness in a quantum cascade heterostructures is investigated by observing the electroluminescence spectra. Localization is more prominent in heterostructures with designed extended states.

### Executive Ballroom 210H

**16:30– 18:30**

### STh4H • Plasmonics, Raman and Resonance Sensing

*Presider: Ralph Jimenez; Univ. of Colorado at Boulder, USA*

**STh4H.1 • 16:30**

**Surface-Enhanced Raman Scattering Immuno-Assay Using Diatom Frustules,** Jing Yang[1], Fanghui Ren[1], Le Zhen[1], Jeremy Campbell[1], Gregory L. Rorrer[1], Alan X. Wang[1]; [1]*Oregon State Univ., USA.* An immunoassay based on surface-enhanced Raman scattering has been developed using diatom frustules to detect antigens with high sensitivity. It was found that the diatom frustules provide 6× higher sensitivity than traditional glass substrates.

**STh4H.2 • 16:45**

**Nanopore fluidic SERS,** chang chen[1,2], Yi Li[1,2], Sarp Kerman[1,2], Pieter Neutens[1,2], Liesbet Lagae[1,2], Tim Stakenborg[1], Pol Van Dorpe[1,2]; [1]*imec, Belgium;* [2]*KU Leuven, Belgium.* We describe a technology combining nanopore fluidic with surface enhanced Raman spectroscopy (SERS) for real-time, single molecule detection at 10 ms level.

**STh4H.3 • 17:00**

**3D plasmonic hollow nanoantennas as tools for neuroscience applications,** Michele Dipalo[1], Mario Malerba[1], Gabriele C. Messina[1], Rosanna La Rocca[1], Ermanno Miele[1], Hayder Amin[1], Alessandro Maccione[1], Luca Berdondini[1], Francesco De Angelis[1]; [1]*Istituto Italiano di Tecnologia, Italy.* 3D plasmonic nanoantennas were fabricated on active biodevices for in-vitro neuroscience experiments. The technique consents to realize nanoantennas patterns suitable for neurons culture and that can be used concurrently as intracellular nanoelectrodes and spectroscopic probes.

## Meeting Room 211 B/D

### CLEO: Science & Innovations

**16:30– 18:30**
**STh4I • Novel Photodetectors**
*Presdier: Tingyi Gu, Columbia Univ., USA*

**STh4I.1 • 16:30**
**Mid-infrared graphene detectors with antenna-enhanced light absorption and photo-carrier collection,** Yu Yao[1], Raji Shankar[1], Patrick Rauter[1], Yi Song[2], Jing Kong[2], Marko Loncar[1], Federico Capasso[1]; *[1]SEAS, Harvard Univ., USA; [2]Electrical Engineering and Computer Science, MIT, USA.* We demonstrated antenna-assisted mid-infrared graphene detectors at room temperature with more than 200 times enhancement of responsivity ( 0.4 V/W at $\lambda0=4.45$ μm) compared to devices without antennas (<2 mV/W).

**STh4I.2 • 16:45**
**Mid-Infrared GaN/AlxGa1-xN Quantum Cascade Detectors Grown by MOCVD,** Yu Song[1], Rajaram Bhat[2], Pranav Badami[1], Tzu-Yung Huang[1], Zah Chung-En[2], Claire F. Gmachl[1]; *[1]Princeton Univ., USA; [2]Corning Incorporated, USA.* A III-nitride-based Quantum Cascade detector grown by MOCVD is designed, fabricated and tested. Peak responsivity of 100 μA/W with detectivity of up to 10^8 Jones at ~ 4 μm is measured.

**STh4I.3 • 17:00**
**High-responsivity 1.7-μm-long InGaAs photodetectors based on photonic crystal with ultrasmall buried heterostructure,** Kengo Nozaki[1,2], Shinji Matsuo[1,3], Koji Takeda[1,3], Tomonari Sato[1,3], Takuro Fujii[1,3], Eiichi Kuramochi[1,2], Masaya Notomi[1,2]; *[1]NTT Nanophotonics Center, Japan; [2]NTT Basic research Labs, Japan; [3]NTT Photonics Labs, Japan.* InGaAs-embedded photonic crystal photodetectors were demonstrated towards realizing photoreceivers with small junction capacitance. A 1-A/W responsivity and a 40-Gb/s eye opening were successfully confirmed for the 1.7-μm-long device.

## Meeting Room 212 A/C

### JOINT

**16:30– 19:00**
**JTh4J • Symposium on High Performance Optics II**
*Presider: Jeff Bude; Lawrence Livermore National Lab, USA*

**JTh4J.1 • 16:30**
**Pulse Compression of a High-Energy Thin-Disk Laser at 100 W of Average Power using an Ar-filled Kagome-Type HC-PCF,** Florian Emaury[1], Clara J. Saraceno[1,2], Benoît Debord[3], Coralie Fourcade Dutin[3], Frédéric Gérôme[3], Thomas Südmeyer[2], Fetah Benabid[3], Ursula Keller[1]; *[1]ETH Zurich, Switzerland; [2]Université de Neuchâtel, Switzerland; [3]CNRS UMR 7252, Univ. of Limoges, France.* We compressed a high-energy SESAM-modelocked thin-disk laser using an Ar-filled Kagome-type HC-PCF: launching 41 μJ, 1.17 ps pulses directly from a 3-MHz oscillator, we obtain 179-fs pulses at 100 W of average power, reaching 80% overall compression efficiency.

**JTh4J.2 • 16:45** Invited
**James Webb Space Telescope (JWST): Optical Performance of a Large Deployable Cryogenic Telescope,** Paul A. Lightsey[1]; *[1]Ball Aerospace & Technologies, USA.* The JWST is a large deployable cryogenic telescope. The fabrication of the mirrors and the precision control for flight positioning of the mirrors using image based Wave Front Sensing and Control will be presented.

## Meeting Room 212 B/D

### CLEO: QELS-Fundamental Science

**16:30– 18:30**
**FTh4K • Nonlinear Plasmonics: From Visible to Terahertz**
*Presider: Gennady Shvets; Univ. of Texas at Austin, USA*

**FTh4K.1 • 16:30**
**Giant nonlinear response from plasmonic metasurfaces coupled to intersubband transitions,** JONGWON LEE[1], Christos Argyropoulos[1], Pai-Yen Chen[1], Mykhailo Tymchenko[1], Feng Lu[1], Frederic Demmerle[2], Gerhard Boehm[2], Markus Amann[2], Andrea Alu[1], Mikhail A. Belkin[1]; *[1]Univ. of Texas at Austin, USA; [2]Walter Schottky Institut, Germany.* We report highly-nonlinear metasurfaces based on coupling of electromagnetically-engineered plasmonic nanoresonators with quantum-engineered intersubband nonlinearities. Experimentally, effective nonlinear susceptibility over 50nm/V was measured for second-harmonic generation under normal incidence.

**FTh4K.2 • 16:45**
**7.5% Optical-to-Terahertz Conversion Efficiency through Use of Three-Dimensional Plasmonic Electrodes,** Shang Hua Yang[1,2], Mohammed R. Hashemi[1,2], Christopher W. Berry[1], Mona Jarrahi[1,2]; *[1]Electrical Engineering and Computer Science Dept., Univ. of Michigan, USA; [2]Electrical Engineering Dept., Univ. of California Los Angeles, USA.* We present a high-efficiency photoconductive terahertz source based on high-aspect ratio plasmonic contact electrodes. At an optical pump power of 1.4 mW, a record-high optical-to-terahertz conversion efficiency of 7.5%.

**FTh4K.3 • 17:00**
**Ultrafast Multi-Terahertz Nanoscopy with Sub-Cycle Temporal Resolution,** Max Eisele[1], Tyler L. Cocker[1], Markus Huber[1], Leonardo Viti[2], Lucia Sorba[2], Miriam S. Vitiello[2], Rupert Huber[1]; *[1]Dept. of Physics, Univ. of Regensburg, Germany; [2]NEST, CNR - Istituto Nanoscienze and Scuola Normale Superiore, Italy.* We combine ultrafast multi-terahertz spectroscopy and near-field microscopy to achieve sub-wavelength spatial (~15 nm) and sub-cycle temporal (~9 fs) resolution. We apply our novel system to photoexcited InAs nanowires and resolve femtosecond carrier dynamics - spatially, temporally and spectrally.

## Marriott Salon I & II

### JOINT

**16:30– 18:30**
**JTh4L • Symposium on Laser-Driven Sources of Particle and X-Ray Beams III** ▶
*Presider: François Légaré; INRS-Energie Mat & Tele Site Varennes, Canada*

**JTh4L.1 • 16:30** Invited ▶
**Picosecond Thin-Disk Lasers,** Thomas Metzger[1], Martin Gorjan[2,3], Moritz Ueffing[2], Catherine Y. Teisset[1], Marcel Schultze[1], Robert Bessing[1], Matthias Häfner[1], Stephan Prinz[1], Dirk Sutter[4], Knut Michel[1], Helena Barros[2], Zsuzsanna Major[2], Ferenc Krausz[2,3]; *[1]TRUMPF Scientific Lasers GmbH + Co. KG, Germany; [2]Dept. für Physik, Ludwig-Maximilians-Universität München, Germany; [3]Max-Planck-Institut für Quantenoptik, Germany; [4]TRUMPF Laser GmbH + Co. KG, Germany.* Short-pulse pumped optical parametric chirped pulse amplification (OPCPA) demands powerful picosecond lasers with high average powers and high pulse energies. We report on the current picosecond thin-disk amplifiers development and their applications in research.

**JTh4L.2 • 17:00** ▶
**Advances in Industrial Grade Tisa Petawatt Lasers for Accelerators,** Christophe A. Simon-Boisson[1], François Lureau[1], Guillaume Matras[1], Sébastien Laux[1], Olivier Casagrande[1], Christophe Radier[1], Olivier Chalus[1], Laurent Boudjemaa[1]; *[1]Thales Optronique SAS, France.* We review the recent results achieved on industrial grade Titanium Sapphire PetaWatt lasers demonstrating clear improvements. Key enabling technologies are presented. Perspectives towards higher peak power of 10 PW are discussed.

## CLEO: Science & Innovations

### Marriott
### Salon III

**16:30– 18:30**
**STh4M • Silicon Modulstors** ▶
*Presider: Jessie Rosenberg; IBM T. J. Watson Research Center, USA*

**STh4M.1 • 16:30** ▶
**Hydrogenated Amorphous Silicon Microcylindrical Resonators for Ultrafast Modulation,** Natasha Vukovic[1], Noel Healy[1], Fariza Suhailin[1], Priynath Mehta[1], Todd Day[2], John Badding[2], Anna C. Peacock[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK;* [2]*Dept. of Chemistry and Materials Research Inst., Pennsylvania State Univ., USA.* We report on the large Kerr induced wavelength shift observed in our hydrogenated amorphous silicon microresonators and demonstrate their use for all-optical modulation and switching on picosecond time scales with only subpicojoule pulse energies.

**STh4M.2 • 16:45** ▶
**Add-drop Microring Resonator for Electro-optical Switching and Optical Power Monitoring,** Anna Lena Giesecke[1], Andreas Prinzen[1], Jens Bolten[1], Caroline Porschatis[1], Bartos Chmielak[1], Christopher Matheisen[1], Thorsten Wahlbrink[1], Holger Lerch[1], Michael Waldow[1], Heinrich Kurz[1]; [1]*AMO GmbH, Germany.* Microring based silicon depletion modulators with high extinction ratio (>25dB) are used for high frequency modulation and as resonant photodetectors at 1340nm (O-band). Photocurrent and power enhancement are investigated for modulators with different Q-factors.

**STh4M.3 • 17:00** ▶
**High speed Si modulators with high modulation efficiency and low free carrier absorption by depleting carriers through fringe field junctions,** Kai-Ning Ku[1], Ming-Chang M. Lee[1]; [1]*Inst. of Photonics Technologies and Dept. of Electrical Engineering, National Tsing Hua Univ., Taiwan.* A high speed Si modulator with fringe field junctions is presented. Low carrier absorption (1.3 dB/mm) and $V\pi L$ (1.8 V-cm) are demonstrated. The measured modulation speed and depth are 11.8-GHz and 8-dB.

### Marriott
### Salon IV

**16:30– 18:30**
**STh4N • Coherent Combination and Amplification**
*Presider: Michalis Zervas; Univ. of Southampton, UK*

**STh4N.1 • 16:30** Invited
**Phase-locked Multicore Fiber Lasers,** Akira Shirakawa[1]; [1]*Univ. of Electro-Communications, Japan.* Arraying fiber lasers is being focused for power and energy scaling and multicore fibers can be a promising format. Phase locking in evanescently-coupled multicore fiber lasers by various in-phase mode selection methods is presented.

**STh4N.2 • 17:00**
**4-fold Increase of the Mode-instability Threshold in an Yb-doped Multi-core Fiber Amplifier Emitting 536 W,** Hans-Jürgen Otto[1], Arno Klenke[1,2], Cesar Jauregui[1], Fabian Stutzki[1], Jens Limpert[1,2], Andreas Tünnermann[1,3]; [1]*Inst. of Applied Physics, Germany;* [2]*Helmholtz-Inst. Jena, Germany;* [3]*Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany.* A compact, pulsed MOPA fiber-laser system employing a 4 core photonic-crystal fiber is presented that exhibits a 4 times increased mode-instability threshold. An average power of 536W with nearly diffraction limited beam quality was achieved.

### Marriott
### Salon V & VI

**16:30– 18:30**
**STh4O • Gravity and Distance Measurements** ▶
*Presider: Kristan Corwin; Kansas State Univ., USA*

**STh4O.1 • 16:30** Invited ▶
**High Sensitivity Gravity Measurement with Cold Atom Interferometry,** Zhongkun Hu[1], Xiao-Chun Duan[1], Min-Kang Zhou[1], Le-Le Chen[1]; [1]*Huazhong Univ of Science and Technology, China.* We report the work of exploring atom interferometry techniques to perform precision gravity measurements in our Lab. The noise suppressions and related modulation experiments for the atom gravimeter will be presented in detail.

**STh4O.2 • 17:00** ▶
**Coherent asynchronous sampling distance measurement using a single polarization-multiplexed ultrafast laser,** Xin Zhao[1], Zheng Gong[1], Ya Liu[1], Jiansheng Liu[1], Zheng Zheng[1]; [1]*School of Electronic and Information Engineering, Beihang Univ., China.* Laser ranging based on asynchronous sampling of ultrashort optical pulses is proposed and experimentally demonstrated using just one polarization-multiplexed mode-locked fiber laser, which produces two orthogonal polarized, coherent pulse trains with slightly different repetition rates.

## CLEO: Applications & Technology

### Marriott
### Willow Glen I-III

**16:30– 18:30**
**ATh4P • Symposium on Advanced Ultrashort Pulse Laser Technologies in Biophotonics and Nanobiophotonics II** ▶
*Presider: Emma Springate; STFC Rutherford Appleton Lab, UK*

**ATh4P.1 • 16:30** Invited ▶
**Plasmonic Nanobubble Theranostics: Detection and Destruction of Drug-Resistant Tumors in a Single Rapid Procedure,** Dmitri Lapotko[1]; [1]*Biochemistry and Cell Biology, Rice Univ., USA.* On-demand plasmonic nanobubbles combine highly sensitive detection and guided destruction of drug-resistant tumors, minimize non-specific toxicity in a rapid theranostic procedure that converts current "macro" treatments into a cancer cell level "micro' modality.

**ATh4P.2 • 17:00** ▶
**Octave Spanning Mid-Infrared Frequency Comb Generation in Silicon Nanophotonic Wire Waveguides,** Bart Kuyken[1,2], Takuro Ideguchi[3], Simon Holzner[3], Ming Yan[3], Theodor W. Haensch[3], Joris Van Campenhout[4], Peter Verheyen[4], Roel Baets[1,2], Gunther Roelkens[1,2], Nathalie Picqué[3]; [1]*Photonics Research Group, Belgium;* [2]*Center for Nano- and Biophotonics, Ghent Univ., Belgium;* [3]*Max Planck Institut für Quantenoptik, Germany;* [4]*imec, Belgium.* A mid-infrared octave spanning frequency comb is generated in a silicon waveguide. By beating the generated comb on a photodetector with a narrow linewidth lightsource the linewidth of the lines is measured to be <100kHz.

## Executive Ballroom 210A

### CLEO: QELS-Fundamental Science

### FTh4A • Quantum Sensing and Metrology—Continued

**FTh4A.4 • 17:15**
**Quantum-Enhanced Precision in Unitary Process Tomography,** Rebecca Whittaker[1], Xiao-Qi Zhou[1], Jonathan Matthews[1], Jeremy L. O'Brien[1], Pete Shadbolt[1], Hugo Cable[2,1]; *[1]Centre for Quantum Photonics, Univ. of Bristol, UK; [2]Centre for Quantum Technologies, National Univ. of Singapore, Singapore.* A novel scheme for unitary quantum process tomography (QPT) is theoretically presented and implemented experimentally. Multi-photon input states are used to obtain quantum-enhanced precision for the unitary estimation. Our results are compared to standard QPT.

**FTh4A.5 • 17:30**
**Sub-wavelength interferencing with thermal light,** Yanhua Zhai[1], Francisco. Becerra[1], Jianming Wen[2], Jingyun Fan[1], Alan L. Migdall[1]; *[1]JQI NIST and Univ. of Maryland, USA; [2]Dept. of Applied Physics, USA.* By using photon-number-resolving detection, high-order correlation interference with thermal light offers high spatial resolution and visibility. Experimentally, a fringe width of 15 nm is obtained for a light wavelength of 780 nm.

**FTh4A.6 • 17:45**
**Experimental demonstration of fundamental bounds in quantum measurements for estimating quantum states,** Hyang-Tag Lim[1], Young-Sik Ra[1], Kang-Hee Hong[1], Seung-Woo Lee[2], Yoon-Ho Kim[1]; *[1]Dept. of Physics, Pohang Univ. of Science and Technology (POSTECH), Korea; [2]Dept. of Physics and Astronomy, Dartmouth College, USA.* We investigate the conditions of an optimal measurement for estimating quantum states with minimal disturbance and maximal reversibility, and experimentally implement it in three-dimensional quantum states encoded by the single photon's polarization and path.

**FTh4A.7 • 18:00**
**Scalable Spatial Super-Resolution using Entangled Photons,** Lee Rozema[1], James D. Bateman[1], Dylan Mahler[1], Amir Feizpour[1], Ryo Okamoto[2], Alex Hayat[1,3], Aephraim M. Steinberg[1]; *[1]Dept. of Physics, Univ. of Toronto, Canada; [2]Research Inst. for Electronic Science, Hokkaido Univ., Japan; [3]Dept. of Electrical Engineering, Technion, Israel.* We demonstrate spatial super-resolution, performing an optical centroid measurement on 4-photon N00N states with a scalable 11-detector measurement. Our results show spatial super-resolution with exponentially better detection efficiency than any previous N00N-state experiment.

## Executive Ballroom 210B

### CLEO: Science & Innovations

### STh4B • Laser-Driven Dynamics in Materials—Continued

**STh4B.3 • 17:15**
**Controlling ablation mechanisms in sapphire by irradiation with temporally shaped femtosecond laser pulses,** Javier Hernandez-Rueda[1], Mario Garcia-Lechuga[1], Jan Siegel[1], Javier Solis[1]; *[1]Instituto De Optica "Daza De Valdes", Spain.* The use of temporally shaped femtosecond laser pulses is shown to enable the control of ablation mechanisms in Sapphire ranging from gentle over strong ablation to explosive boiling.

**STh4B.4 • 17:30**
**Exciton-related electroluminescence from monolayer MoS2,** Yu Ye[1], Ziliang Ye[1], Majid Gharghi[1], Xiaobo Yin[1], Hanyu Zhu[1], Mervin Zhao[1], Xiang Zhang[1]; *[1]UC Berkeley, USA.* We studied the microscopic origin of the electroluminescence from monolayer MoS2 fabricated on a heavily p-type doped silicon substrate. Auger recombination of the exciton-exciton annihilation of bound exciton emission is observed.

**STh4B.5 • 17:45**
**Double-Confinement in Plasmonic Resonators,** Arthur Montazeri[1], Michael Fang[1], Nazir P. Kherani[1], Peyman Sarrafi[1]; *[1]Univ. of Toronto, Canada.* We present a new model to investigate slow-light and light trapping with plasmonic gratings. Controlling plasmon coupling strength in narrow waveguide resonators is used as the building blocks of gratings.

**STh4B.6 • 18:00**
**Filament Interaction with Micro-Water Droplets,** Cheonha Jeon[1], Magali M. Durand[1], Matthieu Baudelet[1], Martin Richardson[1]; *[1]Townes Laser Inst., CREOL, UCF, USA.* The interaction of a laser filament with water droplets was studied to understand the energy dissipation of filaments in aerosols. Shockwave analysis allows the quantification of the energy balance. We discuss the survival of filaments.

## Executive Ballroom 210C

### CLEO: QELS-Fundamental Science

### FTh4C • Carrier Dynamics in 0-D and 1-D Nanostructures—Continued

**FTh4C.4 • 17:15**
**Thresholdless Optical Gain using Colloidal HgTe Nanocrystals,** Pieter Geiregat[1,2], Arjan Houtepen[3], Laxmi Kishore Sagar[2], Christophe Delerue[4], Dries Van Thourhout[1], Zeger Hens[2]; *[1]Information Technology, Universiteit Gent, Belgium; [2]Inorganic and Physical Chemistry, Universiteit Gent, Belgium; [3]Chemistry, Technische Universiteit Delft, Netherlands; [4]IEMN, France.* Thresholdless stimulated emission is observed using nanometer sized colloidal HgTe nanocrystals, in a broad spectral region covering the entire technologically relevant near-infrared spectrum.

**FTh4C.5 • 17:30**
**Ultrafast Optical Properties of PbSe Nano-Rods: One Dimensional Excitons,** Eli Kinigstein[1], Shu-Wei Huang[1], Matthew Sfeir[2], Weon-Kyu Koh[4], Christopher Murray[3], Tony F. Heinz[1], Chee Wei Wong[2]; *[1]Columbia Univ., USA; [2]Center For Functional Nanomaterials, Brookhaven National Laborotory, USA; [3]Univ. of Pennsylvania, USA; [4]Los Alamos National Lab, USA.* Using Supercontinuum Transient Absorption Spectroscopy we observe new ultrafast exciton dynamics in PbSe Nanorods. We report distinct types of biexcitonic interactions, and propose a model to quantitatively describe the bleach using the predicted electronic structure.

**FTh4C.6 • 17:45**
**Towards Single Molecule Infrared Vibrational Spectroscopy and Dynamics,** Joanna M. Atkin[1], Paul Sass[1], Jonas Allerbeck[1], Markus B. Raschke[1]; *[1]Dept. of Physics, Dept. of Chemistry, and JILA, Univ. of Colorado, USA.* We demonstrate ultrafast infrared vibrational free-induction decay probing in scattering-scanning near-field microscopy. We observe long-lived few picosecond vibrational coherences, far in excess of the far-field ensemble response.

**FTh4C.7 • 18:00**
**Ultrafast non-thermal response of Plasmonic resonance in Gold Nanoantennas,** Giancarlo Soavi[1], Giuseppe Della Valle[1], Paolo Biagioni[1], Andrea Cattoni[2], Giulio Cerullo[1], Daniele Brida[3]; *[1]Dipartimento di Fisica, Politecnico di Milano, Italy; [2]Laboratoire de Photonique et de Nanostructures, France; [3]Dept. of Physics and Center for Applied Photonics, Univ. of Konstanz, Germany.* Ultrafast thermalization of electrons in metal nanostructures is studied by means of pump-probe spectroscopy. We track in real-time the plasmon resonsance evolution, providing a tool for understanding and controlling gold nanoantennas non-linear optical response.

## Executive Ballroom 210D

### FTh4D • Nonlinear Metamaterials and Cooling—Continued

**FTh4D.3 • 17:30**
**Color-preserving daytime radiative cooling,** Linxiao Zhu[1], Aaswath Raman[2], Shanhui Fan[2]; *[1]Applied Physics, Stanford Univ., USA; [2]Electrical Engineering, Stanford Univ., USA.* We introduce a general approach to radiatively lower the temperature of a structure, while preserving its color under sunlight. The cooling persists in the presence of considerable non-radiative heat exchange, and for different solar absorptances.

**FTh4D.4 • 17:45**
**Optical refrigeration cools below 100K,** Seth Melgaard[1,2], Alexander R. Albrecht[1], Markus Hehlen[3], Denis Seletskiy[4], Mansoor Sheik-Bahae[1]; *[1]Univ. of New Mexico, USA; [2]Air Force Research Lab, USA; [3]Los Alamos National Labs, USA; [4]Univ. of Konstanz, Germany.* We report a milestone in optical refrigeration, cooling a 10% Yb:YLF crystal to 93K ($\Delta T$~180K); obtaining the coldest solid-state temperature to date. Identification of transition metal impurities via mass spectrometry allows further cooling through purification.

**FTh4D.5 • 18:00**
**Rotation induced cooling of an optically trapped microgyroscope in vacuum,** Yoshihiko Arita[1], Michael Mazilu[1], Kishan Dholakia[1]; *[1]School of Physics and Astronomy, Univ. of St Andrews, UK.* We demonstrate optical trapping of a microgyroscope rotating at MHz rates in vacuum. The particle is cooled to 40K. This is a major step towards measuring the Casimir force resulting in rotational quantum friction.

# CLEO: Science & Innovations

## STh4E • OPO, OPA and Regenerative Amplifiers—Continued

**STh4E.4 • 17:15**

**Burst-mode Femtosecond Non-collinear Parametric Amplifier with Arbitrary Pulse Selection,** Mikhail Pergament[1], Martin Kellert[1], Kai Kruse[1], Jinxiong Wang[1], Guido Palmer[1], Laurens Wissmann[1], Ulrike Wegner[1], Max J. Lederer[1]; [1]*European X-Ray Free-Electron Laser-Facility GmbH, Albert-Einstein-Ring 19, Germany.* We present a high power burst-mode femtosecond non-collinear parametric amplifier. High quality 15fs pulses at up to 4.5MHz intra-burst repetition rate and energies of more than 180µJ are shown. Arbitrary pulse sequences can be selected.

**STh4E.5 • 17:30**

**Simultaneous broadening of the depleted pump and signal from an optical parametric amplifier,** Derrek Wilson[1], Carlos Trallero-Herrero[1], Xiaoming Ren[1]; [1]*J. R. Macdonald Lab, Kansas State Univ., USA.* An optical parametric amplifier signal and its unconverted pump are studied as a method of waveform synthesis. Generating broad spectra with self phase modulation to create coherent multi-octave CEP stabilized pulses is discussed.

**STh4E.6 • 17:45**

**Sub-4-Cycle Pulses Directly From an All-Collinear, High-Repetition-Rate, Mid-IR OPCPA,** Benedikt W. Mayer[1], Christopher R. Phillips[1,2], Lukas Gallmann[1], Martin M. Fejer[2], Ursula Keller[1]; [1]*Inst. for Quantum Electronics, ETH Zurich, Switzerland;* [2]*Edward L. Ginzton Lab, Stanford Univ., USA.* We present an ultra-broadband OPCPA system operating at 3.4 µm delivering 41.6-fs pulses. The average output power is currently 600 mW, corresponding to 12 µJ of pulse energy at a repetition rate of 50 kHz.

**STh4E.7 • 18:00**

**Femtosecond Optical Parametric Oscillator Frequency Combs at Harmonics of the Pump Laser Repetition Frequency,** Richard A. McCracken[1], Derryck T. Reid[1]; [1]*Inst. of Photonics and Quantum Sciences, Heriot Watt Univ., UK.* Various schemes allow femtosecond OPOs to produce pulses at harmonics of their pump laser repetition frequency, ostensibly facilitating access to widely-spaced tunable frequency combs. Here, we show not all approaches possess equivalent carrier-envelope offset characteristics.

## STh4F • THz Imaging—Continued

**STh4F.3 • 17:15**

**Transmission of THz pulses through 3µm apertures: applications for near-field microscopy,** Alexander J. Macfaden[1], John L. Reno[2,3], Igal Brener[2,3], Oleg Mitrofanov[1,2]; [1]*Univ. College London, UK;* [2]*CINT, USA;* [3]*Sandia National Lab, USA.* We demonstrate that THz pulses transmitted through small apertures (~λ/100) exhibit strong evanescent components within 1µm of the aperture. Using this effect, we developed sub-wavelength aperture THz near-field probes that provide 3µm resolution.

**STh4F.4 • 17:30**

**Analysis of various kinds of solar cell using Dynamic Terahertz Emission Microscope,** Hidetoshi Nakanishi[1], Akira Ito[1], Kazuhisa Takayama[2], Iwao Kawayama[2], Hironaru Murakami[2], Masayoshi Tonouchi[2]; [1]*Dainippon Screen Mfg. Co.,Ltd, Japan;* [2]*Osaka Univ., Japan.* We developed a dynamic terahertz emission microscope to investigate dynamic response of photoexcited carriers in various kinds of solar cell, e.g. a monocrystalline silicon solar cell, a polycrystalline silicon solar cell, and a GaAs solar sell.

**STh4F.5 • 17:45**

**Terahertz near-field phase contrast imaging,** François Blanchard[1], Kenji Sumida[2], Christian Wolpert[2], Manuel Tsotsalas[2], Tomoko Tanaka[2,3], Atsushi Doi[3,4], Susumu Kitagawa[2], David G. Cooke[1], Shuhei Furukawa[2], Koichiro Tanaka[2,5]; [1]*Physics, McGill Univ., Canada;* [2]*Inst. for Integrated Cell-Material Sciences, Kyoto Universit, Japan;* [3]*CREST, Japan Science and Technology Agency, Japan;* [4]*Olympus, Japan;* [5]*Physics, Kyoto Univ., Japan.* We demonstrate a method, permitting the observation of dielectric loading of hydrocarbons into a porous coordination polymer nanocrystal (PCP), by spatially resolving the phase difference between the near-field responses of two terahertz resonators.

**STh4F.6 • 18:00**

**Real-time broadband spectroscopic terahertz imaging with diffraction grating and high-sensitivity terahertz camera,** Natsuki Kanda[1,2], Kuniaki Konishi[2], Natsuki Nemoto[3], Katsumi Midorikawa[1,2], Makoto Kuwata-Gonokami[2,3]; [1]*Laser Technology Lab., RIKEN, Japan;* [2]*Photon Science Center, The Univ. of Tokyo, Japan;* [3]*Dept. of Physics, The Univ. of Tokyo, Japan.* We developed a broadband THz spectroscopic imaging method using intense THz pulses and a high-sensitivity THz camera. By using a diffraction grating spectrometer, real-time spectroscopic imaging, or molecular-specific imaging, is realized.

## STh4G • Quantum Cascade Lasers II—Continued

**STh4G.4 • 17:15**

**Genetically Optimized Multi-Wavelengths QCL,** Guy-Maël De Naurois[1], Stefan Kalchmair[1], Tobias Mansuripur[1], Laurent Diehl[2], Christian Pflügl[2], Marko Loncar[1], Federico Capasso[1]; [1]*Harvard Univ., USA;* [2]*Eos Photonics, USA.* We present a genetically optimized multi-wavelengths laser based on an aperiodic sampled grating. We show that the grating phases and amplitudes can be optimized to flatten the spectral signature allowing multi-wavelengths operation.

**STh4G.5 • 17:30**

**High Power (>3 mW) Quantum Cascade Superluminescent Emitter,** Nyan L. Aung[1], Zhouchangwan Yu[2], Ye Yu[3], Yu Yao[4], Peter Liu[5], Xiaojun Wang[6], Jen-Yu Fan[6], Mariano Troccoli[6], Claire F. Gmachl[1]; [1]*Dept. of Electrical Engineering, Princeton Univ., USA;* [2]*Dept. of Engineering, Smith College, USA;* [3]*The Hong Kong Univ. of Science and Technology, China;* [4]*School of Engineering and Applied Science, Harvard Univ., USA;* [5]*Inst. of Quantum Electronics, ETH Zürich, Switzerland;* [6]*AdTech Optics Inc., USA.* We report high power (>3 mW) mid-infrared superluminescent emission around 2100 cm$^{-1}$ from Quantum Cascade devices. The superluminescent emission shows a Gaussian shape spectrum with FWHM of 80 cm$^{-1}$.

**STh4G.6 • 17:45**

**Development of terahertz laser frequency combs,** David P. Burghoff[1], Tsung-Yu Kao[1], Ningren Han[1], Chun Wang Ivan Chan[1], Darren J. Hayton[2], Jian-Rong Gao[2,3], John L. Reno[4], Qing Hu[1]; [1]*Dept. of Electrical Engineering and Computer Science, MIT, USA;* [2]*SRON Netherlands Inst. for Space Research, Netherlands;* [3]*Kavli Inst. of NanoScience, Delft Univ. of Technology, Netherlands;* [4]*Center for Integrated Nanotechnology, Sandia National Labs, USA.* We demonstrate broadband terahertz laser frequency combs, compact semiconductor devices that combine the high power of lasers with the broad spectra of pulsed sources.

**STh4G.7 • 18:00**

**Towards Watt-Level Performance of Terahertz Quantum Cascade Lasers,** Christoph Deutsch[1], Martin Brandstetter[1], Michael Krall[1], Hermann Detz[2], Aaron Maxwell Andrews[2], Werner Schrenk[2], Gottfried Strasser[2], Karl Unterrainer[1]; [1]*Photonics Inst., Technische Universität Wien, Austria;* [2]*Inst. for Solid-State Electronics, Technische Universität Wien, Austria.* Terahertz quantum cascade lasers have not reached watt-level output powers yet. We present surface-plasmon devices with a peak power of 0.94 W. The device consists of two symmetric active regions combined by a wafer-bonding step.

## STh4H • Plasmonics, Raman and Resonance Sensing—Continued

**STh4H.4 • 17:15**

**An Accurate Interferometric Referencing Method for Resonance Tracking in Lab-on-chip Applications,** Farshid Ghasemi[1], Ali Adibi[1]; [1]*Electrical and Computer Engineering, Georgia Inst. of Technology, USA.* Repeatability of resonance detection for on-chip microring resonators is systematically studied. An efficient interferometric method is presented to improve the accuracy by more than one order of magnitude in an 8 nm bandwidth, without any temperature control.

**STh4H.5 • 17:30**

**Wide Dynamic Range Sensing in Photonic Crystal Microcavity Biosensors,** Chun-Ju Yang[1], yi zou[1], Swapnajit Chakravarty[2], Hai Yan[1], Zheng Wang[1], Ray Chen[1,2]; [1]*The Univ. of Texas at Austin, USA;* [2]*Omega Optics Inc., USA.* We experimentally demonstrated that multiplexing of PC sensors with different geometry can achieve a wide dynamic range covering 6 orders of magnitude with potential for 8 or more orders with suitable optimization.

**STh4H.6 • 17:45**

**Plasmonic nano-optical conveyer using C-shaped engravings,** Yuxin Zheng[1], Jason Ryan[1], Paul Hansen[1], Paul Hansen[1], Yao-Te Cheng[1], Tsung-Lu Lu[1], Lambertus Hesselink[1]; [1]*Stanford Univ., USA.* We develop a near-field based optical trapping and conveyor belt system based on a novel plasmonic structure: C-shaped engraving. Using polarization rotation and wavelength switching, we demonstrate controlled transport of nanoparticles along different paths.

**STh4H.7 • 18:00**

**Gold Nanoparticle Coated Silicon Nitride Chips For Intracellular Surface-Enhanced Raman Spectroscopy,** Pieter Wuytens[1], ananth subramanian[1], Alexey Yashchenok[2], Andre Skirtach[1], Roel Baets[1]; [1]*gent Univ., Belgium;* [2]*Max-Planck Inst. of Colloids and Interfaces, Germany.* Using surface-enhanced Raman spectroscopy on gold-nanoparticle-decorated silicon nitride chips, we monitor the release of dextran-rhodamin molecules from capsules inside living cells. This demonstrates the feasibility of using photonic chips for intracellular sensing at visible wavelengths

## Meeting Room 211 B/D

### CLEO: Science & Innovations

### STh4I • Novel Photodetectors—Continued

**STh4I.4 • 17:15**
**Defect-Assisted Sub-Bandgap Avalanche Photodetection in Interleaved Carrier-Depletion Silicon Waveguide for Telecom Band,** Boris Desiatov[1], Ilya Goykhman[1], Joseph Shappir[1], Uriel Levy[1]; [1]*Hebrew Univ. of Jerusalem, Israel.* We experimentally demonstrate avalanche sub bandgap detection of light at 1550 nm wavelength via surface states using the configuration of interleaved PN junctions along a silicon waveguide. The device operates in a fully depleted mode.

**STh4I.5 • 17:30**
**Polarization-resolved Imaging using Elliptical Silicon Nanowire Photodetectors,** Hyunsung Park[1], Kenneth B. Crozier[1]; [1]*School of Engineering and Applied Sciences, Harvard Univ., USA.* We fabricate photodetectors comprising silicon nanowires with elliptical cross sections, and show that their spectral responsivities depend on the incident light's polarization state. We perform polarization-resolved imaging using these photodetectors.

**STh4I.6 • 17:45**
**High Power 20GHz Photodiodes with Microwave Tuning Circuits,** Kejia Li[1], Qiugui Zhou[1], Xiaojun Xie[1], Andreas Beling[1], Joe C. Campbell[1]; [1]*Electrical and Computer Engineering, Univ. of Virginia, USA.* Modified uni-travelling-carrier (MUTC) photodiodes (PDs) with microwave open and shorted stubs having RF output power (PRF_out) of 23 dBm and 21.6 dBm, respectively, at 20 GHz are demonstrated.

**STh4I.7 • 18:00**
**Photodetectors based on Atomically Thin Transition Metal Dichalcogenides,** Thomas Mueller[1], Marco M. Furchi[1], Andreas Pospischil[1]; [1]*Vienna Univ. of Technology, Austria.* We present phototransistors based on atomically thin layers of molybdenum disulfide and van der Waals heterostructures of transition metal dichalcogenides.

## Meeting Room 212 A/C

### JOINT

### JTh4J • Symposium on High Performance Optics II—Continued

**JTh4J.3 • 17:15** Invited
**Metrology and Coatings for the 40 kg LIGO Optics,** Rana X. Adhikari[1]; [1]*California Inst. of Technology, USA.* The 4 km LIGO interferometers seek to measure the gravitational fluctuations from cosmic explosions. In order to do so, their massive mirrors must meet several demanding specifications which are sometimes conflicting. I will describe why the job is so challenging and how the challenges may be met.

**JTh4J.4 • 17:45**
**All-optical helicity dependent switching in amorphous Tb$_{30}$Fe$_{70}$ with a MHz laser oscillator,** Alexander Hassdenteufel[1], Christian Schubert[2], Birgit Hebler[2], Helmut Schultheiss[3,4], Jürgen Fassbender[3,4], Manfred Albrecht[2], Rudolf Bratschitsch[5]; [1]*Chemnitz Univ. of Technology, Germany;* [2]*Univ. of Augsburg, Germany;* [3]*Helmholtz Zentrum Dresden Rossendorf, Germany;* [4]*Technische Universität Dresden, Germany;* [5]*Univ. of Münster, Germany.* All-optical magnetic switching is demonstrated in a Tb-Fe thin film with a conventional laser oscillator instead of a complex and expensive amplifier system. Overheating is prevented by a SiO$_2$/Si substrate as an efficient heat sink.

**JTh4J.5 • 18:00** Invited
**State of the Art Optical Materials for Lithographic Systems for Semiconductor Manufacturing,** Ralf Takke[1]; [1]*Division Optics, Heraeus Quarzglas GmbH & Co. KG, Germany.* 193nm lithography has enabled semiconductor manufacturing to achieve nm resolution. Highest quality optical materials and optics are an essential part of this. Important optical properties of and test methods for these materials will be reported.

## Meeting Room 212 B/D

### CLEO: QELS-Fundamental Science

### FTh4K • Nonlinear Plasmonics: From Visible to Terahertz—Continued

**FTh4K.4 • 17:15**
**Control of grating-coupled ultrafast surface plasmon pulse and its nonlinear emission by shaping femtosecond laser pulse,** Yuta Masaki[1], Kazunori Toma[1], Miyuki Kusaba[1], Kenichi Hirosawa[1], Fumihiko Kannari[1]; [1]*Keio Univ., Japan.* Spatiotemporal nanofocusing of surface plasmon polariton excited by femtosecond laser pulses on a sharp conical Au tip with a tip edge radius of few tens of nanometers is deterministically controlled.

**FTh4K.5 • 17:30**
**Geometrical effects in second-harmonic generation from metal nanoparticles,** Robert Czaplicki[1], Roope Siikanen[1], Jouni Mäkitalo[1], Hannu Husu[1,2], Joonas Lehtolahti[3], Markku Kuittinen[3], Martti Kauranen[1]; [1]*Dept. of Physics, Tampere Univ. of Technology, Finland;* [2]*Centre for Metrology and Accreditation (MIKES), Finland;* [3]*Dept. of Physics and Mathematics, Univ. of Eastern Finland, Finland.* We investigate non-centrosymmetric metal nanoparticles of different geometries by second-harmonic generation. In contrast to recent emphasis on plasmonic resonances, we find that strong responses rely on the character of plasmon oscillations supported by the geometry.

**FTh4K.6 • 17:45**
**Second Harmonic Generations from Au Nanorods Coated with Nonelectrically Poled NLO polymer,** Atsushi Sugita[1], Takuma Hirabayashi[1], Atsushi Ono[1], Yoshimasa Kawata[1]; [1]*Shizuoka Univ., Japan.* Second order nonlinear optical susceptibility of Au nanorods coated with nonelectrically poled NLO polymer will be presented. The SHG conversion efficiency at fully Surface Plasmon resonance was 70 times higher than that at off-resonance conditions.

**FTh4K.7 • 18:00**
**Surface Nonlinearities in Plasmonics,** Alexey V. Krasavin[1], Paulina Segovia[1], Pavel Ginzburg[1], Anatoly V. Zayats[1]; [1]*Dept. of Physics, King's College London, UK.* Plasmonic nanostructures can manipulate nonlinear optical phenomena via local field enhancement, but also can serve as strong nonlinear sources themselves. Surface second-harmonic effects in nanoparticles, surfaces, and metamaterials will be analyzed via advanced hydrodynamic model.

## Marriott Salon I & II

### JOINT

### JTh4L • Symposium on Laser-Driven Sources of Particle and X-Ray Beams III—Continued

**JTh4L.3 • 17:15** ▶
**Adaptive spectral-phase control for laser wakefield electron acceleration,** Cheng Liu[1], Jun Zhang[1], Gregory Golovin[1], Shouyuan Chen[1], Sudeep Banerjee[1], Baozhen Zhao[1], Nathan Powers[1], Isaac Ghebregziabher[1], Donald P. Umstadter[1]; [1]*Physics & Astronomy, Univ. of Nebraska, Lincoln, USA.* An adaptive spectral-phase control method is demonstrated for laser wakefield acceleration of electrons. Phase control capability was implemented to experimentally study the dependence of laser wakefield acceleration on the spectral phase of intense laser light.

**JTh4L.4 • 17:30** Invited ▶
**Status of High-Energy OPCPA at LLE and Future Prospects,** Jonathan D. Zuegel[1]; [1]*Univ. of Rochester, USA.* The scope and status of a mid-scale optical parametric amplifier line (OPAL) that will demonstrate scalable technologies will be presented along with technical challenges and prospects for an OPAL pumped by OMEGA EP.

**JTh4L.5 • 18:00**
**System Design for Joule-class Femtosecond Fiber Amplifiers for Particle Acceleration,** Tino Eidam[1,2], Arno Klenke[1,2], Marco Kienel[1,2], Sven Breitkopf[1], Lorenz von Grafenstein[1], Jens Limpert[1,2], Andreas Tünnermann[1,2]; [1]*Institue of Applied Physics, Friedrich-Schiller-Universität Jena, Germany;* [2]*Helmholtz-Inst. Jena, Germany.* We present a system architecture for high-repetition-rate Joule-class fiber lasers ideally suited for particle acceleration. The necessary power levels are achieved by using temporally and spatially separated amplification and subsequent coherent combination.

## CLEO: Science & Innovations

Marriott
Salon III

### STh4M • Silicon Modulstors—Continued

**STh4M.4 • 17:15**

**Adaptive Controller of Two Tuning Phases in a Microring Based Binary Phase Shift Keying (BPSK) Modulator,** Jonathan Fisher[1], Moshe Nazarathy[1], Anna Kodanev[1], Nadav Shitrit[1], Meir Orenstein[1], Andrea Annoni[2], Francesco Morichetti[2], Andrea Melloni[2]; [1]*Technion Israel Inst. of Technology, Israel;* [2]*Elettronica e Informazione, Politecnico di Milano, Italy.* The state-of-the art for control of microring based devices is tuning just resonant phase. We introduce an extremum-seeking discrete-multitone adaptive controller, concurrently tuning both resonant phase and second coupling phase parameter optimizing microring critical coupling.

**STh4M.5 • 17:30**

**Characterization of electrically-driven silicon photonic Mach-Zehnder switches,** Ryan Aguinaldo[1], George Porter[1], George Papen[1], Yeshaiahu Fainman[1], Shayan Mookherjea[1]; [1]*Univ. of California San Diego, USA.* We demonstrate a new method to extract the electronic carrier-induced loss and coupling coefficients of modern thermo-optic and electro-optic silicon Mach-Zehnder interferometer based 2x2 switches (Sandia, IBM and Kotura-Oracle) from the transmission spectra.

**STh4M.6 • 17:45**

**Distributed Electrode Mach-Zehnder Modulator with Double-Pass Phase Shifters and Integrated Inductors,** Douglas M. Gill[1], William M. Green[1], Chi Xiong[1], Jonathan E. Proesel[1], Alexander V. Rylyakov[1], Clint L. Schow[1], Jessie Rosenberg[1], Tymon Barwicz[1], Marwan Khater[1], Solomon Assefa[1], Steven Shank[2], Carol Reinholm[2], Edward Kiewra[2], Swetha Kamlapurkar[1], Yurii Vlasov[1]; [1]*IBM TJ Watson Research Center, USA;* [2]*IBM Sytems & Technology Group, USA.* A novel high-speed Mach-Zehnder modulator (MZM) fully integrated into a 90 nm CMOS process is presented. The MZM features ‘double-pass’ optical phase shifter segments, and the first use of integrated inductors in a ‘velocity-matched’ distributed-electrode configuration.

**STh4M.7 • 18:00**

**Wavelength Control of Resonant Photonic Modulators with Balanced Homodyne Locking,** Jonathan A. Cox[1], Anthony L. Lentine[1], Daniel J. Savignon[1], Douglas Trotter[1], Andrew Starbuck[1]; [1]*Sandia National Labs, USA.* We present a robust method for control of resonant modulator wavelength that is integrated with an on-chip balanced detector. Experimental results demonstrate long-term locking with low bit error rate over greater than 55 Kelvin.

Marriott
Salon IV

### STh4N • Coherent Combination and Amplification—Continued

**STh4N.3 • 17:15**

**Diffractive Coherent Combining of >kW Fibers,** Gregory D. Goodno[1], Stuart McNaught[1], Josh Rothenberg[1], Peter Thielen[1], Marty Wacks[1]; [1]*Northrop Grumman Aerospace Systems, USA.* Three non-PM, kW-class fiber amplifiers were coherently combined into a 2.4-kW, $M^2$=1.2 beam with 80% efficiency. No power-limiting effects were observed, which anchored scaling predictions to higher powers and efficiencies with larger fiber count arrays.

**STh4N.4 • 17:30**

**0.7 MW Output Power from Coherently Combined Q-switched Photonic Crystal Fiber Laser,** Boris Rosenstein[1], Avry Shirakov[1,2], Daniel Belker[1], Amiel Ishaaya[1]; [1]*Dept. of Electrical and Computer Engineering, Ben-Gurion Univ. of the Negev, Israel;* [2]*Dept. of Physics, Ben-Gurion Univ. of the Negev, Israel.* We experimentally demonstrate a high peak power, Q-switched pulsed, intracavity coherently combined photonic crystal fiber laser in a power oscillator configuration. Our oscillator system provides record high peak power of ~0.7 MW.

**STh4N.5 • 17:45**

**Divided-Pulse Lasers,** Erin S. Lamb[1], Logan G. Wright[1], Frank W. Wise[1]; [1]*School of Applied and Engineering Physics, Cornell Univ., USA.* We demonstrate coherent combining of pulses within a laser cavity and discuss applications to energy scaling and pulse-burst operation. 16-times enhancement of the pulse energy from a fiber laser is demonstrated.

**STh4N.6 • 18:00**

**Transverse-mode Instability in High Power Fiber Amplifiers Involving Thermally-Induced Gratings Without Frequency Offset,** I-Ning Hu[1], Almantas Galvanauskas[1]; [1]*Center for Ultrafast Optical Science, Univ. of Michigan, USA.* Time-dependent coupled-mode theory predicts transverse-mode instabilities in high power fiber amplifiers originating from thermally-induced gratings possessing a spatial phase shift with respect to a beating pattern of two transversal modes of the same frequency.

Marriott
Salon V & VI

### STh4O • Gravity and Distance Measurements—Continued

**STh4O.3 • 17:15**

**Silicon Photonic Integrated Circuit for Fast Distance Measurement with Frequency Combs,** Claudius Weimann[1,2], Matthias Lauermann[1], Thomas Fehrenbach[1], Robert Palmer[1], Frank Hoeller[3], Wolfgang Freude[1,2], Christian G. Koos[1,2]; [1]*Inst. of Photonics and Quantumelectronics (IPQ), KIT, Germany;* [2]*Inst. of Microstructure Technology (IMT), KIT, Germany;* [3]*Carl Zeiss AG, Germany.* We demonstrate a synthetic-wavelength interferometry system on a silicon photonic chip, comprising an interferometer with tunable power splitting ratio and photodetectors. The system enables distance measurements with errors below 5µm and acquisition times of 14µs.

**STh4O.4 • 17:30** Tutorial

**Precision Measurement at the Quantum Limit in Gravitational Wave Detectors,** Nergis Mavalvala[1]; [1]*MIT, USA.* Interferometric gravitational wave detectors are poised to launch a new era of gravitational-wave astronomy. I will describe how we achieve sub-attometer sensitivity in kilometer-scale laser interferometers.

Nergis Mavalvala received a B.A. from Wellesley College, a Ph.D. from MIT, and was a postdoctoral fellow at Caltech. She is now Professor of Physics at the MIT and recipient of a 2010 MacArthur “genius” award. Her research spans quantum optics and optomechanics in relation to interferometric gravitational-wave detectors.

Marriott
Willow Glen I-III

## CLEO: Applications & Technology

### ATh4P • Symposium on Advanced Ultrashort Pulse Laser Technologies in Biophotonics and Nanobiophotonics II—Continued

**ATh4P.3 • 17:15**

**High-speed flow imaging utilizing spectral-encoding of ultrafast pulses and compressed sensing,** Bryan T. Bosworth[1], Mark A. Foster[1]; [1]*Johns Hopkins Univ., USA.* Using chirp processing and pseudorandom bit modulation we demonstrate high-speed structured illumination for compressed sensing imaging of 1-D flows.

**ATh4P.4 • 17:30** Invited

**Progress in laser-driven ion acceleration towards applications in radiotherapy,** Paul McKenna[1], Marco Borghesi[2], David Neely[3], Zulfikar Najmudin[4], Matt Zepf[2], Kevin Prise[2]; [1]*Physics, Univ. of Strathclyde, UK;* [2]*Mathematics and Physics, Queens Univ. Belfast, UK;* [3]*CLF, Rutherford Appleton Lab, UK;* [4]*Blackett Lab, Imperial College London, UK.* I will outline recent progress, in the UK ASAIL laser-ion acceleration programme, which aims to advance laser-driven ion beams to the point at which they will become a serious alternative to conventional accelerators for radiotherapy.

**ATh4P.5 • 18:00**

**Decontamination of Medical Device Surface Using Ultrashort Pulsed Laser Irradiation,** Moinuddin Hassan[1], Brandon Gaiton[1], Ilko K. Ilev[1]; [1]*DP/OSEL/CDRH, FDA, USA.* We present a novel approach for non-contact, rapid and chemical-free decontamination of medical device surfaces using near-infrared ultrashort (nano- to femtosecond) pulse lasers. A proof-of-principal experimental platform is validated through multivariable comparison studies.

## Executive Ballroom 210A

## CLEO: QELS-Fundamental Science

### FTh4A • Quantum Sensing and Metrology—Continued

**FTh4A.8 • 18:15**
**Stimulated Emission Tomography,** Marco Liscidini[1], Lee A. Rozema[2], Chao Wang[2], Dylan Mahler[2], Alex Hayat[2], Aephraim M. Steinberg[2], John E. Sipe[2]; *[1]Physics, Universita degli Studi di Pavia, Italy; [2]Physics, Univ. of Toronto, Canada.* We experimentally demonstrate the reconstruction of the polarization state of entangled photon pairs by stimulated emission tomography.

## Executive Ballroom 210B

## CLEO: Science & Innovations

### STh4B • Laser-Driven Dynamics in Materials—Continued

**STh4B.7 • 18:15**
**Ablation of polymethylmethacrylate by two-color femtosecond synthesized waveform,** Chih-Hsuan Lin[1], Chan Shan Yang[2], Alexey Zaytsev[2], Kuei-Chung Teng[1], Tsing-Hua Her[3], Ci-Ling Pan[1,2]; *[1]Inst. of Photonics technologies, National Tsing Hua Univ., Taiwan; [2]Dept. of Physics, National Tsing Hua Univ., Taiwan; [3]Dept. of Physics and Optical Science, Univ. of North Carolina, USA.* We demonstrated femtosecond laser ablation of PMMA using 2-color waveform synthesis. A modest and yet clear modulation in ablated area versus relative phase between the ω and 2 ω beams is observed.

## Executive Ballroom 210C

## Executive Ballroom 210D

## CLEO: QELS-Fundamental Science

### FTh4C • Carrier Dynamics in 0-D and 1-D Nanostructures—Continued

**FTh4C.8 • 18:15**
**Charge carrier relaxation processes in TbAs nanoinclusions in GaAs measured by optical-pump THz-probe transient absorption spectroscopy,** Laura Vanderhoef[2], Abul K. Azad[1], Cory Bomberger[2], Dibakar Chowdhury[1], Bruce Chase[2], Antoinette Taylor[1], Joshua Zide[2], Matthew Doty[2]; *[1]Los Alamos National Lab, USA; [2]Univ. of Delaware, USA.* By analyzing how carrier relaxation rates depend on pump fluence and sample temperature, we conclude that states of TbAs embedded in GaAs are saturable. This suggests the existence of a bandgap for TbAs nanoparticles.

### FTh4D • Nonlinear Metamaterials and Cooling—Continued

**FTh4D.6 • 18:15**
**Solid-state cryo-cooling using optical refrigeration,** Seth Melgaard[1,2], Alexander R. Albrecht[1], Denis Seletskiy[3], Richard Epstein[1,4], Jay Alden[4], Mansoor Sheik-Bahae[1]; *[1]Univ. of New Mexico, USA; [2]Air Force Research Lab, USA; [3]Univ. of Konstanz, Germany; [4]ThermoDynamic Films LLC, USA.* Optical refrigeration provides the only solid-state technology capable of reaching cryogenic temperatures, currently below 100K. Novel, adaptable designs are implemented for technologies requiring vibration-free cryogenic operation.

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**18:30–20:00 Dinner Break** *(on your own)*

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**20:00–22:00 Postdeadline Paper Sessions**

*The complete schedule of Postdeadline Paper Sessions can be found in the Postdeadline Digest and the CLEO Mobile App.*

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NOTES

## CLEO: Science & Innovations

### Executive Ballroom 210E

### STh4E • OPO, OPA and Regenerative Amplifiers—Continued

**STh4E.8 • 18:15**
**High Repetition Rate, mJ-Level, mid-IR OPCPA System,** Michael Gerrity[1], Susannah Brown[1], Tenio Popmintchev[1], Margaret Murnane[1], Henry Kapteyn[1], Sterling Backus[2,3]; [1]*JILA - Univ. of Colorado at Boulder, USA;* [2]*Kapteyn-Murnane Labs Inc., USA;* [3]*Colorado State Univ., USA.* We describe a kHz repetition-rate mid-IR laser system based on OPCPA, optimized for soft x-ray high harmonic generation. To date we have demonstrated 1.4mJ at 1.6μm, and 550μJ at 3μm, each with bandwidth compressible to <100fs.

### Executive Ballroom 210F

### STh4F • THz Imaging—Continued

**STh4F.7 • 18:15**
**Video Rate THz imaging based on frequency upconversion using a near-IR CMOS camera,** Patrick Tekavec[1], Dylan Fast[1], Ian McNee[1], Vladimir Kozlov[1], Yun-Shik Lee[2], Konstantin L. Vodopyanov[3]; [1]*Microtech Instruments, USA;* [2]*Physics, Oregon State Univ., USA;* [3]*CREOL, College of Optics and Photonics, Univ. Cent. Florida, USA.* We demonstrate a video-rate THz-imaging system based on upconversion of THz pulses into the infrared. Sideband generation by mixing high-power, narrowband THz pulses with picosecond pulses at 1064 nm in QPM-GaAs provide high contrast imaging.

### Executive Ballroom 210G

### STh4G • Quantum Cascade Lasers II—Continued

**STh4G.8 • 18:15**
**Scaling of Micropillar Array Terahertz Lasers into the Subwavelength Regime,** Michael Krall[1,3], Martin Brandstetter[1,3], Christoph Deutsch[1,3], Hermann Detz[2,3], Aaron Maxwell Andrews[2,3], Werner Schrenk[3], Gottfried Strasser[2,3], Karl Unterrainer[1,3]; [1]*Photonics Inst., Vienna Univ. of Technology, Austria;* [2]*Inst. of Solid State Electronics, Vienna Univ. of Technology, Austria;* [3]*Center for Micro- and Nanostructures, Vienna Univ. of Technology, Austria.* We demonstrate terahertz quantum cascade lasers based on arrays of subwavelength micropillar structures, corresponding to scaled-down photonic crystals. Stimulated emission is measured at 4 THz for devices operating in the effective medium regime of the photonic bands.

### Executive Ballroom 210H

### STh4H • Plasmonics, Raman and Resonance Sensing—Continued

**STh4H.8 • 18:15**
**Surface-Enhanced Raman Spectroscopy (SERS) using Nanopillar Arrays as Functional Substrates and an Organic Semiconductor DFB Laser as Excitation Source,** Xin Liu[1,5], Sergei Lebedkin[2], Wilhelm Pfleging[3,4], Heino Besser[3,4], Markus Wissmann[4,5], Irina Nazarenko[6], Timo Mappes[5,7], Sebastian Koeber[5,8], Christian G. Koos[5,8], Manfred Kappes[2], Uli Lemmer[1,5]; [1]*Light Tech. Inst., Karlsruhe Inst. of Tech., Germany;* [2]*Inst. of Nanotechnology, Karlsruhe Inst. of Tech., Germany;* [3]*Inst. for Applied Materials - Applied Materials Physics, Karlsruhe Inst. of Tech., Germany;* [4]*Karlsruhe Nano Micro Facility, Germany;* [5]*Inst. of Microstructure Tech., Karlsruhe Inst. of Tech., Germany;* [6]*Inst. for Environmental Health Sciences and Hospital Infection Control, Medical Center-Univ. of Freiburg, Germany;* [7]*Corporate Research and Tech., Carl Zeiss AG, Germany;* [8]*Inst. of Photonics and Quantum Electronics, Karlsruhe Inst. of Tech., Germany.* We demonstrate an organic semiconductor distributed feedback (DFB) laser as excitation source in surface-enhanced Raman spectroscopy (SERS). SERS-active substrates comprising nanopillar arrays were fabricated by the technique of laser-assisted nano-replication.

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**18:30–20:00 Dinner Break** *(on your own)*

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**20:00–22:00 Postdeadline Paper Sessions**
*The complete schedule of Postdeadline Paper Sessions can be found in the Postdeadline Digest and the CLEO Mobile App.*

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NOTES

## Meeting Room 211 B/D

### CLEO: Science & Innovations

### STh4I • Novel Photodetectors—Continued

**STh4I.8 • 18:15**
**Flexible ZnO Nanocrystal Ultraviolet Photodetector on Bio-membrane,** Jingda Wu[1], Lih Lin[1]; [1]*Electrical Engineering, Univ. of Washington, USA.* We demonstrated an easy-to-fabricate vertical flexible UV photodetector structure with ZnO nanocrystals embedded in a thin and cellulose reed membrane sandwiched between two evaporated electrodes. The device shows photoconductive effect with good performance.

## Meeting Room 212 A/C

### JOINT

### JTh4J • Symposium on High Performance Optics II—Continued

**JTh4J.6 • 18:30** Invited
**Convergent Polishing: Simple, Low Cost Finishing Method of Glass Optics,** T. Suratwala[1], R. Steele[1], M. Feit[1], R. Dylla-Spears[1], R. Desjardin[1], D. Mason[1], L. Wong[1], P. Geraghty[1], P. Miller, N. Shen[1]; [1]*Lawrence Livermore National Lab., USA.* A novel finishing process, called Convergent Polishing, is described where the workpiece regardless of its initial shape will converge to final surface figure under a fixed, unchanging set of polishing parameters in a single iteration.

## Meeting Room 212 B/D

### CLEO: QELS-Fundamental Science

### FTh4K • Nonlinear Plasmonics: From Visible to Terahertz—Continued

**FTh4K.8 • 18:15**
**Plasmon-Enhanced Third-Order Harmonic Generation in Plasmonic-Organic Photonic Crystals,** Fanghui Ren[1], Xiangyu Wang[1], Zhongan Li[2], Jongdong Luo[2], Sei-Hum Jang[2], Alex Jen[2], Alan X. Wang[1]; [1]*Oregon State Univ., USA;* [2]*Univ. of Washington, USA.* We present theoretical and experimental analysis of extraordinary third-order harmonic generation (THG) by organic materials on a plasmonic photonic crystal. The measurement shows that the hybrid nanostructure platform provides over 20 times enhancement in THG efficiency.

## Marriott Salon I & II

### JOINT

### JTh4L • Symposium on Laser-Driven Sources of Particle and X-Ray Beams III—Continued

**JTh4L.6 • 18:15** ▶
**Development of high repetition rate 0.1 - 1 TW CO2 lasers,** Jeremy Pigeon[1], Sergei Tochitsky[1], Chan Joshi[1]; [1]*Electrical Engineering, UCLA, USA.* Amplification of 3 ps pulses to >20GW in a 1Hz CO2 laser MOPA chain is described. Several ways and experimental progress towards increase of the peak power for 10 μm pulses are discussed.

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**18:30–20:00 Dinner Break** *(on your own)*

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**20:00–22:00 Postdeadline Paper Sessions**
*The complete schedule of Postdeadline Paper Sessions can be found in the Postdeadline Digest and the CLEO Mobile App.*

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NOTES

## STh4M • Silicon Modulstors—Continued

**STh4M.8 • 18:15** ▶
**Reflective Optical Phase Modulator Based on High-Contrast Grating Mirrors,** Yu Horie[1], Amir Arbabi[1], Andrei Faraon[1]; [1]*T. J. Watson Lab of Applied Physics, California Inst. of Technology, USA.* We propose a reflective phase-only modulator formed by two layers of high-contrast grating reflectors. By arranging such optical phase modulators in a 2D array, ultra-fast Si-based phase-only spatial light modulators can be realized.

## STh4N • Coherent Combination and Amplification—Continued

**STh4N.7 • 18:15**
**3 % Thermal Load Measured in Tandem-pumped Ytterbium-doped Fiber Amplifier,** You Min Chang[1], Tianfu Yao[1], Hoon Jeong[2], Junhua Ji[3], Seongwoo Yoo[3], Timothy C. May-Smith[1], Jayanta K. Sahu[1], Johan Nilsson[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK;* [2]*Korea Inst. of Industrial Technology, Korea;* [3]*School of Electrical & Electronic Engineering, Nanyang Technological Univ., Singapore.* A tandem-pumped Yb-doped fiber with a quantum defect of 2% generates 3% of heat. We believe this is a record-low thermal load and the first calorimetric measurement of the heat from a fiber core.

## STh4O • Gravity and Distance Measurements—Continued

## ATh4P • Symposium on Advanced Ultrashort Pulse Laser Technologies in Biophotonics and Nanobiophotonics II—Continued

**ATh4P.6 • 18:15**
**2D cognitive optical data processing with phase change materials,** qian Wang[1,2], Jonathan Maddock[1], Edward T. Rogers[1], Tapashree Roy[1], Christopher Craig[1], Kevin F. MacDonald[1], Dan Hewak[1], Nikolay I. Zheludev[1,3]; [1]*Optoelectronics Research Centre and Centre for Photonic Metamaterials, Univ. of Southampton, UK;* [2]*Inst. of Materials Research and Engineering, Singapore;* [3]*Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore.* We demonstrate high-density, multi-level crystallization of a Ge2Sb2Te5 thin film using tightly focused femtosecond laser pulses. The optical reflectivity in each distinct phase states level is characterized for applications in ultra-fast cognitive parallel data processing.

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**18:30–20:00 Dinner Break** *(on your own)*

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**20:00–22:00 Postdeadline Paper Sessions**
*The complete schedule of Postdeadline Paper Sessions can be found in the Postdeadline Digest and the CLEO Mobile App.*

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NOTES

## Executive Ballroom 210A

## CLEO: QELS-Fundamental Science

**08:00–10:00**
**FF1A • Coherent Effects with Quantum Dots**
*Presider: Arka Majumdar; Intel Labs, USA*

**FF1A.1 • 08:00**
**Measuring the local environment of a quantum dot,** Megan Stanley[1], Clemens Matthiesen[1], Jack Hansom[1], Claire Le Gall[1], Maxime Hugues[2], Edmund Clarke[2], Mete Atature[1]; *[1]Cavendish Lab, Univ. of Cambridge, UK; [2]EPSRC National center for III-V Technologies, Univ. of Sheffield, UK.* We present a survey of the solid state environment of a quantum dot utilising resonance fluorescence as a sensitive probe. Nucler field fluctuations are identified with 10 microseconds correlation times by comparison to a theoretical model.

**FF1A.2 • 08:15**
**A comparison between experiment and theory on few-quantum-dot nanolasing in a photonic-crystal cavity,** Jin Liu[1,2], Serkan Ates[1], Michael Lorke[1], Jesper Mørk[1], Soren Stobbe[2], Peter Lodahl[2]; *[1]Danmarks Tekniske Universitet, Denmark; [2]Niels Bohr Inst., Denmark.* We present an experimental and theoretical study on the gain mechanism in a photonic-crystal-cavity nanolaser with embedded quantum dots and find that the gain is mainly provided by the multi-excitonic states of quantum dots.

**FF1A.3 • 08:30**
**Ultrafast Light-Matter Interaction in a Metaphotonic Cavity Containing a Single Quantum Dot,** Kevin Fischer[1,2], Thomas Babinec[1,2], Yousif Kelaita[1,2], Konstantinos Lagoudakis[1,2], Tomas Sarmiento[1,2], Armand Rundquist[1,2], Arka Majumdar[3,4], Jelena Vuckovic[1,2]; *[1]Ginzton Lab, Stanford Univ., USA; [2]Electrical Engineering, Stanford Univ., USA; [3]Electrical Engineering, Univ. of Washington, USA; [4]Physics, Univ. of Washington, USA.* Progress in cavity quantum electrodynamics (cQED) trends to decreasing mode volume and increasing light-matter interaction. We demonstrate a metal-semiconductor nanopillar cQED system that exhibits bright single-photon generation, strong Purcell enhancement, and viability as a new platform for cQED.

## Executive Ballroom 210B

## CLEO: Applications & Technology

**08:00–10:00**
**AF1B • Symposium on Advances in Neurophotonics I** ▶
*Presider: Jin Kang; Johns Hopkins Univ., USA*

**AF1B.1 • 08:00** Invited
**Optogenetic approaches for deciphering the neural circuits of the cortex,** Solange P. Brown[1]; *[1]Solomon H. Snyder Dept. of Neuroscience, Johns Hopkins Univ., USA.* Recent developments in optogenetics have generated new opportunities for deciphering the synaptic organization of the cortex, a massively interconnected neuronal network essential for generating a rich repertoire of behavior, including perception and voluntary movement.

**AF1B.2 • 08:30** Invited ▶
**Non-invasive 3D Optical Imaging of Tissue Microstructure and Microcirculations in Vivo,** Ruikang K. Wang[1], Woo June Choi[1]; *[1]Univ. of Washington, USA.* We present the ability of OCT microangiography to visualize tissue blood flow at capillary level for a variety of biomedical applications, some of which (along with the OCT basics and the enabling technologies) will be highlighted.

## Executive Ballroom 210C

## CLEO: QELS-Fundamental Science

**08:00–10:00**
**FF1C • Metasurfaces I** ▶
*Presider: Hui Cao; Yale Univ., USA*

**FF1C.1 • 08:00** Tutorial ▶
**Spin-Optical Metasurface Route to Spin-Controlled Photonics,** Erez Hasman[1]; *[1]Faculty of Mechanical Engineering, Technion-Israel Inst. of Technology, Israel.* We report on spinoptical metasurfaces manifested by spin-controlled optical modes - optical Rashba effect, where the inversion symmetry is violated. The design of metasurface symmetries via geometric gradients provides a route for spin-controlled nanophotonic applications.

Erez Hasman is a Professor of optical sciences, Technion - Israel Inst. of Technology. He is awarded the Fellow of OSA 2013, "for pioneering contributions in the field of nano-photonics, and specifically for developing a new branch in optics - spinoptics: the symmetry breaking in nanostructures due to spin-orbit interaction".

## Executive Ballroom 210D

**08:00–10:00**
**FF1D • Entangled Photons and Quantum Effects** ▶
*Presider: Yujie Ding; Lehigh Univ., USA*

**FF1D.1 • 08:00** ▶
**Quantum Random Walks in Free Space,** Toni Eichelkraut[1], Christian Vetter[1], Armando Perez-Leija[1], Demetrios N. Christodoulides[2], Alexander Szameit[1]; *[1]Inst. of Applied Physics, Friedrich-Schiller-Universität Jena, Germany; [2]CREOL, Univ. of Central Florida, USA.* We show that two-dimensional continuous time coherent random walks are possible in free space by properly tailoring the associated initial wave functions. Theoretical predictions along with classical experiments demonstrate the feasibility of our scheme.

**FF1D.2 • 08:15** ▶
**Orthogonally polarized correlated photon pair generation on a chip via self-pumped spontaneous non-degenerate FWM,** Christian Reimer[1], Lucia Caspani[1], Yoann Jestin[1], Matteo Clerici[1,2], Marcello Ferrera[1,2], Marco Peccianti[1,3], Alessia Pasquazi[1,3], Brent E. Little[4], Sai T. Chu[5], David J. Moss[1,6], Roberto Morandotti[1]; *[1]INRS-EMT, Canada; [2]School of Engineering and Physical Sciences, Heriot-Watt Univ., UK; [3]Dept. of Physics and Astronomy, Univ. of Sussex, UK; [4]HiQ Photonics, USA; [5]Dept. of Physics and Material Science, City Univ. of Hong Kong, China; [6]School of Electrical and Computer Engineering, RMIT Univ., Australia.* We demonstrate orthogonally polarized photon pair generation via spontaneous non-degenerate four-wave-mixing (FWM) of orthogonally polarized pumps in a CMOS compatible micro-ring resonator by fully suppressing stimulated FWM. Photon coincidences and optical parametric oscillation are measured.

**FF1D.3 • 08:30** ▶
**Pulsed Sagnac polarization-entangled photon source with a PPKTP crystal at telecom wavelength,** Rui-Bo Jin[1], Ryosuke Shimizu[2], Kentaro Wakui[1], Mikio Fujiwara[1], Taro Yamashita[3], Shigehito Miki[3], Hirotaka Terai[3], Zhen Wang[3,4], Masahide Sasaki[1]; *[1]National Inst. of Information and Communications Technology, Japan; [2]Univ. of Electro-Communications, Japan; [3]National Inst. of Information and Communications Technology, Japan; [4]Shanghai Inst. of Microsystem and Information Technology,, China.* We demonstrate pulsed polarization-entangled photons generated from a PPKTP crystal in a Sagnac interferometer configuration at telecom wavelength. We achieved fidelities of 0.981 +- 0.0002 for \psi ^ - and 0.980+-0.001 for \psi ^ + respectively.

## CLEO: Science & Innovations

## Executive Ballroom 210E

### 08:00–10:00
### SF1E • FROG and Pulse Characterization ▶
*Presider: Rick Trebino; Georgia Inst. of Technology, USA*

**SF1E.1 • 08:00** ▶
**Real-time lightwave measurement by using FROG capable of CEP determination with pulse-front tilt,** Takao Fuji[1], Hideto Shirai[1], Yutaka Nomura[1]; [1]*National Inst.s of Natural Sciences, Japan.* We propose frequency-resolved optical gating capable of carrier-envelope phase determination using a reference pulse with a tilted pulse front. Real-time complete waveform measurement of ultrashort pulses has been demonstrated with the method.

**SF1E.2 • 08:15** ▶
**Single-shot Measurement of the Complete Temporal Intensity and Phase of Supercontinuum,** Tsz Chun Wong[1], Michelle Rhodes[1], Rick Trebino[1]; [1]*Georgia Inst. of Technology, USA.* We demonstrate the first technique for the complete temporal measurement of a single supercontinuum pulse. We achieve large ranges and high resolutions using polarization gating, a tilted gate pulse, and the cancellation of geometrical smearing.

**SF1E.3 • 08:30** Invited ▶
**Spectro-Temporal Characterization of All Channels in a Sub-Optical-Cycle Parametric Waveform Synthesizer,** Giulio Maria Rossi[1,3], Giovanni Cirmi[1,3], Shaobo Fang[1,3], Shih-Hsuan Chia[1,3], Oliver D. Muecke[1,3], Franz Kärtner[2,4], Cristian Manzoni[5], Paolo Farinello[5], Giulio Cerullo[5]; [1]*Center for Free-Electron Laser Science, Deutsches Elektronen-Synchrotron DESY, Germany;* [2]*Physics Dept., Univ. of Hamburg, Germany;* [3]*The Hamburg Center for Ultrafast Imaging, Germany;* [4]*Dept. of Electrical Engineering and Computer Science and Research Lab of Electronics, MIT, USA;* [5]*IFN-CNR, Dipartimento di Fisica, Politecnico di Milano, Italy.* We present FROG characterization of all three amplification channels of a two-stage sub-optical-cycle parametric waveform synthesizer covering more than two octaves in bandwidth. A flexible dispersion compensation scheme will permit compression at the multi-mJ level.

## Executive Ballroom 210F

### 08:00–10:00
### SF1F • THz Spectroscopy & Sensing II
*Presider: Peter Jepsen, Danmarks Tekniske Universitet, Denmark*

**SF1F.1 • 08:00**
**Probing Hydration Dynamics of Metal-Organic Frameworks by Broadband THz Pulses,** Christian Wolpert[1,2], Kenji Sumida[1], François Blanchard[3], Koichiro Tanaka[1,4]; [1]*Inst. for Integrated Cell-Material Sciences (WPI-iCeMS), Kyoto Univ., Japan;* [2]*CREST, Japan Science and Technology Agency,, Japan;* [3]*Dept. of Physics, McGill Univ., Canada;* [4]*Dept. of Physics, Graduate School of Science, Kyoto Univ., Japan.* We probe porous metal-organic framework materials (MOFs) using broadband terahertz (THz) pulses. Water molecules that are absorbed by the pores of the material display intermolecular dynamics differing from those of free water.

**SF1F.2 • 08:15**
**Ultra-broadband THz time-domain spectroscopy of common polymers with THz air-photonics,** Francesco D'Angelo[1], Mischa Bonn[1], Ralf Gente[2], Martin Koch[2], Dmitry Turchinovich[1,3]; [1]*Molecular Spectroscopy, Max Plank Inst. for Polymer Research, Germany;* [2]*Fachbereich Physik, Philipps-Universität Marburg, Germany;* [3]*DTU Fotonik, Technical Univ. of Denmark, Denmark.* Several common polymers are characterized in the ultra-broadband Terahertz frequency window 2-15 THz using a THz time-domain spectrometer solely based on air-photonics. The spectral features relevant for materials science and THz photonics are revealed.

**SF1F.3 • 08:30**
**Development of a terahertz Stokes polarimeter with ultra-broadband DAST-DFG source,** Takashi Notake[1], Banghong Zhang[2], Yandong Gong[2], Hiroaki Minamide[1]; [1]*RIKEN RAP, Japan;* [2]*Inst. for Infocom Research, Singapore.* We have developed Stokes polarimeter which can be available over wide terahertz frequency range by using a newly developed silicon quarter-wave plate based on form birefringence. In the system, proper polarization measurements were demonstrated successfully.

## Executive Ballroom 210G

### 08:00–10:00
### SF1G • Vertical Cavity Lasers
*Presider: Luke Mawst; Univ. of Wisconsin-Madison, USA*

**SF1G.1 • 08:00**
**22W Single-Frequency Vertical-External-Cavity Surface-Emitting Laser,** Fan Zhang[1], Bernd Heinen[1], Christoph Möller[1], Matthias Wichmann[1], Bernardette Kunert[2], Arash Rahimi-Iman[1], Wolfgang Stolz[1], Martin Koch[1]; [1]*Dept. of Physics and Materials Sciences Center, Philipps-Universität Marburg, Germany;* [2]*NAsP III/V GmbH, Germany.* We report on a single-frequency semiconductor disk laser which generates 22.1 W output power in continuous wave operation, at a wavelength of 1030 nm. The free-running linewidth is measured to be 3.2 MHz (apparatus limited).

**SF1G.2 • 08:15**
**50% Power Conversion Efficiency on a Non-Oxide VCSEL,** Xu Yang[1], Guowei Zhao[2], Mingxin Li[1], Xiaohang Liu[1], Yu Zhang[1], Dennis Deppe[1,2]; [1]*CREOL, College of Optics & Photonics, Univ. of Central Florida, USA;* [2]*sdPhotonics, LLC, USA.* Over 50% power conversion efficiency (PCE) has been reached in an oxide-free VCSEL. VCSELs with very small size (2 μm) have shown high single transverse mode selectivity and good lasing characteristics.

**SF1G.3 • 08:30** Invited
**Recent progress in near-infrared vertical external cavity surface emitting laser (VECSEL) grown by metal organic vapour phase epitaxy (MOVPE),** Wolfgang Stolz[1]; [1]*Philipps Universitat Marburg, Germany.* Recent developments in technology and active layer design for the realization of high-power (GaIn)As-based VECSEL, applying a specific MOVPE growth process, with cw output powers in excess of 100 W will be presented and discussed.

## Executive Ballroom 210H

### 08:00–10:00
### SF1H • Optical Manipulation for Biomedical Application
*Presider: Chulmin Joo; Yonsei Univ., Korea, Republic of*

**SF1H.1 • 08:00**
**Delivering Nanoparticles and Molecules to the Same Spot with a Superhydrophobic Bulls-eye for Surface-enhanced Raman Scattering,** Wuzhou Song[1], Demetri Psaltis[2], Kenneth B. Crozier[1]; [1]*Havard Univ., USA;* [2]*École polytechnique fédérale de Lausanne, Switzerland.* We present a superhydrophobic silicon bulls-eye. Water droplets remain centered as they dry, enabling delivery of nanoparticles or molecules to the center. SERS spectra of molecules (R6G) at very low concentrations (10E-15 M) are demonstrated.

**SF1H.2 • 08:15**
**Optical manipulation of rod-shaped bacteria and adhesive cellular clusters with novel "tug-of-war" optical tweezers,** Anna Bezryadina[1], John Keith[1], Joseph Chen[2], Zhigang Chen[1,3]; [1]*Dept. of Physics & Astronomy, San Francisco State Univ., USA;* [2]*Dept. of Biology, San Francisco State Univ., USA;* [3]*TEDA Applied Physical Inst. and School of Physics, Nankai Univ., China.* We design a new type of "tug-of-war" optical tweezers with lateral pulling forces and demonstrate full control of rod-shaped and asymmetric bacteria, including breaking up adhesive cellular clusters inhabiting aqueous media.

**SF1H.3 • 08:30**
**Light-driven Rotation of Helical Microstructures in a Fluidic Environment,** Lindsey Anderson[1], Silke R. Kirchner[1], Debora Schamel[2], Peer Fischer[2], Theobald Lohmüller[1], Jochen Feldmann[1]; [1]*Ludwig Maximilians Univ., Germany;* [2]*Max Plank Inst. for Intelligent Systems, Germany.* Inspired by biological microswimmer strategies, we consider the design of helical silica particles. We characterize optically induced rotation of these "microscrews", and discuss their applications as highly controlled microswimmers in the low Reynold's number regime.

## CLEO: Science & Innovations

### Meeting Room 211 B/D

**08:00–10:00**
**SF1I • Microresonotor Combs**
*Presider: Nathan Newbury; NIST, USA*

**SF1I.1 • 08:00**
**All-optical stabilization of a microresonator frequency comb,** Katja Beha[1], Scott B. Papp[1], Pascal Del'Haye[1], Franklyn Quinlan[1], Hansuek Lee[2], Kerry Vahala[2], Scott A. Diddams[1]; *[1]Time and Frequency Division 688, National Inst. of Standards and Technology, USA; [2]T. J. Watson Lab of Applied Physics, California Inst. of Technology, USA.* We demonstrate an optical clock based on stabilization of a microcomb to rubidium optical transitions. The clock's output is the 33 GHz microcomb line spacing, which is a coherent, integer sub-division of the rubidium reference.

**SF1I.2 • 08:15**
**Ultrashort pulse mode-locking from a normal-dispersion on-chip Kerr frequency comb,** Shu-Wei Huang[1], James F. McMillan[1], Jinghui 9. Yang[1], Andrey Matsko[2], Heng Zhou[1], Mingbin Yu[3], Dim-Lee Kwong[3], Lute Maleki[2], Chee Wei Wong[1]; *[1]Columbia Univ., USA; [2]OEwaves, USA; [3]Inst. of Microelectronics, Singapore.* We demonstrate a broadband Kerr frequency comb and mode-locking in a globally-normal-dispersion microresonator. A record short on-chip pulse of 74-fs is directly measured. Supported by analytical theory and numerical modeling, we describe the mode-locking mechanism.

**SF1I.3 • 08:30**
**Fiber-Optic Demonstration of Optical Frequency Division for Erbium Silicon Photonics Integrated Oscillator,** Duo Li[1], Michael Peng[1], Hung-Wen Chen[1], Jinkang Lim[1], Michael R. Watts[1], Franz Kärtner[1,2]; *[1]Electrical Engineering and Computer Science, MIT, USA; [2]Center for Free-Electron Laser Science, Deutsches Elektronen Synchrotron, Germany.* Using fiber-optic components, we demonstrate an optical frequency division scheme for a proposed erbium silicon photonics integrated oscillator. An 80-dB division ratio from 192 THz to 1 GHz is achieved without f-2f interferometer and carrier-envelope-phase locking.

### Meeting Room 212 A/C

**08:00–10:00**
**SF1J • Laser Initiated Self-organization & Patterning**
*Presider: Vassilia Zorba; Lawrence Berkeley National Lab, USA*

**SF1J.1 • 08:00**
**Self-Organization of Waveguides Toward Luminescent Targets in Novel Organic/Inorganic Hybrid Materials,** Makoto Iida[1], Tetsuzo Yoshimura[1], Hideyuki Nawata[2]; *[1]School of Computer Science, Tokyo Univ. of Technology, Japan; [2]Nissan Chemical Industries, LTD, Japan.* We demonstrate self-organization of an optical waveguide toward a luminescent target by self-focusing to enable "optical solder," namely, a self-aligned coupling of two multimode optical fiber cores in a photo-sensitive organic/inorganic hybrid material, SUNCONNECT®.

**SF1J.2 • 08:15**
**Femtosecond Laser Nanostructuring for Polarization Sensitive Imaging,** Martynas Beresna[1], Mindaugas Gecevičius[1], Peter G. Kazansky[1]; *[1]Optoelectronics Research Centre, Univ. of Southampton, UK.* We demonstrate maskless, single-step fabrication of micro-waveplate array by femtosecond direct writing in the bulk of silica glass. The waveplate array enables instant measurement of the distribution of the Stokes vectors in the visible spectrum.

**SF1J.3 • 08:30**
**Diffraction-assisted micropatterning of silicon surfaces by ns-laser irradiation,** Giovanni Mecalco[1], Carlos Acosta-Zepeda[1], Jose Luis Hernandez-Pozos[1], Nikola Batina[2], Israel Morales-Reyes[2], Jörn Bonse[3], Emmanuel Haro-Poniatowski[1]; *[1]Physics, Universidad Autonoma Metropolitana Iztapalapa, Mexico; [2]Chemistry, Universidad Autónoma Metropolitana Iztapalapa, Mexico; [3]Physics, BAM Bundesanstalt für Materialforschung und-prüfung, Germany.* Single-pulse (532 nm, 10 ns) micropatterning of silicon surfaces through a pinhole is demonstrated using scanning electron and atomic force microscopy. The results are compared to the Fresnel diffraction theory and physical mechanisms are discussed.

## CLEO: QELS-Fundamental Science

### Meeting Room 212 B/D

**08:00–10:00**
**FF1K • Photonic Crystals and Complex Plasmonic Nanostructures**
*Presider: Arif Cetin, Boston Univ., USA*

**FF1K.1 • 08:00**
**Ultrafine control of partially loaded single plasmonic nanoantennas fabricated using e-beam lithography and helium ion beam milling,** Yudong Wang[1,2], Martina Abb[2], Stuart A. Boden[1], Javier Aizpurua[3], Cornelis Hendrik de Groot[1], Otto L. Muskens[2]; *[1]Nano Group, ECS, Univ. of Southampton, UK; [2]Physics & Astronomy, Univ. of Southampton, UK; [3]Mat Physics Ctr. CSIC-UPV/ and DIPC, Paseo Manuel Lardizabal 4, Spain.* Plasmonic resonance shift between capacitive and conductive coupling of a partially loaded dimer antenna has been achieved by the ultrafine control of milling partial antenna gaps with nanometer precision using a helium ion beam microscope.

**FF1K.2 • 08:15**
**Enhanced plasmonic performance in ultrathin silver structures using Gas Cluster Ion Beam Irradiation,** Ee Jin Teo[1], Noriaki Toyoda[2], Chengyuan Yang[3], Bing Wang[1], Nan Zhang[1], Andrew A. Bettiol[3], Jinghua Teng[1]; *[1]Inst. of Materials Research and Engineering, Singapore; [2]Univ. of Hyogo, Japan; [3]Physics, National Univ. of Singapore, Singapore.* We demonstrate the use of Gas Cluster Ion Beam (GCIB) nanoprocessing technology for producing ultrathin silver waveguide and disk structures with smoother surfaces and wider grain sizes for enhanced surface plasmon propagation.

**FF1K.3 • 08:30**
**Template Fabricated Plasmonic Nanoholes on Analyte-Sensitive Substrates for Vapor Sensing,** Mark Turner[1], Benjamin Heppner[1], Isabel Rich[1], Nathan Lindquist[1]; *[1]Physics Dept., Bethel Univ., USA.* Template-stripping is used to produce plasmonic nanoholes on chemically-patterned substrates for real-time, multiplex vapor sensing. The open-hole geometry allows simultaneous response from both sides of the chip during exposure to <10 ppm ethanol in nitrogen.

## CLEO: Applications & Technology

### Marriott Salon I & II

**08:00–10:00**
**AF1L • Symposium on Optofluidic Microsystems I**
*Presider: Andreas Vasdekis, Pacific Northwest National Labs., USA*

**AF1L.1 • 08:00** Invited
**Optofluidics 10 years later,** Demetri Psaltis[1]; *[1]EPFL, Switzerland.* We will contrast the plans and expectations at the start of the optofluidics project 10 years ago with the current activities in the domain.

**AF1L.2 • 08:30** Invited
**Optofluidic Bio-Lasers:Bridging Photonics, Nanotechnology, and Biology,** Xudong Fan[1]; *[1]Univ. of Michigan, USA.* The optofluidic bio-laser integrates microfluidics, microcavity, and biochemically related gain medium. I will introduce the unique and advantageous characteristics of the optofluidic bio-laser, describe its current implementations, and discuss the future research and development.

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Follow us @cleoconf on Twitter.

## CLEO: Science & Innovations

Marriott
Salon III

08:00–10:00
### SF1M • Optomechanics I
*Presider: Chee Wei Wong, Columbia Univ., USA*

**SF1M.1 • 08:00**
**Controlling Light with Light in a Plasmonic Nanooptomechanical Metamaterial,** Jun-Yu Ou[1], Eric Plum[1], Jianfa Zhang[1], Nikolay I. Zheludev[1,2]; *[1]Optoelectronics Research Centre, Univ. of Southampton, UK; [2]Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore.* We demonstrate metamaterial with a cubic optical nonlinearity that is ten orders of magnitude greater than the reference nonlinearity of CS2. The nonlinearity has optomechanical nature and is underpinned by light-induced electromagnetic near-field interactions.

**SF1M.2 • 08:15**
**3C-SiC Nanobeam Optomechanical Crystals,** Jonathan Yiho Lee[1], Xiyuan Lu[2], Philip X.-L. Feng[3], Qiang Lin[4]; *[1]Dept. of Electrical and Computer Engineering, Univ. of Rochester, USA; [2]Dept. of Physics and Astronomy, Univ. of Rochester, USA; [3]Dept. of Electrical Engineering and Computer Science, Case Western Reserve Univ., USA; [4]Inst. of Optics, Univ. of Rochester, USA.* We report the first demonstration of high-quality (Qi ~2.8-3.2x10^3) 3C silicon carbide photonic crystal nanobeams. With the strong optomechanical coupling (gOM/2π~100 GHz/nm), we observed clear optical transduction of the thermal mechanical motion of the couple-nanobeam.

**SF1M.3 • 08:30**
**Optomechanics in Gallium Phosphide Microdisks,** Matthew Mitchell[1,2], Aaron C. Hryciw[2], Paul E. Barclay[1,2]; *[1]Inst. for Quantum Science & Tech., Univ. of Calgary, Canada; [2]NRC-National Inst. for Nanotechnology, Canada.* Gallium phosphide microdisk optical cavities with intrinsic quality factors $Q_i$ ~ 2.8 x $10^5$ at 1.5 µm are demonstrated. No two-photon absorption is observed. Saturation of internal optical loss, and optomechanical coupling to radial breathing modes with $g_0$ ~ 30 kHz is observed.

Marriott
Salon IV

08:00–10:00
### SF1N • Next Generation Fiber Designs
*Presider: Ayman Abouraddy; Univ. of Central Florida, CREOL, USA*

**SF1N.1 • 08:00** Invited
**First demonstration of single trench fiber for delocalization of higher order modes,** Deepak Jain[1], Catherine Baskiotis[1], Jaesun Kim[2], Jayanta K. Sahu[1]; *[1]Univ. of Southampton, UK; [2]SPI Lasers, UK.* We demonstrate an ytterbium-doped single-trench fiber ensuring a high losses ratio (~1000) and low power fraction (~0.7) between the higher-order-modes and fundamental-mode with excellent bend robustness and 85% laser efficiency at a wavelength of 1040nm.

**SF1N.2 • 08:30**
**Yb-Doped Photonic Bandgap Fiber Lasers with Record Core Diameter,** Guancheng Gu[1], Fanting Kong[1], Thomas Hawkings[1], Joshua Parsons[1], Maxwell Jones[1], Christopher Dunn[1], Monica Kalichevsky-Dong[1], Kunimasa Saitoh[2], Liang Dong[1]; *[1]ECE/COMSET, Clemson Univ., USA; [2]Graduate School of Information Science and Technology, Hokkaido Univ., Japan.* We have demonstrated ytterbium-doped fiber lasers in 50µm-core photonic bandgap fibers with robust single mode output, a record core diameter for active photonic bandgap fibers, with slope efficiency exceeding 70%.

Marriott
Salon V & VI

08:00–10:00
### SF1O • Integrated Polarization Management
*Presider: To be Determined*

**SF1O.1 • 08:00**
**Polarization Splitting at Infrared Wavelengths using Silicon Nanoridges,** Mohammadreza Khorasaninejad[1], Kenneth B. Crozier[1]; *[1]Harvard Univ., USA.* We propose a polarization splitting method based on near-field interference. Unlike conventional polarizers, our design does not absorb the undesired polarization but rather deflects light in a polarization-dependent manner. This could enable high efficiency polarization-resolved-imaging.

**SF1O.2 • 08:15**
**Separating Left- from Right-Circularly Polarized Light with a Dielectric Metamaterial,** Mohammadreza Khorasaninejad[1], Kenneth B. Crozier[1]; *[1]School of Engineering and Applied Sciences, Harvard Univ., USA.* We experimentally demonstrate a dielectric metamaterial comprising silicon nanofins on a glass substrate. Left- and right-circularly polarized beams incident upon the device are deflected into different directions. Our approach avoids the efficiency issues of plasmonics.

**SF1O.3 • 08:30**
**On-chip synthesis of circularly polarized light with a 2D grating emitter,** Li He[1], Mo Li[1]; *[1]Univ. of Minnesota, Dept. of Electrical and Computer Engineering, USA.* We demonstrate a 2D grating emitter that emits circularly polarized light beam with tunable handedness synthesized from a waveguide mode. Such a device could serve as an interface between silicon photonic waveguides and helicity-dependent optoelectronic devices.

Marriott
Willow Glen I-III

## CLEO: Applications & Technology

08:00–10:00
### AF1P • Photons for Environment
*Presider: Christian Wetzel, Rensselaer Polytechnic Institute, USA*

**AF1P.1 • 08:00** Invited
**Frontiers of Eco-Efficient Ultraviolet Water Treatment Technologies,** D. G. Knight[1]; *[1]Trojan Technologies Inc., Canada.* Development of ecologically-efficient UV water treatment has resulted in lower energy consumption and compact design, as well as a reduced carbon footprint compared to alternate technologies for environmental contaminant treatment such as activated carbon.

**AF1P.2 • 08:30**
**Solid State Mobile Lidar for Ozone Atmospheric Profiling,** Russell J. De Young[1], William Carrion[2]; *[1]Science directorate, NASA Langley Research Center, USA; [2]Coherent Applications Inc., USA.* A tunable Ce:LiCAF laser is pumped by a CLBO crystal pumped by a doubled Nd:YLF laser running at 1 kHz. The UV tunable Ce:LiCAF laser produces two UV pulses between 280 to 295nm. These pulses are transmitted into the atmosphere to profile the concentration of ozone as a function of altitude.

## Executive Ballroom 210A

## CLEO: QELS-Fundamental Science

### FF1A • Coherent Effects with Quantum Dots—Continued

**FF1A.4 • 08:45**
**Controlled modification of the electronic wavefunction and direct observation of quantum decoherence in a room-temperature quantum-dot semiconductor optical amplifier,** Amir Capua[1,3], Ouri Karni[1], Gadi Eisenstein[1], Vitalii Ivanov[2], Vitalii Sichkovskyi[2], Johann Peter Reithmaier[2]; [1]*Technion Israel Inst. of Technology, Israel;* [2]*Univ. Kassel, Germany;* [3]*IBM Research, USA.* A unique experimental setup combining short pulse pump-probe and FROG characterization, enables control by light pulses over the electronic quantum state, and a direct observation of the wavefunction decoherence in a room-temperature semiconductor laser amplifier.

**FF1A.5 • 09:00**
**Deterministic Writing and Control of the Dark Exciton State using Short Single Optical Pulses,** Ido Schwartz[1], Emma Schmidgall[1], Liron Gantz[1], Dan Cogan[1], Eli Bordo[1], David Gershoni[1]; [1]*Physics, Technion, Israel.* We experimentally demonstrate deterministic optical writing of a quantum dot-confined dark exciton, in a pure quantum state using one optical pulse. We then control the spin state of this long-lived exciton using picosecond optical pulses.

**FF1A.6 • 09:15**
**Fast, High Fidelity, Single-Shot Quantum Non-Demolition Measurement of a Quantum Dot Electron Spin using Cavity Exciton-Polariton Resonance,** shruti puri[1], Peter L. McMahon[1], Yoshihisa Yamamoto[1,2]; [1]*Stanford Univ., USA;* [2]*National Inst. of Informatics,, Japan.* We propose a novel scheme for a single-shot, fast (10's of nanoseconds), high fidelity (99.95%) quantum non-demolition (QND) readout of quantum dot (QD) electron spins based on their spin-dependent Coulomb exchange interaction with optically-excited quantum well (QW) microcavity exciton-polaritons.

## Executive Ballroom 210B

## CLEO: Applications & Technology

### AF1B • Symposium on Advances in Neurophotonics I—Continued

**AF1B.3 • 09:00** ▶
**Spatially Multiplexed Fiber-optic Microscopy for Simultaneous Imaging of Multiple Brain Regions,** Jaepyeong Cha[1], Jin U. Kang[1]; [1]*Electrical and Computer Engineering, Johns Hopkins Univ., USA.* Spatially multiplexed fiber-optic imager is experimentally demonstrated. Our system utilizes a trifurcated fiber bundles for real-time brain imaging in 3 different areas.

**AF1B.4 • 09:15** ▶
**Label Free Mid-IR Photothermal Imaging of Bird Brain With Quantum Cascade Laser,** Alket Mertiri[1,6], Atcha Totachawattana[2,6], Hui Liu[2,6], Mi K. Hong[3,6], Tim Gardner[5], Michelle Y. Sander[2,6], Shyamsunder Erramilli[3,4]; [1]*Materials Science and Engineering, Boston Univ., USA;* [2]*Electrical and Computer Engineering, Boston Univ., USA;* [3]*Physics, Boston Univ., USA;* [4]*Biomedical Engineering, Boston Univ., USA;* [5]*Biology, Boston Univ., USA;* [6]*Photonics Center, Boston Univ., USA.* Label free mid-infrared photothermal imaging on bird brain slices is presented. The Amide-I vibrational band is excited by a quantum cascade laser and an Er:doped fiber measures the photothermal response.

## Executive Ballroom 210C

## CLEO: QELS-Fundamental Science

### FF1C • Metasurfaces I—Continued

**FF1C.2 • 09:00** ▶
**Generation of light beams carrying orbital angular momentum using an ultrathin plasmonic metasurface,** Israel De Leon[1], Ebrahim Karim[1], Sebastian A. Schulz[1], Hammam Qassim[1], Jeremy Upham[1], Robert W. Boyd[1,2]; [1]*Physics, Univ. of Ottawa, Canada;* [2]*Inst. of Optics, Univ. of Rochester, USA.* We generate optical orbital angular momentum in the visible regime via spin-to-orbital angular momentum coupling by ultrathin ($\lambda$/30), inhomogeneous, birefringent plasmonic arrays. Such metasurfaces will enable compact, efficient generation of structured light.

**FF1C.3 • 09:15**
**Withdrawn**

## Executive Ballroom 210D

### FF1D • Entangled Photons and Quantum Effects—Continued

**FF1D.4 • 08:45** ▶
**Entanglement in a Bragg Reflection Waveguide,** Rolf Horn[1], Piotr Kolenderski[2], Dongpeng Kang[3], Payam Abolghasem[3], Lukas G. Helt[4], Sergei Zhukovsky[4], Carmelo Scarcella[5], Adriano Della Frera[5], Alberto Tosi[5], John E. Sipe[4], Gregor Weihs[6], Amr S. Helmy[3], Thomas Jennewein[1]; [1]*Inst. for Quantum Computing, Univ. of Waterloo, Canada;* [2]*Inst. of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus Univ., Poland;* [3]*The Edward S. Rogers Sr. Dept. of Electrical and Computer Engineering, Univ. of Toronto, Canada;* [4]*Dept. of Physics, Univ. of Toronto, Canada;* [5]*Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano, Italy;* [6]*Inst. for Experimental Physics, Univ. of Innsbruck, Austria.* We demonstrate that an integrated photonic Bragg Reflection waveguide (BRW) inherently produces polarization entangled photons.

**FF1D.5 • 09:00** ▶
**Impact of Photon Statistics on Two-Photon Excited Fluorescence,** Henning Kurzke[1], Andreas Jechow[1], Michael Seefeldt[1], Jan Kiethe[1], Axel Heuer[1], Ralf Menzel[1]; [1]*Univ. of Potsdam, Inst. of Physics and Astronomy, Germany.* We report on utilizing the photon bunching effect in thermal light to enhance the efficiency of Two-Photon Excited Fluorescence (TPEF) under continuous wave illumination. This has potential applications in microscopy.

**FF1D.6 • 09:15** ▶
**Quantum Effects in Four-Wave Mixing: Collapse and Revival of Bi-Photon Interference,** Rafi Z. Vered[1], Yelena Ben Or[1], Michael Rosenbluh[1], Avi Pe'er[1]; [1]*Physics, Bar Ilan Uinversity, Israel.* We explore the classical-to-quantum transition with light produced by broadband spontaneous FWM in fibers. Observing bi-photon quantum interference and its dependence on internal loss, we demonstrate quantum collapse and revival of the interference contrast.

## CLEO: Science & Innovations

### Executive Ballroom 210E

### SF1E • FROG and Pulse Characterization—Continued

**SF1E.4 • 09:00** ▶
**Real-time optical time-stretch statistical characterization of supercontinuum suppression by minute continuous wave,** Zhibo Ren[1], Kevin Tsia[1], Kenneth Wong[1]; [1]*Univ. of Hong Kong, Hong Kong.* We experimentally demonstrate that a minute continuous-wave becalms Raman soliton and thus actively suppresses supercontinuum. The effects are characterized in detail by real-time spectrally-resolved statistical analysis enabled by optical time-stretch.

**SF1E.5 • 09:15** ▶
**The Coherent Artifact in Interferometric Pulse-Measurement Techniques,** Michelle Rhodes[1], Madhuri Mukhopadhyay[2], Jonathan Birge[3], Gunter Steinmeyer[4], Rick Trebino[1]; [1]*Georgia Inst. of Technology, USA;* [2]*Dept. of Chemistry and Biochemistry, Univ. of Arkansas, USA;* [3]*Lincoln Lab, USA;* [4]*Max Born Inst. for Nonlinear Optics and Short Pulse Spectroscopy, Germany.* We study multi-shot intensity-and-phase measurements of unstable trains of ultrashort pulses using two-dimensional spectral shearing interferometry (2DSI) and self-referenced spectral interferometry (SRSI) in order to identify warning signs of pulse-shape instability.

### Executive Ballroom 210F

### SF1F • THz Spectroscopy & Sensing II—Continued

**SF1F.4 • 08:45**
**THz spectroscopy of bovine serum albumin solution using the long-range guided mode supported by thin liquid films,** Robert Sczech[1], Peter Haring Bolívar[1]; [1]*Universität Siegen, Germany.* We demonstrate THz spectroscopy of mM BSA solutions using the long-range guided mode as an alternative approach to traditional transmission and reflection concepts. The cm propagation lengths pave the way for integrating field-enhancing resonating structures.

**SF1F.5 • 09:00**
**Measurements of Broadband THz Pulse Propagation through dense Fog,** Yihong Yang[1], Mahboubeh Mandehgar[1], Daniel R. Grischkowsky[1]; [1]*Oklahoma State Univ., USA.* We experimentally demonstrate, using a long-path THz-TDS system, non-distorted and non-attenuated broadband THz pulse propagation through a 137 m long path in dense fog with an optical visibility of only 5 m.

**SF1F.6 • 09:15**
**Multi-Step Pattern-Recognition: A Powerful Tool for Substance Identification Based on Real-World Terahertz-Spectra,** Frank Ellrich[1], Daniel Molter[1], Joachim Jonuscheit[1], Georg von Freymann[1], Rene Beigang[1], Frank Platte[2], Konstantinos Nalpantidis[2], Thorsten Sprenger[3], Daniel Hübsch[3], Christoph Fredebeul[2]; [1]*Materials Characterization and Testing, Fraunhofer Inst. for Physical Measurement Techniques IPM, Germany;* [2]*Simulations for Fluid Flow & Optical Technologies, IANUS Simulation GmbH, Germany;* [3]*R&D Public Security, HÜBNER GmbH & Co. KG, Germany.* Combining different chemometric tools we demonstrate the reliable identification of substances out of real-world terahertz-spectra. Systematic evaluation of the spectra allows for the distinction between spectral properties arising from samples geometry versus true material absorption.

### Executive Ballroom 210G

### SF1G • Vertical Cavity Lasers—Continued

**SF1G.4 • 09:00**
**Coherently Coupled Bottom-Emitting Vertical Cavity Laser Arrays,** Zihe Gao[1], Gautham Ragunathan[1], Bradley Thompson[1], Matthew Johnson[1,2], Bibhudutta Rout[3], Kent D. Choquette[1]; [1]*Dept. of Electrical and Computer Engineering, Univ. of Illinois, USA;* [2]*USA Air Force, USA;* [3]*Dept. of Physics, Univ. of North Texas, USA.* We demonstrate 2-dimentional coherently coupled bottom-emitting VCSEL arrays. In-phase operation has been obtained from 3-element triangular arrays, while out-of-phase operation has been obtained from 2x2, 3x3, and 4x4 arrays.

**SF1G.5 • 09:15**
**Single-Mode 850 nm VCSELs Array with High-Power, Single-Lobe Pattern, and Narrow Divergence Angle,** Kai-Lun Chi[1], Jia-Wei Jiang[1], Ying-Jay Yang[2], Jin-Wei Shi[1]; [1]*Electrical Engineering, National Central Univ., Taiwan;* [2]*Electrical Engineering, National Taiwan Univ., Taiwan.* A high-performance single-mode 850 nm VCSEL array is demonstrated. By using Zn-diffusion apertures with the proper array spacing, a circular-symmetric pattern with CW high-power (140 mW) and narrow divergence angle (~$5^0$) have been simultaneously achieved.

### Executive Ballroom 210H

### SF1H • Optical Manipulation for Biomedical Application—Continued

**SF1H.4 • 08:45**
**Microparticles Manipulation by Nonparaxial Accelerating Beams,** Ran Schley[1], Ido Kaminer[1], Elad Greenfield[1], Rivka Bekenstein[1], Yaakov Lumer[1], Mordechai Segev[1]; [1]*Technion Israel Inst. of Technology, Israel.* We introduce loss-proof shape-invariant nonparaxial accelerating beams that overcome both diffraction and absorption, and demonstrate their use in acceleration of microparticles inside liquids along curved trajectories that are significantly steeper than ever achieved.

**SF1H.5 • 09:00** Invited
**Shaping the Future of Biophotonics: Imaging and Manipulation,** Kishan Dholakia[1]; [1]*Univ. of St Andrews, UK.* This talk will describe the use of the generation, use and advantages of complex light fields for applications in light sheet imaging, targeted cell transfection and manipulation.

## Meeting Room
## 211 B/D

## CLEO: Science & Innovations

### SF1I • Microresonotor Combs—Continued

**SF1I.4 • 08:45**
**Phase Measurements and Phase-Locking in Microresonator-Based Optical Frequency Combs,** Pascal Del'Haye[1], William Loh[1], Katja Beha[1], Scott B. Papp[1], Scott A. Diddams[1]; [1]*NIST, USA.* We present a novel scheme for precise phase measurements of individual modes in microresonator-based optical frequency combs. We find microcomb states with characteristic phase-steps of multiples of $\pi$ and $\pi/2$ in the comb spectrum.

**SF1I.5 • 09:00**
**Revealing spectral amplitude and phase correlations of an optical frequency comb with ultrafast pulse-shaping,** Roman Schmeissner[1], Jonathan Roslund[1], Claude Fabre[1], Nicolas Treps[1]; [1]*Laboratoire Kastler Brossel, France.* The spectral correlations of amplitude and phase noise in an optical frequency comb are characterized. Correlations appear at timescales <μs and allow a generalization of comb noise from the repetition rate- and CEO-phase representation.

**SF1I.6 • 09:15**
**Quantum Limited Parameter Estimation with Pulse Shaped Frequency Combs,** Valérian Thiel[1], Pu Jian[1], Jonathan Roslund[1], Nicolas Treps[1], Claude Fabre[1]; [1]*Quantum Optics, Laboratoire Kastler Brossel, France.* Combining a multi-color homodyne detection scheme with techniques from quantum optics, we show the feasibility of shot-noise limited measurements of a medium's parameters, while also being able to compensate for their fluctuations.

## Meeting Room
## 212 A/C

### SF1J • Laser Initiated Self-organization & Patterning—Continued

**SF1J.4 • 08:45**
**Comparison of VO2 thin films deposited by pulsed laser, electron-beam and sputter deposition,** Robert E. Marvel[1]; [1]*Physics, Vanderbilt Univ., USA.* The optical performance and morphology of VO2 thins films deposited by electron beam evaporation, rf magnetron sputtering and pulsed laser deposition are compared. Laser-deposited films are strongly affected by substrate dewetting and epitaxial mismatch.

**SF1J.5 • 09:00**
**Chiral mono-crystalline silicon nano-cone fabrication by optical vortex pumping,** Fuyuto Takahashi[1], Shun Takizawa[1], Hirofumi Hidai[1], Katsuhiko Miyamoto[1], Ryuji Morita[2,3], Takashige Omatsu[1,3]; [1]*Chiba Univ., Japan;* [2]*Hokkaido Univ., Japan;* [3]*CREST, Japan.* We for the first time demonstrated a chiral mono-crystalline cone-shaped silicon structure (chiral Si nano-cone). It was fabricated on a nano-scale by transferring the optical angular momentum of optical vortex to a mono-crystalline Si substrate.

**SF1J.6 • 09:15**
**Guidelines for efficient direct ablation of dielectrics with single femtosecond pulses down to 7 fs,** Marc Sentis[1,2], Olivier Uteza[1,2], Nicolas Sanner[2,1], Maxime Lebugle[2,1]; [1]*LP3 Lab, CNRS, France;* [2]*LP3 Lab, Aix-Marseille Univ., France.* We demonstrated that the measurement of the laser-induced ablation threshold and the fluence for maximum ablation efficiency, are only required to qualify the outcomes of laser ablation in an extended range of applied fluence.

## Meeting Room
## 212 B/D

## CLEO: QELS-Fundamental Science

### FF1K • Photonic Crystals and Complex Plasmonic Nanostructures—Continued

**FF1K.4 • 08:45**
**Triangular nanobeam fabrication strategy for quantum photonic network realization in bulk diamond,** Igal Bayn[1,2], Sara Mouradian[1], Luozhou Li[1,2], Tim Schroeder[1], Ophir Gaathon[1], Ming Lu[3], Aaron Stein[3], Dirk Englund[1]; [1]*Dept. of Electrical Engineering and Computer Science, and Research Lab of Electronics, MIT, USA;* [2]*Dept. of Electrical Engineering, Columbia Univ., USA;* [3]*Center for Functional Nanomaterials, Brookhaven National Lab, USA.* A triangular nanobeam architecture for a bulk-diamond quantum photonic networks based on silicon masking and angular etching is proposed and implemented. Cavities with Q>3×10^3 are demonstrated. S-bent interconnects for realizing a mm-scale network are introduced.

**FF1K.5 • 09:00**
**Photo-oxidative tuning of individual and coupled GaAs Photonic Crystal Cavities,** Alexander Y. Piggott[1], Konstantinos Lagoudakis[1], Michal Bajcsy[1,2], Tomas Sarmiento[1], Jelena Vuckovic[1]; [1]*E. L. Ginzton Lab, Stanford Univ., USA;* [2]*Inst. for Quantum Computing, Univ. of Waterloo, Canada.* We demonstrate a photo-induced oxidation technique for tuning GaAs photonic crystal cavities using a 390nm laser, and show that it is applicable to cavity arrays by tuning an individual cavity in a proximity-coupled cavity pair.

**FF1K.6 • 09:15**
**Cavity-enhanced Spontaneous Emission and Saturable Absorption of Colloidal Quantum Dots,** Shilpi Gupta[1], Edo Waks[1]; [1]*Univ. of Maryland, USA.* We demonstrate spontaneous emission enhancement (by an average factor of 4.6) and saturable absorption of cadmium selenide colloidal quantum dots coupled to a nanobeam photonic crystal cavity, at room temperature.

## Marriott
## Salon I & II

## CLEO: Applications & Technology

### AF1L • Symposium on Optofluidic Microsystems I—Continued

**AF1L.3 • 09:00**
**Liquid-Tuned Plasmonic External Cavity Laser,** Meng Zhang[1], Brian T. Cunningham[2,3]; [1]*Dept. of Physics, Univ. of Illinois at Urbana-Champaign, USA;* [2]*Dept. of Electrical and Computer Engineering, Univ. of Illinois at Urbana-Champaign, USA;* [3]*Dept. of Bioengineering, Univ. of Illinois at Urbana-Champaign, USA.* We developed a single-mode, continuous-wave and electrically pumped plasmonic external cavity laser. It offers a novel label-free biosensing approach by combining the refractive index sensitivity of surface plasmon resonance with the high spectral resolution of laser emission.

**AF1L.4 • 09:15**
**Enabling enhanced emission and low-threshold lasing of organic molecules using special Fano resonances of macroscopic photonic crystals,** Bo Zhen[1], Song-liang Chua[1], Jeongwon Lee[1], Alejandro Rodriguez[1], Xiangdong Liang[1], Steven Johnson[1], John Joannopoulos[1], Marin Soljacic[1], Ofer Shapira[1]; [1]*Research Lab of Electronics, MIT, USA.* We present a novel optofluidic platform comprising organic molecules in solution suspended on photonic crystal slabs. Through macroscopic Fano resonances provided, enhanced spontaneous emission and low-threshold lasing of organic molecules were observed and theoretically analyzed.

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## CLEO: Science & Innovations

## Marriott Salon III

### SF1M • Optomechanics I—Continued

**SF1M.4 • 08:45**

**Optomechanical Nanostructures via Scalable Fabrication in Single-Crystal Diamond,** Aaron C. Hryciw[1], Behzad Khanaliloo[2], Harishankar Jayakumar[2], Chris Healey[2], Paul E. Barclay[1,2]; *[1]National Inst. for Nanotechnology, National Research Council Canada, Canada; [2]Inst. for Quantum Science and Technology, Univ. of Calgary, Canada.* We demonstrate a scalable process flow to fabricate three-dimensional free-standing devices from bulk single-crystal diamond. Using a dimpled fiber taper, we couple selectively to four mechanical modes of a nanobeam to measure its optomechanical response.

**SF1M.5 • 09:00**

**Optical Momentum Transfer to Graphene in Resonators: Generalizing Coulomb-Lorentz Force on a Conductive Single Atomic Layer,** Hossein Mousavi[1], Peter Rakich[2], Zheng Wang[1]; *[1]Dept. of Electrical and Computer Engineering, UT Austin, USA; [2]Dept. of Applied Physics, Yale Univ., USA.* We demonstrate that judicious selection of mirrors/substrates, operational frequency, and graphene location inside a cavity yields unprecedented optical forces on graphene, while tolerably modifies Q of the cavity.

**SF1M.6 • 09:15**

**Electromagnetically Induced Transparency in Si3N4 nanobeam optomechanical crystals,** Marcelo I. Davanco[1], Serkan Ates[2], Yuxiang Liu[3], Kartik Srinivasan[1]; *[1]NIST, USA; [2]The Scientic and Technological Research Council of Turkey, Turkey; [3]Mechanical Engineering, Worcester Polytechnic Inst., USA.* We demonstrate electromagnetically induced transparency in sideband-resolved Si3N4 optomechanical crystals supporting optical modes in the 980 nm band and ≈4GHz mechanical resonances, in both ambient conditions and at cryogenic temperatures.

## Marriott Salon IV

### SF1N • Next Generation Fiber Designs—Continued

**SF1N.3 • 08:45**

**Highly birefringent multicore optical fibers,** James M. Stone[1], Fei Yu[1], Jonathan C. Knight[1]; *[1]Dept. of Physics, Univ. of Bath, UK.* We report on the fabrication and characterization of two polarization maintaining multicore fibres, one with three and the other with ninety eight cores. The beat length and polarization orientation are characterized.

**SF1N.4 • 09:00**

**Plasmonic Nanowire Continuum Light Source,** Behrad Gholipour[1], Nalla Venkatram[1], Paul Bastock[2], Khouler Khan[2], Chris Craig[2], Dan Hewak[2], Nikolay I. Zheludev[1,2], Cesare Soci[1]; *[1]Centre for disruptive photonic technologies (CDPT), Nanyang technological Univ., Singapore; [2]Optoelectronics research centre (ORC), Univ. of Southampton, UK.* Optically pumped gold nanowire, 330 nm in diameter imbedded into silicate optical fiber produces broadband, highly collimated radiation (in the range 470-900 nm) with divergence of less than 4 mrad.

**SF1N.5 • 09:15**

**Growth of Glass-clad Cr4+:YSO Crystal Fiber for White Light Interferometry,** Kuang-Yu Hsu[1], Shih-Chang Wang[1], Dong-Yo Jheng[1], Tuan-Shu Ho[1], Teng-I Yang[1], Sheng-Lung Huang[1]; *[1]National Taiwan Univ., Taiwan.* Glass-clad Cr4+:YSO crystal fibers were grown using the laser-heated pedestal growth method. Quasi-3-level behavior of the Cr4+:YSO was observed, and the emission was red shifted to 1302 nm with a 3-dB bandwidth of 230 nm.

## Marriott Salon V & VI

### SF1O • Integrated Polarization Management—Continued

**SF1O.4 • 08:45**

**Polarization-selective Coupling to Long-Range Surface Plasmon-Polariton Waveguides,** J. P. Balthasar Mueller[1], Kristján Leósson[2], Federico Capasso[1]; *[1]School of Engineering and Applied Sciences, Harvard Univ., USA; [2]Science Inst., Univ. of Iceland, Iceland.* We use plasmonic antenna arrays to unidirectionally couple incident light in two different polarization states to long-range surface plasmon polariton waveguide modes propagating in opposite directions. The structures enable polarization-sorting with extinction rates in excess of 30dB.

**SF1O.5 • 09:00**

**Metal Nanorods Array Embedded Silicon Waveguide Polarization Beam Splitter,** Sangsik Kim[1], Minghao Qi[1]; *[1]School of Electrical and Computer Engineering and Birck Nanotechnology Center, Purdue Univ., USA.* We present a polarization beam splitter with a metal nanorods array embedded between two silicon waveguides. Localized surface plasmon resonance of the metal array introduces the birefringence with short coupling length and broad bandwidth.

**SF1O.6 • 09:15**

**Polarization Cross-coupling Between Microring and Bus Waveguide in Double-layer SOI,** Hesam Moradinejad[1], Amir H. Atabaki[2], Hossein Taheri[1], Ali A. Eftekhar[1], Ali Adibi[1]; *[1]Georgia Inst. of Technology, USA; [2]MIT, USA.* We investigate polarization cross-coupling between modes of microring resonators and waveguides due to structural asymmetries. We experimentally demonstrate the coupling between a double-layer SOI waveguide fundamental TM mode and microring higher-order radial TE modes.

## Marriott Willow Glen I-III

## CLEO: Applications & Technology

### AF1P • Photons for Environment—Continued

**AF1P.3 • 08:45**

**Noble-Metal-Free Sunlight Harvesting Meta-surface for Water Evaporation,** Shinya Hakuta[1,2], Kevin F. MacDonald[1], Nikolay I. Zheludev[1,3]; *[1]Optoelectronics Research Centre & Centre for Photonic Metamaterials, Univ. of Southampton, UK; [2]Frontier Core-Technology Labs, Fujifilm Corporation, Japan; [3]Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore.* We present ultrathin multilayer metamaterial absorbers based on abundant, low-cost materials, to effectively harness solar energy for heating and evaporation of water.

**AF1P.4 • 09:00**

**Multipoint Temperature and Pressure Sensing System for Monitoring CO2 Sequestration Wells,** Ansas Kasten[1], Sachin N. Dekate[1], Reza Ghandi[1], William A. Challener[1], Roger Jones[2], Russell Craddock[2]; *[1]GE Global Research, USA; [2]GE Druck Ltd., UK.* A new interrogation scheme for pressure and temperature measurement in CO2 sequestration wells by MEMS sensors via fiber optic cable has been developed. The technique should enable sensor multiplexing for distributed downhole measurements.

**AF1P.5 • 09:15**

**Highly Efficient InGaN-based LED with Embedded Cubic Airvoids,** Da-Wei Lin[1], Jhih-Kai Huang[1], Che-Yu Liu[1], Ruey-Wen Chang[1], Sheng-Wen Wang[1], Gou-Chung Chi[1], Hao-chung Kuo[1]; *[1]Dept. of Photonics and Inst. of Electro-Optical Engineering, National Chiao Tung Univ., Taiwan.* Highly efficient InGaN-based LEDs with embedded sidewall passivation cubic airvoids made by nanoimprint lithography were demonstrated. The LEDs with embedded airvoids exhibit a 45% enhancement of light output at 20 mA compared with conventional LEDs.

## Executive Ballroom 210A

## CLEO: QELS-Fundamental Science

### FF1A • Coherent Effects with Quantum Dots—Continued

**FF1A.7 • 09:30**
**Reservoir-assisted coherent control of a quantum dot spin,** Jack Hansom[1], Carsten Schulte[1], Claire Le Gall[1], Clemens Matthiesen[1], Edmund Clarke[2], Jacob Taylor[3,4], Mete Atature[1]; [1]*Cavendish Lab, Univ. of Cambridge, UK;* [2]*EPSRC National Centre for III-V Technologies, Univ. of Sheffield, UK;* [3]*Joint Quantum Inst., Univ. of Maryland, USA;* [4]*National Inst. of Standards and Technology, USA.* We demonstrate all-optical coherent manipulation of a quantum dot spin through coherent population trapping with a sub-linewidth spin splitting, enabled by the hyperfine interaction with a mesoscopic nuclear spin ensemble.

**FF1A.8 • 09:45**
**Feedback-Enhanced Entanglement of Photons from a Biexciton Cascade,** Sven M. Hein[1], Franz Schulze[1], Nicolas L. Naumann[1], Alexander Carmele[2], Andreas Knorr[1]; [1]*Institut für theoretische Physik, TU Berlin, Germany;* [2]*Institut für Quantenoptik und Quanteninformation, Austrian Academy of Sciences, Austria.* The entanglement of photons from a biexciton cascade is strongly diminished by exciton fine-structure splitting. We demonstrate an optical feedback mechanism to counteract this loss and to control the photon entanglement.

## Executive Ballroom 210B

## CLEO: Applications & Technology

### AF1B • Symposium on Advances in Neurophotonics I—Continued

**AF1B.5 • 09:30** Invited ▶
**Visible Brain-wide Networks at Single-neuron Resolution with Micro-Optical Sectioning Tomography,** Qingming Luo[1,2]; [1]*Britton Chance Center for Biomedical Photonics, Wuhan National Lab for Optoelectronics-Huazhong Univ. of Science and Technology, China;* [2]*MoE Key Lab for Biomedical Photonics, Dept. of Biomedical Engineering, Huazhong Univ. of Science and Technology, China.* We report a protocol combining a novel resin-embedding method for maintaining fluorescence, an automated fluorescence MOST system for long-term stable imaging, and a digital reconstruction-registration-annotation pipeline for tracing the axonal pathways individually in the mouse brain.

## Executive Ballroom 210C

## CLEO: QELS-Fundamental Science

### FF1C • Metasurfaces I—Continued

**FF1C.4 • 09:30** ▶
**Experimental Huygens' Surface for NIR Wavelengths,** Carl Pfeiffer[1], Naresh K. Emani[2], Amr M. Shaltout[2], Alexandra Boltasseva[2], Vladimir M. Shalaev[2], Anthony Grbic[1]; [1]*Electrical Engineering and Computer Science, Univ. of Michigan, USA;* [2]*Electrical & Computer Engineering and Birk Nanotechnology Center, Purdue Univ., USA.* A Huygens' surface that efficiently refracts normally incident light to an angle $\varphi$=35° at telecommunication wavelengths is reported. This represents the first experimental demonstration of an isotropic metasurface that provides wavefront control for arbitrarily polarized light.

**FF1C.5 • 09:45** ▶
**Twisting light using nano-waveguide arrays,** Jingbo Sun[1], Xi Wang[1], Tianboyu Xu[1], Alexander N. Cartwright[1], Natalia M. Litchinitser[1]; [1]*State Univ. of New York at Buffalo, USA.* We experimentally demonstrate that an array of subwavelength channels with a spiral size distribution milled in a metal film can be used to manipulate the phase front of light beam and produce a vortex beam.

## Executive Ballroom 210D

### FF1D • Entangled Photons and Quantum Effects—Continued

**FF1D.7 • 09:30** ▶
**Quantum Control of Molecular Gas Hydrodynamics,** Sina Zahedpour Anaraki[1,2], Jared K. Wahlstrand[1,3], Howard Milchberg[1,3]; [1]*Inst. for Research in Electronics and Applied Physics, Univ. of Maryland, College Park, USA;* [2]*Electrical and Computer Engineering, Univ. of Maryland, College Park, USA;* [3]*Dept. of Physics, Univ. of Maryland, College Park, USA.* We show that the deposition of energy in nitrogen by a train of ultrafast pulses can be greatly enhanced or diminished using multiple pulses spaced near the molecular rotational revival or half revival period.

**FF1D.8 • 09:45** ▶
**Increasing Weak Measurement SNR with Recycling,** Courtney Byard[1], Trent Graham[1], Andrew Jordan[2], Paul Kwiat[1]; [1]*Physics, Univ. of Illinois at UC, USA;* [2]*Physics and Astronomy, Univ. of Rochester, USA.* Recycling unmeasured photons in a system utilizing weak measurements can substantially improve the signal-to-noise ratio, even in a double-pass system. We achieve an improvement by a factor of 1.36 over a system without recycling.

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**10:00–10:30 Coffee Break,** *Concourse Level*

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NOTES

## CLEO: Science & Innovations

### Executive Ballroom 210E

### SF1E • FROG and Pulse Characterization—Continued

**SF1E.6 • 09:30** ▶

**Frequency-Resolved Optical Gating with Second-Harmonic and Sum-Frequency Generations,** Yuichiro Kida[1], Yuta Nakano[1], Kazuya Motoyoshi[1], Totaro Imasaka[1,2]; [1]*Dept. of Applied Chemistry, Graduate School of Engineering, Kyushu Univ., Japan;* [2]*Division of Optoelectronics and Photonics, Center for Future Chemistry, Kyushu Univ., Japan.* A frequency-resolved optical gating (FROG) that simultaneously acquires two second-harmonic-generation FROG traces and a cross-correlation FROG trace is reported. This FROG allows robust and reliable characterization of two unknown pulses.

**SF1E.7 • 09:45** ▶

**Single-shot, high dynamic and long temporal range measurement of 4-fs pulses,** Thomas Oksenhendler[1], Sunilkumar Anumula[2], Andrea Trabattoni[2], Giuseppe Sansone[2], Gabriel Tempea[3], Francesca Calegari[2], Mauro Nisoli[2]; [1]*FASTLITE Ultrafast Sci Instrumentation, France;* [2]*Dept. of Physics, Plitecnico di Milano, Italy;* [3]*Femtolasers Produktions GmbH, Austria.* Single-shot Self-Referenced Spectral Interferometry method, with 40-dB dynamic range, was implemented for complete temporal characterization of 4-fs, 1.9-mJ pulses. The experimental results are in excellent agreement with pulse reconstruction from streaking with isolated attosecond pulses.

### Executive Ballroom 210F

### SF1F • THz Spectroscopy & Sensing II—Continued

**SF1F.7 • 09:30**

**Hindered Molecular Reorientation of Lithium Ion Doped Succinonitrile in the Terahertz Range,** Daniel Nickel[1], Hongtao Bian[2], Junrong Zheng[2], Daniel M. Mittleman[1]; [1]*Electrical and Computer Engineering, Rice Univ., USA;* [2]*Chemistry, Rice Univ., USA.* The THz range permittivity of succinonitrile exhibits Debye-like behavior in its plastic-crystal phase, with a characteristic Cole-Cole relaxation time of 65ps ±17ps which increases considerably in the presence of ionic dopants.

**SF1F.8 • 09:45**

**Broadband Terahertz Spectroscopy of Electrically Gated Graphene,** Sayyed Hadi Razavipour[1], Wayne Yang[1], David A. Valverde Chavez[1], Eric Whiteway[1], François Blanchard[1], Michael Hilke[1], David G. Cooke[1]; [1]*McGill, Canada.* Broadband terahertz modulation at room temperature is realized using electrically gated graphene in the 1-10 THz range. By gate voltage modulation, the Drude conductivity of graphene varies along with the THz transmission response.

### Executive Ballroom 210G

### SF1G • Vertical Cavity Lasers—Continued

**SF1G.6 • 09:30**

**Heterogeneously Integrated Long-Wavelength VCSEL using High-Contrast Grating on Silicon,** James E. Ferrara[1], Weijian Yang[1], Li Zhu[1], Connie J. Chang-Hasnain[1]; [1]*EECS, Univ. of California Berkeley, USA.* We report an electrically pumped AlGaInAs-silicon VCSEL using a high-contrast grating reflector on silicon. CW output power >1.5 mW, thermal resistance of 1.46 K/mW, and 5 Gb/s direct modulation is demonstrated.

**SF1G.7 • 09:45**

**Control of the Emitted Polarization in a 1310 nm spin-VCSEL Subject to Circularly Polarized Optical Injection,** Sami Alharthi[1], Antonio Hurtado[1], Ville-Markus Korpijärvi[2], Mircea Guina[2], Ian Hening[1], Michael Adams[1]; [1]*Computer Science and Electronic Engineering, Univ. of Essex, UK;* [2]*Optoelectronics Research Centre (ORC), Tampere Univ. of Technology, Finland.* We report the first optical injection experiment on a dilute nitride 1300 nm spin-VCSEL at room temperature. Effective control of the polarization of the light emitted by the spin-VCSEL is theoretically predicted and experimentally demonstrated.

### Executive Ballroom 210H

### SF1H • Optical Manipulation for Biomedical Application—Continued

**SF1H.6 • 09:30**

**Optical magnetometry of single NV center scanning local magnetic field in micro fluid devices,** Kangmook Lim[1,2], Benjamin Shapiro[3,4], Jacob Taylor[5], Edo Waks[1,5]; [1]*Electrical and Computer Engineering, Univ. of Maryland, USA;* [2]*Inst. for Research in Electronics and Applied Physics, USA;* [3]*Fischell Dept. of Bioengineering, Univ. of Maryland, USA;* [4]*Inst. for Systems Research, USA;* [5]*Joint Quantum Inst., USA.* By combining magnetic nanoparticle 3D positioning system and NV ESR measurements in micro-fluid device, we demonstrate sensing of magnetic fringe field of a magnetic bead repeatedly displaced and mapping field profile of the magnetic dipole.

**SF1H.7 • 09:45**

**Power-Dependent Buffering Capacity of Silicon Nitride Microring-Resonator-Based Microparticle Buffers on an Optofluidic Chip,** Jiawei Wang[1], Andrew W. Poon[1]; [1]*Electronic and Computer Engineering, Hong Kong Univ. of Science and Technology, Hong Kong.* We demonstrate power-dependent buffering capacity of silicon nitride microring resonator-based microparticle buffers on an optofluidic chip. We observe power dependent buffering capacity of 7 to 21 particles for 2.2μm polystyrene microparticles, and buffering capacity of 14 red-blood-cells.

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**10:00–10:30 Coffee Break,** *Concourse Level*

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NOTES

Meeting Room
211 B/D

Meeting Room
212 A/C

## CLEO: Science & Innovations

### SF1I • Microresonotor Combs—Continued

**SF1I.7 • 09:30**
**Bandwidth Shaping of Parametric Frequency Combs via Dispersion Engineering,** Yoshitomo Okawachi[1], Michael R. Lamont[1,2], Kevin Luke[3], Daniel O. Carvalho[3], Michal Lipson[2,3], Alexander L. Gaeta[1,2]; [1]*School of Applied and Engineering Physics, Cornell Univ., USA;* [2]*Kavli Inst. at Cornell for Nanoscale Science, Cornell Univ., USA;* [3]*School of Electrical and Computer Engineering, Cornell Univ., USA.* We investigate experimentally and theoretically the role of higher-order-dispersion on the bandwidth of microresonator-based parametric frequency combs. Our results demonstrate that fourth-order dispersion plays a critical role in determining the spectral bandwidth.

**SF1I.8 • 09:45**
**Tunable Frequency Comb Generation from a Microring with a Thermal Heater,** Xiaoxiao Xue[1], Yi Xuan[1,2], Pei-Hsun Wang[1], Jian Wang[1,2], Daniel E. Leaird[1], Minghao Qi[1,2], Andrew M. Weiner[1,2]; [1]*School of Electrical and Computer Engineering, Purdue Univ., USA;* [2]*Birck Nanotechnology Center, Purdue Univ., USA.* We demonstrate a novel comb tuning method for microresonator-based Kerr comb generators. Continuously tunable, low-noise, and coherent comb generation is achieved in a CMOS-compatible silicon nitride microring resonator.

### SF1J • Laser Initiated Self-organization & Patterning—Continued

**SF1J.7 • 09:30**
**Time-resolved femtosecond laser pulse absorption at the surface of transparent dielectrics,** Nicolas Sanner[1], Maxime Lebugle[1], Marc Sentis[1], Olivier Uteza[1]; [1]*Aix-Marseille Univ., France.* Time-resolved absorption of a 500-fs laser pulse by fused silica is measured. The results evidence a strong contribution of linear absorption for high pump fluence, during the entire pulse length.

**SF1J.8 • 09:45**
**Femtosecond laser tuning of Si microring resonators by surface amorphization through a thick $SiO_2$ cladding,** Daniel Bachman[1], Zhijiang Chen[1], Ying Y. Tsui[1], Robert Fedosejevs[1], Vien Van[1]; [1]*Electrical and Computer Engineering, Univ. of Alberta, Canada.* Single femtosecond laser pulses are used to modify the surface of c-Si waveguides clad by $SiO_2$ for permanent tuning of microring resonators. Positive, controllable resonance shifts that vary with fluence are demonstrated, inducing little loss.

Meeting Room
212 B/D

## CLEO: QELS-Fundamental Science

### FF1K • Photonic Crystals and Complex Plasmonic Nanostructures—Continued

**FF1K.7 • 09:30**
**Strain Tuning of a Quantum Dot Strongly Coupled to a Photonic Crystal Cavity,** Shuo Sun[1], Hyochul Kim[1], Glenn S. Solomon[2], Edo Waks[1]; [1]*Electrical and Computer Engineering, Univ. of Maryland, USA;* [2]*National Inst. of Standards and Technology, USA.* We experimentally demonstrate reversible strain-tuning of a quantum dot strongly coupled to a photonic crystal cavity. We observe a clear anti-crossing between the quantum dot and the cavity using the strain tuning technique.

**FF1K.8 • 09:45**
**Four-wave Mixing in Slow-light Graphene-silicon Photonic Crystal Waveguides,** Hao Zhou[1,2], Tingyi Gu[1], James F. McMillan[1], Nick Petrone[3], Arend van der Zande[3], James C. Hone[3], Mingbin Yu[4], Guo-Qiang Lo[4], Dim-Lee Kwong[4], Guoying Feng[2], Shouhuan Zhou[2,5], Chee Wei Wong[1]; [1]*Optical Nanostructures Lab, Columbia Univ., USA;* [2]*College of Electronic Information, Sichuan Univ., China;* [3]*Mechanical Engineering, Columbia Univ., USA;* [4]*The Inst. of Microelectronics, Singapore;* [5]*North China Research Inst. of Electro-Optics, China.* We demonstrate the enhanced four-wave mixing generated in silicon photonic crystal waveguides with monolayer graphene. An enhanced high conversion efficiency and wide detuning bandwidth is observed.

Marriott
Salon I & II

## CLEO: Applications & Technology

### AF1L • Symposium on Optofluidic Microsystems I—Continued

**AF1L.5 • 09:30**
**Reconfigurable Plasmofluidic Lenses,** Yongmin Liu[1], Chenglong Zhao[2], Yanhui Zhao[2], Nicholas Fang[3], Tony J. Huang[2]; [1]*Northeastern Univ., USA;* [2]*The Pennsylvania State Univ., USA;* [3]*MIT, USA.* Utilizing laser-induced surface bubbles on a metal film, we demonstrate a reconfigurable plasmonic lens in a microfluidic environment to achieve divergence, collimation, and focusing of surface plasmons.

**AF1L.6 • 09:45**
**Automated Single Molecule Nucleic Acid Detection with a Waveguide Chip,** Joshua W. Parks[1], Lynnell Zempoaltecatl[2], Richard A. Mathies[3], Aaron Hawkins[2], Holger Schmidt[1]; [1]*Electrical Engineering, Univ. of California Santa Cruz, USA;* [2]*Electrical and Computer Engineering, Brigham Young Univ., USA;* [3]*Chemistry, Univ. of California Berkeley, USA.* Lambda DNA (λ-DNA) molecules were labeled with SYBR Gold nucleic acid stain using a PDMS-based programmable microfluidic chip (Automaton). Single DNA molecules were detected in a vertically integrated liquid-core waveguide chip.

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**10:00–10:30 Coffee Break,** *Concourse Level*

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NOTES

## CLEO: Science & Innovations

### Marriott
### Salon III

### SF1M • Optomechanics I—Continued

**SF1M.7 • 09:30**
**Cavity Optomechanical Magnetometry on a Chip,** Eoin Sheridan[1], Stefan Forstner[1], Christopher Humphreys[1], Halina Rubinsztein-Dunlop[1], Warwick P. Bowen[1]; [1]*School of Mathematics and Physics, Univ. of Queensland, Australia*. A microscale, picotesla range, silicon-chip optical magnetometer. Earth-field, fiber coupled operation, with 60 µm resolution and 40 MHz bandwidth lead to potential applications in microfluidic-MRI, spin physics in condensed matter systems and ultracold atom clouds.

**SF1M.8 • 09:45**
**Design and Fabrication of Optomechanical Crystal Nanobeam Cavity with High Optomechanical Coupling Rate,** Yongzhuo Li[1], Kaiyu Cui[1], Xue Feng[1], Yidong Huang[1], Zhilei Huang[1], Fang Liu[1], Wei Zhang[1]; [1]*Tsinghua Univ., China.* An optomechanical crystal nanobeam cavity with high optomechanical coupling rate is proposed and fabricated. Only by adjusting the radius of the air holes, the cavity realizes an optomechanical coupling rate as high as 1.24 MHz.

### Marriott
### Salon IV

### SF1N • Next Generation Fiber Designs—Continued

**SF1N.6 • 09:30**
**Aperiodic all-solid VLMA-LPF strengthening the singlemode operation over the near infra-red spectral range,** Aurélien Benoit[1,3], Romain Dauliat[2], Raphael Jamier[1], Stephan Grimm[2], Kay Schuster[2], François Salin[3], Georges Humbert[1], Philippe Roy[1]; [1]*Xlim Research Inst., France;* [2]*Inst. of Photonic Technology, Germany;* [3]*Eolite Systems, France.* The singlemodeness of an all-solid very large mode area fiber, based on an aperiodic cladding microstructuration, is experimentally evidenced. This outstanding ability is confirmed over a large spectral range spanning from 1 to 2 µm.

**SF1N.7 • 09:45**
**Model for Pump Absorption in Rare-Earth Doped Double Clad Fibers,** V R Supradeepa[1], John M. Fini[1]; [1]*OFS Labs, USA.* We introduce and provide experimental verification for a new model and representation of pump absorption in rare-earth-doped double-clad fibers based on underlying physics. The model allows for simple evaluation of wavelength resolved, length dependent absorption.

### Marriott
### Salon V & VI

### SF1O • Integrated Polarization Management—Continued

**SF1O.7 • 09:30**
**Broadband mode-evolution-based four-port polarizing beam splitter,** Zhan Su[1], Erman Timurdogan[1], Ehsan S. Hosseini[1], Jie Sun[1], Gerald Leake[2], Douglas Coolbaugh[2], Michael R. Watts[1]; [1]*Research Lab of Electronics, MIT, USA;* [2]*College of Nanoscale Science & Engineering, Univ. at Albany, USA.* The first demonstration of a four-port integrated polarizing beam splitter is reported. The device was fabricated on a silicon-on-insulator platform and exhibits crosstalk level < -10dB over a 150nm bandwidth.

**SF1O.8 • 09:45**
**Selective excitation of guided modes in integrated aluminum nitride photonic circuits,** Matthias Stegmaier[1], Wolfram Pernice[1]; [1]*Inst. of Nanotechnology, Karlsruhe Inst. of Technology (KIT), Germany.* We demonstrate methods to identify the modal composition of light guided through integrated multimode waveguides and discuss a scheme how arbitrary higher-order modes can selectively be excited. Exemplary, we show efficient and broadband polarization conversion.

### Marriott
### Willow Glen I-III

## CLEO: Applications & Technology

### AF1P • Photons for Environment—Continued

**AF1P.6 • 09:30**
**Withdrawn**

**AF1P.7 • 09:45**
**Trace NO2 Detection Using a Multi-mode Diode Laser and Cavity Enhanced Absorption Spectroscopy,** Andreas Karpf[1], Gottipaty N. Rao[1]; [1]*Adelphi Univ., USA.* A simplified trace gas detector using a multi-mode Fabry-Perot diode laser and cavity enhanced absorption spectroscopy has been developed and used to detect NO2 at the 100 ppt level.

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**10:00–10:30 Coffee Break,** *Concourse Level*

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NOTES

## Executive Ballroom 210A

## CLEO: QELS-Fundamental Science

### 10:30–12:15
### FF2A • Quantum Memories

*Presider: Irina Novikova; College of William & Mary, USA*

**FF2A.1 • 10:30** Invited

**Quantum State Engineering for High Efficiency Quantum Memories and Cavity Line Narrowing,** Stefan Kröll[1], Mahmood Sabooni[2], Qian Li[1], Diana Serrano[1], Lars Rippe[1]; [1]*Physics, Lund Univ., Sweden;* [2]*Max-Planck-Institut für Quantenoptik, Germany.* A 56% efficiency quantum memory is created by inserting a <1% efficiency memory in a low-finesse cavity. Changing the memory absorption profile by optical pumping decreases the cavity mode-spacing by >4 orders of magnitude.

**FF2A.2 • 11:00**

**Progress towards the development of rare-earth doped waveguides for quantum communications applications,** sara marzban[1], John Bartholomew[1], Matthew J. Sellars[1], Khu Vu[1]; [1]*Laser Physics Centre, Australian National Univ., Australia.* Photon echo measurements were conducted on a slab waveguide of TeO_2 deposited on a substrate of 0:005%Pr^3+: Y_2SiO_5. The results indicate that planar waveguide technology could be utilized for quantum communication purposes.

## Executive Ballroom 210B

## CLEO: Applications & Technology

### 10:30–12:30
### AF2B • Symposium on Advances in Neurophotonics II ▶

*Presider: Nicusor Iftimia; Physical Sciences Inc., USA*

**AF2B.1 • 10:30** Invited ▶

**Serial optical coherence scanner for brain imaging and mapping,** Taner Akkin[1], Hui Wang[1]; [1]*Dept. of Biomedical Engineering, Univ. of Minnesota, USA.* The serial optical coherence scanner reconstructs macroscopic tissues at microscopic resolution using intrinsic optical contrasts. The anatomy, nerve fiber architectures and fiber orientations are shown in ex-vivo rat brains.

**AF2B.2 • 11:00** Invited ▶

**Optical Coherence Imaging of Hemodynamics, Metabolism, and Cell Viability during Brain Injury,** Vivek J. Srinivasan[1], Shau Poh Chong[1], Conrad Merkle[1], Harsha Radhakrishnan[1], Conor Leahy[1]; [1]*Univ. of California Davis, USA.* Pre-clinical quantitative imaging endpoints have been challenging in mouse models of cerebrovascular disease. Here we present optical coherence imaging platforms that can quantify blood flow, capillary perfusion, cellular status, and oxygen extraction based on intrinsic scattering signatures.

## Executive Ballroom 210C

## CLEO: QELS-Fundamental Science

### 10:30–12:30
### FF2C • Metasurfaces II ▶

*Presider: Erez Hasman; Technion-Israel Inst. of Technology, Israel*

**FF2C.1 • 10:30** ▶

**Spectrally Selective Chiral Silicon Metasurfaces Based on Infrared Fano Resonances,** Chih-Hui Wu[1], Nihal Arju[1], Jonathan Fan[3], Igal Brener[2], Gennady Shvets[1]; [1]*Univ. of Texas at Austin, USA;* [2]*Sandia National Labs,, USA;* [3]*Univ. of Illinois at Urbana-Champaign, USA.* Silicon-process compatible metasurface was designed and tested in the infrared wavelength range. These metasurfaces show very high Q (>100), extreme chirality, and polarization conversion along with very low-loss operation. They show promise for sensing applications.

**FF2C.2 • 10:45** ▶

**Nanostructured Transparent Conducting Oxide Films for Polarization Control with Plasmonic Metasurfaces,** Jongbum Kim[1], Yang Zhao[2], Aveek Dutta[1], Sajid M. Choudhury[1], Alexander Kildishev[1], Andrea Alu[2], Alexandra Boltasseva[1]; [1]*Purdue Univ., USA;* [2]*The Univ. of Texas at Austin, USA.* TCOs enable the realization of practical plasmonic and metamaterial devices at the telecommunication frequency due to their low optical loss. We have fabricated GZO plasmonic waveplates, which convert linearly polarized light into circularly polarized light.

**FF2C.3 • 11:00**

**Maximizing Strong Coupling between Metasurface Resonators and Intersubband Transitions,** Salvatore Campione[1,2], Alexander Benz[1,2], John F. Klem[2], Michael B. Sinclair[2], Igal Brener[1,2], Filippo Capolino[3]; [1]*Center for Integrated Nanotechnologies, Sandia National Labs, USA;* [2]*Sandia National Labs, USA;* [3]*Univ. of California Irvine, USA.* We analyze strongly coupled systems that use metasurface resonators and provide an electrodynamic model based on the quasi-static electric near fields that can be used to predict and maximize Rabi splitting varying resonator geometry.

## Executive Ballroom 210D

### 10:30–12:30
### FF2D • Quantum Effects in Lattices ▶

*Presider: Zhigang Chen; San Francisco State Univ., USA*

**FF2D.1 • 10:30** Invited ▶

**Realization of the Harper Hamiltonian with Ultracold Atoms in Optical Lattices,** Hirokazu Miyake[1], Georgios A. Siviloglou[1], Colin J. Kennedy[1], William C. Burton[1], Wolfgang Ketterle[1]; [1]*Dept. of Physics, MIT, USA.* We experimentally realized the Harper Hamiltonian with charge neutral, ultracold atoms in optical lattices using laser-assisted tunneling and a potential energy gradient. The energy spectrum of this Hamiltonian is the fractal Hofstadter butterfly.

**FF2D.2 • 11:00** ▶

**Rashba Effective Spin-Orbit Coupling In Photonic Lattices,** Yonatan Plotnik[1], Mikael Rechtsman[1], Simon Stützer[2], Yaakov Lumer[1], Stefan Nolte[2], Alexander Szameit[2], Mordechai Segev[1]; [1]*Technion Israel Inst. of Technology, Israel;* [2]*Friedrich Schiller Universität, Germany.* We demonstrate theoretically and experimentally the Rashba effect using light in two "counterpropagating" photonic lattices. We observe breaking of inversion symmetry in the resulting band structure.

Thank you for
attending CLEO: 2014.

Look for your
post-conference survey
via email and let us
know your thoughts on
the program.

## CLEO: Science & Innovations

### 10:30–12:30
### SF2E • Frequency Combs and CEP ▶

*Presider: Simon Birkholz, Max-Born-Institut, Germany*

**SF2E.1 • 10:30** ▶
**Self-referenced frequency comb measurement by a polarization line-by-line pulse shaper,** Chi-Cheng Chen[1], Chen-Bin Huang[1], Shang-Da Yang[1]; [1]*Inst. of Photonics Technologies, National Tsing Hua Univ., Taiwan.* A polarization line-by-line pulse shaper is used in analytically measuring optical arbitrary waveforms (OAWs) of 100% duty cycle without reference, which is essential for high repetition rate OAWs.

**SF2E.2 • 10:45** ▶
**Enhanced Self-frequency Shift of Cavity Soliton in Mode-locked Octave-spanning Frequency Comb Generation,** Lin Zhang[1], Qiang Lin[2], Anu Agarwal[1], Lionel Kimerling[1], Jurgen Michel[1]; [1]*Dept. of Materials Science and Engineering, MIT, USA;* [2]*Dept. of Electrical and Computer Engineering, Univ. of Rochester, USA.* We show a significant self-frequency shift of ultrafast cavity solitons associated with Kerr frequency combs in a dispersion-flattened nonlinear cavity. Dispersion induces a frequency shift up to 20% of the pump frequency.

**SF2E.3 • 11:00** ▶
**Coherent Frequency Comb Generation in a Silicon Nitride Microresonator with Anomalous Dispersion,** Pei-Hsun Wang[1], Yi Xuan[1,2], Jian Wang[1], Xiaoxiao Xue[1], Daniel E. Leaird[1], Minghao Qi[1,2], Andrew M. Weiner[1,2]; [1]*School of Electrical and Computer Engineering, Purdue Univ., USA;* [2]*Birck Nanotechnology Center, Purdue Univ., USA.* We observe a transition to a coherent-comb state in a SiN-microresonator with anomalous dispersion. Although ~300 fs pulse trains are generated after line-by-line shaping, the intensity within the microring does not appear to be pulse-like.

### 10:30–12:30
### SF2F • Advanced THz Emission Mechanisms

*Presider: François Blanchard; McGill Univ., USA*

**SF2F.1 • 10:30**
**Generation of CW Terahertz Waves in the 3 THz Range Using a MZM-Based Flat Comb Generator,** Isao Morohashi[1], Yoshihisa Irimajiri[1], Motohiro Kumagai[1], Akira Kawakami[1], Takahide Sakamoto[1], Norihiko Sekine[1], Satoshi Ochiai[1], Shukichi Tanaka[1], Tetsuya Kawanishi[1], Iwao Hosako[1]; [1]*NICT, Japan.* THz waves in the 3 THz range have been generated by photonic down-conversion using a Mach-Zehnder-modulator-based flat comb generator. THz waves were detected by a hot electron bolometer mixer with a quantum cascade laser.

**SF2F.2 • 10:45**
**Tunable Narrowband Terahertz Generation by Optical Rectification in Single Domain Lithium Niobate Crystal,** Iwao Kawayama[1], Zhang Caihong[1], Yuri Avetisyan[1,2], Hironaru Murakami[1], Masayoshi Tonouchi[1]; [1]*Inst. of Laser Engineering, Osaka Univ., Japan;* [2]*Microwave Engineering Dept., Yerevan State Univ., Armenia.* A simple approach to generate high energy, frequency- and bandwidth- tunable multicycle THz pulses by optical rectification of pre-shaped fs-laser pulses in the single domain lithium niobate crystal is proposed and demonstrated.

**SF2F.3 • 11:00**
**Highly Stable Continuous Wave Terahertz Generation with Widely Tunable Dual-Mode Laser,** Hiroyoshi Togo[1], Steven Jones[1], JaeYoung Kim[1], Yoshiyuki Doi[2], Takashi Yamada[2], Nobutatsu Koshoubu[2]; [1]*NTT Microsystem Integration Labs, Japan;* [2]*NTT Photnics Labs, Japan.* Presented here is a highly stable CW THz generation utilizing a dual-mode laser capable of producing a wide range of differential frequencies. This laser employs an AOTF in a single external cavity for dual-mode selection.

### 10:30–12:30
### SF2G • Laser Dynamics

*Presider: Amr Helmy, Univ. of Toronto, Canada*

**SF2G.1 • 10:30**
**Comparison of Dynamical Properties of Ground- and Excited-State Emission in Quantum-Dot Lasers,** Dejan Arsenijević[1], Holger Schmeckebier[1], Marc Spiegelberg[1], Dieter Bimberg[1], Vissarion Mikhelashvili[2], Gadi Eisenstein[2]; [1]*Dept. of Solid-State Physics, Technische Universität Berlin, Germany;* [2]*Electrical Engineering Dept. and the Russell Berrie Nanotechnology Inst., Technion, Israel.* We compare dynamical properties of ground and excited state emission from 1.31 μm quantum-dot lasers. Dichroic facet mirrors ensure oscillations at either ground or excited state. Maximum bandwidths observed are 10.51 and 16.25 GHz, respectively.

**SF2G.2 • 10:45**
**Quantum-dot-laser two-state self-mixing-velocimetry: Simulation and Experiment,** Mariangela Gioannini[1], Marius Dommermuth[2], Lukas Drzewietzki[3], Stefan Breuer[3]; [1]*Dipartimento di Elettronica e Telecomunicazioni, Politecnico di Torino, Italy;* [2]*Inst. of Theoretical Physics, Eberhard Karls Universität Tübingen, Germany;* [3]*Inst. of Applied Physics, Technische Universität Darmstadt, Germany.* Two-state-laser self-mixing is demonstrated. An additional Doppler-signal originating from the two-state-interaction yields the potential of high-velocity detection. Simulations verify the results and identify the relevant mechanism for the Doppler signal-generation.

**SF2G.3 • 11:00**
**Recent advances in ultrafast MIXSELs,** Mario Mangold[1], Christian A. Zaugg[1], Sandro M. Link[1], Alexander Klenner[1], Matthias Golling[1], Bauke W. Tilma[1], Ursula Keller[1]; [1]*Dept. of Physics, Inst. for Quantum Electronics, ETH Zurich, Switzerland.* A high-power MIXSEL combining 570-fs-pulses and repetition-rate scalability from 5 GHz to record high 101.2 GHz is presented. Additionally, we achieve record low timing jitters of a free-running and piezo-stabilized picosecond MIXSEL.

## Meeting Room
## 211 B/D

## CLEO: Science & Innovations

### 10:30–12:30
### SF2I • Combustion and Plasma Diagnostics
*Presider: Thomas Reichardt; Sandia National Labs, USA*

**SF2I.1 • 10:30**
**Investigation of Fiber-Based Endoscopes for Quantitative 3D Flow and Flame Imaging,** MinWook Kang[1], Xuesong Li[2], Lin Ma[2,1]; [1]*Mechanical Engineering, Virginia Tech, USA;* [2]*Aerospace and Ocean Engineering, Virginia Tech, USA.* This work describes instantaneous three-dimensional (3D) measurements using fiber-based endoscopes. Experimental and numerical results demonstrate their potential for kHz 3D measurements, and also for overcoming practical issues like optical access and equipment cost.

**SF2I.2 • 10:45**
**High-Temperature Flow Sensing Using Regenerated Gratings in Self-Heated High Attenuation Fibers,** Rongzhang Chen[1], Aidong Yan[1], Kevin P. Chen[1]; [1]*Dept. of Electrical and Computer Engineering, Univ. of Pittsburgh, USA.* We report a high-temperature flow sensing technique based on thermally regenerated fiber Bragg gratings in high attenuation fibers. It can provide flow rate measurements up to 800 °C with compensation for ambient temperature variations.

**SF2I.3 • 11:00**
**Detection of PbCl2 using Collinear Photofragmentation and Atomic Absorption Spectroscopy,** Tapio Sorvajärvi[1], Juha Toivonen[1]; [1]*Tampereen Teknillinen Yliopisto, Finland.* PbCl2 causes corrosion in waste combusting power plants and there is no method to monitor it. We demonstrate the use of collinear photofragmentation and atomic absorption spectroscopy (CPFAAS) to successfully detect PbCl2 in-situ in a hot furnace.

## Meeting Room
## 212 A/C

### 10:30–12:30
### SF2J • Innovations in Laser Processing of Materials
*Presider: Emmanuel Haro-Poniatowski; Physics Dept., UAM-Iztapalapa, Mexico*

**SF2J.1 • 10:30**
**Terahertz-driven non-resonant magnetization dynamics in cobalt,** Carlo Vicario[1], Peter Derlet[1], Fernando Ardana-Lamas[1,3], Clemens Ruchert[1], Barati Tudu[2], Jan Luning[2], Christoph P. Hauri[1,3]; [1]*Paul Scherrer Institut, Switzerland;* [2]*Univ. Pierre et Marie Curie, France;* [3]*Ecole Polytechnique Federale de Lausanne, Switzerland.* We demonstrate non-resonant magnetization dynamics in the ferromagnetic cobalt thin film induced by a high-field Terahertz pulse. The magnetization dynamics are coherent and exactly follow the THz carrier oscillations.

**SF2J.2 • 10:45**
**Movies of filaments and plasma,** Andreas U. Velten[1,2], Andreas Schmitt-Sody[3], Adrian Lucero[3], Ladan Arissian[4], Xiaozhen Xu[4], Chengyong Feng[4], Shermineh Rostami[4], Brian Kamer[4], Jean-Claude M. Diels[4]; [1]*Lab for Optical and Computational Instrumentation, Univ. of Wisconsin-Madison, USA;* [2]*Medical Engineering, Morgridge Inst. for Research, USA;* [3]*Air Force Research Lab, USA;* [4]*Dept. of Physics and Astronomy, Univ. of New Mexico, USA.* Using a streak camera, and combining over 1,000 synchronized frames, 4D (2 D space, time in ps and wavelength) movies of the light and plasma emission in the wake of filaments are produced.

**SF2J.3 • 11:00** Invited
**3D chemical imaging of Li-ion batteries using femtosecond laser plasma spectroscopy,** Huaming Hou[1], Vassilia Zorba[1]; [1]*Lawrence Berkeley National Lab, USA.* We introduce the use of femtosecond laser plasma spectroscopy in chemical imaging of Li-ion battery system components. Spatially resolved mapping of major and minor elements of Li-ion batteries is presented and correlated to electrochemical performance.

## Meeting Room
## 212 B/D

## CLEO: QELS-Fundamental Science

### 10:30–12:15
### FF2K • Nanophotonic and Plasmonic Coupling to Quantum Emitters
*Presider: Vladimir Shalaev; Purdue Univ./Birck Nanotechnology, USA*

**FF2K.1 • 10:30**
**Spin Polarized Light Emission from Quantum Dots Coupled to Multipolar Nanoantennas,** Sergey Kruk[1], Manuel Decker[1], Isabelle Staude[1], Stefan Schlecht[1], Michael Greppmair[1], Dragomir N. Neshev[1], Yuri S. Kivshar[1]; [1]*Australian National Univ., Australia.* We experimentally demonstrate spin-polarized light emission from quantum dots coupled to a single-element nanoantenna with resonant multipolar moments. We observe spin-momentum locking resulting in photons of opposite spin emitted in opposite directions.

**FF2K.2 • 10:45**
**Boosting the photon-extraction efficiency of nanophotonic structures by deterministic microlenses,** Manuel Gschrey[1], Marc Seifried[1], Luzy Krüger[1], Ronny Schmidt[1], Jan-Hindrik Schulze[1], Tobias Heindel[1], Sven Burger[2], Sven Rodt[1], Frank Schmidt[2], Andre Strittmatter[1], Stephan Reitzenstein[1]; [1]*Technische Universität Berlin, Germany;* [2]*Zuse-Institut Berlin, Germany.* A novel concept for enhancing the photon-extraction efficiency of nanophotonics structures is presented. We apply in-situ electron beam lithography to enhance the single photon flux of single quantum dots by deterministically aligned microlenses.

**FF2K.3 • 11:00**
**Highly Directional Emission of Photons from Nanocrystal Quantum Dots Positioned on Circular Plasmonic Lens Antennas,** Moshe G. Harats[1,3], Nitzan Livneh[2,3], Shira Yochelis[2,3], Yossi Paltiel[2,3], Ronen Rapaport[1,2]; [1]*Racah Inst. of Physics, Hebrew Univ. of Jerusalem, Israel;* [2]*The Dept. of Applied Physics, Selim and Rachel Benin School of Engineering and Computer Science, Hebrew Univ. of Jerusalem, Israel;* [3]*The Center for Nanoscience and Nanotechnology, Hebrew Univ. of Jerusalem, Israel.* We show enhanced directional emission from nanocrystal quantum dots positioned at the center of a circular plasmonic lens. A collimation with a divergence of only ~4 degrees FWHM is achieved, with a spectrally broad bandwidth.

## Marriott
## Salon I & II

## CLEO: Applications & Technology

### 10:30–12:00
### AF2L • Symposium on Optofluidic Microsystems II
*Presider: To be Determined*

**AF2L.1 • 10:30** Invited
**Optofluidic Manipulation and Sorting for Small Size Particle and Bio-molecule,** Ai-Qun LIU[1]; [1]*School of Electrical & Electronic Engineering, Nanyang Technological Univ., Singapore.* It is significant research approach in the field of manipulation and sorting of a small size of particle and molecule with dimensions of tens to hundreds of nanometers in a microfluidic chip.

**AF2L.2 • 11:00**
**Freezing of microparticles in an electro-optofluidic platform,** Mohammad Soltani[1,2], Jessica L. Killian[1], Jun Lin[1,2], Michal Lipson[1], Michelle D. Wang[1,2]; [1]*Cornell Univ., USA;* [2]*Howard Hughes Medical Inst., USA.* We show ability to simultaneously trap micron-size particles in an optical field and freeze their position by rapidly changing the direction of Poynting vector in an optofluidic waveguide using an electrically controlled Mach-Zehnder switch.

## CLEO: Science & Innovations

**Marriott Salon III**

### 10:30–12:30
### SF2M • Optomechanics II
*Presider: Marcelo Davanco; NIST, USA*

**SF2M.1 • 10:30**
**A fully integrated chip-scale optomechanical oscillator,** Yongjun Huang[1,2], Xingsheng Luan[1], Ying Li[1], James F. McMillan[1], Di Wang[1], Archita Hati[3], David A. Howe[3], Mingbin Yu[4], Guo-Qiang Lo[4], Dim-Lee Kwong[4], Chee Wei Wong[1]; *[1]Columbia Univ., USA; [2]School of Communication and Information Engineering, Univ. of Electronic Science and Technology of China, China; [3]National Inst. of Standards and Technology, USA; [4]The Inst. of Microelectronics, Singapore.* We demonstrate a chip-scale slot-type photonic crystal optomechanical oscillator fully integrated with an on-chip waveguide Ge photoreceiver, which exhibits high-harmonic tunable RF oscillations and high-quality optical resonances with controlled detuned continuous-wave laser drive.

**SF2M.2 • 10:45**
**Coherent Regenerative Optomechanical Oscillation of a Silica Microsphere in an Aqueous Environment,** Wenyan Yu[1], Wei Jiang[2], Qiang Lin[2,3], Tao Lu[1]; *[1]Electrical and Computer Engineering, Univ. of Victoria, Canada; [2]Inst. of Optics, Univ. of Rochester, USA; [3]Electrical and Computer Engineering, Univ. of Rochester, USA.* We observed optomechanical oscillations at 384-kHz by immersing a silica microsphere in an aqueous environment. Despite of high dissipation, the device displays a laser threshold power of 0.98-mW and a mechanical Q of 1,648.

**SF2M.3 • 11:00**
**Synchronization of Multiple Optomechanical Oscillators,** Mian Zhang[1], Michal Lipson[1,2]; *[1]Electrical and Computer Engineering, Cornell Univ., USA; [2]Kavli Inst. at Cornell, Cornell Univ., USA.* We design and fabricate a 2×2 optomechanical oscillator array. We show the onset of synchronized mechanical oscillations when the array is excited by a single continuous wave laser.

**Marriott Salon IV**

### 10:30–12:15
### SF2N • High Energy fs Fiber Laser & Applications
*Presider: Shinji Yamashita; Univ. of Tokyo, Japan*

**SF2N.1 • 10:30** Invited
**Fiber Lasers for Accelerators and Accelerator Driven Light Sources,** Ingmar Hartl[1]; *[1]DESY, Germany.* Lasers are an indispensable tool for current XUV and X-ray free electron light sources and are key to future laser driven accelerator technology. We discuss the role of fiber-laser technology in this emerging field.

**SF2N.2 • 11:00**
**Spatially Separated Non-linear Pulse Compression,** Arno Klenke[1,2], Steffen Hädrich[1,2], Jens Limpert[1,2], Andreas Tünnermann[1,3]; *[1]Inst. of Applied Physics, Friedrich-Schiller-Universität Jena, Germany; [2]Helmholtz-Inst. Jena, Germany; [3]Fraunhofer Inst. of Applied Optics and Precision Engineering, Germany.* We demonstrate the coherent combination of pulses that are spectrally broadened in two spatially separated solid-core large-pitch fibers. The 320 fs input pulses could be compressed to the sub-30fs regime.

**Marriott Salon V & VI**

### 10:30–12:30
### SF2O • Special and Spatial Filters
*Presider: Mo Li, National Taiwan Univ., Taiwan*

**SF2O.1 • 10:30**
**Ultrahigh Suppression and Reconfigurable RF Photonic Notch Filter using a Silicon Nitride Ring Resonator,** David Marpaung[1], Blair Morrison[1], Ravi Pant[1], Chris Roeloffzen[2,3], Arne Leinse[4], Marcel Hoekman[4], Rene Heideman[4], Benjamin J. Eggleton[1]; *[1]CUDOS Univ. of Sydney, Australia; [2]Telecommunication Engineering, Univ. of Twente, Netherlands; [3]Satrax BV, Netherlands; [4]LioniX BV, Netherlands.* We report a technique to simultaneously optimize the peak rejection and the resolution of a radiofrequency photonic notch filter based on a silicon nitride ring resonator.

**SF2O.2 • 10:45**
**Supersymmetric mode converters,** Matthias Heinrich[1], Simon Stützer[2], Mohammad-Ali Miri[1], Ramy El-Ganainy[3], Stefan Nolte[2], Demetrios N. Christodoulides[1], Alexander Szameit[2]; *[1]CREOL The College of Optics and Photonics, Univ. of Central Florida, USA; [2]Inst. of Applied Physics, Friedrich-Schiller-Univ., Germany; [3]Max-Planck Inst. for the Physics of Complex Systems, Germany.* We present the first experimental realization of optical supersymmetry and demonstrate mode conversion and global phase-matching between SUSY partner structures. Our results may pave the way for compact and highly efficient integrated mode-division-multiplexing schemes.

**SF2O.3 • 11:00**
**A High-Q Tunable Interior-Ridge Microring Filter,** Erman Timurdogan[1], Zhan Su[1], Jie Sun[1], Michele Moresco[1], Gerald Leake[2], Douglas Coolbaugh[2], Michael R. Watts[1]; *[1]Research Lab of Electronics, MIT, USA; [2]College of Nanoscale Science & Engineering, Univ. at Albany, USA.* A tunable interior-ridge microring filter is demonstrated with a high quality factor of 1.5×105, while achieving a thermal tuning efficiency of 5.5µW/GHz. The filter demonstrates a record low insertion-loss <0.05dB over an uncorrupted 4-THz free-spectral-range.

**Marriott Willow Glen I-III**

## CLEO: Applications & Technology

### 11:00–12:30
### AF2P • Photons for Energy
*Presider: Christian Wetzel; Rensselaer Polytechnic Inst., USA*

**AF2P.1 • 10:30** Invited
**Withdrawn**

**AF2P.2 • 11:00**
**Semi-transparent and colored photovoltaic structures by using ultra-thin a-Si,** Jae Yong Lee[1], Kyu-Tae Lee[1], Sungyong Seo[1], L. Jay Guo[1]; *[1]EECS, Univ. of Michigan, USA.* We exploit optical resonance in an ultra-thin (6 to 31 nm) undoped amorphous silicon/organic hybrid photovoltaic (PV) structures that can produce semi-transparent transmissive colors insensitive to incidence angle of up to ±70° regardless of polarization.

## Executive Ballroom 210A

## CLEO: QELS-Fundamental Science

### FF2A • Quantum Memories—Continued

**FF2A.3 • 11:15**
**High-fidelity heralded polarization-state transfer of a photon onto a single atom,** Christoph Kurz[1], Philipp Müller[1], Michael Schug[1], Pascal Eich[1], Jan Huwer[1], Jürgen Eschner[1]; *[1]Saarland Univ., Germany.* We demonstrate heralded absorption of a single laser photon by a single trapped atomic ion, thereby mapping the photonic polarization state onto the atomic spin state with 97.9(1) % average fidelity.

**FF2A.4 • 11:30**
**Raman quantum memory based on an ensemble of nitrogen-vacancy centers coupled to a microcavity,** Khabat Heshami[1], Charles Santori[2], Behzad Khanaliloo[1], Chris Healey[1], Victor M. Acosta[2], Paul E. Barclay[1,3], Christoph Simon[1]; *[1]IQST, Physics and Astronomy, Univ. of Calgary, Canada; [2]Hewlett Packard Labs, USA; [3]NRC National Inst. for Nanotechnology, Canada.* We propose a scheme to realize quantum memories based on Raman coupling for storing photons in the electronic spin of NV$^-$ ensembles. We include all optical transitions in a 9-level configuration and evaluate the efficiencies.

**FF2A.5 • 11:45**
**A THz-Bandwidth Optical Memory for Quantum Storage,** Duncan England[1], Kent Fisher[2], Jean-Philippe MacLean[2], Philip J. Bustard[1], Kevin Resch[1], Benjamin J. Sussman[1]; *[1]National Research Council, Canada; [2](2) Inst. for Quantum Computing, Univ. of Waterloo, Canada.* We have demonstrated a THz-bandwidth quantum memory using the optical phonon modes of room-temperature diamond. A noise-floor of just 0.007 photons per pulse provides the opportunity to store photons produced by spontaneous parametric downconversion.

**FF2A.6 • 12:00**
**Molecular Single Photons for Atomic Experiments,** Wilhelm Kiefer[1], Petr Siyushev[1], Kim Kafenda[1], Jörg Wrachtrup[1,2], Ilja Gerhardt[1,2]; *[1]3. Physikalisches Institut, Univ. of Stuttgart and Stuttgart Research Center of Photonic Engineering (SCoPE), Pfaffenwaldring 57, D-70569, Germany; [2]Max Planck Inst. for Solid State Research, Heisenbergstrasse 1, D-70569, Germany.* Single organic molecules allow for the generation of high-flux single photons. At cryogenic conditions, these photons can be as narrow as a few MHz. It is possible to find suitable molecules matching to a variety of atomic transitions, allowing for quantum hybrid systems of atoms and molecules.

## Executive Ballroom 210B

## CLEO: Applications & Technology

### AF2B • Symposium on Advances in Neurophotonics II—Continued

**AF2B.3 • 11:30** Invited
**High-Resolution Optical Microscopy Imaging of Cortical Oxygen Delivery and Consumption,** Sava Sakadzic[1], Emiri T. Mandeville[1,2], Louis Gagnon[1], Joseph J. Musacchia[1], Mohammad A. Yaseen[1], Meryem A. Yucel[1], Joel Lefebvre[3], Frederic Lesage[3], Anders Dale[4], Katharina Eikermann-Haerter[1], Cenk Ayata[1,2], Vivek J. Srinivasan[1,5], Eng Lo[1,2], Anna Devor[1,4], David A. Boas[1]; *[1]Dept. of Radiology, Harvard Medical School, Massachusetts General Hospital, USA; [2]Dept. of Neurology, Harvard Medical School, Massachusetts General Hospital, USA; [3]Département de génie électrique, École Polytechnique de Montréal, Canada; [4]Dept.s of Radiology and Neurosciences, Univ. of California, San Diego, USA; [5]Dept. of Biomedical Engineering, Univ. of California Davis, USA.* We combined Two-Photon Microscopy imaging of oxygen partial pressure (PO2) with spectral domain OCT measurements of cerebral blood flow to quantify oxygen extraction from cerebral microvasculature during metabolic and blood flow perturbations.

**AF2B.4 • 12:00** Invited
**Optical sensing and control in live animals for early detection of diseases,** Daniel C. Cote[1,2]; *[1]Universite Laval, Canada; [2]CRI-USMQ, Canada.* We show we can monitor blood vessel permeability, myelin degeneration and microglial activity with video rate microscopy. Advanced fiber optic tools are shown to permit control of activity in the spinal cord.

## Executive Ballroom 210C

## Executive Ballroom 210D

## CLEO: QELS-Fundamental Science

### FF2C • Metasurfaces II—Continued

**FF2C.4 • 11:15**
**Timing Performance Improvement of Scintillator Detectors via Inclusion of Reflection Metasurfaces,** Mark S. Brown[1], Ioannis Papakonstantinou[1]; *[1]Electrical and Electronic Engineering, UCL, UK.* A reflection metasurface is used to optimise the light transport within a scintillator detector dramatically reducing the time resolution. We present a structure design and potential improvements in Positron-Emission Tomography.

**FF2C.5 • 11:30**
**Large-scale Lithography-free Metasurface with Spectrally Tunable Super Absorption,** Kai Liu[1], Xie Zeng[1], Suhua Jiang[2], Dengxin Ji[1], Haomin Song[1], Nan Zhang[1], Qiaoqiang Gan[1]; *[1]Dept. of Electrical Engineering, The State Univ. of New York at Buffalo, USA; [2]Dept. of Materials Science, Fudan Univ., China.* We demonstrate a simple, low-cost and large-area lithography-free method to fabricate three-layered metasurface structures with tunable, broadband and omnidirectional absorption properties.

**FF2C.6 • 11:45**
**Optical Magnetic Mirrors using All Dielectric Metasurfaces,** Sheng Liu[1,2], Igal Brener[1,2], Jeremy B. Wright[1,2], Thomas Mahony[1,2], Young Chul Jun[1,2], Salvatore Campione[1,2], James Ginn[1,2], Daniel A. Bender[1], Joel R. Wendt[1], Jon Ihlefeld[1], Paul Clem[1], Michael B. Sinclair[1]; *[1]Sandia National Labs, USA; [2]Center for Integrated Nanotechnologies, USA.* We experimentally demonstrate the magnetic mirror behavior of all-dielectric metasurfaces at optical frequencies through phase measurements using time-domain-spectroscopy. The unique boundary conditions of magnetic mirrors can lead to advances in sensors, photodetectors and light sources.

**FF2C.7 • 12:00**
**Numerically Stable Reconstruction of Wavelength-Scale Objects with Sub-Wavelength Resolution,** Sandeep Inampudi[1], Nicholas A. Kuhta[2], Viktor A. Podolskiy[1]; *[1]Dept. of Physics and Applied Physics, Univ. of Massachusetts, USA; [2]Dept. of Physics, Oregon State Univ., USA.* We present numerically stable expansion basis for diffraction-based far-field computational imaging systems and demonstrate the capabilities of reconstructing wavelength-scale objects with wavelength/20 resolution.

### FF2D • Quantum Effects in Lattices—Continued

**FF2D.3 • 11:15**
**Lieb Photonic Topological Insulator,** Miguel A. Bandres[1], Mikael Rechtsman[1], Alexander Szameit[2], Mordechai Segev[1]; *[1]1Physics Dept. and Solid State Inst., Technion, Israel; [2]Inst. of Applied Physics, Friedrich-Schiller-Universitat Jena, Germany.* We show that a Lieb photonic lattice of helical waveguides (without any external field) have one-way edge states that are topologically protected against backscattering as they pass through defects or around corners.

**FF2D.4 • 11:30**
**Highly Efficient Eigenstate-Assisted Long-Distance Quantum State Transfer in Photonic Lattices,** Armando P. Leija[1], Markus Graefe[1], René Heilmann[1], Robert Keil[1], Steffen Weimann[1], Demetrios N. Christodoulides[2], Alexander Szameit[1]; *[1]Inst. of Applied Physics, Friedrich-Schiller-Universität Jena, Germany; [2]CREOL, UCF, USA.* We introduce a new perfect state transfer protocol based on single-photon W-eigenstates of photonic lattices. Such W-eigenstates appear as impulse response of the system, e.g., when single photons are launched into single sites.

**FF2D.5 • 11:45**
**Simulation of two-mode squeezing in photonic waveguide lattices,** Simon Stützer[1], Alexander S. Solntsev[2], Stefan Nolte[1], John E. Sipe[3], Andrey A. Sukhorukov[2], Alexander Szameit[1]; *[1]Inst. of Applied Physics, Germany; [2]Nonlinear Physics Centre, Research School of Physics and Engineering, Australia; [3]Dept. of Physics and Inst. for Optical Sciences, niversity of Toronto, Canada.* We utilized classical light simulating a nonclassical quantum process. Specially modulated waveguide arrays were utilized to emulate two-mode squeezed vacuum states as the intensity in our arrays correspond to the photon number distribution of the squeezed states.

**FF2D.6 • 12:00**
**Harmonic Oscillation in Coupled Waveguide Arrays,** Jianxiong Wu[1], Arash Joushaghani[1], J. Stewart Aitchison[1]; *[1]Electrical and Computer Engineering, Univ. of Toronto, Canada.* Following the idea of optical analogy to electronic systems, harmonic oscillations are spatially mimicked in waveguide arrays. We study and demonstrate the oscillations of light in AlGaAs waveguide arrays.

## CLEO: Science & Innovations

### Executive Ballroom 210E

### SF2E • Frequency Combs and CEP—Continued

**SF2E.4 • 11:15** ▶
**Direct carrier-envelope phase control of a sub-MHz Yb amplifier,** Tadas Balciunas[1], Tobias Flöry[1], Tomas Stanislauskas[2], Roman Antipenkov[2], Arunas Varanavicius[2], Andrius Baltuska[1], Gunter Steinmeyer[3]; [1]*Technische Universität Wien, Austria;* [2]*Faculty of Physics, Vilnius Univ., Lithuania;* [3]*Max Born Inst., Germany.* We demonstrate direct feed-forward CEP control of a regenerative amplifier in a single stage, resulting in unprecedented sub-100 mrad phase jitters of an amplified system. Energy scalability of the approach is shown.

**SF2E.5 • 11:30** ▶
**1.13-GHz Repetition Rate, Sub-Femtosecond Timing Jitter, CNT-Mode-Locked Ultrafast Yb:KYW Laser,** Heewon Yang[1], Hyoji Kim[1], Junho Shin[1], Chur Kim[1], Sun Young Choi[2], Guang-Hoon Kim[3], Fabian Rotermund[2], Jungwon Kim[1]; [1]*Korea Advanced Inst. of Science and Technology, Korea;* [2]*Ajou Univ., Korea;* [3]*Korea Electrotechnology Research Inst., Korea.* We show 1.13-GHz repetition rate, 0.70-fs timing jitter optical pulse train directly generated from diode-pumped, CNT-mode-locked Yb:KYW laser. The measured jitter is the lowest for GHz pulse trains, and is suitable for high-resolution analog-to-digital conversion.

**SF2E.6 • 11:45** ▶
**Jitter Reduction in Digitally Synchronized Lasers,** Russell wilcox[1], Lawrence Doolittle[1], Gang Huang[1], Alan Fry[2]; [1]*Lawrence Berkeley National Lab, USA;* [2]*SLAC National Accelerator Lab, USA.* We synchronize a mode-locked Ti:sapphire laser to a 2.8GHz RF reference with 25fs jitter using an all-digital phase-locked loop, and a new technique for measuring the closed-loop transfer function and optimizing complex gain.

**SF2E.7 • 12:00** ▶
**Passive Synchronization between Two-Color Mode-Locked Lasers with Long-Term Stability and Subfemtosecond Timing Jitter,** Dai Yoshitomi[1], Kenji Torizuka[1]; [1]*Natl Inst of Adv Industrial Sci & Tech, Japan.* We demonstrate passive synchronization between Ti:sapphire and Yb-doped fiber mode-locked lasers with long-term stability for 6 h with the aid of active temperature stabilization. A timing jitter of 0.75 fs was achieved between two-color pulses.

### Executive Ballroom 210F

### SF2F • Advanced THz Emission Mechanisms—Continued

**SF2F.4 • 11:15**
**Gain Enhancement Effect of Surface Plasmon Polaritons on Terahertz Stimulated Emission in Optically Pumped Monolayer Graphene,** Tetsuya Kawasaki[1], Takayuki Watanabe[1], Tetsuya Fukushima[1], Yuhei Yabe[1], Stephane A. Boubanga Tombet[1], Akira Satou[1], Alexander A. Dubinov[2], Vladimir Y. Aleshkin[2], Vladimir Mitin[3], Victor Ryzhii[1], Taiichi Otsuji[1]; [1]*RIEC, Tohoku Univ., Japan;* [2]*Russian Academy of Science, Russia;* [3]*Univ. at Buffalo, USA.* We experimentally observed the surface plasmon polaritons (SPPs) in photoexcited monolayer graphene. The results support the occurrence of the gain enhancement effect by the excitation of SPPs on terahertz stimulated emission in optically pumped graphene.

**SF2F.5 • 11:30**
**Flat THz Launcher Antenna,** Unai Beaskoetxea[1], Miguel Beruete[1], Mokhtar Zehar[2], Amit Agrawal[3], Shuchang Liu[4], Karine Blary[2], Abdallah Chahadih[2], Xiang-Lei Han[2], David Etayo[1], Miguel Navarro-Cia[5], Ajay Nahata[4], Tahsin Akalin[2], Mario Sorolla[1]; [1]*Universidad Pública de Navarra, Spain;* [2]*Inst. of Electronics, Microelectronics and Nanotechnology (IEMN), France;* [3]*Syracuse Univ., USA;* [4]*Univ. of Utah, USA;* [5]*Imperial College London, UK.* 1D and 2D leaky-wave corrugated antennas working at terahertz frequencies are numerically and experimentally studied. These structures allow temporal-pulse and beam shaping by engineering the leakage rate of the surface waves induced by the corrugations.

**SF2F.6 • 11:45**
**Frequency tunable, high dynamic range THz spectrometer using parametric processes in Lithium Niobate crystal,** Kosuke Murate[1], Yuusuke Taira[1], Saroj R. Tripathi[1], Shin'ichiro Hayashi[2], Koji Nawata[2], Hiroaki Minamide[2], Kodo Kawase[1,2]; [1]*Nagoya Univ., Japan;* [2]*RIKEN, Japan.* We developed spectrally flat THz wave spectrometer with the dynamic range of more than 7 orders, based on optical parametric processes in Lithium Niobate crystals for the emission and detection of THz waves.

**SF2F.7 • 12:00**
**Improved InGaAs/InAlAs photoconductive THz receivers: 5.8 THz bandwidth and 80 dB dynamic range,** Björn Globisch[1], Roman, J. B. Dietz[1], Dennis Stanze[1], Helmut Roehle[1], Thorsten Göbel[1], Martin Schell[1]; [1]*Fraunhofer Heinrich Hertz Inst., Germany.* We investigate optimal Be-doping conditions of low-temperature-grown InGaAs/InAlAs photoconductive antennas with respect to their carrier lifetimes and carrier mobility. Employed as THz-TDS receiver bandwidths of 5.8 THz with a dynamic range of up to 80 dB is achieved.

### Executive Ballroom 210G

### SF2G • Laser Dynamics—Continued

**SF2G.4 • 11:15**
**Modulation Characteristics Enhancement by Mutual Injection Locking of Monolithically Integrated Laser Diodes,** dong Liu[1], Changzheng Sun[1], Bing Xiong[1], Yi Luo[1]; [1]*Tsinghua Univ., China.* Modulation characteristics enhancement by mutual injection locking of monolithically integrated lasers is demonstrated. Resonance frequency as high as 34.3 GHz is recorded. The nonlinearity and chirp performances are simultaneously improved compared with free running state.

**SF2G.5 • 11:30**
**SESAM and Gain Chip Optimization Leading to a Record Performance of an Ultrafast Electrically Pumped VECSEL,** Christian A. Zaugg[1], Stephan Gronenborn[2], Holger Moench[2], Mario Mangold[1], Michael Miller[3], Ulrich Weichmann[2], Wolfgang P. Pallmann[1], Matthias Golling[1], Bauke W. Tilma[1], Ursula Keller[1]; [1]*Inst. for Quantum Electronics, ETH Zurich, Switzerland;* [2]*Philips Technologie GmbH Photonics Aachen, Germany;* [3]*Philips Technologie GmbH Photonics U-L-M PHotonics, Germany.* With an improved gain chip and SESAM we set new benchmarks for modelocked electrically pumped VECSELs, i.e. shortest pulses (2.47 ps), highest average power (53.2 mW), peak power (4.7 W) and repetition rate (18.2 GHz).

**SF2G.6 • 11:45**
**Experimental study of the stability of harmonic mode-locking in quantum dot passively mode-locked lasers,** Jesse Mee[1], Ravi Raghunathan[2], David Murrell[2], Alex Braga[3], Yan Li[4], Luke F. Lester[2]; [1]*Air Force Research Labs, USA;* [2]*Bradley Dept. of Electrical and Computer Engineering, Virginia Polytechnic Inst. and State Univ., USA;* [3]*Center for High Technology Materials, Univ. of New Mexico, USA;* [4]*APIC Corporation, USA.* The stability of harmonic mode-locking in a two-section quantum dot passively mode-locked laser is examined using a Frequency Resolved Optical Gating pulse measurement system and shown for the first time to be a stable effect.

**SF2G.7 • 12:00**
**Phase-Locked Quantum-Dot Mode-Locked Lasers For Wider Frequency Combs Generation,** Tatiana Habruseva[1,2], Dejan Arsenijević[4], Dieter Bimberg[4], Guillaume Huyet[1,3], Stephen P. Hegarty[1,3]; [1]*CAPPA, Cork Inst. of Technology, Ireland;* [2]*Aston Univ., UK;* [3]*Tyndall National Inst., Ireland;* [4]*Institut für Festkörperphysik, Technische Universität Berlin, Germany.* We describe the technique allowing generation of wider frequency combs with low phase noise and pulses of shorter duration in quantum-dot mode-locked lasers. The devices are stabilized using coherent sidebands optical injection.

## Meeting Room 211 B/D

## CLEO: Science & Innovations

### SF2I • Combustion and Plasma Diagnostics—Continued

**SF2I.4 • 11:15**
**Towards Simultaneous Measurement of OH and $HO_2$ in Combustion Using Faraday Rotation Spectroscopy,** Brian Brumfield[1], Xueliang Yang[2], Joseph Lefkowitz[2], Yiguang Ju[2], Gerard Wysocki[1]; [1]*Dept. of Electrical Engineering, Princeton Univ., USA;* [2]*Dept. of Mechanical and Aerospace Engineering, Princeton Univ., USA.* Preliminary results from the development of a dual wavelength Faraday rotation spectrometer for simultaneous quantification of $HO_2$ and OH in combustion research are presented.

**SF2I.5 • 11:30** Invited
**Instantaneous Volumetric Combustion Diagnostics,** Lin Ma[1]; [1]*Dept. of Aerospace and Ocean Engineering, Virginia Tech, USA.* This paper reports instantaneous and volumetric flame measurements based on tomographic techniques. Experimental results at kHz temporal rate, in a volume of 16×16×16 cm3, and with a spatial resolution of 2~3 mm, are discussed.

**SF2I.6 • 12:00**
**Noninvasive Ultrafast Imaging Diagnostics in Low-Temperature Plasmas,** Waruna Kulatilaka[1], Jacob Schmidt[1], Sukesh Roy[1], Kraig Frederickson[2], Walter Lempert[2], James Gord[3]; [1]*Spectral Energies LLC, USA;* [2]*The Ohio State Univ., USA;* [3]*Air Force Research Lab, USA.* We demonstrate femtosecond laser pulses for two-photon LIF imaging of atomic species in nonequilibrium plasmas. Femtosecond excitation enables improved signal-to-noise ratio, suppression of photolytic interferences, kilohertz-rate imaging, and potential for quenching-free measurements.

## Meeting Room 212 A/C

### SF2J • Innovations in Laser Processing of Materials—Continued

**SF2J.4 • 11:30**
**Controlled cell adhesion on microstrucured Polydimethylsiloxane (PDMS) surface using femtosecond laser,** Ali Alshehri[1,3], Z. .. Al-Rekabi[1,4], R. Hickey[1], A. E. Pelling[1,2], Ravi Bhardwaj[1]; [1]*physics, Univ. of Ottawa, Canada;* [2]*biology, Univ. of Ottawa, Canada;* [3]*physics, , King Khalid Univ., Saudi Arabia;* [4]*Mechanical Engineering, Univ. of Washington, USA.* We demonstrate controlled cell adhesion on Polydimethylsiloxane (PDMS) substrate microstrucured by a femtosecond laser. The effect of micro structures on cell attachment, alignment, patterned growth and cells proliferation were investigated over 24hrs, 48hrs and 72hrs.

**SF2J.5 • 11:45**
**Laser-induced dispersion control,** Gennady Rasskazov[1], Anton Ryabtsev[1], Vadim V. Lozovoy[1], Marcos Dantus[1]; [1]*Michigan State Univ., USA.* We present pump-probe measurements that reveal significant changes in the group delay dispersion of a femtosecond laser pulse being controlled by the relative delay between two pulses. We suggest applications for this time-domain shaping approach.

**SF2J.6 • 12:00**
**Locally and Reversibly Control the coupling of photonic crystal cavities using photochromic tuning,** Tao Cai[1], Ranojoy Bose[1], Glenn S. Solomon[2], Edo Waks[1,2]; [1]*Electrical Engineering, Univ. of Maryland, USA;* [2]*Joint Quantum Inst., Univ. of Maryland and National Inst. of Standards and Technology, USA.* We demonstrate a method to control the coupling interaction in a coupled-cavity photonic crystal molecule by using a local and reversible photochromic tuning technique. This method is promising for development of integrated photonic devices with large number of cavities.

## Meeting Room 212 B/D

## CLEO: QELS-Fundamental Science

### FF2K • Nanophotonic and Plasmonic Coupling to Quantum Emitters—Continued

**FF2K.4 • 11:15**
**Far-off-resonant coupling between a semiconductor quantum dot and an optical cavity,** Anders M. Lund[1], Mikkel Settnes[1,2], Per Kaer[1], Jesper Mørk[1]; [1]*Dept. of Photonics Engineering, DTU Fotonik, Technical Univ. of Denmark, Denmark;* [2]*Dept. of Micro- and Nanotechnology Engineering, Technical Univ. of Denmark, Denmark.* We present an investigation of the far-off-resonant coupling between a semiconductor quantum dot and a cavity. We show that the enhanced coupling observed in experiments is explained by Coulomb interactions with wetting layer carriers.

**FF2K.5 • 11:30**
**Efficient single photon sources based on nanodiamonds on a plasmonic platform,** Yen-Chun Chen[1], Cheng-Yen Tsai[1], Chun-Yuan Wang[2], Shangir Gwo[2], Wen-Hao Chang[1]; [1]*Electrophysics, National Chiao Tung Univ., Taiwan;* [2]*Physics, National Tsing Hua Univ., Taiwan.* We report on an efficient room-temperature source of single photons based on single nitrogen-vacancy centers in nanodiamonds (NDs) placing on a large-area plasmonic platform formed by crystalline gold flakes covered with a thin dielectric layer.

**FF2K.6 • 11:45**
**Accessing the Magnetic Dipole and Electric Quadrupole of Quantum Dots with Light,** Petru Tighineanu[1], Søren Stobbe[1], Peter Lodahl[1]; [1]*Niels Bohr Inst., Denmark.* We show that semiconductor quantum dots possess large magnetic-dipole and electric-quadrupole moments, which can be accessed with light. Moreover, quantum dots are capable of mediating multipolar interactions on dipole-allowed transitions and therefore are fundamentally different than atoms.

**FF2K.7 • 12:00**
**Probing plasmonic electro-magnetic environment with $Eu^{3+}$,** Natalia Noginova[1], Rabia Hussain[1], Mikhail A. Noginov[1], David Keene[2], Maxim Durach[2], Sergey Kruk[3], Dragomir N. Neshev[3], Isabelle Staude[3], Yuri S. Kivshar[3]; [1]*Norfolk State Univ., USA;* [2]*Georgia Southern Univ., USA;* [3]*Research School of Physics and Engineering, Australian National Univ., Australia.* We use spontaneous emission of $Eu^{3+}$ ions as a spectroscopic tool to probe modifications of optical fields in close vicinity of metal and under the conditions of the optically-induced magnetic resonance.

## Marriott Salon I & II

## CLEO: Applications & Technology

### AF2L • Symposium on Optofluidic Microsystems II—Continued

**AF2L.3 • 11:15**
**Effect of Solar Thermal Energy on Photoreactions' Rate,** Seyyed Mohammad Hosseini Hashemi[1], Jae-Woo Choi[1], Demetri Psaltis[1]; [1]*EPFL, Switzerland.* The Shockley-Queisser limit predicts that at least 70% of solar energy is available to be converted into heat. In this paper, we show that this heating component can play a significant role in photocatalytic reactions.

**AF2L.4 • 11:30** Invited
**Optofluidic Integration: Past, present, and future,** Holger Schmidt[1]; [1]*Univ. of California Santa Cruz, USA.* Optofluidics promises devices and systems in which both optical and fluidic components are integrated on the same chip. We will review progress in this field to date and present an outlook on future opportunities.

## CLEO: Science & Innovations

### Marriott Salon III

### SF2M • Optomechanics II—Continued

**SF2M.4 • 11:15**
**Tuning Fork Cavity Optomechanical Transducers,** Yuxiang Liu[1,2], Marcelo I. Davanco[2], Chaoyang Ti[1], Vladimir Aksyuk[2], Kartik Srinivasan[2]; [1]*Mechanical Engineering, Worcester Polytechnic Inst., USA;* [2]*Center for Nanoscale Science and Technology, National Inst. of Standards and Technology, USA.* We present on-chip Si3N4 optomechanical transducers that integrate nanomechanical tuning forks with microdisk resonators for displacement measurements. Enhanced mechanical Q relative to single cantilevers and mechanical frequency adjustment by beam stress engineering were realized.

**SF2M.5 • 11:30**
**Observation of Brillouin Scattering Induced Transparency in a Silica Microsphere Resonator,** JunHwan Kim[1], Mark Kuzyk[2], Kewen Han[1], Hailin Wang[2], Gaurav Bahl[1]; [1]*Mechanical Science and Engineering, Univ. of Illinois at Urbana-Champaign, USA;* [2]*Physics, Univ. of Oregon, USA.* We experimentally demonstrate induced transparency in silica microsphere resonator using forward Brillouin scattering.

**SF2M.6 • 11:45**
**Coherent Excitation of Multiple Nano-opto-mechanical Modes in Silicon with Ultrafast Time-domain Spectroscopy,** Jonathan A. Cox[1], Aleem Siddiqui[1], Peter Rakich[2], Robert L. Jarecki[1], Andrew Starbuck[1]; [1]*Sandia National Labs, USA;* [2]*Applied Physics, Yale Univ., USA.* We present the first time-domain measurement of a guided-wave nano-optomechanical system, resulting in the coherent excitation of multiple mechanical modes. We deconvolved the electronic and mechanical responses to observe the evolution of the coherent superposition.

**SF2M.7 • 12:00**
**Integrated silicon optomechanical transducers and their application in atomic force microscopy,** Jie Zou[1,2], Houxun Miao[1,2], Thomas Michels[1,2], Vladimir Aksyuk[1]; [1]*Center for Nanoscale Science and Technology, NIST, USA;* [2]*Maryland Nanocenter, Univ. of Maryland, USA.* We present integrated optomechanical transducers with exposed tips and demonstrate ultrahigh force sensitivity and large bandwidth. The transducer is implemented as an atomic force microscope probe in the contact mode and nanoscale resolution is demonstrated.

### Marriott Salon IV

### SF2N • High Energy fs Fiber Laser & Applications—Continued

**SF2N.3 • 11:15**
**Multi-MW Soliton Pulse Generation at 1700 nm in a Photonic Crystal Rod,** Nicholas Horton[1], Kriti Charan[1], Dimitre Ouzounov[1], Chris Xu[1]; [1]*Cornell Univ., USA.* We demonstrate tunable soliton generation in excess of 3 MW peak power in the 1,700 nm spectral region using a solid-core photonic crystal rod pumped by a compact femtosecond fiber source. This system can potentially be used for in vivo deep tissue multiphoton microscopy.

**SF2N.4 • 11:30**
**High energy pulse compression regimes in hypocycloid-core kagome hollow-core photonic crystal fibers,** Benoît Debord[1], Frédéric Gérôme[1,2], Meshaal Alharbi[1], Clemens Hoenninger[3], Eric Mottay[3], Anton Husakou[4], Fetah Benabid[1,2]; [1]*GPPMM Group, Xlim Research Inst., CNRS UMR 7252, France;* [2]*GLOphotonics S.A.S, France;* [3]*Amplitude Systèmes, France;* [4]*Max Born Inst., Germany.* Strong self-compressions of high energy femtosecond laser pulses were experimentally obtained in several hypocycloid-core kagome fibers and under different regimes. By tailoring the fiber properties, the maximum compression-ratio was scaled over 100-600 µJ pulse energies.

**SF2N.5 • 11:45**
**Energetic and high average power femtosecond fiber laser using chirped- and divided-pulse amplification,** Yoann Zaouter[2], Florent Guichard[1,2], Robert Braunschweig[2], Marc Hanna[1], Franck Morin[2], Clemens Hoenninger[2], Eric Mottay[2], Frederic Druon[1], Patrick Georges[1]; [1]*Laboratoire Charles Fabry, France;* [2]*Amplitude Systèmes, France.* We implement, in the same femtosecond fiber amplifier setup, both chirped pulse amplification and divided pulse amplification. The generation of 45 W of compressed average power at 100 kHz, together with 320 fs and 450 µJ pulses, is demonstrated using a rod-type ytterbium-doped fiber.

**SF2N.6 • 12:00**
**17.6 THz waveform synthesis by phase-locked Raman sidebands generation in HC-PCF,** Meshaal Alharbi[1,2], Benoît Debord[1], Madhoussoudhana Dontabactouny[1], Frédéric Gérôme[1], Fetah Benabid[1,2]; [1]*GPPMM group, XLIM research Inst., CNRS UMR 7252, Univ. of Limoges, France;* [2]*Physics Dept., Univ. of Bath, UK.* We report on the generation of a periodic train pulse waveform with 17.6THz repetition rate and ~26fs pulse duration. The waveform is generated by an all-fiber set-up consisting of hydrogen-filled hollow-core photonic crystal fiber.

### Marriott Salon V & VI

### SF2O • Special and Spatial Filters—Continued

**SF2O.4 • 11:15**
**An on-chip partial drop wavelength selective broadcast network,** Zhan Su[1], Erman Timurdogan[1], Jie Sun[1], Michele Moresco[1], Gerald Leake[2], Douglas Coolbaugh[2], Michael R. Watts[1]; [1]*Research Lab of Electronics, MIT, USA;* [2]*College of Nanoscale Science & Engineering, Univ. at Albany, USA.* A wavelength selective 1-by-8-port optical broadcasting system is proposed and demonstrated utilizing partial drop adiabatic microring tunable filters, achieving a 92.7GHz filter bandwidth, 36.2nm Free-Spectral-Range, low power-variation (0.11dB), and aggregate excess loss of only 1.1dB.

**SF2O.5 • 11:30**
**Optical and near infrared plasmonic filters integrated with terahertz metamaterials,** Iain J. McCrindle[1], James Grant[1], Timothy D. Drysdale[1], David R. Cumming[1]; [1]*School of Engineering, Univ. of Glasgow, UK.* We have designed, simulated and fabricated multi-spectral materials operating in visible, near infrared and terahertz wavebands by combining plasmonic filters with metamaterials. Multi-spectral materials offer a path to the creation of co-axial multi-spectral imagers.

**SF2O.6 • 11:45**
**All-optical control of optofluidic ring resonator filled with magnetic fluid,** Yang Liu[1], Lei Shi[1], Xinliang Zhang[1]; [1]*Wuhan National Lab for Optoelectronics, Huazhong Univ of Science and Technology, China.* An all-optical controllable optofluidic ring resonator based on a silica microcapillary filled with magnetic fluid is proposed and demonstrated. A tuning sensitivity of 0.15nm/mW and a tuning range of up to 3 nm are achieved.

**SF2O.7 • 12:00**
**High-Q Ring Resonators in Directly-Written Chalcogenide Glass Waveguides,** Shahar Levy[1], Matvey Klebanov[2], Victor Lyubin[2], Avi Zadok[1]; [1]*Faculty of Engineering, Bar-Ilan Univ., Israel;* [2]*Dept. of Physics, Ben-Gurion Univ., Israel.* Planar waveguide ring resonators are directly written in thin films of As2S3 glass, using two-photon laser beam lithography at 810 nm. Q values of 80,000 are observed.

### Marriott Willow Glen I-III

## CLEO: Applications & Technology

### AF2P • Photons for Energy—Continued

**AF2P.3 • 11:15**
**Chaos-assisted, broadband trapping of light,** Changxu Liu[1], Andrea Di Falco[2], Thomas F. Krauss[3], Andrea Fratalocchi[1]; [1]*PRIMALIGHT, Electrical Engineering;Applied Mathematics and Computational Science, King Abdullah Univ. of Science and Technology (KAUST), Saudi Arabia;* [2]*SUPA;School of Physics and Astronomy, Univ. of St. Andrews, UK;* [3]*Dept. of Physics, Univ. of York, UK.* By combining analytic theory, parallel ab-initio simulations and experiments, we demonstrate how to exploit chaos to dramatically enhance light trapping performance.

**AF2P.4 • 11:30** Invited
**High Efficiency Solar Building Envelopes for Integrated Delivery of Environmental Control Systems,** Anna Dyson[1], Kenton Phillips[1], Justin Shultz[1], Jason Vollen[1], Matt Gindlesparger[1], Nick Novelli[1]; [1]*Center for Architecture Science and Ecology,, Rensselaer Polytechnic Inst., USA.* Efficacious delivery of power requirements for all environmental control systems is demonstrated through an optically transparent solar building envelope that modulates daylight, intercepts solar heat gain, while delivering electricity and high quality heat towards applications. Efficacious delivery of power requirements for all environmental control systems is demonstrated through an optically transparent solar building envelope that modulates daylight, intercepts solar heat gain, while delivering electricity and high quality heat towards applications.

**AF2P.5 • 12:00**
**Highly Efficient Light Extraction GaN-based Light Emitting Diode with Nano-rods in Micro-holes Compound Structure,** Che-Yu Liu[1], Jhih-Kai Huang[1], Da-Wei Lin[1], Hung-Wen Huang[1], Po-Tsung Lee[1], Gou-Chung Chi[1], Hao-chung Kuo[1], Chun-Yen Chang[2]; [1]*Electro-Optical Engineering, National Chiao Tung Univ., Taiwan, Taiwan;* [2]*Electronics Engineering, National Chiao Tung Univ., Taiwan.* We demonstrated a high-power GaN-based light emitting diodes (LEDs) with micro-hole array and nano-rods compound structure. The light output power of LED with micro-hole array and nanorods was as high as 1.27 times, as compared with standard LED.

## Executive Ballroom 210A

### CLEO: QELS-Fundamental Science

## Executive Ballroom 210B

### CLEO: Applications & Technology

**AF2B • Symposium on Advances in Neurophotonics II—Continued**

## Executive Ballroom 210C

## Executive Ballroom 210D

### CLEO: QELS-Fundamental Science

**FF2C • Metasurfaces II—Continued**

**FF2C.8 • 12:15**
**Meta-Weaves: Nonreciprocal Sector-Way Surfaces,** yarden mazor[1], Ben Z. Steinberg[1]; [1]*School of EE, Tel-Aviv Univ., Israel*. Generalized 2D nonreciprocity in metasurfaces is achieved by weaving nano-scale one-way threads. The association of t → -t with z → -z, commonly used in time-reversal asymmetry analysis, proves insufficient as shown by the resulting "sector-way" propagation dynamics.

**FF2D • Quantum Effects in Lattices—Continued**

**FF2D.7 • 12:15**
**Appearance of a Photonic Thermalization Gap in Symmetry-Constrained Anderson-Disordered Photonic Lattices,** Hasan E. Kondakci[1], Ayman F. Abouraddy[1], Bahaa E. Saleh[1]; [1]*Univ. of Central Florida, CREOL, USA*. We show that coherent light traveling through a 1-D lattice of coupled waveguides with off-diagonal disorder exhibits super-thermal statistics (g^(2)>2) with a photonic thermalization gap at asymptotic propagation distances.

## Meeting Room 211 B/D

## Meeting Room 212 A/C

### CLEO: Science & Innovations

**SF2I • Combustion and Plasma Diagnostics—Continued**

**SF2I.7 • 12:15**
**Emission and expansion features of ns and fs laser ablation plumes in an ambient environment,** Sivanandan S. Harilal[1]; [1]*Purdue Univ., USA*. We investigated the role of background gas pressure on spectral emission features, absolute line intensities, signal to background ratios, plume hydrodynamics, and ablation craters for ns and fs laser ablation plumes.

**SF2J • Innovations in Laser Processing of Materials—Continued**

**SF2J.7 • 12:15**
**Strategy in achieving almost complete polarization conversion from 2D circular nanohole arrays,** Lai Yin Yiu[1], Zhaolong Cao[1], H C. Ong[1]; [1]*The Chinese Univ. of Hong Kong, Hong Kong*. We study the dependence of chirality from 2D nanohole arrays on azimuthal angle and hole geometry experimentally and numerically. A strategy based on coupled mode theory is proposed to achieve almost complete polarization conversion.

## Meeting Room 212 B/D

### CLEO: QELS-Fundamental Science

## Marriott Salon I & II

### CLEO: Applications & Technology

### Executive Ballroom 210E

### Executive Ballroom 210F

### Executive Ballroom 210G

## CLEO: Science & Innovations

### SF2E • Frequency Combs and CEP—Continued

**SF2E.8 • 12:15** ▶

**Characterization of ultra-high repetition rate mode-locked lasers with an integrated all-optical RF spectrum analyzer,** Marcello Ferrera[2,1], Christian Reimer[1], Alessia Pasquazi[3], Marco Peccianti[3], Matteo Clerici[1,2], Lucia Caspani[1], Sai T. Chu[4], Brent E. Little[5], Roberto Morandotti[1], David J. Moss[6]; [1]*INRS-EMT, Canada;* [2]*Heriot-Watt Univ., UK;* [3]*Univ. of Sussex, UK;* [4]*City Univ. of Hong Kong, China;* [5]*HiQ Photonics, USA;* [6]*RMIT Univ., Australia.* We report an on-chip all-optical CMOS-compatible radio frequency spectrum analyzer with a bandwidth exceeding 2.5 THz, and use it to measure the intensity power spectra of mode-locked lasers with repetition rates up to 400 GHz.

### SF2F • Advanced THz Emission Mechanisms—Continued

**SF2F.8 • 12:15**

**Bridging the THz to RF gap by four-wave mixing in a highly nonlinear fiber. Stabilization of an opto-millimeter wave,** Antoine Rolland[1], Lucien Pouget[1], Marc Brunel[1], Mehdi Alouini[1]; [1]*Optique et Photonique, Institut de Physique de Rennes, France.* Optoelectronic down-conversion of a THz optical beatnote to a RF intermediate frequency is performed with a standard MZ modulator followed by a zero dispersion-slope fiber. This allows to detect an intermediate frequency in the MHz range in order to phase lock the THz beatnote.

### SF2G • Laser Dynamics—Continued

**SF2G.8 • 12:15**

**Controlled Lasing from Active Optomechanical Resonators,** Thomas Czerniuk[1], Christian Brüggemann[1], Jan Tepper[1], Sebastian Brodbeck[2], Christian Schneider[2], Martin Kamp[2], Sven Höfling[2], Boris A. Glavin[3], Dmitri R. Yakovlev[1,4], Andrey V. Akimov[4,5], Manfred Bayer[1]; [1]*Experimentelle Physik 2, TU Dortmund Univ., Germany;* [2]*Technische Physik, Univ. of Würzburg, Germany;* [3]*V. E. Lashkaryov Inst. of Semiconductor Physics, Ukraine;* [4]*A. F. Ioffe Physical-Technical Inst., Russian Academy of Sciences, Russia;* [5]*School of Physics and Astronomy, Univ. of Nottingham, UK.* Microcavity lasers possess mechanical resonances due to stopbands in the Bragg reflector's phonon dispersion. By injecting a picosecond strain pulse into the resonator we excite these modes, providing an ultrafast effective modulation of the emission.

### Marriott Salon III

### Marriott Salon IV

### Marriott Salon V & VI

## CLEO: Science & Innovations

### SF2M • Optomechanics II—Continued

**SF2M.8 • 12:15**

**Optical Trapping of 60 nm Diameter Particles in Photonic Crystal Slot-Microcavities,** S. Hamed Mirsadeghi[1], Jeff F. Young[1]; [1]*Physics and Astronomy, Univ. Of British Columbia, Canada.* We report optical trapping of 60 nm Au nanoparticles using photonic crystal slot-cavities with Q's of ~7200 and 0.3mW of guided power at 1.6µm. Histograms of the cavity transmission are used to quantitatively analyze the trapping dynamics by modeling the back-action of the nanoparticles in the trap.

### SF2O • Special and Spatial Filters—Continued

**SF2O.8 • 12:15**

**Ultrathin transmission visible spectrum filters with wide viewing angle,** Kyu-Tae Lee[1], Sungyong Seo[1], Jae Yong Lee[1], L. Jay Guo[1]; [1]*Electrical Engineering and Computer Science, Univ. of Michigan, USA.* We report high angular tolerant transmission visible spectrum filters exploiting strong resonance behaviors in an ultrathin semiconductor layer between two metals. The angle robust property remains over a wide incident angular range up to ±70°.

### Marriott Willow Glen I-III

## CLEO: Applications & Technology

### AF2P • Photons for Energy—Continued

**AF2P.6 • 12:15**

**Impact of Surface Recombination on the Performance of Phosphor-Free InGaN/GaN Nanowire White Light Emitting Diodes,** shaofei zhang[1], Ashfiqua T. Connie[1], Hieu Pham Trung Nguyen[1], Qi Wang[1], Ishiang Shih[1], Zetian Mi[1]; [1]*ECE, Mcgill Univ., Canada.* We show that the performance of InGaN/GaN axial nanowire LEDs is largely limited by the poor carrier injection efficiency. We have further demonstrated high performance phosphor-free white LEDs using InGaN/GaN/AlGaN dot-in-a-wire core-shell heterostructures.