| Executive Ballroom 210A | Executive Ballroom 210B | Executive Ballroom 210C | Executive Ballroom 210D |
|---|---|---|---|
| CLEO: QELS-Fundamental Science | CLEO: Science & Innovations | CLEO: QELS-Fundamental Science | JOINT |

**08:30–10:00 Plenary and Awards Session II,** *Civic Auditorium*

**10:00–10:30 Coffee Break,** *Exhibit Halls 1 & 2*

**10:30–12:30 Market Focus Session III: Medical and Aesthetic Lasers–The Future of Light-tissue Interactions,** *Exhibit Hall 2*

## 10:30–12:30
## QW1A • New Trends in High-harmonic Generation

*Presider: Giuseppe Sansone; Politecnico di Milano, Italy*

**QW1A.1 • 10:30**
**Control of Harmonic Generation from Relativistic Mirrors,** SUBHENDU KAHALY[1], Sylvain Monchocé[1], Henri Vincenti[1], Brendan Dromey[2], Matthew Zepf[2], Philippe Martin[1], Fabien Quéré[1]; [1]*Service des Photons, Atomes et Molécules,, Commissariat a l'Energie Atomique, CEA, SACLAY, France;* [2]*Centre for Plasma Physics, School of Mathematics and Physics, Queen's University Belfast, United Kingdom.* We demonstrate for the first time that fine varying of the density gradient of a plasma mirror along with laser spatial phase on target allows total control over the harmonic generation mechanisms and harmonic spatial properties.

**QW1A.2 • 10:45**
**High-harmonic generation from replenishing solid tapes,** Brian Shaw[1,2], Jeroen van Tilborg[1], Thomas Sokollik[1], Carl B. Schroeder[1], Wim P. Leemans[1,2]; [1]*LOASIS Program, Lawrence Berkeley National Lab, USA;* [2]*Applied Science and Technology, University of California, Berkeley, USA.* High-harmonic generation from a replenishing tape surface allows for multi-Hz applications. Operating in the sub-relativistic Coherent Wake Emission (CWE) regime, we have experimentally investigated the spectrum, conversion efficiency, and divergence for several different tape materials.

## 10:30–12:30
## CW1B • SHG and Parametric Devices

*Presider: Valentin Petrov; Max Born Institute, Germany*

**CW1B.1 • 10:30**
**Dynamical Behavior of an Ultrafast OPO near Degeneracy,** Stephen Wolf[1], Chris R. Phillips[1], Alireza Marandi[1], Konstantin Vodopyanov[1], Martin Fejer[1], Robert Byer[1]; [1]*Stanford University, USA.* In an OPO near degeneracy, intensity and spectral oscillations at sub rep-rate frequencies are investigated numerically and verified experimentally. These oscillations are explained by the existence of two coherent frequency combs with different offset frequencies.

**CW1B.2 • 10:45**
**Pulse Compression in a Synchronously Pumped Optical Parametric Oscillator with a Graphene Saturable Absorber,** 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, CNRS-Université Paris Sud 11, France.* We report on the first experimental demonstration of pulse length compression in a synchronously pumped optical parametric oscillator by use of an intracavity ultrafast graphene saturable absorber.

## 10:30–12:30
## QW1C • Symposium on Quantum Simulators: Quantum Simulators I

*Presider: Stefan Kuhr; University of Strathclyde, Scotland, UK*

**QW1C.1 • 10:30** Invited
**Exploring non-equilibrium many-body physics with alkaline earth atoms and molecules,** Ana M. Rey[1]; [1]*University of Colorado at Boulder JILA, USA.* I will describe our proposal of exploring quantum magnetism and rich non-equilibrium many-body phenomena in state of the art alkaline-earth atoms optical lattice clocks and in polar molecules in optical lattices experiments. Both are currently operated at temperatures above quantum degeneracy.

## 10:30–12:30
## JW1D • Symposium on Advances in Extreme UV Science and Applications: Advances in Extreme UV Science and Applications II

*Presider: Patrick Naulleau; Lawrence Berkeley National Laboratory*

**JW1D.1 • 10:30** Invited
**High power EUV LPP,** Daniel J. Brown[1], Robert J. Rafac[1], Alexander Schafgans[1], Igor V. Fomenkov[1], David Myers[1], Alex I. Ershov[1], Richard L. Sandstrom[1], Georgiy O. Vaschenko[1], Palash Das[1], Wayne J. Dunstan[1], Daniel Riggs[1], Robert Bergstedt[1], Tao Yezheng[1]; [1]*Cymer, Inc., USA.* Laser produced plasma (LPP) systems are the leading approach for extreme-ultra-violet (EUV) lithography of circuit features at sub-20nm nodes. This paper reviews technology and development progress for high-power sources optimized for EUV lithography.

**Thank you for attending CLEO: 2013. Look for your post-conference survey via email and let us know your thoughts on the program.**

Wednesday, 12 June

| Executive Ballroom 210H | Executive Ballroom 210G | Executive Ballroom 210F | Executive Ballroom 210E |
|---|---|---|---|
| CLEO: QELS-Fundamental Science | CLEO: Science & Innovations | | |

**08:30–10:00 Plenary and Awards Session II,** *Civic Auditorium*

**10:00–10:30 Coffee Break,** *Exhibit Halls 1 & 2*

**10:30–12:30 Market Focus Session III: Medical and Aesthetic Lasers–The Future of Light-tissue Interactions,** *Exhibit Hall 2*

## 10:30–12:30
## QW1E • Laser Filamentation

*Presider: Matteio Clerici, Heriott Watt, UK*

**QW1E.1 • 10:30**

**Nitrogen lasing in air,** Arthur Dogariu[1]; Richard B. Miles[1]; [1]*Princeton University, USA.* We demonstrate lasing in atmospheric air from multi-photon dissociation of molecular nitrogen followed by resonant two-photon pumping of the atomic nitrogen fragments. The backwards stimulated emission provides a remote laser source for standoff detection.

**QW1E.2 • 10:45**

**Propagation Dynamics of Dressed Optical Filaments,** Matthew Mills[1]; [1]*University of Central Florida, CREOL, USA.* We demonstrate that the longevity of an optical filament can be drastically increased by prudently surrounding it with a low intensity annular wavefront. Here, we systematically study the dynamics and robustness of such dressed filaments.

## 10:30–12:30
## CW1F • Opto-mechanical Systems I

*Presider: Vasily Astratov; University of North Carolina at Charlotte, United States*

**CW1F.1 • 10:30**

**A superhigh-frequency optoelectromechanical system based on a slotted photonic crystal cavity,** Xiankai Sun[1], Xufeng Zhang[1], Menno Poot[1], Chi Xiong[1], Hong X. Tang[1]; [1]*Yale University, USA.* We develop an all-integrated optoelectromechanical system that operates up to 4.20 GHz. The in-plane bulk acoustic modes of a photonic crystal membrane are electrocapacitively actuated and optically detected by a high-Q slotted photonic crystal cavity.

**CW1F.2 • 10:45**

**Electromagnetically induced transparency and wavelength conversion in Si3N4 microdisk optomechanical resonators,** Yuxiang Liu[1,2], Marcelo Davanço[1,3], Vladimir Aksyuk[1], Kartik Srinivasan[1]; [1]*Center for Nanoscale Science and Technology, National Inst of Standards & Technology, USA;* [2]*Institute for Research in Electronics and Applied Physics, University of Maryland, USA;* [3]*Department of Applied Physics, California Institute of Technology, USA.* We demonstrate electromagnetically induced transparency and wavelength conversion between 980 nm and 1300 nm bands in Si3N4 microdisk optomechanical resonators, through radiation pressure coupling of multiple high-Q optical modes with a mechanical mode.

## 10:30–12:30
## CW1G • Mode-locked Semiconductor Lasers

*Presider: A. Coleman; University of Illnois*

**CW1G.1 • 10:30**

**Passive and Hybrid Mode-Locking From a Monolithic InGaN/GaN Laser Diode,** Vojtech F. Olle[1], Adrian Wonfor[1], Luca Sulmoni[2], Peter P. Vasil'ev[1,3], Jean-Michel Lamy[2], Jean-Francois Carlin[2], Nicolas Grandjean[2], Richard Penty[1], Ian H. White[1]; [1]*University of Cambridge, United Kingdom;* [2]*Ecole Polytechnique Fédérale de Lausanne, Switzerland;* [3]*PN Lebedev Physical Institute, Russian Federation.* We report 4ps and 8ps pulse generation from a two-section monolithic InGaN/GaN laser by hybrid and passive mode-locking, respectively. Pulse trains at a repetition rate of 28.6GHz and an emission wavelength of 422nm are generated

**CW1G.2 • 10:45**

**Femtosecond pulse generation in proton bombarded passively mode locked InAs quantum dot lasers,** Patrick Finch[1,2], Ian O'Driscoll[1,2], Peter Blood[3], Peter M. Smowton[3], Angela Sobiesierski[3], Russell Gwilliam[4]; [1]*Tyndall National Institute, Ireland;* [2]*Centre for Advanced Photonics and Process Analysis, Cork Institute of Technology, Ireland;* [3]*School of Physics and Astronomy, Cardiff University, United Kingdom;* [4]*Advanced Technology Institute, University of Surrey, United Kingdom.* Sub-picosecond optical pulses are demonstrated in a two-section passively mode locked InAs quantum dot laser structure using a randomly populated distribution and a proton bombarded absorber.

## 10:30–12:30
## CW1H • Ultrashort Pulse Measurement

*Presider: Rick Trebino, Georgia Tech, USA*

**CW1H.1 • 10:30**

**Non-iterative Data Inversion of Phase Retrieval by Omega Oscillating Filtering (PROOF),** Chi-Cheng Chen[1], Yi-Shiun Chen[1], Chen-Bin Huang[1], Shang-Da Yang[1]; [1]*Institute of Photonics Technologies, National Tsing Hua University, Taiwan.* We proposed a non-iterative data inversion process for the PROOF method that could measure attosecond extreme ultraviolet pulses. Our experiments successfully retrieved the spectral phases of near infrared comb.

**CW1H.2 • 10:45**

**Sparsity-based super-resolution in instruments for diagnostics of short pulses,** zohar Avnat[1], Pavel Sidorenko[1], Yoav Shechtman[1], Yonina C. Eldar[1], Mordechai Segev[1], Oren Cohen[1]; [1]*technion, Israel.* We demonstrate experimentally algorithmic super-resolution for diagnostic of short pulses (amplitude and phase). Our approach is based on using the measured data for finding a mathematical basis in which the pulse is represented compactly.


**08:30–10:00 Plenary and Awards Session II,** *Civic Auditorium*

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## 10:30–12:30
## AW1I • Microscopy

*Presider: Yu Chen; University of Maryland at College Park, United States*

**AW1I.1 • 10:30** Invited

**Adaptive Optics Imaging for Studying Retinal Vasculature in Health and Disease,** Stephen A. Burns[1]; [1]*Indiana Univ., USA.* We will discuss the optical techniques used in our adaptive optics vascular imaging measurements and present examples of measurements of blood flow velocity, vascular wall thickness in systemic hyptertension, and vascular remodeling in diabetes.

## 10:30–11:45
## JW1J • Symposium on High Power Diode Laser Arrays: Technology and Applications: High Power Diode Laser Arrays I

*Presider: Andy Bayramian; Lawrence Livermore National Laboratory, United States*

**JW1J.1 • 10:30** Invited

**High Efficiency kW-class QCW 88x nm Diode Laser Bars,** Manoj Kanskar[1], J. G. Bai[1], Z. Chen[1], W. Dong[1], S. Elim[1], X. Guan[1], M. DeVito[1], M. Grimshaw[1], S. Zhang[1]; [1]*nLight, USA.* We present results of kW-class diode laser bars with optimized fill factors, cavity lengths, and facet reflectivity that demonstrated electrical-to-optical efficiency of 70% and operation of over 100 million shots in QCW mode.

## 10:30–12:30
## CW1K • Manipulation & Detection of THz Radiation

*Presider: Tsuneyuki Ozaki; INRS-EMT, Canada*

**CW1K.1 • 10:30**

**Terahertz electric-field vector camera,** Masatoshi Takeda[1], Takehiro Tachizaki[1], Naoya Yasumatsu[1], Shinichi Watanabe[1]; [1]*Department of Physics, Faculty of Science and Technology, Keio University, Japan.* We have succeeded in capturing two-dimensional spatial vector distribution of terahertz electric-field by the spinning electro-optic sensor method combined with a CCD camera, which is useful for terahertz polarization imaging and terahertz vector beam analysis.

**CW1K.2 • 10:45**

**Shingle-Shot Observation of THz Field with a Reflective Echelon Mirror,** Yasuo Minami[1], Yusuke Hayashi[1], Jun Takeda[1], Ikufumi Katayama[1]; [1]*Yokohama National University, Japan.* We demonstrated a simple scheme not only for terahertz (THz) generation with a grating-coupled LiNbO3 crystal, but also for single-shot detection of the generated THz field with a CMOS camera and a reflective echelon.

## 10:30–12:30
## CW1L • Quantum Cascade Lasers

*Presider: Frank Tittel; Rice University, United States*

**CW1L.1 • 10:30** Tutorial

**Progress in quantum cascade lasers: wavelength agility and frequency comb generation,** Jérôme Faist[1]; [1]*ETH Zurich, Switzerland.* The quantum cascade laser, operates over an extremely wide wavelength range in the Mid-infrared with high output power and low power consumption. A new generation of devices show enhanced wavelength multiplexing and tuning agility capabilities.

Jérôme Faist was born in Switzerland and obtained his Ph.D. in Physics in 1989 from the Swiss Institute of Technology in Lausanne. He then worked successively at IBM Rueschlikon (89-91) and Bell Laboratories (91-97). He was nominated full professor in the physics institute of the University of Neuchâtel (1997) and then full professor in the ETH Zurich (2007). His key contribution to the development of the quantum cascade laser was recognized by a number of awards that include the IEEE/LEOS William Streifer Award for Scientific Achievement and National Swiss Latsis Prize 2002. His present interests include the development of Mid-infrared and terahertz quantum cascade lasers and frequency combs, the physics of strong light-matter coupling in metallic resonators and quantum dots intraband devices.

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## 10:30–12:30
## CW1M • Infrared Fiber Lasers

*Presider: Peter Moulton, QPEAK Inc., USA*

**CW1M.1 • 10:30**

**A monolithic cladding pumped holmium-doped fibre laser,** Alexander Hemming[1], Nikita Simakov[1], Alan Davidson[1], Shayne Bennetts[1,2], Mark Hughes[1], Neil Carmody[1], Phil Davies[1], Leonardo Corena[1], Dmitrii Stepanov[1], John Haub[1], Robert Swain[3], Adrian Carter[4]; *[1]Defence Science and Technology Organisation, Australia; [2]Department of Quantum Science, Australian National University, Australia; [3]Sub-Micron Engineering, USA; [4]Nufern Inc., USA.* We present a single-mode, monolithic holmium-doped silica fibre laser resonantly pumped by thulium-doped fibre lasers through a fused fibre pump combiner. We report the highest achieved output power for a holmium laser of 407 W.

**CW1M.2 • 10:45**

**Amplification of ns–pulses beyond 1 MW–peak power in Tm3+–doped photonic crystal fiber rod,** Christian Gaida[1,3], Martin Gebhardt[1,3], Pankaj Kadwani[1], Lasse Leick[2], Jes Broeng[2], Lawrence Shah[1], Martin Richardson[1]; *[1]CREOL, USA; [2]NKT Photonics, Denmark; [3]IAP, Germany.* We utilize thulium doped PCF rods for amplification of ns–pulses in MOPA configuration and achieve MW–level peak powers with sub 10 ns pulses at 2 µm. The utilization of end caps will enable multi MW peak powers.

## 10:30–12:30
## QW1N • Novel Nanooptical & Plasmonic Fabrication

*Presider: Henri Lezec; National Inst of Standards & Technology, United States*

**QW1N.1 • 10:30** Tutorial

**The Chemical Design of Plasmonic Building Blocks,** Christopher B. Murray[1]; *[1]Univ. of Pennsylvania, USA.* Colloidal nanocrysals (NCs) of controlled crystal size, shape and structure provide ideal plasmonic/photonic building blocks. This talk will present the "current best practices" in preparation, isolation and characterization and organization of optically active NCs.

Professor Christopher B. Murray holds the Richard Perry University Professorship in Chemistry and Materials Science at the University of Pennsylvania in Philadelphia PA where is research focuses on the preparation, characterization and integration of nanomaterials. He received his B. Sc. degree with Honors in Chemistry from St. Mary's University in Halifax N. S., Canada (1988) and his PhD. in Chemistry from the Massachusetts Institute of Technology in 1995. Chris joined IBM Research from 1995 to 2006 staff scientist and Manager at IBM's T. J. Watson Research Center leading the "Nanoscale Materials & Devices" department. Chris is a pioneer in the synthesis, characterization and integration of nanostructured materials into photonic and electronic devices contributing more than 125 scholarly articles and 25 patents in this area.

## 10:30–12:30
## CW1O • Optical Materials and Devices I

*Presider: Uriel Levy; Hebrew University of Jerusalem, Israel*

**CW1O.1 • 10:30** Tutorial

**Plasmonic and Semiconductor Building Blocks for Nanophotonic Devices,** Mark Brongersma[1]; *[1]Stanford University, USA.* I will discuss nanoscale optoelectronic devices composed of optically resonant semiconductor and metallic building blocks, including sources, modulators, and photodetectors

Mark Brongersma is an Associate Professor and Keck Faculty Scholar in the Department of Materials Science and Engineering at Stanford University. He leads a research team of ten students and three postdocs. Their research is directed towards the development and physical analysis of new materials and structures that find use in nanoscale electronic and photonic devices. He received a National Science Foundation Career Award, the Walter J. Gores Award for Excellence in Teaching, the International Raymond and Beverly Sackler Prize in the Physical Sciences (Physics) for his work on plasmonics, and is a Fellow of the Optical Society of America, the SPIE, and the American Physical Society. Dr. Brongersma received his PhD in Materials Science from the FOM Institute in Amsterdam, The Netherlands, in 1998. From 1998-2001 he was a postdoctoral research fellow at the California Institute of Technology.

## 10:30–12:30
## QW1P • Symposium on Nanophotonics at the DOE/SC Nanoscale Science Research Centers: Active and Passive Optical Metamaterials

*Presider: Abul Azad; Los Alamos National Laboratory, United States*

**QW1P.1 • 10:30** Invited

**Ultrafast dynamics of nanorod-based plasmonic metamaterial and their excitonic hybrids,** Gregory A. Wurtz[1], Gary Wiederrecht[2], Anatoly V. Zayats[1]; *[1]Physics, King's College London, United Kingdom; [2]Center for Nanoscale Materials, Argonne National Laboratory, USA.* We discuss the ultrafast dynamics and spectral response of plasmonic metamaterials and their excitonic hybrids.

Wednesday, 12 June

## CLEO: QELS-Fundamental Science

### QW1A • New Trends in High-harmonic Generation—Continued

**QW1A.3 • 11:00** Invited

**High-Order Harmonic Comb from Relativistic Electron Spikes,** Alexander S. Pirozhkov[1], Masaki Kando[1], Timur Z. Esirkepov[1], Tatiana A. Pikuz[1,2], Anatoly Y. Faenov[1,2], Koichi Ogura[1], Yukio Hayashi[1], Hideyuki Kotaki[1], Eugene N. Ragozin[3,4], David Neely[5,6], Hiromitsu Kiriyama[1], Takuya Shimomura[1], Manabu Tanoue[1], Yoshiki Nakai[1], Masahiro Okamoto[1], Shuji Kondo[1], Shuhei Kanazawa[1], James K. Koga[1], Yuji Fukuda[1], Masaharu Nishikino[1], Takashi Imazono[1], Noboru Hasegawa[1], Tetsuya Kawachi[1], Hiroyuki Daido[1,7], Yoshiaki Kato[8], Paul R. Bolton[1], Sergei V. Bulanov[1], Kiminori Kondo[1]; [1]*Advanced Beam Technology Division, Quantum Beam Science Directorate, Japan Atomic Energy Agency, Japan;* [2]*Joint Institute for High Temperatures, Russian Academy of Sciences, Russian Federation;* [3]*P. N. Lebedev Physical Institute, Russian Academy of Sciences, Russian Federation;* [4]*Moscow Institute of Physics and Technology (State University), Russian Federation;* [5]*Central Laser Facility, Rutherford Appleton Laboratory, STFC, United Kingdom;* [6]*Department of Physics, SUPA, University of Strathclyde, United Kingdom;* [7]*Applied Laser Technology Institute, Tsuruga Head Office, Japan Atomic Energy Agency, Japan;* [8]*The Graduate School for the Creation of New Photonics Industries, Japan.* We present the new regime of high-order harmonics generation by multi-TW femtosecond lasers irradiating gas jet targets. We describe new results concerning the off-axis XUV harmonics emission, angular distribution and source size.

**QW1A.4 • 11:30**

**Wavelength scaling of high-harmonic generation efficiency close to the multiphoton ionization regime,** Chien-Jen Lai[1], Giovanni Cirmi[1,2], Shu-Wei Huang[1], Eduardo Granados[1], Kyung-Han Hong[1], Jeffrey Moses[1], Phillip Keathley[1], Siddharth Bhardwaj[1], Franz X. Kaertner[1,2]; [1]*Electrical Engineering and Computer Science, Massachusetts Institute of Technology, USA;* [2]*Center for Free-Electron Laser Science, DESY and Department of Physics, Hamburg University, Germany.* Our experiment shows a less dramatic wavelength scaling of high harmonic generation efficiency between the tunneling and the multiphoton ionization regimes, which can be explained by a modified three-step model with complex ionization time.

## CLEO: Science & Innovations

### CW1B • SHG and Parametric Devices—Continued

**CW1B.3 • 11:00** Invited

**Ultra-stable CW OPOs in the Visible,** Fabien Bretenaker[1], Oussama Mhibik[1], David Paboeuf[1], Cyril Drag[1]; [1]*Laboratoire Aime Cotton, France.* We describe an intracavity doubled continuous wave singly resonant OPO (CW-SHG-SRO), exhibiting tunable operation between 585 and 678 nm. Its frequency is locked to better than 1 kHz over 1 s relatively to a cavity.

**CW1B.4 • 11:30**

**Conversion efficiency and green power of compact reverse-proton-exchanged MgO:LiNbO3 waveguides,** Rostislav V. Roussev[1], Venkata Bhagavatula[1], Uta B. Goers[2]; [1]*Optical Physics, Corning Incorporated, USA;* [2]*Manufacturing Technology and Engineering, Corning Incorporated, USA.* A sub-cm-long reverse-proton-exchanged waveguide with record normalized efficiency showed 44.2% peak internal continuous-wave single-pass conversion, 196-mW peak green, and overall conversion peaking at 30%, being above 25% for green outputs above 80 mW

## CLEO: QELS-Fundamental Science

### QW1C • Symposium on Quantum Simulators: Quantum Simulators I—Continued

**QW1C.2 • 11:00** Invited

**Photonic Quantum Simulators,** Philip Walther[1]; [1]*Universitat Wien, Austria.* In my talk I will review recent photonic quantum simulation experiments of frustrated Heisenberg- and XY-interacting spins as well as the sampling of bosons using integrated random walk structures.

**QW1C.3 • 11:30**

**Experimental BosonSampling in a Tunable Optical Network,** Matthew A. Broome[1,2], Alessandro Fedrizzi[1,2], Saleh Rahimi-Keshari[2], Justin Dove[3], Scott Aaronson[3], Timothy C. Ralph[2], Andrew White[1,2]; [1]*Centre for Engineered Quantum Systems, School of Mathematics and Physics, University of Queensland, Australia;* [2]*Centre for Quantum Computer and Communication Technology, School of Mathematics and Physics, University of Queensland, Australia;* [3]*Computer Science and Artificial Intelligence Laboratory, Massachusetts Institute of Technology, USA.* We report an experimental demonstration of BosonSampling: an intermediate-model of quantum-computing. We verify that the scattering probabilities for three-photon interference are given by permanents of sub-matrices of a larger unitary matrix describing the optical network

## JOINT

### JW1D • Symposium on Advances in Extreme UV Science and Applications: Advances in Extreme UV Science and Applications II—Continued

**JW1D.2 • 11:00**

**Laser-based plasma sources at 6.6 and 60 nm,** Majid masnavi[1]; [1], *USA.* Potential high power laser-based xenon and terbium plasma sources are identified based on the reflectivity profiles of the available LaN/B4C, LaN/B, and Al/Yb/Sio multilayer mirrors for applications such as surface processing and semiconductor industry.

**JW1D.3 • 11:15** Invited

**Metrology Sources for EUV Lithography,** Steve Home[1], Paul Blackborow[1], Matthew M. Bensen[1], Matthew J. Partlow[1], Deborah Gustafson[1], Michael Goldstein[2]; [1]*Energetiq Technologies, Inc, USA;* [2]*SEMANTECH, USA.* Mask inspection and validation are key elements of the EUV lithography infrastructure. Requirements for the light sources to enable these tools will be introduced, and one source described in detail. As the field develops, enhanced sources will be required; two will be described.

## CLEO: QELS-Fundamental Science

## CLEO: Science & Innovations

### QW1E • Laser Filamentation—Continued

**QW1E.3 • 11:00**
**Direct, Absolute Measurements of the High-intensity Nonlinear Refractive Index in Gases,** Jared K. Wahlstrand[1], Yu-Hsiang Cheng[1], Howard Milchberg[1]; *[1]University of Maryland at College Park, USA.* The nonlinear refractive index in air components and noble gases is measured absolutely using spectral interferometry in a thin gas target. Contributions from bound electronic states, molecular alignment, and free electrons from ionization are observed.

**QW1E.4 • 11:15**
**The effect of long timescale gas dynamics on femtosecond filamentation,** Yu-Hsiang Cheng[1], Jared K. Wahlstrand[1], Nihal Jhaji[1], Howard Milchberg[1]; *[1]Univ. of Maryland, College Park, USA.* We show that a localized and long-lived quasi-stationary gas density depression exists after filament-generated-plasma recombination. Its millisecond timescale dynamics is governed by thermal diffusion and has strong effects on high-repetition-rate filamentation and supercontinuum generation.

**QW1E.5 • 11:30**
**Generation of Super-luminescent Jet Light through Disrupted Conical Emission,** Zhijun Xu[1], Yang Yu[1], Zhang Nan[1], Jiefeng Zhao[1], Xiaonong Zhu[1]; *[1]Nankai University, China.* Super-luminescent jet light is produced via disrupted conical emission excited by focused millijoule 50 fs laser pulses in air. Phase-matching requirement of four-wave mixing at specific diffraction angles is responsible for the observed phenomenon.

### CW1F • Opto-mechanical Systems I—Continued

**CW1F.3 • 11:00**
**Stabilization of a linear optonanomechanical oscillator to its ultimate thermodynamic limit,** Emanuel Gavartin[1], Pierre Verlot[1], Tobias J. Kippenberg[1,2]; *[1]Ecole Polytechnique Federale de Lausanne, Switzerland; [2]Max Planck Institute for Quantum Optics, Germany.* We realize a non-invasive optomechanical stabilization scheme and apply it to the fundamental mechanical mode of a nanobeam. We are able to significantly decrease its frequency noise to its ultimate thermodynamic limit at room temperature.

**CW1F.4 • 11:15**
**Electro-mechanical Detection of Near Infrared Optical Intensity Modulation in Silicon,** Siddharth Tallur[1], Sunil A. Bhave[1]; *[1]School of Electrical and Computer Engineering, Cornell University, USA.* We report chip-scale electro-mechanical detection of near-IR optical intensity modulation at 174.2MHz and 1.198GHz in silicon. This constitutes the first experimental demonstration of a photon to phonon translator in a CMOS compatible platform.

**CW1F.5 • 11:30**
**Aluminum nitride piezo-optomechanical nanobeam cavity,** Linran Fan[1], Xiankai Sun[1], Chi Xiong[1], Carsten Schuck[1], Hong X. Tang[1]; *[1]Electrical Engineering, Yale University, USA.* We develop a piezoelectrically actuated, one-dimensional photonic and phononic crystal nanocavity fabricated from aluminum nitride. High-quality piezo-optomechanical nanobeam cavities with intrinsic optical Q of 120,000 and mechanical Q over 10,000 are obtained.

### CW1G • Mode-locked Semiconductor Lasers—Continued

**CW1G.3 • 11:00**
**Optical pulse generation from single-section InAs/GaAs quantum dot edge-emitting lasers,** Cosimo Calò[1], Kamel Merghem[1], Ricardo Rosales[1], Elisabeth Galopin[1], Oumkelthoum Moustapha[1], Aristide Lemaître[1], Igor Krestnikov[2], Geraud Bouwmans[3], Anthony Martinez[1], Abderrahim Ramdane[1]; *[1]CNRS Laboratory for Photonics and Nanostructures, France; [2]Innolume GmbH, Germany; [3]PhLAM/IRCICA, Université Lille, CNRS UMR8523/USR3380, France.* Pulse generation from single-section Fabry-Pérot InAs/GaAs edge-emitting quantum dot lasers is reported at 1.3 µm. Mode-locking performances of the devices are studied as function of injection current and optical spectrum shape.

**CW1G.4 • 11:15**
**Wavelength Tunable Graphene Modelocked VECSEL,** Christian A. Zaugg[1], Zhipei Sun[2], Daniel Popa[2], Silvia Milana[2], Tero Kulmala[2], Ravi S. Sundaram[2], Valentin J. Wittwer[1], Mario Mangold[1], Oliver D. Sieber[1], Matthias Golling[1], Y. Lee[3], Jong-Hyun Ahn[3], A. C. Ferrari[2], Ursula Keller[1]; *[1]Institute for Quantumelectronics - Department of Physics, ETH Zurich, Switzerland; [2]Department of Engineering, University of Cambridge, United Kingdom; [3]School of Advanced Materials Science and Engineering, Advanced Institute of Nanotechnology, Sungkyunkwan University, Republic of Korea.* A VECSEL was passively modelocked with a single-layer graphene saturable absorber mirror generating pulses as short as 473 fs. A very broad wavelength tuning range over 46 nm was achieved with three different VECSELs.

**CW1G.5 • 11:30**
**Self-Mode-Locked Vertical External-Cavity Surface-Emitting Laser (VECSEL),** Alexander R. Albrecht[1], Denis V. Seletskiy[2], Jeffrey G. Cederberg[3], Mansoor Sheik-Bahae[1]; *[1]Department of Physics and Astronomy, University of New Mexico, USA; [2]Department of Physics and Center for Applied Photonics, University of Konstanz, Germany; [3]Sandia National Laboratories, USA.* Self-mode-locking has been observed in an InGaAs VECSEL at 1030 nm with sub-500 fs pulses at 1 GHz. The mechanism is attributed to negative ultrafast Kerr lensing in the gain structure.

### CW1H • Ultrashort Pulse Measurement—Continued

**CW1H.3 • 11:00**
**Measuring Many-Picosecond-Long Ultrashort Pulses on a Single Shot Using XFROG and Pulse-Front Tilt,** Tsz Chun Wong[1], Rick Trebino[1]; *[1]Physics, Georgia Institute of Technology, USA.* We demonstrate the use of pulse-front tilt in cross-correlation frequency-resolved optical gating (XFROG) to measure complex many-picosecond-long pulses on a single shot.

**CW1H.4 • 11:15**
**The coherent artifact in modern pulse-shape measurements,** Michelle Rhodes[1], Gunter Steinmeyer[2], Justin Ratner[1], Rick Trebino[1]; *[1]Georgia Institute of Technology, USA; [2]Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy, Germany.* We simulate multi-shot measurements of trains of pulses with unstable shapes using SPIDER, SRSI, SHG FROG, PG FROG, and XFROG. Interferometric methods measure only the coherent artifact, while FROG methods better approximate the trains.

**CW1H.5 • 11:30**
**Near to mid-IR ultra-broadband third harmonic generation in multilayer graphene: few-cycle pulse measurement using THG dispersion-scan,** Francisco Silva[1,2], Miguel Miranda[1,3], Stephan Teichmann[2], M. Baudish[2], Mathieu Massicotte[2], Frank Koppens[2], Jens Biegert[2,4], Helder Crespo[1]; *[1]IFIMUP-IN and Departamento de Física e Astronomia, Universidade do Porto, Portugal; [2]Institut de Ciencies Fotoniques, Spain; [3]Department of Physics, Lund University, Sweden; [4]ICREA-Institució Catalana de Recerca i Estudis Avançats, Spain.* We report enhanced third-harmonic generation (THG) in graphene films from the near -to the mid-IR. Moreover, we use this process for few-cycle pulse measurements with the new technique of THG dispersion-scan.

## CLEO: Applications & Technology

### AW1I • Microscopy—Continued

**AW1I.2 • 11:00**
**Hyperspectral Multi-Point Confocal Microscope,** Andreas U. Velten[1,2], John G. White[1], Thomas R. Mackie[1,2], Kevin W. Eliceiri[1,2]; [1]*Laboratory for Optical and Computational Instrumentation, University of Wisconsin-Madison, USA;* [2]*Medical Devices, Morgridge Institute for Research, USA.* We demonstrate a high speed spectral confocal microscope that utilizes an Amici prism for spectral separation with near optimal sensitivity and a multi-point confocal design with computational image reconstruction for high speed collection.

**AW1I.3 • 11:15**
**Quantification of Rat Cervical Microstructure using Fourier Transform-Second-Harmonic Generation Imaging,** Tung Yuen Lau[1], Harpreet K. Sangha[1], Edward K. Chien[2,3], Barbara L. McFarlin[4], Amy J. Wagoner Johnson[1], Kimani C. Toussaint[1]; [1]*Mechanical Science and Engineering, Univ of Illinois at Urbana-Champaign, USA;* [2]*Alpert Medical School, Brown University, USA;* [3]*Women and Infants Hospital of Rhode Island, USA;* [4]*Women, Children and Family Health Science, Univ of Illinois at Chicago, USA.* We apply Fourier transform-second-harmonic generation imaging to evaluate unstained rat cervical tissue in both 2D and 3D. Our technique validates the existence of 3D microstructures consisting of collagen fibers in rat cervical tissue.

**AW1I.4 • 11:30** Invited
**Phase Contrast Endomicroscopy,** Jerome. C. Mertz[1]; [1]*Boston Univ., USA.* A microscope add-on is described that measures phase and amplitude in a single shot. The technique is quantitative, light efficient, and works with incoherent illumination. We apply this technique to dynamic biological imaging.

## JOINT

### JW1J • Symposium on High Power Diode Laser Arrays: Technology and Applications: High Power Diode Laser Arrays I—Continued

**JW1J.2 • 11:00** Invited
**Cryolaser: Innovative Cryogenic Diode Laser Bars Optimized for Emerging Ultra-high Power Laser Applications,** Paul Crump[1]; [1]*Ferdinand-Braun Institut, Germany.* Cryolaser diode laser designs exploit the improvement in semiconductor material properties at sub-zero temperatures to increase efficiency and power. Optimized single 9xx-nm laser bars demonstrate record peak pulse energy of 2J (1.7kW, 1.2ms, -50°C).

**JW1J.3 • 11:30**
**Beam Quality Improvement of Broad-Area Laser Diodes by Fast-to-Slow Axis Mode Imaging,** Andrew Jones[1], Juliet Gopinath[1]; [1]*Department of Electrical, Computer, and Energy Engineering, University of Colorado - Boulder, USA.* A novel technique for beam quality improvement of a broad-area diode array has been demonstrated. For each emitter, the fast-axis mode is imaged back onto the slow axis, improving beam quality while preserving slope efficiency.

## CLEO: Science & Innovations

### CW1K • Manipulation & Detection of THz Radiation—Continued

**CW1K.3 • 11:00**
**Single-shot, spatio-temporal electro-optic mapping of THz waveforms with linear detection using Temporal Electric-field Cross-correlation (TEX),** Nicholas H. Matlis[1], Guillaume Plateau[1], Jeroen van Tilborg[1], Wim P. Leemans[1]; [1]*Lawrence Berkeley National Laboratory, USA.* We present an electro-optic method for single-shot spatio-temporal THz waveform-mapping which avoids distortions associated with spectral encoding and retains the benefits of nonlinear cross-correlation but using linear detection. THz waveforms from laser-plasma accelerator are reconstructed.

**CW1K.4 • 11:15**
**Self-referenced Spectral-Domain Interferometry for THz Detection,** Gargi Sharma[1], Kanwarpal Singh[1], Akram Ibrahim[1], Ibraheem Al-Naib[1], Roberto Morandotti[1], Francois Vidal[1], Tsuneyuki Ozaki[1]; [1]*Advanced Laser Light Source, INRS-EMT, Canada.* We demonstrate self-referenced spectral-domain interferometry (SDI) for terahertz detection. It not only overcomes the limitation of over-rotation for intense terahertz fields, but also considerably increases the signal-to-noise ratio, when compared with conventional SDI techniques.

**CW1K.5 • 11:30**
**Highly sensitive Terahertz-wave Detection by using Nonlinear Parametric Conversion,** Shin'ichiro HAYASHI[1], Kouji Nawata[1], Kodo Kawase[2,1], Hiroaki Minamide[1]; [1]*RIKEN, Japan;* [2]*Nagoya University, Japan.* We report on a highly sensitive detection of sub-nanosecond terahertz-waves with wide dynamic range using frequency up-conversion in a nonlinear MgO:LiNbO3 crystal at room temperature. We obtained the dynamic range of more than 100 dB.

### CW1L • Quantum Cascade Lasers—Continued

**CW1L.2 • 11:30**
**In Vitro Measurements of Physiological Glucose Concentrations in Biological Fluids Using Mid-infrared Spectroscopy,** Sabbir Liakat[1], Kevin A. Bors[1], Tzu-Yung Huang[1], Anna Michel[1,2], Eric Zanghi[1,3], Claire F. Gmachl[1]; [1]*Electrical Engineering, Princeton University, USA;* [2]*Woods Hole Oceanographic Institute, USA;* [3]*Mechanical Engineering, Massachusetts Institute of Technology, USA.* Predictions of glucose concentrations throughout the physiological range are obtained in vitro using partial least squares regression analysis of Mid-infrared transmission spectra. Concentrations as low as 30 mg/dL are predicted to clinical accuracy.


Wednesday, 12 June

## Marriott San Jose Salon III

### CLEO: Science & Innovations

**CW1M • Infrared Fiber Lasers—Continued**

**CW1M.3 • 11:00** Invited

**2 Micron Fiber Lasers Using Multi-component Glass Fibers,** Shibin Jiang[1]; *[1]AdValue Photonics, Inc., USA.* This paper summarizes our progress in 2 micron fiber lasers using Tm and Tm-Ho-co-doped multi-component glass fibers. Performance of single frequency lasers, Q-switched lasers, and mode-locked lasers will be presented.

**CW1M.4 • 11:30**

**High-power Yb: and Tm:fiber amplifiers seeded by a femtosecond passively phase-stable Er:system,** Marcel Wunram[1], Sören Kumkar[1], Patrick Storz[1], David Fehrenbacher[1], Daniele Brida[1], Alfred Leitenstorfer[1]; *[1]Department of Physics and Center for Applied Photonics, University of Konstanz, Germany.* Synchronous high-power Yb: and Tm:amplifiers both coherently seeded by the same broadband passively phase stable Er:fiber system are demonstrated. Microjoule-level pulse energy and sub-200-fs operation at a repetition rate of 10 MHz are obtained.

## Marriott San Jose Salon IV

### CLEO: QELS-Fundamental Science

**QW1N • Novel Nanooptical & Plasmonic Fabrication—Continued**

**QW1N.2 • 11:30** Invited

**Chiral Plasmonic Films and Nanoparticles,** David Norris[1]; *[1]ETH Zurich, Switzerland.* We use template stripping to obtain metallic films and colloidal nanoparticles with chiral shape. Chiral nanoparticles, a long-standing fabrication challenge, can exhibit strong circular dichroism and non-linear optical effects, useful for sensing and signal processing.

## Marriott San Jose Salon V & VI

### CLEO: Science & Innovations

**CW1O • Optical Materials and Devices I—Continued**

**CW1O.2 • 11:30**

**Printable EO Polymer Modulators,** Harish Subbaraman[1], Xiaohui Lin[2], Tao Ling[3], Xingyu Zhang[2], L. Jay Guo[3], Ray T. Chen[2]; *[1]Omega Optics, Inc, USA; [2]Electrical and Computer Engineering, The University of Texas at Austin, USA; [3]Electrical Engineering and Computer Science, University of Michigan - Ann Arbor, USA.* An EO polymer modulator is fabricated utilizing a combination of UV imprinting and ink-jet printing, and operation up to 15MHz is demonstrated. The measured V-pi of the modulator is 8V. This process will increase throughput and reduce cost.

## Marriott Willow Glen I-III

### CLEO: QELS-Fundamental Science

**QW1P • Symposium on Nanophotonics at the DOE/SC Nanoscale Science Research Centers: Active and Passive Optical Metamaterials—Continued**

**QW1P.2 • 11:00** Invited

**All-Dielectric Metamaterials: Path to Low Losses and High Spectral Selectivity,** Gennady Shvets[1], Chihhui Wu[1], NIhal Arju[1], Glen Kelp[1], Burton Neuner[1], Gregory Ten Eyck[3], Michael B. Sinclair[3], Igal Brener[2,3]; *[1]Physics, University of Texas at Austin, USA; [2]Center for Integrated Nanotechnologies, Sandia National Laboratories, USA; [3]Sandia National Laboratories, USA.* Ohmic losses severely limit the performance of metamaterials. High-index semiconductors offer an attractive alternative. We review several meta-surfaces based on silicon and silicon carbide enabling infrared applications such as polarization manipulation and thermal emission

**QW1P.3 • 11:30** Invited

**New Directions in Active and Tunable Metamaterials,** Igal Brener[1], Hou-Tong Chen[2]; *[1]Center for Integrated Nanotechnologies, Sandia National Labs, USA; [2]Center for Integrated Nanotechnologies, Los Alamos National Laboratory, USA.* We will present some of the recent projects at CINT that aim at optically and electrically tunable Metamaterials. This is achieved by combining far and mid infrared planar metamaterials with semiconductors, superconductors and other substrates.

## Executive Ballroom 210A

### CLEO: QELS-Fundamental Science

**QW1A • New Trends in High-harmonic Generation—Continued**

**QW1A.5 • 11:45**
**Ultrahigh-Efficiency High Harmonic Generation Driven by UV Lasers,** Dimitar Popmintchev[1], Ming-Chang Chen[1], Carlos H. García[2], Jose Antonio Perez Hernández[3], Jonathas P. Siqueira[1], Susannah Brown[1], Franklin Dollar[1], Barry C. Walker[4], Patrik Grychtol[1], Luis Plaja[2], Margaret M. Murnane[1], Henry Kapteyn[1], Tenio Popmintchev[1]; *[1]JILA, University of Colorado at Boulder, USA; [2]Grupo de Investigación en Óptica Extrema, Universidad de Salamanca, Spain; [3]Centro de Láseres Pulsados CLPU, Spain; [4]University of Delaware, USA.* We demonstrate bright high harmonic generation driven by UV lasers with ultra-high conversion efficiency approaching 10^-3 and ultra-narrow single-harmonic bandwidth of ~0.2%. The enhanced flux results from improved phase-matching combined with a stronger single-atom yield.

**QW1A.6 • 12:00**
**High-Order Harmonics of Bichromatic Counter-Rotating Elliptically-Polarized Drivers: Fully Controlled Polarization State and Novel Selection Rules,** avner fleischer[1], Pavel Sidorenko[1], Oren Cohen[1]; *[1]Technion Israel Institute of Technology, Israel.* We show, theoretically and experimentally, that the polarization of high-order harmonics driven by counter-rotating elliptically-polarized bichromatic lasers are completely controllable: from linear through elliptic to circular polarization. New selection rules are observed.

**QW1A.7 • 12:15**
**Measurement of Coherence Lengths of Below Threshold Harmonics in Solid Argon,** Georges ndabashimiye[1,2], Shambhu Ghimire[2,1], David Reis[1,2], David Nicholson[1,2]; *[1]Applied Physics, Stanford University, USA; [2]PULSE, SLAC, USA.* We report the measurement of the coherence lengths of 7th and 9th harmonics of Ti:sapphire laser radiation in solid argon crystals under strong-field excitation.

## Executive Ballroom 210B

### CLEO: Science & Innovations

**CW1B • SHG and Parametric Devices—Continued**

**CW1B.5 • 11:45**
**Tunable, Pulsed Multi-Wavelength Intracavity Optical Parametric Oscillator Using 2D MgO:PP-APPLN,** Yen-Hung Chen[1], Wei-Kun Chang[1], Shang-Sheng Huang[1], Hung-Ping Chung[1], Bing-Zhong Liu[1], Jui-Wen Chang[1]; *[1]Department of Optics and Photonics, National Central University, Taiwan.* We report a tunable, pulsed multi-signal-line intracavity optical parametric oscillator based on a highly integrated 2D MgO:PP-APPLN in a Nd:YVO4 laser. >3.2-kW three signal lines with almost equal peak intensity were obtained from the system.

**CW1B.6 • 12:00**
**PPSLT KHz OPO/OPA Tunable in 3-3.5 µm Pumped by 1ns 30mJ Nd-laser System,** Danail V. Chuchumishev[1], Alexander G. Gaydardzhiev[1], Dimitar Shumov[3], Stuart Samuelson[3], Torsten Fiebig[2], Claus-Peter Richter[2], Ivan Buchvarov[1,2]; *[1]Department of Physics, Sofia University St. Kliment Ohridski, Bulgaria; [2]Feinberg School of Medicine, Northwestern University, USA; [3]Deltronic Crystal Industries Inc., USA.* We demonstrate 5.7-mJ mid-IR PPSLT based OPO/OPA pumped by 30-mJ 1.4 ns Nd-laser system operated at 0.5-kHz repetition rate. The output wavelength is temperature tuned within water absorption peak (3000-3500 nm).

**CW1B.7 • 12:15**
**A high power mid-IR ZGP ring OPO,** Alexander Hemming[1], Jim Richards[2], Alan Davidson[1], Neil Carmody[1], Nikita Simakov[1], Mark Hughes[1], Phil Davies[1], Shayne Bennetts[1,3], John Haub[1]; *[1]Defence Science and Technology Organisation, Australia; [2]Bob Seymour and Associates, Australia; [3]Department of Quantum Science, Australian National University, Australia.* We present results from a mid-IR ZGP ring OPO that demonstrates further power scaling of a cascaded mid-IR laser system. The system achieved 30.2 W of mid-IR output with excellent beam quality of $M^2 = 1.3$.

## Executive Ballroom 210C

### CLEO: QELS-Fundamental Science

**QW1C • Symposium on Quantum Simulators: Quantum Simulators I—Continued**

**QW1C.4 • 11:45**
**Estimating Immanants from Interferometric Photon Coincidences,** Barry C. Sanders[1], Si-Hui Tan[2], Hubert de Guise[3], Yvonne Y. Gao[4]; *[1]Institute for Quantum Science & Technology, University of Calgary, Canada; [2]Centre for Quantum Technologies, National University of Singapore, Singapore; [3]Physics, Lakehead University, Canada; [4]Physics and Applied Physics, Yale University, USA.* We develop a theory for multi-channel passive optical interferometery with one or zero photon entering each input port, and we show that the output photon coincidences yield information about immanants of the interferometer transformation matrix.

**QW1C.5 • 12:00**
**Playing a quantum game with polarization vortices,** Antonio Pinheiro[1], Carlos Eduardo Souza[1], Dilson Caetano[2], Jose Augusto Huguenin[2], Alexandre Schmidt[2], Antonio Z. Khoury[1]; *[1]Universidade Federal Fluminense, Brazil; [2]Universidade Federal Fluminense, Brazil.* The quantum mechanical approach to the well known prisoners dilemma, one of the basic examples in Game Theory, is implemented with polarization vortices. Spin-orbit entanglement is used to implement a rich universe of strategies.

**QW1C.6 • 12:15**
**Coherent cavity networks with complete connectivity,** Almut Beige[1]; *[1]University of Leeds, United Kingdom.* Cavity-fiber networks are proposed which mediate cavity-cavity interactions in a huge variety of configurations. Coherent cavity networks with complete connectivity can be created with potential applications in quantum computing and the simulation of biological systems.

## Executive Ballroom 210D

### JOINT

**JW1D • Symposium on Advances in Extreme UV Science and Applications: Advances in Extreme UV Science and Applications II—Continued**

**JW1D.4 • 11:45** Invited
**Development of a Coherent EUV Scatterometry Microscope,** Hiroo Kinoshita[1,3], Tetsuo Harada[1,3], Yutaka Nagata[2,3], Takeo Watanabe[1,3], Katsumi Midorikawa[2]; *[1]Center for EUV Lithography, University of Kyogo, Japan; [2]Riken ASI, Japan; [3]JST, CREST, Japan.* A coherent scatterometry microscope using a high-order harmonic light from a femtosecond laser has been developed. Using this system, measurement of CD values and defects inspection such as missing patterns and bridge defects were demonstrated.

**JW1D.5 • 12:15**
**Soft X-Ray Image Plane Holographic Microscopy,** Jaroslav Nejdl[4], Isela Howlett[1,2], David Carlton[1,3], Weilun Chao[1,3], Erik H. Anderson[1,3], Mario Marconi[1,2], Jorge Rocca[1,2], Carmen S. Menoni[1,2]; *[1]NSF Center for EUV Science & Technology, Colorado State University, USA; [2]Electrical and Computer Engineering, Colorado State University, USA; [3]Center for X-Ray Optics, Lawrence Berkeley National Laboratory, USA; [4]FNSPE, Czech Technical University in Prague, Czech Republic.* Image plane holographic microscopy is demonstrated combining coherent illumination from a compact 46.9 nm wavelength laser with Fresnel zone plate optics. The method enables imaging of low absorption samples with high resolution.

**10:45–15:45 NIF Tour** *(Pre-Registered attendees only)*

**12:30–13:30 Lunch and Unopposed Exhibit Only Time,** *Exhibit Halls 1 and 2 (concessions available)*

**13:30–15:00 JW2A • POSTER SESSION II: Energy, Sensing, and Nonlinear Optics,** *Exhibit Hall 3*

**14:00–16:00 Market Focus Session IV: Optics & Innovation for Energy & the Environment,** *Exhibit Hall 2*

**15:00–16:30 Coffee Break (15:00-15:30) and Unopposed Exhibit Only Time,** *Exhibit Halls 1 and 2*

## CLEO: QELS-Fundamental Science

## CLEO: Science & Innovations

### QW1E • Laser Filamentation—Continued

**QW1E.6 • 11:45**
**Dispersive Wave Emission by Mid-IR Filaments in Solids,** Skirmantas Ališauskas[1], Daniil Kartashov[1], Audrius Pugzlys[1], Daniele Faccio[2], Aleksei Zheltikov[3,4], Alexander Voronin[3], Andrius Baltuska[1]; *[1]Photonics Institute, Vienna University of Technology, Austria; [2]Institute of Photonics and Quantum Sciences, Heriot-Watt University, United Kingdom; [3]Physics Department, Russian Quantum Center, International Laser Center, M.V. Lomonosov Moscow State University, Russian Federation; [4]Department of Physics and Astronomy, Texas A&M University, USA.* We present experimental and numerical investigation of a new filamentation regime of Mid-infrared femtosecond pulses in solids. Efficient emission of dispersive waves without fundamental spectrum broadening and continuum generation is observed in this regime.

**QW1E.7 • 12:00**
**Guiding of meter scale AC discharges by laser filamentation in air,** Aurelien Houard[1], Guillaume Point[1], Yohann Brelet[1], Jérôme Carbonnel[1], Yves-Bernard André[1], Bernard Prade[1], Leonid Arantchouk[2], Andre Mysyrowicz[1]; *[1]Laboratoire d'Optique Appliquée, France; [2]Laboratoire de Physique des Plasmas, France.* We study the guiding effect of femtosecond laser filaments on high-voltage electric discharges generated by a compact Tesla coil. Meter scale repetitive discharges are demonstrated.

**QW1E.8 • 12:15**
**Influence of the anomalous dispersion on the supercontinuum generation by femtosecond laser filamentation,** Durand M. Maëva[1,2], Khan Lim[1], Vytautas Jukna[3], Erik McKee[1], Matthieu Baudelet[1], Aurelien Houard[2], Martin Richardson[1], Andre Mysyrowicz[2], Arnaud Couairon[3]; *[1]Townes Laser Institute, CREOL - University of Central Florida, USA; [2]LOA, ENSTA - Ecole Polytechnique - CNRS, France; [3]Centre de Physique theorique, Ecole Polytechnique - CNRS, France.* Measurements and numerical simulations of the continuum created by laser filamentation in anomalous dispersion regime of fused silica allow us to identify the extreme blueshifted peak as an axial component of the conical emission.

### CW1F • Opto-mechanical Systems I—Continued

**CW1F.6 • 11:45**
**Eliminating Structural Loss in Optomechanical Resonators Using Elastic Wave Interference,** Mian Zhang[1], Gustavo O. Luiz[2], Shreyas Shah[1], Paulo A. Nussenzveig[3], Gustavo S. Wiederhecker[2], Michal Lipson[1,4]; *[1]Electric and Computer Engineering, Cornell University, USA; [2]Instituto de Fisica Gleb Wataghin, Universidade Estadual de Campinas, Brazil; [3]Instituto de Física, Universidade de São Paulo, Brazil; [4]Kavli Institute at Cornell, Cornell University, USA.* We theoretically and experimentally demonstrate that the support loss of double-disk optomechanical resonators can be minimized using destructive elastic wave interference. We show 100MHz Si3N4 resonators with mechanical quality factor of 10000 at room temperature.

**CW1F.7 • 12:00**
**Optomechanical Transduction in Coupled Wheel Resonators,** Chenguang Huang[1,2], Jiahua Fan[1,2], Ruoyu Zhang[1,2], Lin Zhu[1,2]; *[1]Department of Electrical and Computer Engineering, Clemson University, USA; [2]Center for Optical Materials Science and Engineering Technologies, Clemson University, USA.* We investigate the optomechanical transduction in two side-coupled wheel resonators and show that it is related to the optical energy distribution. We also demonstrate sensitive optomechanical transduction when degrading Q factors of one resonator.

**CW1F.8 • 12:15**
**Dynamic cooling of a mechanical resonator in the strong coupling regime,** Yong-Chun Liu[1,2], Yun-Feng Xiao[1], Xingsheng Luan[2], Chee Wei Wong[2]; *[1]State Key Laboratory for Mesoscopic Physics and School of Physics, Peking University, China; [2]Optical Nanostructures Laboratory, Columbia University, USA.* We propose uniquely dynamically-modulated dissipative cooling scheme in strong optomechanical coupling, which significantly enhances the cooling process. This overcomes quantum backaction and instantaneous phonon occupations below the steady-state cooling limit can be achieved.

### CW1G • Mode-locked Semiconductor Lasers—Continued

**CW1G.6 • 11:45**
**Sub-100 MHz Passively Modelocked VECSEL,** Christian A. Zaugg[1], Alexander Klenner[1], Oliver D. Sieber[1], Matthias Golling[1], Bauke W. Tilma[1], Ursula Keller[1]; *[1]Institute for Quantumelectronics - Department of Physics, ETH Zurich, Switzerland.* We demonstrate a record-low pulse repetition rate of 99.6 MHz from a passively modelocked VECSEL employing a conventional cavity. Fundamental modelocking was verified with an average output power of 30 mW in 20 ps pulses.

**CW1G.7 • 12:00**
**Four-Wave Mixing Mediated Stabilization of an Orthogonally Coupled Monolithic CPM Laser,** Abhijeet Ardey[1], Edris Sarailou[1], Peter J. Delfyett[1]; *[1]CREOL, The College of Optics and Photonics, University of Central Florida, USA.* We experimentally confirm four-wave mixing process as the dominant mechanism responsible for injection locking in case of a novel monolithically integrated orthogonally coupled colliding pulse mode-locked (CPM) laser.

**CW1G.8 • 12:15**
**Generating Terahertz Pulses Using Mode-Locked Side-Wall Sampled-Grating Distributed Bragg Reflector Lasers,** Lianping Hou[1], Mohsin Haji[1], John H. Marsh[1]; *[1]University of Glasgow, United Kingdom.* We report for the first time generation of 640 GHz and 1.28 THz pulse repetition frequencies with high reproducibility, controllability and a wide operation range using passively mode-locked side-wall sampled-grating distribute Bragg reflector lasers.

### CW1H • Ultrashort Pulse Measurement—Continued

**CW1H.6 • 11:45**
**Highly-Sensitive Ultrafast Pulse Characterization Utilizing Four-wave Mixing in an Amorphous Silicon Nanowaveguide,** Ke-Yao Wang[1], Keith G. Petrillo[1], Mark A. Foster[1], Amy C. Foster[1]; *[1]Electrical and Computer Engineering, Johns Hopkins University, USA.* We demonstrate frequency-resolved optical gating using four-wave mixing in a hydrogenated amorphous silicon nanowaveguide. The ultrahigh nonlinearity and the wide conversion bandwidth of this device allow characterization of sub-ps pulses with high sensitivity.

**CW1H.7 • 12:00**
**Characterization of infrared femtosecond pulses by using transient-grating self-referenced spectral interferometry,** Jun Liu[1]; *[1]Shanghai Inst of Optics and Fine Mech, China.* We propose a new technique for femtosecond pulse characterization---transient-grating self-referenced spectral interferometry. Using this technique, we built an extremely simple, alignment-free device and successfully sub-two-cycle 10-fs pulses at 1.75 μm.

**CW1H.8 • 12:15**
**Complete waveform characterization of ultrashort pulses,** Takao Fuji[1], Yutaka Nomura[1]; *[1]National Institutes of Natural Sciences, Japan.* A new pulse characterization concept capable to measure the absolute value of carrier-envelope phase has been demonstrated. Complete waveforms of sub-single-cycle pulses were characterized by using the method.

**10:45–15:45 NIF Tour** *(Pre-Registered attendees only)*

**12:30–13:30 Lunch and Unopposed Exhibit Only Time,** *Exhibit Halls 1 and 2 (concessions available)*

**13:30–15:00 JW2A • POSTER SESSION II: Energy, Sensing, and Nonlinear Optics,** *Exhibit Hall 3*

**14:00–16:00 Market Focus Session IV: Optics & Innovation for Energy & the Environment,** *Exhibit Hall 2*

**15:00–16:30 Coffee Break (15:00-15:30) and Unopposed Exhibit Only Time,** *Exhibit Halls 1 and 2*

## CLEO: Applications & Technology

### AW1I • Microscopy—Continued

**AW1I.5 • 12:00**
**Effect of gold nanoparticles on the mechanical property of stress fibers in endothelial cells,** Zi Li Ma[1], Yu Huang[2], Kam T. Chan[1]; [1]*EE Department, CUHK, China;* [2]*School of Biomedical Sciences, CUHK, China.* The impact of gold nanoparticles to stress fibers (SFs) in HUVEC cells was studied by cutting the SFs from their mid-point with a femtosecond laser and recording their recoil dynamics in the real time.

**AW1I.6 • 12:15**
**High-throughput Imaging of Single Viruses using Self-assembled Nano-lenses and On-Chip Holography,** Onur Mudanyali[1], Euan McLeod[1], Wei Luo[1], Alon Greenbaum[1], Ahmet F. Coskun[1], Yves Hennequin[2], Cedric P. Allier[2], Aydogan Ozcan[1,3]; [1]*Electrical Engineering, University of California, Los Angeles, USA;* [2]*Minatec, CEA LETI, France;* [3]*California NanoSystems Institute, University of California, Los Angeles, USA.* We demonstrate, for the first time in lensfree microscopy, optical imaging of single viruses and nano-particles (<100nm) over a large field-of-view (e.g., >20 mm2) using self-assembled nano-lenses and lensfree computational microscopy on a chip.

## JOINT

### JW1J • Symposium on High Power Diode Laser Arrays: Technology and Applications: High Power Diode Laser Arrays I—Continued

## CLEO: Science & Innovations

### CW1K • Manipulation & Detection of THz Radiation—Continued

**CW1K.6 • 11:45**
**Temporal Slicing of High-Field Multi-THz Waveforms Using an Ultrafast Semiconductor Switch,** Bernhard Mayer[1], Christian Schmidt[1], Johannes Bühler[1], Denis V. Seletskiy[1], Daniele Brida[1], Alexej Pashkin[1], Alfred Leitenstorfer[1]; [1]*Department of Physics and Center for Applied Photonics, University of Konstanz, Germany.* Intense multi-THz transients are controlled on a sub-cycle timescale using an ultrafast plasma mirror. We monitor the temporal slicing via ultrabroadband electro-optic detection of the electric field.

**CW1K.7 • 12:00**
**A Non-Reciprocal Broadband Terahertz Isolator,** Mostafa Shalaby[1], Marco Peccianti[2], Yavuz Ozturk[3], Roberto Morandotti[1]; [1]*INRS-Energie Mat & Tele Site Varennes, Canada;* [2]*Institute for Complex Systems-CNR, Italy;* [3]*Ege University, Turkey.* We experimentally demonstrate an isolator based on a magnetic non-reciprocal retarder operating with broadband terahertz pulses. Our device depends on permanently magnetized Strontium Iron Oxide, where Faraday rotations up to (194o/T) were obtained.

**CW1K.8 • 12:15**
**Ultrafast, All-Terahertz Plasmonic Modulation in Metals,** Abdulhakem Y. Elezzabi[1], Shawn Greig[1], Pouya Maraghechi[1]; [1]*University of Alberta, Canada.* We report on the effect of induced surface charges on the propagation of the terahertz (THz) radiation via particle plasmons. The phenomenon is attributed to a change of the surface conductivity of the metallic particles.

### CW1L • Quantum Cascade Lasers—Continued

**CW1L.3 • 11:45**
**A Rotational Sample/Reference Cell for High-accuracy Real-time Spectroscopic Trace-gas Sensing,** Clinton J. Smith[1], Wen Wang[1], Gerard Wysocki[1]; [1]*Electrical Engineering, Princeton University, USA.* We demonstrate real-time drift correction of a quantum cascade laser based direct absorption trace-gas sensor using a rotating in-line reference cell. High accuracy and performance sufficient for long-term environmental monitoring has been demonstrated.

**CW1L.4 • 12:00**
**Intracavity Sensing via Compliance Voltage Measurement in an External Cavity Quantum Cascade Laser,** Mark C. Phillips[1], Matthew S. Taubman[1]; [1]*Pacific Northwest National Laboratory, USA.* We present experimental demonstration of a new technique for trace gas sensing by measuring changes in the compliance voltage spectrum of an external cavity quantum cascade laser due to intracavity absorbing species.

**CW1L.5 • 12:15**
**Chirped Laser Dispersion Spectroscopy with Directly Modulated Quantum Cascade Laser,** Andreas Hangauer[1], Georg Spinner[1,2], Michal Nikodem[1,3], Gerard Wysocki[1]; [1]*Princeton University, USA;* [2]*ETH Zuerich, Switzerland;* [3]*Laser Spectroscopy Group, Wroclaw Research Centre EIT+, Poland.* A feasibility study of chirped laser dispersion spectroscopy (CLaDS) with utilizing direct modulation of a quantum cascade laser instead of external modulators is presented. Optimization of laser parameters enables nearly single- and dual-sideband CLaDS operation.

Wednesday, 12 June

**10:45–15:45 NIF Tour** *(Pre-Registered attendees only)*

**12:30–13:30 Lunch and Unopposed Exhibit Only Time,** *Exhibit Halls 1 and 2 (concessions available)*

**13:30–15:00 JW2A • POSTER SESSION II: Energy, Sensing, and Nonlinear Optics,** *Exhibit Hall 3*

**14:00–16:00 Market Focus Session IV: Optics & Innovation for Energy & the Environment,** *Exhibit Hall 2*

**15:00–16:30 Coffee Break (15:00-15:30) and Unopposed Exhibit Only Time,** *Exhibit Halls 1 and 2*

## Marriott San Jose Salon III

### CLEO: Science & Innovations

**CW1M • Infrared Fiber Lasers—Continued**

**CW1M.5 • 11:45**
**2 to 3 μm Raman-soliton continuum enabled by a nanotube mode-locked Tm-doped MOPFA,** MENG ZHANG[1], Edmund J R. Kelleher[1], Timothy H. Runcorn[1], V. M. Mashinsky[2], Oleg I. Medvedkov[2], E. M. Dianov[2], Zhipei Sun[3], Daniel Popa[3], T. Hasan[3], A. C. Ferrari[3], Ben H. Chapman[1], Sergei V. Popov[1], James R. Taylor[1]; [1]*Department of Physics, Imperial College London, United Kingdom;* [2]*Fiber Optics Research Center, General Physics Institute, Russian Federation;* [3]*Department of Engineering, University of Cambridge, United Kingdom.* We demonstrate a Raman-soliton continuum extending from 2 to 3 μm, in a highly germanium-doped silica-clad fiber, pumped by a nanotube mode-locked thulium-doped fiber system delivering 12 kW sub-picosecond pulses at 1.95 μm.

**CW1M.6 • 12:00**
**Highly Stable PM Raman Fiber Laser at 1680 nm,** Ask S. Svane[1], Xiaomin Liu[1], Karsten Rottwitt[1]; [1]*Department of Photonics Engineering, DTU Fotonik, Denmark.* We demonstrate thermal stabilization of a Raman fiber laser. At 1680 nm the laser emission exceeds 500 mW with a power variation below 0.5 %, both linewidth and wavelength variations are under 1 pm.

**CW1M.7 • 12:15**
**High-Pulse-Energy All-Normal, All-Fiber Passively Mode-Locked Laser at 1.06μm,** Yu Wang[1], Amos Martinez[1], Shinji Yamashita[1]; [1]*Department of Electronic Engineering, The University of Tokyo, Japan.* We achieved passively mode-locked all-fiber lasing at the wavelength of 1.06μm with pulse energy over 20nJ using an all-normal cavity configuration. Simulation result showed that WDM had primary filtering effect in the experiment.

## Marriott San Jose Salon IV

### CLEO: QELS-Fundamental Science

**QW1N • Novel Nanooptical & Plasmonic Fabrication—Continued**

**QW1N.3 • 12:00**
**Patterning Plasmonic Nanostructures through Resistless Nanoimprinting in Metal,** Li Fan[1], Leo T. Varghese[1], Yi Xuan[1], Minghao Qi[1]; [1]*School of Electrical and Computer Engineering and Birck Nanotechnology Center, Purdue University, USA.* We report a low-cost method that allows silicon molds to directly imprint metals and achieve high-fidelity pattern transfer with vertical sidewalls and ultra-high resolution. Large-scale extraordinary light transmission through silver apertures is demonstrated.

**QW1N.4 • 12:15**
**Nanolithography based on Two-Surface-Plasmon-Polariton-Absorption,** yunxiang Li[1], Fang Liu[1], Long Xiao[1], Yidong Huang[1]; [1]*Electronic Engineering, Tsinghua University, China.* Nanolithography utilizing the nonlinear absorption of two surface plasmon polaritons in resists has been demonstrated. The linewidth of ~λ0/11 are achieved by illuminating the plasmonic mask with the femtosecond laser, which is potential for future nanofabrication.

## Marriott San Jose Salon V & VI

### CLEO: Science & Innovations

**CW1O • Optical Materials and Devices I—Continued**

**CW1O.3 • 11:45**
**Cryogenic photonic module based on silicon photonic wire waveguides,** Tatsurou Hiraki[1,2], Tai Tsuchizawa[1,2], Hiroyuki Shibata[1,3], Hidetaka Nishi[1,2], Hiroshi Fukuda[1,2], Rai Kou[1,2], Kotaro Takeda[2], Koji Yamada[1,2]; [1]*NTT Nano Photonics Center, Japan;* [2]*NTT Microsystem Integration Laboratories, Japan;* [3]*NTT Basic Research Laboratories, Japan.* We report a low-loss silicon photonic waveguide module for cryogenic applications. The fiber-to-waveguide coupling loss is 1.9 dB/facet at 4K. As a feasibility demonstration, carrier lifetime in a Si waveguide at 4K is successfully measured.

**CW1O.4 • 12:00**
**Silicon-platformed nonlinear waveguide in lithium niobate membrane,** Takuya Utsugida[1,2], Sunao Kurimura[1,2], Yusuke Muranaka[1,2], Eiki Mochizuki[1,2], Hirochika Nakajima[2]; [1]*National Institute for Materials Science, Japan;* [2]*Waseda University, Japan.* A novel waveguide structure in Mg:LN membrane was developed on Si platform by wet and dry etching processes. Periodically poled structure in the membrane achieved QPM SHG at telecommunication band.

**CW1O.5 • 12:15**
**Strain-Engineered SiGe Quantum-Well Nanomembranes for Far-Infrared Intersubband Device Applications,** Faisal Sudradjat[1], Pornsatit Sookchoo[2], Habibe Durmaz[1], Arnold M. Kiefer[2], Max G. Lagally[2], Roberto Paiella[1]; [1]*Boston University, USA;* [2]*University of Wisconsin - Madison, USA.* SiGe/Si quantum-well nanomembranes, where stress due to lattice mismatch is relaxed via elastic strain sharing rather than defect formation, are developed and their potential for far-infrared intersubband device applications is demonstrated.

## Marriott Willow Glen I-III

### CLEO: QELS-Fundamental Science

**QW1P • Symposium on Nanophotonics at the DOE/SC Nanoscale Science Research Centers: Active and Passive Optical Metamaterials—Continued**

**QW1P.4 • 12:00** Invited
**Realization of All-dielectric Optical Metamaterials,** Yuanmu Yang[1], Parikshit Moitra[1], Zachary Anderson[1], Jason G. Valentine[1]; [1]*Vanderbilt University, USA.* We present experimental realization of zero-index all-dielectric optical metamaterials. The metamaterials exhibit a nearly isotropic response, leading to angular selectivity of transmission and enhanced directive emission from quantum dots placed within the metamaterial.

**10:45–15:45 NIF Tour** *(Pre-Registered attendees only)*

**12:30–13:30 Lunch and Unopposed Exhibit Only Time,** *Exhibit Halls 1 and 2 (concessions available)*

**13:30–15:00 JW2A • POSTER SESSION II: Energy, Sensing, and Nonlinear Optics,** *Exhibit Hall 3*

**14:00–16:00 Market Focus Session IV: Optics & Innovation for Energy & the Environment,** *Exhibit Hall 2*

**15:00–16:30 Coffee Break (15:00-15:30) and Unopposed Exhibit Only Time,** *Exhibit Halls 1 and 2*

## JOINT

### 13:30–15:00
### JW2A • POSTER SESSION II: Energy, Sensing, and Nonlinear Optics

**JW2A.01**
**Direct Measurement of Third-Order Nonlinearity of Green Fluorescent Protein,** Abu Thomas[1]; [1]*Northwestern, USA.* We present the measurement of χ(3) nonlinearity of Green Fluorescent Protein. The nonlinear index is n2 = 10 19m2=W, opening the possibility of using genetically engineerable and naturally occuring proteins in cells as a source of four wave mixing experiments.

**JW2A.02**
**Weak-value Amplification of Low-light-level Cross Phase Modulation,** Amir Feizpour[1], Greg Dmochowski[1], Matin Hallaji[1], Chao Zhuang[1], Alex Hayat[1], Aephraim Steinberg[1]; [1]*Physics, University of Toronto, Canada.* We report on our experimental progress towards observing weak-value amplification of low-light-level cross-phase modulation which will be the first observation of a weak measurement relying on true entanglement between distinct systems.

**JW2A.03**
**Electron Density Measurements of Plasma Columns for N2 Atmospheric Lasing,** Jennifer Elle[1], Sina Anaraki[1], Joe Penano[2], Daniel F. Gordon[2], Tony Ting[2], Phillip Spangle[1,2], Howard Milchberg[1]; [1]*IREAP, University of Maryland, USA;* [2]*NRL, USA.* Emission of N2 and time-resolved electron density are measured in a several centimeter long plasma column. Peak density is 6*1015 cm^-3 and emission from the second positive system of N2 is observed.

**JW2A.04**
**Amplification of ultrashort optical-vortex pulses with programmable topological-charge control,** Keisaku Yamane[1,2], Yasunori Toda[1,2], Ryuji Morita[1,2]; [1]*Hokkaido University, Japan;* [2]*JST, CREST, Japan.* We demonstrate the amplification of ultrashort optical-vortex pulses through the optical parametric process, where optical-vortex seed pulses with computer-controlled topological charges are employed. In this scheme, the low-throughput drawback of the vortex converter is overcome.

**JW2A.05**
**Imaging the crystal structure of few-layer two-dimensional crystals by optical nonlinearity,** Leandro M. Malard[1], Thonimar V. Alencar[1], Ana Paula M. Barbosa[1], Kin Fai Mak[2], Ana Maria de Paula[1]; [1]*Physics, Universidade Federal de Minas Gerais, Brazil;* [2]*Physics, Columbia University, USA.* We observed strong second harmonic generation (SHG) from odd-layer MoS2 atomic crystal, while no SHG is present for the even layer numbers regions. The SHG intensity measurements provides an optical tool for imaging the crystal structure..

**JW2A.06**
**Enhancement of Au Nanoparticle Formation by Shaping fs-pulses,** Paulo H. Ferreira[1], Jonathas P. Siqueira[1], Daniel Silva[2], Lino Misoguti[1], Cleber Mendonca[1]; [1]*São Carlos Institute of Physics, University of São Paulo, Brazil;* [2]*Physics Institute, University of São Paulo, Brazil.* The influence of fs-pulse train period on the Au nanoparticles production was studied. Using a pulse shaping technique, the period was tunned in order to match Raman resonances that enhance the Au nanoparticle formation process.

**JW2A.07**
**Frequency-time identical and reversal in ultrafast optical parametric processes,** Chenji Gu[1]; [1]*University of California Merced, USA.* We demonstrate identical and reversal relations between temporal pulse shapes and their spectrum envelopes through ultrashort optical parametric processes in the picosecond and femtosecond regimes.

**JW2A.08**
**Can low power laser induce dimple on air-water interface?,** GOPAL VERMA[1], Abhishek Gaurav[1], James Nair[1], Kamal Singh[1]; [1]*Department of Physical Science, IISER Mohali, India.* We investigate deformations of various fluid interfaces by a low power laser beam under total-internal-reflection. While air-water interface deformations are undetectable, unlike claimed recently [3], soft interface produces large bump-type fluid-lens and not a dimple.

**JW2A.09**
**Withdrawn**

**JW2A.10**
**Plasma column from laser filamentation in air as a virtual radio-frequency antenna,** Guillaume Point[1], Aurelien Houard[1], Yohann Brelet[1], Jérôme Carbonnel[1], Leonid Arantchouk[2], Bernard Prade[1], Yves-Bernard André[1], Andre Mysyrowicz[1]; [1]*Laboratoire d'Optique Appliquée, France;* [2]*Laboratoire de Physique des Plasmas, France.* We demonstrate the use of a plasma column created by femtosecond filamentation and heated by a high-voltage discharge from a Tesla coil as an effective radio-frequency emitting antenna.

**JW2A.11**
**Photo-induced enhancement of ferroelectricity in Ba0.1Sr0.9TiO3/La0.7Sr0.3MnO3 heterostructures,** Yu-Miin Sheu[1], Stuart A. Trugman[1], Li Yan[1], Chih-Piao Chuu[2], Zhenxing Bi[1], Quanxi Jia[1], Antoinette Taylor[1], Rohit P. Prasankumar[1]; [1]*Los Alamos National Lab, USA;* [2]*Institute of Atomic and Molecular Sciences, Academia Sinica, Taiwan.* We optically create an enhanced ferroelectric polarization in ferroelectric/ferromagnet heterostructures that remains stable for over one day, as detected using second harmonic generation. This opens up the possibility of non-contact optically-controlled data storage.

**JW2A.12**
**Dark blue Cerenkov second harmonic generation in the octagonal quasi periodically poled $MgO:LiNbO_3$,** Xuedong Fan[1], Chuanlong Ma[1], Wan-hua Zheng[1]; [1]*Chinese Acad Sci Inst of Semiconductor, China.* We report the first observation of the dark blue nonlinear Cerenkov radiation by SHG in an octagonal QPPLN. Experimentally, diffraction patterns are observed, and the measured diffraction angles agree well with the theoretical results.

**JW2A.13**
**Ultraviolet-shift supercontinuum generation by cross-phase modulation in photonic crystal fiber,** Lei Zhang[1], Sigang Yang[1], Hongwei Chen[1], Minghua Chen[1], Shizhong Xie[1]; [1]*Department of Electronic Engineering, Tsinghua University, China.* We report the experimental demonstration of the supercontinuum extended to ultraviolet region of 200-400 nm by the effect of cross phase modulation between the anti-Stokes signal at 400-550 nm and pump soliton.

**JW2A.14**
**Self-similar parabolic scaling beams in free space,** Nan Gao[1], Changqing Xie[1]; [1]*Key Laboratory of Nano-Fabrication and Novel Devices Integrated Technology, Institute of Microelectronics, China.* We generalize the concept of diffraction free beams to self-similar scaling solutions, whose beam width scale parabolically during propagation. Utilizing the linearity of free space, these beams are easily realized using binary diffractive optics.

**JW2A.15**
**Mid-wave IR Oscillation Enhanced Optical Amplification in Thin Fe-doped Lithium Niobate Slabs,** Jingwen Zhang[1], Hao Wang[1], Xiudong Sun[1], Hua Zhao[1]; [1]*Physics, Harbin Institute of Technology, China.* Anomalous gain enhancement was observed in thin indium tin oxide-, zinc selenide-coated, and uncoated Fe-doped lithium niobate (Fe:LN) slabs. Coating dependent strong scattering near the surface normal was also observed and investigated in these slabs.

**JW2A.16**
**Wave Instabilities in Nonlinear Schroedinger Systems with nonvanishing background,** Klemens Katterbauer[1], Stefano Trillo[2], Andrea Fratalocchi[1]; [1]*Primalight (www.primalight.org), Department of Electrical Engineering, King Abdullah Univ of Sci & Technology, Saudi Arabia;* [2]*Department of Engineering, Universita d Ferrara, Italy.* Wave instabilities in NLS systems for non-vanishing background were investigated and an effective mechanism for the trapping and localization of energy in small spatial scales was demonstrated.

**JW2A.17**
**Supercontinuum generation by noise-like pump pulses in normally dispersive single-mode fibers,** Alexey Zaytsev[1], Chih-Hsuan Lin[2], Yi-Jing You[2], Chia-Chun Chung[1], Chi-Luen Wang[3], Ci-Ling Pan[1,2]; [1]*Department of Physics, National Tsing Hua Univerity, Taiwan;* [2]*Institute of Photonics Technologies, National Tsing Hua Univerity, Taiwan;* [3]*Cleverwave Technology Inc, Taiwan.* Low energy threshold (32 nJ) and flat supercontinuum spectrum in 1040-1240 nm wavelength are demonstrated by noise-like pump pulses in normally dispersive single mode fibers.

**JW2A.18**
**A Hollow Beam Supercontinuum Generation in A GeO2 Doped Triangular-core Photonic Crystal Fiber,** Ben X. Zhang[1,2], Huifeng Wei[2,1], Xian Zhu[1], Weijun Tong[2], Nengli Dai[1], Jinyan Li[1]; [1]*Wuhan National Laboratory of Optoelectronics, Huazhong Univ of Science and Technology, China;* [2]*State Key Laboratory of Optical Fiber and Cable Manufacture Technology, Yangtze Optical Fiber and Cable Company Ltd, China.* We report a GeO2 doped triangular-core photonic crystal fiber which is allow the generation of a hollow beam supercontinuum ranging from 540 to 1540 nm through a nonlinear-optical transformation by femtosecond pulses at 1038 nm.

**JW2A.19**
**Dispersion of Nonlinearity and Modulation Instability in Subwavelength Semiconductor Waveguides,** Andrey V. Gorbach[1], Xuesong Zhao[1], Dmitry Skryabin[1]; [1]*University of Bath, United Kingdom.* We demonstrate that strong dispersion of nonlinearity in subwavelength waveguides can lead to the modulational instability in the regime of normal group velocity dispersion through the mechanism independent from higher order dispersions of linear waves.

**JW2A.20**
**Enhancing optical nonlinearity through engineered exciton coupling in organic-inorganic nanocomposites,** Xiaoze Liu[1,2], Yifan Zhang[3], Michael Slootsky[3], Stephen R. Forrest[3,4], Vinod M. Menon[1,2]; [1]*Dept. of Physics, Graduate School and University Center of the City University of New York (CUNY), USA;* [2]*Dept. of Physics, Queens College of the City University of New York (CUNY), USA;* [3]*Dept. of Physics, University of Michigan, USA;* [4]*Dept. of Electrical Engineering and Computer Science and Dept. of Materials Science and Engineering, University of Michigan, USA.* We show enhancement in optical nonlinear absorption by engineering the coupling between excitons of 3,4,7,8-naphthalenetetracarboxylic dianhydride (NTCDA) and ZnO nanowires. Energy transfer between the excitonic systems and exciton scattering are found to be competing processes.

**JW2A.21**
**High order optical harmonic generation in ionization-free regime: origin of the process,** Anatoli V. Andreev[1], Sergey Y. Stremoukhov[1]; [1]*M. V. Lomonosov Moscow State University, Russian Federation.* New interpretation of the high order harmonic generation in atomic gases interacting with laser fields is presented. The mechanism is in the temporal evolution of atomic electron density spatial distribution in the external laser field.

**JW2A.22**
**Nonlinear Graphene Plasmons in Planar Geometries,** Andrey V. Gorbach[1]; [1]*University of Bath, United Kingdom.* Using perturbation expansion of Maxwell equations with nonlinear boundary conditions, an amplitude equation is derived and analysis is performed of nonlinear TM and TE surface plasmons in planar dielectric-graphene-dielectric geometries.

**JW2A.23**
**Phase-Sensitive Amplification in Fiber-Loop for QPSK Signal Regeneration,** Kyo Inoue[1], Shouma Okazaki[1]; *[1]Osaka University, Japan.* Phase-sensitive amplification in a loop configuration with two pump lights is described. Its output phase has a stepwise transfer function with a step difference of π/2, which can be used for regenerating QPSK signals.

**JW2A.24**
**Supercontinuum Generation in Femtosecond Noncollinear Bi-filamentation,** Inhyuk Nam[1,2], Yongsing You[1], Taek Il Oh[1], Hyyong Suk[2], Ki-Yong Kim[1]; *[1]University of Maryland at College Park, USA; [2]Gwangju Institute of Science and Technology, Republic of Korea.* We observe enhanced supercontinuum (SC) radiation emitted from noncollinear bi-filaments produced by two crossed femtosecond laser pulses in air. The spectrum is much broader than single-filament-produced SC under the same net input energy.

**JW2A.25**
**Effect of a Tightly Focused Gaussian Beam on the Broadband SHG Response of Chirped Poled Lithium Niobate,** Ameneh Bostani[1], Meenu Ahlawat[1], Amirhossein Tehranchi[2,3], Roberto Morandotti[3], Raman Kashyap[1,2]; *[1]Engineering Physics, Ecole Polytechnique de Montreal, Canada; [2]Electrical Engineering, Ecole Polytechnique de Montreal, Canada; [3]INRS-EMT, Canada.* It is demonstrated, both theoretically and experimentally, that employing tightly focused Gaussian beam is possible to engineer the efficiency profiles and suppresses ripples in the second-harmonic response of a 30-nm-bandwidth chirped aperiodically poled lithium niobate.

**JW2A.26**
**High Repetition Rate MW Peak Power at 532 nm Using Microchip Laser,** Rakesh Bhandari[1], Takunori Taira[1]; *[1]Institute for Molecular Science, Japan.* Efficient second harmonic conversion of a passively Q-switched microchip laser, obtaining 1.9 MW peak power, 740μJ, 400 ps pulses at 500 Hz, with > 60% SHG conversion efficiency, without using focusing optics, is reported.

**JW2A.27**
**Stability Analysis of an Intracavity Pumped OPO,** Xuan Luo[1], Ladan Arissian[1], Jean-Claude M. Diels[1]; *[1]Center for High Technology Materials, University of New Mexico, USA.* Simulation of quasi-phase-matching processes for ultrafast pulses in an intracavity pumped OPO is presented. Results reveal an effective cross phase modulation which introduces the coupling between OPO and pump cavities.

**JW2A.28**
**Complete Pump Depletion by Autoresonant Wave Mixing in Nonuniform Second Order Media,** Oded Yaakobi[1], Lucia Caspani[1], Matteo Clerici[1,2], Francois Vidal[1], Roberto Morandotti[1]; *[1]Institut National de la Recherche Scientifique - Centre Énergie Matériaux et Télécommunications (INRS-EMT), University of Québec, Canada; [2]School of Engineering and Physical Sciences, Heriot-Watt University, United Kingdom.* We propose an analytical theory for the autoresonant phase matching of parametric processes in generic non-uniform $\chi^{(2)}$ media. We determine the necessary criteria for achieving complete pump depletion in terms of the physical experimental parameters.

**JW2A.29**
**A High Peak Power, Nanosecond Tm:fiber MOPA System for Mid-IR OPO Pumping,** Pankaj Kadwani[1], Martin Gebhardt[1,2], Christian Gaida[1,2], Lawrence Shah[1], Martin Richardson[1]; *[1]University of Central Florida, CREOL, USA; [2]Friedrich-Schiller University Jena, Institute of Applied Physics, Germany.* We report on a thulium fiber MOPA system utilizing a photonic crystal fiber (PCF) based power amplifier generating >40 kW, ~6.5 ns pulses as a tunable, narrow linewidth source for mid-IR OPO pumping.

**JW2A.30**
**Thermal effects in SHG with Focused Gaussian Beams,** HWANHONG LIM[1], Sunao Kurimura[1], Keisuke Noguchi[1,2], Wataru Nagashima[1,2], Ichiro Shoji[2]; *[1]National Institute for Materials Science, Japan; [2]Chuo University, Japan.* We present thermal effects in single pass CW SHG with focused Gaussian beams. Thermal dephasing and lensing effects depending on the SH power are demonstrated with the calculated temperature change in PPMgSLT crystals.

**JW2A.31**
**Spectral and Temporal Effects in a Picosecond Optical Parametric Oscillator Based on an Aperiodically Poled Nonlinear Crystal,** 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, CNRS-Université Paris Sud 11, France.* We investigate cavity length detuning in a picosecond synchronously pumped optical parametric oscillator based on an aperiodically poled nonlinear crystal. A strong dependence on the sign of the quasi-phase matching period chirp is observed.

**JW2A.32**
**Overcoming Intra-Cavity Nonlinear Phase Limitations in Cavity-Enhanced Optical Parametric Chirped Pulse Amplification through Cavity-Locking,** Aleem M. Siddiqui[1], Jeffrey Moses[1], Kyung-Han Hong[1], Franz X. Kärtner[1,2]; *[1]Massachusetts Institute of Technology, USA; [2]Center for Free-Electron Laser Science, DESY and Dept. of Physics, University of Hamburg, Germany.* In cavity-enhanced OPCPA, nonlinear phase shifts imparted on the intracavity pump pulse limit pump power loading and degrade system performance. We show that cavity-locking offsets these effects, maintaining dramatic bandwidth extension and high conversion efficiency.

**JW2A.33**
**Evolution of ellipticity of ultrashort infrared pulses propagating in air,** Shermineh Rostami[1], Ladan Arissian[1], Jean-Claude M. Diels[1]; *[1]Center for High Technology Materials, University of New Mexico, USA.* We measure the polarization evolution of ultrashort pulses (filaments) propagating in air for various pulse widths and energies. We observe the change of light ellipticity close to circular polarization.

**JW2A.34**
**Improvement in resolution using four-wave mixing in nonlinear confocal microscopy,** Yongzhang Leng[1,2], Dong Hun Park[1,2], Victor Yun[1,2], Pak Cho[1,2], Warren N. Herman[2], Julius Goldhar[1,2]; *[1]University of Maryland at College Park, USA; [2]Laboratory for Physical Sciences, USA.* Improvement of resolution beyond the Rayleigh limit is obtained by monitoring non-resonant four wave mixing generated by the target in a confocal scanning microscope configuration.

**JW2A.35**
**Reduced propagation losses in quasi-phase-matched GaAs/AlGaAs waveguides,** Shigeki Yoshida[1], Kaori Hanashima[1], Ikuma Ohta[1], Tomonori Matsushita[1], Takashi Kondo[1]; *[1]materials engineering, University of Tokyo, Japan.* We have achieved the lowest propagation loss of 1.3 dB/cm in a quasi-phase-matched GaAs/AlGaAs waveguide by optimizing MBE growth temperature. An expected normalized conversion efficiency of the waveguide will exceed that of a PPLN waveguide.

**JW2A.36**
**Hybrid As2S3:Er-TeO2 Loss Compensated Nonlinear Waveguides,** Steve Madden[1], Khu T. Vu[1], Zhe Jin[1], Kunlun Yan[1], Duk-Yong Choi[1], Xin Gai[1], Barry Luther-Davies[1]; *[1]Laser Physics Centre, Australian National University, Australia.* Single mode anomalous dispersion As2S3 on Er doped TeO2 waveguides with near zero propagation loss under 1475nm pumping are demonstrated. Fully lossless waveguides with high nonlinear coefficient can be achieved with higher 1480nm pump power.

**JW2A.37**
**Triple-wavelength Nd-laser system by cascaded electro-optic periodically poled lithium niobate Bragg modulator,** Shoutai Lin[1]; *[1]Feng Chia University, Taiwan.* A cw triple-wavelength selectable Nd:GdVO4 laser was demonstrated. When switching the dc voltages and applying 25 W pump power, the output wavelength can be selected among 912, 1063, and 1342 nm with watt-level output power.

**JW2A.38**
**Evanescent-Coupling-Assisted Four-Wave Mixing in a Silicon Directional Coupler,** Wei Ding[1], Owain Staines[1], Gareth Hobbs[1], Andrey V. Gorbach[1], Charles de Nobriga[1], William Wadsworth[1], Jonathan C. Knight[1], Dmitry Skryabin[1], Michael John Strain[2], Marc Sorel[2], Richard De La Rue[2]; *[1]Department of Physics, University of Bath, United Kingdom; [2]Department of Electronics and Electrical Engineering, University of Glasgow, United Kingdom.* Evanescent-coupling-induced group velocity dispersion (GVD) in a subwavelength silicon directional coupler is observed to significantly modify four-wave-mixing (FWM) spectra. As the separation between two silicon wires decreases, the increasing dispersion gradually suppresses the FWM gain.

**JW2A.39**
**Raman laser from an on chip, high Q polymer microcavity,** Beibei Li[1], Xue-Feng Jiang[1], Qihuang Gong[1], Yun-Feng Xiao[1]; *[1]Peking University, China.* We observe the polydimethylsiloxane (PDMS) Raman laser from a PDMS coated microcavity, which is to our knowledge the first demonstration of polymer microcavity Raman laser.

**JW2A.40**
**Third-Order Nonlinearities of Ge28Sb12Se60 for Waveguide Devices,** Molly R. Krogstad[1], Elisabeth Rengnath[1], Wounjhang Park[1], Juliet Gopinath[1]; *[1]University of Colorado, USA.* The optical nonlinearities of the chalcogenide Ge28Sb12Se60 are studied using the z-scan technique with femtosecond and picosecond laser pulses at 1.0 μm. Results indicate this glass shows promise for nonlinear optical waveguide devices.

**JW2A.41**
**Oxidation of Ag Nanowires Studied by Terahertz Spectroscopy,** Yao-Jun Tsai[1], Chi-Ying Chang[1], Pei-Chen Yu[1], Hyeyoung Ahn[1]; *[1]National Chiao Tung University, Taiwan.* The electrical conductivity of silver nanowire assembly is measured by using terahertz spectroscopy. Growth of the surface-oxidized layer on silver nanowires hinders electron transportation through the nanowire-to-nanowire junction and reduces the conductivity of nanowire network.

**JW2A.42**
**Asymmetric Backscattering of Ultraviolet Light by Low-Refractive Index Thin Film of Tilted Alumina Nanorods,** Xing Yan[1], Kamaraju Natarajan[2], Tanuj Saxena[2], Michael Shur[1,2]; *[1]Physics, Applied Physics, and Astronomy, Rensselaer Polytechnic Institute, USA; [2]Department of Electrical, Computer, and System Engineering, Rensselaer Polytechnic Institute, USA.* Asymmetric backscattering was observed at 266 nm for tilted alumina nanorods array. Novel approach for modeling of light scattering by nanoporous films was proposed and was shown to be in good agreement with measured data.

**JW2A.43**
**Optimized Yttrium Iron Garnet Growth On Silicon For Films With High Faraday Rotation,** Andrew Block[1]; *[1]Electrical Engineering, University of Minnesota, USA.* Abstract Bismuth and cerium YIG films with Faraday rotations of 4000°/cm and 10000°/cm were obtained on Si, and a complete model for the growth and crystallization required to obtain such films is presented.

**JW2A.44**
**Analysis of Time-Dependent Electron Distribution in KTa1-xNbxO3 Crystals for High-Speed Beam Deflector,** Jun Miyazu[1], Tadayuki Imai[1], Junya Kobayashi[1]; *[1]NTT Photonics Laboratories, NTT Corporation, Japan.* The time-dependent electron distribution generated by applying a voltage is analyzed in KTa1-xNbxO3 crystals. The optimum voltage and its application time for using the crystals as a beam deflector is derived with this analysis.

## JW2A • POSTER SESSION II: Energy, Sensing, and Nonlinear Optics—Continued

**JW2A.45**
**80-MHz difference-frequency generation of femtosecond pulses in the mid-IR using GaS0.4Se0.6,** Marcus Beutler[1], Ingo Rimke[1], Edlef Büttner[1], Vladimir Panyutin[2], Valentin Petrov[2]; *[1]APE, Germany; [2]Max Born Institute, Germany.* We employ GaS0.4Se0.6 nonlinear crystal for difference-frequency generation between signal and idler of a synchronously pumped femtosecond OPO at 80 MHz achieving continuous tuning from 4 μm (>11 mW) to 12 μm (>0.5 mW).

**JW2A.46**
**Few-Mode Cr-Doped Crystalline Core Fiber Cladded by High-Index Glass,** Wei-Lun Wang[1], Yi-Chung Huang[1], Jau-Sheng Wang[1], Sheng-Lung Huang[2], Wood-Hi Cheng[1]; *[1]Department of Photonics, National Sun Yat-Sen University, Taiwan; [2]Graduate Institute of Photonics and Optoelectronics, National Taiwan University, Taiwan.* A few-mode Cr-doped crystalline core fiber (FMCDCCF) cladded by high-index glass is demonstrated. The FMCDCCF exhibited a V-value below four at 1400nm to provide five few-mode characteristics for possibility use in broadband fiber amplifiers.

**JW2A.47**
**Nonlinear Spectra/Dispersion of Quinolinium Dyes Using Dual-Arm Z-scan,** Trenton R. Ensley[1], Honghua Hu[1], Zhong'an Li[3], Sei-Hum Jang[3], Alex K-Y. Jen[3], David J. Hagan[1,2], Eric W. Van Stryland[1,2]; *[1]CREOL, The College of Optics & Photonics, University of Central Florida, USA; [2]Department of Physics, University of Central Florida, USA; [3]Department of Materials Science & Engineering, University of Washington, USA.* We report two-photon absorption spectra and nonlinear refraction dispersion of a new series of quinolinium heptamethine cyanine dyes measured using our dual-arm Z-scan and fit of spectra and dispersion with an essential-state model.

**JW2A.48**
**Observation of Strong Tunable Self-defocusing Nonlinearity in M-cresol/Nylon Thermal Solutions,** Valton Smith[1], Brian Y. Leung[1], Zhigang Chen[1], Weining Man[1]; *[1]San Francisco State University, USA.* We report a new type of Kerr-like nonlinear media (m-cresol/nylon solutions) exhibiting a giant tunable self-defocusing nonlinearity. Their nonlinear response can be enhanced dramatically by increasing the nylon concentration and is verified to be isotropic.

**JW2A.49**
**Absorptive Thin Film Characterization with Spectroscopic Full-field Optical Coherence Tomography,** Tuan-Shu Ho[1], Chien-Chung Tsai[1], Kuang-Yu Hsu[1], Sheng-Lung Huang[1,2]; *[1]Graduate Institute of Photonics and Optoelectronics, National Taiwan University, Taiwan; [2]Department of Electrical Engineering, National Taiwan University, Taiwan.* We have developed a spectroscopic full-field optical coherence tomography system, which can provide an ultrahigh isotropic spatial resolution. The complex refractive index and thickness of an embedded absorptive thin film was simultaneously measured.

**JW2A.50**
**Complementing Trends of Photoluminescence and Terahertz Intensities in Staggered InGaN Quantum Wells,** Guan Sun[1], Ruolin Chen[1], Yujie J. Ding[1], Hongping Zhao[1], Guangyu Liu[1], Jing Zhang[1], Nelson Tansu[1]; *[1]Lehigh University, USA.* We demonstrate that photoluminescence and terahertz intensities show complementing trends for staggered InGaN quantum wells (QWs), dictated by separation of electrons and holes.

**JW2A.51**
**Direct Laser Writing of Metallic Nanostructures for Nanophotonics,** Wei-Er Lu[1], Yongliang Zhang[1], Xuan-Ming Duan[1], Zhen-Sheng Zhao[1]; *[1]Technical Institute of Physics and Chemistry, Chinese Academy of Science, China.* We report on controllable fabrication of metallic microstructures by direct laser writing in aqueous solution of metal ion. Various planar nanostructures including metamaterials were demonstrated with subwavelength resolution and high fabrication efficiency.

**JW2A.52**
**Spectroscopic Characterization of Cobalt Doped ZnSe/S Crystals as Saturable Absorbers and Gain Elements for IR Solid-State Lasers,** Jeremy Peppers[1], Yuri Terekhov[1], Vladimir Fedorov[1], Dmitri Martyshkin[1], Sergey B. Mirov[1]; *[1]University of Alabama at Birmingham, USA.* We report on fabrication and spectroscopic characterization of Co:(Fe:):ZnSe/S crystals for saturable absorbers and gain elements for IR solid-state lasers.

**JW2A.53**
**Domain engineered EDIT waveguides on *z*-cut $LiNbO_3$,** Tristan D. Crasto[1], Hendrik Steigerwald[1], Vijay Sivan[1], Andreas Boes[1], Arnan Mitchell[1]; *[1]Royal Melbourne Institute of Technology, Australia.* The fabrication of optical waveguides, using Etching During the Indiffusion of Ti (EDIT) technique, on *z*-cut lithium niobate crystals of different compositions is presented. It's compatibility with electric field domain engineering is also demonstrated.

**JW2A.54**
**Spontaneous and induced optical absorption in ultra-low loss amorphous Ta2O5 and SiO2 dielectric thin films,** Ashot Markosyan[1], Roger Route[1], Martin Fejer[1], Dinesh Patel[2,3], Carmen Menoni[2,3]; *[1]E.L. Ginzton Laboroatory, Stanford University, USA; [2]Department of Electrical and Computer Engineering, Colorado State University, USA; [3]NSF ERC for Extreme Ultraviolet Science and Technology, Colorado State University, USA.* The optical absorption @1064 nm in Ta2O5 and SiO2 thin films is affected with simultaneous illumination ranging from 266 to 780 nm. The effect is attributed to filling of trap states in the forbidden gap.

**JW2A.55**
**Emission from a Dipole-Forbidden Energy State in a GaAs Quantum-Ring Induced by Dressed Photon,** Takashi Yatsui[1], Wataru Nomura[1], Takaaki Mano[2], Hideki T. Miyazaki[2], Kazuaki Sakoda[2], Tadashi Kawazoe[1], Motoichi Ohtsu[1]; *[1]University of Tokyo, Japan; [2]National Institute for Materials Science, Japan.* A significant decrease in the decay time of the emission from a dipole-forbidden state in a GaAs quantum-ring was observed, using the near-field interaction induced by the close proximity of an apertured fiber probe tip.

**JW2A.56**
**Electro-optic Switching of VO2 for Infrared Spatial Light Modulation,** Alain Hache[1], Bassel Abdel Samad[1], Mohamed Chaker[2], Ali Herndaoui[2], Sebastien Vigne[2]; *[1]Universite de Moncton, Canada; [2]LMN/INRS-EMT, Canada.* Optical switching of VO2 thin films with co-planar surface electrodes is demonstrated and characterized for spatial light modulating applications in the Mid-infrared. Switch time, amplitude, voltage, and recovery are reported for different electrode gap sizes.

**JW2A.57**
**Directional fiber-optic level meter based on a micro-air- bubble drifted in a liquid core fiber Fabry-Pérot interferometer,** Cheng-Ling Lee[1], Yang-Chen Zheng[1], Han-Jung Chang[1]; *[1]Electro-Optical Engineering, National United University, Taiwan.* We propose a novel, directional fiber-optic level meter based on a micro-air-bubble drifted in a liquid-core fiber-Fabry-Pérot-interferometer which can detect non-horizontal state of structure/object and also be able to discriminate the inclining to clockwise/counterclockeise directions.

**JW2A.58**
**A high-speed quantum random number generator prototype,** Feihu Xu[1,2], Bing Qi[1,2], He Xu[1], Jiancheng Xuan[1], Xiongfeng Ma[3,2], Hoi-Kwong Lo[1,2], Li Qian[1]; *[1]Electrical & Computer Engineering, University of Toronto, Canada; [2]Physics, University of Toronto, Canada; [3]Institute for Interdisciplinary Information Sciences, Tsinghua University, China.* We present a high-speed real-time quantum random number generator prototype by measuring the quantum phase noise of a laser. The simplicity and robustness of our design suggest that it is readily commercialized for practical applications.

**JW2A.59**
**Fiber-optic DTS Application in Performance Assessment of Pre-drainage Boreholes,** Nima Noraei Danesh[1], Saiied M. Aminossadati[1], Mehmet S. Kizil[1], Eddie Prochon[1]; *[1]School of Mechanical and Mining Engineering, The University of Queensland, Australia.* The performance of pre-drainage boreholes can be assessed by utilization of fiber-optic Distributed Temperature Sensors (DTS). This study investigates interpretation of flow behavior in pre-drainage boreholes by measuring temperatures in a mechanistic simulator.

**JW2A.60**
**Edge Self-Interference of a Laser Beam and Application to Thin Film Metrology,** Alain Hache[1], Phong Anh Do[1], Mohamed Touaibia[1]; *[1]Physics, Universite de Moncton, Canada.* Self-interference of a laser beam reflected off the edge of a thin film is used to measure optical thickness changes. Theory and experiment are presented, and applications include surface temperature measurement and thin film metrology.

**JW2A.61**
**Precise Measurement of High-Speed Vibration Displacement Using Triangle-Wave Phase Modulation,** Yosuke Tanaka[1], Naoyuki Miyata[1], Takashi Kurokawa[1]; *[1]Tokyo Univ of Agriculture and Technology, Japan.* We propose a measurement system for high-speed vibration displacement using an interferometer with triangle-wave phase modulation. Displacement less than ±45 nm by 1-MHz vibration is proved measurable within a standard deviation of 1.5 nm.

**JW2A.62**
**Cladding Mode Recoupling based Displacement Sensor by Concatenating Up Taper and Chirped Fiber Bragg Grating,** Tao Qi[1], Shilin Xiao[1], Jie Shi[1], Zhao Zhou[1], Meihua Bi[1]; *[1]The State Key Laboratory of Advanced Optical Communication Systems and Networks, China.* Displacement sensor based on the cladding modes recoupling by using fiber up taper cascaded with chirped fiber Bragg grating is demonstrated. The reflection power difference reaches 135 μW within displacement change of 3750 μm.

**JW2A.63**
**Development of the External Cavity Quantum Cascade Laser for spectroscopic applications,** Denys Marchenko[1], Julien Mandon[1], Simona M. Cristescu[1], Frans J.M. Harren[1]; *[1]Molecular and Laser Physics, Radboud University, Netherlands.* We describe the development of a widely and continuously tunable, mode-hop-free External Cavity QCL for the detection of medically relevant molecules. Several key issues are implemented to achieve fast detection and high spectral resolution.

**JW2A.64**
**High sensitivity tapered fiber Mach-Zehnder interferometer with optical attractive near-field force for active microsensing,** Nan-Kuang Chen[1,2], Tsung-Hsun Yang[1], Yi-Ning Chen[1,2], Zhao-Ying Chen[1], Shien-Kuei Liaw[3]; *[1]Electro-Optical Engineering, National United University, Taiwan; [2]Optoelectronics Research Center, National United University, Taiwan; [3]Electronic Engineering, National Taiwan University of Science and Technology, Taiwan.* We demonstrate micro tapered fiber Mach-Zehnder-interferometer with one of the abrupt tapers is stretched and thinned to a diameter of 3.64 μm to strongly enhance the optical attractive force for high sensitivity cellular-dimension microsensing.

**JW2A.65**
**Mid-infrared Chemical Sensors On-a-Chip Using Air-clad Pedestal Silicon Waveguides,** Pao T. Lin[1], Vivek Singh[1], Juejun Hu[2], Kathleen Richardson[3], J. David Musgraves[4], Igor Luzinov[4], Joel Hensley[5], Anu Agarwal[1], Lionel Kimerling[1]; *[1]Massachusetts Institute of Technology, USA; [2]University of Delaware,, USA; [3]The College of Optics & Photonics (CREOL), University of Central Florida., USA; [4]Clemson University, USA; [5]Physical Sciences Inc., USA.* Pao Tai Lin*, Vivek Singh, Juejun Hu, Kathleen Richardson, J. David Musgraves, Igor Luzinov, Joel Hensley, Lionel C. Kimerling, and Anu Agarwal

**JW2A.66**
**Low-loss High-speed Speckle Reduction using a Colloidal Dispersion,** Brandon Redding[1], Graham Allen[1], Eric Dufresne[2], Hui Cao[1]; *[1]Applied Physics, Yale University, USA; [2]Mechanical Engineering and Materials Science, Chemical and Environmental Engineering, Yale University, USA.* We present a simple and robust approach to achieve low-loss, high-speed speckle reduction using a colloidal dispersion. This approach is compact, low cost, requires no external power, and is compatible with commercially available lasers.

## JW2A • POSTER SESSION II: Energy, Sensing, and Nonlinear Optics—Continued

**JW2A.67**
**Design, Fabrication, and Testing of a Pd-Based Integrated Optical Hydrogen Sensor,** Nicholas Carriere[1], Farshid Bahrami[1], M.z. Alam[1], Mo Mojahedi[1], J. Stewart Aitchison[1]; *[1]Electrical Engineering, University of Toronto, Canada.* A palladium-based integrated optical hydrogen sensor on a silicon-on-insulator platform was designed, fabricated, and tested. The sensitivity and response time of the sensor was recorded for hydrogen concentrations varying from 0-4%.

**JW2A.68**
**Sensitive Detection of Carbon Monoxide using a Compact High Power CW DFB-QCL based QEPAS Sensor,** Przemyslaw Stefanski[1,2], Rafal Lewicki[1], Jan Tarka[1,2], Yufei Ma[3], Mohammad Jahjah[1], Frank K. Tittel[1]; *[1]Electrical & Computer Engineering, Rice University, USA; [2]Laser & Fiber Electronics Group, Wroclaw University of Technology, Poland; [3]National Key Laboratory of Science and Technology on Tunable Laser, Harbin Institute of Technology, China.* Development of an ultra-sensitive, selective, and compact QEPAS-based CO sensor employing a high power CW DFB-QCL is reported. A minimum detectable concentration of 4ppbv was achieved for CO line (2169.2cm-1) using a 5sec data acquisition time.

**JW2A.69**
**Silicon-on-Insulator spectrometers with integrated GaInAsSb photodiode array for wideband operation from 1500 to 2300 nm,** Eva Ryckeboer[1,2], Alban Gassenq[1,2], Nannicha Hattasan[1,2], Laurent Cerutti[3], Bart Kuyken[1,2], Jean-Baptiste Rodriguez[3], Eric Tournie[3], Roel Baets[1,2], Gunther Roelkens[1,2]; *[1]INTEC, Photonics Research Group, Ghent University - imec, Belgium; [2]center for Nano- and Biophotonics (NB photonics), Ghent University, Belgium; [3]Institut d'Electronique du Sud (IES), Universite Montpellierhotonics (NB photonics), Ghent University, France.* Four echelle-type spectrometers on SOI with integrated GaInAsSb photodiodes for 1500-2300 nm are realized. A maximum channel crosstalk of -10 dB, dark current of -2.5 µA and responsivity of 0.61 A/W at 1530 nm and 0.7 A/W at 2200 nm are obtained.

**JW2A.70**
**Absorption Spectroscopy of CO2 at 4.3 µm Utilizing an Off-Beam QEPAS Spectrophone and an IR-LED,** Stefan Böttger[1], Ulrike Willer[2], Wolfgang Schade[1,2]; *[1]Fraunhofer Heinrich-Hertz-Institute, Germany; [2]Clausthal University of Technology, Energy Research Center of Lower Saxony, Germany.* An IR-LED at 4.3 µm and an off-beam QEPAS spectrophone as optical detector are utilized for absorption spectroscopy. With an absorption path of 5 cm a detection limit of 150 ppm is achieved for carbon dioxide.

**JW2A.71**
**A large area polymer-based substrate with broadband absorption for surface enhanced Raman scattering,** Ming Yang[1], Qiang Wu[1], Jiwei Qi[1], Zhandong Chen[1], Jingjun Xu[1]; *[1]The MOE Key Laboratory of Weak Light Nonlinear Photonics, TEDA Applied Physics School and School of Physics, Nankai University, China.* We fabricate a large area polydimethylsiloxane-based substrate for surface-enhanced Raman scattering by combining femtosecond laser microstructuring and soft lithography techniques. The substrate exhibits broadband absorption in the region of 350-1000 nm and reproducible enhancement factor 10^7.

**JW2A.72**
**Interferometric Fiber Strain Sensor using Fiber Bragg Grating based Optical Ruler,** Shih-Hsiang Hsu[1], Jung-Chen Hsu[1], Shan-Chi Chen[1]; *[1]National Taiwan University of Science and Technology, Taiwan.* An interferogram from a two-staged optical low-coherence Mach-Zehnder interferometer is demonstrated to double the sensitivity improvement for fiber strain sensing using the fiber Bragg grating based optical ruler through its narrow linewidth reflection spectrum.

**JW2A.73**
**Trace Detection of NO2 Using Cavity Ring-Down Spectroscopy and a Diode Laser,** Andreas Karpf[1], Gottipaty N. Rao[1]; *[1]Physics Dept., Adelphi University, USA.* A violet multi-mode diode laser and cavity ring-down spectroscopy were used to detect trace amounts of NO2. The laser excites multiple cavity modes, simplifying the detector alignment and making it less susceptible to vibration.

**JW2A.74**
**Compact On-chip Multiplexed Photonic Gas Sensors,** Zhixuan Xia[1], Ali Asghar Eftekhar[1], David Gottfried[2], Qing Li[1], Ali Adibi[1]; *[1]School of Electrical and Computer Engineering, Georgia Institute of Technology, USA; [2]Institute for Electronics and Nanotechnology, Georgia Institute of Technology, USA.* A compact resonator-based integrated photonic sensor for the detection of multiple gas analytes with high resolution is demonstrated. On-chip references are employed to compensate for environmental effects and laser instabilities to achieve high accuracy.

**JW2A.75**
**Laser Diagnostics as a Tool to Improve Combustion-based Atmospheric SiO2 Layer Deposition,** Alfons Burkert[1], Wolfgang Paa[1], Andreas Neudeck[3], Dirk Müller[1], Andreas Heft[2], Arnd Schimanski[2]; *[1]Microscopy, IPHT Jena, Germany; [2]INNOVENT e.V., Germany; [3]TITV, Germany.* SiO-LIF fields, and temperatures based on OH-LIF and OH* where used to optimize the burner to substrate distance and the thread temperature during SiOx layer deposition on glass and threads in an atmospheric HMDSO/propane/air flame.

**JW2A.76**
**Theory of Phase-Locking of Large Multistable Fiber Amplifier Array Coupled in an External Cavity,** Erik J. Bochove[1], Mohammad R. Zunoubi[1], Christopher J. Corcoran[1]; *[1]Directed Energy Directorate, Air Force Research Laboratory, USA.* The transmission characteristic of a fiber amplifier array is shown to be a multivalued function of pump power, analogous to a passive etalon with Kerr nonlinearity (Felber et al, APL,1976), of which highest gain solutions possess robust phase-locking.

**JW2A.77**
**Intrusion Detection Based on Quantum Interference,** Clifford Bishop[1], Travis S. Humble[1], Ryan S. Bennink[1], Brian P. Williams[1,2]; *[1]Quantum Information Science Group, Oak Ridge National Laboratory, USA; [2]Department of Physics, University of Tennessee, USA.* We present a new method for intrusion detection which is based on the Mach-Zehnder interference effect. This device provides monitored surveillance by continuously measuring the intensity of light collected by a pair of photodetectors.

**JW2A.78**
**Photonic Crystal Chemical Absorption Spectroscopy for Multiplexed Detection of Xylene and TCE in Water,** Wei-Cheng Lai[1], Swapnajit Chakravarty[2], Ray T. Chen[1,2]; *[1]University of Texas at Austin, USA; [2]Omega Optics, USA.* We experimentally demonstrate simultaneous selective detection of xylene and trichloroethylene using photonic crystal waveguide. Sensitivity is improved by slow light effect of PC to 1ppb (v/v) for xylene and 10ppb (v/v) for TCE in water.

**JW2A.79**
**Chirped Laser Dispersion Spectroscopy for Remote Sensing of Methane at 1.65µm - Analysis of System Performance,** Genevieve Plant[1], Michal Nikodem[1], David M. Sonnenfroh[2], Gerard Wysocki[1]; *[1]Electrical Engineering, Princeton University, USA; [2]Physical Sciences Inc., USA.* A chirped laser dispersion spectroscopy system, operating at 1.65µm to target atmospheric methane, is presented. A discussion of the long-term stability, sensitivity, and long open-path integrated measurements is provided.

**JW2A.80**
**Sensitive Detection of CO and N2O using a High Power CW 4.61 µm DFB-QCL Based QEPAS Sensor,** Yufei Ma[1,2], Rafal Lewicki[2], Manijeh Razeghi[3], Xin Yu[1], Frank K. Tittel[2]; *[1]Harbin Institute of Technology, China; [2]Rice University, USA; [3]Northwestern University, USA.* A high power CW DFB-QCL based CO and N2O QEPAS sensor demonstrating the MDL of 1.5 ppbv and 23 ppbv, respectively was developed. Continuous monitoring of atmospheric CO and N2O concentration levels were performed.

**JW2A.81**
**Development of an Open-Path / QCL- Setup for Intra-Pulse Determination of NO and $NO_2$ Emissions,** Christoph Reidl-Leuthner[1], Bernhard Lendl[1]; *[1]Institute of Chemical Technologies and Analytics, Vienna University of Technology, Austria.* Combining 300ns - pulsed quantum cascade lasers with an open-path- setup allows recording micro-spectra (~2$cm^{-1}$) of the resolving narrow absorption bands of gaseous analytes during a single pulse, while minimizing the influence of the environmental matrix.

**JW2A.82**
**Influence of morphology on the plasmonic enhancement effect of Au@TiO2 core-shell nanoparticles in dye-sensitized solar cells,** Lin Fan Cheng[1]; *[1]Chemistry, National Tsing Hua University, Taiwan.* Plasmonic core-shell nanoparticles (PCSNPs) can function as optical nanoantennas and improve the efficiency of dye-sensitized solar cells (DSSCs). We report a new synthesis route for the control of morphology of Au@TiO2 PCSNPs and systematically studied its influence on the enhancement effect.

**JW2A.83**
**Direct electrical contact of slanted ITO film on axial p-n junction silicon nanowire solar cells,** Ya-Ju Lee[1], Yung-Chi Yao[1], Chia-Hao Yang[1]; *[1]National Taiwan Normal University, Taiwan.* A novel scheme of direct electrical contact on vertically aligned silicon nanowire (SiNW) axial p-n junction is demonstrated by means of oblique-angle deposition of slanted indium-tin-oxide (ITO) film for photovoltaic applications.

**JW2A.84**
**Investigation of Nano-Sized Hole/Post Patterned Sapphire Substrates-Induced Strain-Related Quantum-Confined Stark Effect of InGaN-Based Light-Emitting Diodes,** Vincent Su[1], Po-Hsun Chen[1], Ming-Lun Lee[1], Yao-Hong You[1], Cheng-Ju Hsieh[1], Chieh-Hsiung Kuan[1], Yi-Chi Chen[1], Hung-Chou Lin[1], Han-Bo Yang[2], Ray-Ming Lin[2], Quan-Yi Lee[2], Fu-Chuan Chu[2]; *[1]National Taiwan University, Taiwan; [2]Chang Gung University, Taiwan.* This paper demonstrates that the efficiency of InGaN-based light-emitting diodes with nano-post patterned sapphire substrates is superior to that with nano-hole patterned sapphire substrates under the same nano-scale feature owing to reduced quantum-confined stark effect.

**JW2A.85**
**A Lidar based on Optical Sampling by Cavity Tuning,** LIN YANG[1], Jinsong Nie[2], Lingze Duan[1]; *[1]Physics, University of Alabama in Huntsville, USA; [2]State Key Laboratory of Pulsed Power Laser, China.* We report the demonstration of a lidar based on optical sampling by cavity tuning. Target vibration as fast as 50 Hz has been successfully detected at an equivalent free-space distance of over 2 km.

**JW2A.86**
**Observation of Raman Resonance of a Probe in a Rb Cell Added to an Ethane-Rb Laser for Realizing a Superluminal Laser,** Joshua M. Yablon[1], Shih Tseng[1], Zifan Zhou[1], Selim M. Shahriar[1,2]; *[1]EECS, Northwestern University, USA; [2]Physics, Northwestern University, USA.* We report sub-natural linewidth Raman resonance for a probe applied to an auxiliary Rb cell added to an Ethane-Rb laser as a key step towards realizing a superluminal ring laser for ultrasensitive gyroscopy and accelerometry.

**JW2A.87**
**Dynamics of Fourier Domain Mode Locked Lasers,** Svetlana Slepneva[1,2], Ben O'Shaughnessy[1,2], Bryan Kelleher[1,2], Stephen P. Hegarty[2], Andrei G. Vladimirov[1,3], Guillaume Huyet[1,2]; *[1]Centre for Advanced Photonics and Process Analysis, Cork Institute of Technology, Ireland; [2]Tyndall National Institute, Ireland; [3]Weierstrass Institute for Applied Analysis and Stochastics, Germany.* We analyze the dynamics of Fourier Domain Mode Locked lasers and show that the frequency-sweep asymmetry in the output originates from inherent field-matter nonlinearities, resulting in two regions: chaos and mode group stepping.

**JW2A.88**
**Immersion Birefringent Transducer for Angular Displacement Measurement in Heterodyne Interferometer,** Ruey-Ching Twu[1], Ching-Shing Wang[1], Jhao-Sheng Wang[1]; *[1]Electro-Optical Engineering, Southern Taiwan University of Science Technology, Taiwan.* A novel birefringent transducer is proposed for optically measuring angular displacement based on a heterodyne interferometry. As a result, a resolution of 2.85×10-5 deg with a dynamic range of over 5deg has been achieved.

## JOINT

### JW2A • POSTER SESSION II: Energy, Sensing, and Nonlinear Optics—Continued

**JW2A.89**
**Progress of the Beijing regional time and frequency network,** Chao Gao[1,3], Bo Wang[1,2], Xi Zhu[1,3], Jing Miao[1,3], Yu Bai[1,3], Tianchu Li[1,4], Lijun Wang[1,2]; *[1]Joint Institute for Measurement Science, Tsinghua University, China; [2]The state key lab of precision Measurement Technology and Instrument, Department of Precision Instruments, Tsinghua University, China; [3]Department of Physics, Tsinghua University, China; [4]National Institute of Metrology, China.* We report progress of the Beijing regional time and frequency network and a series of innovations used for it, including the fiber based multiple-access RF dissemation system, phase-locked free space RF dissemination system.

**JW2A.90**
**Unified Theory of Oscillator Phase Noise with Application to Optoelectronic Oscillators,** William Loh[1,2], Siva Yegnanarayanan[1], Rajeev J. Ram[2], Paul Juodawlkis[1]; *[1]Massachusetts Inst of Tech Lincoln Lab, USA; [2]Electrical Engineering and Computer Science, Massachusetts Institute of Technology, USA.* We present a general theory of phase noise for white noise perturbation that can be applied to any oscillator. Our theory agrees well with phase-noise measurements of a hybrid optoelectronic oscillator.

**JW2A.91**
**Interwoven frequency comb,** Koji Masuda[1,2], Ladan Arissian[2], Jean-Claude M. Diels[2]; *[1]Department of Physics and Astronomy, University of New Mexico, USA; [2]Center for High Tech Materials, University of New Mexico, USA.* A mode-locked Ti:sapphire laser with intracavity Fabry-Perot produces a frequency comb at 7 GHz including a fine structure at 100 MHz. The complex nature of this interwoven comb is analyzed.

**JW2A.92**
**Performance Enhanced of Silicon Solar Cells Using Spin-On-Film Processes and Indium Nanoparticles Plasmonics,** Wen-Jeng Ho[1], Yi-Yu Lee[1], Jheng-Jie Liu[1], Yuan-Tsz Chen[1], Chi-He Lin[1], Po-Hung Tsai[1]; *[1]National Taipei University of Technology, Taiwan.* We demonstrate the enhanced performances of Si-solar-cells using the spin-on-film device-processes and Indium-nanoparticle plasmonics. The short-circuit-current of the cell with indium-nanoparticles-plasmonics increase by 56.03% (from 3.48 to 5.43 mA) is obtained, compared to the bare-solar-cell.

**JW2A.93**
**Observing the Propagation of Fluorescent Light in Doped Polymer Films,** Po-Rui Chen[1], Jonathon White[1], Rui-Hung Hsu[2], Arnold C. Yang[3]; *[1]Photonics Engineering, Yuan Ze University, Taiwan; [2]Materials Science, Sun Yat-Sen University, Taiwan; [3]Materials Science, Tsing-Hua University, Taiwan.* By making use of spot excitation to generate photoluminescence, and parallel grooves to extract light, light propagation in a polymer film was quantified. Scatterings contribution in limiting the propagation distance was determined by simulation.

**JW2A.94**
**Effect of InGaN/GaN Multiple Quantum Wells with p-n Quantum Barriers on Efficiency Droop in Blue Light-emitting Diodes,** Sheng-Wen Wang[1], Da-Wei Lin[1], Chia-Yu Lee[1], Che-Yu Liu[1], Yu-Pin Lan[1], Hao-chung Kuo[1], Shing-Chung Wang[1]; *[1]National Chiao Tung University, Taiwan.* The QW sandwiched by the sigle-pn-QB had a less electric field than the other QWs .The simulation results demonstrated that by selecting suitable position of p-n QB, the distribution of carriers could be effectively improved.

**JW2A.95**
**The Crystalline and Optical Properties of (11-22) Semipolar GaN and InGaN/GaN MQWs on (1-100) M-Sapphire,** Yun-Jing Li[1], Shih-Pang Chang[2], Kuok Pan Sou[2], Jet-Rung Chang[1], Ruey-Wen Chang[2], Chun-Yen Chang[1], Yuh-Jen Cheng[3]; *[1]Electronics Engineering, National Chiao Tung University, Taiwan; [2]Institute of Electro-Optical Engineering, National Chiao Tung University, Taiwan; [3]Research Center for Applied Sciences, Academia Sinica, Taiwan.* We report the growth temperature effect on the crystalline and optical properties of (11-22) semipolar GaN and InGaN/GaN MQWs. It shows that a lower growth temperature at 1020°C produces better crystalline and optical properties.





**Thank you for attending CLEO: 2013. Look for your post-conference survey via email and let us know your thoughts on the program.**

NOTES

## CLEO: QELS-Fundamental Science

### 16:30–18:30
### QW3A • Optics of Random Media
*Presider: Anatoly Zayats; Univ of London King's College London, United Kingdom*

**QW3A.1 • 16:30** Invited

**Color Production by Isotropic Nanostructures with Short-range Order in Bird Feather Barbs,** Hui Cao[1], Heeso Noh[1], Seng Fatt Liew[1], Vinodkumar Saranathan[1], Richard Prum[1], Jason Forster[1], Eric Dufresne[1], Simon Mochrie[1]; [1]*Yale Univ., USA.* We studied how the short-range-ordered nanostructures in bird feather barbs create angle-invariant colors. By manipulating the interplay between light scattering and absorption, we fabricated biomimetic nanostructures that produce isotropic color.

**QW3A.2 • 17:00**

**Active control of the emission of an optofluidic random laser,** nicolas bachelard[1], Patrick Sebbah[1], Xavier Noblin[2], Sylvain Gigan[1]; [1]*Institut Langevin, CNRS, France;* [2]*Laboratoire de Physique de la Matire Condensee, CNRS, France.* We present an innovative mirrorless optofluidic random laser where the optical cavity has been replaced by a random scattering structure. We achieve emission control at any desired wavelength by iteratively shaping the optical pump profile.

## CLEO: Science & Innovations

### 16:30–18:30
### CW3B • Nonlinear Optical Materials
*Presider: Peter Schunemann; BAE Systems Inc, United States*

**CW3B.1 • 16:30** Invited

**Advances in Hydrothermally Grown UV Nonlinear Crystals,** Joseph W. Kolis[1], Colin McMillen[1], David C. Brown[2], Henry Giesber[3]; [1]*Clemson Univ., USA;* [2]*Snake Creek Lasers, USA;* [3]*Advanced Photonic Crystals, USA.* Single crystals of alkali metal borates for deep UV non-linear applications are grown using the hydrothermal method. Particular emphasis will be placed on the structure and properties of the ABBF category of crystals.

**CW3B.2 • 17:00**

**Studies of Sub Millisecond Domain Dynamics in Rubidium Doped KTP, Using Real-Time In-Situ SHG,** Gustav Lindgren[1], Andrius Zukauskas[1], Valdas Pasiskevicius[1], Fredrik Laurell[1], Carlota Canalias[1]; [1]*Applied Physics, KTH - Royal Institute of Technology, Sweden.* We demonstrate real-time, in-situ SHG as a technique for studying the sub-millisecond dynamics of periodic poling in Rb-doped KTP. Using this technique we established the parameters which have the most influence on the domain dynamics.

## CLEO: QELS-Fundamental Science

### 16:30–18:30
### QW3C • Symposium on Quantum Simulators: Quantum Simulators II
*Presider: Philip Walther, Universitat Wien, Austria*

**QW3C.1 • 16:30** Invited

**Quantum Simulation of Dirac Points,** Leticia Tarruell[1], Daniel Greif[2], Thomas Uehlinger[2], Gregor Jotzu[1], Tilman Esslinger[2]; [1]*Institute for Quantum Electronics, ETH Zurich, Switzerland;* [2]*Laboratoire Photonique, Numérique et Nanosciences, CNRS/IOGS/Université, France.* We report on the creation of Dirac points with adjustable properties in a tunable honeycomb optical lattice [1,2]. We directly measure their position, observe them merge and map out this topological transition in parameter space.

**QW3C.2 • 17:00** Invited

**Quantum Dynamics of a Single, Mobile Spin Impurity,** Stefan Kuhr[1]; *University of Strathclyde, Scotland, UK.* Our results pave the way for a new approach to study quantum magnetism, mobile impurities in quantum fluids, and polarons in lattice systems.

### 16:30–18:30
### QW3D • Ultrafast Dynamics in Strongly Correlated Materials
*Presider: Rupert Huber; Universität Regensburg, Germany*

**QW3D.1 • 16:30**

**Ultrafast Magnetization Dynamics Induced by Acoustic Pulses in Nickel Thin Films,** Jiwan Kim[1], Mircea Vomir[1], Jean-Yves Bigot[1]; [1]*Institut de Physique et Chimie des Matériaux de Strasbourg, UMR 7504 CNRS, Université de Strasbourg, France.* : We show that acoustic pulses generated by femtosecond laser pulses in a ferromagnetic thin film can efficiently couple to the magnetization after its propagation at long distances via a change in the magneto-crystalline anisotropy.

**QW3D.2 • 16:45**

**Tracking Charge Localization via Transient Electron-Phonon Coupling in a Stripe-ordered Nickelate,** Giacomo Coslovich[1], Bernhard Huber[1], Wei-Sheng Lee[2], Yi-De Chuang[3], Yi Zhu[1], Takao Sasagawa[4], Zahid Hussain[3], Hans A. Bechtel[3], Micheal C. Martin[3], Zhi-Xun Shen[2], Robert W. Schoenlein[1], Robert A. Kaindl[1]; [1]*Materials Sciences Division, Lawrence Berkeley National Laboratory, USA;* [2]*SIMES, SLAC National Accelerator Laboratory and Stanford University, USA;* [3]*Advanced Light Source, Lawrence Berkeley National Laboratory, USA;* [4]*Materials and Structures Laboratory, Tokyo Institute of Technology, Japan.* We study the low-energy conductivity dynamics after femtosecond perturbation of the stripe-ordered phase in a strongly-correlated nickelate. The experiments reveal ultrafast suppression and recovery of electron-phonon coupling that tracks the atomic-scale localization of correlated charges.

**QW3D.3 • 17:00**

**Coupling between antiferromagnetic and superconducting order in an oxide heterostructure revealed using ultrafast optical spectroscopy,** Jingbo Qi[1], Jason Haraldsen[1], Jianxin Zhu[1], Stuart A. Trugman[1], Antoinette Taylor[1], Quanxi Jia[1], Rohit P. Prasankumar[1]; [1]*Los Alamos National Laboratory, USA.* Ultrafast optical pump-probe spectroscopy is used to study a heterostructure consisting of superconducting and antiferromagnetic films. We observed a new slow relaxation process that reveals the interaction between superconducting and antiferromagnetic order at the interface.

## CLEO: QELS-Fundamental Science

## CLEO: Science & Innovations

### 16:30–18:30
### QW3E • Supercontinuum Generation and Temporal Solitons
*Presider: Mark Foster; Johns Hopkins University, United States*

**QW3E.1 • 16:30**
**Rogue wave buster,** Ayhan Demircan[1], Shalva Amiranashvili[2], Carsten Bree[2], Fedor Mitschke[3], Gunter Steinmeyer[4]; [1]*Invalidenstr. 114, Germany;* [2]*WIAS, Germany;* [3]*University of Rostock, Germany;* [4]*Max-Born-Institute, Germany.* Rogue wave formation from a high-order soliton in optical fibers can be inhibited by simultaneously launching dispersive waves at suitable delay, wavelength, and duration. Addition of low-energy wave-packets dramatically affects the emerging soliton amplitude statistics.

**QW3E.2 • 16:45**
**Linking frequency combs to supercontinuum generation: from cascaded four-wave mixing to Cherenkov radiation,** Miro Erkintalo[2], Ray Xu[2], Stuart Murdoch[2], John M. Dudley[1], Goëry Genty[3]; [1]*Université de Franche-Comté, France;* [2]*University of Auckland, New Zealand;* [3]*Tampere University of Technology, Finland.* We show theoretically, numerically, and experimentally that cascaded four-wave mixing arising from symmetry-breaking constitute the physical interpretation of soliton-induced Cherenkov radiation and associated soliton spectral recoil observed in supercontinuum generation.

**QW3E.3 • 17:00**
**Propagation of few-cycle pulses in nonlinear Kerr media: Harmonic generation,** Yuzhe Xiao[1], Drew N. Maywar[2], Govind P. Agrawal[1]; [1]*The Institute of Optics, University of Rochester, USA;* [2]*Electrical, Computer, and Telecom. Eng. Technology, Rochester Institute of Technology, USA.* We apply the recently developed time-transformation technique to optical pulse propagation in nonlinear Kerr media, and to study carrier-wave shocking and generation of odd-order harmonics.

### 16:30–18:30
### CW3F • Opto-mechanical Systems II
*Presider: Kartik Srinivasan; National Inst of Standards & Technology, United States*

**CW3F.1 • 16:30**
**Chip-Scale Cavity-Optomechanical Accelerometer,** Tim Blasius[1], Alexander G. Krause[1], Oskar Painter[1]; [1]*Applied Physics, California Institute of Technology, USA.* We demonstrate an optomechanical accelerometer using a v-groove fiber coupled photonic crystal nanocavity integrated with a high-Q nanotethered test mass. The nanocavity frequency can be tuned to that of an input laser by on-chip capacitive actuators.

**CW3F.2 • 16:45**
**Si3N4 nanobeam optomechanical crystals,** Marcelo I. Davanco[1,2], Jasper Chan[2], Amir Safavi-Naeini[2], Oskar Painter[2], Kartik Srinivasan[1]; [1]*Center for Nanoscale Science and Technology, National Inst of Standards & Technology, USA;* [2]*Applied Physics, Caltech, USA.* We demonstrate sideband-resolved Si3N4 optomechanical crystals supporting 10^5 quality factor optical modes at 980 nm, coupled to GHz frequency mechanical modes.We also develop slot-mode-based geometries for enhanced optomechanical coupling and multimode applications.

**CW3F.3 • 17:00**
**Optomechanical torsional sensing in photonic crystal split-beam nanocavities,** Marcelo Wu[1,2], Aaron C. Hryciw[2], Mark R. Freeman[2,3], John P. Davis[3], Paul E. Barclay[1,2]; [1]*Physics and Astronomy, University of Calgary, Canada;* [2]*National Institute for Nanotechnology, National Research Council, Canada;* [3]*Physics, University of Alberta, Canada.* Photonic crystal split-beam nanocavities are proposed and fabricated for optomechanical detection of torsional motion. Large optomechanical transduction around 20 GHz/nm allows for predicted torsional sensitivities down to 10^-20 Nm/Hz^(-1/2).

### 16:30–18:30
### CW3G • Nano and Polariton Lasers
*Presider: A. Helmy; Univ. of Toronto, Canada*

**CW3G.1 • 16:30**
**Polarization Properties of GaN Nanowire Lasers,** Antonio Hurtado[1,2], Huiwen Xu[1], Jeremy B. Wright[1,4], Sheng Liu[3,4], Qiming Li[4], George T. Wang[4], Ting S. Luk[3,4], Jeffrey Figiel[4], Karen Cross[4], Ganesh Balakrishnan[1], Luke Lester[1], Igal Brener[3,4]; [1]*Center for High Technology Materials, University of New Mexico, USA;* [2]*University of Essex, United Kingdom;* [3]*Center for Integrated Nanotechnology, Sandia National Laboratories, USA;* [4]*Sandia National Laboratories, USA.* The polarization properties of GaN nanowire lasers are studied experimentally by analyzing their end-facet emission. We demonstrate that the polarization state varies for different transverse modes. Linear and elliptical polarizations are observed in our measurements.

**CW3G.2 • 16:45**
**Dynamically Color-Controllable Lasing from a Single CdSSe Alloy Nanowire,** Zhicheng Liu[1], Leijun Yin[1], Hao Ning[1], Zongyin Yang[2], Limin Tong[2], Cun-Zheng Ning[1]; [1]*School of Electrical, Computer, and Energy Engineering, Arizona State University, USA;* [2]*State Key Laboratory of Modern Optical Instrumentation, Department of Optical Engineering, Zhejiang University, China.* We report a simultaneous two-color lasing with wavelength separation of 107 nm in a single CdSSe alloy nanowire. The output color can be tuned continuously from green to red by controlling two pump beams.

**CW3G.3 • 17:00** Invited
**Nanolasers Employing Epitaxial Plasmonic Layers,** Chih-Kang K. Shih[1]; [1]*Physics, The University of Texas, USA.* By using an atomically smooth epitaxial Ag film as the plasmonic platform and InGaN@GaN core-shell nanorod acting as the gain medium we report successful operation of low-threshold, continuous-wave (CW) operation of a green nanolaser.

### 16:30–18:30
### CW3H • Ultrafast Nonlinear Optics
*Presider: Jeffrey Moses; Massachusetts Institute of Technology, United States*

**CW3H.1 • 16:30**
**Mid-infrared Supercontinuum Generation in Silicon Waveguides,** Michael R. Lamont[1,3], Ryan K. Lau[1], Austin Griffith[2], Y. Henry Wen[1], Yoshitomo Okawachi[1], Michal Lipson[2,3], Alexander L. Gaeta[1,3]; [1]*School of Applied and Engineering Physics, Cornell University, USA;* [2]*School of Electrical and Computer Engineering, Cornell University, USA;* [3]*Kavli Institute at Cornell for Nanoscale Science, Cornell University, USA.* We demonstrate supercontinuum generation (SCG) spanning from telecom to Mid-infrared wavelengths beyond 3.6 μm, using a silicon-on-insulator wire waveguide, which represents the first octave-spanning SCG from a silicon chip.

**CW3H.2 • 16:45** Invited
**Light Scattering from Soliton-induced Relativistically Travelling Inhomogeneities,** Daniele Faccio[1], Eleonora Rubino[2], S. Cacciatori[2], F. Belgiorno[3], Fabio Biancalana[1,4], Mohammed F. Saleh[4], Arnaud Couairon[5]; [1]*School of Engineering and Physical Science, SUPA, Heriot-Watt Univ., United Kingdom;* [2]*Dipartimento di Scienza e Alta Tecnologia, Universita dell'Insubria, Italy;* [3]*Dipartimento di Matematica, Politecnico di Milano, Italy;* [4]*Max Planck Institute for the Science of Light, Germany;* [5]*Centre de Physique Theorique, CNRS, Ecole Polytechnique, France.* Light scattering from a Kerr induced inhomogeneity is revisited, unveiling novel emission channels resulting essentially from the formation of shock front instabilities. These exhibit different features in the presence of negative or positive GVD.


## CLEO: Applications & Technology

### 16:30–18:30
### AW3I • OCT: Technology Development and Applications

*Presider: Benjamin Vakoc; Harvard Medical School, United States*

**AW3I.1 • 16:30** Invited

**OCT Image Guidance for RFA Therapy of Cardiac Arrhythmias,** Andrew M. Rollins[1]; [1]*Case Western Reserve Univ., USA.* OCT imaging has the potential to improve radio-frequency ablation therapy of cardiac arrhythmias by providing real-time information such as confirmation of catheter contact; confirmation of lesion development, early detection of over-treatment, and identification of critical structures.

**AW3I.2 • 17:00**

**Functional optical coherence tomography for imaging middle ear dynamics,** Ernest Chang[1], Jeffrey T. Cheng[2], John Rosowski[2], Seok-Hyun Yun[3]; [1]*Physical Sciences Inc., USA;* [2]*Massachusetts Eye and Ear Infirmary, USA;* [3]*Wellman Center for Photomedicine, USA.* We use OCT to take three-dimensional volumetric snapshots of the moving eardrum and the ossicular chain behind the eardrum in a cadaveric chinchilla with which can generate 3D amplitude and phase maps

## JOINT

### 16:30–18:30
### JW3J • Symposium on High Power Diode Laser Arrays: Technology and Applications:High Power Diode Laser Arrays II

*Presider: Andy Bayramian; Lawrence Livermore National Laboratory, United States*

**JW3J.1 • 16:30** Invited

**Engineering Diode Laser Pumps for Extremely Large Scale Laser Systems,** Robert Deri[1]; [1]*Lawrence Livermore National Laboratory, USA.* Several large scale laser applications require diode pumps for high efficiency and average power, but are sensitive to diode performance-cost tradeoffs. This paper describes approaches for addressing these issues, using the example of inertial fusion energy drivers.

**JW3J.2 • 17:00** Invited

**High Power High Brightness Laser Diode Sources,** Olivier Rabot[1], Andreas Kohl[1]; [1]*Quantel, France.* This paper reports on progress of QCW diode pump sources. Performance of the different building blocks such as the diode stacks, cooling systems and diode drivers are discussed. An outlook on future developments is given.

## CLEO: Science & Innovations

### 16:30–18:30
### CW3K • Advanced THz Emission Mechanisms

*Presider: Peter Jepsen; Danmarks Tekniske Universitet, Denmark*

**CW3K.1 • 16:30**

**Withdrawn**

**CW3K.2 • 16:45**

**32 µW pulsed terahertz emission from high mobility InAlAs/InGaAs multi-nanolayer structures,** Roman J. Dietz[1], Björn Globisch[1], Dennis Stanze[1], Thorsten Göbel[1], Martin Koch[2], Bernd Sartorius[1], Martin Schell[1]; [1]*Photonic Components, Fraunhofer Heinrich-Hertz-Institute, Germany;* [2]*Department of Physics, Philipps-Universität Marburg, Germany.* We measured pulsed THz emission from high-mobility MBE grown InGaAs/InAlAs multi-nanolayer structures. The detected average THz power was 32 µW at 32 mW optical excitation power. The bandwidth of the THz pulses exceeds 4 THz.

**CW3K.3 • 17:00**

**Broadband THz generation using Interdigitated Photoconductive antennas with a 15 fs, high power oscillator,** Peter Hale[1], Julien Madeo[1,2], Catherine Chin[1], Sukhdeep Dhillon[2], Juliette Mangeney[2], Jérôme Tignon[2], Keshav Dani[1]; [1]*Femtosecond Spectroscopy Unit, Okinawa Inst. of Science and Technology, Japan;* [2]*Laboratoire Pierre Aigrain, Ecole Normale Supérieure, France.* We study the generation of broadband THz radiation (~18 THz) with high peak electric field (~0.5 kV/cm) using a low temperature GaAs interdigitated photoconductive antenna and a high-power, high repetition rate, 15 femtosecond Ti:Sapphire oscillator.

### 16:30–18:30
### CW3L • Atmospheric Sensing

*Presider: Uricke Willer, Technische Universität Clausthal, Germany and Mark Zondlo, Princeton, USA*

**CW3L.1 • 16:30** Invited

**Recent Advances QCLs, High Finesse Optical Cavities and Robotic Instrumentation: Addressing Climate Change With New Experimental Strategies,** Jim Anderson[1]; [1]*Harvard, USA.* Accelerating changes in the Earth's climate resulting from potent feedbacks that control the structure of the climate require fundamentally new observational strategies. The union of new laser technology, optics and robotic deployment are described.

**CW3L.2 • 17:00**

**Resonant photoacoustic gas sensing with silicon tuning forks,** Michael Köhring[1], Ulrike Willer[2], Wolfgang Schade[1,2]; [1]*Fraunhofer Heinrich Hertz Institute, Germany;* [2]*Institute for Energy Research and Physical Technologies, Technical University of Clausthal, Germany.* Silicon micro tuning forks are used as highly frequency selective sound detector for photoacoustic spectroscopy. The resonant properties and temperature dependencies of these sensors are investigated using the example of a fiber coupled methane sensor.

## Marriott San Jose Salon III

### CLEO: Science & Innovations

**16:30–18:15**
**CW3M • Single Frequency Fiber Lasers**
*Presider: Shibin Jiang; AdValue Photonics, Inc., United States*

**CW3M.1 • 16:30**
**Generation of 9 W, 4 kHz linewidth 13C2H2 frequency-stabilized fiber laser output with core pumped erbium-doped amplifier,** Akira Fujisaki[1,2], Keisuke Kasai[2], Masato Yoshida[2], Toshihiko Hirooka[2], Masataka Nakazawa[2]; [1]*Telecommunication company, Furukawa Electric, Japan;* [2]*Research Institute of Electrical Communication, Tohoku University, Japan.* We demonstrate a record-high output power of 9 W and an ultranarrow linewidth of 4 kHz by combining a 13C2H2 frequency-stabilized fiber laser, a core-pumped erbium-doped fiber amplifier, and a cascaded-Raman 1480-nm fiber-laser pumping source.

**CW3M.2 • 16:45**
**200W Gain-Switched-Diode-Seeded, Single-Polarization, Narrow-Linewidth, All-Fiber, Picosecond MOPA,** Peh Siong Teh[1], Ho-Yin Chan[1], Richard J. Lewis[1], Shaif-ul Alam[1], David P. Shepherd[1], David J. Richardson[1]; [1]*Optoelectronics Research Centre, University of Southampton, United Kingdom.* We report a fully fiberized, single-polarization, gain-switched, diode-seeded fiber MOPA delivering 28ps pulses at a repetition frequency of 214MHz with 200W of average output power and up to 0.93μJ pulse energy.

**CW3M.3 • 17:00**
**Single-frequency pulse amplification in a higher-order mode fiber amplifier with fundamental-mode output,** Jeffrey W. Nicholson[1], John M. Fini[1], X. Liu[1], A. DeSantolo[1], P. Westbrook[1], R. Windeler[1], E. Monberg[1], F. DiMarcello[1], C. Headley[1], D. DiGiovanni[1]; [1]*OFS Laboratories, USA.* Single-frequency and narrow-linewidth pulse amplification is demonstrated in an erbium-doped higher-order mode fiber with effective area of 6000um2 and output long-period grating for re-conversion of the output beam back to the fundamental mode.

## Marriott San Jose Salon IV

### CLEO: QELS-Fundamental Science

**16:30–18:30**
**QW3N • Waveguide & Plasmonics**
*Presider: Natalia Litchinitser; University at Buffalo, The State University of New York, United States*

**QW3N.1 • 16:30**
**Optically Defined Plasmonic Waveguides in Crystalline Semiconductors at Optical Frequencies,** Herman Man Kai Wong[1], A. S. Helmy[1]; [1]*The Edward S. Rogers Sr. Department of Electrical and Computer Engineering, University of Toronto, Canada.* A nanoscale all-semiconductor waveguide designed to support a plasmonic gap mode (PGM) at high optical excitation intensity is introduced. The PGM properties such as mode confinement and dispersion are widely tunable through varying the excitation intensity.

**QW3N.2 • 16:45**
**Engineering Metallic Nanocavity Radiation for Efficient Uni-/Bi-directional Coupling into Integrated Waveguide,** Myung-Ki Kim[1], Zheng Li[1], Ming C. Wu[2], Ryan Going[2], Hyuck Choo[1]; [1]*Electrical Engineering, California Institute of Technology, USA;* [2]*Electrical Engineering & Computer Sciences, UC Berkeley, USA.* We propose a new, simple way to engineer the radiation patterns of subwavelength-scale metallic semiconductor cavities for coupling light from a nanoscale metal cavity into integrated waveguides uni-/bi-directionally with efficiency up to ~90%.

**QW3N.3 • 17:00**
**Plasmonic nanoparticle interaction in hybrid plasmonic-dielectric waveguides,** Thomas Kaiser[1], Séverine Diziain[1], Christian Helgert[1], Carsten Rockstuhl[2], Thomas Pertsch[1]; [1]*Institute of Applied Physics, Abbe Center of Photonics, Friedrich-Schiller-Universität Jena, Germany;* [2]*Institute of Condensed Matter Theory and Solid State Optics, Abbe Center of Photonics, Friedrich-Schiller-Universität Jena, Germany.* We theoretically and experimentally investigate plasmonic nanostructures that are fabricated atop a dielectric waveguide. Different geometric parameters lead to a strongly tunable dispersion that displays even negative group velocity. We analyze the underlying coupling mechanisms.

## Marriott San Jose Salon V & VI

### CLEO: Science & Innovations

**16:30–18:30**
**CW3O • Optical Materials and Devices II**
*Presider: Zhaowei Liu; University of California San Diego, United States*

**CW3O.1 • 16:30** Invited
**Theory-guided Nano-engineering of Organic Electro-optic Materials for Integration with Silicon Photonics, Plasmonics, and Metamaterial Devices,** Larry R. Dalton[1]; [1]*Chemistry, University of Washington, USA.* New quantum and statistical mechanical theoretical methods are used to guide the devellopment of new OEO materials optimized for integration with the new hybrid device architectures.

**CW3O.2 • 17:00**
**Realization of Tellurium-based all Dielectric Optical Metamaterials using a Multi-cycle Deposition-etch Process,** Sheng Liu[2,1], Jon F. Ihlefeld[2], Jason Dominguez[2], Edward Gonzales[2,1], John E. Bower[2], Bruce D. Burckel[2], Michael B. Sinclair[2], Igal Brener[2,1]; [1]*Center for Integrated Nanotechnologies, Sandia National Laboratories, USA;* [2]*Sandia National Laboratories, USA.* Tellurium dielectric resonator metamaterials were fabricated using a newly developed multi-cycle deposition-etch process. Deposition and etching of Tellurium were studied in detail. All the samples showed two transmission minima corresponding to magnetic and electric dipole resonances.

## CLEO: QELS-Fundamental Science

## CLEO: Science & Innovations

## CLEO: QELS-Fundamental Science

### QW3A • Optics of Random Media—Continued

**QW3A.3 • 17:15**
**Wave-Particle Duality during Hyper-Transport of Light in Dynamic Disorder,** Roman Kreiserman[1], Liad Levi[1], Yevgeny Krivolapov[1], Shmuel Fishman[1], Mordechai Segev[1]; [1]*Physics, Technion, Israel.* We present an analytic spectral wave theory describing the propagation of wavepackets in dynamically-evolving disordered potentials, in the hyper-transport regime. The results are examined in the context of Bohr's correspondence principle.

**QW3A.4 • 17:30**
**Anomalous diffusion of light in 1D random dimer waveguide arrays,** Simon Stützer[1], Uta Naether[2], Tsamikos Kottos[3], Rodrigo A. Vicencio[2], Mario I. Molina[2], Andreas Tünnermann[1], Stefan Nolte[1], Demetrios N. Christodoulides[4], Alexander Szameit[1]; [1]*Friedrich-Schiller-Universität Jena, Institute of Applied Physics, Abbe Center of Photonics, Germany;* [2]*Universidad de Chile, Departamento de Física and MSI-Nucleus on Advanced Optics, Center for Optics and Photonics (CEFOP), Facultad de Ciencias, Chile;* [3]*Wesleyan University, Department of Physics, USA;* [4]*University of Central Florida, College of Optics and Photonics, USA.* We experimentally demonstrate super-diffusion and the delocalization-localization phase transition in a random dimer structure. The system is implemented using weakly-coupled optical waveguides.

**QW3A.5 • 17:45**
**Position Dependent Diffusion of Light in Disordered Waveguides,** Raktim Sarma[1], Alexey Yamilov[2], Brandon Redding[1], Ben Payne[2], Heeso Noh[1], Hui Cao[1]; [1]*Applied Physics, Yale University, USA;* [2]*Department of Physics, Missouri University of Science & Technology, USA.* Position-dependent diffusion of light is observed experimentally in quasi-two-dimensional disordered optical waveguides. Strong wave interference effects make the diffusion coefficient depend on the size and shape of the random medium as well as the dissipation.

**QW3A.6 • 18:00**
**Breakdown of quantum-classical Correspondence Principle when light interacts with fluctuating disorder,** Ammon Hanan Sheinfux[1], Tal Kachman[1], Yaakov Lumer[1], Yonatan Plotnik[1], Moti Segev[1]; [1]*Technion Israel Institute of Technology, Israel.* We study, experimentally and theoretically, interactions between a soliton and a transient trapping potential. The soliton can be guided by such a potential, while its motion is arrested at the potential minimum by radiation dampening.

### CW3B • Nonlinear Optical Materials—Continued

**CW3B.3 • 17:15**
**Periodically Poled $KTiOAsO_4$ for Second Harmonic Generation in the Green Region,** Andrius Zukauskas[1], Valdas Pasiskevicius[1], Fredrik Laurell[1], Carlota Canalias[1]; [1]*Applied Physics, KTH - Royal Institute of Technology, Sweden.* We present high-quality room temperature periodic poling of $KTiOAsO_4$ with a period of 8.49 μm. The crystals are evaluated for SHG at 533 nm, and show $d_{eff}$ = 10.5 pm/V and $\eta_{norm}$ = 1.19%/Wcm.

**CW3B.4 • 17:30**
**Enhanced Electro-Optic Spectral Tuning in Multi-Wavelength APPLN Optical Parametric Generator,** Yen-Hung Chen[1], Hung-Ping Chung[1], Wei-Kun Chang[1], Hsueh-Tsung Lyu[1], Jui-Wen Chang[1], Chien-Hao Tseng[1]; [1]*Department of Optics and Photonics, National Central University, Taiwan.* We report the first demonstration of electro-optically tunable, multi-wavelength optical parametric generators based on domain-engineered APPLN. Several orders of magnitude enhancement on the device tuning rate over a conventional one was obtained.

**CW3B.5 • 17:45**
**Plasma Density Measurement Using a Dispersion Interferometer Based on Second-Harmonic Generation in Orientation-Patterned GaAs,** Douglas J. Bamford[1], Elizabeth Cummings[1], Dmitriy Panasenko[1], David B. Fenner[2], Joel Hensley[2], Rejean Boivin[3], Thomas N. Carlstrom[3], Michael A. Van Zeeland[3]; [1]*Physical Sciences Inc., USA;* [2]*Physical Sciences Inc., USA;* [3]*General Atomics, USA.* A dispersion interferometer based on second-harmonic generation in orientation-patterned GaAs has been used to measure the line density of electrons in a radio-frequency plasma with a detection limit of 7 x $10^{16}$ $m^{-2}$.

**CW3B.6 • 18:00**
**A hybrid integrated balanced optical cross-correlator using PPKTP waveguides,** Patrick T. Callahan[1], Tony D. Roberts[2], Philip Battle[2], Amir Nejadmalayeri[1], Franz X. Kärtner[1,3]; [1]*Dept. of Electrical Engineering and Computer Science and Research Laboratory of Electronics, Massachusetts Institute of Technology, USA;* [2]*AdvR, Inc., USA;* [3]*Center for Free-Electron Laser Science, DESY and Dept. of Physics, University of Hamburg, Germany.* A hybrid integrated balanced optical cross-correlator using continuous PPKTP channel waveguides and dielectric coatings is demonstrated for use in femtosecond and sub-femtosecond timing applications.

### QW3C • Symposium on Quantum Simulators: Quantum Simulators II—Continued

**QW3C.3 • 17:30**
**Quantum control of spin-correlations in ultracold lattice gases,** Philipp Hauke[1], Robert Sewell[1], Morgan W. Mitchell[1,2], Maciej Lewenstein[1,2]; [1]*Institut de Ciencies Fotoniques, Spain;* [2]*ICREA, Spain.* We describe a new technique for preparing and detecting spatial spin-correlations and multipartite entanglement in a quantum lattice gas based on entropic cooling via quantum non-demolition (QND) measurement and feedback.

**QW3C.4 • 17:45**
**Correlated photons in quantum dot-cavity quantum electrodynamics: beyond the single cavity,** Arka Majumdar[1,2], Armand Rundquist[1], Michal Bajcsy[1], Jelena Vuckovic[1]; [1]*Physics Department, U C Berkeley, USA;* [2]*Electrical Engineering, Stanford University, USA.* We show that the use of a coupled cavity or a bimodal cavity can improve single photon generation significantly relative to a single quantum dot strongly coupled to a cavity.

**QW3C.5 • 18:00**
**Degenerate high-orbital microcavity exciton-polariton condensates in a lattice,** Na Young Kim[1], Kenichiro Kusudo[2], Yoshihisa Yamamoto[1,2], Andreas Loeffler[3], Sven Hoefling[3], Alfred Forchel[3]; [1]*Stanford University, USA;* [2]*National Institute of Informatics, Japan;* [3]*University of Wuerzburg, Germany.* We explore two degenerate high-orbital exciton-polariton condensates in a honeycomb lattice. We measure the order parameter of the condensates, identifying the vortex-antivortex lattice order. We also study the intensity correlation relation between two condensates.

### QW3D • Ultrafast Dynamics in Strongly Correlated Materials—Continued

**QW3D.4 • 17:15**
**Coherent Magnetization Dynamics Investigated with Magneto Optical Four Wave Mixing,** Marie Barthelemy[1], Mircea Vomir[1], Monica Sanchez Piaia[1], Jean-Yves Bigot[1]; [1]*Institut de Physique et Chimie des Matériaux de Strasbourg, UMR 7504 CNRS, Université de Strasbourg, France.* A three beams four wave mixing experiment using ultrashort pulses in a magneto optical configuration is presented. It allows distinct measurements of population and coherent contributions of magnetization dynamics in a ferrimagnetic bismuth doped garnet.

**QW3D.5 • 17:30**
**Speeding up of Transient Carrier Relaxation during Non-Equilibrium Photoinduced Phase Transition in Manganites,** Tianqi Li[1,2], Aaron Patz[1,2], Jiaqiang Yan[2], Thomas Lograsso[2], Leonidas Mouchliadis[3], Ilias E. Perakis[3], Jigang Wang[1,2]; [1]*Department of Physics and Astronomy, Iowa State University, USA;* [2]*Ames Laboratory, USA;* [3]*Department of Physics, University of Crete, Greece.* We observe a distinct excitation-fluence-dependent transient carrier relaxation in a strongly correlated colossal magnetoresistive manganite that correlates with photoinduced magnetic and electronic phase transitions characterized by nonlinear photoexcitation behaviors.

**QW3D.6 • 17:45**
**Ultrafast Demagnetization and Precession Damping Times in Rare Earth Doped Cobalt Films,** Leandro H. Andrade[2,3], Mircea Vomir[1], Jiwan Kim[1], Monica Sanchez Piaia[1], Antonio D. Santos[4], Jean-Yves Bigot[1]; [1]*Institut de Physique et Chimie des Matériaux de Strasbourg, UMR 7504 CNRS, Université de Strasbourg, France, France;* [2]*Departamento de Física, ICEB/UFOP, Ouro Preto, MG, Brasil, Brazil;* [3]*Centro de Lasers e Aplicações, IPEN-CNEN, São Paulo, SP, Brasil, Brazil;* [4]*Departamento de Física dos Materiais e Mecânica, IF/USP, São Paulo, SP, Brasil, Brazil.* We show that the ultrafast demagnetization (τM) and precession damping (ηM) times of rare-earth-doped Cobalt films have different physical origins. ηM is due to impurity induced spin scattering while τM is attributed to spin-orbit interaction

**QW3D.7 • 18:00** **Invited**
**Ultrafast Order Parameter Dynamics and Critical Phenomena of Ising-Nematic Phase in Iron Pnictides,** Jigang Wang[1]; [1]*Iowa State Univ., USA.* Femtosecond-resolved polarimetry characterizes a two-step polarization recovery after non-equilibrium photoexcitation of BaFe2As2. This underpins the nematicity as an independent degree of freedom responsible for the anisotropy, which demonstrates a benchmark approach to anisotropic quantum fluids.

## CLEO: QELS-Fundamental Science

## CLEO: Science & Innovations

### QW3E • Supercontinuum Generation and Temporal Solitons—Continued

**QW3E.4 • 17:15**
**Raman-assisted octave-spanning continuum generation in single-crystal diamond for sub-cycle pulse synthesis,** Chih-Hsuan Lu[1], Fan Yang Li[1], Miaochan Zhi[2], Alexei Sokolov[2], Shang-Da Yang[1], Andy Kung[1,3]; *[1]Institute of Photonics Technologies, National Tsing Hua University, Taiwan; [2]Institute for Quantum Science and Engineering and Department of Physics and Astronomy, Texas A&M University, USA; [3]Institute of Atomic and Molecular Sciences, Academia Sinica, Taiwan.* A coherent continuum is generated by Raman-assisted four-wave mixing in single-crystal diamond of an 8 fs laser pulse. The bandwidth of the spectrum will support the synthesis of an isolated single-cycle femtosecond pulse.

**QW3E.5 • 17:30**
**Raman enhanced supercontinuum generation from 2 - 20 μm in GaAs using 3 ps $CO_2$ laser pulses,** Jeremy Pigeon[1], Sergei Tochitsky[1], Chan Joshi[1]; *[1]Electrical Engineering, UCLA, USA.* Supercontinua covering the entire mid-IR region were obtained by sending a train of 3 ps $CO_2$ laser pulses through a 67mm GaAs crystal. The spectral width is attributed to stimulated Raman scattering and self-phase modulation.

**QW3E.6 • 17:45**
**Scalar and vector modulational instability induced by parametric resonance in periodically tapered PCFs,** Fabio Biancalana[2,1], Andrea Armaroli[1], Arnaud Mussot[3], Alexandre Kudlinski[3], Maxime Droques[3]; *[1]Max-Planck-Inst Physik des Lichts, Germany; [2]School of Engineering & Physical Sciences, Heriot-Watt University, United Kingdom; [3]Laboratoire PhLAM UMR CNRS 8523, IRCICA, Universite' Lille 1, France.* We analyze the modulational instability process induced by periodic variations of the parameters of a PCF along the propagation direction, induced by an analogue of the parametric resonance in mechanics.

**QW3E.7 • 18:00**
**Supercontinuum Generation by Mid-IR femtosecond Filaments in Molecular Gases,** Daniil Kartashov[1], Skirmantas Ališauskas[1], Audrius Pugzlys[1], Alexander Voronin[2], Aleksei Zheltikov[2,3], Massimo Petrarca[4], Pierre Béjot[4], Jerome Kasparian[4], Jean-Pierre Wolf[4], Andrius Baltuska[1]; *[1]Photonics Institute, Vienna University of Technology, Austria; [2]Physics Department, Russian Quantum Center, International Laser Center, M.V. Lomonosov Moscow State University, Russian Federation; [3]Department of Physics and Astronomy, Texas A&M University, USA; [4]Université de Genève, Switzerland.* We present experimental and numerical investigation of multi-millijoule mid-IR supercontinuum generation by mid-IR femtosecond filaments in molecular gases. Drastic difference in spectra between atomic and molecular gases and crucial role of Raman scattering is demonstrated.

### CW3F • Opto-mechanical Systems II—Continued

**CW3F.4 • 17:15**
**Feedback locking of slot-type optomechanical oscillators to external low-noise reference clocks,** Jiangjun Zheng[1], Ying Li[1], Noam Goldberg[1], Mickey McDonald[2], Archita Hati[3], Ming Lu[4], Stefan Strauf[5], Tanya Zelevinsky[2], David Howe[3], Chee Wei Wong[1]; *[1]Columbia University, USA; [2]Department of Physics, Columbia University, USA; [3]National Institute of Standards and Technology, USA; [4]Center for Functional Nanomaterials, Brookhaven National Laboratory, USA; [5]Department of Physics and Engineering Physics, Stevens Institute of Technology, USA.* We demonstrated feedback and harmonic locking of chip-scale slot-type optomechanical oscillators to external low-noise reference clocks, with suppressed timing jitter by three orders of magnitude at close-to-carrier offset frequencies.

**CW3F.5 • 17:30**
**Experimental demonstration of light-assisted templated self assembly using photonic-crystal slabs,** Eric Jaquay[1], Luis Javier Martinez[1], Camilo Mejia[1], Michelle L. Povinelli[1]; *[1]University of Southern California, USA.* We demonstrate experimentally that the near field of a photonic-crystal slab can be used to trap square arrays of nanoparticles. This process of light-assisted, templated, self assembly exploits the guided resonant mode for force enhancement.

**CW3F.6 • 17:45**
**Giant Resonant Light Forces in Microspherical Photonics,** Yangcheng Li[1], Alexey V. Maslov[2], Oleksiy Svitelskiy[1], David Carnegie[3], Edik Rafailov[3], Vasily N. Astratov[1]; *[1]Department of Physics and Optical Science, University of North Carolina at Charlotte, USA; [2]University of Nizhny Novgorod, Russian Federation; [3]School of Electrical Engineering and Physics, University of Dundee, United Kingdom.* Giant optical propelling velocities of 15-20 μm polystyrene microspheres are observed in evanescent fiber-taper-to-microsphere couplers. The results demonstrate a possibility of parallel particle-sorting according to the frequency of their whispering gallery mode resonances.

**CW3F.7 • 18:00**
**Phase shifting, strong coupling, and parametric feedback squeezing of an opto-electromechanical device,** Menno Poot[1], Hong X. Tang[1]; *[1]Electrical Engineering, Yale University, USA.* A nanoelectromechanical resonator is used as an on-chip phase shifter. Unprecedentedly strong electrostatic effects are observed and using real-time parametric feedback the thermal motion of the resonator is squeezed below 3dB.

### CW3G • Nano and Polariton Lasers—Continued

**CW3G.4 • 17:30**
**Room Temperature Polariton Lasing from GaN Nanowire Array in a Dielectric Microcavity,** Bo Xiao[1], Junseok Heo[1], Shafat Jahangir[1], Pallab Bhattacharya[1]; *[1]Department of Electrical Engineering and Computer Science, University of Michigan, USA.* Polariton lasing from epitaxially grown GaN nanowire array embedded in a dielectric microcavity is demonstrated at room temperature under optical excitation. Simulations of cavity mode and polariton emission characteristics of the device are presented.

**CW3G.5 • 17:45**
**GaAs Electrically Injected Exciton-Polariton Laser,** Bo Xiao[1], Ayan Das[1], Sishir Bhowmick[1], Junseok Heo[1], Pallab Bhattacharya[1]; *[1]Department of Electrical Engineering and Computer Science, University of Michigan, USA.* Electrically injected polariton lasing from a GaAs-based modulation-doped microcavity diode has been demonstrated under an applied magnetic field of 7 Tesla at 30 K. Polariton lasing and condensation characteristics have been measured and analyzed.

**CW3G.6 • 18:00** Invited
**Polariton Lasing at Room Temperature,** Nicolas Grandjean[1]; *[1]Ecole Polytechnique Federale de Lausanne, Switzerland.* III-nitride semiconductors exhibit robust excitons, which makes them desirable for strong light-matter interaction. Provided high quality factor microcavities, room-temperature non-linear emission is achieved due to quasi-equilibrium polariton condensation, referred to as polariton lasing.

### CW3H • Ultrafast Nonlinear Optics—Continued

**CW3H.3 • 17:15**
**A Semiconductor Saturable Absorber for Mid-infrared Wavelengths,** Jean Wei[2,1], Joel M. Murray[2,1], Leonel P. Gonzalez[1], Yong Chang[3], Siva Sivanathan[4], Shekhar Guha[1]; *[1]US Air Force Research Laboratory, USA; [2]UES, Inc., USA; [3]Sivananthan Laboratories, USA; [4]University of Illinois at Chicago, USA.* Saturable absorption of nanosecond and picosecond duration pulses in a thin HgCdTe film is reported at 4.6 micrometer. The material shows promise as a mode locker for Mid-infrared ultrafast lasers.

**CW3H.4 • 17:30**
**Time transformation approach to nonlinear pulse propagation: Kerr and delayed Raman response,** Yuzhe Xiao[1], Drew N. Maywar[2], Govind P. Agrawal[1]; *[1]The Institute of Optics, University of Rochester, USA; [2]Electrical, Computer, and Telecom. Eng. Technology, Rochester Institute of Technology, USA.* We extend the time-transformation technique to include the delayed Raman response and apply it to study the impact of the width of few-cycle optical pulses on intrapulse Raman scattering and dispersive wave generation.

**CW3H.5 • 17:45** Invited
**Optical Kerr effect in the strong field regime,** Pierre Béjot[1], Eric Cormier[2], Edouard Hertz[1], Bruno Lavorel[1], Jerome Kasparian[3], Jean-Pierre Wolf[3], Olivier Faucher[1]; *[1]ICB, Université de Bourgogne, France; [2]CELIA, Université de Bordeaux, France; [3]GAP-Biophotonics, Université de Genève, Switzerland.* The work reports on a comparative study of the optical Kerr response of atoms exposed to strong and short near infrared laser pulses.

## CLEO: Applications & Technology

### AW3I • OCT: Technology Development and Applications—Continued

**AW3I.3 • 17:15**
**In Vivo Optical Coherence Tomography (OCT) Imaging of Transplant Kidney: Feasibility Studies,** Yu Chen[1], Peter Andrews[2], Jeremiah Wierwille[1], Wei Gong[3], Hsing-Wen Wang[1]; [1]*Bioengineering, University of Maryland, USA;* [2]*Cell Biology, Georgetown University, USA;* [3]*Photonic and Electric Engineering, Fujian Normal University, China.* We demonstrated the feasibility of OCT to image human kidneys during transplantation. OCT visualized the extent of tubular necrosis and Doppler OCT (DOCT) revealed renal blood flow dynamics that is correlated with post-transplant renal function.

**AW3I.4 • 17:30**
**OCT-based Profiler for Automating Ocular Surface Prosthetic Fitting,** Mircea Mujat[1], R. Daniel Ferguson[1], Ankit Patel[1], Nicusor Iftimia[1]; [1]*Physical Sciences Inc., USA.* An OCT-based profiler was developed for ocular surface prosthetic fitting. Multiple surfaces corresponding to different parts of the cornea and sclera were measured and automatically segmented and stitched together generating a large-area anterior-segment ocular surface.

**AW3I.5 • 17:45**
**OCTANE: Optical Coherence Tomography Advanced Nanophotonic Engine,** Kyle Preston[1], Arthur Nitkowski[1], Nicolás Sherwood-Droz[1], Andrew Berkeley[2], Bradley S. Schmidt[2], Arsen R. Hajian[2]; [1]*Tornado Spectral Systems, USA;* [2]*Tornado Spectral Systems, Canada.* We introduce OCTANE, the first product line of chip-based spectrometers using silicon photonics for spectral domain optical coherence tomography (SD-OCT). It is well suited for low-cost, high-volume applications in both the medical and industrial fields.

**AW3I.6 • 18:00**
**Dual Modality Optical Imaging Approach for Real-time Assessment of Skin Burns,** Ernest Chang[1], Mircea Mujat[1], R. Daniel Ferguson[1], Ankit Patel[1], Milind M. Rajadhyaksha[3], Nicusor Iftimia[1]; [1]*Physical Sciences Inc., USA;* [2]*Memorial Sloan-Kettering Cancer Center, USA.* A dual modality optical imaging approach based on high-resolution reflectance confocal microscopy (RCM) and optical coherence tomography (OCT) is proposed for assessing skin burns gravity.

## JOINT

### JW3J • Symposium on High Power Diode Laser Arrays: Technology and Applications:High Power Diode Laser Arrays II—Continued

**JW3J.3 • 17:30** Invited
**Laser Diode Arrays - Designs and Production Techniques for Fusion Energy Power Plants,** Ryan Feeler[1]; [1]*Northrop Grumman Cutting Edge Optronics, USA.* Novel laser diode array designs and manufacturing methods are discussed, with a focus on providing the lowest-cost solution for the specific application of DPSS pumping in fusion energy power plants.

**JW3J.4 • 18:00** Invited
**Scalable Compact Laser diode Array Technology for High Energy Applications,** Prabhu Thiagarajan[1], Steve Smith[1], Brian Caliva[1], Jason Helmrich[1], Suhit Das[1], Feliks Lapinski[1], Greg Pennington[1], Robert Walker[1], Mark McElhinney[1]; [1]*Lasertel Inc, USA.* Multi-kw compact CW and QCW laser diode array technology is presented for use in high energy applications. Performance of the fully soldered compact arrays and approaches for scalability to sub-megawatt class laser diode modules are discussed.

## CLEO: Science & Innovations

### CW3K • Advanced THz Emission Mechanisms—Continued

**CW3K.4 • 17:15**
**Substantial Radiation Enhancement in Photoconductive Terahertz Emitters by Utilizing Plasmonic Contact Electrodes,** Christopher W. Berry[1], Mohammed Reza Hashemi[1], Mehmet Unlu[1], Mona Jarrahi[1]; [1]*Electrical Engineering and Computer Science, University of Michigan, USA.* We experimentally show that utilizing plasmonic contact electrodes enhances the optical-to-terahertz conversion efficiency of photoconductive terahertz emitters and can offer 50 times higher radiation powers than conventional photoconductive terahertz emitter designs without plasmonic electrodes.

**CW3K.5 • 17:30** Invited
**Scanning Laser THz Imaging System and Its Application,** Masayoshi Tonouchi[1]; [1]*Institute of Laser Engineering,, Osaka Univ., Japan.* Recent progress of a scanning laser THz emission microscope and a scanning laser THz point source near field imaging system is reviewed and its prospect is discussed.

**CW3K.6 • 18:00**
**Coherent effect in nonlinear excitation of low-temperature-grown GaAs by 1.5 μm pulses,** Yuki Tomiyasu[1], Yoriko Tominaga[1], Yutaka Kadoya[1]; [1]*Hiroshima University, Japan.* The mechanism of the nonlinear photo-carrier generation in low-temperature-grown GaAs by 1.5 μm pulses was investigated. The effect of intermediate excitation on the photo response was distinctly observed and found to be largely coherent.

### CW3L • Atmospheric Sensing—Continued

**CW3L.3 • 17:15**
**Faraday Rotation Spectroscopy of O2 Using a Distributed Feedback Diode Laser and a Static Magnetic Field,** Eric J. Zhang[1], Brian Brumfield[1], Gerard Wysocki[1]; [1]*Princeton University, USA.* Faraday rotation spectroscopy is used for measurement of O2 at atmospheric conditions. Low operating powers (< 10 W) are achieved by using rare-earth magnets for DC magnetic field generation. A sensitivity of 1.7 ppmv/√Hz is demonstrated.

**CW3L.4 • 17:30**
**Cross-band Relative Absorption Technique for Molecular Mixing Ratio Determination,** Denis Pliutau[1], Narasimha S. Prasad[1]; [1]*NASA Langley Research Center, USA.* We describe a new approach for molecular mixing ratio measurements based on spectral lines matching of various molecules with oxygen resulting in substantial reductions of temperature and pressure induced errors and close weighting functions matching.

**CW3L.5 • 17:45**
**Remote Range Resolved Chemical Detection Using Dual Comb Interferometry,** Sylvain Boudreau[1], Simon Levasseur[1], Simon Roy[2], Jérôme Genest[1]; [1]*Centre d'optique, photonique et laser, Universite Laval, Canada;* [2]*Rechercher et développement pour la défense Canada, Canada.* We demonstrate detection and ranging of various targets, including aerosols, gas spectral signatures and translucent sample thickness using dual comb interferometry. High-resolution hyperspectral traces are obtained from targets at a distance of 175 m.

**CW3L.6 • 18:00**
**Advanced Difference Frequency Generation Laser Spectrometer: Design and Airborne Field Performance,** Dirk Richter[1], Petter Weibring[1], James G. Walega[1], Alan Fried[1]; [1]*Institute of Arctic and Alpine Research, University of Colorado, USA.* We report on the design and performance of a new Difference Frequency Generation spectrometer operated aboard a Gulfstream-V jet during the Deep Convective Cloud and Chemistry research study (DC3) during the spring of 2012.

## CW3M • Single Frequency Fiber Lasers—Continued

**CW3M.4 • 17:15**
**Highly scalable coherent fiber combining using interferometric technique,** Marie Antier[1], Jerome Bourderionnet[1], Christian Larat[1], Eric Lallier[1], Eric Lenormand[1], Jerome Primot[2], Gerard Mourou[3], Arnaud Brignon[1]; *[1]Thales Research & Technology, France; [2]ONERA, France; [3]IZEST, France.* We demonstrate the scalability of fiber phase locking system using interferometric method. The system allows complete phase error map measurement with a l/60 rms accuracy in a single acquisition of only 6 pixels per fiber.

**CW3M.5 • 17:30** Invited
**Single-Frequency Fiber Amplifiers for Gravitational Wave Detection,** Peter Wessels[1,2], Malte Karow[1,2], Vincent Kuhn[1,2], Michael Steinke[1,2], Henrik Tünnermann[1,2], Dietmar Kracht[1,2], Jörg Neumann[1,2]; *[1]Laser Zentrum Hannover e.V., Germany; [2]Centre for Quantum Engineering and Space-Time Research - QUEST, Germany.* Gravitational wave detectors require linearly-polarized, high-power, single-frequency laser sources and set demanding requirements on their stability and beam quality. We discuss current approaches to fulfill the requirements for the upcoming generation of gravitational wave detectors.

**CW3M.6 • 18:00**
**Passive Coherent Beam Combining of Fiber Lasers: Accurate Measurements of Phase Error Tolerance,** James R. Leger[1], Johan Nilsson[2], Hung-Sheng Chiang[1], Jayanta Sahu[2]; *[1]Electrical and Computer Engineering, University of Minnesota, USA; [2]Optoelectronics Research Centre, University of Southampton, United Kingdom.* A cladding-pumped dual core ytterbium fiber laser is designed and fabricated to measure phase error tolerance in passive coherent beam combining. We show quantitative measurements on the effects of longitudinal modes on phase error tolerance.



## QW3N • Waveguide & Plasmonics—Continued

**QW3N.4 • 17:15**
**Macroscopic Engineering of Polarized Emission from Aligned Hybrid Gold Nanorods,** Jiafang Li[1], Siyun Liu[1], Lin Gan[1], Zhi-Yuan Li[1]; *[1]Institute of Physics, Chinese Academy of Sciences, China.* Here we report on the generation and engineering of polarized emission from aligned hybrid gold nanorods embedded in a Polyvinyl Alcohol film, where circularly polarized input light can be converted into broadband linearly polarized emission.

**QW3N.5 • 17:30**
**Plasmonic nano-coaxial waveguides for 90-degree bends and T-splitters,** Wonseok Shin[1], Wenshan Cai[1], Peter B. Catrysse[1], Georgios Veronis[1], Mark Brongersma[1], Shanhui Fan[1]; *[1]Stanford University, USA.* Nearly perfect 90-degree bends and T-splitters are demonstrated in plasmonic nano-coaxial waveguides at the telecommunication wavelength, with bending and splitting efficiencies greater than 97% and 99%, respectively.

**QW3N.6 • 17:45**
**Holey metallic lens for light focusing,** Satoshi Ishii[1,2], Vladimir M. Shalaev[1], Alexander Kildishev[1]; *[1]Birck Nanotechnology Center, Purdue University, USA; [2]National Institute of Information and Communications Technology, Japan.* It is experimentally demonstrated that subwavelength holes milled in a metallic film as a set of concentric circular rings can focus linearly polarized light in the visible range.

**QW3N.7 • 18:00**
**Hybrid Fabrication of Tapered Gold Double-Helices for Near-Infrared Frequencies,** Isabelle Staude[1], Manuel Decker[1], Michael Renner[2], Erik Waller[2], Dragomir N. Neshev[1], Georg von Freymann[2], Yuri S. Kivshar[1]; *[1]Nonlinear Physics Centre, Australian National University, Australia; [2]Physics Department and Research Center OPTIMAS, University of Kaiserslautern, Germany.* We combine direct laser writing with electron-beam lithography to fabricate arrays of 3D tapered gold double-helices with feature sizes well below 100 nm, enabling chiral metamaterials and helical nanoantennas at telecom frequencies.



## CW3O • Optical Materials and Devices II—Continued

**CW3O.3 • 17:15**
**Engineered Thin Film Lithium Niobate Substrate for High Gain-Bandwidth Electro-optic Modulators,** Vincent Stenger[1], James Toney[1], Andrea Pollick[1], James Busch[1], Jon Scholl[1], Peter Pontius[1], Sri Sriram[1]; *[1]SRICO, Inc, USA.* This paper reports the demonstration of a high-speed electro-optic modulator in crystal ion sliced thin film lithium niobate (TFLN™). Experimental results indicate potential to realize a 100 GHz TFLN™ modulator at 1550 nm with Vπ=2.5V.

**CW3O.4 • 17:30**
**Tuning Fano Resonances with Graphene,** Naresh K. Emani[1], Ting-Fung Chung[2], Ludmila Prokopeva[1], Alexander Kildishev[1], Yong Chen[2], Alexandra Boltasseva[1,3]; *[1]Electrical and Computer Engineering, Purdue University, USA; [2]Physics, Purdue University, USA; [3]Photonics Engineering, DTU Fotonik, Denmark.* We demonstrate strong electrical control of plasmonic Fano resonances in dolmen structures using tunable interband transitions in graphene. Such graphene-plasmonic hybrid devices can have applications in light modulation and sensing.

**CW3O.5 • 17:45**
**Room temperature formation of microcavity polaritons in ZnO nanoparticles,** Xiaoze Liu[1,2], David Goldberg[1,2], Vinod M. Menon[1,2]; *[1]Dept. of Physics, Graduate School and University Center of the City University of New York (CUNY), USA; [2]Dept. of Physics, Queens College of the City University of New York (CUNY), USA.* We demonstrate the formation of microcavity polaritons at room temperature in a dielectric microcavity embedded with ZnO nanoparticles. Stoke shift of polariton emission is shown to be dependent on the excitonic content of the polaritons.

**CW3O.6 • 18:00**
**Efficient field emission from bundle array of carbon-nanotube-on-silicon-nanowire heterojunctions,** Yung-Jr Hung[1], San-Liang Lee[1], Hsuan-Chen Chang[1], Kuei-Yi Lee[1], Ying-Sheng Huang[1]; *[1]Dept. Electronic Engineering, National Taiwan Univ. of Sci. & Tech., Taiwan.* Released electrostatic screening effect and Joule heating in bundle arrays of carbon-nanotube-on-silicon-nanowire heterojunctions realized with novel fabrication approach enables efficient field emission of 0.9 V/μm turn-on field and >5 mA/cm$^2$ current density.

## CLEO: QELS-Fundamental Science

### QW3A • Optics of Random Media—Continued

**QW3A.7 • 18:15**
**The resolution limit for far-field optical imaging,** Evgenii E. Narimanov[1]; [1]*Purdue University, USA.* Using the methods of the information theory, we derive the fundamental limit to the resolution of optical imaging, and demonstrate that in the far-field, contrary to the conventional wisdom, it is neither equal nor close to one half of the wavelength.

## CLEO: Science & Innovations

### CW3B • Nonlinear Optical Materials—Continued

**CW3B.7 • 18:15**
**Novel Method on n2 Measurement of Organic Dyes,** Shiva Shahin[1], Khanh Kieu[1], Seth Marder[2], Robert A. Norwood[1], Nasser Peyghambarian[1]; [1]*College of Optical Sciences, University of Arizona, USA;* [2]*Chemistry and Biochemistry, Georgia Institute of Technology, USA.* A novel technique is introduced to characterize the nonlinear properties of organic dyes in solution. This technique uses LCOF system and is based on the spectral broadening of laser pulses due to SPM.

## CLEO: QELS-Fundamental Science

### QW3C • Symposium on Quantum Simulators: Quantum Simulators II—Continued

**QW3C.6 • 18:15**
**Topological creation and destruction of edge states in photonic graphene,** Mikael Rechtsman[1], Yonatan Plotnik[1], Julia Zeuner[2], Alexander Szameit[2], Mordechai Segev[1]; [1]*Technion Israel Institute of Technology, Israel;* [2]*Institute of Applied Physics, Germany.* We experimentally and theoretically demonstrate a topological transition in photonic graphene. By applying a uniaxial strain, the system transforms from one that supports states localized on the edge to one that does not.

### QW3D • Ultrafast Dynamics in Strongly Correlated Materials—Continued

NOTES

## CLEO: QELS-Fundamental Science

## CLEO: Science & Innovations

### QW3E • Supercontinuum Generation and Temporal Solitons—Continued

**QW3E.8 • 18:15**
**Experimental Observation of Three-Soliton Molecules in Dispersion-Managed Fibers,** Philipp Rohrmann[1], Alexander Hause[1], Fedor Mitschke[1]; [1]*Institut für Physik, Universität Rostock, Germany.* We present the first experimental observation of a stable bound state of three dispersion-managed solitons. The existence regime of such a structure is mapped out in terms of separation, relative phase, and energy.

### CW3F • Opto-mechanical Systems II—Continued

**CW3F.8 • 18:15**
**New Directions in High-Q Optomechanical Membrane Resonators,** Pen-Li Yu[1], Thomas P. Purdy[1], Garrett D. Cole[2], Cindy A. Regal[1]; [1]*JILA, University of Colorado and National Institute of Standards and Technology, USA;* [2]*Vienna Center for Quantum Science and Technology and University of Vienna, Austria.* We study methods to improve the Q of a variety of highly-stressed resonators for cavity optomechanics. We realize ultrahigh-Q metal/SiN membranes and crystalline membranes, and have begun to control external loss via modified support structures.

### CW3G • Nano and Polariton Lasers—Continued

### CW3H • Ultrafast Nonlinear Optics—Continued

**CW3H.6 • 18:15**
**Compressible supercontinuum generation by two-color excitation in the group velocity horizon,** Ayhan Demircan[1], Shalva Amiranashvili[2], Carsten Bree[2], Gunter Steinmeyer[3]; [1]*Invalidenstr. 114, Germany;* [2]*Weierstrass Institute for Applied Analysis and Stochastics (WIAS), Germany;* [3]*Max-Born-Institut (MBI), Germany.* A novel two-color excitation scheme is discussed for generation of broadband white-light continua with superior coherence properties in photonic crystal fibers. These continua promise compression into the single-cycle regime.

NOTES

## CLEO: Applications & Technology

### AW3I • OCT: Technology Development and Applications—Continued

**AW3I.7 • 18:15**
**Extended focus optical coherence tomography with optical fiber based Bessel beam illumination,** Dora Juan Juan Hu[1,2], Lu Yan[3], Paul Steinvurzel[3], Michalina Gora[1], Weina Lu[1], Siddharth Ramachandran[3], Yixin Wang[3], Guillermo J. Tearney[1]; *[1]Wellman Center for Photomedicine, Massachusetts General Hospital, USA; [2]RF and Optical Department, Institute for Infocomm Research, Singapore; [3]Department of Electrical and Computer Engineering, Boston University, USA.* We demonstrate an extended depth of focus (DOF) for optical coherence tomography (OCT) using a Bessel-like higher order fiber mode. The DOF is enhanced by 7× and the lateral resolution is about 10 μm.

## JOINT

### JW3J • Symposium on High Power Diode Laser Arrays: Technology and Applications:High Power Diode Laser Arrays II—Continued

## CLEO: Science & Innovations

### CW3K • Advanced THz Emission Mechanisms—Continued

**CW3K.7 • 18:15**
**Plasmonic Terahertz Monochromatic Coherent Emission from an Asymmetric Chirped Dual-Grating-Gate InP-HEMT with a Photonic Vertical Cavity,** Takayuki Watanabe[1], Akira Satou[1], Tetsuya Suemitsu[1], Wojciech Knap[2], Viacheslav V. Popov[3], Taiichi Otsuji[1]; *[1]Research Institute of Electrical Communication, Tohoku University, Japan; [2]LC2 Laboratory, Université Montpellier 2 & CNRS, France; [3]Kotelnikov Institute of Radio Engineering and Electronics, Russian Academy of Sciences, Russian Federation.* We designed and fabricated InP-based high electron mobility transistors featuring an asymmetric chirped dual-grating-gate structure which greatly enhances plasma instability, resulting in intense monochromatic superradiant emission at 3.55 THz at 140K for the first time.

### CW3L • Atmospheric Sensing—Continued

**CW3L.7 • 18:15**
**Optical Parametric Oscillator based detection of HCN for bio-medical applications,** Denis Arslanov[1], Yuwei Jin[1], Julien Mandon[1], Simona M. Cristescu[1], Frans J. M. Harren[1]; *[1]Molecular and Laser Physics, Radboud Universiteit Nijmegen, Netherlands.* A cw OPO, combined with photoacoustic spectroscopy, is used for the detection of HCN emission from leaves, seeds and Pseudomonas bacteria; next to its presence in human breath, with a detection limit of 0.4 ppbv (10s).

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**CW3M • Single Frequency Fiber Lasers—Continued**



**QW3N • Waveguide & Plasmonics—Continued**

**QW3N.8 • 18:15**

**Loss-Proof Self-Accelerating Plasmons and Exponentially Growing Beams,** Ran Schley[1], Ido Kaminer[1], Rivka Bekenstein[1], Guy Bartal[2], Mordechai Segev[1]; [1]*Physics, Technion Israel Institute of Technology, Israel;* [2]*Electrical Engineering, Technion Israel Institute of Technology, Israel.* We introduce a new class of 1 & 2-dimensional beams that overcome both diffraction & absorption, enabling accelerating plasmons that maintain their intensity profile. In free space these beams exhibit a counterintuitive exponential intensity growth.



**CW3O • Optical Materials and Devices II—Continued**

**CW3O.7 • 18:15**

**Broadband saturable and reverse saturable absorption in graphene-based nanocomposites,** Saima Husaini[1], Jonathan E. Slagle[2], Joel M. Murray[1,3], Shekhar Guha[1], Leonel P. Gonzalez[1], Robert G. Bedford[1]; [1]*Sensor's Directorate/Materials and Manufacturing Directorate, Air Force Research Laboratories, USA;* [2]*Science Applications International Corp, USA;* [3]*UES Inc., USA.* Nonlinear optical studies are carried out on graphene-based polymer composites in the nanosecond and picosecond temporal regime. These graphene-composites demonstrate saturable absorption followed by reverse saturable absorption which depends on graphene content and operation regime.

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