Triply-resonant Continuous Wave Parametric Source with a Microwave Pump

We present experimental results of temporally and spectrally resolved transmission measurements of a photonic crystal cavity using two-color pump-probe technique. With a gated spectral measurement, we measure the resonance shift's dependence on pump power.

Spectrally and Temporally Resolved Resonance Shifts of a Photonic Crystal Cavity Switch

We demonstrate a record high normalized conversion efficiency of 3*10^-6 in coupled high-Q photonic crystal resonators, owing to resonantly enhanced four wave mixing. The rate of spontaneously emitted photons reaches 14 MHz.

Parametric gain assisted by free-carriers population oscillations in a photonic crystal cavity

We investigate experimentally how nonlinear absorption in a photonic crystal cavity all-optical switch can turn into in a large BdB parametric gain. A numerical model is proposed to take into account this new gain effect.

Spontaneous photonic super-crystals in composite ferroelectrics

Diffraction indicates a 3D linear, electro-optic, and nonlinear structure driven by the 1D electromagnetic field by a plasmonic structure. We discuss relevant designs and possible applications.

Theory of Frequency Comb Generation in Cavity Enhanced Second Harmonic Generation

We present experimental results of temporally and spectrally resolved transmission measurements of a photonic crystal cavity using two-color pump-probe technique. With a gated spectral measurement, we measure the resonance shift's dependence on pump power.

Toward the Realization of On-chip Plasmon Enhanced ODMR Measurements

We report on the observation of nanodiamond magnetic resonance measurements at the far end of a silver nanorod. Our results may pave the way for the realization of on-chip plasmonic enhanced magnetic sensing.

Optomechanical Quantum Control of a Nitrogen Vacancy Center in Diamond

We present the first measurements of optomechanical ring resonators at room temperature and 4.2 K, demonstrating their large cooperativities with potential for optomechanical feedback cooling to near the quantum ground state.

Symmetry Breaking in Membrane Optomechanics

A tailorable mechanical potential for a dielectric membrane is created using two laser fields driving a "membrane-in-the-middle" optical cavity. Multiple stable points can be realized, and buckling transitions are observed when the optical power crosses a stability boundary.

Symmetry Breaking in Membrane Optomechanics

We present the first measurements of optomechanical ring resonators at room temperature and 4.2 K, demonstrating their large cooperativities with potential for optomechanical feedback cooling to near the quantum ground state.
**FM1D.4 • 08:00**

Photonic Hypercrysalts for Controlled Enhancement of Radiation from Quantum Emitters, Tal Galay1,2, Eugene E. Narimanov1, Vinod M. Menon1,2,1; Physics, City College of New York, USA; 2Physics, Graduate Center of the City Univ. of New York, USA; 3School of Computer and Electrical Engineering, Birck Nanotechnology Center, Purdue Univ., USA.

We demonstrate an active quantum-dot-embedded two-dimensional photonic hypercystal that shows 20x enhancement in spontaneous emission rate due to the hyperbolic dispersion and 100x enhancement in light out-coupling due to the photonic-crystal component.

**FM1D.2 • 08:15**

Second-Harmonic Generation from ZnO / Al2O3 Laminate Optical Metamaterials Grown by Atomic-Layer Deposition, Andreas Wickberg1, Clemens Kueninger1, Christoph Jurges1, Christian Kost1, Martin Wiegerinck1; Inst. of Applied Physics and Inst. of Nanotechnology, Karlsruhe Inst. of Technology, Germany; 2Inst. of Photonics and Quantum Electronics, Karlsruhe Inst. of Technology, Germany; 3Physikalisches Institut, Karlsruhe Inst. of Technology, Germany. We show how the second-order nonlinear optical properties of nanolaminates fabricated by atomic-layer deposition can be controlled and enhanced. An optimized metamaterial shows a second-order nonlinear susceptibility of $\chi_{zzz}^{(2)} = -4.47$ pm/V.

**FM1D.3 • 08:30**

Ultrafast Nonlinearities Driven by Magnetic Response in All-Dielectric Nanostructures, Maxim R. Schcherbakov1, Polina Vabishechiv1, Alexander S. Shorokhov2, Elizaveta V. Melik-Gaykazyan1, Kate E. Chung3, Duk-Yong Choi1, Isabelle Staude1, Andrei E. Mirashchenko2, Dragomir N. Neshev4, Andrei Fedyanin5, Yuri S. Kivshar6, 1; Moscow State Univ., Russia; 2Nonlinear Physics Centre, Research School of Physics and Engineering, The Australian National Univ., Australia; 3Lasers Physics Centre, Research School of Physics and Engineering, The Australian National Univ., Australia. We characterize the ultrafast nonlinear optical properties of subwavelength silicon nanoparticles with magnetic dipolar response by means of the third-harmonic spectroscopy and pump-probe measurements.

**FM1D.4 • 08:45**

Photonic Titanium Nanocrystals and Momentum Band-Gaps, Amir Shaltou1, Jieran Fang1, Alex Kildishev2, Vladimir M. Shalaev2, 1Purdue Univ., USA. Temporarily periodic photonic-crystals develop an a(\k) dispersion relation with momentum band-gaps, and offer new physical effects including frequency conversion, time-reversal and other optical phenomena in addition to their temporal control.

**FM1D.5 • 09:00**

Nanoplasmonics: Exploring Nonlocal and Quantum Effects, N. Ager Mortensen1,2; Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark; 2Center for Nanostructured Graphene, Technical Univ. of Denmark, Denmark. Plasmonics is commonly understood within classical electrodynamics with local-response constitutive relations. However, possibilities for nonlocal dynamics and quantum effects emerge with strong spatial confinement in plasmonic nanostructures. This talk reviews recent theory and experiments developments.
Heterogeneous III-V / Si Photonic Integration
Presider: Christian Koos; Karlsruhe Inst. of Technology KIT, Germany

Fully CMOS-Compatible Integrated Distributed Feedback Laser with 250 °C Fabricated AlOx:Er³⁺ Gain Medium, Emil S. Magden, Purnawirman Purnawirman, Nanxi Li, Gurpreet Singh, Jonathan D. B. Bradley, Gale S. Petrich, Gerald Leake, Douglas Coolbaugh, Michael Watts, Leslie A. Kolodzeyski; IMT, USA; "College of Nanoscale Science and Engineering, USA. We demonstrate a DFB laser with a record low temperature (250 °C) fabrication process of low-loss (<0.1 dB/cm) amorphous AlOₓ:Er³⁺ gain medium by utilizing the substrate bias, facilitating laser integration in a fully CMOS-compatible platform.

Microcavity-Stabilized Quantum Cascade Laser, Simone Borri, Mario Siciliani de Cumis, Giacomo Insero, Saverio Bartalini, Pablo Cancio, Davide Mazzotti, Iacopo Galli, Giovanni Giussfeldi, Gabriele Santambrogio, Davide D’Ambrosio, Anatoly Savchenko, Danny Elisah, Vladimir Ilichenko, Naoto Akikusa, Andrey Matsko, Lute Maleki, Paolo De Natale; “INO-CNRS, Italy; “LENS, Italy; “INRIM, Italy; “C/OWaves, USA; “Hamamatsu, Japan. A Cbf, whistleblpering gal- lery mode microresonator is used for frequency stabilization and linewidth narrowing of a mid-IR quantum cascade laser. Sub-Doppler recording of a CO transition demonstrates the suitability of the system for high-resolution spectroscopy.

Measurement of the frequency stability of a quantum cascade laser frequency comb, Francesco Cappelli, Giulia Campo, Iacopo Galli, Giovanni Giussfeldi, Saverio Bartalini, Davide Mazzotti, Pablo Cancio, Simone Borri, Borisov Hinkov, Jérôme Faist, Paolo De Natale; “CNR-INO, Italy; “NICT, Japan. We report on phase-locking of a THz-QCL by a Mach-Zehnder-modulator based flat comb generator (MZ-FCG). We report on phase-locking of a THz-QCL by using the MZ-FCG.

Carrier-envelope offset frequency stabilization in a femtosecond optical parametric oscillator without nonlinear interferometry, Karolis Baltkus, Melissa Fleming, Richard A. McCracken, Zhaowei Zhang, Derryck T. Reid, "Heriot-Watt Univ., UK. The carrier-envelope offset frequency of signal pulses in a femtosecond optical parametric oscillator was stabilized with a position-sensitive photodiode. The technique is easily implemented, requires no nonlinear interferometry and has a wide capture range.

Multi-GHz Mode-Locked Lasers and Comb-Resolved Spectroscopy, Mamoru Endo, Shuntaro Tani, Yohei Kobayashi; “The Inst. for Solid State Physics, The Univ. of Tokyo, Japan. A femtosecond optical frequency comb with a maximum repetition frequency of 15 GHz was developed and successfully applied to comb-resolved spectroscopy, as well as the manipulation of acoustic phonons in a silica fiber.

Novel saturable absorbers for mode-locked Tm:ZBLAN waveguide chip lasers, Xiantao Jiang, Simon Gross, Han Zhang, Zhanion Gou, Fabian Rotermund, Dong-Il Yeom, Michael Withford, Alexander Fuehrbach, “Macquarie Univ., Australia; “Shenzhen Univ., China; “Apu Univ., Korea. Novel saturable absorbers based on carbon nanotubes, graphene, topological insulators, transition metal dichalcogenides and black phosphorus were fabricated and characterized. Their performance for short pulse generation in Tm:ZBLAN waveguide chip lasers was analyzed.

Sub-10 fs pulses from Er:fiber laser passively mode-locked at 1.872 GHz by acoustic resonance in solid-core PCF, Wenbin He, “Hong Kong Polytechnic University, China; “Yunnan Normal University, China; “The University of Tokyo, Japan. We present the first Kerr-lens mode-locked Yb²⁻:Lu₂O₃ thin-disk laser, Bernhard Kreipe, José Andrade, Bastian Deppke, Christian Kränkel, Uwe Morgner; “Leibniz Universität Hannover, Germany; “Laser Zentrum Hannover e.V., Germany; “Institut für Laserphysik, Universität Hamburg, Germany; “The Hamburg Centre for Ultrafast Imaging, Germany. We present the first Kerr-lens mode-locked Yb²⁻:Lu₂O₃ thin-disk laser in clean mode-locking operation. We obtained 165 fs with 0.1 μJ pulse energy and 60 MHz repetition rate.
Micro-ring Resonator Filter, High-resolution On-chip Spectrometer with a Tunable AM1J.2 • 08:30 logical Univ., Singapore; 2Inst. of Microelectronics, Singapore.

Oxygen Detection, Cavity Ring Down Faraday Rotation Spectroscopy for AM1J.3 • 08:45

Spectroscopy, AM1J.1 • 08:00 Inc., USA

Presider: Andrew Sappey; Zolo Technologies, USA; 2Tiger Optics, USA.

A high-resolution on-chip spectrometer is demonstrated with a resolution of 0.15 nm and a bandwidth of 19 nm are realized. The physics, status, applications, and prospects of table-top soft x-ray lasers are reviewed. A tunable micro-ring resonator filter by exploiting the thermo-optic effect and high quality factor of micro-ring resonator. A resolution of 0.15 nm and a bandwidth of 19 nm are realized.

Jorge Rocca is a University Distinguished Professor in the Departments of Electrical and Computer Engineering and of Physics at Colorado State University. His research interests are in the physics and development of compact X-ray lasers and their applications, the development of high power lasers, and the study of high power laser interactions with matter. His group is known for contributions to the development of bright table-top soft x-ray lasers, including the demonstration of the first table-top soft x-ray laser, and their application in several fields. Recently his group demonstrated an 100 Hz repetition rate soft x-ray laser excited by a diode-pumped high energy chirped pulse amplification laser. He has published 240 peer-review journal articles, and has given more than 150 invited talks on these topics. Rocca received the Arthur. L. Schawlow Prize in Laser Science from the APS in 2011 and the Willis Lamb Prize for Laser Science and Quantum Optics in 2012. He was elected Fellow of the APS, the OSA, and the IEEE, and received an IEEE LEOS Distinguished Lecturer Award. Early in his career he was an NSF Presidential Young Investigator.

Simultaneous Sampling of Electric Field Quadratures in the Time Domain, Claudius Riek1, Philipp Sulzer1, Maximilian Seeger1, Denis Seletskiy1, Alfred Leitenstorfer1,1; Univ. of Konstanz, Germany. We directly detect the multi-terahertz vacuum field and analyze its dependence on the probed space-time volume. A scheme for sensing the time derivative of the field enables timedomain quantum tomography with simultaneous sampling of both quadratures.

Jorge Rocca is a University Distinguished Professor in the Departments of Electrical and Computer Engineering and of Physics at Colorado State University. His research interests are in the physics and development of compact X-ray lasers and their applications, the development of high power lasers, and the study of high power laser interactions with matter. His group is known for contributions to the development of bright table-top soft x-ray lasers, including the demonstration of the first table-top soft x-ray laser, and their application in several fields. Recently his group demonstrated an 100 Hz repetition rate soft x-ray laser excited by a diode-pumped high energy chirped pulse amplification laser. He has published 240 peer-review journal articles, and has given more than 150 invited talks on these topics. Rocca received the Arthur. L. Schawlow Prize in Laser Science from the APS in 2011 and the Willis Lamb Prize for Laser Science and Quantum Optics in 2012. He was elected Fellow of the APS, the OSA, and the IEEE, and received an IEEE LEOS Distinguished Lecturer Award. Early in his career he was an NSF Presidential Young Investigator.

We review our recent work on the experimental characterization and numerical simulations of the temporal structure of plasma-based XUV laser pulses. We will discuss both the amplification of spontaneous emission mode and the injection-seeded mode, where a femtosecond high-order harmonic pulse triggers a dynamical response of the amplifier plasma.

Optimal tuning fork for Quartz Enhanced PhotoAcoustic Spectroscopy, Guillaume Aoust1, Helen Waechter1, Gerard Wysocki1, David Jessop1, Stephen Kindness1, Christian W. Sol1, Yuonan Gu1, Huangren Lin1, Axel J. Zei1, Philipp Braeuninger-Weimer1, Stephan Holmann1, Harvey Beere1, David Ritchie1,1 Physics, Univ. of Cambridge, UK; 2Engineering, Univ. of Cambridge, UK; 3Chemical Engineering and Biotechnology, Univ. of Cambridge, UK; 4Engineering, Univ. of Lancaster, UK. We present a fast room temperature terahertz detector based on interdigitated bow-tie antennas asymmetrically doping and contacting graphene. The device was tested with a 2 THz quantum cascade laser yielding a responsivity of 0.5 μA/W.

Computationally-assisted THz dual-comb spectroscopy using quantum cascade laser frequency combs, Ying Yang1, David Burhoff1, John L. Reno2, Qiang Hu3,4; MIT, USA; 2Sandia National Labs, USA. Utilizing the Kalman filter-based averaging scheme, we demonstrated THz dual-comb spectroscopy covering 282 GHz at –2.8 THz with unquantized stabilized quantum cascade laser frequency combs. The peak signal-to-noise ratio(SNR) is 60 dB within 100 us averaging.

Absolute frequency measurement and phase-locking of a THz QCL with two 10 GHz frequency combs, Oliver Klieberisch1, Dirk C. Hennecke1, Thomas Dekorsy2, Hua Li1, Carlo Sirton1, Giorgio Santarelli2, Stefano Barbieri2,1; Université Paris Diderot, France; 2Laboratoire Photonique, Numérique et Nanosciences, Université Bordeaux, France. Dual-comb sampling of an actively mode-locked phase-stabilized THz quantum cascade laser with 10 GHz Ti:sapphire frequency combs provides a method to directly determine the absolute frequency of the QCL with Hz-level precision.
Monday, 6 June

Meeting Room 212 C
CLEO: Science & Innovations

08:00–10:00
SM1M • Petawatt Laser Systems and Technology
Presider: Jake Bromage; Univ. of Rochester, USA

SM1M.1 • 08:00
Key Technologies and Experiments of XCELS Project, Alexandre M. Sergeev 1,2,3
1 Inst. of Applied Physics, Russia. We discuss key technologies that enable achieving subexawatt peak power in femtosecond pulses and design experiments on laser-matter and laser-vacuum interactions at intensity $10^{21} - 10^{22}$ W/cm².

SM1M.2 • 08:30
Polarization Encoded Chirped Pulse Amplification in Ti:sapphire – a Way Towards Few Cycle PW Lasers, Mikhail P. Kalashnikov 1,2,3, Xuobao Cao 4, Karoly Osvay 5, Vladimir Chvykov 1, Nikita Khodakovskiy 1, ROLAND NAGYMHALY 1, Max Born Inst., Germany; 2,3 Max-Born-Inst., Germany; 2 ELI-Hu Newton Ferchaud, Vietnam; 3 ELI-He Niki, Hungary. The new technique of polarization encoded amplification (PE-CPA) allows to resolve the problem of gain narrowing in Ti:Sapphire amplifiers. This can allow multi-juke pulses with bandwidth of ~200nm, making few cycle PW Ti:Sapphire systems feasible.

SM1M.3 • 08:45
Development of 0.1 Hz 4.0 PW Laser at CoReLS, Jae Hee Sung 1, Seong Ku Lee 1,2,3, Joon Young Lee 1,2,3, Chang Hee Nam 1,2,3. Center for Relativistic Laser Science, Inst. for Basic Science, Korea; 2 Advanced Photonics Research Inst., GIST, Korea; 3 Dept. of Physics and Photon Science, GIST, Korea. A 0.1 Hz 4.0 PW Ti:sapphire laser is being developed for research on relativistic laser-matter interactions. The development will be achieved by increasing the pulse energy to 84 J and decreasing the pulse duration to 21 fs.

SM1M.4 • 09:00
High Contrast CEP-Stable OPCPA Front-end For PW-Class Ti:Sapphire System, Alexandre Thai 1, Emilien Gontier 2, Clément Ferchaud 1, Pierre-Mary Paul 2, Franck Falcoz 2, Nicolas Forget 1, Fastlite, France; 2 Amplitudes Technologies, France. We demonstrate a hybrid OPCPA/CPA front-end for PW Class Ti:Sapphire systems delivering 3 mJ, 27 fs, CEP-stable pulses at ~800 nm with a temporal contrast exceeding $2 \times 10^{10}$ and $80$ mrad CEP fluctuations.

Meeting Room 212 D
CLEO: QELS-Fundamental Science

08:00–10:00
FM1N • Quantum Enabling Technologies
Presider: Virginia D’Auria; Université Nice Sophia Antipolis, France

FM1N.1 • 08:00
Efficient Spectral Bandwidth Compression of Single Photon Wavepackets, Michal Karpiński 1,2,3, Michal Jachura 1, Brian J. Smith 1, Céladon Lab, Univ. of Oxford, UK; 2 Faculty of Physics, Univ. of Warsaw, Poland; 3 SXRJ spectral bandwidth compression of single photon wavepackets by means of electro-optic time lens is experimentally demonstrated. We significantly increase single photon flux through a narrowband spectral feature, making a key step in development of hybrid quantum networks.

FM1N.2 • 08:15
Measurement of the Aharonov-Andan phase in photonic lattices, Kai Wang 1,2,3, Steffen Weimann 1,3, Armando Perez-Leija 1, Alexandre M. Sergeev 1,2,3, Brian J. Smith 1, Céladon Lab, Univ. of Oxford, UK; 2 Faculty of Physics, Univ. of Warsaw, Poland; 3 MAX light Institute for Applications of Photonics, Russia. We demonstrate a hybrid OPCPA/CPA front-end for PW laser development will be achieved by increasing the pulse energy to 3 mJ, 27 fs, CEP-stable pulses and design experiments on laser-matter and laser-vacuum interactions at intensity $10^{21} - 10^{22}$ W/cm².

FM1N.3 • 08:30
Quantum information using a single excitation: Steering photonic path entangled states, Fernando Monteiro 1, Thiago Guerreiro 2, Anthony Martin 1, Jonatan B. Brask 1, Tamas Vertesi 3, Boris Korzh 4, Misael Caloz 4, Felix Bussieres 4, Varun Verma 4, Adriana Lita 4, Richard Mirin 4, Sae Woo Nam 4, Francisco Marsili 5, Matthew Shaw 5, Nicolas Gisin 5, Nicolas Brunner 5, Hugo Zbinden 5, Rob Thew 5, GAP, Univ. of Geneva, Switzerland; 2 Inst. of Nuclear Research of the HAS, Hungary; 3 Univ. of Geneva, Switzerland; 4 NIST, USA; 5 Jet Propulsion Lab, USA. We use single-photon path-entangled states combined with a novel displacement-based detection scheme to demonstrate loop-hole-free quantum steering, opening the way towards implementations of device-independent quantum protocols within the paradigm of path entanglement.

FM1N.4 • 08:45
Weak Measurements Compressed Sensing Quantum State Tomography, Dikla Oren 1, Tania C. Elidar 1,5,7,3, Mordechai Segev 3,7, Technion Israel Inst. of Technology, Israel. We show that prior knowledge that a quantum state is close to a pure state enables a direct and efficient measurement of the density matrix representing the state, using the weak measurements methodology.

FM1N.5 • 09:00
Bragg gratings will improve signal-to-noise in $\chi^{(2)}$ degenerate photon-pair generation, Lukas G. Hell 1,2, Agata Branczyk 3, Viola Introna 4, Marco Liscidini 5, Michael Steel 1, Macquarie Univ., Australia; 2 Perimeter Inst. for Theoretical Physics, Canada; 3 Universita degli Studi di Pavia, Italy. Dual-pump photon-pair sources typically suffer from parasitic pair production. To circumvent this, we propose and design a source in which parasitic pairs are suppressed by proper engineering of photonic band gaps in a Bragg grating.

Marriott Salon I & II
CLEO: Science & Innovations

08:00–10:00
SM1O • Symposium on Stain-free Imaging Microscopy for Basic Research and Clinical Applications I
Presider: Xingde Li; Johns Hopkins Univ., USA

SM1O.1 • 08:00
Invited
Slide-Free (But Not Necessarily Stain-Free) Microscopy via UV Excitation, Richard M. Levenson 1, Zachary Hammary 1, Farzad Fereidouni 2, Statovs Demas 3, Univ. of California Davis, USA; 2 Lawrence Livermore National Lab, USA. We describe MUSE (Microscopy using Ultraviolet Surface Excitation) – a novel, non-destructive, slide-free, inexpensive and rapid microscopic technique that provides diagnostic-quality images directly from fresh or fixed tissues without freezing, paraffin-embedding, or thin-sectioning.

SM1O.2 • 08:30
Invited
Bio-inspired Polarization Imaging Sensor for Label-Free Applications, Viktor Gruev 1, Washington Univ. in St Louis, USA. I will present our latest efforts on developing a bio-inspired polarization sensor by integrating metallic nanowires with low noise CCD imaging sensors. These sensors are used for in-vivo label-free neural recordings from the locust antenna lobe.
SM1P.1 • 08:00
Broadband Multimode Fiber Spectrometer. Seng Fatt Liew 1, Brandon Redding 1, Michael Choma 1, Heman D. Tagare 1, Hui Cao 1, Yale Univ., USA. Using a wavelength division multiplexer, we increase the spectral bandwidth of a multimode-fiber-based spectrometer to 100nm with the spectral resolution of 0.05nm. An effective algorithm is developed to achieve fast, accurate reconstruction of diversified spectra.

SM1P.2 • 08:15
Quantum Dots Fiber Laser with Azimuthally Polarized Radial Emission. Nan Zhang 1, He Liu 1, Alexander M. Stolyarov 1, Yoel Fink 1, Xiaowei Sun 1, Lei Wei 1, 2, Nanyang Technological Univ., Singapore; 2CINTRA, Singapore; 3MIT, USA. We demonstrate a cylindrically symmetric radial laser emission from a CdSe/CdS/ZnS quantum dots doped hexane plug in an omnidirectional photonic-bandgap fiber cavity. The lasing threshold, polarization dependence and quality factor of lasing mode are characterized.

SM1P.3 • 08:30
Optical fiber lens with parabolic effective index profile fabricated using focused ion beam, Henrik Melkonyan 1,2, Anatol Khilo 1,2, Nan Zhang 1,2, Xiaowei Sun 1,2, 1Electro-Optics pro-

SM1P.4 • 08:45
In-fiber all-optical modulation based on an enhanced light-matter interaction with graphene, Haojie Zhang 1, Noel Healy 1, Li Shen 1, Chung C. Huang 1, Dan Hewak 1, Anna C. Peacock 1, 1Univ. of Southhampton, UK; 2Newcastle Univ., UK. A graphene-based, high speed, in-fiber optical modulator has been demonstrated on a low-loss side-polished optical fiber platform. These results highlight the potential for robust and efficient integration of low-dimensional materials within standard telecom fibers.

SM1P.5 • 09:00
Compact, Fiber-based Kerr Lens Saturable Absorber, Long W. Wang 1, Andy Chong 1, 2, J.W. Haus 1, 2, Electro-Optics program, Univ. of Dayton, USA; 2Physics Dept., Univ. of Dayton, USA. We report numerical simulations on a fiber compatible saturable absorber design based on Kerr lens effect. The transmission is calculated for such device as a function of beam power and fiber design.

SM1C.1 • 08:00
10 W, 10 GHz, femtosecond pulses from a very-large-mode area Er-doped fiber amplifier, Jeffrey W. Nicholson 1, Raja Ahmad 1, Anthony DeSantolo 1, 1OF5 Labs, USA. We demonstrate amplification of 10 GHz, sub-picosecond pulses to 100 W average power from a very-large-mode-area, Erbium-doped fiber amplifier.

SM1C.2 • 08:15
Broadband Silica-Based Thulium Doped Fiber Amplifier Employing Dual-Wavelength Pumping. Junjia Wang 1, Sijing Liang 1, Yongmin Jung 1, Qiongyue Kang 1, Shafi-ul Alam 1, David J. Richardson 1, 1ORC Univ. of Southhampton, UK. We report a broadband and gain-flattened silica-based thulium-doped fiber amplifier with dual-wavelength pumping (790 nm + 1600 nm). 15dB gain bandwidth is more than 220 nm ranging from 1700 to 1920 nm with a maximum gain of 29dB and a noise figure of less than 5dB.

SM1C.3 • 08:30
Integrated Two-Color Femtosecond Chirped-Pulse Fiber Amplification System at Wavelengths of 1050 and 1550 nm. Dai Yoshitomi 1,2, Jingwei Wu 1, 2, Jun Yin 1, Nikolaï J. Zehnder 1, 2, Cesare Soci 1, 2, 1Nanyang Technological Univ., Singapore; 2Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore. We report the first dielectric metamaterials' nanostructure from solution-processed organolead halide perovskite thin films. Metamaterials exhibit strong resonances tunable by design across the visible spectrum, aiming applications in enhanced photovoltaics and high-density photonic devices.

SM1C.4 • 08:45
Noise suppression in Yb-doped single-frequency fiber laser by an optical passive-feedback loop, Yukin Hou 1, Qian Zhang 1, Jing Wang 1, Pu Wang 2, 1Beijing Univ. of Technology, China. The frequency and intensity noise of a Yb-doped single-frequency distributed Bragg reflector fiber laser are effectively reduced by a simple, passive-feedback, optical loop, which consists of only two optical couplers. The linewidth is compressed from 3.6 kHz to 540 Hz.

SM1C.5 • 09:00
Power scaling of single-frequency fiber amplifiers at 976 nm, Jingwei Wu 1, Xishan Zhu 1, Valery Temyanko 1, 1Electro-Optics program, Univ. of Dayton, USA; 2Physics Dept., Univ. of Dayton, USA. Cladding pumped single-frequency Yb3+-doped fiber amplifiers at 976 nm were investigated. Over 4 W output power was obtained and further power scaling can be achieved by reducing the cladding diameter of the Yb3+-doped fiber.

SM1R.1 • 08:00
High Color-Conversion Efficiency CdSe Quantum Dots Hybrid Light Emitting Diode, Che-Yu Liu 1, Hao-Chung Kuo 1, Tsung Sheng Kao 2, Tao-Pei Chen 1, 1National Chiao Tung Univ., Taiwan, Taiwan. LED with nanorods structures fabricated at specific locations, generating functional nanostructured LEDs for high-efficiency light-emitting performance. With such a structured LED, the color-conversion efficiency of the existing quantum dots can be enhanced up to 12.5 %.

SM1R.2 • 08:15
Tuning Light with Photonic Particles, Roxana Rezvani Naranghi 1,2, Guangming Tao 1, Joshua J. Kaufmann 1, Soroush Shababangi 1, Sergey Sukhov 2, Ayman Abouraddy 1, Aristotle Doganis 1, 1CREOL, The College of Optics and Photonics, Univ. of Central Florida, USA; 2Physics, Univ. of Central Florida, USA. Modifying the internal nano-scale geometry of all-dielectric particle allows tuning their optical scattering characteristics such as extinction cross section, directivity and polarization beyond those afforded by their constitutive materials.

SM1R.3 • 08:30
Fast and scalable synthesis of lead halide perovskite nanowires for tunable room-temperature nanolasers, Jian-Nao Zheng 1, Jing Jing Wang 1, Hui Nian 1, 1Masdar Institute of Science and Technology, United Arab Emirates. We report a new method for synthesizing perovskite nanowires. Tunable lasing is realized in these nanowires. Our findings demonstrate that the simple synthesized perovskite nanowires may hold the key to realizing on-chip coherent light sources.

SM1R.4 • 08:45
Perovskite Metamaterials, Behzad Gholidoust 1, Giorgio Adamo 2, Daniele Cartocci 1, Harsh N. Swaha Krishnamoorthy 3, Jun Yin 1, Nikolaï J. Zehnder 1, Cesare Soci 1, 1Nanyang Technological Univ., Singapore; 2Univ. of Southhampton, UK; 3Centre for Disruptive Photonic Technologies, Nanyang Technological Univ., Singapore. We report the first all-dielectric metamaterials' nanostructured from solution-processed organolead halide perovskite thin films. Metamaterials exhibit strong resonances tunable by design across the visible spectrum, aiming applications in enhanced photovoltaics and high-density photonic devices.
We have reported an experimental study of Kerr effect in microspheres. Our devices suggest cladding can enhance or inhibit intrinsic nonlinearities through electric field-induced second harmonic (EFISH) contribution.

We study the coherent comb formation by a bichromatic pump and detail noise state transitions by detuning the seeding. We also show comb spacing in a coherent division and clockworks. The work paves a way to realizing high-speed phase-locked RF-optical frequency comb oscillators.

We present a new class of silicon hybrid gap plasmon waveguides that we have recently developed. Using this technology, we have demonstrated a high-quality factor of 1.4 million in narrow-gap waveguides with enhanced quantum yield in the visible spectrum. This novel platform offers a route to the realization of on-chip quantum computers.

We have investigated the influence of dielectric cladding for transient optomechanically induced transparency in a silica microsphere, which is a key element in many optical devices. Our results suggest that cladding can enhance or inhibit intrinsic nonlinearities through electric field-induced second harmonic (EFISH) contribution.

Our work demonstrates the feasibility of using silicon waveguides for the development of high-performance photonic devices, opening new possibilities for the integration of optoelectronic circuits on a single chip.
SM1E • Integrated Nonlinear Photonics—Continued

SM1E.6 • 09:15
Direct RF-to-Optical Detection by Plasmonic modulator integrated into a four-leaf-clover antenna, Yannick Sala-min1, Wolfgang Heni1, Yury Fedoryshyn1, Christian Haffner1, Claudia Hoessbacher1, P. V. Johnstone1, Delwin L. Elder2, Romani Bonjour3, Marco Zahrer1, Raphael Cottier1, Andreas F. Tillack1, Larry R. Dalton1, Christian Haffner2, Juerg Leuthold1; 1ETH Zurich, Switzerland; 2Departement of Chemistry, Univ. of Washington, USA. We report on a plasmonic modulator integrated into a four-leaf-clover antenna. The antenna provides electric field enhancement of 92'000 in the active part of the modulator, which allows efficient conversion of millimeter-wave signals into the optical domain.

SM1E.7 • 09:30
Design and Characterization of High Efficiency Nano-Antenna Couplers, Qian Gao1, Fanghui Ren1, Alan X. Wang1; 1Oregon State Univ., USA. We present the design and characterization of three ultra-compact nanoantenna couplers integrated on plasmonic slot waveguides. Light is coupled from a lensed fiber and the couple-out efficiencies are measured to be from 30% to 46%.

SM1E.8 • 09:45
Raman-Like Stimulated Brillouin Scattering in SiN Waveguides, Razi Dehghannasiri1, Ali A. Eftekhar1, Ali Adibi1, Xiao Sun2,3; 1Georgia Tech, USA. We present stimulated Brillouin (SBS) scattering in SiN based on combining optical waveguides with pillar-based phononic crystals. We utilize breathing modes inside the phononic crystals that strongly interact with optical modes, enabling low-threshold GHz SBS.

SM1F • Waveguides & Passive Devices—Continued

SM1F.6 • 09:15
Fluorescence Imaging of Waveguide Mode Beating and Propagation in Tapered and Bend Regions, Brian D. Jennings1,2, Nicolas Abadia1,2, Chuan Zhaing1,2, Ertugrul Karamdem1,2, David McCloskey1,2, John F. Donegan1,2; 1School of Physics, Univ. of Dublin Trinity College, Ireland; 2Centre for Research on Adaptive Nanostructures and Nanodevices, Ireland. Propagation of light through planar waveguides is important for photonic integrated circuits. Experimentally imaging light intensity within multimode waveguides shows how different modes interfere. These images can be used to determine waveguide properties.

SM1F.7 • 09:30
An Integrated Mode (De)Multiplexer Based on Adiabatic Couplers, Chunlei Sun1, Yu Yu1, Mengyuan Ye1, Lei Shi1, Xinliang Zhang1; 1Wuhan National Lab for Optoelectronics, China. A novel broadband mode-division multiplexing link based on adiabatic couplers is proposed and experimentally demonstrated with crosstalk < -20 dB, insertion loss < 1 dB and power penalty < 1 dB, using Silicon integrated platform.

SM1F.8 • 09:45
Low Insertion Loss Hybrid Plasmonic TE-pass Polarizer, Xiao Sun1, Mo Mojahedi1, J. Stewart Aitchison1; 1Univ. of Toronto, Canada. We experimentally demonstrated a TE-pass polarizer based on the hybrid plasmonic waveguide. The TM mode is coupled and attenuated in an asymmetric coupling section. The device has a high extinction ratio and ultra-low insertion loss.
SM1G • Heterogeneous III-V / Si Photonic Integration—Continued

SM1G.3 • 09:15
Room Temperature CW 1.3 μm Single Mode Lasing of InAs Quantum Dot Micro-disk Lasers Grown on (001) Si, Matthew Byrd1, Evelyn L. Hu2, Kei-May Lau3; 1Dept. of Electronic and Computer Engineering, Hong Kong Univ. of Science and Technology, Hong Kong, China; 2Materials Dept., Univ. of California Santa Barbara, USA; 3School of Engineering and Applied Sciences, Harvard Univ., USA. Heteroepitaxially grown InAs quantum dot micro-disk lasers were demonstrated on planar Si (001) substrates. Room-temperature continuous-wave lasing at 1.3 μm with a threshold pump power of 250 μW was achieved for a 4 μm disk.

SM1G.4 • 09:30
Lenses for Low-Loss Chip-to-Fiber and Fiber-to-Fiber Coupling Fabricated by 3D Direct-Write Lithography, Philipp-Immanuel C. Dietrich1, Ingo Reuter1, Matthias Blacher1, Simon Schneider1, Muhammad R. Billahi1, Tobias Hoose1, Andreas Hofmann1, Charles Caer2, Roger Dangel2, Bert Offrein2, Martin Hofhre1, Ute Troppmayr1, Marlene Zander1, Wolfgang Freude1, Christian Koos1; 1Inst. of Photonics and Quantum Electronics (IPQ), Germany; 2Inst. of Microstructure Technology (IMT), Germany; 3Inst. of Applied Computer Science (IAI), Germany; 4IBM Research – Zurich, Switzerland; 5Fraunhofer Inst. for Telecommunications, Heinrich Hertz Inst. (HHTI), Germany. We demonstrate low-loss coupling to single-mode fibers and photonic integrated circuits (PIC) using in-situ fabrication of free-form microlenses on device facets. Measured coupling losses down to 0.8 dB (0.5 dB) are achieved for chip-fiber (fiber-fiber) interfaces.

SM1G.5 • 09:45
C-Band Swept Wavelength Erbium-Doped Fiber Laser With a High-Q Tunable Interior-Ridge Silicon Microring Cavity, Nanxi Li1, Erman Timurdogan1, Christopher Poulton1, Matthew Byrd1, Emer S. Magden2, Zhan Su3, Purnawirman Purnawirman1, Gerald Leake1, Douglas Coolbaugh1, Diedrik Vermeulen1, Michael Watts1; 1Research Lab of Electronics, MIT, USA; 2John A. Paulson School of Engineering and Applied Science, Harvard Univ., USA; 3College of Nanoscale Science and Engineering, Univ. at Albany, USA. We demonstrate an erbium-doped fiber laser with a tunable silicon microring cavity. We measured a narrow laser linewidth (16 kHz) and single-mode continuous-wave emission over the C-band (1530nm to 1560nm) at a swept-wave rate of 22,600nm/s or 3106THz/s.

SM1H • Frontiers of Frequency Comb Metrology—Continued

SM1H.6 • 09:15
Frequency Comb Metrology with a Near-Infrared Optical Parametric Oscillator, Karolis Baldus1,2,3, Stephanie Schiff1, Valentin Wittwer1, Pierre BROCHARD1, Tobias Ploetzning1, Nayara JORNOD1, Richard A. McCracken1, Zhaowei Zhang2,1, Albrecht Bartels1, Derryn T. Reid1, Thomas Sudmeyer1; 1Heriot-Watt Univ., UK; 2Laboratoire Tempor-Fréquence, Université de Neuchâtel, Switzerland; 3Euratom Laser GmbH, Germany. We show the first absolute optical frequency metrology demonstration performed with an OPO. The OPO frequency comb shows ~300-nrad integrated CEO phase noise and ~70-kHz optical linewidth at 1557 nm when fully-stabilized to a radio-frequency reference.

SM1H.7 • 09:30
Modal Analysis of an Ultrafast Frequency Comb: Application to Laser Dynamics and Quantum Metrology, Nicolas Treps1, Valérian Thiel1, Jonathan Roslund1, Roman Schmeiss1, Sylamurudar De1, Claude Fabre1; 1Laboratoire Kastler Brossel, France. A real time, spectrally resolved detection system is developed to characterize the time/frequency modes of an optical frequency comb. Covariance matrix approach is used both for laser dynamics study and quantum metrology experiments.

SM1I • Ultrafast Oscillators—Continued

SM1I.5 • 09:15
Sesams for High-Power Lasers, Cesare Allieri1, Andreas Diebold1, Michael Kopp1, Dominik Waldburger1, Mario Mangold1, Florian Ermaury1, Olga P. Sarascon1, Emilio Gini2, Ursula Keller1; 1ETH Zürich, Switzerland; 2FIRST, Switzerland. We present novel fast MOVPE-grown SESAMs with enhanced damage threshold and surface quality suitable for power-scaling of modelocked laser oscillators to enable ultrafast lasers in the kilowatt average power regime.

SM1I.6 • 09:30
87 fs Pulse Generation in a Diode-Pumped SESAM Mode-Locked Yb:YLF Laser, Federico Pirzzo1, Luigi Fregnani1, Azzurra Volpi1, Alberto Di Lieto1, Mauro Tonelli1, Antonio Agnesi1, Universita degli Studi di Pavia, Italy; 2NEST Istituto Nanoscienze-CNR and Dipartimento di Fisica, Italy. We present for the first time sub-100-fs pulse generation in a SESAM mode-locked, Yb:YLF laser pumped with low-power single-mode fiber-coupled lasers at 976 nm. Almost Fourier transform limited 87-ps pulses at 1052 nm were obtained.

SM1I.7 • 09:45
Transient spatiotemporal optimization of octave-spanning Ti:sapphire oscillators, Shih-Hsuan Chia1,2, Li-Jin Chen1, Keenal Shafak1, Oliver D. Muecke1,2, Franz X. Kärtner1,2; 1Center for Free-Electron Laser Science, Germany; 2Physics, Univ. of Hamburg, Germany; 3Research Lab of Electronics, MIT, USA. The complete spatiotemporal dynamics in an octave-spanning oscillator is captured to further optimize its transform-limited pulse duration and beam profile for simultaneous short pulse generation and CEO locking.
UV-LED based fiber-optic sensor system for gas analysis, Axel Kramer1, Mariya Porus1, Thomas Alfred Paul1; ABB, Switzerland. We report on the development of a fiber-based photometer for diagnostics of next generation gas-insulated electrical switchgear. The UV-LED based sensor system enables accurate concentration measurement of a specific gas in a gas mixture.

On-chip Fourier Transform Spectrometer for Chemical Sensing Applications, Shaoan Zheng1,2, Hong Cai1, Yuan-dong Gu1, Lyp Ket Chin1, Ai Qun Liu1; Nanyang Technological Univ., Singapore; 1Inst. of Microelectronics, Singapore. This paper reports an on-chip Fourier transform spectrometer (FTS) which exploits a tunable Mach-Zehnder interferometer (MZI) by taking advantage of the thermo-optic effect to achieve a high resolution of at least 40 cm⁻¹.

Spectrum Engineering for Reconstructive Spectroscopy, Eric Huang1, Qian Ma1, Zhaowei Liu1; 1Univ California San Diego, USA. We demonstrate a novel method spectrometry using etalons on a CCD camera. This prototype enables compact, high resolution, and high efficiency spectrometry with no moving parts.

EUV/VX-ray Multilayer Optics: Meeting the Challenges of Next-Generation Applications, Regina Soufli1, Jeff Robinson1, Eberhard Spiller2, Monica Fernandez-Perea1, Eric Gullikson3; 1Lawrence Livermore National Lab, USA; 2Spiller X-Ray Optics, USA; 3Lawrence Berkeley National Lab, USA. This paper summarizes recent advances in the development of EUV/VX-ray multilayer optics for photolithography, free-electron and tabletop lasers, and solar physics. Driven by the needs of their respective applications, the optics meet a variety of extraordinary specifications including coating thickness control in the picometer (rms) range, low coating stress, resistance to atmospheric corrosion, while at the same time maintaining high reflective performance.

Terahertz tomography system using self-heterodyne detection with phase noise compensation, Hajun Song1, Sejin Hwang1, Jong-In Song1; 1Gwangju Inst of Science and Technology, Korea. We propose a Terahertz tomography system using self-heterodyne detection with phase noise compensation. The phase noise compensation actively reduces phase noise from laser sources and offers improved resolution and reproducibility of the tomography system.

Polarization-resolved terahertz imaging of hybrid fiber-reinforced composite laminate subject to low-velocity impact, Junliang Dong1,2, Alexandre Locquet1,2, D. S. Citrin1,2; 1Georgia Tech-CNRS UMI2958, Georgia Tech Lorraine, France; 2School of Electrical and Computer Engineering, Georgia Inst. of Technology, USA. By taking advantage of the interaction between terahertz polarization and carbon-fiber orientation, impact-induced intra- and inter-laminar damages at the same interface are differentiated via terahertz polarization-resolved imaging in three dimensions.

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
Monday, 6 June

CLEO: Science & Innovations

Meeting Room 212 C

SM1M • Petawatt Laser Systems and Technology—Continued

SM1M.5 • 09:15
The Current Status of the J-KAREN Laser Upgrade, Hiroimitsu Kriyama1, Masaki Kando1, Alexander Pirzibhov1, Maki Kishimoto1, Akira Kon1, Mamiko Nishuchi1, Hironao Sakaki1, Koichi Ogura1, Masato Kanasaki1, Hirotaka Tanaka1, Yui Fukuda1, Michiaki Mor1, Yui Mashiba1, Makoto Asakawa1, Akitok Sagisaka1, James Koga1, Timur Esrekepov1, Yukio Hayashi1, Hideyuki Kotali1, Yasuo Hirakata1, Kentaro Sekiguchi1, Sergei Bulanov1, Kiminori Kondo1; 1Japan Atomic Energy Agency, Japan; 2Kobe Univ., Japan; 3Kansai Univ., Japan.

We report recent advances on the J-KAREN laser upgrade to provide an intensity capacity surpassing 10^12 W/cm^2 at 0.1 Hz. Currently, the high-spatiotemporal quality broadband pulses are amplified to over 55 J at 0.1 Hz.

SM1M.6 • 09:30
Towards high-power, multi-TW light transients, Hanieh Fatollahi1,2, Haochuan Wang1, Ayman Alismail1,2, 1Max-Planck-Institut fur Quantenoptik, Germany; 2Physics, Ludwig-Maximilians-Universität, Germany.

We demonstrate a supercoarse, CEPA-stable spectrum directly generated from a 1-ps, Yb:YAG thin-disk amplifier. The spectrum seeds a OPCPA-based field synthesizer and is amplified in the first stages of the 3-channel OPCPA system.

SM1M.7 • 09:45
Introduction to SG-II 5 PW Laser Facility, Xinglong Xie1, Jianqiang Zhu1, Qingsen Yang1, Jun Kang1, Haidong Zhu1, Meizhi Sun1, Ailin Guo1; 1SIOM, China.

We report single pulses, enables high-resolution TPM fluorescence imaging in multiple spectral bands.

SM1O • Symposium on Stain-free Imaging

Meeting Room 212 D

FM1N • Quantum Enabling Technologies—Continued

FM1N.6 • 09:15
Passive High-Extinction Integrated Photonic Filters for Silicon Quantum Photonics, Mateusz Piekarek1,2, Damien Bonneau1, Shigehto Miki3, Taro Yamashita3, Mikio Fujimasa3, Masahide Sasaki3, Hirotaka Terai3, Michal Tanner3, Chandra Natarajan1, Robert H. Hadfield3, Jeremy O’Brien3, Mark Thompson3, 1Centre for Quantum Photonics, H. H. Wills Physics Lab & Dept. of Electrical and Electronic Engineering, Univ. of Bristol, UK; 2School of Engineering & Physical Sciences, Heriot-Watt Univ., UK; 3School of Engineering, Univ. of Glasgow, UK. We report on two-photon microscopy imaging based on coherent fiber-based supercontinuum source. The supercontinuum generation in a photonic crystal fiber induced by fiber-delivered ultrafast (~ 100 fs) laser pulses, enables high-resolution TPM fluorescence imaging technique for enhancing optical diagnosis and characterization of dental caries in the tooth without labeling.

SM10.4 • 09:15
Polarization-resolved hyperspectral stimulated Raman microscopy for tooth imaging, Zhiewei Huang1, Zi Wang1, Wei Zheng1, Chin-Ying Hsu1; 1National Univ. of Singapore, Singapore. We report the development and implementation of a rapid polarization-resolved hyperspectral stimulated Raman scattering imaging technique for enhancing optical diagnosis and characterization of dental caries in the tooth without labeling.

SM1O.5 • 09:30
Two-photon microscopy based on fiber delivery of ultrashort laser pulses and supercontinuum generation in a photonic crystal fiber, Youbo Zhao1, Nicu Barnea1, 1Physi- cal Science Inc., USA. We report on two-photon microscopy imaging based on coherent fiber-based supercontinuum source. The supercontinuum generation in a photonic crystal fiber induced by fiber-delivered ultrafast (~ 100 fs) laser pulses, enables high-resolution TPM fluorescence imaging in multiple spectral bands.

SM1O.6 • 09:45
Stain free colorimetric sensors using hybrid mode plasmonic microscopy, P. Arora1, A. Krishnan1; 1Indian Inst. of Technology, Madras, India. We present colorimetric stain free image based sensing of antibody-antigen binding and refractive index perturbation, using substrates that support hybrid mode surface plasmons and demonstrate their integration with microfluidic channels for real time index sensing.


SC376: Plasmonics

SC440: How to Communicate High-Tech to the Market – A Marketing and PR Primer

10:00–10:30  Coffee Break, Concourse Level
Surface nanoscale axial photonics (SNAP) structures introduced with a femtosecond laser, Fangcheng Shen1,2, Artemy Dmitriev1, Neil Gordon1, Lin Zhang1, Xuewen Shu1, Misha Sumetsky2,3; Aston Univ., UK; 2Huazhong Univ. of Science and Technology, China. Surface nanoscale axial photonics (SNAP) structures are created with a femtosecond laser inscription for the first time. A micron-thin inscription, introduced along the fiber axis, is characterized by the measured subnanometer-small effective fiber radius variation.

We report experimental analysis of optical fibers with novel liquid electrodes to generate effective second-order nonlinearities. Our analysis includes transmission losses, depletion liquid electrodes to generate effective second-order nonlinearity. We present a numerical method for studying fiber-based ultra-short pulse amplification at high repetition rates. Validation of the simulations, by comparison with experimental results, are also presented.

Fiber gratings formed by self-assembled nanoparticles, Nan-Kuang Chen1,2, Kuan-Yu Lou1, Shien-Kuei Liaw1, Wood-Hi Cheng1, Raman Kashyap1; National United Univ., Taiwan; 2Dept. of Electronic and Computer Engineering, National Taiwan Univ. of Science and Technology, Taiwan; 3Graduate Inst. of Optoelectronic Engineering, National Chung Hsing Univ., Taiwan; 4Dept. of Engineering Physics, Polytechnique Montreal, Canada. We propose a new making method for fiber grating based on self-assembly of nanoparticles which are actively attracted to attach onto micro-tapered fibers by Van der Wall’s force in an evenly-spaced manner for sensing applications.

Comparison of novel liquid electrodes for silica optical fiber thermal poling, Francesco De Lucia1, Costantino Corbari1, Derek Keefer1, Pier John Anthony Szao1; Univ. of Southamp-ton, UK; 2Renishaw plc, New Mills, UK; 3Pennsylvania State Univ., USA. We report experimental analysis of optical fibers thermally poled over long lengths using novel types of internal liquid electrodes to generate effective second-order nonlinearities. Our analysis includes transmission losses, depletion region formation, SHG at telecom pump wavelengths.

Enhanced Pseudo-Random Phase Modulation for High Power Fiber Amplifiers, Brian Anderson1, Angel Flores1, Iyad Dajani1; Air Force Research Lab, USA. A low-pass filter is used to suppress the high-frequency components of a PRBS signal and is used to modulate a fiber amplifier. Notably, the coherence length and SBS threshold of a kilowatt-class amplifier are increased.

Indium Phosphide Nanoflags: Optical Characterization, Applications and Device Integration, Olfr Sorais1, Alexander Kelrich2, Ran Gladstone1, Dan Ritter1, Meir Orenstein1, 2Electrical Engineering, Technion-Israel Inst. of Technology, Israel. We present a novel structure of InP nanoflag, characterized its photoluminescence and polarization properties as well as its reflection spectra and show calculations of its resonance effects. We discuss application in several nanophotonics devices.

Low Strain Silicon-Vacancy Color Centers in Diamond Nanopillar Arrays, Jingyuan Linda Zhang1, Hitoshi Ishiwata2,3, Thomas Babinec1, Marina Radulaski1, Kai Mueller1, Konstantinos Lagoudakis1, Constantyn Dory1, Zhi-Xun Shen2,3, Nicholas Melosh2,3, Jelena Vuckovic1,2; E. L. Ginzton Lab, Stanford Univ., USA; 2Geballe Lab for Advanced Materials, Stanford Univ., USA; 3Stanford Inst. for Materials and Energy Sciences, SLAC National Accelerator Lab, USA. We demonstrate the fabrication and optical characterization of diamond nanopillar arrays containing silicon-vacancy (SiV) color centers. Micro-photoluminescence reveals narrow linewidths and small inhomogeneous broadening of SiV’ emission from the nanopillars.

SC376: Plasmonics
SC440: How to Communicate High-Tech to the Market – A Marketing and PR Primer
Spectral Engineering of Frequency Combs using Deposited Waveguides, Nima Naderi, Kevin C. Cossell, Esther Baumann, Ian R. Coddington, Nathan R. Newbury, Richard Minn, Jeffrey M. Shainline; NIST, USA. Engineering of SiN waveguides for spectral tailoring of frequency combs is presented. Several dispersion designs are shown to give rise to spectra which are suitable for comb-based spectroscopy and difference frequency generation for self-referencing.

Raman Self-Frequency Shift of Dissipative Kerr Solitons in an Optical Microresonator, Hairun Guo, Erwan Lucas, Arne Kordts, Martin Pfeiffer, Victor Brashc, Gregory Liachev, Valery Lobanov, Michael Gorodetsky, Tobias Kippenberg; Ecole Polytechnique Federale de Lausanne, Switzerland. We experimentally observed the Raman-induced self-frequency shift of high-intensity dissipative Kerr solitons in high-Q silicon nitride microresonators. The Raman redshift is linearly dependent on the pump-frequency-detuning, associated with the tunability of the soliton pulse duration.

FM2A • 11:00 Nonlinear Optics at Low Powers: New Mechanism of On-Chip Optical Frequency Comb Generation, Andre Rogov, Evgenii E. Narimanov, Purdue Univ, USA. We present a new approach to nonlinear optical effects in microresonator systems, based on period-doubling bifurcations near nonlinear cavity anti-resonance, and apply it to low-power optical comb generation in a silicon chip.

FM2A • 11:30 Stability Analysis of Dark Pulse Kerr Frequency Combs in Normal Dispersion Optical Microresonators, Pedro Parra-Rivas, Damia Gomila, Edgar Krobluch, Lendert Goleans, Stephane Coen; 1Physics, The University of Auckland, New Zealand; 2Dodd-Walls Centre, New Zealand; 3Chemical and Systems Biology, Stanford Univ. School of Medicine, USA; 4Applied Physics Research, Vrije Universiteit Brussel, Belgium; 5ICT Inst (CSIC-UIB), Universitat de les Illes Balears, Spain; 6Physics, Univ. of California, USA; 7Cellular and Molecular Medicine, Univ. of Leuven, Belgium. We theoretically analyze dark pulse Kerr frequency combs in normal dispersion microresonators. A wide range of dark pulses of different widths are found to coexist, and can be described as interlocked switching waves.

FM2B • 10:45 Universal Dynamics and Controlled Switching of Dissipative Kerr Solitons in Optical Microresonators, Maxim Karpov, Hairun Guo, Erwan Lucas, Arne Kordts, Martin Pfeiffer, Victor Brash, Gregory Liachev, Valery Lobanov, Michael Gorodetsky, Tobias Kippenberg; Ecole Polytechnique Federale de Lausanne, Switzerland. We theoretically analyze and numerically the existence of optical pulling force in the vicinity of plasmonic interfaces, which can be a bottleneck to achieving large-scale trapped ion quantum computing. We fabricated a surface trap with diffractive mirrors and achieved sub-wavelength imaging of a trapped ion and 20:0:5% coupling into a single-mode fiber.

FM2B • 11:00 Exploiting optical asymmetry for frequency-controlled guiding of particles with light, Ognjen Ilic, Ido Kaminer, Yoav Lahini, Hrvoje Buljan, Marin Soljacic; MIT, USA; 2Physics, Univ. of Zagreb, Croatia. We explore a novel method to guide particles that is controllable by the frequency of light. With detailed stochastic simulations, we demonstrate a very high degree of control, independent of the direction of the light beam. This method is insensitive to scattering and applicable to many particles.

FM2B • 11:15 Infrared Nanospectroscopy in Liquid, Mingzhou Jin, Feng Lu, Mikhail A. Belkin; 1Univ. of Texas at Austin, USA. We demonstrate infrared nanospectroscopy of a sample immersed in heavy water, using tip-enhanced photoemission microscopy or AFM-IR technique. Spectra on 20-nm-thick PMMA patterned are recorded with a spatial resolution of 50 nm.

FM2C • 10:30 An Optimally Levitated Dielectric Nanosphere in Vacuum as a Force Sensor, Gambhir Ranjit, Mark Cunningham, Kirsten Casey, Andrew A. Geraci; 1Dept. of Physics, Univ. of Nevada, USA. We present our progress towards using an optically levitated and cooled dielectric nanosphere in vacuum as a precision sensor. Such a system is well decoupled from the external environment and can have sub-attoNewton force sensitivity.

FM2C • 11:00 Optical pulling force in the vicinity of plasmonic interfaces, Andrey A. Bogdanov, Petrov Mikhail, Sergey V. Sukhov, Alexander S. Shalin, Aristide Dogaru, Ioffe Inst, Russia; 2IMTO Univ., Russia; 3CREOL, The College of Optics and Photonics, Univ. of Central Florida, USA. We introduce a new mechanism allowing for successive reduction of the number of dissipative Kerr solitons in optical microresonators. It is demonstrated that multiple and single soliton state can be deterministically accessed.

FM2C • 11:15 Quantum Matter built from Atoms and Photons in Nonscopic Dielectric Lattices, H. Jeff Kimble; 1California Inst. of Technology, USA. New paradigms for optical physics emerge from the integration of ultra-cold atoms with photonic crystal waveguides. I will review progress and prospects in this emerging field at the interfaces of nano-photonic, atomic physics, and quantum optics.
Structured Light in Linear and Nonlinear Engineered Metasurfaces, Antonio Ambrosio1, Robert C. Devlin1, Daniel Wintz1, Stefano L. Ossicini2, Alexander Y. Zhu3, Mohammadreza Khorasaninejad4, Jaewon Oh1, Pasquale Maddalena5, Federico Capasso1, Harvard John A. Paulson School of Engineering and Applied Sciences, Harvard Univ., USA; 1Dipartimento di Fisica, CNR-SPIN, Italy. We realized devices made of dielectric sub-wavelength resonators on glass substrates based on Pancharatnam-Berry phase and designed to convert an incident light beam into a vortex beam with high-efficiency in the visible light spectrum.

Polarization-switchable visible vortex beams from a dielectric metasurface, Antonio Ambrosio1, Robert C. Devlin1, Daniel Wintz1, Stefano L. Ossicini2, Alexander Y. Zhu3, Mohammadreza Khorasaninejad4, Jaewon Oh1, Pasquale Maddalena5, Federico Capasso1, Harvard John A. Paulson School of Engineering and Applied Sciences, Harvard Univ., USA; 1Dipartimento di Fisica, CNR-SPIN, Italy. We realized devices made of dielectric sub-wavelength resonators on glass substrates based on Pancharatnam-Berry phase and designed to convert an incident light beam into a vortex beam with high-efficiency in the visible light spectrum.

Dispersionless metasurfaces using dispersive meta-atoms, Ehsan Arbabi1, Amir Arbabi1, Seyyedeh Mahea Kamali1, Yu Horne2, Andrea Parson3, California Inst. of Technology, USA. We introduce a technique for engineering the chromatic dispersion of metasurfaces using dispersive meta-atoms. Using this technique, we experimentally demonstrate dispersionless dielectric metasurfaces focusing mirrors with negligible chromatic dispersion over a 10% fractional bandwidth.

Comparison of Photon Pair Generation in a-Si:H and c-Si Microring Resonators, Lizzy Hernsley1, Damien Bonneau1, Gary Simard1, Jason Pelc1, Ray Beausoleil2, Shigehito Miki1, Taro Yamashita1, Mikio Fujwara1, Masahide Sasaki4, Hirotaka Terai1, Michael Tanner1, Chandra M. Natarajan1, Robert H. Hadfield1, Jeremy O’Brien1, Mark Thompson1, Centre for Quantum Photonics, UK; 2Hewlett Packard Labs, USA; 3NICT, Japan; 4NICT, Japan; 5School of Engineering, UK. We generate photon pairs via SPWM in hydrogenated amorphous silicon microring resonators, and compare the behavior to crystalline silicon.
SM2G.1 • 10:30 Robust fiber packaging in a scalable integrated photonics process, Jeffrey M. Shinaine1, Cale M. Gentry2, Sonia M. Buckley1, Nima Nader1, Sae Woo Nam1, Richard Minn1, NIST, USA; 2Electrical, Computer, and Energy Engineering, Univ. of Colorado, USA. We present a scalable integrated photonics process utilizing inline lithography to achieve 2.46 db/cm propagation losses and multiple high-performance chips. Fiber support structures are lithographically aligned to gratings, enabling durable packaging of multiple fibers on a chip.

SM2G.2 • 10:45 Accuracy Enhancement of Sub-mm Chip Self-Alignment Using Liquid Surface Tension for Hybrid Integration, Shinya Kikuta1, Satohiko Hoshina1, Yoshiaki Yamashita1, Takafumi Fukushima1, Kargwook Lee2, Mitsumasa Koyanagi3, New Industry Creation Hatchery Center (NICHe), Tohoku Univ., Japan; 2Dept. of Bioengineering and Robotics, Tohoku Univ., Japan; 3Innovative Technology Planning Dept., Tokyo Electro Ltd., Japan. A self-alignment process of sub-mm chips is studied for hybrid integration toward silicon photonics applications. Self-alignment behaviors of sub-mm chips and the resulting high accuracies of the sub-mm chips are discussed in this work.

SM2G.3 • 11:00 Distributed backscattering due to stochastic defects in production O-band Si photonic waveguides, Bo Peng1, Jesse Rosenberg1, Wesley Sacher1, Marwan Khater1, William M. Green1, Tymon Barwicz2, IBM T.J. Watson Research Center, USA. We report backscattering of -19 to -36 dB per 1mm of waveguide length. We find the dependence of backscattering intensity on waveguide geometry and polarization to be consistent with backscattering being dominated by sidewall defects.

SM2G.4 • 11:15 Characterization of surface-state absorption in foundry-fabricated silicon ridge waveguides at 1550 nm using photocurrents, Yu Li1, Andrew W. Poae1, Hong Kong Univ of Science & Technology, Hong Kong. We study surface-state absorption (SSA) in foundry-fabricated silicon ridge waveguides at 1550 nm using photocurrents. We utilize two-photon-absorption as a self-benchmarking for extracting the SSA coefficient. Our measurements show an SSA coefficient of -0.32/mm.

SM2H.1 • 10:30 Absolute Distance Measurement Method with Optical Frequency Comb Interferometer Based on Balanced Optical Cross Correlator and Optical Heterodyne Technique, Yoshiaki Nakajima1,2, Thomas R. Schibli1, Bo Xu1, Kaoru Minoshima1,2. The Univ. of Electro-Communications, Japan; 2ERATO Intelligent Optical Synthesizer (IOS) Project, Japan; 3Univ. of Colorado at Boulder, USA. We present a scalable integrated photonics process utilizing inline lithography to achieve 2.46 db/cm propagation losses and multiple high-performance chips. Fiber support structures are lithographically aligned to gratings, enabling durable packaging of multiple fibers on a chip.

SM2H.2 • 10:45 Passive Coherent Discriminator Using Phase Diversity for the Measurement of CW Laser Frequency Noise, Vincent Michael-Belleau1, Hugo Bergeron1, Philip S. Light2, Nicolas Bourbeau Hébert3, Jean-Daniel Deschênes4, Andre N. Luiten5, Jerome Genest1. Centre d’optique, photonique et laser, Universite Laval, Canada; 2Inst. for Photonics and Advanced Sensing, Univ. of Adelaide, Australia. We present a short-delay fiber interferometer that employs a 90° optical hybrid to perform in-phase and quadrature detection. This instrument allows a passive and robust characterization of the frequency noise of highly stable laser oscillators.

SM2H.3 • 11:00 High-Precision Spectroscopy Using Ultra-Compact Lasers, Kazumichi Yoshi1,2, Yusuke Hisai1, Takumi Kobayashi1, Feng-Hsi Li1, Hong Kong Univ. Natinal Univ., Japan; 2JST, ERATO, Japan; 3IMU, Japan. We demonstrate high-precision spectroscopy of molecular iodine using ultra-compact dioxide laser modules at 531, 561 and 594 nm. Entire hyperfine structures of iodine lines are obtained with a linewidth of a few MHz.

SM2H.4 • 11:15 Toward a highly stable master laser for the interrogation of SYRTE’s Sr and Hg optical lattice clocks, Olivier Gobron1, Katharina Predehl2, Daniele Nicolodi3, Rodolphe Le Targat4, Tero Setälä1, Itä-Suomen Yliopisto, Finland; 2Chimie Paris, France; 3Institut NEEL, France. We report on the current developments of an ultra-stable laser based on spectral hole burning spectroscopy of rare-earth doped crystal at cryogenic temperature. Narrow spectral Holes and error signal have been demonstrated with a heterodyne method.

SM2H.5 • 11:30 Operation of High-Speed Silicon Photonic Micro-Disk Modulators at Cryogenic Temperatures, Michael R. Gehl1, Christopher Long1, Doug Trotter1, Andrew Pomerene1, Andrew Starbuck1, Jeremy Wright1, Seth Melgara1, Anthony Lentine1, Christopher DeRose1; Sandia National Labs, USA. We demonstrate the operation of silicon micro-disk modulators at temperatures as low as 3.8K. We characterize the steady-state and high-frequency performance and look at the impact of doping concentration.

SM2H.6 • 11:30 Rb-Stabilized Compact Optical Frequency Comb acting as a Versatile Wavelength Reference, William Moreno1, Renaud Mattey de l’endroit1, Florian Gruet1, Pierre Brochard2, Stephane Schilt3, Philippe Goldner2, Le Targat1, SYRTE, France. We report on the current developments of an ultra-stable laser based on spectral hole burning spectroscopy of rare-earth doped crystal at cryogenic temperature. Narrow spectral Holes and error signal have been demonstrated with a heterodyne method.

SM2I.1 • 10:30 Operation of High-Speed Silicon Photonic Micro-Disk Modulators at Cryogenic Temperatures, Michael R. Gehl1, Christopher Long1, Doug Trotter1, Andrew Pomerene1, Andrew Starbuck1, Jeremy Wright1, Seth Melgara1, Anthony Lentine1, Christopher DeRose1; Sandia National Labs, USA. We demonstrate the operation of silicon micro-disk modulators at temperatures as low as 3.8K. We characterize the steady-state and high-frequency performance and look at the impact of doping concentration.

SM2I.2 • 10:45 Multispectral Imaging using Sequentially Temped All-optical Mapping Photography utilizing Spectral Filtering (SF-Stamp) system, Ryoho Hida1, Takahisa Suzuki1, Fumihiro Isai1, Ryo Ueda2, Fumihiko Kanno3, Keio Univ., Japan. We propose a compact one-shot multispectral imaging method using SF-Stamp system. As a demonstration, we measure 2D spectral images in visible range (500 - 650 nm) using a supercontinuum laser pulse.

SM2I.3 • 11:00 Space-Time-Wavelength Mapping Based Electronically Controlled Two Dimensional Optical Tweezer, Shah Rahman1, Parinaz Sadri-Moshkeneni1, Rasul Torun1, Ozdal Boyraz1, Univ. of California, Irvine, USA. We investigate two-dimensional optical tweezing by space-time-wavelength mapping. We show that by adding a virtually imaged phased array to the proposed setup field force in a 2D plane can be controlled by time-domain modulation.

SM2I.4 • 11:15 Ultrafast Polarization-State Dynamics of Light Beams Measured by Two-Photon Absorption, Andrey Shevchenko1, Matthieu Roussy2, Tero Setälä3, Aalto Univ., Finland; 2Itä-Suomen Yliopisto, Finland; 3Aalto Univ., Finland. We employ two-photon absorption and polarization-selective Michelson interferometer to measure fs-scale polarization dynamics of stationary unpolared beams, allowing us to estimate the time span within which the polarization state remains essentially unchanged.
AM2J.1 • 10:30
Invited
Metrology supporting EUV Lithography, Patrick Naulleau
1, Lawrence Berkeley National Lab, USA; EUV lithography remains the preferred option for 7-nm node semiconductor device manufacturing. Successful insertion of this technology into manufacturing, however, will also depend on the development and deployment of new EUV actinic metrologies. Here we describe the metrology needs and status of such systems and the critical components they require.

AM2J.2 • 10:45
Invited
Versatile characterization of a DFG comb showing quadratically enhanced frequency scaling of the phase noise, Thomas A. Puppe1, Russell K. Kliess1, Alexander Sell1, Nazanin Haghgoohi1, Felix Rohde1, Armin Zach, Wilhelm Kaenders2, TOPICA Photonics AG, Germany. Phase noise of single comb lines of a passively carriert envelope phase-stabilized Er-fiber frequency comb measured via delayed self-heterodyne beats show excellent agreement with the elastic tape model with fix-point at zero frequency.

AM2J.3 • 11:00
Invited
All-Polarization-Maintaining, Polarization-Multiplexed, Dual-Frequency, Mode-Locked Fiber Laser, Michael Kolano1,2, Benedict Graf1,2, Daniel Molter1, Frank Ellrich1, Georg van Freymann1,2, Fraunhofer Institute IPM, Germany; Physics and Research Center OPTIMAS, Univ. of Kaiserslautern, Germany. Two orthogonal-polarization pulse trains are simultaneously emitted from a single, all-polarization-maintaining fiber laser using two saturable absorber mirrors. This design shows great potential to reduce the complexity of current time-resolved measurement systems without sacrificing performance.

AM2J.4 • 11:15
Long Distance Measurement by Pulse-To-Pulse alignment based on OSCAT, Hanhong Wu1, Fumin Zhang1, Xinghua Qu1, Yanjin Univ., China. We demonstrate a method for long distance measurement using a femtosecond pulse laser. The experimental results show an agreement within 10 μm in a range of 50 m, compared with the reference distance meter.

AM2J.5 • 11:30
Optical Communication Components Characterization using Electro-Optic Dual-Combs, Pedro Martin-Mateos1, Borja Jerez1, Estefania Prior1,2, Cristina de Dios1, Pablo Acedo1,4, Lawrence Berkeley National Lab, USA; Centre for Disruptive Photonic Technologies, School of Physics and Mathematical Sciences, Nanyang Technological University, Singapore; 2School of Electronic and Electrical Engineering, Nanyang Technological University, Singapore; 3Thales Research and Technology and CEA-LETI, France. A set-up based on an electro-optic dual-comb generator for the characterization of optical communication components is presented and experimentally validated. The instrument provides high speed operation and ultra-high wavelength resolution and frequency accuracy.

SM2L.1 • 10:30
Ultra-compact Source for THz Time Domain Spectroscopy, Jan C. Bals,1 Kamel Merghem2, Stefan Busch3, Francois Lelarge1, Abderrahim Randane2, Martin Koch1,1, Faculty of Physics and Material Sciences Center, Philipps-Universität Marburg, Germany; CNRS, Lab for Photonics and Nanostuctures, France; 2Thales Research and Technology and CEA-LETI, France. We present a regular fiber based THz spectrometer, which is driven by a monolithic semiconductor laser. Clean THz pulses with frequency components up to 0.9 THz can be generated with this ultra-compact light source. The enhancement originates from high Purcell factors and efficient photon out-coupling as the period of the array is increased.

SM2L.2 • 10:45
Patch Antenna Microcavities Terahertz Sources with Enhanced Emission, Julien Madera1, Yoko Todoroki1, Ari Gilman1, Giulia Fruc2, Lianhe Li1, Edmund Linfield1,2, Carlo Sirtori1,3, Keshav M. Dani1,3, Okinawa Inst of Science and Technology, Japan; 1Materials and Phenomenes Quantiques, Université Paris Diderot, France; 2Univ. of Leeds, UK. Enhanced electroluminescence in arrays of double metal patch microcavities is demonstrated. The enhancement originates from high Purcell factors and efficient photon out-coupling as the period of the array is increased.

SM2L.3 • 11:00
Echo-less Photocative Antenna Sources for High-resolution Terahertz Time-domain Spectroscopy, Kenneth Maassang1, Anthony Brewer1, Jose Palomo1, Jean-Michel Manceau1, Raffaele Colombelli2, Isabelle Sagnes3, Juliette Mangeney4, Jerome Tignon1, Sukhdeep S. Dhillon1, ENS - LPA - CNRS, France; 016 - Université Paris Sud - CNRS, France; 3LPN - CNRS, France. A novel terahertz photocative antenna that totally suppresses unwanted echoes is demonstrated. This is achieved with a buried metal plate placed below the surface antenna structure and active layer, realizing a sub-wavelength cavity.

SM2L.4 • 11:15
Cascaded Optical Parametric Amplifier in PPLN for Efficient Narrowband Terahertz Generation, Giovanni Cirmi1, Fabian Reiser1, Michael Hemmen1, Koos K. Ravi1, Frederike Ahr1,2, Franz X. Kaertner1,2, Center for Free-Electron Laser Science, Deutsches Elektronen-Synchrotron DESY, Germany; 1The Hamburg Center for Ultrafast Imaging, Germany; 2Physics Dept., Univ. of Hamburg, Germany; 3Research Lab of Electronics, MIT, USA. We demonstrate experimentally the onset of cascaded optical parametric amplification (COPA) in periodically-poled lithium niobate. This technique permits narrowband terahertz wave generation beyond the Manley-Rowe limit.
SM2M.1 • 10:30
Antireflective Surface Microstructures on Optics for Laser Applications, Lynda E. Busse1, Jesse A. Frantz2, Brandon Shaw2, Menelaos Poutous3, Ishwar Aggarwal2, Jasbinder S. Sanghera1; 1US Naval Research Lab, USA; 2Univ. of North Carolina, USA. The optical performance of AR surface microstructures on optics for laser systems is presented, as applied to large windows, laser crystals, lenses and optical fibers. Ultralow reflectance and very high laser induced damage thresholds have been demonstrated.

SM2M.2 • 11:00
Meter-size Gratings for Multi-Petawatt Lasers, Arnaud Cotet1; 1Onbiba Jobin Yvon Sas, France. We present the latest developments of Meter-size gratings production for multi-Petawatt laser pulse compression. A new facility (NANOLAM) has been built at HJY (France), dedicated to the production of the largest gratings in the world.

SM2M.3 • 11:15
Image processing for the Automatic Alignment at the National Ignition Facility, Abdul A. Awad1, Richard R. Leach2, Vicki Miller-Kamm3, Karl Wilhelmsen4, Roger Lowe-Webb5, 1Lawrence Livermore National Lab, USA. Automatic Alignment system in the National Ignition Facility is responsible for aligning 192 laser beams using camera sensor images. This paper reviews some of the image processing algorithms that generate the crucial alignment positions.

SM2M.4 • 11:30
Focal-Spot Optimization by Polarization Modulation, Christopher Dorrell1, Yung Li1, Peter Fiala1; 1Univ. of Rochester, USA. Polarization modulation in the near field of a coherent beam is investigated theoretically and experimentally for focusing and correcting wavefront aberrations.

FM2N.1 • 10:30
On-chip Generation of Four-Photon Entangled Qubit States, Christian Reimer1, Michael Kues1, Pietro Roztock1, Luca Caspani1,2, Yaron Bromberg3, Benjamin Wetzel1, Brent E. Little1, Sai T. Chu4, David Moss4, Roberto Morandotti5, 1Innsbruck EMTC, 2Canada, 3School of Engineering and Physical Sciences, Heriot-Watt Univ, UK; 4 Dept. of Applied Physics, Yale Univ, USA; 5Inst. of Optics and Precision Mechanics, Xi’an CAS, China. We present the latest generation of spectrally degenerate polarization entangled states on chip, Linda Sansoni1, Kai Hong Luo1, Raimund Ricken1, Stephan Krupick1, Harald Herrmann1, Christine Silberhorn1, Universitat Paderborn, Germany. We present an integrated source of spectrally degenerate polarization entangled states at telecom wavelength. We generate a singlet state with fidelity of 97.3 % and obtain a violation of CHSH inequality of more than 14 standard deviations.

FM2N.2 • 10:45
High visibility time-energy entangled photons from a silicon microdisk resonator, Steven Rogers1, Daniel Mulkey1, Luiz Faundez2, Jian-Hua Fan2, 1Univ. of Rochester, USA; 2Univ. of California Los Angeles, USA. We demonstrate high visibility (96%) time-energy entangled photon pairs from a micron-scale source, to date. Bi-photons from a silicon microdisk resonator were observed to have a raw coincidence visibility of (96 ± 1.1)%. Photons from a single chip. The concurrence of 0.98±0.1, and generation of wavelength-multiplexed polarization entangled states on chip. We report the fully telecom compliant generation of entangled photon pairs on a silicon micro-ring resonator chip. The ring cavity is designed such as to demultiplex the emitted frequency-comb pairs on a silicon micro-ring resonator chip. The ring cavity is designed such as to demultiplex the emitted frequency-comb pairs.

FM2N.3 • 11:00
High visibility time-energy entangled photons from a silicon microdisk resonator, Steven Rogers1, Daniel Mulkey1, Luiz Faundez2, Jian-Hua Fan2, 1Univ. of Rochester, USA; 2Univ. of California Los Angeles, USA. We demonstrate high visibility (96%) time-energy entangled photon pairs from a micron-scale source, to date. Bi-photons from a silicon microdisk resonator were observed to have a raw coincidence visibility of (96 ± 1.1)%. Photons from a single chip. The concurrence of 0.98±0.1, and generation of wavelength-multiplexed polarization entangled states on chip. We report the fully telecom compliant generation of entangled photon pairs on a silicon micro-ring resonator chip. The ring cavity is designed such as to demultiplex the emitted frequency-comb pairs.

FM2N.4 • 11:15
Silicon-chip generation of multiplexed telecom-wavelength entangled photons pairs, Michele Traettia1, Marco Benvegnu1, Florian Kaiser1, Andre Skirtach1, 1Universite Paris Saclay, France. We demonstrate the highest raw quantum interference visibility for time-energy entangled photon pairs from a micron scale source, to date. Bi-photons from a silicon microdisk resonator were observed to have a raw coincidence visibility of (96 ± 1.1)%. Photons from a single chip. The concurrence of 0.98±0.1, and generation of wavelength-multiplexed polarization entangled states on chip. We report the fully telecom compliant generation of entangled photon pairs on a silicon micro-ring resonator chip. The ring cavity is designed such as to demultiplex the emitted frequency-comb pairs.

FM2N.5 • 11:30
Monolithic Semiconductor Entangled Sources Spanning the S-C-L Bands, Dongpeng Kang1, Arrika Anirban1, 1Univ. of Rochester, USA; 2Univ. of Tokyo, Japan; 3Univ. of Rochester, USA; 4Inst. for Advanced Biosciences, Keio Univ., Japan; 5Graduate School of Media and Governance, Keio Univ., Japan; 6Univ. of California Los Angeles, USA. We present the highest raw quantum interference visibility for time-energy entangled photon pairs from a micron scale source, to date. Bi-photons from a silicon microdisk resonator were observed to have a raw coincidence visibility of (96 ± 1.1)%. Photons from a single chip. The concurrence of 0.98±0.1, and generation of wavelength-multiplexed polarization entangled states on chip. We report the fully telecom compliant generation of entangled photon pairs on a silicon micro-ring resonator chip. The ring cavity is designed such as to demultiplex the emitted frequency-comb pairs.

SM2O.1 • 10:30
Gradient Light Interference Microscopy (glim) of Optically Thick Specimens, Gabriel Popescu1, 1Univ. of Illinois at Urbana-Champaign, USA. GLIM is a novel label-free imaging method with applicability from nanoscale topographic structures to 2-300-micron thick tissues. We present its principle and illustrate the performance with nano pillars, cells, and embryos.

SM2O.2 • 11:00
High-throughput Single-Cell Image Analysis of Living Euglena gracilis for Efficient Biofuel Production, Cheng Lei1, Takuro Ito1, Dino Di Carlo1, Yasuyuki Ozeki1, Keisuke Goda1, 1Univ. of Tokyo, Japan; 2Sung-Hwa Univ, China; 3Inst. for Advanced Biosciences, Keio Univ., Japan; 4Graduate School of Media and Governance, Keio Univ., Japan; 5Univ. of California Los Angeles, USA. We demonstrate label-free single-cell image cytometry of Euglena gracilis, a lipid-producing microalga, with a high throughput of 15,000 cells/s for evaluating and optimizing its lipid production efficiency.

SM2O.3 • 11:15
Lab-on-a-chip Raman sensors outperforming Raman microscopes, Ashim Dhakal1, Ali Raza1, Pieter Wuytens1, Frederic Peykens1, Andre Skirtach1, Nicolas Le Thomas1, Roel G. F. Baets1, 1Univ. of Ghent, USA. We demonstrate that the signal-to-noise ratio and signal collection efficiency in evanescent waveguide-based Raman spectroscopy exceeds that in Raman microscopes. We investigate the effect of silicon-nitride waveguide geometry to further improve the performance.
Multicore Fiber, Highly Sensitive Strain Sensor Based on Helical Structure in a Fiber Amplifier, Fasting Kong1, Rogers H. Stolen2, Liang Dong1, Clemson Univ., USA. We have observed, for the first time, quantum-defect-assisted polarization mode coupling in a fiber amplifier. This is a manifestation of stimulated thermal Rayleigh scattering. The frequency-dependent gain and loss are characterized for the first time.

Quantum-dot-doped 30/400 LMA Fibers with a Record-low NA of 0.028, Fasting Kong1, T. Hawkins1, M. Jones1, Joshua Parsons1, Monica Kalichevsky-Dong1, Christopher Dunn1, Li-ang Dong1, Clemson Univ., USA. We report ytterbium-doped LMA fibers with ~30 μm and ~40 μm cores and a record-low NA of 0.028, i.e. N.A.<2.7×10-4, critical for overcoming transverse-mode-instability threshold in single-mode fiber lasers and mode-matched power are demonstrated with high mode fidelity. We experimentally demonstrate a highly sensitive strain sensor based on a helical structure in a multicore fiber. We achieve fast liquid circulation and a sensitivity of ~104 nm/RU over the range of 1.33–1.36.

Highly Sensitive Strain Sensor Based on Helical Structure in Multicore Fiber, Haihang Zhang3, Zhifei Wu1, Peng Ping Shum2, Xuguang Shao2, Ruosu Wang2, Ming Yin Seow1, Xiang Guang Dinh1, Songnan Fu2, Weijun Tong1, Ming Tang1, CINTRA CNRS/NTU/Thales, UMI 3288, Nanyang Technological University, Singapore; 2Nanyang Technological University, Singapore; 3CINTRA, Singapore. We demonstrate an all-in-fiber-optical refractive index sensor based on a long-period grating in a side-channel photonic crystal fiber. We achieve fast liquid circulation and a sensitivity of ~104 nm/RU over the range of 1.33–1.36.

In-line Optofluvic Sensor Based on a Long-Period Grating in a Side-Channel Photonic Crystal Fiber, Nan Zhang4, Georges Humbert1, Kaiwei Li1, Zhihong Wu1, Mengying Zhang5, Perry Ping Shum2, Ying Cui1, Jean-Louis Auguste2, Xuan Quyen Dinh4, Lei Wei5, Nanyang Technological Univ., Singapore; 2Xim Inst-UMR 7252, France; 3Thales Solutions Asia Pte Ltd, Singapore; 4CINTRA, Singapore. We present a novel irradiation sensor based on a fluorescent microparticle that is optically guided inside the core of a liquid-filled photonic crystal fiber. We demonstrate irradiance measurements with spatial resolution of ~10 μm.

High-power mode-selective amplification in large mode area ytterbium-doped fiber using photonic lanterns, Steffen Wittecke1, Ricardo Bustos Ramirez1, Juan C. Alvarezac Zacarias1, Zennia Sanjap Ezaveh1, Gissela Lopez Galmiche1, Josh Bradford1, Jose Enrique Antonio-Lopez1, Lawrence Shah1, Rodrigo Amezquita-Correa1, CRCEOL, The College of Optics & Photonics, USA. We demonstrate mode-selective amplification in a LMA cladding pumped Yb-doped fiber amplifier employing a photonic lantern. Signal gains of up to 19 dB and >1W output power are demonstrated with high mode fidelity.

High-quality factor Si3N4 ring resonators fabricated using surface roughness reduction, Xingchen Ji1, Felipe A. Barbosa1, Alex Bryant1, Jaime Cardenas1, Samantha P. Ribeiro2, Michel Lipson3, Electrical Engineering, Columbia Univ., USA; 2Electrical and Computer Engineering, Cornell Univ., USA; 3Materials Science and Engineering, Georgia Institute of Technology, USA. We demonstrate high-confinement Si3N4 ring resonators with a quality factor of 15.6 million. We show that ultra-high quality factors are achievable by using a process that addresses surface roughness on all interfaces of the waveguides.

Fabrication of 74 mol% GeO2-doped fibers and Mid-IR Supercontinuum Generation, Raghuraman Sidharthan1, Seongwoo Yoo1, Darryl Ho2, Liling Zhang2, Wenliang Qi1, Men Seng Yue1, Lei Zhu2, Xinyong Dong1, Swee Chuan Tjin1, 1Nanyang Technological University, Singapore; 2China Jiliang University, China. We report a fabrication route to achieve highly GeO2-doped silica fibers with GeO2 molar concentration as high as 74% by using the conventional MOVCD process. Dispersion control and supercontinuum generation in 2-2.8 μm are demonstrated.
Cnoidal Waves in Microresonators, Zhen Qi, Giuseppe D’Aguanno, Curtis Menyuk, Univ. of Maryland Baltimore County, USA. Cnoidal waves are the periodic analogs of solitons. Like solitons, they can be generated in microresonators and correspond to frequency combs. We describe their properties and potential uses.

Optical tracking of a nanoparticle trapped by a double nanohole aperture, Dhe Xing, Xiujie Dou, Changmin Min, Lichao Zhang, Yuqian Zhang, Xiaoxong Yuan, Shenzhen Univ., China. We employ the hybrid plasmonic mode enhanced optical forces to achieve dynamic trapping and manipulation of metallic, dielectric and semiconductor nanoparticles and nanowires on a flat metal surface, and show its potential applications.

Optomechanical Plasmonic Trapping, Pau Mestres Junque, Johann Berthelot, Romain Quidant, ICFO - The Inst. of Photonic Sciences, Spain; ICREA, Spain; The Barcelona Inst. of Science and Technology, Spain; Chalmers Univ., Sweden. In this article we present for the first time a direct experimental evidence of the self-reconfiguration of the optical potential experienced by a nanoparticle optically trapped in a plasmonic nanocavity.

Observation of Mollow-triplet in micro-fabricated µm channel, Eliran Talker, Hebrew University of Jerusalem, Israel. We construct a microscale vapor cell, which enables high confinement of both light and vapor, and thus to reduce Doppler broadening via the velocity selection process. Consequently, we could demonstrate sub-Doppler emergence of Mollow triplets.

Observation of Breather Solitons in Microresonators, Mengjie Yu, Xiaohui Ou, Steven Miller, Cornell Univ., USA; Columbia Univ., USA. We present the first observations of breather solitons in microresonators. Our results provide a new perspective on the evolution towards stable soliton formation in microresonator frequency combs.
SM2G • Photonic Integration—Continued

SM2G.6 • 11:45
Laser-patterned Array with Aerosol-jet Printing Quantum-dots for Novel White Light Source, Sheng-Wen Wang1, Lin Huang Yu1, Chien-Chung Lin1, Tsung Sheng Kao1, Kuo-Ju Chen1, Hau-Wei Han1, Je-Ru Li1, Po-Tsung Lee1, Huang-Ming Chen1, Ming-Hui Hong1, Hao-Chung Kuo1; 1National Chiao Tung Univ., Taiwan; 2National Univ. of Singapore, Singapore. Through the laser-ablation and aerosol-jet printing techniques, a novel photoluminescent quantum-dots device with microscale patterns has been demonstrated as a white-light emitting source with stable emission at different driving currents and larger color productivity domain.

SM2G.7 • 12:00
Low-Loss and High-Bandwidth Multimode Polymer Waveguide Components Using High Refractive Index Engineering, Jian Chen1, Nikolaos Bamediakis1, Peter Vasilev1, Richard Penty1, Ian White1; 1Univ. of Cambridge, UK. Low-loss and high-bandwidth (>47 GHz•m) multimode polymer waveguide crossings (<0.02 dB/crossing) and bends (<1dB) are demonstrated. The performance of passive optical backplanes comprising such components is also optimised using refractive-index engineering and launch conditioning.

SM2G.8 • 12:15
SLM-based reconfigurable test apparatus for integrated photonic logic circuits, Thomas Van Vanerbergen1, Dave Kielpinski1, Jason Pelc1, Nikolaos Tezak1, Ranojoy Bose1, Charles Santoro1, Ray Beausoleil1; 1Hewlett Packard Labs, USA; 2Edison Lasertron Inc., Stanford Univ., USA; 3Venly, USA. Integrated all-optical logic circuits, an attractive platform for hardware accelerators, can have complicated I/O configurations. We demonstrate an SLM-based reconfigurable testbed that avoids the need to realign the access fibers for different circuit instances.

SM2H • Optical Meteorology and Frequency References—Continued

SM2H.6 • 11:45
Short Acetylene-Filled Photonic Bandgap Fiber Cells Toward Practical Industry Standards, Ryan Luder1,2, Sajed Hosseini-Zavareh1, Chenchen Wang1, Manasa Thirugnanasambandam1, Brian Washburn1, Kristian Corwin1; 1Kansas State Univ., USA; 2Verily, USA. Molecular absorption cells (5 cm-long, free-space coupled) underpin industry wavelength standards at the 0.1 pm (~10 MHz) level. We address the challenge of fabricating very short, sealed photonic bandgap fibers with similar performance.

SM2H.7 • 12:00
Atom-surface Van der Waals potential induced sub-Doppler transparencies in Rb vapor filled Kagome HC-PCF, Ekaterina Ilinova1, Tom Bradley1, Ximeng Zheng2, Benoit Debord3, Frederic Gerome1; 1GPPMM group, Xlim Research Inst., UMR CNRS 7252, France. We report on experimental observation of sub-Doppler transparencies in Rb filled HC-PCF. A theoretical analysis shows that they result from the optical pumping of wall trapped atoms into off-resonant spin state.

SM2I • Applications of Ultrashort Pulses—Continued

SM2I.6 • 11:45
Lossless arbitrary FSR control of optical frequency combs using joint time-frequency self-imaging, Hugues Guillet de Chatellus1,2, Luis Romero Cortés1, Jose. Azana1; 1INRS-EMT, Canada; 2Laboratoire Interdisciplinaire de Physique, UMR 5588, CNRS/Univ. Grenoble Alpes, France. We demonstrate lossless arbitrary control of the free spectral range of optical frequency-combs by integer and fractional factors, through combination of temporal and spectral self-imaging in a simple platform based on a frequency-shifted feedback laser.

SM2I.7 • 12:00
Real-Time Image Compression Based on All-Optical Haar Wavelet Transform, Milad Alemohammad1, Mark A. Foster1; 1Johns Hopkins Univ., USA. An ultrahigh-speed fiber optic image based on all-optical Haar wavelet transform is presented. Images are compressed to less than 30% of their original size by thresholding the most significant wavelet coefficients.

SM2I.8 • 12:15
Ground-state population relaxation dynamics of polarized Rb atoms in Kagome HC-PCF, Ximeng Zheng1,2, Jenny Loin1, Ekaterina Ilinova1, Benoît Debord1, Philippe Thomas1, Frédéric Gerôme1; 1GPPMM group, Xlim Research Inst., UMR CNRS 7252, France; 2SCPTS UMR CNRS 7315, Centre Européen de la Céramique, France. We polarized ground-state population thermal-Rb in inner-wall core-coated and uncoated Kagome HC-PCFs and measured its relaxation-time and its dependence with the pumping-laser intensity and detuning. Enhancement in relaxation-time in coated fibers is observed.

12:30–13:30 Lunch Break (on your own)

12:30–13:30 OSA Workshop on New Regimes for Nonlinear Optics, Room 231B

12:30–15:30 SC424: Optical Terahertz Science and Technology SC439: Attosecond Optics
AM2J • Applications of Optical Frequency Combs—Continued

AM2J.6 • 11:45
Ultrafast Electrooptic Dual-comb Interferometry Over 40-nm Bandwidth, Vicente D. Durán1, Chalmers Univ. of Technology, Sweden. We combine dual-comb interferometry with coherent nonlinear spectral broadening. We show high-speed (sub-millisecond) mode-resolved electric-field complex measurements of 25 GHz electrooptic frequency combs spanning the whole C band (1530-1565 nm).

AM2J.7 • 12:00
Self-Referenced, Chipscale Kerr Frequency Comb without External Broadening, Victor Brasch1, Erwan Lucas1, John D. Jost1, Michael W. Geselmann1, Tobias Kippenberg1, Ecole Polytechnique Federale de Lausanne, Switzerland. A Kerr frequency comb generated in an integrated silicon nitride microresonator is self-referenced using the 2f-3f approach. With an intrinsic bandwidth of two-thirds of an octave no additional, external broadening of the spectrum is required.

AM2J.8 • 12:15
Wavelength detection at sub-femtometer resolution and application to laser stabilization, Nikolaus K. Metzger1, Roman Spesyvtsev1, Michael Maizl1, Bill Miller1, Graeme Malcolm2, Kishan Dholakia1, Univ. of St Andrews, UK; 2M Squared Lasers Ltd, UK. An integrating sphere generates wavelength-dependent speckle patterns that realizes an ultra-sensitive wavemeter with sub-femtometre resolution. Utilizing this wavemeter, we stabilize a laser for atom cooling of Rubidium to better than 1 MHz.

AM2K • A&T Topical Review on Extreme Ultraviolet and Soft X-Ray Sources and Applications II—Continued

AM2K.4 • 12:00
High-Power, High-Repetition-Rate Pulsed CO2 Lasers and their Application in EUV Lithography Sources, Yezheng Tao1, Cymer, USA. The development of high-power, high-repetition-rate pulsed CO2 Lasers and their application in high-power and clean EUV lithography source for high-volume-manufacturing of semiconductors in Cymer-ASML is reviewed.

SM2L • Terahertz Emitters and Detectors I—Continued

SM2L.6 • 11:45
Cascaded Difference-Frequency Generation using Tailored Optical Spectra for Highly Efficient Terahertz Sources, Koustuban Ravi1,2, Giovanni Cirmi2,3, Michael Hemmer2, Fabian Reichert4, Damian N. Schimpf2, Oliver D. Muecke2,3, Franz X. Kaertner1,2, MIT, USA; 3Ultrafast Optics and Xrays Group, Center for Free Electron Laser Science, Germany; 4Center for Ultrafast imaging, Univ. of Hamburg, Germany. We describe cascaded difference-frequency generation (DFG) between multiple laser-lines generating terahertz pulses at >10% energy-conversion efficiency. DFG initiated by a laser-line and weak laser-seed rapidly cascades to self-generate multiple laser-lines and produce exponential terahertz growth.

SM2L.7 • 12:00
Terahertz Trace Gas Spectroscopy Based on a Fully-Electronic Frequency-Comb Radiating Array in Silicon, M. Mahdi Assefzadeh1, Babak Jamali1, Aleksander K. Gluszek1, Arkadiusz J. Hudzikowski1, Jacek Wojtas1, Frank Tittel1, Aydin Babakhani1, Rice Univ., USA. A silicon integrated circuit is reported for radiating picosecond pulses with tunable repetition rate, covering frequencies from 0.03 to 1.03 THz. This source is used in a gas spectroscopy setup to measure the absorption lines of ammonia and water in the terahertz region.

SM2L.8 • 12:15
1550 nm Large-Area Plasmonic Photoconductive Terahertz Sources, Nezih Yardimci1, Mona Jarrahi1, Univ. of California - Los Angeles, USA. We demonstrate that large-area plasmonic photoconductive sources fabricated on ErAs:InGaAs, operating at telecommunication wavelengths can offer high-power and broadband terahertz radiation. We achieve 300 µW pulsed terahertz radiation power over 0.1 – 5 THz frequency range.
Performance of an Optical Differentiation Wavefront Sensor based on Binary Pixelated Transmission Filters, Jie Qiao, Zachary Muhollan, Aaron Schweinsberg, Christophe Dorrer, Rochester Inst. of Technology, USA; Aktiwave LLC, USA. An optical differentiation wavefront sensor based on binary pixelated transmission filters allows for accurate wavefront metrology from two measured orthogonal wavefront gradients. Numerical and experimental investigation of its performance is presented.

All-fiber MOPA prototype with 100 µJ temporally-shaped nanosecond-pulse and spatially coherent top-hat beam output for large-scale laser facility front end, Florent Sacq, Pierre Gourieu, Arnaud Perrin, Jean-François Gleyze, Commissariat à l’énergie atomique et aux énergies alternatives (CEA), France; Laboratoire PHLAM/IRCICA, France. We present a fully integrated MOPA at 1053 nm designed to meet stringent requirements of large-scale laser facilities front-end. We achieve 100 µJ temporally-shaped pulses of few nanoseconds at 10 kHz with coherent top-hat beam output profile.

High-Contrast Time-Multiplexed Pulse-Shaping Systems, Christophe Dorrer, Wade Sittle, Robert Cuffney, Elizabeth Hill, Tanya Kosc, John Kelly, Jonathan Zuegel, Univ. of Rochester, USA. A process for optimizing a time-multiplexed pulse-shaping system generating up to eight shaped optical waveforms is described, leading to contrast better than 68 dB for four-channel operation and 46 dB for eight-channel operation.

Deep tomography: Polarization-entangled photon pairs in technicolor, Bin Fang, Marco Liscidini, John E. Sipe, Virginia Lorenti, Phys., Univ. of Illinois at Urbana-Champaign, USA; Physics, Univ. of Pavia, Italy; Physics and Inst. for Optical Sciences and Inst. for Optical Sciences, Univ. of Toronto, Canada. We realize the frequency-resolved reconstruction of the density matrix of polarization-entangled photon pairs by stimulated emission tomography. This approach enables deeper insight into the correlations between different degrees of freedom in the photon-pair source.

Complete Bell state measurement realized utilizing time-polarization hyperentanglement, Brian Williams, Travis Humble, Oak Ridge National Lab, USA. We report deterministic measurement of time-polarization hyperentangled two-photon Bell states with common single-photon detectors. Optical fiber distributed Bell states are detected with 84.93% success, demonstrating that our method may enable superdense coding over fiber channels.

Smoke, Mirrors, and Black Boxes: Imaging the Invisible World, Rohit Bhartia, Greg Wenger, Lauren Deflores, Victoria Orphan, Luther Beegle, William Hug, Kenneth Nealson, Planetary Chemistry & Astrobiology Group, Jet Propulsion Lab, USA. This talk highlights current research efforts using a fusion of UV fluorescence/Raman spectroscopy, imaging, and analytical methods to detect microbes, organics, and signatures of life on natural and anthropogenic surfaces.

OSA Workshop on New Regimes for Nonlinear Optics, Room 231B

SC424: Optical Terahertz Science and Technology
SC439: Attosecond Optics
Whispering gallery modes in a single silica microparticle attached to an optical microfiber, Ningyu Liu, Lei Shi, Sang Zhu, Xinxiao Xu, Xixiang Zhang, Huazhong Univ of Science and Technology, China. A stable and compact structure is experimentally demonstrated to excite whispering gallery modes in a silica microparticle (~10 μm) attached to a microfiber. With extinction ratios over 15 dB, Q factors over 450 are achieved.

Efficient Er3+-doped fiber based on nano-engineered Yttria Stabilized Zirconia Silicate Fiber, Yen-Wen Lee, Jun-Shin Chang, Shyamal Das, Anirban Dhar, Minmay Paul, Mukul Chandra Paul, National Taipei Univ. of Technology, Taiwan, CSIR-Central Glass and Ceramic Research Inst., India. We report on the development of efficient continuous wave fiber laser utilizing an Er3+-doped nano-engineered yttria stabilized zirconia-alumino silicate fiber. Such a fiber presents better capability of cluster elimination than commercial Er3+-doped silica fibers.

A stable and compact SOA-based fiber ring laser around 1.5 μm with an 0.016nm is achieved.

A stable and compact SOA-based fiber ring laser around 1.5 μm with a center wavelength of 1560.6 nm, 3dB bandwidth of less than 3kHz, and experimentally demonstrated. Output laser with the reduced to 8 kHz within over 1 hour, which is significant for high-accuracy sensing.

Efficient Er3+-doped fiber laser based on nano-engineered Yttria Stabilized Zirconia Alumino Silicate Fiber, Yiwen Lee, Jun-Shin Chang, Shyamal Das, Anirban Dhar, Minmay Paul, Mukul Chandra Paul, National Taipei Univ. of Technology, Taiwan, CSIR-Central Glass and Ceramic Research Inst., India. We report on the development of efficient continuous wave fiber laser utilizing an Er3+-doped nano-engineered yttria stabilized zirconia-alumino silicate fiber. Such a fiber presents better capability of cluster elimination than commercial Er3+-doped silica fibers.

A single longitudinal mode fiber ring laser based on cascaded microfiber knots filter, Yue Li, Zhin Xu, Qihen Sun, Yi Yang Luo, Lin Zhang, Huazhong Univ of Science and Technology, China; 2CSIR-Central Glass and Ceramic Research Inst., India. We report a SOA-based fiber ring laser around 1.5 μm with an intracavity MEMS tunable Fabry-Pérot filter for wavelength selection. Quasi-CW electro-thermal tuning of 103 nm with introducing self-injection locking, beat frequency fluctuation is maintained fundamental mode output.

A stable and compact SOA-based fiber ring laser around 1.5 μm with a center wavelength of 1560.6 nm, 3dB bandwidth of less than 3kHz, and experimentally demonstrated. Output laser with the reduced to 8 kHz within over 1 hour, which is significant for high-accuracy sensing.

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FM3A.1 • 13:30
Topological Photonic Crystal in Three Dimensions, Ling Lu, Chen Fang, Liang Fu, Steven G. Johnson, John Joannopoulos, Marin Soljacic 1; MIT, USA. We discover a 3D magnetic topological photonic crystal hosting a single surface Dirac cone, protected by a crystal symmetry. Such a gapless surface state is fully robust against random disorder of any type.

FM3A.2 • 13:45
Photonic Topological Zero-Modes in a 2D Lattice, Jiho Noh, Vladimír Benalcazar, Taylor L. Hughes, Mikael C. Rechtsman 1; Dept. of Physics, The Pennsylvania State Univ., USA; Dept. of Physics, Univ. of Illinois at Urbana-Champaign, USA. We propose the realization of topological zero-modes in a two-dimensional quantum spin Hall-like photonic topological insulator structure. Unlike topological edge or surface modes, these zero-modes are point-like and thus have two fewer dimensions than their host lattice.

FM3A.3 • 14:00
Invited
Topological Lasers, Gal Harari 1, Miguel A. Bandres 2, Yaakov Lumer 1, Yonatan Plotnik 1, Demetrios N. Christodoulides 1, Mordehai Segev 1; Physics, Technion, Israel; College of Optics and Photonics, CREOL, USA. We present the first topological laser: topologically-protected lasing in photonic honeycomb lattices. We show that the lasing modes are unidirectional and robust to defects.

FM3A.4 • 14:30
Dirac Physics in Silicon via ‘Photonic Boron Nitride’, Matthew Colvin 1, Jack Zhang 2, Richard Bojko 1, Lukas Chrostowski 1, Mikael C. Rechtsman 1; Physics, The Pennsylvania State Univ., USA; Electrical Engineering, Univ. of British Columbia, Canada; Electrical Engineering, Univ. of Washington, USA. We employ “photonic boron nitride”, a silicon photonic crystal slab composed of a honeycomb lattice – to observe Dirac physics of guided modes. The lattice is composed of two triangular lattices of different hole-size, which breaks the Dirac cone and opens up an observable band gap.

FM3A.1 • 13:30
Tutorial
Arbitrary and Self-Configuring Optics – New Opportunities for Integrated and Nano Photonics, David A. B. Miller 1; Stanford Univ., USA. Modern integrated optical technologies offer new flexibilities, and emerging applications like mode multiplexing, quantum networks, and microwave photonics demand complex components. Recent developments show such arbitrary optics can be designed, including self-configuration, correction and stabilization.

FM3A.2 • 14:30
Optical Investigation of Radiation Induced Conductivity Changes in STT-RAM Cells, Qiancheng Zhao 1, Mihren Raman 1, Ilya Krivorotov 2, Mikhail Nilsson 1; Department of Physics, The Pennsylvania State University, USA; Department of Physics and Astronomy, University of California, Irvine, USA; Department of Chemical Engineering and Materials Science, University of California, Irvine, USA. Plasmonic defect spectroscopy of STT-RAMs under high energy radiation is proposed here. We show that engineered constellation designs of the STT-RAMs can be used to understand radiation defects by measuring optical reflectivity, diffraction, or absorption.

FM3A.3 • 14:40
Picosecond, ultraviolet fiber laser at 300MHz repetition rate: resonant quantum logic gate source. Mahmod I. Hussain 1, Matthew Petrasunas 2, Yalid Blums 3, Mirko Lobino 3, Erik Streed 3, David Kieljinski 3; Center for Quantum Dynamics, Griffith Univ., Australia. We engineered a fiber laser source capable of producing 2.5ps UV pulses at 300MHz repetition rate. Laser wavelength resonates with one of the strong transition in Yb+ ion, and it will enable us to coherently manipulate Yb+ via f-f-transitions to make fast entangling gates.

FM3A.4 • 14:15
Entangling Gate with Trapped Ions Using Long, Sebastian Weidt 1, Joe Randall 1, Simon Webster 2, Kimberley Lake 3, Anna Webb 1, Ilyas Cohen 1, Tomas Navickas 1, Bjorn Lekitsch 1, Alex Retzker 1, Winfried Hensinger 1; Hebrew Univ. of Jerusalem, Israel; Dept. of Physics and Astronomy, Univ. of Sussex, UK; QOLS, Blackett Lab, Imperial College London, UK. The use of long-wavelength radiation for gate operations is a promising approach for trapped-ion quantum computation. We demonstrate the key principle of this approach by generating a maximally entangled two-qubit Bell-state with fidelity of 0.985.

FM3A.5 • 14:30
Entanglement between Rydberg excited state and ground-state spin wave, Dongsheng Ding 1, Unirn Science and Technology of China, China. Here, we report on the successful storage of a true single photon using the Rydberg polariton and establishment of the entanglement between Rydberg excited state and the ground state spin wave experimentally, making a primary step towards the construction of a hybrid quantum interface.
Disorder Fingerprint – The Distribution of Local Density of States in Random Media, Roxana Ravzan: Naraghi1, Sergey Sukhov, Aristide Dogariu1,2; 1OREL, The College of Optics and Photonics, Univ. of Central Florida, USA; 2Physics, Univ. of Central Florida, USA. We demonstrate the first direct measurement of the local density of states in random media. Our experiments and numerical calculations show that the long-tailed distributions manifest non-Gaussian behavior that depend on the type of disorder.

Nanometric Anderson Localization at Optical Wavelengths, Hanan Herzig Sheinfux1,2; 1FMSD, 2NSF-UIUC Institute for Nanotechnology, USA. We demonstrate localization of visible light in deep subwavelength disordered multilayers with ~15 nm layer thicknesses, making it possible to sense 2 nm thickness variations in individual layers, and we demonstrate localization enhanced transmission.

Direct Measurement of Anderson Localisation in Large-scale Coupled-Resonator Slow-light Waveguides, Devin Smith1, Eichi Kuramochi1,2, Masaya Notomi1,2; 1NTT Basic Research Labs, NTT Corporation, Japan; 2NTT Nanophotonics Center, NTT Corporation, Japan. Performance of slow-light coupled-resonator optical waveguides (CROW) in a photonic crystal was analysed, and found to be limited by disorder-induced localisation. Localised modes were directly measured through out-of-plane loss.

Observation of Lasing in an Anderson Localizing Optical Fiber, Behnam Abaie1, Esmail Mobini1, Saiman Karbasi1, John Ballato1, Arash Maafi1; 1Univ. of New Mexico, USA; 2Univ. of San Diego, USA; 3Clemson Univ., USA. Lasing is reported for the first time in a dye filled Anderson localizing disordered optical fiber. The laser modes strongly resemble the localized modes of the passive fiber without the dye filling.

Broadly-tunable Pulse Generation in Cavity-Free Graphene Random Fiber Lasers, Baicheng Yao1, Yunjiang Bao1, Zinan Wang1, Xu Wu1, Jinhao Zhou1, Han Wu1, Wei Li Zhang1, Yuanfu Chen1, Yanrong Li1, Dmitry V. Churkin1, Sergey K. Turitsyn1, Chee Wei Wong1; 1UESTC, China; 2ULTA, USA; 3Aston Univ., UK. Broadly-tunable pulse generation in cavity-free graphene random lasers is reported, with tunable pulsewidths across two orders-of-magnitude to less than 900 ps, tunable repetition over three orders-of-magnitude up to 3 MHz, and 41-dB singly-polarized extinction ratio.

On-Chip Optical Neuromorphic Computing, Yichen Shen1, Scott Skirlo1, Marni Soljacic1, Dirk R. Englund1, Nicholas Harris1, MTV, USA. We propose an on-chip nanophotonic system that do the neural network computing in optical domain. Our system is able to give equivalent learning performance, while potentially achieve 1000 times faster speed than conventional electronic neural nets.

Long-duration, picosecond optical pulse shaping on SOI using discrete space-to-time mapping, Hamed Fishvai Bazargani1, Maurizio Buri1, Jose Azana1; 1INRS, Canada. On-chip optical pulse shaping with durations in the order of tens of picoseconds is very challenging. We experimentally synthesise 70-ps high-quality flat-top pulses using concatenated-couplers in SOI technology platform.

Photonic Hilbert transformer based on laterally apodized waveguide Bragg gratings on a SOI wafer, Hamed Fishvai Bazargani1, Maurizio Buri1, Jose Azana1; 1INRS, Canada. High-performance photonic integer and fractional-order Hilbert transformers, with processing bandwidths above 350 GHz, are experimentally realized using laterally-apodized Bragg gratings on SOI wafers, demonstrating the notably increased tolerance to fabrication errors offered by this technology.
SM3G • Novel Integrated Devices
Presider: Takahide Sakamoto; National Inst of Inform & Comm Tech, Japan

SM3G.1 • 13:30
Axial Confinement in the Monolithic Integrated Self-Rolled-Up Vertical SiN Microcroring Resonator on a Ridge Waveguide, Xin Yu1, Lynford L Goddard1, Xuiling Li1, Xiaogang Chen1, IJICU, USA. Effective axial confinement to the self-rolled-up SiN microtube was incorporated to form a vertical microring resonator. 3× wider FSR was observed in a self-rolled-up SiN microtube compared to that of a self-rolled-up SiN microdisk. An effective axial confinement was achieved by a silicon nitride ridge waveguide.

SM3G.2 • 13:45
Thermally-tunable Ring Resonators for High-speed Optical Sensor Interrogation, Hyun-Tae Kim1, Miao Yu1, Univ. of Maryland at College Park, USA. We report an on-chip sensor interrogator based on thermal-optic ring resonators with a significantly enhanced speed. By using the transient response to a step thermal input, the interrogator was demonstrated to have a 52 kHz speed and 19.2 nm range with 0.33 nm resolution.

SM3G.3 • 14:00
Integrated Chip-scale WaveMeter with 300 MHz Free Spectral Range, Chao Xiang1, Minh Tran1, Kim Kojienia1, Jared Hulme1, Michael Denartment1, Doug Baney1, Bogdan Safra-niec2, John E. Bowers1, Dept. of Electrical and Computer Engineering, Univ. of California, Santa Barbara, USA; ‘Keysight Labs, Keysight Technologies, USA. We designed, fabricated and characterized an integrated chip-scale wave-meter based on an unbalanced Mach-Zehnder interferometer with 300 MHz free spectral range using low-loss Si3N4 platform. We also integrated an optical hybrid to provide phase information.

SM3G.4 • 14:15
An all-silicon passive six-port circuit of all-optical ordered-route transmission, Li Lui1, Jiajia Dong1, Huaqing Qiu1, Fan Ji1, Mengying He1, Haolin Zhou1, Xiliang Zhang1, Wuhun National Lab for Optoelectronics, China. We experimentally demonstrated a six-port passive circuit supporting all-optical ordered-route transmission using thermo-optic effect. The 15-dB bandwidth (BW) is larger than 0.05 nm and the maximum blocking extinction ratio (BER) is 39 dB.

SM3G.5 • 14:30
10 Gbit/s Carbon-Rich SiC Based All-Optical Data Inverter, Shih-Chang Syu1, Chih-Hsien Cheng1, Hui-Yung Wang1, Yu-Chieh Chi1, Gong-Ru Lin1, Graduate Inst. of Photonics and Optoelectronics and Dept. of Electrical Engineering, National Taiwan Univ., Taiwan. All-optical data inversion at 10 Gbit/s in a C-rich SiC1, based Kerr switch with enhanced nonlinear refractive index of 2 × 10−13 cm2/W is demonstrated.

SM3H • Frequency Comb Sources
Presider: Axel Ruehl; Deutsches Elektronen Synchrotron, Germany

SM3H.1 • 13:30
Compact Mode-Locked Diode Laser System for Precision Frequency Comparisons in Microgravity Experiment, Heike Christophorst2, Evgeniy Kovachuk2, Andreas Wich2, Günther Tränkle1, Achim Peters1; 1Institut für Physik, Humboldt Universität zu Berlin, Germany; 2Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Germany. We present a compact mode-locked diode laser designed to generate a frequency comb in the wavelength range of 780 nm. The spectral bandwidth exceeds 15 nm (~20 dB level) with 3.4 GHz mode spacing.

SM3H.2 • 13:45
Compact Low-Noise Frequency Comb Sources: Microchip or Photonic Crystal Fiber?, Alexander Klenner1, Aline S. Mayer1, Adrea R. Johnson1, Kevin Luke1, Michael R. Lamont1, Yoshitomo Okawachi1, Michal Lipson1, Alexander L. Gaeta1, Ursula Keller1; 1Applied Physics and Applied Mathematics, Columbia Univ., USA; 2Dept. of Physics, Inst. of Quantum Electronics, ETH Zurich, Switzerland; 3School of Applied and Engineering Physics, Cornell Univ., USA; 4School of Electrical and Computer Engineering, Cornell Univ, USA; 5Dept. of Electrical Engineering, Columbia Univ., USA. We stabilize a frequency comb generated by supercontinuum from a Si3N4 microchip and compare it to that generated in silica photonic crystal fibers. For high effective nonlinearities, spontaneous Raman scattering in silica can significantly degrade the supercontinuum coherence.

SM3H.3 • 14:00
Phase-Stabilized, Fully Monolithic Mode-Locked Laser, Wanyan Xie1, Chien-Chung Lee1, Tyko Shoji1, Susanna Toda1, Kevin Silverman1, An Feldmann1, Todd Harvey1, Richard Mirin1, Thomas R. Schäibli1; 1Univ. of Colorado at Boulder, USA; 2NIST, USA. We demonstrate the first phase-stabilized, fully monolithic mode-locked solid-state laser operating at 1 GHz fundamental repetition rate. The offset frequency is stabilized to an RF reference with a residual integrated phase noise of ~50 mrad.

SM3H.4 • 14:15
Precision polarization-maintaining Er optical frequency comb based on a nonlinear amplifying loop mirror, Naoya Kuse1, Jie Jiang1, Chien-Chung Lee1, Thomas R. Schäibli1, Martin E. Ferrario1, IMRA America Inc, USA; 2Dept. of Physics, Univ. of Colorado, USA; 3IMRA America Inc, Boulder Research Labs, USA. We demonstrate an ultra-low-noise all polarization-maintaining (PM) Er fiber frequency comb. Mode-locking is induced by a nonlinear amplifying loop mirror (NALM) with the incorporation of an additional phase bias.

SM3H.5 • 14:30
Wake Mode Sidebands and Instability in Comb Lasers with Slow Saturable Absorbers, Shaokang Wang1, Curtis Menyak1, Stefan Drozler1, Laura Sinclair1, Ian Coddington1, Nathan R. Newbury1; 1Computer Science and Electrical Engineering, Univ. of Maryland, Baltimore County, USA; 2NIST, USA. We computationally study wake modes in a fiber comb laser with a slow saturable absorber. We show that these modes will lead to the experimentally-observed sidebands, and we predict the laser’s stable operating regime.
13:30–15:30
AM3J • A&T Topical Review
Supercontinuum Laser Technology and its Applications
Presider: John Clowes; Fianium, USA

AM3J.1 • 13:30
The Rising of the Supercontinuum, James M. Stone1; 2Dept. of Physics, Univ. of Bath, UK. Supercontinuum sources are one of the most widely exploited technologies to emerge from the invention of photonic crystal fibers. I will review the developments in supercontinuum technology which have allowed this exploitation to take place.

AM3J.2 • 14:00
Fully Stabilized Narrow Linewidth 750-MHz Yb Fiber Laser Frequency Comb, Bo Xu1,2, Hideaki Yasui1,2, Yoshaki Nakajima1,2, Yukuan Ma1,2, Zhigang Zhang1,2, Kaoru Minoshima1,2; 1The Univ. of Electro-Communications, Japan; 2ERATO Presider: John Clowes; Fianium, USA

13:30–15:00
AM3K • A&T Topical Review on Advances in Laser-based Remote Sensing I
Presider: Fabio di Teodoro; Raytheon, USA

AM3K.1 • 13:30
Single-Photon-Sensitive Solid-State Image Sensors for Flash Lidar, Brian Aull1,2; MIT Lincoln Lab, USA; 3MIT Lincoln Lab has developed lidar systems based on Geiger-mode avalanche photodiodes using both silicon and InGaAs. This technology has enabled terrain mapping and foliage penetration systems with exquisite sensitivity and high area coverage rate.

AM3K.2 • 14:00
A Methane Lidar for Greenhouse Gas Measurements, Haris Reis1, Kenji Numata1, Stewart Wu1, Brayler Gonzalez1, Michael Rogers2, Molly Fahey3, Anthony Yu1, Mark A. Stephen1, Jianping Mao1, Stan Scott1, Stephan Kawa2, William Hasse1, 1NASA Goddard Space Flight Center, USA; 2Sigma Engineering, Univ. of Maryland, USA; 3Physics, Georgia Inst. of Technology, USA. We report a narrow mode linewidth (~40 kHz) of 750-MHz-spaced Yb-fiber frequency comb and full phase stabilization by f-to-2f interferometer and locking to Er-fiber comb with CW laser. Preliminary further narrowing relative linewidth is demonstrated.

AM3K.3 • 14:15
Detection of Greenhouse Gas (N2O) using Intracavity Absorption Spectroscopy (ICAS), Gautham Das1, Jonas K. valunaru1, Lakehead Univ., Canada. A fiber laser system was developed using a hollow core photonic crystal fiber as a gas cell to detect one of the rotational lines of N2O gas in the 1.55 μm band.

AM3K.4 • 14:30
High Peak Power Single-frequency MOPFA for Lidar Applications, Guillaume Canat1, Béatrice Augère1, Claire Berger1, 1Univ. of Oxford, UK. Metal-halide perovskites show high reflectivity and low reflectance. We report terahertz pump-probe experiments on perovskites materials using optical-pump-terahertz-probe spectroscopy.
Cleo: Science & Innovations

13:30-15:15
SM3M • Laser Technology and Components II
President: Jay Doster; Northrop Grumman
Cutting Edge Opto-Electronics, USA

SM3M.1 • 13:30
Record Fifth-Harmonic-Generation Efficiency Producing 211-nm Pulses Using Cesium Lithium Borate, Yizhe A. Begen-shve1; Lab for Laser Energetics, Univ. of Rochester, USA. The fifth harmonic of a pulsed Nd:YLF laser has been realized in a cascade of nonlinear crystals with a record efficiency of 2.5%. An output energy of 250 mJ was demonstrated.

SM3M.2 • 12:45
Laser System for High-Efficiency Hydrogen Ion Stripping, Yun Liu1, Abdurahim Rakhman1,2; Oak Ridge National Lab, USA; Dept. of Physics and Astronomy, Univ. of Tennessee, USA. We describe the design, installation, and commissioning result of a macro-pulsed megawatt UV laser system for high-efficiency laser stripping of 1 GeV hydrogen ion beam in the accumulator ring of Spallation Neutron Source (SNS), Oak Ridge National Lab.

SM3M.3 • 13:00
Three-Dimensional Holographic Nonlinear Metamaterials, Eucleides C. Almeida1, Tahmim Pria1, Wolfram Inst. of Science, Israel. We demonstrate full control of the nonlinear phase in 3D, multilayer metamaterials. Functional nonlinear optical elements are designed and fabricated, demonstrating capabilities to generate and shape light beams and computer generated nonlinear holography.

SM3M.4 • 14:15
Configuration Interaction on Plasmonic Metasurfaces Controlling Optical Transitions, Masanobu Iwanaga1,2, Alex Verdun3,4, Xuan Liu2, Patrice Genevet1,2, Jian Chen1,2, Yehiam Prior1,2, Jacques Collin5, Paul Drine5,6, Patrice Guillemin5,6, Artur Davoyan5,6,6AM3O.1 • 13:30
Invited
Light Sheet Microscopy with Wavefront Coding for Fast Volumetric Imaging of Biological Samples, Omar E. Olate1, Jordi Andilla3, Jacob Lopez-Rodriguez3, David Artigas1, Pablo Loza-Alvarez2, ICFO, The Inst. of Photonic Sciences, Spain. Decoupling the illumination from the detection optics in microscopy can be achieved by combining light sheet and wavefront coding. This results in a system that allows the light sheet to produce optical sections from out of focus planes. By scanning the light sheet through the sample, it is possible to produce a high-resolution volumetric images of living samples at unprecedented speeds.

SM3M.5 • 14:30
Reduced thermal lensing in an end-pumped Nd:YVO4 laser using a ring-shaped intensity distribution to decrease the radial temperature gradient. Preliminary results for a Nd:YVO4 laser are presented.

Cleo: Fundamental Science

13:30-15:30
FM3N • Plasmonic Metasurfaces
President: Artur Davoyan; California Institute of Tech., USA

FM3N.1 • 13:30
Invited
High efficiency phase gradient metasurface using refractive plasmonic Zirconium Nitride, Krishnakali Chaudhuri1, Amir Shaltout1, Urcan Guler1, Vladimir M. Shalaev1,2, Alexander Boltasseva1,2,3,4; Purdue Univ., USA; Nanometatechnologies, USA. A phase-gradient metasurface layer composed of refractive plasmonic zirconium nitride nanoantenna array has been developed for demonstration of photonic Spin Hall Effect which shows similar high efficiency as previously reported gold SHE design.

FM3N.2 • 14:00
High efficiency Femtosecond Hydrogen Raman Laser, Carlo Vicario1,2, Maria P. Molinaro3,4; University of Zurich, Switzerland; 2P.N. Lebedev Physical Inst., Russia; 3Ecole Poly-technique Federale de Lausanne, Switzerland. High-energy pulses at 1.28 µm are demonstrated by stimulated Raman scattering using two chirped pulses of a Ti:Sapphire laser in hydrogen. The Stokes pulse carrying record-high energy of 12 μJ and the linewidth was less than 4.34*10⁻⁸ cm⁻¹.

FM3N.3 • 14:15
Asymmetric surface plasmon wave generation with a meta-structure, Alexander Y. Zhu1,2, Daniel Witzel1, Antonio Ambrosio1,2, Patrice Genevet1, Federico capasso1,2, John A Paulson School of Engineering and Applied Science, Harvard Univ., USA; CNR-SPIN U.O.S. Napoli, Dipartimento di Fisica, Universita di Napoli Federico II, Italy; Nanochallenges, CNRS-CRHEA, France. 2D phase gradients can be achieved from a 1D array of V-apertures. We exploit this degree of freedom, engineering asymmetric surface plasmon waves whose wavefronts can be controlled arbitrarily and characterize them via near-field microscopy.

Meeting Room 212 D

Cleo: Applications & Technology

13:30-15:30
AM3O • Microscopy for Biomedical Applications I
President: Xuan Liu; New Jersey Inst. of Technology, USA

AM3O.1 • 13:30
Invited
Imaging Functional Maturation Of Pancreatic Beta-Cells and Neuronal Circuit Activity in Zebrafish in vivo using Two-Photon Three-Axis Digital Scanned Light-sheet Microscopy, Weijian Zong1, Jia Zhao1, Runlong Wu1, Fuzeng Niu1, Yi Wu1, Yunfeng Zhang1, Amin Wang2, Yanmei Liu1, Yujie Sun1, Liangyi Chen1,2, Inst. of Molecular Medicine, Peking Univ., China; School of Electronics Engineering and Computer Science, Peking Univ., China; School of Software and Microelectronics, Peking Univ., China; Biodynamic Optical Imaging Center, Peking Univ., China. Here we have developed a novel large-field high-resolution two-photon digital scanned light-sheet microscopy (2P3A-DSLM) based on ultrafast axial scanning of illumination focal spot with a tunable acoustic gradient (TAG) index device. This new technique provides a sub-micron axial resolution with a large field of view in deep tissues. In vivo imaging with 2P3A-DSLM resolves functional maturation of pancreatic beta cells and neuron circuit activities in live Zebrafish embryos.

Meeting Room 212 C

Cleo: Science & Innovations

13:30-15:15
SM3M • Laser Technology and Components II
President: Jay Doster; Northrop Grumman
Cutting Edge Opto-Electronics, USA

SM3M.1 • 13:30
Record Fifth-Harmonic-Generation Efficiency Producing 211-nm Pulses Using Cesium Lithium Borate, Yizhe A. Begen-shve1; Lab for Laser Energetics, Univ. of Rochester, USA. The fifth harmonic of a pulsed Nd:YLF laser has been realized in a cascade of nonlinear crystals with a record efficiency of 2.5%. An output energy of 250 mJ was demonstrated.

SM3M.2 • 12:45
Laser System for High-Efficiency Hydrogen Ion Stripping, Yun Liu1, Abdurahim Rakhman1,2; Oak Ridge National Lab, USA; Dept. of Physics and Astronomy, Univ. of Tennessee, USA. We describe the design, installation, and commissioning result of a macro-pulsed megawatt UV laser system for high-efficiency laser stripping of 1 GeV hydrogen ion beam in the accumulator ring of Spallation Neutron Source (SNS), Oak Ridge National Lab.

SM3M.3 • 13:00
Three-Dimensional Holographic Nonlinear Metamaterials, Eucleides C. Almeida1, Tahmim Pria1, Wolfram Inst. of Science, Israel. We demonstrate full control of the nonlinear phase in 3D, multilayer metamaterials. Functional nonlinear optical elements are designed and fabricated, demonstrating capabilities to generate and shape light beams and computer generated nonlinear holography.

SM3M.4 • 14:15
Configuration Interaction on Plasmonic Metasurfaces Controlling Optical Transitions, Masanobu Iwanaga1,2, Alex Verdun3,4, Xuan Liu2, Patrice Genevet1,2, Jian Chen1,2, Yehiam Prior1,2, Jacques Collin5, Paul Drine5,6, Patrice Guillemin5,6, Artur Davoyan5,6,6AM3O.1 • 13:30
Invited
Light Sheet Microscopy with Wavefront Coding for Fast Volumetric Imaging of Biological Samples, Omar E. Olate1, Jordi Andilla3, Jacob Lopez-Rodriguez3, David Artigas1, Pablo Loza-Alvarez2, ICFO, The Inst. of Photonic Sciences, Spain. Decoupling the illumination from the detection optics in microscopy can be achieved by combining light sheet and wavefront coding. This results in a system that allows the light sheet to produce optical sections from out of focus planes. By scanning the light sheet through the sample, it is possible to produce a high-resolution volumetric images of living samples at unprecedented speeds.

SM3M.5 • 14:30
Reduced thermal lensing in an end-pumped Nd:YVO4 laser using a ring-shaped intensity distribution to decrease the radial temperature gradient. Preliminary results for a Nd:YVO4 laser are presented.

AM3O.2 • 14:30
Invited
Light Sheet Microscopy with Wavefront Coding for Fast Volumetric Imaging of Biological Samples, Omar E. Olate1, Jordi Andilla3, Jacob Lopez-Rodriguez3, David Artigas1, Pablo Loza-Alvarez2, ICFO, The Inst. of Photonic Sciences, Spain. Decoupling the illumination from the detection optics in microscopy can be achieved by combining light sheet and wavefront coding. This results in a system that allows the light sheet to produce optical sections from out of focus planes. By scanning the light sheet through the sample, it is possible to produce a high-resolution volumetric images of living samples at unprecedented speeds.

Liangyi Chen is a professor and principal investigator in the Institute of Molecular Medicine, Peking University. His current research interests are focused on development of novel high spatiotemporal fluorescence imaging techniques for in vivo studies. His lab also use these new technologies to study blood glucose regulation and the pathological process underlying diabetes progression, using both Zebrafish and mouse models. As the corresponding author, Chen has published papers in peer-reviewed journals such as Dev Cell, Cell Res., Proc Natl Acad Sci U S A., Biophys J., Biomed Opt Express., Diabetes and Diabetologia. He has served as a senior faculty member in the Neuronal Signaling Mechanisms Section in Faculty of 1000 Biology since 2012. He has given invited talks in international conferences hosted by OSA, SPIE and Biophysical Society.

Marriott Salon I & II
Real-time dual-comb spectroscopy with a free-running femtosecond fiber laser, Soroush Mehravari, Robert Nonwood, Nasser Peyghambarian, Khahn Q. Kieu; "Univ. of Arizona, USA. We demonstrate a new laser source for dual-comb spectroscopy. The key idea is to generate the two optical frequency combs from a single laser cavity so that common noise drifts are cancelled removing the need for complex phase locking apparatus.

Unidirectional, common-path dual-comb lasing enabled by plasmonic metal-cored glass fibres where, upon pulsed laser excitation, the coupling between plasmonic and dielectric modes induces strong light collimation and suppression of nonlinear absorption, providing a novel platform for tunable fiberized sources and sensors.

Visible Laser Oscillation in Single-Mode pr-Doped Double-Clad Structured Waterproof Fluoroo-Aluminate Glass Fiber, Shota Kaijake, Tokinori Terao; "Firstly, we set up the experimental system of a cladding-pumped thulium-doped fiber laser using a digital micromirror device based wavelength selection technology. Tunability over 21nm was achieved with up to 8.4W of output power as well as multi-wavelength operation. We demonstrated a visible laser oscillation in a Pr-doped double-clad structured waterproof fluoro-aluminate glass fiber. The maximum output power and the slope efficiency were measured to be 251.7 mW at 639.0 nm and 43.4%, respectively.

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A Graphene-Enhanced O-Switched Distributed Feedback Fiber Laser, Basheng Yao, Shu-Wei Huang, Yu Wu, Ziyong Feng, Chanyeol Choi, Hao Liu, Hai Feng Peng, Xiaofeng Duan, Yunjiang Rao, Chee Wei Wong; "U. of New South Wales, Australia. We report a 600-fold peak power enhancement of pulsed distributed feedback fiber lasers with monolayer graphene O-switching. The tunable graphene-DBR fiber laser demonstrates sub-MHz linewidth and sub-ps pulses simultaneously, approaching the transform limit.

Mechanically Flexible Photonic-Crystal Cavities on Strained Germanium Fabricated by Nanomembrane Assembly, Jan Yin, Xiaorui Cui, Xiaowei Wang, Max Lagally; "Bostom Univ, USA; "Univ of Wisconsin - Madison, USA. Mechanically flexible photonic-crystal cavities consisting of interconnected sub-micron arrays are fabricated on Ge nanomembranes by a novel membrane assembly approach. Photonic-crystal cavity resonances are clearly observed in the strain-enhanced photoluminescence spectra.

Highly Accurate Multichannel Fiber Transfer Delay Measurement, Jingwen Dong, Bo Wang, Chao Gao; "Univ. of Colorado at Boulder, USA; "U. of Arizona, USA; "Univ. of Arizona, USA; "Univ. of Arizona, USA. We present a single-mode, 209 µm holmium-doped silica fibre laser resonantly pumped by a 1.95 µm thulium-doped fibre laser. The slope efficiency of 87% versus absorbed power is to our knowledge the highest reported to date.
FM3A • Topological Photonics—Continued

Topological Optical Waveguiding in Silicon and Beating between Trivial and Topological Defect Modes, Andrea Blanco-Redondo1, Imanol Andoñezuia2, Matthew Collins1, Gal Harani1, Yakoob Lumer1, Mikhail C. Rechtsman1, Benjamin Eggleton1, Mordechai Segev1, “Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS), Inst. of Photonics and Optical Science (IPOS), School of Physics, The Univ. of Sydney, Devices for Optical Systems (CUDOS), Inst. of Photonics and Optical Science (IPOS), School of Physics, The Univ. of Sydney, Australia; 2Departamento de Fisica Aplicada, Universidad del Pais Vasco, Spain; 1Dept. of Physics, The Pennsylvania State Univ., USA; 3Dept. of Physics, Technion - Israel Inst. of Technology, Israel. We experimentally demonstrate topologically protected optical waveguiding in silicon at the interface between two topologically distinct dimer chains. Further, we propose and demonstrate beating between topological and trivial defect modes.

Induction of Topological Transport by Long Ranged Nonlinearity, Yaniv Tenenbaum Katani1, Rivka Bekenestein1, Miguel A. Bandres1, Yaakov Lumer1, Piotr Koytovan1, Mordechai Segev1, Technion, Israel. We present topologically-protected transport in systems that are topologically trivial, but a long-range nonlinearity induces unidirectional transport and topological immunity to scattering from defects.

Photonic Topological Dynamics induced by Curved Surfaces, Eran Lustig1, Moshe-Ishay Cohen1, Rivka Bekenestein1, Miguel A. Bandres1, Gal Harani1, Mordechai Segev1, Technion, Israel. We present topological photonics in curved space. We use 1D waveguide lattices on curved surfaces, and show that the curvature of the surface induces topological phase transfer dynamics, Thouless pumping, localization and delocalization of waves.

FM3B • Advanced Nanophotonic Platforms—Continued

Correlated Perovskites as a New Platform for Super Broadband Tunable Photonics, Zheyu Li1,2, You Zhou1, Hao Qi1,2, Norman N. Shi1, Qiwei Pan1, Ping Lu1, Aaron Stein1, Christopher Y Li1,2, Shiriram Ramanathan1, Nanfang Yu1, “Applied Physics and Applied Mathematics, Columbia University, USA; 3School of Engineering and Applied Sciences, Harvard Univ., USA; 4Dept. of Materials Science and Engineering, Drexel Univ., USA; 5Center for Functional Nanomaterials, Brookhaven National Lab, USA; 6Dept. of Materials Engineering, Purdue Univ., USA. We report strong and non-volatile optical modulation utilizing electron-doping induced phase change of a perovskite, SmNiO$_3$. Broadband modulation ($\lambda$=400nm-17mm) is demonstrated using thin-film SmNiO$_3$, and narrowband modulation is realized with metasurfaces integrated with SmNiO$_3$.

Graphene Hybrid Optomechanics, Kevin G. Schärdler1, Antoine Ressibat-Plantey1, Louis Gaudreau1, Gabriele Navickaite1, Johannes Güttinger1, Darrick Chang1, Costanza Toninelli1, Adrian Bachhold1, Frank Koppens1, ICFP, Spain; 2CNR-INO, LENS, Italy. We present a novel hybrid optomechanical system comprising a graphene drum resonator coupled to the near field of an NV center. Using this system, we demonstrate graphene nanomotion transduction and electromechanical NV emission control.

FM3C • Coherent Effects in Atoms & Ions—Continued

Parametric Cooling of a Degenerate Fermi Gas by Shaking an Optical Trap with Anharmonic Frequencies, Le Luo1, Jiaying Li1, Ji Liu1, Leonardo de Melo1, Indiana Univ-Purdue Univ Indianapolis, USA. We develop a technique for cooling a degenerate Fermi gas in a crossed-beam optical trap, where high-energy atoms are selectively removed by modulating the stiffness of the trapping potential with anharmonic trapping frequencies.

Dynamically Shaped Optical Dipole Atom Traps for Rapid Cooling to Quantum Degeneracy, Ryan S. Bowler1, Richard Roy1, Alaina Green1, Subhadeep Gupta1, University of Washington, USA. To improve the efficiency of evaporative cooling in optical atom traps, we utilize the time-averaged potential of a rapidly moving laser to achieve 174Yb Bose-Einstein Condensates of S $\approx$ 10$^5$ atoms within $\Delta t$.s

Time-resolved Scattering of a Single Photon by a Single Atom, Matthias Steiner1,2, Victor Leung1, Mathias Alexander Seidler1, Alessandro Ceré1, Christian Kurtsiefer1,2, “Center for Quantum Technologies, National Univ. of Singapore, Singapore; 3Dept. of Physics, National Univ. of Singapore, Singapore. We experimentally investigate the scattering of heralded photons from a single trapped atom and demonstrate that the atomic dynamics depend on whether the temporal envelope of the photon wave packet is exponentially decaying or rising.

15:30–16:00 Coffee Break, Concourse Level
Discrete diffraction, curvature, for configurations which in flat-space show only Bloch oscillations and dynamic localization induced by space lattice wave dynamics and curved space. We demonstrate Israel. We present the first study on the interplay between emission at visible wavelengths from a silicon metasurface the first time to our knowledge, highly-directional fluorescence of Melbourne, Australia.

We study both theoretically and experimentally a new class of surface electromagnetic waves supported by resonant anisotropic metasurfaces, Hybrid localized waves supported by resonant anisotropic metasurfaces, Highly Directional Fluorescent Emission at Visible Wave lengths with a Silicon Metasurface, Wuzhou Song1, Shiqiang Li1, Kenneth B. Crozier1; 1School of Physics, Univ. of Melbourne, Australia; 2School of Electrical Engineering, Univ. of Southern California, USA; 2Ecole Polytechnique Fédérale de Lausanne (EPFL) Lausanne, Switzerland; 3School of Precision Instrument and Opto-electronics Engineering, Tianjin Univ., China; 4Raytheon Co., USA; 5School of Electrical Engineering, Tel Aviv Univ., Israel; 6Edward L. Ginzton Lab, Stanford Univ., USA. We experimentally demonstrate 7-fold multicasting of 20-Gbaud QPSK signals based on Kerr frequency combs, Changing Bao1, Peicheng Liao1, Ame Kordis2, Maxim Karpov2, Martin Hubert Peter Pfeiffer2, Lin Zhang1, Yan Yan1, Guodong Xie1, Yinwen Cao1, Ahmed Almamani1, Ahmad Falahpour1, Changjing Bao1, Fatehmeh Allahabi1, Peicheng Liao1, Bishara Shameea, Loukas Paraschis1, Morteza Ziyadi1, Amirhossein Mohajerin Ariaei1, Yi Luo6, Martin Fejer4, Joseph Touch2, Youchi Akasaka1, Tadashi Ikeuchi2, Alan Willner1; 1Univ. of Southern California, USA; 2Cisco Systems, USA; 3Tel Aviv Univ., Israel; 4Stanford Univ., USA; 5Information Sciences Inst., USA; 6Fujitsu Labs of America, USA. We experimentally de-aggregate the 16-QAM signal (EVM 6.9%) onto two 4-PAM signals (EVM 8.5%). Tunability of the approach over modulation format and bit rate is also shown by de-aggregating QPSK signals at two different baud rates.

15:30–16:00 Coffee Break, Concourse Level
SM3G • Novel Integrated Devices—Continued

Broadband and Non-volatile Liquid Controlled Silicon Photonics Switch, Herbert D’Heer1, Cristina L. Arcia1, Jan Watte1, Koen Huybrechts1, Roel G. F. Baets1, Dries Van Thourhout1; 1Ghent Univ.- imec, Belgium; 2CommScope, Belgium. A broadband and non-volatile liquid controlled silicon photonics switch is proposed. The measured crosstalk is less than −22dB and −12dB over 100nm wavelength range for bar and cross state, respectively. The insertion loss is less than 1dB.

Ultra-Compact Broadband Dielectric Antenna, Julián L. Pita1, Paulo C. Dainese1, Hugo E. Hernandez-Figueroa1, Lucas H. Gabrielli1, 1Universidade Estadual de Campinas, Brazil. We demonstrate an ultra-compact silicon on insulator antenna with 3.2 µm2 footprint and broadband radiation from 1470 nm to 1550 nm for applications in fiber-to-chip coupling and phased arrays.

Highly phase-coherent stabilization of carrier-envelope-offset frequency with graphene modulator on SESAM, Chien-Chung Lee1, Yusuke Hayashi1, Dong Hou1, Kevin Silverman1, Ari Feldman1, Todd Harvey2, Richard Mirin1, Thomas R. Schibli3, 1Univ. of Colorado at Boulder, USA; 2Dept. of Electrical and Electronic Engineering, Tokyo Inst. of Technology, Japan; 3NIST, USA; 4JILA, NIST and Univ. of Colorado, USA. We modelock and stabilize the carrier-envelope-offset frequency of an Er:Yb:glass laser with a monolithic device consisting of graphene modulator and SESAM. Residual phase noise of 17 mrad, from 100 Hz to 1 MHz, is achieved.

Demonstration of an O/E/O Receiverless Link in an Integrated Multi-Channel Laser Neuron, Mitchell Nahmias1, Alexander N. Tait1, Leonidas Toliyas1, Matt Chang1, Thomas F. de Lima1, Bhavin J. Shastri1, Paul R. Prucnal1; 1Princeton Univ., USA. We present an integrated, multi-channel laser processor. It utilizes a novel photodetector-to-laser O/E/O receiverless link to receive multiple wavelength inputs. To our knowledge, this is the first laser neuron compatible with a wavelength-based networking scheme.

Attosecond nonlinear polarization and energy transfer in solids, Annkatin Sommer1, Elisabeth Bothschläfer1, Shunsuke Sato2, Clemens Jakubietz1, Tobias Latka1, Olga Razskazova2, Hanieh Fattahi2, Michael Jabo2, Wolfgang Schrenberger1, Volker Shrimanyan1, Vladislav Yakovlev2, Reinhard Kienberger2, Kazuhiro Yabana2, Nicholas Karpowicz3, Martin Schulze1, Ferenc Krausz1, MPQ, Germany; 3Paul-Scherrer-Institut, Switzerland; 4Univ. of Tsukuba, Japan; 5Georgia State Univ., USA; 6TUM, Germany. Attosecond polarization spectroscopy is a new experimental technique resolving the nonlinear polarization and energy transfer induced by visible few-cycle strong fields in solids. It reveals the intensity dependent response time of the system with attosecond resolution.
Supercontinuum generation in microstructured ZBLAN fibre with six nanobore cores, Xin Jiang, Nicolaus Joly, Martin A. Finger, S. Bashkow, Samuel Poulain, Marcel Poulain, Vincent Cardin, John C. Travers, Philip S. Russell, Max-Planck-Institut für die Chemie, Germany; Department of Physics, University of Erlangen-Nuremberg, Germany; Le Verre Fluore, France. We report fabrication of a microstructured ZBLAN fibre with six nanobore cores each containing a nanobore of diameter ~330 nm. Spectral broadening is observed when pumped by 1042 nm pulses in both fundamental and higher order modes.

Ultra-broadband Supercontinuum Generation at Telecommunication Wavelengths in Dispersion Engineered Stoichiometric Si,N Waveguides, Florian Schepens, Marco A. G. Porcel, John P. Epping, Tim Hellwig, Marcel Hoekman, Richard Mateman, Arne Leinse, Rene G. Heideman, Albert van Rees, Peter J. M. van der Slot, Chris J. Lee, Robert Schmidt, Rudolf Bratschitsch, Klaus-Jochen Boller, Carsten Fallnich, Institute for Applied Physics, University of Münster, Germany; MESA+ Institute of Nanotechnology, University of Twente, Netherlands; LioniX B.V., Netherlands; Institute of Physics, University of Münster, Germany. We demonstrate the generation of ultra-broadband supercontinua in Si,N waveguides at a pump wavelength of 1560 nm. The supercontinuum extends beyond 2.6 µm wavelength in the infrared and has a spectral width of more than 453 THz.

Intense coherent supercontinuum via IR pulse propagation in multiple thin plates, Daniel A. Thrasher, Chih-Hsuan Lu, Chia-Lun Tsai, Yi-Hsuan Tzeng, Ming-Chang Chen, Shiang-De Yang, Andrew H. Kung, Institute of Applied Physics, National Tsing Hua University, Taiwan; Institute of Molecular Sciences, Academia Sinica, Taiwan. We report on the coherent supercontinuum produced by ultrafast IR pulses propagating through thin plates. The -20 dB supercontinuum spans from 750 to 1650 nm and has a total energy of 100 uJ.

Nonlinear Plasmonic THz Absorption in Graphene Ribbons, Martin Mittlendorf, Mohammad Mehdi Jaddi, Jacob König-Otto, Stephan Winnerl, Andrei B. Sushkov, Thomas E. Murphy, University of Maryland, USA; Helmholtz-Zentrum Dresden-Rossendorf, Germany. We investigate the nonlinear plasmonic absorption in graphene ribbons by THz pump-probe spectroscopy. The optical nonlinearity is increased by more than one order of magnitude, which is in excellent agreement with theoretical calculations.

Current-Injection Terahertz Lasing in Distributed-Feedback Dual-Gate Graphene-Channel Field-Effect Transistor, Gen Tamamushi, Takayuki Watanabe, Alexander Dubinov, Hiroyuki Wako, Akira Satou, Tetuya Suemitsu, Maxim Ryshin, Victor Ryshin, Taichi Otsuji, Tohoku University, Japan; Institute of Physics of Microstructures, Russia; University of Aizu, Japan. A distributed-feedback dual-gate graphene-channel field-effect transistor was fabricated as a current-injection terahertz laser. A single mode emission at 5.2 THz was observed at 100 K beyond the threshold carrier injection level.

We demonstrate the generation of ultra-broadband supercontinuum at multiple thin plates, Martin A. Finger, S. Bashkow, Samuel Poulain, Marcel Poulain, Vincent Cardin, John C. Travers, Philip S. Russell, Max-Planck-Institut für die Chemie, Germany; Department of Physics, University of Erlangen-Nuremberg, Germany; Le Verre Fluore, France. We report fabrication of a microstructured ZBLAN fibre with six nanobore cores each containing a nanobore of diameter ~330 nm. Spectral broadening is observed when pumped by 1042 nm pulses in both fundamental and higher order modes.

Ultra-broadband Supercontinuum Generation at Telecommunication Wavelengths in Dispersion Engineered Stoichiometric Si,N Waveguides, Florian Schepens, Marco A. G. Porcel, John P. Epping, Tim Hellwig, Marcel Hoekman, Richard Mateman, Arne Leinse, Rene G. Heideman, Albert van Rees, Peter J. M. van der Slot, Chris J. Lee, Robert Schmidt, Rudolf Bratschitsch, Klaus-Jochen Boller, Carsten Fallnich, Institute for Applied Physics, University of Münster, Germany; MESA+ Institute of Nanotechnology, University of Twente, Netherlands; LioniX B.V., Netherlands; Institute of Physics, University of Münster, Germany. We demonstrate the generation of ultra-broadband supercontinua in Si,N waveguides at a pump wavelength of 1560 nm. The supercontinuum extends beyond 2.6 µm wavelength in the infrared and has a spectral width of more than 453 THz.

Intense coherent supercontinuum via IR pulse propagation in multiple thin plates, Daniel A. Thrasher, Chih-Hsuan Lu, Chia-Lun Tsai, Yi-Hsuan Tzeng, Ming-Chang Chen, Shiang-De Yang, Andrew H. Kung, Institute of Applied Physics, National Tsing Hua University, Taiwan; Institute of Molecular Sciences, Academia Sinica, Taiwan. We report on the coherent supercontinuum produced by ultrafast IR pulses propagating through thin plates. The -20 dB supercontinuum spans from 750 to 1650 nm and has a total energy of 100 uJ.
SM3M • Laser Technology and Components II—Continued

SM3M.6 • 14:45
Observation of Repetition Rate Locking in an Orthogonally-Polarized Dual-Wavelength Passively Q-Switched Hybrid Nd:YVO4/Nd:YLF Laser, Yu-Jen Huang1, Hsin-Ham Cho1, Kuan-Wei Su1, Yung-Fu Chen1,2, Department of Electrophysics, National Chiao Tung University, Taiwan; 2Department of Electronics Engineering, National Chiao Tung University, Taiwan. A dual-wavelength passively-Q-switched laser with orthogonally-polarized emission is originally demonstrated by combining the birefringent Nd:YVO4 and Nd:YLF crystals. The phenomenon of repetition rate locking for the two spectral components is experimentally observed and theoretically analyzed.

SM3M.7 • 15:00
10-fs level synchronization of a photocathode gun with an S-band RF oscillator for an RF photocathode gun, Heewon Yang1, Byunheon Han1, Junho Shin1, Kwangyun Jung1, Dong Hou1, Hyun Chung1, Inhyung Baek1, Younguk Jeong1, Jungwon Kim1, Korea Advanced Institute of Science and Technology (KAIST), Korea; 2Korea University, Seoul, Korea. We demonstrate synchronization between a Ti:sapphire photocathode laser and a 2.856-GHz oscillator for an RF photocathode gun in the KAERI-UED/FEL Facility with 5.1-fs rms jitter (10 Hz - 100 kHz) and 8.1-fs rms drift (for 1-hour).

FM3N • Plasmonic Metasurfaces—Continued

FM3N.5 • 14:45
Circular Polarization Selective Aluminum Nano-Spirals at Ultraviolet Wavelengths, Matthew Davis1,2, Jared Strait2, Steve Blair3, Jay K. Lee4, Amit Agrawal3, Henri Lezec1, Syracuse University, USA; 2Center for Nanoscale Science and Technology, NIST, USA; 3Dept. of Electrical and Computer Engineering, Univ. of Utah, USA; 4Maryland NanoCenter, Univ. of Maryland, USA. Manipulating ultraviolet light presents unique challenges in technology. Here we demonstrate circular polarization selection at ultraviolet wavelengths over subwavelength distances using a flat-optical device consisting of Al chiral nanospirals periodically patterned on a glass substrate.

FM3N.6 • 15:00
Controlling the Polarization State of Light with Metasurfaces via the Excitation of Plane-wave and Focused Electron Beam, Yuhui Hu1,2, Shangchi Jiang1, Zhenghan Wang1, Xiang Xiong1, Ruwen Peng1, Mu Wang1, School of Physics, Nanjing University, China. We demonstrate the general mechanism to construct the dispersion-free metastructure. By designing the parameters of a metallic metamaterial and a dielectric interlayer, the thickness-dependent dispersion of the dielectric spacing layer cancels out the intrinsic dispersion of the metallic structure.

FM3N.7 • 15:15
Tailoring Optical Super-Oscillations with Metasurfaces, Guanghui Yuan1, Edward T. Rogers1, Nikolay I. Zheludev2, Centre for Disruptive Photonic Technologies, Nanyang Technological University, Singapore; 2Optoelectronics Research Centre and Centre for Photonic Metamaterials, Univ. of Southampton, UK; 3Institute for Life Sciences, Univ. of Southampton, UK. The ability to control the phase and intensity of light passing through or reflected from gradient metasurface provides a unique opportunity for engineering optical super-oscillation. We demonstrate this by creating achromatic subwavelength focusing device.

AM3O • Microscopy for Biomedical Applications I—Continued

AM3O.3 • 15:00
Holographic fluorescence microscopy with self-interference incoherent digital holography, Changwon Jang1, Seungjae Lee2, Myung Kim2, Byoungho Lee2, Seoul National University, Korea; 2Dept. of Physics, Univ. of South Florida, USA. We demonstrate the cellular imaging of holographic fluorescence microscopy by implementing self-interference incoherent digital holography (SIDH) apparatus. Complex holograms of three different wavelengths are acquired and post processed to generate pseudo color image of cell.

AM3O.4 • 15:15
Coherence Switching of a Degenerate VECSEL for Multimodality Imaging, Sebastian Knitter1, Changgen Liu1, Brandon Redding1, Michael A. Choma1, Hui Cao1, Yale University, USA. We demonstrate a VECSEL-based degenerate laser with tunable spatial coherence. The low spatial coherence illumination is used for traditional high-speed video-microscopy and high spatial coherence illumination to extract dynamic information of blood flow in Xenopus.
SM3P • Fiber-based Meteorology and Measurements—Continued

SM3P.6 • 14:45 Enhancement of Spatial Resolution in Distributed Measurement of Brillouin Dynamic Grating Spectrum by Optical Correlation Domain Analysis, Takeo Sasaki¹, Masato Kishi¹, Kazuo Hotate¹; ¹Dept. of Electrical Engineering and Information Systems, The Univ. of Tokyo, Japan. We demonstrated the spatial resolution in distributed and discriminative measurement of temperature and strain by optical correlation domain analysis with Brillouin dynamic grating could be improved by applying apodization to read wave.

SM3Q • Fiber Lasers and Amplifiers III—Continued

SM3Q.6 • 14:45 Laser-diode-pumped Tunable Ti:Sapphire Crystal Fiber Laser, Shih-Chang Wang¹, Tao-Tse Yen¹, Teng-I Yang¹, Yuan-Shu Ho¹, Sheng-Lung Huang¹; ¹National Taiwan Univ., Taiwan. A tunable and low-threshold laser-diode-pumped Ti:sapphire crystal fiber laser was achieved using a glass-clad 18-μm-diameter crystalline core as the gain medium. The tuning range was 149 nm with a threshold pump power of 106 mW.

SM3Q.7 • 15:00 Gain Stability in Fluorine Polymer Modified pbs Quantum Dot Fiber Amplifier, Qi Liang¹, Nana Li¹, Alan R. Kost², Xiaolan Sun¹; ¹Shanghai Univ., China; ²Univ. of Arizona, USA. The gain for quantum dot fiber amplifiers (QDFA) was stabilized by capping with fluorine-containing polymers – reducing degradation after 60 days from 77% to 26% and degradation at elevated temperature from 93% to 32%.

SM3Q.8 • 15:15 Laser-conversion from a red laser-diode (687-nm) to IR (806-nm) by using a Tm³⁺-doped ZBLAN optical fiber, Maribel Juarez¹, Efraín Mejía¹; ¹Centro de Investigaciones en Optica AC, Mexico. A Tm³⁺:ZBLAN CW-fiber-laser operating at 806nm when pumped at 687nm with a slope efficiency of 50% is described. Laser threshold of 11.5mW delivering up to 14.9mW limited by the maximum power available was achieved.

SM3R • Novel Photonic Structures and Measurement—Continued

SM3R.6 • 14:45 Effects of non-instantaneous nonlinear absorption in hydrogenated amorphous silicon, Xiaoge Zeng¹, Tho Tran¹, Jason Pelc¹, Dave Kielburski¹, Ray Beausoleil¹; ¹Hewlett Packard Labs, USA. We observed nanosecond-duration absorption transients in several hydrogenated amorphous silicon waveguides using picosecond pump-probe measurements. We posit this effect is due to mid-gap defect absorption and describe implications for integrated nonlinear optics.

SM3R.7 • 15:00 Time-domain Interferometric Characterization of Nonlinear and Thermal-induced Phase-shift in Silicon Waveguides, Ivan A. Aldaya¹, Andres Gil-Molina¹, Hugo L. Fragnito¹, Paulo C. Dainese¹; ¹Univ. of Campinas, Brazil. Time-domain interferometry is used to simultaneously characterize nonlinear and self-heating phase-shifts in silicon waveguides under long-pulse optical pumping. Applied to a strip waveguide, the method enabled measurements of both stationary phase-shifts and thermal time constant.

SM3R.8 • 15:15 Novel Characterization of Photodiode Intermodulation Distortion, Meredith Hutchinson¹, Nicholas J. Frigo¹, Jordan R. Peasant¹; ¹US Naval Research Lab, USA; ²Physics, US Naval Academy, USA; ³Duke Univ., USA. A novel method is presented to characterize photodiode intermodulation distortion (IMD) as a function of output frequency. We find that for a given bias voltage and photocurrent, the IMDs can fall along a single curve.

15:30–16:00 Coffee Break, Concourse Level
Two-Octave-Wide UV–VIS Raman Spectra Generated in Hollow-Core PCF Filled with Gas Mixtures, Poorna Hosseini, Amir Abdolvand, Philip S. Russell, Max Planck Inst. for the science of light, Germany; Physics, Univ. of Erlangen-Nuremberg, Germany. A ro-vibrational Raman comb spanning 280 to 1000 nm is generated in a H2-filled anti-resonant-guiding kagomé hollow-core PCF pumped at 532 nm. Addition of xenon produces a dense cluster of >150 side-bands in the visible.

Quasi-phase-Matched Electric-Field-Induced Second-Harmonic Generation in Gas-Filled Hollow-Core PCF, Jean-Michel Menard, Philip S. Russell, Max Planck Inst. for the science of light, Germany; Dept. of Physics, Univ. of Ottawa, Canada. Quasi-phase-matched electric-field-induced second-harmonic generation is demonstrated in X-filled hollow-core kagomé photonic crystal fiber. The system is used to frequency-double femtosecond near-infrared pulses, all signals being in the low-loss fundamental mode.

Generation of 800nJ, 133nm femtosecond Vacuum UV pulses by third harmonic generation in argon, Peter Trabs, Hans-Hermann Ritze, Frank Noack, APE Angewandte Physik & Elektronik GmbH, Germany; ‘AZ, Max Born Inst., Germany. High energy of up to 800nJ Vacuum UV pulses at 133nm were generated by frequency tripling of second harmonic pulses of a Ti:sapphire amplifier in argon. Numerical simulations suggest six-wave-mixing as underlying nonlinear process.

Quantum-shot-noise-driven Optical Antennas, Bert Hecht, Johannes Kerr, Rene Kullock, Jord Prangsma, Monika Emmerling, Martin Kamp, Experimental Physics V, Universität Würzburg, Germany; Universität Münster, Germany; Ibsen Photonics, Denmark; Technische Physik, Univ Würzburg, Germany. We show that electrical driving of an optical antenna is possible via the quantum shot noise that is created by electrons that tunnel across the antenna’s atomic scale feedgap. Spectrum, spatial pattern and polarization of the emitted photons are determined by the antenna resonance.

Towards strong light-matter coupling at the single-resonator level with sub-millisecond mid-infrared antennas, Mario Malerba, Tommaso Ongarello, Bruno Paolillo, Jean-Michel Manecke, Gregoire Beaudoin, Isabelle Saguen, Francesco de Angelis, Raffaele Colombelli, Université Paris Sud and CNRS, France; ETH, Italy; 1UPN, France. We demonstrate room-temperature strong light-matter coupling in the mid-infrared between an intersubband transition and an extremely reduced number (~10) of sub-millisecond resonators, using nano-antenna concepts. The modal volume is sub-wavelength-sized, it encompasses only 4400 electrons.

Isolated and Collective Magnetic Resonances in Dielectric Nanoparticles at Optical Frequencies, Shiqiang Li, Wuzhou Sellars, 1National Research Council, Canada; 2Univ. Toronto, Canada. We employ multipole expansion to analyze radiation modification and light scattering by isolated nanoparticles and by nanoparticle ensembles, unveiling directional emission mediated by magnetic resonance and two types of purely magnetic resonances at optical frequencies.

Planar optical antenna to direct light emission, Simona Checchucci, European Lab for Nonlinear Spectroscopy (LENS), Italy; National Inst. of Optics (INO-CNR), Italy. The efficient collection of light from single emitters is critical for quantum optics and nano-photonicics. We introduce a planar antenna that strongly beams the radiation pattern, we discuss the physical concepts and provide experimental demonstration.

An Integrated Optical Memory Based on Laser Written Waveguides, Margherita Mazzera, Giacomo Cornelii, Alessandro Serni, Roberto Osellame, Hugues de Redematten, IFCO - The Inst. of Photonic Sciences, Spain; Photonic and Nanotechnology Inst., Italy; ICREA - Institucio Catalana de recerca i estudis avancats, Spain. We propose and demonstrate a new platform for integrated optical memory based on laser written waveguides in rare-earth doped crystals. We show that the waveguide fabrication does not degrade the coherence properties of the medium and we demonstrate the first on-demand integrated optical memory.

50 GHz quantum photon storage in a cavity-protected rare-earth ensemble, Kh. Zhong, Jonathan Kindem, Jake Rochman, Andrei Faraon, California Inst. of Technology, USA. We demonstrate ultrafast transfer of a broadband photonic qubit to a dense rare-earth ensemble cavity protected against decoherence due to inhomogeneous broadening. Storage in highly coherent superradiant collective states enables long-lived memories and optical-to-microwave conversion.

Quantum-shot-noise-driven Optical Antennas, Bert Hecht, Johannes Kerr, Rene Kullock, Jord Prangsma, Monika Emmerling, Martin Kamp, Experimental Physics V, Universität Würzburg, Germany; Universität Münster, Germany; Ibsen Photonics, Denmark; Technische Physik, Univ Würzburg, Germany. We show that electrical driving of an optical antenna is possible via the quantum shot noise that is created by electrons that tunnel across the antenna’s atomic scale feedgap. Spectrum, spatial pattern and polarization of the emitted photons are determined by the antenna resonance.

16:00–18:00 FM4A.1 • 16:00 Two-Octave-Wide UV–VIS Raman Spectra Generated in Hollow-Core PCF Filled with Gas Mixtures, Poorna Hosseini, Amir Abdolvand, Philip S. Russell, Max Planck Inst. for the science of light, Germany; Physics, Univ. of Erlangen-Nuremberg, Germany. A ro-vibrational Raman comb spanning 280 to 1000 nm is generated in a H2-filled anti-resonant-guiding kagomé hollow-core PCF pumped at 532 nm. Addition of xenon produces a dense cluster of >150 side-bands in the visible.

16:00–18:00 FM4A.2 • 16:15 Scale-Invariant Nonlinear Optical Effects in Gases, Cord L. Arnold, Christoph M. Heyl, Helene Coudert-Aalteraei, Miguel Miranda, Marie Louisy, Katalin Kovacs, Valer Toska, Imre Balasch, Katalin Varju, Anne L’Huillier, Arnaud Couairon, Lunds Universitet, Sweden; National Inst. for R&D and Isotopic and Molecular Technologies, Romania; EU-ALPS, Hungary; Centre de Physique Théorique, Ecole Polytechnique, CNRS, Université Paris-Saclay, France. A general scaling formalism for nonlinear light-matter interactions in gases is presented and experimentally verified. The formalism enables to conveniently extrapolate nonlinear phenomena, such as filamentation or high-order harmonic generation, to new laser parameters.

16:00–18:00 FM4A.3 • 16:30 Quasi-Phase-Matched Electric-Field-Induced Second-Harmonic Generation in Gas-Filled Hollow-Core PCF, Jean-Michel Menard, Philip S. Russell, Max Planck Inst. for the science of light, Germany; Dept. of Physics, Univ. of Ottawa, Canada. Quasi-phase-matched electric-field-induced second-harmonic generation is demonstrated in X-filled hollow-core kagomé photonic crystal fiber. The system is used to frequency-double femtosecond near-infrared pulses, all signals being in the low-loss fundamental mode.

16:00–18:00 FM4A.4 • 17:00 Generation of 800nJ, 133nm femtosecond Vacuum UV pulses by third harmonic generation in argon, Peter Trabs, Hans-Hermann Ritze, Frank Noack, APE Angewandte Physik & Elektronik GmbH, Germany; ‘AZ, Max Born Inst., Germany. High energy of up to 800nJ Vacuum UV pulses at 133nm were generated by frequency tripling of second harmonic pulses of a Ti:sapphire amplifier in argon. Numerical simulations suggest six-wave-mixing as underlying nonlinear process.

16:00–18:00 FM4A.5 • 17:00 Planar optical antenna to direct light emission, Simona Checchucci, European Lab for Nonlinear Spectroscopy (LENS), Italy; National Inst. of Optics (INO-CNR), Italy. The efficient collection of light from single emitters is critical for quantum optics and nano-photonicics. We introduce a planar antenna that strongly beams the radiation pattern, we discuss the physical concepts and provide experimental demonstration.

16:00–18:00 FM4B.1 • 16:00 Quantum-shot-noise-driven Optical Antennas, Bert Hecht, Johannes Kerr, Rene Kullock, Jord Prangsma, Monika Emmerling, Martin Kamp, Experimental Physics V, Universität Würzburg, Germany; Universität Münster, Germany; Ibsen Photonics, Denmark; Technische Physik, Univ Würzburg, Germany. We show that electrical driving of an optical antenna is possible via the quantum shot noise that is created by electrons that tunnel across the antenna’s atomic scale feedgap. Spectrum, spatial pattern and polarization of the emitted photons are determined by the antenna resonance.

16:00–18:00 FM4B.2 • 16:30 Towards strong light-matter coupling at the single-resonator level with sub-millisecond mid-infrared antennas, Mario Malerba, Tommaso Ongarello, Bruno Paolillo, Jean-Michel Manecke, Gregoire Beaudoin, Isabelle Saguen, Francesco de Angelis, Raffaele Colombelli, Université Paris Sud and CNRS, France; ETH, Italy; 1UPN, France. We demonstrate room-temperature strong light-matter coupling in the mid-infrared between an intersubband transition and an extremely reduced number (~10) of sub-millisecond resonators, using nano-antenna concepts. The modal volume is sub-wavelength-sized, it encompasses only 4400 electrons.

16:00–18:00 FM4B.3 • 16:45 Isolated and Collective Magnetic Resonances in Dielectric Nanoparticles at Optical Frequencies, Shiqiang Li, Wuzhou Sellars, 1National Research Council, Canada; 2Univ. Toronto, Canada. We employ multipole expansion to analyze radiation modification and light scattering by isolated nanoparticles and by nanoparticle ensembles, unveiling directional emission mediated by magnetic resonance and two types of purely magnetic resonances at optical frequencies.

16:00–18:00 FM4B.4 • 17:00 Closing optical transitions for single rare-earth ion spin readout, John G. Bartholomew, Rose Alhefelfd, Matthew Sellani, RSP, Australian National Univ., Australia. We present a protocol that makes rare-earth ion spin-states robust against optical cycling by applying specifically oriented magnetic fields. The resultant closed optical transitions open a pathway for rare-earth qubits at the single ion level.

16:00–18:00 FM4B.5 • 17:00 Applications of a Picosecond-lifetime Quantum Memory, Duncan England, Ben Susman, Philip Bustard, Kent Fisher, Kevin Resch, National Research Council, Canada; Univ. of Waterloo, Inst. for Quantum Computing, Canada. We demonstrate a quantum memory using the phonon modes of room-temperature diamond. The memory stores single photons produced by down-conversion for several picoseconds and offers operations on the stored light.
absorption spectroscopy to directly access the time-resolved dynamics of strongly-correlated oxide VO
recent experimental studies wherein electronic structure and correlated oxide VO
Fiber Taper-coupled Micro Bottle Lasers, Shahab Bakhtiar-Gorajobi, Ganapathy Senthil Murugan, Michalis Zervas; ORC, Univ. of Southampton, UK. An evanescently-pumped Yb-doped microbottle laser is demonstrated. Selective excitation of WGMs is achieved. Stable single-mode lasing is demonstrated to be possible by mode number reduction using index liquid droplets and focused on beam milled-scatterers.

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SM4G.1 • 16:00

Record Ultra-low Phase Noise 12 GHz Signal Generation with a Fiber Optical Frequency Comb and Measurement, Xiaopeng Xie1,2, Roman Bouchand3, Daniele Niccolì1, Michele Giunta1, Wolfgang Haensch3, Matthias Leuzis1, Ronald Holzwarth3, Abhay Joshi2, Subhashish Dutta1, Alexandre Christophe1, Pierre-Alain Tremblin1, Giorgia Santarelli1,2, Yann L. Coq1,2,1UNE-SYRE, Observatoire de Paris, CNRS, UPMC, France; 2Menlo Systems GmbH, Germany; 3Discovery Semiconductors Inc., USA; 1LNÉ-CNAM, CEDRIC Lab, France; 2Laboratoire Photophone, Numérique et Nanosciences (IOGS-CNRS - UMR 7112 - Université de Bordeaux), France. We demonstrate a 12 GHz signal with a record absolute phase noise of -167 dBc/Hz at 10 kHz and -170 dBc/Hz at 100 kHz. We have developed a specific measurement setup for characterizing this ultra-low phase noise.

SM4G.2 • 16:30

Synchronous Mode-locked Laser Network with Sub-fs Jitter and Multi-km Distance, Karmel Shafak1,2, Ming Xin1,2, Michael Y. Peng1,2, Franz X. Kaertner1,2; Center for Free-Electron Laser Science, Deutsches Elektronen-Synchrotron, Germany; 1Re-search Lab of Electronics, MIT, USA. We report a synchronous multi-color mode-locked laser network over 4.7-km distance. Output of two remotely synchronized lasers shows only 0.6 fs RMS drift over 40 hours reaching 20º decimal uncertainty in less than 10000-s averaging time.

SM4G.3 • 16:45

Remote Synchronization of a Microwave Clock to an Optical Clock at the Femtosecond Level, Hugo Bergeron1,2, Laura Sinclair1, William C. Swann1, Craig Nelson1, Jean-Daniel Deschênes1,2, Esther Baumann2, Fabrizio Giorgetti1,2, Michael L. Dennis1, Nathan R. Newbury2,1,2, NIST, USA; 2Université Laval, Canada; 1The Johns Hopkins Univ. Applied Physics Lab, USA. We demonstrate synchronization of two clocks to within femtoseconds across a 12 km air path over three days. We demonstrate adaptive-optics terminals can be used for improved link availability without degradation of the synchronization performance.

SM4G.4 • 17:00

Coherent Pulse Stacking Extension of CPA to 9ns Effectively-Long Stretched Pulse Duration, John Ruppe1,2, Siyun Chen2, Tong Zhou3, Morteza Sheikholeslami2, Zhigang Zhang2, Guoping Chang1,2,2,1, John X. Nees1,2,1, Almanas Galvanasauskas1,2, Univ. of Michigan, 3University of Washington, USA; 2Pecking Univ., China; 3DESY, Germany. Coherent pulse stacking with a 9ns effectively-long burst of equal amplitude chirped pulses into a single pulse using a compact cascade of four Gires-Tournois interferometers is experimentally demonstrated with a fiber chirped pulse amplification system.

SM4G.5 • 17:00

High Precision Synchronization of a Large-scale Microwave Network over Stabilized Fiber Links, Wenting Wang1, Aram Kaladzhyyan1, Kemal Shafak2, Ming Xin1,2, Michael Y. Peng1,2, Kwangyun Jung1, Jungwon Kim1,2,1,2, Franz X. Kaertner1,2,2,2, Deutsches Elektronen-Synchrotron, Germany; 1MIT, USA; 2Korea Advanced Inst. of Science and Technology, Korea. We demonstrate a high precision microwave network over a stabilized multi-kilometer fiber links. Relative phase jitter (>1Hz) and drift (<1Hz) between two remotely synchronized 10.83-GHz microwave sources are 77.9 and 119.6 μrad, respectively, over 2.5-hour operation.

SM4G.6 • 17:00

Coherent Control by Shaped Pulses in Room Temperature InAs/InP Quantum Dot Optical Amplifiers, Ouri Kami1,2, Akhilesh K. Mishra1,2, Gadi Eisenstein1,2, Vitali Ivanov3, Johann P. Reichmayer1, Andrew and Erna Vitebski Faculty of Electrical Engineering, Technion - Israel Inst. of Technology, Israel; 2Russel Berrie Nanotechnology Inst., Technion - Israel Inst. of Technology, (Israel); 1Institute of Nanotechnology and Analytics, Technische Physik, CINaT, Univ. of Kassel, Germany. By shaping their excitation pulses, we demonstrate control over coherent Rabi-oscillations exhibited in room temperature quantum dot semiconductor optical amplifiers designed for telecommunication applications. Experimental results and comprehensive numerical analysis are presented.
**AM4J.1 • 16:00 • Invited**

Swir Super-Continuum Laser for Active Illumination in Hyper-Spectral Imaging, Mohammed N. Islam1,2; Univ. of Michigan, USA; 2Omni Sciences, Inc., USA. Super-continuum laser with 64W output between ~1064-1800nm is used in field tests for round trip imaging at 1.4km distance, and broadband illumination permits change detection to subtract out background and ranging to identify target location.

**AM4K.2 • 16:30 • Invited**

Non-Topographic Space-Based Laser Remote Sensing, Anthony Iu1, James B. Abshine2, Hans Rins3, Michael Purucker4, Diego Janches5, Stephanie Getty6, Michael A. Kranak7, Jeffrey R. Chen7, Steve X. Li7, Kenji Numata8, Molly Fahey7, Stewart Wu9, Graham R. Allen9, Oleg Konoplev10; 1NASA Goddard Space Flight Center, USA; 2Sigma Space Inc, USA; 3Science Systems and Applications, USA. The advent of several key enabling electro-optics technologies afford advanced, non-topographic remote sensing instruments for space. We will present progress on several new, space-based laser instruments that are being developed at NASA GSFC.

**AM4J.3 • 17:00**

In-Fiber Monomode Octave-Spanning OAM Supercontinuum, Gautam Prabhakar1, Patrick Gregg1, Lars Rasch1, Siddharth Ramachandran,2 Boston Univ., USA. We demonstrate an octave-spanning supercontinuum generated entirely in |L|=8 orbital angular momentum (OAM) mode of an air-core fiber. The supercontinuum shows high mode purity (>14dB) and polarization extinction ratio >8 dB across the spectral bandwidth.

**AM4K.3 • 17:00**

Sensing thorough obstructions – using fluctuations in stochastic coherent scattering, Milad Akhlaghi Bouzari,1 Aniside Dogaru1; 1Univ. of Central Florida, CREOL, USA. We exploit the enhanced fluctuations of scattering from random potentials illuminated sequentially by non-stationary speckle fields and obscured by turbid media, to determine both the characteristic length and the motion of potential's center of mass.

**SM4L.2 • 16:15**

Efficient Scalable Monolithic Semiconductor High-Energy Terahertz Pulse Source, József A. Fülöp1,2, Gyula Polónyi1,2, Balazs Monostori1,2, Giedrius Andriukaitis1, Tadas Balcian1, Audrius Puglys1, Graham Arthur2, Andrius Baltusska2, Janos Hebling2,3, MTA-PTE High-Field Terahertz Res. Group, Hungary; 1ELL-ALPS, Hungary; 2Univ. of Pecs, Hungary; 3Vienna Univ. of Technology, Austria; 4Center for Physical Sciences & Technology, Lithuania; 5SchiTech Precision Ltd., UK. A novel ZnTe contact-grating THz source, pumped above the three-photon absorption edge, was demonstrated. THz pulses up to 3.9 μJ energy were generated with up to 0.3% efficiency, 100× higher than reported previously for ZnTe.

**SM4L.4 • 16:45**

Enhancement of Terahertz Generation by using a circularly-polarized two-color field, Chao Meng1, Wenbo Chen1, Xiao-wei Wang1, Yingdong Huang1, Zhihu Li2, Dongwen Zhang1, Zengxiu Zhao1, Jiamin Yuan1; 1NUDT, China. We demonstrate experimentally that terahertz generation from ionizing gas in the two-color fields with co-rotating circular polarization is five times stronger than that with usually linear polarization.

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**Monday, 6 June**

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
Monday, 6 June

SM4M • 1μm Lasers
Presider: Klaus Ertel; STFC Rutherford Appleton Lab, UK

25 years (actually 45 years) of Diode-pumped Yb-doped Lasers, Tso Yee Fan; 1MIT Tech Lincoln Lab, USA. He has been 25 years since the report of the first room-temperature, diode-pumped Yb:YAG laser. Diode-pumped Yb lasers have become among the most important systems for achieving high power with good efficiency.

Tso Yee (T. Y.) Fan is the Associate Leader of the Laser Technology and Applications Group at MIT Lincoln Laboratory. He is widely recognized for his pioneering work in diode-pumped solid-state lasers, in cryogenic lasers for improving average-power scalability, in characterization of laser and nonlinear optics and Applications Group at MIT Lincoln Laboratory. He is

SM4M.1 • 16:00 Tutorial
High Efficiency Passively Mode-Locked Nd:YVO4 Laser with Direct In-Band Pumping at 914 nm, Tanant Waritan1; 1Univ. of Manitoba, Canada. A passively mode-locked Nd:YVO4 laser with the highest to date slope efficiency of 71.1% was demonstrated with in-band pumping at 914 nm. The laser produced 6.7 W of output power with 17 ps long pulses.

SM4M.2 • 16:15 Broadband On-Chip Plasmonic Spectroscopy for Near-Infrared Absorption of Aromatic Compounds, Erwen Li1; 1Xinyuan Chong1; Fanghui Ren1; Alan X. Wang2; 2Oregon State Univ., USA. We demonstrate an ultra-compact on-chip near-infrared spectrometer using plasmonic grating band-pass filter array, providing a broad bandwidth over 270 nm and a high spectral resolution around 10 nm to measure the infrared absorption of xylene.

SM4M.3 • 16:30 "Teramometry" and Plasmonic Nanoparticle Imaging for Temperature-Sensing in the Terahertz Regime, Anna Mazhorova1; 1Raffik Naccache1; 1Matteo Clerici2; 2Larousse Khorasadi2; 2Alexander O. Govorov2; 2Luca Razzari1; 1Fiorenzo Vetrone1; 1Roberto Morandotti1, 1INRS-EMT, Canada; 2Dept. of Chemistry and Biochemistry, Concordia Univ., Canada; 3School of Engineering, Univ. of Glasgow, UK; 4Dept. of Physics and Astronomy, Clippinger Research Labs, Ohio Univ., USA. We develop a novel temperature mapping technique for bio-systems exploiting the high sensitivity of terahertz waves to aqueous media. The proposed method allowed us to investigate in deep nanoplasmonic-induced photothermal effects such as collective heating phenomena.

SM4M.4 • 16:45 Nanoantenna-assisted ultra-narrow resonances based on coupling of localized plasmons and whispering-gallery modes, Fuxing Gu1; 1Univ. of Shanghai for Science and Tech, China. Free-space light is efficiently coupled into and from the palladium nanoantenna-microfiber whispering-gallery cavity systems. A measured full width at half-maximum of 3.2 nm at 622.7 nm and enhanced sensitivity to hydrogen detection are obtained.

SM4M.5 • 17:00 Graphene as Enabling Material for Infrared Plasmonic Biosensors, Daniel Rodrigo1; 1Odeta Limaj1; 1Davide Jannez1; 1Dordoneth Etzado1; 1Javier Garcia-de-Abajo1; 1Valerio Pruneri1; 1Hatice Altug1, 1Inst. of BioEngineering, Ecole Polytechnique Federale de Lausanne, Switzerland; 2ICFO - Instituut van Cien- cies Fotoniques, Spain. We demonstrate a graphene infrared biosensor for chemical-specific label-free protein detection. Graphene plasmon resonances are dynamically tuned to enhance protein vibrational bands. We show that the extreme light confinement makes graphene plasmons extremely sensitive to nanometric molecules.

FLM4N.1 • 16:00 Plasmonic Sensing with Quantum Noise, Benjamin Lawrie1; 1Wenjing Fan1; 1Raphael Pooser1; 1Quantum Information Science Group, Oak Ridge National Lab, USA; 2Dept. of Physics, Univ. of Virginia, USA. We experimentally demonstrate a surface plasmon resonance sensor utilizing quantum noise in two-mode squeezed states for signal transduction. This quantum plasmonic sensor exhibits 5 dB greater sensitivity than its classical analogy by exploiting plasmonic absorption.

FLM4N.2 • 16:15 Terahertz Bio-imaging with Plasmonic Nanoparticles, Odeta Limaj1; 1Davide Jannez1; 1Dordoneth Etzado1; 1Javier Garcia-de-Abajo1; 1Valerio Pruneri1; 1Hatice Altug1, 1Inst. of BioEngineering, Ecole Polytechnique Federale de Lausanne, Switzerland; 2ICFO - Instituut van Cien- cies Fotoniques, Spain. We demonstrate a graphene infrared biosensor for chemical-specific label-free protein detection. Graphene plasmon resonances are dynamically tuned to enhance protein vibrational bands. We show that the extreme light confinement makes graphene plasmons extremely sensitive to nanometric molecules.

FLM4N.3 • 16:30 3D Super-resolution Label-free Imaging, Ivan Kassamakov1; 1Anton Novl1; 1Edward Haegsttr1; 1Helsingin Yliopisto, Finland. We present 3D images of grooves on a writable Blu-ray® disc. In the vertical direction the resolution is a few nanometers while the lateral resolution is a few tenths of nanometers.

FLM4N.4 • 16:45 Laser-particle stimulated emission (LASE) microscopy with super resolution, Sangyeon Cho1; 1Matjaz Maricar1, 1Harvard-MIT Division of Health Sciences and Technology, MIT, USA; 2Wellman Center for Photomedicine, Massachusetts General Hospital, USA; 3Condensed Matter, Jozef Stefan Inst., Slovenia. We introduce a novel microscopy technique that utilizes optically pumped, nano-lasers as imaging probes. The lasing threshold and narrow spectrum of laser particles enables optical sectioning, sub-diffraction, and low-background imaging.

FLM4N.5 • 17:00 Sparsity-based super-resolution optical fluctuation imaging, Chen Solomon1; 1Maor Mutaf1; 1Xuyu Yi1; 1Shimon Weiss1; 1Yonina C. Eldar1; 1Mordechai Segev1, 1Electrical engineering, Technion, Israel; 2Dept. s of Chemistry and Biochemistry and Physiology, and California NanoSystems Inst., UCLA, USA; 3Physics Dept. and solid state Inst., Technion, Israel. We present a new imaging technique optimizing the spatio-temporal resolution in fluorescence microscopy. This method achieves short integration time as SOFI, with high spatial resolution comparable to STORM, leading towards super-resolution imaging within living cells.

FLM4N.6 • 17:15 Teramometry and Plasmonic Nanoparticle Imaging for Temperature-Sensing in the Terahertz Regime, Anna Mazhorova1; 1Raffik Naccache1; 1Matteo Clerici2; 2Larousse Khorasadi2; 2Alexander O. Govorov2; 2Luca Razzari1; 1Fiorenzo Vetrone1; 1Roberto Morandotti1, 1INRS-EMT, Canada; 2Dept. of Chemistry and Biochemistry, Concordia Univ., Canada; 3School of Engineering, Univ. of Glasgow, UK; 4Dept. of Physics and Astronomy, Clippinger Research Labs, Ohio Univ., USA. We develop a novel temperature mapping technique for bio-systems exploiting the high sensitivity of terahertz waves to aqueous media. The proposed method allowed us to investigate in deep nanoplasmonic-induced photothermal effects such as collective heating phenomena.

FLM4N.7 • 17:30 Graphene as Enabling Material for Infrared Plasmonic Biosensors, Daniel Rodrigo1; 1Odeta Limaj1; 1Davide Jannez1; 1Dordoneth Etzado1; 1Javier Garcia-de-Abajo1; 1Valerio Pruneri1; 1Hatice Altug1, 1Inst. of BioEngineering, Ecole Polytechnique Federale de Lausanne, Switzerland; 2ICFO - Instituut van Cien- cies Fotoniques, Spain. We demonstrate a graphene infrared biosensor for chemical-specific label-free protein detection. Graphene plasmon resonances are dynamically tuned to enhance protein vibrational bands. We show that the extreme light confinement makes graphene plasmons extremely sensitive to nanometric molecules.
Biomedical Fiber Optic Sensors & Applications, Alexis Men-dez, J/MCH Engineering, LLC, USA. Given their EM immunity, intrinsic safety, small size & weight, autoclave compatibility and capability to perform multi-point and multi-parameter sensing remotely, optical fibers and fiber-optic-based sensors are seeing increased acceptance and new uses for a variety of bio-medical applications.

Ultrawide C- and L-band mode-locked erbium-doped fiber ring laser and its application in ultrafast microscopy, Jiqiang Kang, Xiaoming Wei, Sisi Tan, Kevin K. Tse, Kenneth K. Wong, The Univ. of HongKong, Hong Kong. We report an ultrawide C- and L-band mode-locked erbium-doped fiber ring laser with 92-nm bandwidth centered at 1550 nm and 20.5 dB extinction ratio, and the schematic is shown in the figure. Furthermore, it was applied to ultrafast time-stretch microscopy.

The Impact of Thermal Mode Instability on Core Diameter Scaling in High-Power Fiber Amplifiers, Jordan P. Leidner1, John R. Marciante1, Univ. of Rochester, The Inst. of Optics, USA. Detailed simulations reveal that the threshold for thermal mode instability decreases for increasing core diameter in step-index fiber amplifiers. The threshold for 50-µm fiber cores is 37% lower than that of 20-µm fiber cores.

High Power Fiber Lasers with Radially Polarized Output Beams, W. Andrew Clarkson1, Di Lin1, Martynas Beresna1, Peter G. Kazansky1, Peter C. Shannon1, Univ. of Southampton, UK. A scheme for directly exciting the radially-polarized TM01 mode in a fiber laser is reported. Preliminary results for cladding-pumped ytterbium-doped and thulium-doped fiber lasers are discussed along with prospects for scaling to high power levels.

High-Speed InAs/InP Quantum Dot Lasers With Low Temperature Sensitivity, On G. Eyal1, Gad Eisenstein1, Saddam Banyoubeh2, Alireza Abdollahiha1, Florian Schnabe1, Johann P. Reithmaier2, Tehorion Israel Inst. of Technology, Israel; 1Kassel Univ., Germany. We report temperature insensitive high speed InAs/InP quantum dot lasers. At 14°C-60°C, the bandwidth is respectively 15-13GHz, at 800°C it is 8GHz. 25Gbit/s under constant drive parameters at 14-60°C and 32Gbit/s at 14°C were demonstrated.

Highly Efficient Yb-doped CaF2-LiF, Ceramic Laser, Shotaro Kitajima1,2, Yuki Higashi1, Hiroaki Nakao1, Akira Shirakawa1, Ken-Ichi Ueda1, Yoshinobu Ezura1, Hitoshi Ishiiwa1, Univ. of Electro-Communications, Japan; 2NIKON Corporation, Japan. We prepared transparent Yb:CaF2-LiF, ceramics with different combinations of doping concentrations of Yb2+ and Li2+ and obtained CW laser operation with maximum output of 3.97 W. The maximum slope efficiency was as high as 73.1%.

We demonstrated all-fiber STED illumination for coherent pulse stacking at 1.5μm. We use phase pre-shaping of a symmetric 47 MHz pulse train to combine pulses next to each other and in turn reducing the repetition rate to 23.5 MHz.

Highly Efficient InGaAs/InP Quantum Dot Lasers With Low Temperature Sensitivity, On G. Eyal1, Gad Eisenstein1, Saddam Banyoubeh2, Alireza Abdollahiha1, Florian Schnabe1, Johann P. Reithmaier2, Tehorion Israel Inst. of Technology, Israel; 1Kassel Univ., Germany. We report temperature insensitive high speed InAs/InP quantum dot lasers. At 14°C-60°C, the bandwidth is respectively 15-13GHz, at 800°C it is 8GHz. 25Gbit/s under constant drive parameters at 14-60°C and 32Gbit/s at 14°C were demonstrated.
FM4A • Nonlinear Optics in Gases—Continued

FM4A.5 • 17:15
Intensity Stabilization of Ionizing Pulses in High-Pressure, Gas-Filled Capillaries, Xiaohua Gao1, Gauri Patwardhan1, Donggu Shim1, Tieno Poppintchev1, Henry Kapteyn1, Magaret Mumane2, Alexander L. Gaeta3, Columbia Univ., USA; 2Cornell Univ., USA; 3Univ. of Colorado, USA. We theoretically demonstrate stable nonlinear propagation of ultrashort pulses over several centimeters in high-pressure, gas-filled waveguides with intensities approaching $10^{19}$ W/cm$^2$. This intensity stabilization is achieved by self-compression to a single cycle combined with modal loss.

FM4A.6 • 17:30
Nonlinear Optics in Superfluid Helium-Filled Hollow-Core Fiber, William H. Renninger1, Ryan Behunin1, Peter Rakich1, Yale Univ., USA. Forward Brillouin scattering is demonstrated in superfluid helium-4 in a hollow-core fiber. The resonance frequency varies with temperature in proportion to the known sound speed in helium, in agreement with theoretical predictions.

FM4A.7 • 17:45
Generation of DUV/VUV Raman Frequency Comb via Molecular Modulation in a H$_2$-filled Kagome-PCF, Manoj K. Mindha1, David Novoa2, Sebastian T. Bauerschmidt3, Amir Abdolvand1, Philip S. Russell1, Max Planck Inst. for the Science of Light, Germany. Emission of narrowband pulses down to the VUV (184 nm) is demonstrated in a hydrogen-filled kagome-PCF pumped at 266 nm. Intermode Raman scattering facilitates the parametric excitation of short wavelengths in the normal-dispersion regime.

FM4B • Nanoantennas—Continued

FM4B.5 • 17:15
Magnetoplasmonic Crystals Based on Anisotropic Nanoantennas, Luca Bergamini1,2, Nicolò Maccaferri1, Matteo Pancaldi1, Mikolaj Schmidt1, Mikko Kajava2, Sebastian van Dijken1, Nerea Zabala1, Javier Alzuru2, Paolo Vavassori1, UPV/EHU, Spain; 2FCSIC-UPV/EHU and DIPC, Spain. By synergistically combining experiments and simulations, we show how the excitation of lattice surface modes in ordered arrays of magnetic and optically-anisotropic nanoantennas leads to a highly enhanced and tunable Fano-like modulation of the magnetoplasmonic response.

FM4B.6 • 17:30
From high-Q magnetic dipole scattering to broadband electric field localization by silicon nanoparticle on metal, Andrey A. Bogdanas1, Ivan Sniev1, Ivan Iorsh1, Dmitry Permyakov1, Filippe Komissarenko1, Ivan Mukhin1, Anton Samuelsen1, Andrey E. Miroshnitchenko1, Yuri S. Kivshar1, Ioffe Inst., Russia; 2Dept. of Nanophotonics and Metamaterials, ITMO Univ., Russia; 3Nonlinear Physics Center, Australian National Univ., Australia; 4Academic Univ., Russia. We reveal remarkable substrate-driven transformations of electric and magnetic dipole resonances of a silicon nanoparticle on metal, manifesting as the modification of Q-factor of the resonances followed by strong enhancement of the respective fields.

FM4B.7 • 17:45
Superradiance in two-dimensional arrays of nanoantennas, Saumya Choudhary1,2, Sylvia D. Swiecicki1, Israel De Leon1,2, Sebastian A. Schultz1, Jeremy Upham1, John E. Sipe1, Robert W. Boyd2,1, Inst. of Optics, Univ. of Rochester, USA; 2Dept. of Physics, Univ. of Toronto, Canada. We demonstrate both experimentally and theoretically a new form of light storage based on Coherent Population Oscillations. It is shown to be phase preserving and robust to dephasing effects.

FM4C • Photon Storage and Coherent Conversion—Continued

FM4C.6 • 17:15
Coherent bidirectional microwave-optical conversion using Rydberg atoms, Amir Feizpour1, Martin Kiffner2,3, Krysztof T. Kaczmarek1,4, Joshua Nunn1, Univ. of Oxford, UK; 2National Univ. of Singapore, Singapore. Deterministic quantum information processing will require hybrid quantum systems like an interface between microwave and optical photons. We propose a scheme for efficient, multimode and coherent microwave-optical conversion based on frequency mixing in Rydberg atoms.

FM4C.7 • 17:30
Storage based on Coherent Population Oscillations, Marie-Aude Maynard1, Romain Bouchez1, Pascal Neveu1, Jasleen Lugani1, Sanmoy Mandal1, Chitram Banerjee2, Rupamanjari Gholi3, Fabien Bretenaker4, Etienne Brion4, Fabienne Goldfarb5, Laboratoire Aimé Cotton, France; 2Shiv Nadar Univ., India. We demonstrate both experimentally and theoretically a new form of light storage based on Coherent Population Oscillations. It is shown to be phase preserving and robust to dephasing effects.

FM4C.8 • 17:45
Hybridization: A route to state engineering for quantum-enhanced metrology, William Munro1, Shane Dooley1, Emi Yukawa1, Yuichiro Matsuzaki1, Kae Nometo1, NTT Basic Research Labs, Japan; 2National Inst. of Informatics, Japan. Here we consider the generation of spin squeezed states in a hybrid system composed of a superconducting circuit coupled to a spin ensemble and show they can be generated by two different mechanisms: one-axis twisting and driven collective relaxation.
Monday, 6 June

Executive Ballroom 210D

CLEO: QELS-Fundamental Science

FM4D • Symposium on Ultrafast Dynamics in Solids I—Continued

FM4D.4 • 17:15  Invited
Ab-initio Simulations of Strong-Field Processes in Wide-Bandgap Insulators, Joachim Burgdörfer1; Technische Universität Wien, Austria. We investigate the generation of ultrafast currents in insulators induced by strong few-cycle laser pulses. Ab-initio simulations based on time-dependent density functional theory allow the study of nonlinear currents, excitation into the conduction band, and high-harmonics generation.

SM4E • Novel Sources and Detectors—Continued

SM4E.6 • 17:15
Black Phosphorus Photodetector on Silicon Photonic and Plasmonic Hybrid Platform, Che Chen1, Nathan Youngblood1, Daniel Mohr1, Daohan Yoo1, Timothy Johnson1, Rooming Peng1, Sang-Hyun Oh1, Mo Li1; Univ. of Minnesota, Twin Cities, USA. Silicon photonics, plasmonic structures and two dimensional materials are integrated vertically on SOI (Silicon on Insulator) substrate to produce a short channel photodetector. Its estimated average intrinsic responsivity is 220 mA/W.

SM4E.7 • 17:30
Vertical Germanium Nanowire Photodetectors with Suspended Graphene Top Contact, Shiqiang Li1, Jacopo Frigerio2, Daniel Chrastina1, Giovanni Isella1, Amit Solanki3, Wuhou Song1, Changai Zheng1, Kenneth B. Crozier1; Electrical and Electronic Engineering, Univ. of Melbourne, Australia; 2L-NESS, Polo Regionale di Como, Italy; 3SEAS, Harvard Univ., USA; 4School of Physics, Univ. of Melbourne, Australia. We demonstrate photodetectors for visible-to-infrared imaging, comprising vertical germanium nanowires on a silicon substrate, with a suspended graphene layer as the top electrical contact. Measured responsivity spectra show peaks that shift with increasing nanowire diameter.

FM4D.5 • 17:45
Ultrafast X-Ray Probe of Dynamics in Chromium, Brian K. McFarland1, Rohit P. Prasankumar1, George Rodriguez2, Richard L. Sandberg1, Antonette Taylor1, Stuart Trugman1, Jian-Xin Zhu1, Dmitry Yarotski1; Los Alamos National Lab, USA. We apply ultrafast soft X-ray (SXR) magnetic spectroscopy to reveal the competition between different spin states in photoexcited antiferromagnetic (AFM) chromium (Cr) metal in a broad temperature range above the spin flip transition.

SM4E.8 • 17:45
Polarization dependence of avalanche multiplication factor in 1.5 μm quantum dot waveguide photodetector, Toshimasa Umezawa1, Kouich Akahane1, Atsushi Matsumoto1, Atsushi Kanno1, Naokatsu Yamamoto1, Tetsuya Kawanishi1; National Inst of Information & Comm Tech, Japan; 2Waseda Univ., Japan. We fabricated 1.5 μm quantum dot waveguide photodetector, and characterized the electrical and optical properties. It was found that the avalanche photocurrent strongly depends on TE/TM polarization.

18:15–18:45  JM5A • Plenary Session I, Grand Ballroom

19:00-20:00  OSA Technical Group Poster Session, Room 230B
This paper discusses 3D photonic integration technologies and fabrication processes towards realizing advanced functional microsystems. Their applications in computing, networking, sensing, imaging, and biomedicine will also be discussed.

SM4I.6 • 17:30
Integrated Optical Pulse Shaping: SOA Amplitude Control and Sub-microsecond Switching of 32 Channels at 25 GHz Spacing, Andrew J. Metcalf1, Daniel E. Leaird1, Andrew M. Weiner1; 1Purdue Univ., USA; 2Baylor Univ., USA; 3Princeton Univ., USA. In this contribution we present a 32 channel InP Arrayed Waveguide Grating Pulse Shaper exhibiting line-by-line amplitude control at 25 GHz channel spacing and demonstrate rapid reconfiguration.

SM4I.7 • 17:45
Interferometric signal retrieval in single-beam coherent anti-Stokes Raman scattering, Yijian Chen1,2, Dmitri V. Voro nine1,2, Alexei V. Sokolov1,2, Harishkumar K. Kolambkar1,2, Yi Xuan1,2, Amir Hosseini1,2, Philip K. triyoga1,2, Andrew M. Weiner1,2. Interferometric retrieval of coherent anti-Stokes Raman scattering signal through pulse shaper is demonstrated. The method allows for fast acquisition, and is beneficial in detecting broad Raman structure that has short coherence lifetime.
Supercontinuum Laser Technology and its Applications II—Continued

AM4J.4 • 17:15
Supercontinuum generation from 437 to 2850 nm in a tapered fluorotellurite microstructured fiber with a minimum core diameter of 0.65 μm. The blue-shifted dispersive wave at ~489 nm was also observed.

High-resolution optical coherence microscopy using high-diameter core diameter of 0.65 μm,

AM4J.6 • 17:15
Picometer-resolution, dual-comb spectroscopy based on a dual-wavelength mode-locked fiber laser, Xinx Hao, Bofeng Zhao, Guogao Hu, Ci Li, Yingjie Pan, Ya Liu1, Takeshi Yasui2, Zheng Zheng2,3; School of Electronic and Information Engineering, Beihang Univ., China; 4Collaborative Innovation Center of Geospatial Technology, China; 5Institute of Technology and Science, Tokushima Univ., Japan; 6Graduate School of Engineering Science, Tokushima Univ., Japan. A dual-comb spectroscopy scheme with picometer spectral resolution is experimentally demonstrated using one frequency-unstabilized, dual-wavelength passively mode-locked fiber ring laser, and the dual-comb spectroscopy system is drastically simplified by the use of the dual-comb laser.

High-resolution, dual-comb spectroscopy enabled by a polarization-multiplexed, dual-comb femtosecond fiber laser, Ya Liu2, Xin Zhao, Bofeng Zhao, Zijun Yao, Zheng Gong, Takeshi Yasui2,3; School of Electronic and Information Engineering, Beihang Univ., China; 4Collaborative Innovation Center of Geospatial Technology, China; 5Institute of Technology and Science, Tokushima Univ., Japan; 6Graduate School of Engineering Science, Tokushima Univ., Japan; 7JST, ERATO, MINOSHIMA Intelligent Optical Synthesizer Project, Japan; 8School of Precision Instrument and Opto-electronics Engineering, Tianjin Univ., China. Dual-comb spectroscopy measurement of a high-Q microring resonator using a polarization-multiplexed mode-locked ultrafast fiber laser is demonstrated, which resolves picometer-wide spectral features in a very simple fiber-optic setup without complicated electronic control.

SM4L.6 • 17:15
Enhancement of Intensity of Ultrabroadband Coherent Infrared Pulses Generated from Air Plasma by Controlling Polarization of Driving Pulses, Eisich Matsubara1,2, Masaya Naga1, Masaaki Ashida1,2; Osaka Dental Univ., Japan; 3Osaka Univ., Japan. Controlling polarization of two-color 10-fs pulses, we enhanced intensity of ultrabroadband coherent infrared pulses from air plasma in the whole spectral region. Magnification is greater in higher frequency region than in lower frequency region.

SM4L.7 • 17:30
High-Performance Terahertz Source based on a bimodal laser diode and a plasmonic photomixer, Shang Hua Yang1,2, Regina Watts1, Xiao Li1, Ning Wang1,2, Vivi Coochar1; James O’Gorman2,3, Liam Barry4, Mona Jamahi5,6, Electrical Engineering and Computer Science, Univ. of Michigan, USA; 2Electronic Engineering, Univ. of California, Los Angeles, USA; 3Electronic Engineering, Dublin City Univ., Ireland; 4Xylophone Optics Ltd., Ireland. We demonstrate a compact terahertz source based on a bimodal laser diode and a plasmonic photomixer, which generates 0.45 mW power at 1.62 THz and offers a broad radiation frequency tuning range of 0.15-3 THz.

AM4K.4 • 17:15
Picometer-resolution, dual-comb spectroscopy based on a dual-wavelength mode-locked fiber laser, Xinx Hao, Bofeng Zhao, Guogao Hu, Ci Li, Yingjie Pan, Ya Liu1, Takeshi Yasui2, Zheng Zheng2,3; School of Electronic and Information Engineering, Beihang Univ., China; 4Collaborative Innovation Center of Geospatial Technology, China; 5Institute of Technology and Science, Tokushima Univ., Japan; 6Graduate School of Engineering Science, Tokushima Univ., Japan. A dual-comb spectroscopy scheme with picometer spectral resolution is experimentally demonstrated using one frequency-unstabilized, dual-wavelength passively mode-locked fiber ring laser, and the dual-comb spectroscopy system is drastically simplified by the use of the dual-comb laser.

AM4K.5 • 17:30
Picometer-resolution, dual-comb spectroscopy based on a dual-wavelength mode-locked fiber laser, Ya Liu2, Xin Zhao, Bofeng Zhao, Zijun Yao, Zheng Gong, Takeshi Yasui2,3; School of Electronic and Information Engineering, Beihang Univ., China; 4Collaborative Innovation Center of Geospatial Technology, China; 5Institute of Technology and Science, Tokushima Univ., Japan; 6Graduate School of Engineering Science, Tokushima Univ., Japan; 7JST, ERATO, MINOSHIMA Intelligent Optical Synthesizer Project, Japan; 8School of Precision Instrument and Opto-electronics Engineering, Tianjin Univ., China. Dual-comb spectroscopy measurement of a high-Q microring resonator using a polarization-multiplexed mode-locked ultrafast fiber laser is demonstrated, which resolves picometer-wide spectral features in a very simple fiber-optic setup without complicated electronic control.

AM4K.6 • 17:45
High-resolution optical coherence microscopy using high-power supercontinuum source in 1700 nm spectral band, Masahito Yamanaka, Tatsumi Terashima, Hiyoriyuki Kawagoe, Norihiko Nishizawa1; Nagoya Univ., Japan. We developed high-resolution optical coherence microscopy using a high-power supercontinuum source in 1700 nm spectral band, and we demonstrated to image biological samples with 6 μm lateral and 2.8 μm axial resolution at high imaging depth.

AM4K.7 • 17:45
A Chip-scale sub-μg/kHz12 optomechanical DC accelerometer at the thermodynamic limit, Jaime Flores1, Yongjun Huang, Ziqiang Cal1, Vito Iaia1, Chee Wei Wong1, UCLA, USA. We report a record solid-state optomechanical oscillator (OMO) for acceleration detection down to the thermodynamical limit, at 0.35 mV/Hz1/2 resolution and 1.9 mV/Hz sensitivity, through optical pumping and RF readout of the radiation-pressure-driven backaction oscillation.

SM4L.8 • 17:45
A High-Power Photomixer with Plasmonic Contact Electrodes, Shang Hua Yang1,2, Mona Jamahi3,4, Electrical Engineering and Computer Science, Univ. of Michigan, Ann Arbor, USA; 3Electrical Engineering, Univ. of California, Los Angeles, USA. We demonstrate continuous-wave terahertz generation from a photomixer with plasmonic contact electrodes that offers record-high radiation powers as high as 17 mW at 1 THz and a 2 THz frequency tuning range.
SM4M • 1mm Lasers—Continued

SM4M.3 • 17:15
5.3 W average output power MHz Q-switched Yb:YAG channel waveguide laser delivering ~1 μJ pulse energy, Sargis Hakobyan, Valentin Wittwer, Kore Haase, Christian Kränkel, Thomas Sudmeyer, Thomas Calmano, Institut für Laser-Physik, Universität Hamburg, Germany; The Hamburg Centre for Ultrafast Imaging, Universität Hamburg, Germany. We demonstrate an Yb:YAG femtosecond-laser-written channel-waveguide-laser with record-high average-output-power of 5.7 W and 78% slope-efficiency in CW and 5.3 W for Q-switched operation with 11-ns pulses and ~1-μJ energy at 5.4-MHz repetition-rate.

SM4M.4 • 17:30
750-nm LED-pumped Nd:YAG laser with 9% optical efficiency, Kuan-Yan Huang, Cheng-Kuo Su, Meng-Wei Lin, Yu-Chung Chiu, Yu-Chieh Huang, National Tsing Hua Univ., Taiwan. We report generation of 1.15-mJ/pulse energy at 1064 nm from a single-transverse-mode Nd:YAG laser pumped by 13-mJ energy in a 1-ns pulse width from an array of 750-nm LED dies.

SM4M.5 • 17:45
Yb:YAG thin-disk multi-pass amplification system with image relay, Yoshihiro Ochi, Keesuke Nagashima, Momoko Matuyama, Japan Atomic Energy Agency, Japan. We have developed Yb:YAG thin-disk multi-pass amplification system adopting image relay to keep the beam size on the thin-disk constant. By this system pulse energy amplification to > 20 mJ was demonstrated.

FM4N • Plasmonic Sensing—Continued

FM4N.6 • 17:30
Observation of Single Molecule Dynamic Behaviors with SERS: Desorption and Conformation Switching, Jing Long, Tian Yang, Shanghai Jiao Tong Univ., China. Reproducible ultrahigh SERS enhancement in deterministic plasmonic hotspots allows chemical events on the single molecule level to be observed in real time, including plasmon-driven dimerization of 4NBT to DMAB, DMAB desorption and trans-cis conformation switching.

FM4N.7 • 17:45
Surface Enhanced Raman Spectroscopy on Single Mode Nanophotonic-Plasmonic Waveguides, Frédéric Peyskens, Ashim Dhakal, Pol Van Dorpe, Nicolas Le Thomas, Roel G. F. Baets, Ghent Univ., Belgium; imec, Belgium; KU Leuven, Belgium. We analyze the generation of Surface Enhanced Raman Spectroscopy signals from integrated bowtie antennas, excited and collected by a single mode silicon nitride waveguide, and discuss strategies to enhance the Signal-to-Noise Ratio.

AM4O • Microscopy for Biomedical Applications II—Continued

AM4O.5 • 17:15
Ultrafast Confocal Fluorescence Microscopy by Frequency-Division-Multiplexed Multi-Line Focusing, Hideharu Mikami, Hirofumi Kobayashi, Syed Hamad, Yasuyuki Ozeki, Keesuke Goda, The Univ. of Tokyo, Japan; Japan Science and Technology Agency, Japan. We propose and demonstrate ultrafast fluorescence confocal microscopy at a record high frame rate of 32,000 fps. This is made possible by frequency-division multiplexing with multi-line focusing.

AM4O.6 • 17:30
Multiplexed Color Imaging Using Demosaiced Pixel Super-Resolution, Yichen Wu, Yibo Zhang, Wei Luo, Aydogan Ozcan, Univ. of California Los Angeles, USA. We demonstrate a holographic color imaging technique that alleviates Bayer demosaicing related color artifacts in digital holography under multiplexed color illumination, improving the imaging speed by 3-fold compared to sequential color illumination.

JM5A • Plenary Session I, Grand Ballroom

18:15–18:45

19:00-20:00

OSA Technical Group Poster Session, Room 230B
Harry A. Wood

Quantitative characterisation of endoscopic imaging fibres, and its application for microscopy, Sia Tan, Xiaoming Wei, Jiqiang Kang, Kenneth K. Wong, Univ. of Hong Kong, China. We experimentally observe dissipative soliton resonance in a thulium-doped fiber laser operating in the anomalous dispersion regime. The laser output exhibits broad quasi-Gaussian spectra (~38 nm) centered at 1970 nm. The system is subsequently applied to spectrally encoded confocal microscopy.

Fiber Optic SPR Nanosensor for Erythromycin Detection

SM4Q.6 • 17:30
High peak power Erbium-Ytterbium single frequency pulsed fiber amplifier using a compressive strain gradient, Guillaume Canat, Steve Makon-Makon, Laurent Lombard, Julien Le Gouvel, Anne Durecu, ONERA, The French Aerospace Lab, France. We report on a 385W peak power single-mode single-frequency pulsed fiber amplifier using a compressive strain gradient reaching 24% optical-optical efficiency. This is the highest combination of peak power and efficiency for such an amplifier.

SM4Q.7 • 17:30
A 186-Watt all-fiber single-stage superfluorescent source, Jianqi Kang, Yu Hu, Wei Liu, Michael Hennerm, Luis E. Zapata, Gengzi Zhou, Damian N. Schimpf, Tino Eidam, Jens Limpert, Andreas Tünnermann, Franz X. Kaertner, Guoqing Chang, Center for Free-Electron Laser Science, DESY, Germany; The Hamburg Centre for Ultrafast Imaging, Germany; Inst. of Applied Physics, Friedrich-Schiller-Univ. Jena, Germany; Helmholtz Institut Jena, Germany. We demonstrate a compact Ytterbium-fiber MOPA system operating at 1018 nm, serving as powerful and compatible seed for cryogenically-cooled Yb:YLF amplifier. The output average power reaches 87 W with pulse energy of 4.9 µJ.

SM4R.6 • 17:15
Efficient Electroluminescence from III/V Quantum-Well-in-Nanopillar Light Emitting Diodes Directly Grown on Silicon, Indrasen Bhattacharya, Sanjaya Deshpande, Gillard N. Malheiro-Silveira, Connie J. Chang-Hasnain, Univ. of California Berkeley, USA. We have grown and fabricated InGaAs active region, InP clad nanopillar diodes at deterministic positions on silicon using selective area epitaxy. Room temperature radiative dominant electroluminescence at 1460 nm wavelength is reported from these devices.

SM4R.7 • 17:30
A Single InN Nanopillar Photodetector with Extended Infrared Response Grown by MOCVD, Lung-Hsing Hsu, Chien-Ting Kuo, Yuh-Jen Cheng, Kuan-Chao Chen, Hao-Chung Kuo, Shih-Yen Lin, Chien-Chung Lin, National Chiao Tung Univ., Taiwan; Research Center for Applied Sciences, Academia Sinica, Taiwan. An extended infrared photosresponse is observed in a high quality InN pillar/p-GaN photodetector with self-assembly epitaxy grown by LP-MOCVD. The IR portion photocurrent as high as 14.2% can be measured via AM1.5G solar simulated spectra.

SM4R.8 • 17:45
Impact of Temperature on Spatial Hole Burning and Modulation Bandwidth of Reflective Semiconductor Optical Amplifier, Anaelle Maho, Karim Mehrazni, Sophie Barbey, Francois Leclaire, Roman Brenot, Alcatel-Thales III-V Lab, France. At high temperature, RSOA display negligible spatial hole burning which limits their modulation bandwidth. Still, we demonstrate direct modulation at 60°C up to 10 Gbit/s and 5 Gbit/s for C- and O-band RSOA.
Broadband Nonlinear Photoresponse of Monolayer MoSe₂: A constant modulation depth of ~80% is revealed across the entire excitation spectrum, indicating a strong and tunable response to optical excitation. This feature is particularly interesting for applications in photodetection and nonlinear optics.

Direct comparison of second and third harmonic generation in monolayer MoSe₂ and WSe₂ shows substantial differences in the efficiency of nonlinear responses. These results highlight the importance of material choice and the potential for tuning the nonlinear response through material engineering.

Layer-Dependent Third-Harmonic Generation in Multilayer Graphene: The thickness of the graphene layers plays a critical role in the third harmonic generation process. Our experiments demonstrate that the efficiency of third harmonic generation increases with the number of layers, up to a certain point, after which the enhancement saturates.

Pseudospin-Dependent Spectroscopy of Single Quantum Dots: We report on the experimental demonstration of pseudospin-dependent spectroscopy in single quantum dots. This phenomenon, where the pseudospin state of a quantum dot is detected with high fidelity, opens up new avenues for quantum interrogation and quantum information processing.

Gate-Voltage-Dependence of Förster Transfer in Graphene: We have observed a strong dependence of the Förster transfer efficiency on the gate voltage in graphene, indicating the potential for gate-tunable energy transfer in nanoscale devices.

Graphene-Filed-Effect Transistors: We present the first demonstrations of graphene-field-effect transistors (GFETs) with excellent performance, including high on/off ratios and fast switching speeds, making them promising candidates for future electronic applications.

Phase-Change Materials for Emerging Photonics: We discuss the potential of phase-change materials as tunable components in photonics systems, highlighting their scalability, ease of integration, and potential for low-power operation.

Gate-Modulated Mode-Locking in Graphene: We report on the experimental demonstration of mode-locking in graphene, a phenomenon that could lead to the development of new types of optical oscillators and pulse generators.
FTu1D.1 • 08:00
Nanocavity-enabled Ultrafast Generation of Highly-indistinguishable Photons, Kevin Fischer1, Kai Müller2, Constantin Döry1, Tomasz Sarmiento1, Konstantinos Lagoudakis1, Armand Rundquist1, Yousif Kelaïta1, Jelena Vuckovic1, 1E. L. Ginzton Lab, Stanford Univ., USA; 2Walter Schottky Institut, Technische Universität München, Germany. Indistinguishable photon emission was investigated from a quantum-dot-photonic crystal resonator system for the first time. This solid-state cavity quantum-electrodymanical platform produced robust and high-fidelity generation of indistinguishable photons at unprecedented rates.

FTu1D.2 • 08:15
Complete Coherent Control of a Strongly Coupled Quantum Dot-Cavity Polariton System, Constantin Döry1, Kevin Fischer1, Kai Müller1, Konstantinos Lagoudakis1, Tomasz Sarmiento1, Armand Rundquist1, Jingyuan L. Zhang1, Yousif Kelaïta1, Jelena Vuckovic1; 1Stanford Univ., USA. We investigated an ultrafast phonon-assisted population transfer between polaritons from a strongly coupled quantum dot-photonic crystal cavity system. In particular, we demonstrated complete coherent control and single-photon generation from a polaron.

FTu1D.3 • 08:30
Invited
Nanophotonic Quantum Interface for a Single Solid-state Spin, Shuo Sun1, Hyochul Kim1, Glenn Solomon1, Edo Waks1, 1Univ. of Maryland, College Park, USA; 2NIST, USA. We realize a nanophotonic quantum interface for a quantum dot spin by strongly coupling the quantum dot to a nanophotonic cavity. This interface enables a spin-photon quantum phase switch, and also allows optical spin readout.

FTu1D.4 • 09:00
Towards high-cooperativity strong coupling of a quantum-dot in a tunable microcavity: the role of emitter broadening, Sebastian Starostec1, Lukas E. Greuter1, Andreas V. Kuhlmann1, Richard J. Warburton1; 1Univ. of Basel, Switzerland. We study single InGaAs quantum-dots within a tunable microcavity and observe a large Rabi splitting and high cooperativity (5.5). The dynamics are limited by spectral wandering; we report intriguing thermo-optic oscillation dynamics, for the first time in a high-Q LiNbO3 microresonator that results from combined effects of thermal refraction, thermal expansion, and photo-refraction.

FTu1D.5 • 09:00
Trapezoidal Shape Subwavelength Grating Waveguide Based High Quality Factor Micro-ring Resonator, Zheng Wang1, Xiaochuan Xu1, D. L. Fan1,2, Yaguo Wang1, Ray Chen1,2; 1Materials Science and Engineering Program, The Univ. of Texas at Austin, USA; 2Electrical and Computer Engineering, The Univ. of Texas at Austin, USA. We report the design and experimental demonstration of high quality factor, trapezoidal shape subwavelength grating waveguide micro-ring resonators (SWGMRs). A 5 μm radius SWGMR with a quality factor as high as 11,500 has been demonstrated for the first time.

FTu1E.1 • 08:00
Ultra-high Q Whispering Gallery Mode Electro-optic Resonators on Silicon Chip, Mohammad Soltani1, Vladimir Ilicenko2, Andrej Matko2, Anatoly Savchenkov1, John Schiferl1, Colm Ryan1, 1Lawall, USA; 2University of Rochester, USA. We show the ability of silicon photonics to overcome the long-standing challenge of efficient integrated coupling to ultra-high Q whispering-gallery-mode Lithium-Tantalate and Lithium-Niobate resonators. Coupling efficiency exceeding 90% with Q>45 millions is demonstrated.

FTu1E.2 • 08:15
Suppressing the Fundamental thermo-Optic Noises of a High-Q Microresonator, Xian B. Sun1, Hanxiao Liang1, Rui Luo2, X.-C. Zhang1, Qiang Lin2,3; 1The Inst. of Optics, USA; 2Dept. of Electrical and Computer Engineering, Univ. of Rochester, USA. We report a novel approach to dramatically suppress the fundamental temperature fluctuations and thermo-optic noises of a high-Q microresonators by orders of magnitude, achieved remarkably via pure optical means without cooling the device temperature.

FTu1E.3 • 08:30
Frequency locked micro ring resonators for wide band frequency referencing, Roy T. Zekert1, Liron Stern1, Noa Mazur1, Uri Levy1; 1The hebrew Univ. of Jerusalem, Israel. We propose and experimentally demonstrate a chip-scale based wideband optical frequency reference operating in a dual band spectral regime of near IR and telecom, by frequency locking a microring resonator to an acetylene absorption line.

FTu1E.4 • 08:45
Thermo-Optic Oscillation Dynamics in a High-Q Lithium Niobate Microresonator, Hanxiao Liang1, Wei C. Jiang1, Xuan B. Sun1, X.-C. Zhang1, Qiang Lin2; 1Univ. of Rochester, USA. We report intriguing thermo-optic oscillation dynamics, for the first time in a high-Q LiNbO3 microresonator that results from combined effects of thermal refraction, thermal expansion, and photo-refraction.

FTu1E.5 • 09:00
Trapezoidal Shape Subwavelength Grating Waveguide Based High Quality Factor Micro-ring Resonator, Zhong Wang1, Xiaochuan Xu1, D. L. Fan1,2, Yaguo Wang1, Ray Chen1,2; 1Materials Science and Engineering Program, The Univ. of Texas at Austin, USA; 2Electrical and Computer Engineering, The Univ. of Texas at Austin, USA; 2Omega Optics, Inc, USA; 3Mechanical Engineering, The Univ. of Texas at Austin, USA. We report the design and experimental demonstration of high quality factor, trapezoidal shape subwavelength grating waveguide micro-ring resonators (SWGMRs). A 5 μm radius SWGMR with a quality factor as high as 11,500 has been demonstrated for the first time.

FTu1F.1 • 08:00
Invited
Design of Efficient Few Mode Optical Amplifiers for Fiber Capacity Increase, Peter M. Krummrich1, Simon Akhtari1, 1Technische Universität Dortmund, Germany. Efficient optical amplifiers are key components for fiber capacity increase by space division multiplexing in long haul transmission. Design recommendations are reviewed with a focus on fiber types, pump concepts, gain and noise figure equalization.
08:00–10:00

Stu1G • High-Speed Integrated Sub-Systems
Presider: Guo-Wei Lu; Natl. Inst. of Info. & Comm. Tech., Japan

Stu1G.1 • 08:00
50 Tbit/s Massively Parallel WDM Transmission in C and L Band Using Interleaved Cavity-Soliton Kerr Combs, Pablo Marin8, Jörg Pfeiffer7, Maxim Kaprov1, Philipp Trocha1, Ralf Rosenberger1, Kovendhan Vijayan2, Stefan Wolf3, Juned N. Kemal2, Arne Kordts7, Martin Pfeiffer7, Victor Brachts3, Wolfgang Freude8, Tobias Kimpenberg3, Christian Koons8,1.1 École Polytechnique Fédérale de Lausanne (EPFL), Switzerland; 2Inst. of Photonics and Quantum Electronics, Karlsruhe Inst. of Technology, Germany; 3Inst. of Microstructure Technology, Karlsruhe Inst. of Technology, Germany. Interleaving two soliton Kerr combs we generate 179 carriers for WDM transmission and demonstrate transmission of a data stream of 50Tbit/s over 75km. This is the highest data rate achieved with a chip-scale comb source.

Stu1G.2 • 08:30
100 Gbps Pattern Matching using Spatial-Spectral Holographic Time Domain Correlation, Zeb W. Barber1, Calvin Harrington1, R. K. Mohan1, Colin Stiller2, Trent Jackson3, Peter Sellin4, Kristian Merkle5, Montana State Univ. - Spectrum Lab, USA; 6S2 Corporation, USA. Spatial-spectral holographic real-time correlative matched filtering of high bandwidth signals is demonstrated. Simple text searches for long phrases in PSK formatted optical data streams at rates up to 100 Gbps are presented.

Stu1G.3 • 08:45
Experimental Demonstration of 7 Tbs/Second Switching Using Novel Silicon Photonic Integrated Circuit, Yunhong Ding1, Valeria Kamchevska1, Kjeld Dalgaard2, Peihong Ye1, Rameez Asif1, Simon Gross1, Michael Withford2, Michael Galli1, Toshio Moriake1, Leif K. Oxenløwe1,2. 1Danmarks Tekniske Universitet, Denmark; 2Dept. of Physics and Astronomy, Centre for Ultra-high-bandwidth Devices for Optical Systems (CUDOS) and MQ Photonics Research Centre, Australia. We demonstrate BER performance <10^-9 for a 1 Tbs/second channel over 7-core fiber and SDM switching using a novel silicon photonic integrated circuit composed of a 7x7 fiber switch and low loss SDM couplers.

Stu1G.4 • 09:00
Error-free Dispersion-Uncompensated Transmission at 20 Gb/s over SSFMS using a Hybrid III-V/SOI DML with MRR Filtering, Valentina Cristofori1, Valeria Kamchevska1, Yunhong Ding1, Alexandre Shen2, Guang-Hua Du3, Christiano Peccherecht1, Leif K. Oxenløwe1, DTU Fotonik, Denmark; 3Ill-V Lab, France; 4FOTON Lab, ENSAT, Univ. de Rennes 1, France. Error-free 20-Gb/s directly-modulated transmission is achieved by enhancing the dispersion tolerance of a III-V/SOI DFB laser with a silicon micro-ring resonator. Loss (~0.4 dB) penalty compared to back-to-back with small fiber is demonstrated after 5-km SSFMS.

Stu1H.1 • 08:00
Near-field Integration of a Si,N Nanobeam and a SiO2 Microcavity for Heisenberg-Limited Displacement Sensing, Ryan D. Schilling1, Hendrik Schütz1, Amir Ghadimi1, Vívishe Sudhí2, Dalziel Wilson3, Tobias Kimpenberg3. 1École Polytechnique Fédérale de Lausanne (EPFL), Switzerland; 2Inst. of Photonics and Quantum Electronics, Karlsruhe Inst. of Technology, Germany. We experimentally demonstrate integration of a Si,N nanobeam in the evanescent near-field of a SiO2 optical microdisk resonator realizes displacement imprecision >30dB below the standard quantum limit at room-temperature.

Stu1H.2 • 08:15
Thermometry with Optomechanical Cavities, Thomas Purdy1, Karen Gutter1, Karlik Sinnavass1, Nikolai Klimov2,4, Zeesah Ahmed1, Jacob Taylor1,2. 1UQ, NIST, USA; 2CNST, NIST, USA; 3Joint Center for Quantum Information and Computer Science, UMD, USA; 4Thermodynamic Metrology Group, Sensor Science Division, PML, NIST, USA. The thermally-driven motion of a nanomechanical resonator may be employed as an absolute thermometer. We experimentally measure radiation pressure shot noise induced quantum correlations to absolutely calibrate the motional signal transduced onto an optical probe.

Stu1H.3 • 08:30
Laser Frequency Stabilization Using Pound-Drever-Hall Technique with an Integrated TiO2, Ahthermal Resonator, Emir S. Magden1, Michael Y. Peng1, Jonathan D. Bradley1, Gerald Leake1, Douglas Coolbaugh1, Leslie A. Kolodziejski1, Franz X. Kaerner1, Michael Watts1. 1MIT, USA; 2College of Nanoscale Science and Engineering, USA. We demonstrate laser frequency stabilization of a continuous-wave laser using an integrated TiO2, ahthermal cavity as a reference for the first time, and show linewidth improvement by a factor of 6 compared to a SIN cavity.

Stu1H.4 • 08:45
ModeLocked Mid-Infrared Frequency Combs in a Silicon Microresonator, Mengjie Yu1,2, Yoshitomo Okawachi1,2, Austin Griffith1,2, Michel Lipson1,2, Alexander L. Gaeta2. 1Electrical and Computer Engineering, Cornell Univ., USA; 2Applied Physics and Applied Mathematics, Columbia Univ., USA; 3Electrical Engineering, Columbia Univ., USA; 4Applied and Engineering Physics, Cornell Univ., USA. We demonstrate a near octave-spanning and soliton mode-locked mid-infrared frequency comb in a silicon microresonator. The soliton state can be accomplished via either pump laser detuning or electrical tuning of the free-carrier lifetime.

Stu1H.5 • 09:00
Stability of Mode Locked Microresonator Frequency Combs, Alexander Klenner1, Chaitanya S. Joshi1,2, Jae K. Jang1,2, Kevin Luke1, Xingchen Ji1,2, Yoshitomo Okawachi1,2, Michel Lipson1,2, Alexander L. Gaeta2. 1Electrical and Computer Engineering, Cornell Univ., USA; 2School of Applied and Engineering Physics, Cornell Univ., USA; 3Dept. of Electrical and Computer Engineering, Cornell Univ., USA. We show that soliton-mode-locked silicon nitride microresonators are highly stable against external perturbations. Mode-locking is maintained even for relatively large RMS pump-power noise and thermal shifts, which represents a key feature for potential applications.

Stu1H.6 • 09:15
μm range optical fiber parametric chirped pulse amplification of short pulses at 1 μm, Philippe Morin1, Jérôme Dubertrand2, Patrick Beaure d’Augères1, Géraud Bouwmand3, Alexandre Kudlinski4, Yves Quemerais2, Arnaud Musso4, Emmanuel Hugonnier1. 1Commissariat à l’Énergie Atomique, France; 2Laboratoire PHLAM-IRICIA, France. We report here on a FOPCPA where 1053 nm laser pulses are amplified in a LMA FBG fiber by an all-fiber pulse in a μm range with a gain of 53 dB and compressed up to about 400 fs.

Stu1I.2 • 08:15
Higher order soliton breakup via implosion, Ihar Babuikh1,2, Ayan Tagil1, Hakan Sayinski1, Jan-Hendrik Delmam2, Uwe Morger1, Gunter Steinmeyer1, Aymen Deimic1,2. 1Institut für Quantenoptik, Universität Hannover, Germany; 2Max-Born-Institut, Germany; 3Laser Zentrum Hannover e.V., Germany; 4Hannover Centre for Optical Technologies, Germany. We report a novel breakup scenario of ultra-short high-order solitons in optical waveguides, via formation of a shock far below subcycle level, followed by a dramatic and complete transition into a dispersive wave.
**CLEO: Applications & Technology**

**ATuU**  08:00–10:00  **Wavelength, Frequency, and Spectral Techniques**

**Presider:** Michael Frish; Physical Sciences Inc., USA

**ATuU.1**  08:00  **Precision Spectroscopy to Enable Traceable Dynamic Measurements of Pressure**  Zeev Ahmed, Kevin O. Douglas, NIST, USA. We present recent work aimed at creating a standard for the dynamic measurement of pressure. A near-IR laser spectroscopy system is demonstrated for measuring 8 cm⁻¹ in 50 µs with a 4 kHz repetition rate.

**ATuU.2**  08:30  **Temporal Encoding of Spectral Modulations in Chirped Pulses**  Nicholas H. Matsis, Anatoly Makischenku, Michael C. Duhmer, DESY, Germany; University of Michigan, USA. We derive a connection between time and frequency domains for sinusoidal modulations of chirped optical pulses and demonstrate its use as a single-shot, ultrafast diagnostic for periodic structures.

**ATuU.3**  08:45  **Ultra-Narrow Line Filters with Enhanced Transmittance for Low-Frequency Raman Spectroscopy**  Valery Koutechev, Oleg Smolenski, Alexei Glebov, OptiGrate Corp, USA. Volume Bragg grating based notch filters extend Raman spectroscopy in THz-frequency range, as low as 4 cm⁻¹. Recent advances in the technology enabled filters for visible region with high OD and losses below 5-10%.

**ATuU.4**  09:00  **The Study of Spectral Camera based on Ghost Imaging via Sparsity Constraints with Sunlight Illumination**  Shentao Liu, Shiyu Tan, Jianrong Wu, Enrong Li, Shengshen Han, Key Lab for Quantum Optics and Center for Cold Atom Physics of CAS, Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China. Spectral camera based on ghost imaging via sparsity constraints can acquire information at a rate significantly higher than Nyquist. We compare the results reconstructed by ghost imaging and ghost imaging via sparsity constraints with sunlight illumination.

**ATuU.5**  09:30  **Design for High Efficiency Full Spectrum Photovoltaics**  Harry Atwater, CaliforniaInst. of Technology, USA. Advances in photovoltaics moved the advanced research frontiers towards concepts that can enable ultrahigh efficiency (η = 30-50% and beyond). Achievement of ultrahigh efficiencies requires addressing fundamental optical principles and full solar spectrum utilization. Making significant progress requires combining i) fundamental principles governing limits to solar conversion efficiency ii) materials with high radiative efficiency) and iii) new electromagnetic design concepts.

**ATuU.6**  10:00  **Enhancing the Efficiency of Thermophotovoltaics with Photon Recycling**  Tianyao Xiao, John Holzrichter, Eli Yablonovitch, University of California Berkeley, USA. We show that photon recycling utilizing the spectral selectivity of the photovoltaic band edge enables 48% thermophotovoltaic heat-to-electricity conversion efficiency at 1200°C with InₓGa₁₋ₓAs cells, and present experimental methods to demonstrate this concept.

**ATuU.7**  10:30  **Hybrid Cascade-Type Energy Cell for Harvesting Solar and Mechanical Energy**  Guocheng Liu, Dayan Ban, University of Waterloo, Canada. This paper presents the first cascade-type compact hybrid energy cell (CHEC) that is capable of simultaneously or individually harvesting solar and strain energies. The CHEC’s ability is demonstrated by deploying a single 1.0 cm²-sized CHEC to charge a commercial capacitor.

**ATuU.8**  11:00  **Ultrafast optical switching between hidden states of correlated electron systems with Nonlinear Optics**  G. Timothy Noe, Rice University, USA. We describe an optical high harmonic generation based technique for resolving the local (micron scale) crystallographic and electronic point group symmetries of crystals and apply it to resolve the crystallographic and electronic symmetries of SrIrO₃.

**ATuU.9**  11:30  **Invited**

**CLEO: QELS-Fundamental Science**

**FTu1L**  08:00–10:00  **Novel Approaches to Probing Dynamics in Correlated Electron Materials**

**Presider:** Rohit Prasankumar, Los Alamos National Lab, USA

**FTu1L.1**  08:00  **Nonlinear Terahertz-Spin Interaction in Thulium Orthoferrite**  Sebastian Baier, Matthias Hohenleutner, Tobias Kampfrath, Anatoly Zvezdin, Rupert Huber, Rostislav Mikhailovsky, Univer. of Regensburg, Germany; Fritz-Haber-Institut der MPG, Germany; Pozhkov General Physics Inst., Russia; Radboud Univ. Nijmegen, Netherlands. Few cycle THz transients pump electronic transitions coupled to the spin system in thulium orthoferrite to trigger coherent magnons. Exploiting this novel driving mechanism we realize the first nonlinear interaction between THz pulses and spins.

**FTu1L.2**  08:15  **Magnet-Crystal-Field-Transition Hybridization in ErFeO₃**  Xinwei Li, Qi Zhang, CaliforniaInst. of Technology, USA. We report on new hybridization between the magnetic and crystal-field transition in ErFeO₃ single crystal at low temperatures using terahertz pulses. We observe magnon-CFT hybridization as anticrossing behavior as a function of magnetic field.

**FTu1L.3**  08:30  **Invited**

**FTu1L.4**  09:00  **Ultrafast optical switching between hidden states of electronic matter under non-equilibrium conditions**  Dragan Mihailovic, Jozef Stefan Inst., Slovenia. We report on new hidden states of matter created under femtosecond timescale non-equilibrium conditions in dichalcogenides and complex oxides, focusing on their origin, optical and electronic control, relaxation mechanisms and applications leading to ultrafast opto-memristors.
Passively harmonic mode-locked high repetition rate Tm/Saturable Absorber, with a Combination of Higher-Order Solitons and a SESAM

A 440 fs, 9.2 GHz Hybrid Mode-Locked Fiber Laser with an output power of 60 mW and a frequency of 10 GHz; 1.55 μm HCN frequency stabilized and mode-locked

We have successfully demonstrated a 0.95 ps, 1.5 mm. The real-time correlation between temporal evolution of comb-like dispersion-decreasing fiber, 7-cycle Pulses from an Er-fiber laser with Self-Similar evolution in a 'whole mid-infrared' wavelength region of 6-18 μm, is demonstrated by utilizing an optical vortex pumped 2-μm optical parametric oscillator in combination with a AgGaSe₂, difference frequency generator.

We experimentally observe widely tunable mid-IR femtosecond pulses by resonant radiation, generated by direct three-wave-mixing from a soliton in PPLN. The poling pitch gives a parametrically tunable resonant radiation, a feature absent in Kerr media.

We generate over 10 mW of broadband pulses at 7 to 10 micrometer wavelength in orientation-patterned gallium phosphide by difference frequency mixing between the fundamental and Raman-shifted component of a femtosecond Er fiber laser.

We experimentally observe widely tunable mid-IR femtosecond pulses by resonant radiation, generated by direct three-wave-mixing from a soliton in PPLN. The poling pitch gives a parametrically tunable resonant radiation, a feature absent in Kerr media.

Ultrafast photocurrent spectroscopy is used to reveal the material's promise for use in nonlinear optical devices.
Tuesday, 7 June

Executive Ballroom 210A

FTu1A • Novel Optical Materials—Continued

FTu1A.6 • 09:30
Transient Nonlinear Refraction Measurements of Titanium Nitride Thin Films, Jennifer Reed1, Manuel R. Ferdinandus2, Nathaniel Kinsey3, Clayton DeVault1, Urcan Guler1, Vladimir Shalaev1, Alexandre Boulasseva1, Augustine Urbas1, 1Air Force Research Lab, USA; 2Air Force Inst. of Technology, USA; 3Birk Nanotechnology Center, USA; 4Nanometa Technologies, USA. Using the highly sensitive optical beam deflection method, transient nonlinear refraction of thin film titanium nitride is measured. The results show a large negative instantaneous nonlinearity, followed by a long lived positive decay.

FTu1A.7 • 09:45
Observing the Interplay Between Surface and Bulk Optical Nonlinearities in Thin Van Der Waals Crystals, Skylar Deckoff-Jones1, Jinjing Zhang2, Christopher Petoukhoff3, Michael K. Man4, Sidong Lei4, Robert Vajtai2, Ajayan Pulickel2, Diyar Talbayev1, Julien Madec1, Keshav M. Dani1, Tulane Univ., USA; 2Oakland Inst. of Science and Technology, Japan; 3Rice Univ., USA. Thickness dependence of second harmonic generation in atomically thin InSe is studied. A strong resonance is observed, attributed to interference between distinct surface and bulk nonlinear contributions.

FTu1B • Graphene and 2D Plasmonics—Continued

FTu1B.6 • 09:15
Electrical Excitation of Plasmons in Graphene through the 2D Čerenkov Effect, Ido Kaminer1, Yaniv Tenebaum Ron1, Hivoje Buljan2, Yichen Shen1, Ognjen Ilic2, Josue Lopez1, Liang Jie Wong1, John Joannopoulos3, Marin Soljacic4, Technion Israel Inst. of Technology, Israel; 2Physics, MIT, USA; 3Physics, Univ. of Zagreb, Croatia; 4Singapore Inst. of Manufacturing Technology, Singapore. We show that charge carriers flowing inside graphene can emit graphene plasmons (GPs) through a 2D Čerenkov effect (ĈE), providing a highly efficient, tunable, and ultrafast conversion mechanism from electrical signal to plasmonic excitation.

FTu1B.8 • 09:45
Towards On-Chip, Tunable X-ray Sources based on Graphene Plasmons, Xiao Lin1, Hongsheng Chen2, MIT, USA; 2College of Information Science and Electronic Engineering, Zhejiang Univ., China. We show that charge carriers flowing inside graphene can emit graphene plasmons through a Čerenkov effect (ĈE). By using a high field confinement of graphene plasmons enabled the creation of table-top and robustly tunable free-electron sources from the IR to hard X-ray regime.

Executive Ballroom 210B

Executive Ballroom 210C

FTu1C • Quantum Entanglement II—Continued

FTu1C.6 • 09:15
Bayesian Mean Estimation for Finite Two-Photon Experiments, Brian Williams1, Pavel Lougovski2, Oak Ridge National Lab, USA. Experimental two-photon state tomography commonly utilizes frequency based methods which under-utilize experimental data and require preliminary calibrations. We use Bayesian analysis to make informed physical estimates without initial calibrations. We report experimental and simulated results.

FTu1C.7 • 09:30
Quantum Correlated Photon-Pairs From Warm Rb-Vapor, Prathamesh Donvalkar1, Chaitali Joshi1, Sven Ramelow1, Alexander L. Gaeta1, Cornell Univ., USA; 2Faculty of Physics, Univ. of Vienna , Austria. Using a diamond scheme in warm Rb-vapor, we generate quantum-correlated photon-pairs by spontaneous four-wave mixing. Using a Rb-filled photonic-band gap fiber, this system could achieve pair generation efficiencies of 10−3 pairs/input photon.

FTu1C.8 • 09:45
Development of a Space-Proof Polarization-Entangled Photon Source, Fabian O. Steinlechner1, Eric Wille1, Eric Beckert2, Rupert Ursin1, IQOQI Vienna, Austria; 2Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany; 3European Space Agency, ESTEC, Netherlands. We report on the engineering and testing of a highly efficient entangled photon source that can sustain the strong vibrations and thermal fluctuations of space flight and operation in space.

Executive Ballroom 210D

FTu2A • Plenary Session II, Grand Ballroom

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

10:30–11:30 JTu2A

11:30–19:30 Exhibition Open, Exhibit Halls 1, 2, & 3

11:30–13:30 Pizza Lunch with Exhibitors & Unopposed Exhibit Time Only, Exhibit Halls 1, 2, & 3

12:00–13:30 VIP Industry Leaders Networking Event: Connecting Corporate Executives, Young Professionals and Students, Exhibit Hall 1

12:00–15:00 SC352: Introduction to ultrafast pulse shaping—principles and applications

12:00–16:00 SC270: High Power Fiber Lasers and Amplifiers

13:00–14:30 Market Focus Session I: Precision Manufacturing Using Ultrafast Lasers, Exhibit Hall Theater
FTu1D • Advances in Quantum Dot Photonics—Continued

FTu1D.5 • 09:15
Probing resonant linewidth narrowing in quantum dot emission with above-band light, Oliver Gaszczak1, Vivien Loo1, Sergey V. Polyakov2, Edward Flagg2, Glenn Solomon1;2; 'Joint Quantum Inst., NIST & Univ. of Maryland, USA; 2NIST, USA; 'Dept. of Physics and Astronomy, West Virginia Univ., USA. An above-band laser can increase the brightness from emission with above-band light, with a strong near-resonant monochromatic laser with the application of spectral filtering.

FTu1D.6 • 09:30
Characterization of the local charge environment of a single quantum dot via resonance fluorescence, Disheng Chen1, Gary R. Lander1, Kyle S. Krowpman1, Glenn Solomon1, Edward Flagg1; 'Dept. of Physics and Astronomy, West Virginia University, USA; 'Joint Quantum Inst., NIST, USA. Resonant photoluminescence excitation spectra and autocorrelation measurements indicate that a quantum dot experiences discrete spectral shifts and continuous drifts due to fluctuations in the local charge environment. Specifically, the fluctuations of few nearby charge traps.

FTu1D.7 • 09:45
Franson interference in the filtered resonance fluorescence from a quantum dot, Manoj Periss1, Benjamin Petrak1, Kumarasiri Kanthasinghe1, Andreas Muller1; 'Univ. of South Florida, USA. We report Franson interference from the light scattered by a single two-level InAs quantum dot interacting with a strong, near-resonant monochromatic laser with the application of spectral filtering.

STu1E • Novel Applications of Microresonators—Continued

STu1E.6 • 09:15
Hybrid Resonant Coupling Modulator in Vertically-Integrated Silicon on Silicon Nitride Platforms, Amir Hossein Hosseini1, Majid Sodagar1, Hamed Shams Mousavi1, Ali A. Eftekhar1, Ali. Adibi2; 'Georgia Inst. of Technology, USA. We report a resonant hybrid modulator at rates exceeding cavity linewidth using coupling modulation. Integrated in a silicon-on-silicon nitride (SiON) platform, the device utilizes the high-speed plasma dispersion in Si and high-Q resonance in SiN.

STu1E.7 • 09:30
Tunable coupling of whispering gallery mode resonators on elastomer substrates, Tobias M. Siegle1, Stefan Schierle1, Sarah Kraemmer1, Benjamin Richter1, Sentayehu Wondimu1, Peter Schuch1, Christian Koos1, Heinz Kalt1; 'Inst. of Applied Physics, Karlsruhe Inst. of Technology, Germany; 'Zoologisches Institut, Karlsruhe Inst. for Technology, Germany; 'Inst. of Microstructure Technology, Karlsruhe Inst. for Technology, Germany. Photonic molecules consisting of dye-doped polymeric WGM resonators exhibiting super-mode lasing are realized post fabrication by reducing the gap between the cavities. Flexible elastomer substrates allow a precise tuning of the coupling gap.

STu1E.8 • 09:45
Ultrasonic Cavity Optomechanical Magnetometry, Beibei Li1, Eoin Sheridan1, Stefan Fontaine1, Halina Rubasz-tein-Dunlop1, Warwick Bowen1; 'The Univ. of Queensland, Australia. Cavity Optomechanical magnetometry is realized by embedding the magnetostrictive material into the high Q microcavity, with sensitivity of 30 pT/Hz1/2.

STu1E.7 • 09:45
Investigation of Inter-Core Cross-Talk in Cladding Pumped Double-Clad 6-Core Erbium Doped Fiber Amplifier, Cang Jin1,2, Bin Huang1,2, Haoshuo Chen1,2, Nicolas K. Fontaine1, Roland Ryf1, René-Jean Essambre1, Bora Ung1,2, Younès Mes-saddeq1, Sophie LaRochelle1; 'Bell Labs, Nokia, USA; 'COPL, Université Laval, Canada; 'CREOL, Univ. of Central Florida, USA; 'Département de génie électrique, ÉTS, Canada. We investigated the cross-talk in 6-core erbium doped amplifiers. Results indicate that the amplifier has lower cross-talk when the fiber bending radius >30 mm. The bending induced pump distribution nonuniformity can be reduced by randomly-twisting the fiber.

STu1F • Fiber Technology for Telecommunication—Continued

STu1F.5 • 09:15
Wideband All-Optical 3R WDM Regeneration Based on Dual-Pump Parametric Amplifier, Mohammad Amin Shoaie1, Armand Vedadi1, Camille-Sophie Brès1; 'Ecole polytechnique fédérale de Lausanne, Switzerland. Simultaneous all-optical 3R regeneration of WDM channels is demonstrated, based on dual-pump parametric amplification with sinusoidal modulated pumps. We observe receiver sensitivity improvement better than 1.5dB for five WDM channels modulated with 10Gb/s NRZ-OOK data.
Microring slow light structures built on the 60-nm-thick silicon continuously tunable optical delay line with the maximum engineering, Shanghai Jiao Tong Univ., China. We report a and Pulse Shapes using Nonlinear Optical Signal Processing Inter-channel Interference Mitigation of Heterogeneous System configurations. Is experimentally demonstrated. The robustness of this approach for wavelength-overlapped channels mitigation approach for wavelength-overlapped channels with combinations of different baud rates and pulse shapes is experimentally demonstrated. The robustness of this approach is verified by OSNR improvements under different system configurations.

STu1G.6 • 09:30
Inter-channel Interference Mitigation of Heterogeneous Wavelength-Overlapped Channels of Different Baud Rates and Pulse Shapes using Nonlinear Optical Signal Processing, Yongwen Cao,1,2,3, Morteza Ziyadi,1,2,3, Amirhossein Mohajerian Ariaei,1, Ahmed Almairman,1, Fatemeh Alshahi,1, Changjing Bao,1, Peicheng Liao,1, Ahmad Fallahpour,1, Bishara Shameem,1, Carsten Langrock,1, Martin Fejer,1, Moshe Tur,1, Alan Willner,1,2,3, Linjie Zhou,1,2,3, Linjie Zhou,1,2,3, Linjie Zhou,1,2,3.

STu1G.7 • 09:45
56 Gb/s DMT Signal Generated by an Integrated Silicon Ring Modulator, Ke Xu,1 Chyi Yan Wong,1 Liang Zhang,1, Lei Liu,1 Ning Liu,1 Chi Wai Chow,1 Hon Ki Tsang,1, Harbin Inst. of Technology, Shenzhen, China; 2State Key Lab of Advanced Optical Communication Systems and Networks, Dept. of Electronic Engineering, Shanghai Jiao Tong Univ., China; 3Hong Kong, Hong Kong. We demonstrate a 56 Gb/s DMT signal using a compact silicon microring modulator. The measured bit error rate of back to back modulated signal is well below the FEC limit.
Chiao Tung Univ., Taiwan.

We designed a linear filter based on linearly chirped continuous waves, and the best linearity of 0.9997 are measured and analyzed.

Yang

Hsin-An Lin

Gradient Grating Period Guided-Mode Resonance Filter, Compact Wavelength Detection System Based on a

We have successfully designed and tested the first working high-resolution, mid-IR OCT system that can simultaneously perform structural and chemical analysis of samples using novel low-coherent, high power QC emitters.

Spectroscopy and Imaging Using a Mid-IR Quantum Cascade Optical Coherence Tomography (OCT) System, Deborah Varrell1, Mei Chai Zheng2, Claire F. Emch2, Martin Chowe1,3

1Princeton Univ., USA; 2Hong Kong Univ. of Science and Technology, China. We have successfully designed and tested the first working high-resolution, mid-IR OCT system that can simultaneously perform structural and chemical analysis of samples using novel low-coherent, high power QC emitters.
STu1M.6 • 09:15
Handedness of Laguerre-Gaussian LG\(_01\) Mode in a Unidirectional Ring Laser, Robin T. Uren\(^1\), W. Andrew Clarkson\(^1\), \(^1\)Univ. of Southampton, UK. A single-frequency Nd:YAG ring laser operating on the Laguerre-Gaussian LG\(_01\) mode with well determined handedness of helical phase front is demonstrated. We show that by reversing the lasing direction the handedness can be changed.

STu1M.7 • 09:30
Pulsed Amplification of 2 µm Concentric Vortex Beams, Keith Miller\(^1\), Yuan Li\(^1\), Wenzhe Li\(^1\), Ramesh Shori\(^2\), Eric Johnson\(^1\), \(^1\)Clemson Univ., USA; \(^2\)SPAWAR System Center, USA. Amplification and preservation of spatial mode integrity of concentric vortex beams was demonstrated even when subjected to severe transient thermal lensing in a flashlamp-pumped setup.

FTu1N.4 • 09:15
Terahertz-driven High Harmonic Generation in Bulk Crystals, Fabian Langer\(^1\), Matthias Hohenleutner\(^1\), Olaf Schubert\(^1\), Matthias Koen\(^1\), Ulrich Huttner\(^1\), Stephan W. Koch\(^1\), Mackillo Kir\(^1\), Rupert Huber\(^1\); \(^1\)Dept. of Physics, Univ. of Regensburg, Germany; \(^2\)Dept. of Physics, Univ. of Marburg, Germany. High harmonic bursts from a bulk solid are studied in the time domain. The data reveal a non-resonantly driven, non-perturbative quantum interference of crystal electrons from multiple valence bands.

FTu1N.5 • 09:45
Femtosecond Nonlinear Response of Bulk Plasmons in a Highly Doped Semiconductor, Michael Woerner\(^1\), Tobias Tylorski\(^1\), Sascha Kalusnak\(^2\), Sergey Sadofev\(^2\), Thomas Elsaesser\(^1\), \(^1\)Max Born Inst., Germany; \(^2\)Humboldt Univ., Germany. Using midinfrared 2-color pump-probe spectroscopy we study longitudinal bulk plasmons in ZnO. The plasmon resonance undergoes a strong red-shift upon intraband excitation of electrons caused by an enhanced mass in the hot plasma.

FTu1N.6 • 09:45
Development of a Pediatric Vision Screening Device for Remote Assessment of Binocular Fixation and Focus using Birefringence Properties of the Eye, Kristina Irsch\(^1,2\), Boris Gramatikov\(^1\), Yi-Kai Wu\(^1\), David Guyton\(^1\), \(^1\)The Wilmer Eye Inst., The Johns Hopkins Univ. School of Medicine, USA; \(^2\)Institut de la Vision / CIC 1423, Quinze-Vingts National Eye Hospital, France. This talk reviews the development of a new pediatric vision screener, which employs polarization-modulated, retinal-birefringence-scanning-based eye alignment detection and bull’s eye focus detection with an improved target system.

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

10:30–11:30 JTu2A • Plenary Session II, Grand Ballroom

11:30–19:30 Exhibition Open, Exhibit Halls 1, 2, & 3

11:30–13:30 Pizza Lunch with Exhibitors & Unopposed Exhibit Time Only, Exhibit Halls 1, 2, & 3

12:00–13:30 VIP Industry Leaders Networking Event: Connecting Corporate Executives, Young Professionals and Students, Exhibit Hall 1

12:00–15:00 SC352: Introduction to ultrafast pulse shaping–principles and applications
SC410: Finite Element Modelling Methods for Photonics and Optics

12:00–16:00 SC270: High Power Fiber Lasers and Amplifiers
SC438: Photonic Metamaterials

13:00–14:30 Market Focus Session I: Precision Manufacturing Using Ultrafast Lasers, Exhibit Hall Theater
STu1P • Mode-locked Fiber Lasers I—Continued

STu1P6 • 09:15
Optimized Spectral Filtering for Few-Femtosecond Timing Jitter from a Picosecond Fiber Laser, Wei Chen1, Youjian Song1, Ming-le Hu1, Chingue Wang2, Jiaojiao Wang2, Xin Zhao1,2,3
1Beihang Univ., China; 2Shenzhen Univ., China; 3Hunan Univ., China. We report a 40-fs pulse width after compression from a chirped-volume Bragg grating with a 57-MW peak power.

STu1P7 • 09:30
High power femtosecond all-fiber chirped pulse amplification system based on Cherenkov radiation, Ruoyu Sun1, Dongchen Jin1, Fangzhou Tan1, Pu Wang2, 1Beijing Univ. of Technology, China; 2Beijing Univ. of Technology, China. We report a 60-W femtosecond Yb-doped all-fiber chirped-pulse-amplification system based on Cherenkov radiation generated by Er-doped dispersion-managed mode-locked fiber laser. The pulse width after compression by chirped-volume Bragg grating is 597-fs with 5.7-MW peak power.

STu1Q • 09:45
Rigorous Characterization and Analysis of the Operating States in a Passively Mode-Locked Fiber Laser, Joseph W. Haelter1, Nicholas G. Usechak1; 1US Air Force Research Lab, USA. This work experimentally investigates the full spectrum of operational regimes that exist in a standard nonlinear polarization-rotation-based mode-locked fiber ring laser in order to understand and ultimately control these states within the cavity.

STu1Q6 • 09:45
Femtosecond OPO Based on Orientation-Patterned Gallium Phosphate (OP-GaP), Qiutian Hu1, Zachary Loporo2, Peter G. Schunemann3, Konstantin L. Vodopyanov4; 1CREOL, 2Bae Systems, Incorporated USA, 3ICFO -The Inst. of Photonic Sciences, Spain, 4BAE Systems, USA. We report the first femtosecond OP-GaP-based OPO suitable for ultrabroadband frequency comb generation. The 15-dB bandwidth of 2.6-4.2 nm was obtained from a compact low-threshold (14 mW) OPO pumped by 65-fs Er-fiber laser.

STu1Q7 • 09:30
Cascade, deep-infrared, femtosecond optical parametric oscillator based on CdSbP4, Chaitanya Kumar D. Suddapalli1, A. Esteban-Martín2, A. Santana1, K. T. Zawilski3, Peter G. Schunemann3, M. Ebrahim-Zadeh4, A. Esteban-Martin2, 1ICFO -The Inst. of Photonic Sciences, Spain, 2Radiantis, Polígon Camí Ral, Spain, 3BAE Systems, Incorporated USA, 4Instituto Catalana de Recerca i Estudis Avançats (ICREA), Spain. We report the first cascaded pump-tuned mid-IR femtosecond OPO based on CdSbP4, providing rapid and hands-free tuning in 6-7 µm wavelength range, with an output power of 80 MHz.

STu1Q8 • 09:45
Long-Wave Optical Parametric Oscillator with 45 mJ Pulse Energy Based on Nonlinear Conversion in ZnGeP2, Annette Bakkland1, Helge Fornum2, Espen Lippert3, Magnus W. Haakstad1; 1Norwegian Defense Research Establishment, Norway, 2ICFO -The Inst. of Photonic Sciences, Spain, 3BAE Systems, Incorporated USA. We demonstrate an erbium-doped fiber laser based on WS2 saturable absorber and intracavity laser based on WS2, capable of generating 45 mJ pulses with 45 mJ energy and a beam quality of M2 = 3.1 are generated using a ZnGeP2-based master oscillator/power amplifier, pumped by a cryogenic Q-switched Ho:YLF laser.
**Executive Ballroom 210A**

### 13:30–15:30

**FTu3A • Orbital Angular Momentum**  
**Presider:** Mo Mojahedi; Univ. of Toronto, Canada

**Orbital Angular Momentum in Photon-Phonon Coupling,** Zhu Zhihan; Iliwen Sheng; Chunyaun Mu; Wei Gao; HUST, China; 1 Dept. of Physics and Max Planck Centre for Extreme and Quantum Photonics, Univ. of Ottawa, Canada. We present the physical nature of orbital angular momentum (OAM) in photon-phonon coupling. Exploiting the controllable OAM transfer between light and sound, we demonstrate reversible OAM photon-phonon conversion for the first time.

**FTu3A.1 • 13:30**

**Orbital Angular Momentum in Photon-Phonon Coupling,** Zhu Zhihan; Iliwen Sheng; Chunyaun Mu; Wei Gao; HUST, China; 1 Dept. of Physics and Max Planck Centre for Extreme and Quantum Photonics, Univ. of Ottawa, Canada. We present the physical nature of orbital angular momentum (OAM) in photon-phonon coupling. Exploiting the controllable OAM transfer between light and sound, we demonstrate reversible OAM photon-phonon conversion for the first time.

**FTu3A.2 • 13:45**

**Raman scattering for intense high orbital angular mo-**

### 13:30–15:30

**FTu3B • Electron Plasmonics and Optomechanics**  
**Presider:** Bo Zhen, MIT, USA

**Plasmonic Hot-Electron Transfer in the Strong Coupling**  
**Regime,** Peng Zeng; Jasper Cadisch; Debabrata Chakraborty; Trevor Smith; Ann Roberts; John Sader; Timothy Davis; Daniel Gomez; Univ. of Melbourne, Australia; CSIRO, Australia. In this talk we will show that waveguide-plasmon polaronics, which result from the strong coupling of localised plasmon resonances in metal nanowires and waveguide modes, result in hybrid states exhibiting hot-electron character-

### 13:30–15:30

**FTu3C • Non-Classical State Engineering and Characte-**

### 13:30–15:30

**FTu3C.1 • 13:30**

**Single-shot, Full Characterization of a Single-Photon State,** Olivier Gazzano; Tim Thoma; Elizabeth Goldschmidt; Serguei Y. Polyakov; Vivien Loo; Glenn Solomon; 1 Joint Quantum Inst., NIST & Univ. of Maryland, USA; NIST; Gaithersburg, USA. Quantum light parameters (purity, indistinguishability...) are usually determined using multiple sequential measure-

### 13:30–15:30

**FTu3C.2 • 13:45**

**A Single-Photon Subtractor for Multimode Quantum**  
**States,** Clément Jacquard; Valentin Averchenko; Young-Sik Ra; Jonathan Roslund; Yen Cai; Adrien Dufour; Claude Fabre; Nicolas Treps; 1 Laboratoire Kastler Brossel, France. We describe a mode-selective single-photon subtraction device based on sum-frequency generation and ultrafast pulse shaping for multimode quantum state engineering. Its essential feature is the tunability of the single-photon subtraction mode.

**FTu3C.3 • 14:00**

**Full mode reconstruction of a light field via a photon-**

### 13:30–15:30

**FTu3C.4 • 14:15**

**Enhanced Thermal Images of Faint Objects via Photon**  
**Addition / Subtraction,** Claudio G. Parazzoli; Barbara Aa Capron; **BR&T, The Boeing Company, USA. We strongly increased the Signal to Noise Ratio in a long-baseline inter-**

### 13:30–15:30

**FTu3C.5 • 14:30**

**Tomography of Single-Photon Subtraction Process in**  
**Multiple Time-Frequency Modes,** Young-Sik Ra; Clément Jacquard; Adrien Dufour; Claude Fabre; Nicolas Treps; 1 Laboratoire Kastler Brossel, France. We present a method to characterize single-photon subtraction process in multiple time-frequency modes. To obtain complete information of the process, we use coherent-state quantum process tomography, and express the results by a quantum process matrix.
Worth Scarabelli Labs, USA; 4Dept. of Electrical Engineering, Columbia Univ., USA; 2Cavendish Lab, Univ. of Cambridge, UK; 5Sandia National Labs, USA; 6National Inst. for Materials Science (NIMS), Japan.

of indistinguishable single photons. We report fabrication of Silicon-vacancy (SiV) centers in diamond are bright sources using single defects in diamond and nuclear spins as high multiple photons and process the achieved information by e.g. angular momentum transfer, when the polarization state evolves as the photons propagate, due to the waveguide birefringence.

Circular Gratings for Efficient Collection from Implanted Silicon Vacancy Centers in Diamond, Jiabao Zheng1, Matthew E. Trustheim1, Tim Schroder1, Michael Walsh1, Camille Stavrakas2, Benoit Pouget2, Mustafa Gundogar2, Christian Hepp1, Jose L. Pacheco1, Edward Bielejec1, Paola Cappellaro2, [Research Lab of Electronics, MIT, USA; 2Univ. of Tokyo, Japan; 3Univ. of Ulm, Germany; 4Harvard - Smithsonian center for Astrophysics, USA; 5Sandia Labs, USA; 6National Inst. for Materials Science (NIMS), Japan].

Diamond optomechanical crystals in the resolved-sideband regime, Michael Burek1, Justin D. Cohen1, Sean M. Meenehan1, Thibaud Rueelle1, Sujuan Meesala1, Mikhail Lukin2, Oskar Painter3, Marko Loncar4, Harvard Univ., USA; 2California Inst. of Technology, USA; 3EPFL, Switzerland. We demonstrate diamond optomechanical crystals (OMCs), which support a ~6 GHz mechanical cavity coupled to a co-resonant ~200 THz photon field. Diamond OMCs are optically driven to a cooperativity ~1, highlighted by observed ‘phonon lasing’.

Maskless Creation of Silicon Vacancy Centers in Photonic Crystal Cavities, Tim Schroder1, Matthew E. Trustheim1, Michael Walsh1, Camille Stavrakas2, Benoit Pouget2, Mustafa Gundogar2, Christian Hepp1, Jose L. Pacheco1, Edward Bielejec1, Paola Cappellaro2, [Research Lab of Electronics, MIT, USA; 2Univ. of Tokyo, Japan; 3Univ. of Ulm, Germany; 4Harvard - Smithsonian center for Astrophysics, USA; 5Sandia Labs, USA; 6National Inst. for Materials Science (NIMS), Japan].

We demonstrate an optomechanical device in piezo-optomechanical circuits, Ritesh Agarwal1, Ulrike von Goethe1, Christopher保持的力矩的光波振子和半导体镁铝酸镁在声波光子学中的应用。
Executive Ballroom 210G

13:30–15:30
STu3G • Integrated Photonics
Presider: Lin Zhu; Clemson Univ., USA

First demonstration of CMOS compatible electrical programmable photonic memory cell, Junfeng Song1,2, Eu-Jin Lime1, xianshu luo1, Qings Fang1, Chao Li1, Lianbo Jia1, Xiaoguang Tu1, Ying Huang1, Tsung-Tang Law2, Guoqiang Lo1, 1Inst. of Microelectronics, Singapore; 2College of Electronic Science and Engineering, Jilin Univ., China. We propose an electrically programmable, multi-level non-volatile photonic memory cell (PMC) fabricated by standard CMOS compatible processes. A micro-ring resonator (MRR) was built using the PMC to demonstrate programmable and erase functions.

Executive Ballroom 210H

13:30–15:30
STu3H • Trace Gas and Isotope Detection
Presider: Todd Stievater; US Naval Research Lab.

First demonstration of CMOS compatible electrical programmable photonic memory cell, Junfeng Song1,2, Eu-Jin Lime1, xianshu luo1, Qings Fang1, Chao Li1, Lianbo Jia1, Xiaoguang Tu1, Ying Huang1, Tsung-Tang Law2, Guoqiang Lo1, 1Inst. of Microelectronics, Singapore; 2College of Electronic Science and Engineering, Jilin Univ., China. We propose an electrically programmable, multi-level non-volatile photonic memory cell (PMC) fabricated by standard CMOS compatible processes. A micro-ring resonator (MRR) was built using the PMC to demonstrate programmable and erase functions.

Meeting Room 211 B

13:30–15:30
STu3I • Ultrafast MIR Sources
Presider: Tenio Popmintchev; JILA, Univ. of Colorado at Boulder, USA

Towards all Yb based, High Repetition Rate FOPA Systems, Mathieu Giguere1, Adam Stepheandier2, Torsten Mann2, Francois Leger2, Bruno E. Schmidt3; 1AMPHOS GmbH, Germany; 2INRS-EMT, Canada. Starting from a 100kHz picosecond Yb laser, we derive tunable 10-15fs visible pulses for intrapulse difference frequency generation of potentially CEP stable, few-cycle IR pulses as the seed source for a subsequent FOPA chain.

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Tuesday, 7 June

STu3G.1 • 13:30
Tutorial
Micro Cavities for Soliton Frequency Combs and Optical Clocks, Kerry Vahala1, 2California Institute of Tech., USA. Progress on soliton frequency microcombs is described including review of dissipative Kerr microcavity soliton physics. Applications including integrated optical clocks, microwave sources and optical synthesizers are discussed.

STu3H.1 • 13:30
Tutorial
Sensitive Trace Gas and Isotope Measurements using Cavity Enhanced Absorption Spectroscopy, Erik Kerstel1, Daniele Romanini1, Samir Kassal1, Mathieu Daenron2, Arnaelle Landais2; 1Lab of Interdisciplinary Physics, Univ. of Grenoble Alps / CNRS, France; 2ILSC, CNRS, France. This presentation will review cavity-enhanced techniques for the measurement of trace gas concentrations and isotopic ratios in particular. It will give an introduction to the principle of optical isotope ratio measurements and discuss recent advances.

Kerry Vahala is the Jenkins Professor and Professor of Applied Physics at Caltech. His research group has created the highest Q-factor chip-based optical resonators and also launched many of the subjects of study in the field of optical microcavities. Vahala has received an Alexander von Humboldt Award for his work on high-Q devices. He was also involved in the early effort to develop quantum-well lasers for optical communications and received the IEEE Sarnoff Award for his research on quantum-well laser dynamics. He is a fellow of the IEEE, the IEEE Photonics Society, and The Optical Society.

Erik Kerstel received a Ph.D. degree from Princeton University in 1993. Since 2009 he has been a Professor of Physics at the University of Grenoble Alps. Following a post-doctoral fellowship at the European Laboratory for Non-linear Spectroscopy (LENS) in Florence, Italy, he joined the University of Groningen, where he started to apply laser spectroscopy to stable isotope ratio measurements, supported by a 5-year fellowship of the Royal Netherlands Academy of Sciences (KNAW). His lab demonstrated applications in the fields of biomedicine, ice core research, and airborne atmospheric research. In Grenoble his research interests are primarily the application of ultra-sensitive optical sensing techniques to isotope and trace gas measurements in the environmental sciences. He currently organizes the next edition of the Field Laser Applications in Industry and Research (FLAIR) conferences.

STu3G.2 • 14:30
First demonstration of CMOS compatible electrical programmable photonic memory cell, Junfeng Song1,2, Eu-Jin Lime1, xianshu luo1, Qings Fang1, Chao Li1, Lianbo Jia1, Xiaoguang Tu1, Ying Huang1, Tsung-Tang Law2, Guoqiang Lo1, 1Inst. of Microelectronics, Singapore; 2College of Electronic Science and Engineering, Jilin Univ., China. We propose an electrically programmable, multi-level non-volatile photonic memory cell (PMC) fabricated by standard CMOS compatible processes. A micro-ring resonator (MRR) was built using the PMC to demonstrate programmable and erase functions.

STu3H.2 • 14:30
Measuring Isotope Ratios of Large Molecules Using a Swept External Cavity Quantum Cascade Laser, Brian Brunfield1, Mark C. Phillips1; 1Pacific Northwest National Lab, USA. We measure isotope ratios for species with broadband absorption features using a swept external cavity quantum cascade laser. Isotopic precisions of ~1% (per mil) are demonstrated for methanol (MeOH/MeOD) and ethanol (EOH/EOD) vapor.

STu3I.2 • 14:00
110-fs, 5.3-µm ZGP Parametric Amplifier Driven by a ps Ho:YAG Chirped Pulse Amplifier, Tsuneto Kanai1, Pavel Mlejdic1, Sarayoo Kangaparambil1, Heinrich Hoogland2, Ronald Holzwarth2, Audrina Pugash2, Andrius Baltska1, 1Vienna Univ. of Technology, Austria, 2Menlo Systems GmbH, Germany. 110-fs, 5-3-µm parametric amplifier driven by a ps 2.1-µm Ho:YAG chirped pulse amplifier is demonstrated. It offers an all-in-one solution for seeding, pumping, and CEP stabilization of few-cycle pulses in 2nGef, and similar mid-IR crystals.

STu3I.4 • 14:30
Octave-spanning 1.5-optical-cycle 6.5-µm OPA pumped by a ps Ho:YAG Chirped Pulse Amplifier, Tsuneto Kanai1, Peter Krogen1,2,3, 110-fs, 5.3-µm parametric amplifier driven by a ps 2.1-µm Ho:YAG chirped pulse amplifier is demonstrated. It offers an all-in-one solution for seeding, pumping, and CEP stabilization of few-cycle pulses in 2nGef, and similar mid-IR crystals.

STu3G.3 • 14:30
Towards all Yb based, High Repetition Rate FOPA Systems, Mathieu Giguere1, Adam Stepheandier2, Torsten Mann2, Francois Leger2, Bruno E. Schmidt3; 1AMPHOS GmbH, Germany; 2INRS-EMT, Canada. Starting from a 100kHz picosecond Yb laser, we derive tunable 10-15fs visible pulses for intrapulse difference frequency generation of potentially CEP stable, few-cycle IR pulses as the seed source for a subsequent FOPA chain.
Digital Micromirror Device Camera Used for High-Speed and High-Resolution Imaging, Wei Feng, Fumin Zhang, Xin-ghua Qu, Tianjin Univ., China. We incorporate the hardware restrictions of existing image sensors, implement a hardware prototype with a digital micromirror device (DMD) camera, and theoretically analyze the per-pixel coded exposure to realize high-speed and high-resolution imaging.

Imaging Current Distributions and Temperature Profiles in GaN HEMTs using Nitrogen Vacancy Centers in Nanodiamonds, Christopher Fay, Kevin Bagnall, Matthew Trusheim, Alberto Lauri, Evelyn Wang, Dirk R. Englund, MIT, USA; Imperial College, UK. We demonstrate simultaneous wide-field (>1000 μm) measurements of magnetic fields and temperature on GaN HEMTs using nitrogen vacancy centers in nanodiamonds.

Nanoscale metal substrates fabrication for surface enhanced fluorescence using the nanosecond speckle-modulated laser pulses, Stanislav O. Gurbatov1,2, Oleg Vitrik1,2, Yun Kelchin1,2, Aleksandr A. Kuchmikhin1,2, IACP FEB RAS, Russia; Far Eastern Federal University, Russia. Nanosecond speckle-modulated laser pulses were applied to fabricate nanotextured metal substrates for surface enhanced fluorescence (SEF) applications. The fabricated Au substrates demonstrate spatially uniform SEF signal from the Rhodamine 6G organic dye with averaged 5-fold enhancement factor.

Thermal Modeling and Heat Mitigation for Femtosecond-Laser-Based Silicon Processing, Jie Qiao, Laurent Taylor, Jun Qiao1,2 Rochester Inst. of Technology, USA; College of Materials Science and Metallurgy, The Univ. of Science and Technology Beijing. Femtosecond laser processing of silicon has shown effective material removal, but with heat-induced formation of raised surface features. The surface heating phenomenon was simulated to optimize laser parameters for mitigating thermal effects in femtosecond processing.

High-Speed Printing with Polygon Scan Heads, Glenn Stutz, "Optical Engineering, Lincoln Laser, USA. This presentation provides an overview of the leading edge scan head technology for high speed printing which allows users to implement an integrated total solution approach for true X/Y scan heads at line speeds of 200 meters per second.

Femtosecond laser processing and the high-energy pumping, which allows us to isolate intrinsic quasi-particle scattering dynamics inside the surface states.

Join the conversation. Use #CLEO16. Follow us @cleoconf on Twitter.
Tuesday, 7 June

**CLEO: Science & Innovations**

**13:30–15:15**

**STu3M • High Energy and High Average Power Laser Systems**

*Presider: Hiromitsu Kiriyama; Japan Atomic Energy Agency, Japan*

_STu3M.1 • 13:30*

_A 100J-Level Nanosecond Pulsed DPSSL System for Next Generation Petawatt Laser Systems_, Andy J. Bayramian, 1SLAC National Accelerator Lab, USA; 2Central Laser Facility, STFC Rutherford Appleton Lab, UK; 3HILASE, Inst. of Physics, Czech Republic. We report the generation of 108 J pulses of duration 10 ns at 1 Hz with a conversion efficiency of 21% confirming the energy scalability of DIPOLE, a DPSSL based on cryogenically-cooled Yb:YAG amplifier technology.

_STu3M.2 • 14:00*

_High Energy, High Average Power, DPSSL System for Next Generation Petawatt Laser Systems_, Andy J. Bayramian, 1SLAC National Accelerator Lab, USA. Phase 1 performance of the HAPLS pump laser, a high-energy DPSSL based on Nd:glass, successfully produced 70J at 1053nm from a single aperture and 99 J at 527nm using LBO frequency converter running at 3 Hz repetition rate.

**FTu3N.1 • 13:30**

_Toward Unifying Spectroscopic Function with Diffractive Structure using Strong Fields, X-Rays, and Electrons_, Ryan N. Coffee, 1SLAC National Accelerator Lab, USA; 2The PULSE Inst., USA. Strong field molecular control can be used as a correlation parameter, allowing one to combine free electron laser based x-ray spectroscopy together with ultra-fast electron diffraction. We will discuss this also in the light of emerging non-linear x-ray techniques.

**FTu3N.2 • 14:00**

_Opportunities for chiral discrimination using high harmonic generation in tailored laser fields_, Olga Smirnova, 1Yann Mairese, 2Sergei Patchkovskii, 3Max Born Inst., Germany; 4CELIAT, France. We discuss future perspectives for chiral discrimination with HHG, the ways of increasing chiral dichroism using tailored laser pulses, new detection schemes involving high harmonic phase measurements, and reconstruction of chiral response in pump-probe schemes.

**FTu3N.3 • 14:15**

_Attosecond probing of nuclear vibration with frequency shift in harmonic spectrum_, Linx He, 1Pengfei Lan, 2Chunyaang Zhai, 3Feng Wang, 4Wenjing Shi, 5Qingbin Zhang, 6Xiaosong Zhu, 7Pexiang Lu, 8Huazhong Univ of Science and Technology, China; 9 Wuhan Inst. of Technology, China. We report the first experimental observation of frequency shift in high order harmonic generation (HHG) from isotopic molecules $H_2$ and $D_2$, from which we successfully retrieve the nuclear vibrations in these isotopic molecules.

**FTu3N.4 • 14:30**

_Bond Selective Probe by Time-Resolved Photoelectron Spectroscopy: Ring-Opening Dynamics of 1,3-Cyclohexadiene_, Ryo Ikuboi, 1Taro Sekikawa, 1Yu Hanabuchi, 1Testuya Taketsugu, 1Applied Physics, Hokkaido Univ., Japan; 2Chemistry, Hokkaido Univ., Japan. Ring-opening dynamics of 1,3-cyclohexadiene upon two-photon excitation at 400 nm was revealed by time-resolved photoelectron spectroscopy using high harmonic photons probing the lower-lying occupied molecular orbitals, which are the fingerprints of the molecular structure.

**Marriott Salon I & II**

**13:30–15:15**

**ATu3O • A&T Topical Review on Neurophotonics I**

*Presider: Kishan Dholakia; University of St Andrews, UK*

**ATu3O.1 • 13:30**

_Optical Technology Development for Mouse Brain Imaging_, Chris Xu, 1Applied and Engineering Physics, Cornell Univ., USA. Optical imaging of the structure and function deep within a mouse brain is a major scientific challenge in neuroscience. We review recent advances in multiphoton microscopy for mouse brain imaging, and discuss some future directions.

**ATu3O.2 • 14:00**

_Integrated graphene sensor on high-Q silicon-ring resonator for neurotransmitter detection_, Yuzuki Kobayashi, 1Rai Kou, 2Suzuyo Inoue, 3Tai Tsuchizawa, 4Ueno Yuko, 5Satoru Suzuki, 6Hiroti Hibi, 7Tsuiki Yamanoto, 8Kaji Yamada, 9Chika Nakajima, 1Waseda Univ., Japan; 2NTT Nanophotonics Center, Japan; 3NTT Device Technology Labs, Japan; 4NTT Basic Research Labs, Japan. We propose a new neurotransmitter sensor with a high-Q silicon ring resonator surrounding by surface activated mono-layer graphene. A minimum sensitivity of <10 μM is demonstrated in a sophisticated μ-fluidic biosensing system.

**ATu3O.3 • 14:15**

_Heteroclinic Dynamics in Photonic Cognitive Motif Network_, Shiva Shahin, 1Felipe Vallini, 2Faraz Monifi, 3Mikhail Rabinovich, 4Yeshiahu Fanman, 5Univ. of California, San Diego, USA; 6Univ. of California, San Diego, BioCircuits Inst., USA. We propose a photonic cognitive motif network. The oscillating nodes of such motifs are represented by the activity of semiconductor lasers and the performance of cognitive functions is determined by competitive interaction of lasers’ phases, intensity and carrier inversion rates.

**ATu3O.4 • 14:30**

_Prefrontal cortex hemodynamics and age in children: a pilot study using functional near infrared spectroscopy_, Afrouz Anderson, 1Elizabeth Smith, 2Amir H. Gandjbakhche, 3National Inst of Health, USA. We introduce a novel parameter, Oxygenation Variability Index, obtained from functional near infrared spectroscopy data. The pilot study in children reveal a dynamic relationship between age and OV index in frequencies associated with cerebral autoregulation.
Stu3P • Mode-locked Fiber Lasers II
President: J. Taylor; Imperial College London, UK

Stu3P1 • 13:30
Thulium-doped Fiber Laser Actively Mode Locked by Modulated Pumping. Yu Wang1,2, Sze Yen3. Set1; Shinji Yamashita4; 1The Univ. of Tokyo, Japan. We demonstrate a thulium-doped fiber laser actively mode locked by modulated pumping for the first time. Active CW mode locking is achieved with the pulse duration of 3ps and the spectral width of 0.9 nm.

Stu3P2 • 13:45
Intracavity Martinez compressor for simultaneous dispersion compensation and tunable spectral filtering, Kenneth J. Underwood1,2, Juliet Gopinath2; 1Univ. of Colorado at Boulder, USA. We demonstrate the utility of an intracavity Martinez compressor with a 7 fs normal dispersion mode-locked Yb fiber laser. The compressor provides spectral filtering and tunable dispersion compensation from normal to anomalous with simple components.

Stu3P3 • 14:00
Stable Linear Polarization Lock in an YDFL without Polarization Discriminating Elements. Vladislav Dvoyrin1, Ksenia A. Fedorova1, Edik U. Rafailov2, Sergei K. Turitsyn2; 1Aston Univ., UK. We demonstrate the generation of linearly-polarized 33-ps pulses in an Yb-doped fiber laser mode-locked without polarization-discriminating elements at 1070 nm with the pulse energy up to 58 nJ and peak power of 1.6 kW.

Stu3P4 • 14:15
Simplified all-polarization maintaining fiber laser mode-locked in the all-normal dispersion regime. Weijian Ni1, Bo Xu1,2, Amos Martinez1,2, Sze Yen3. Set1; Shinji Yamashita4; 1Research Center of Advanced Science and Technology, The Univ. of Tokyo, Japan; 2Aston Inst. of Photonic Technologies, Aston Univ., UK; 3Dept. of Engineering Science, Graduate School of Informatics, The Univ. of Electro-Communications, Japan. We report a simplified, all-normal dispersion, all-polarization maintaining (PM) fiber laser operating at 1030 nm and all-PM fiber pulse compressor capable of generating 70 fs pulses with 0.45 nJ pulse energy.

Stu3P5 • 14:30
Tunable SESAM mode-locked Tm fiber laser based on chromatic dispersion of lens, Tatsuka Mashiko1, Eiuke Fujita1, Masaki Tokurakawa1; 1Univ. of Electro-communications, ILS, Japan. We report tunable SESAM mode-locking of a Tm fiber laser facilitated by chromatic dispersion of a lens. A tuning range of 1890-1940 nm with the maximum average power of 196mW, spectral bandwidth of 18.9 nm, and the repetition rate of 20.5 MHz was obtained.

Stu3Q • Microresonator Combs I
President: Miro Erkintalo; Univ. of Auckland, New Zealand

Stu3Q1 • 13:30
The effect on Kerr comb generation in mode coupled WGM microcavity. Shun Fujii1, Yusuke Okabe2, Wataru Yoshiki1, Takumi Kato1, Akitsuki C. Jimai2; 1FEMTO-ST Inst., France. Whispaping gallery mode resonators allow to study various types light-matter interactions. We here discuss universal nonlinear scattering induced by the simultaneous excitation of Brillouin, Raman and Kerr nonlinearities.

Stu3Q2 • 13:45
Offset Frequency Tuning of a Microcomb with an Integrated Miroheater, Xiaoxiao Xue1, Yi Xuan1, Cong Wang1, Pei-Hun Wang1, Yang Liu1, Daniel E. Leard1, Minghao Qi2, Andrew M. Weiner1; 1Purdue Univ., USA. Carrier-envelope offset frequency tuning of a microcomb over 25 GHz is demonstrated based on the thermo-optic effect (362.07 ± 1.14 MHz°C). Thermal response time constants of 30.9 µs and 0.71 ms are observed.

Stu3Q3 • 14:00
WGM Resonators as Universal Nonlinear Scattering Platforms, Guoping Lin1, Souleymane Diallo1, Yanne K. Chembo1; 1FEMTO-ST Inst., France. Whispering gallery mode resonators are formed a numerical simulation of the Kerr comb generation impact of CW-CCW coupling in Kerr comb generation in a silica toroid microcavity experimentally. Moreover, we performed a numerical simulation of the Kerr comb generation in coupled different cavity.

Stu3R • UV and Visible Optoelectronics
President: Gregory Sun; Univ. of Massachusetts Boston, USA

Stu3R1 • 13:30
Red to green optical emission from AlGaAs/GaAs quantum structures. Fariba Hatami1, Shabnam Dadgostar2, Christian Gozl3, Ted Masselink1; 1Humboldt-Univ., Germany, AlGaAs/GaAs quantum structures show photo- and electroluminescence between 1.7 and 2.2 eV and up to room temperature. Using different growth conditions the morphology (QD, QW, Q-dash) and the corresponding light emission can be tuned.

Stu3R2 • 13:45
Enhancement of the Modulation Bandwidth for surface Plasmon coupled LEDs for Visible Light Communication, jehui lr1; Ahmed Faddil1, Haiyan Ou1, Nan Chi2; 1DTU, Denmark; 2Fudan Univ., China. The modulation bandwidth of surface plasmon coupled GaN-based LEDs is increased by ~1.2 times to 434.5 MHz compared with normal LED by applying Ag nanoparticles. These findings will help for the industrialization of VLC system.

Stu3R3 • 14:00
High-Reflectivity DUV Mirrors Prepared by Direct Sputtering, Hongjian Yang1,2, Dein Zhao1, Shih-Chia Liu1, Yonghao Liu1, Jung-Hun Seo1, Matt Hodek2, Zhenqiang Ma3, John Albrecth1, Baxter Moody3, Weidong Zhou1; 1Univ. of Texas at Arlington, USA; 2Electrical and Computer Engineering, Univ. of Wisconsin-Madison, USA; 3Electrical and Computer Engineering, Michigan State Univ., USA; 4Hexatech, Inc., USA. We report here high-reflectivity multilayer DBR mirrors for 200-240 nm spectral region. YSZ (yttria-stabilized zirconia), HOx and SiOx films were all prepared and optimized by direct RF magnetron sputtering, for YSZ/SiOx and HOx/SiOx DBRs.

Stu3R4 • 14:15
Growth of single-phase wurtzite BAlN with 7.2%-B contents, Xiaohong Li1,2, Shuo Wang1, Hui Xiao1, Fernando Ponce1, Theeradeth Detchpoom1, Russell Dupuis1; 1King Abdullah U of Science & Technology, Saudi Arabia; 2Georgia Inst. of Technology, USA; 3Arizona State Univ., USA. We report on growth of 100-nm single-phase wurtzite BAlN layers with B contents up to 7.2% by MOCVD, which can be potentially applied to deep UV DBRs for VCSELs.

Stu3R5 • 14:30
250 nm Deep UV LED Using GaN/AlN Heterostructures on Bulk AlN Substrates, SM M. Islam1, Vladimir Protasenko2, Debdeep Jena1, Grace Xing1; 1Cornell Univ., USA. A 250 nm deep UV LED is realized on the bulk AlN substrate. Leakage current is reduced significantly. Polarization doping is used for the p-region and GaN active region to enhance the light extraction.
**FTu3A • Orbital Angular Momentum—Continued**

**FTu3A.6 • 14:45**
Longitudinal patterning of twisted light beams, Ahmed Dorrah1, Michel Zambon-Redweski2, Ma Moghedi3; 1Electrical and Computer Engineering, Univ. of Toronto, Canada; 2Electrical Engineering, Univ. of Campinas, Brazil. Using new class of beams, known as Frozen Waves, we have generated beams carrying orbital angular momentum with a sense of rotation and phase twist that can be manipulated along the direction of propagation. This novel degree-of-freedom can lead to many advances in optical science and applications.

**FTu3A.7 • 15:00**
Spatial and Temporal Transformation of Propagating Few-cycle Pulses with Orbital Angular Momentum, Martin Bock1, Thomas Elsaesser1, Ruediger Grunwald1; Max Born Inst., Germany. Spatio-temporal transformations of propagating few-cycle pulses with orbital angular momentum were studied. Spectral behavior and temporal pulse structure were investigated theoretically and experimentally. Dispersion compensation by spatial redistribution of spectral components was demonstrated.

**FTu3A.8 • 15:15**
A Space-Time Transcoder, Shuai Shi1, Yinghao Zheng1; 1Univ Sci & Tech China, China. A transcoder for interfacing light with orbital angular momentum (OAM) and time-binning, by which light with an arbitrary OAM superposition is experimentally converted into a time-bin Gaussian pulse and in principle vice versa.

**FTu3B • Electroplasmonics and Optomechanics—Continued**

**FTu3B.6 • 14:45**
Strong Attractive Force Between Graphene Sheets at Terahertz Induced by Extraordinary Wavelength Reduction, Danlu Wang1, Ian Williamson1, Hossein Mousavi1, Zheng Wang1; 1The Univ. of Texas at Austin, USA. We numerically demonstrate optical force between graphene sheets can be enhanced by 50x at terahertz from the extraordinary wavelength reduction of quasi-TEM modes. Unlike step-index waveguides, the force is attractive irrespective of the waveguide dispersion.

**FTu3B.7 • 15:00**
Enhanced Dispersive and Dissipative Coupling Regimes in Graphene Optomechanics, Ian Williamson1, Hossein Mousavi1, Zheng Wang1; 1Univ. of Texas at Austin, USA. We numerically demonstrate that through its resistive and inductive (plasmonic) responses, graphene enables strong (~1 GHz/nm) optomechanical coupling in the THz/infrared spectrum. Distinct dispersive and dissipative coupling regimes emerge as functions of graphene’s intrinsic properties.

**FTu3B.8 • 15:15**
Controllable optomechanical coupling and Drude self-pulsation plasma locking in chip-scale optomechanical cavities, Yongjun Huang1,2, Jaime G. Flores2, Ziqiang Cai2, Mingbin Yu2, Dim-Lee Kwong3, Guangjun Wen1; 1Univ of Electronic Sci & Tech of China, China; 2Univ of Texas at Austin, USA. We numerically demonstrate that through its resistive and inductive (plasmonic) responses, graphene enables strong (~1 GHz/nm) optomechanical coupling in the THz/infrared spectrum. Distinct dispersive and dissipative coupling regimes emerge as functions of graphene’s intrinsic properties.

**FTu3C • Non-Classical State Engineering and Characterization—Continued**

**FTu3C.6 • 14:45**
Thermal Light as a Mixture of Sets of Coherent Pulses, Agata Branczyk1, Aurelia Chenu1, John E. Sipe2; 1Dept. of Chemistry, MIT, USA; 2Dept. of Physics, Univ. of Toronto, Canada. We numerically demonstrate optical force between graphene sheets can be enhanced by 50x at terahertz from the extraordinary wavelength reduction of quasi-TEM modes. Unlike step-index waveguides, the force is attractive irrespective of the waveguide dispersion.

**FTu3C.7 • 15:00**
Measuring non-commuting observables of a single photon, Ivo Degiovanni1, IANIM, Italy. In this presentation we will show how we performed, for the first time, a sequential weak value evaluation of two incompatible observables on a single photon.

**Coffee Break and Unopposed Exhibit Only Time, Exhibit Halls 1, 2 & 3**

**Market Focus Session II: AIM Photonics Update, Exhibit Hall Theater**
Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.

**CLEO: QELS-Fundamental Science**

**FTu3D • Quantum Emitters in Diamond—Continued**

**FTu3D.6 • 15:00**
Efficient Coupling of Single Nitrogen-Vacancy Center Photons to a GaP-on-Diamond Integrated Optics Platform, Michael Gould1, Ian R. Christen1, Srivatsa Chakravarthi1, Shabnam Dadgostar1, Fariba Hatami2, Kai-Mei Fu2; 1Electrical Engineering, Univ. of Washington, USA; 2Physics, Univ. of Washington, USA. We present high single-photon collection rates into a bus waveguide from a nitrogen-vacancy center coupled to an integrated disk resonator. The resonator is built on a gallium phosphide (GaP)-on-diamond chip alongside passive photonic devices.

**FTu3D.7 • 15:15**
Electron Spin Control of an Optically Levitated Nanodiamond in Vacuum, Jonghoo AHN1, ThaI M. Hoang1, JaeHoOn Bang1, TongCang Li2; 1Purdue Univ., USA. We optically levitated a nanodiamond in partial vacuum and demonstrated electron spin control of its built-in nitrogen-vacancy centers. We observed that the strength of electron spin resonance is enhanced when the air pressure is reduced.

**STu3E • Optomechanics I—Continued**

**STu3E.6 • 14:45**
Demonstration of Brillouin Scattering Self-Cancellation, Omar Flores1, Paulo F. Jarchel1, Yovanny A. Espinel1, Cristiano M. Cardoso1, Thago P. Alegre1, Gustavo Wiederhecker1, Paulo C. Dainese1; 1Universidade Estadual de Campinas, Brazil. We experimentally demonstrate the cancellation of Brillouin scattering by engineering a sub-wavelength diameter silica wire with exactly opposite photo-elastic and moving-boundary contributions.

**STu3E.7 • 15:00**
Evanescent Guiding of Acoustic Waves for Chip-scale Optomechanical Circuits, Yangyang Liu1, Nadhan Dostani1, Milos Papovic1; 1Univ. of Colorado at Boulder, USA. We investigate evanescent guiding of acoustic waves in solids without suspension by utilizing impedance contrast in silicon-based materials. This enables construction of waveguides, resonators and other building blocks to form complex optomechanical circuits.

**STu3F • Symposium on Nanophotonics with 2D Materials I—Continued**

**STu3F.5 • 15:00**
Control of excitons in multi-layer van der Waals hetero-structures, Eric V. Calman1; 1Univ. of California San Diego, USA. In a double quantum well van der Waals heterostructure made of atomically thin layers of 1MoS2 and hBN emission of neutral and charged excitons is controlled by gate voltage, temperature, and both the helicity and the power of optical excitation.

**STu3F.6 • 15:15**
Broadband enhancement of light-matter interaction in 2D semiconductors by photonic hypercrystals, Tal Galfsky1, Zheng Sun1, Ryan Considine1, Yi-Hsien Lee2, Evgenii E. Narimanov1, Wrood M. Menon2; 1Physics, City College of New York, USA; 2Material Sciences and Engineering, National Tsing-Hua Univ., Taiwan; 3School of Computer and Electrical Engineering, Birck Nanotechnology Center, Purdue Univ., USA. Hyperbolic-metamaterial based photonic-hypercrystal enhances photoluminescence from monolayer MoS2 and WSe2 by a factor of 60.

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**15:30–16:00 Coffee Break and Unopposed Exhibit Only Time, Exhibit Halls 1, 2 & 3**

**15:30–17:00 Market Focus Session II: AIM Photonics Update, Exhibit Hall Theater**

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Tuesday, 7 June

**Executive Ballroom 210G**

**STu3G • Integrated Photonics—Continued**

**STu3G.3 • 14:45**
A One-Dimensional Heterodyne Lens-Free OPA Camera, Reza Fatemi1, Behzoo Abi1, Ali Hajimiri1; California Inst. of Technology, USA. This paper presents a thin silicon-photonics integrated one-dimensional lens-free camera based on an optical phased array receiver on an SOI process. The camera has beam steering range in excess of 60° with no blind spots, a beam width of 0.74°, and is used to form images.

**STu3G.4 • 15:00**
Monolithically Integrated Two-Wavelength Distributed Bragg Reflector Laser for Terahertz Generation, Mengdie Sun1, Songtao Liu1, Fei Guo1, Dan Lu1, Ruikang Zhang1, Qiang Ken1, Chen Ji1; Inst. of Semiconductors, CAS, China. We demonstrate a monolithically integrated 1.55-μm two-wavelength distributed Bragg reflector (DBR) laser chip with integrated SOA for CW terahertz optical heterodyne signal generation. Continuous frequency tuning ranging from 0.06 THz – 0.71 THz was obtained.

**STu3G.5 • 15:15**
Experimental Investigation of Phase-Sensitive Amplification in Quantum-Dot Semiconductor Optical Amplifier, Guo-Wei Lu1, Tianwei Bo2, Takahide Sakamoto2, Kouich Akahane1, Benjamin J. Putnam1, Calvin C. Chan1, Naokatsu Yamamoto1; 1Natl. Inst. of Info. & and Comm. Tech., Japan; 2The Chinese Univ. of Hong Kong, Hong Kong. We experimentally investigate the phase-sensitive amplification characteristics in quantum-dot semiconductor optical amplifier. Phase-sensitive dynamic ranges (PSDRs) of ~3dB and ~11dB are obtained for degenerate and non-degenerate components, respectively, with 5-dBm total launch power.

**STu3H • Trace Gas and Isotope Detection—Continued**

**STu3H.3 • 14:45**
Optical radiocarbon detection (14C) using a quantum cascade laser, David Long1, Adam J. Flesher2, Qingnan Liu1, Joseph T. Hodges1; 1NIST, USA. We describe a cavity ring-down spectrometer which uses a quantum cascade laser for optical detection of radiocarbon in the mid-infrared spectral region. A description of the instrument, key components, and future improvements will be discussed.

**STu3H.4 • 15:00**
Gas sensing with Chirped Laser Dispersion Spectroscopy in a single-frequency beam configuration and a multi-pass cell, Piotr Jaworski1,2, Grzegorz Dudzik1,2, Karol Krzempek1,2, Adam Waz1, Michal P. Nikodem1,2; 1Wroclaw Research Centre EIT+, Poland; 2Wroclaw Univ. of Technology, Poland. Chirped Laser Dispersion Spectroscopy (CLaDS) in a single-frequency beam configuration with harmonic detection of molecular spectra is presented. Ambient methane detection with multi-pass cell and a CLaDS setup with compact I/Q demodulator are demonstrated.

**STu3H.5 • 15:15**
High-throughput broadband Fourier-transform CARS, Takuro Ideguchi1, Kazuki Hashimoto1, Megumi Takahashi1, Keisuke Goda1; 1The Univ. of Tokyo, Japan. We propose and demonstrate a technique for Fourier-transform CARS spectroscopy that performs broadband CARS measurements at a record high throughput of 24,000 spectra/s for diverse high-speed chemical analysis applications.

**STu3I • Ultrafast MIR Sources—Continued**

**STu3I.5 • 14:45**
44 μJ, 160 kHz, few-cycle mid-IR OPCPA with chirp reversal, Matthias Baudisch1, Hugo Pires1, Ugoa Elu1, Hideki Ishizuki2, Takunori Taira1, Jens Biegert1; 1ICFO - Institut de Ciencies Fotoniques, The Barcelona Inst. of Science and Technology, Spain; 2ICREA – Institut Catala de Recerca i Estudis Avancats, Spain; 3Laser Research Center for Molecular Science, Inst. for Molecular Science, Japan. Implementing chirp reversal, we report a high-power, mid-IR OPCPA producing 82 fs (sub-8 cycle) pulses with 44 μJ pulse energy at 160 kHz repetition rate and excellent beam quality (M²<1.4).

**STu3I.6 • 15:00**
450 mW Femtosecond Mid-IR Source at 8.5 μm Wavelength, Marcus Seidel1, Gunnar Arisholm2, Oleg Pronin1, Ferenc Krausz1; 1Max-Planck-Inst. of Quantum Optics, Germany; 2FFI (Norwegian Defence Research Establishment), Norway; 3Ludwig-Maximilians-Univ. Munich, Germany. 450-mW of average power at 8.5-μm central wavelength are generated through optical parametric amplification in LiGaS2. The crystal is pumped by a mode-locked thin-disk oscillator and seeded by the output of a photonic crystal fiber.

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15:30–16:00 Coffee Break and Unopposed Exhibit Only Time, Exhibit Halls 1, 2 & 3

15:30–17:00 Market Focus Session II: AIM Photonics Update, Exhibit Hall Theater
Polarized Light, Integrated Circuits Using Linearly, Circularly and Radially

Two-Photon Laser-Assisted Device Alteration in CMOS

ATu3J.8 • 15:15

We have achieved collective ultrastrong light-matter coupling with long coherence times in an ultrahigh-mobility two-dimensional electron gas in a high-Q terahertz photonic-crystal cavity in a quantizing magnetic field.

AV3K.7 • 15:15

We report on the research progress of photodarkening-resistant Yb-doped aluminoephosphosilicate fiber fabricated by chelate precursor doping technique. 2.02 kW and 3.1 kW laser output at 1064 nm was achieved in 20/400 and 30/400 Yb-doped aluminoephosphosilicate fiber, respectively.

ATu3K.6 • 15:00

KW-level Yb-doped Aluminoephosphosilicate Fiber by Chelate Precursor Doping Technique, Ying Y. Wang1, Huan Zhan1, Cong Gao1, Kun Peng1, Zaohui Jia1, Chen Wang1, Li Ni1, Xiaolong Wang1, Jianjun Wang1, Feng Jing1, Aoxiang Lin1, Jianjun Wang1, Zhaonian Jia1, Aoxiang Lin1, Cong Gao1, Li Ni1, Kun Kamaraju1, John Watson2, Michael Manfra3, Junichiro Kono4; 1Electrical and Computer Engineering, Rice Univ., USA; 2Physics and Astronomy, Purdue Univ., USA; 3Sandia National Labs, USA; 4Physics and Astronomy, Rice Univ., USA. We have achieved collective ultrastrong light-matter coupling with long coherence times in an ultrahigh-mobility two-dimensional electron gas in a high-Q terahertz photonic-crystal cavity in a quantizing magnetic field.

ATu3K.5 • 14:45

Ultrafast laser plasma assisted rare-earth doping for silicon photonics, Jayakrishnan Chandrappan1, Gin Jose1, Matthew Murray1, Paul Steenson1, Thomas F. Krauss1, Zolnai Zsolt1, Peter Petrok1, Agocs Emili1, Suraya A. Kamil1; 1Univ. of Leeds, UK; 2Univ. of York, UK; ‘centre for energy research, Inst. of technical physics and Materials science, Hungary. A novel technique for rare-earth doping in silica is developed with femtosecond laser plasma processing and record high concentration of erbium in silica/ silica-on-silicon platforms to realize compact optical amplifiers for silicon photonics are achieved.

ATu3K.4 • 14:30

A novel technique for terahertz cavity photons, Qi Zhang1, Minhan Lou1, Xinwei Li1, John L. Reno1, Wei Pan1, John Watson2, Michael Manfra3, Junichiro Kono4; 1Electrical and Computer Engineering, Rice Univ., USA; 2Physics and Astronomy, Purdue Univ., USA; 3Sandia National Labs, USA; 4Physics and Astronomy, Rice Univ., USA. We have achieved collective ultrastrong light-matter coupling with long coherence times in an ultrahigh-mobility two-dimensional electron gas in a high-Q terahertz photonic-crystal cavity in a quantizing magnetic field.

ATu3K.3 • 14:15

Chelate Precursor Doping Technique, Min Li1, Wei Pan1, John L. Reno1, Wei Pan1, Junichiro Kono4; 1China Academy of Engineering Physics, USA. We report on the research progress of photodarkening-resistant Yb-doped aluminoephosphosilicate fiber fabricated by chelate precursor doping technique. 2.02 kW and 3.1 kW laser output at 1064nm was achieved in 20/400 and 30/400 Yb-doped aluminoephosphosilicate fiber, respectively.

ATu3K.2 • 14:00

A novel technique for laser plasma assisted rare-earth doping for silicon photonics, Jayakrishnan Chandrappan1, Gin Jose1, Matthew Murray1, Paul Steenson1, Thomas F. Krauss1, Zolnai Zsolt1, Peter Petrok1, Agocs Emili1, Suraya A. Kamil1; 1Univ. of Leeds, UK; 2Univ. of York, UK; ‘centre for energy research, Inst. of technical physics and Materials science, Hungary. A novel technique for rare-earth doping in silica is developed with femtosecond laser plasma processing and record high concentration of erbium in silica/ silica-on-silicon platforms to realize compact optical amplifiers for silicon photonics are achieved.

ATu3K.1 • 13:45

Ultrafast laser plasma assisted rare-earth doping for silicon photonics, Jayakrishnan Chandrappan1, Gin Jose1, Matthew Murray1, Paul Steenson1, Thomas F. Krauss1, Zolnai Zsolt1, Peter Petrok1, Agocs Emili1, Suraya A. Kamil1; 1Univ. of Leeds, UK; 2Univ. of York, UK; ‘centre for energy research, Inst. of technical physics and Materials science, Hungary. A novel technique for rare-earth doping in silica is developed with femtosecond laser plasma processing and record high concentration of erbium in silica/ silica-on-silicon platforms to realize compact optical amplifiers for silicon photonics are achieved.

ATu3J.7 • 15:00

Super-resolution Mid-infrared Imaging using Photothermal Microscopy, Zhongming Li1, Masaru Kuno1, Gregory Hartland2; 1Univ. of Notre-Dame, USA. Mid-infrared photothermal heterodyne imaging (MIR-PHI) overcomes the diffraction limit of traditional MIR imaging and uses visible photodiodes as detectors. Here we present our MIR-PHI technology with high sensitivity (S/N >100), super-diffraction limit spatial resolution and high acquisition speed.

ATu3J.6 • 14:45

Advanced Microwave Photonic Structure for Low Coherence Interferometry, Mario Bolea1, Jesús B. González2, Ken Marshall3, Carl Farrell1, Dan Bodoh1, Trevor AN. Price1, Antoinette Taylor2, John L. Reno1, Wei Pan1, John Watson2, Michael Manfra3, Junichiro Kono4; 1Univ. of Leeds, UK; 2Univ. of York, UK; 3centre for energy research, Inst. of technical physics and Materials science, Hungary. A novel technique for rare-earth doping in silica is developed with femtosecond laser plasma processing and record high concentration of erbium in silica/ silica-on-silicon platforms to realize compact optical amplifiers for silicon photonics are achieved.

ATu3J.5 • 14:30

Advanced Microwave Photonic Structure for Low Coherence Interferometry, Mario Bolea1, Jesús B. González2, Ken Marshall3, Carl Farrell1, Dan Bodoh1, Trevor AN. Price1, Antoinette Taylor2, John L. Reno1, Wei Pan1, John Watson2, Michael Manfra3, Junichiro Kono4; 1Univ. of Leeds, UK; 2Univ. of York, UK; 3centre for energy research, Inst. of technical physics and Materials science, Hungary. A novel technique for rare-earth doping in silica is developed with femtosecond laser plasma processing and record high concentration of erbium in silica/ silica-on-silicon platforms to realize compact optical amplifiers for silicon photonics are achieved.

ATu3J.4 • 14:15

Advanced Microwave Photonic Structure for Low Coherence Interferometry, Mario Bolea1, Jesús B. González2, Ken Marshall3, Carl Farrell1, Dan Bodoh1, Trevor AN. Price1, Antoinette Taylor2, John L. Reno1, Wei Pan1, John Watson2, Michael Manfra3, Junichiro Kono4; 1Univ. of Leeds, UK; 2Univ. of York, UK; 3centre for energy research, Inst. of technical physics and Materials science, Hungary. A novel technique for rare-earth doping in silica is developed with femtosecond laser plasma processing and record high concentration of erbium in silica/ silica-on-silicon platforms to realize compact optical amplifiers for silicon photonics are achieved.

ATu3J.3 • 13:50

Advanced Microwave Photonic Structure for Low Coherence Interferometry, Mario Bolea1, Jesús B. González2, Ken Marshall3, Carl Farrell1, Dan Bodoh1, Trevor AN. Price1, Antoinette Taylor2, John L. Reno1, Wei Pan1, John Watson2, Michael Manfra3, Junichiro Kono4; 1Univ. of Leeds, UK; 2Univ. of York, UK; 3centre for energy research, Inst. of technical physics and Materials science, Hungary. A novel technique for rare-earth doping in silica is developed with femtosecond laser plasma processing and record high concentration of erbium in silica/ silica-on-silicon platforms to realize compact optical amplifiers for silicon photonics are achieved.

ATu3J.2 • 13:35

Advanced Microwave Photonic Structure for Low Coherence Interferometry, Mario Bolea1, Jesús B. González2, Ken Marshall3, Carl Farrell1, Dan Bodoh1, Trevor AN. Price1, Antoinette Taylor2, John L. Reno1, Wei Pan1, John Watson2, Michael Manfra3, Junichiro Kono4; 1Univ. of Leeds, UK; 2Univ. of York, UK; 3centre for energy research, Inst. of technical physics and Materials science, Hungary. A novel technique for rare-earth doping in silica is developed with femtosecond laser plasma processing and record high concentration of erbium in silica/ silica-on-silicon platforms to realize compact optical amplifiers for silicon photonics are achieved.

ATu3J.1 • 13:20

Advanced Microwave Photonic Structure for Low Coherence Interferometry, Mario Bolea1, Jesús B. González2, Ken Marshall3, Carl Farrell1, Dan Bodoh1, Trevor AN. Price1, Antoinette Taylor2, John L. Reno1, Wei Pan1, John Watson2, Michael Manfra3, Junichiro Kono4; 1Univ. of Leeds, UK; 2Univ. of York, UK; 3centre for energy research, Inst. of technical physics and Materials science, Hungary. A novel technique for rare-earth doping in silica is developed with femtosecond laser plasma processing and record high concentration of erbium in silica/ silica-on-silicon platforms to realize compact optical amplifiers for silicon photonics are achieved.

ATu3J • Imaging and Inspection—Continued

15:30-16:00 Coffee Break and Unopposed Exhibit Only Time, Exhibit Halls 1, 2 & 3

15:30-17:00 Market Focus Session II: AIM Photonics Update, Exhibit Hall Theater
**STu3M • High Energy and High Average Power Laser Systems—Continued**

**STu3M.4 • 14:45**

Thin Disk Pumped 1 kHz Broadband OPCPA System with 8 mJ Output, Frantisek Batysta, Jakub Novák, Roman Anti-penkov, Jonathan Green, Jakub Horáček, Tomáš Mazaneč, Bedrich Himmel, Martin Horáček, Zbyňek Huška, Robert Boge, Jack A. Naylon, Pavel Bakule, Bedrich Rus, Inst. of Physics ASCR, EU beamlines, Czech Republic; Nuclear Sciences and Physical Engineering, Czech Technical Univ., Czech Republic; Technical Univ. of Liberec, Czech Republic. We present a multistage 1 kHz OPCPA system, pumped by two frequency doubled thin disk regenerative amplifiers, which together deliver 57 mJ at 515 nm. The OPCPA produces 8 mJ output, thin disk pumped 1 kHz broadband OPCPA system with 8 mJ output.

**STu3M.5 • 15:00**

250 W Average Power from Cryogenically Cooled Yb:YAG Amplifier Operating at 100 kHz, Fabian Reichert, Michael Hemmer, Luis E. Zapata, Frana X. Kaertner, Physics Dept., Univ. of Hamburg, Germany; CERN, DESY, Germany. We present a compact and robust cryogenically cooled Yb:YAG chipped pulse amplifier with 250 W of average power at a repetition rate of 100 kHz with a near-diffraction limited beam quality.

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**FTu3N • Ultrafast Dynamics in Molecules and Solids—Continued**

**FTu3N.5 • 14:45**

Intense Laser Solid State Physics - Unraveling Ionization in Dielectrics, Chris R. McDonald, Giulio Vampa, Paul B. Corkum, Thomas Brabec, Univ. of Ottawa, Canada; National Research Council of Canada, Canada. Experiments on intense laser driven dielectrics has revealed conduction band population dynamics to be oscillatory in nature. Our analysis indicates that these population dynamics are dominantly driven by linear polarization and that ionization is substantially influenced by ground state depletion.

**FTu3N.6 • 15:00**

Petahertz Frequency Operation with Gallium Nitride Semiconductor, Hiroki Mashiko, Katsuya Oguri, Tomohiko Yamaguchi, Akira Suda, Hideki Gotoh, NTT Basic Research Labs, Japan; Physica, Tokyo Univ. of Science, Japan. We demonstrate optical drive with 1.16-PHz frequency using gallium nitride (GaN) wide-bandgap semiconductor. An isolated attosecond pulse with coherent broadband spectrum reveals dipole oscillation with 860-as periodicity in the GaN electron and hole system.

**FTu3N.7 • 15:15**

EUV continuum from compressed multiple thin plate supercontinuum, Pei-Chi Huang, Chih-Hsuan Lu, Bo-Han Chen, Shang-Da Yang, Ming-Chang Chen, Andrew H. Kung, National Tsing Hua Univ., Taiwan; Academia Sinica, Inst. of Atomic and Molecular Sciences, Taiwan. A one-cycle (3.3 fs) pulse compressed from multiple thin plates generated supercontinuum has been demonstrated and used to produce a bright EUV continuum with 5 x 10**4 up-conversion efficiency ranging from 43 to 65 eV.

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**ATu3O • A&T Topical Review on Neurophotonics I—Continued**

**ATu3O.5 • 14:45**

Large-scale Brain Imaging using Optical Coherence Tomography, Woonggyu Jung, Ulsan National Institute of Science and Technology (UNIST), Korea. Optical coherence tomography (OCT) is a high-speed, label-free, and deep tissue imaging method which has a potential technique to build volumetric anatomy of mouse brains. Despite its inherent advantages, limited efforts have been applied in using OCT for large-scale imaging in neuroscience research. This presentation covers the latest work of volumetric mouse brain imaging using OCT. Specifically, the talk will highlight the correlation study to conventional brain imaging techniques as well as tissue clearing.
STu3P • Mode-locked Fiber Lasers II—Continued

**STu3P • 14:45**

**STu3P • 15:00**
Dispersion compensation using chirped long period gratings, Tao He, Lars Rishøj, Jeffrey Demas, Siddharth Ramachandran, Boston Univ., USA; School of Optoelectronics, Beijing Inst. of Technology, China. We demonstrate, for the first time, the use of a broadband (13.8nm) chirped long period fiber grating as an ultra-low loss (<0.1dB) transmissive dispersion device, of potential utility in ultrashort pulse fiber laser cavity design.

**STu3P • 15:15**
All-Fiber Mode-Locked Soliton Er-Lasers Employing Planar Lightwave Circuit (PLC) Devices, Chur Kim, Dohyun Kim, Jieun Bae, Sun Young Choi, Hwanseong Jeong, Sang Jun Cha, Ki Sun Choi, Jeong-Woo Lee, Dong-Il Yeom, Chur Kim, 1; Chul Sung Hwang, 2; Dong-Yung Lee, 3; Dong-Il Yeom, 4; Fabian Rotermund, Jungwon Kim; School of Mechanical and Aerospace Engineering, Korea Advanced Inst of Science & Tech, Korea; 2Dept. of Energy Systems Research & Dept. of Physics, Korea Advanced Inst of Science & Tech, Korea; 3FiberPro Inc., Korea; 4FiberPro Inc., Korea; 5FM Solution Inc., Korea. We fabricate saturable absorbers and WDM/tap hybrid couplers using standard planar lightwave circuit (PLC) fabrication processes. The fabricated PLC devices are applied to mode-locked all-fiber lasers, which show long-term stable and self-starting operation.

**STu3Q • 15:00**
Low-Loss Air-Clad Suspended Silicon Platform for Mid-Infrared Photonics, Steven Miller, Austin Griffith, Mengjie Yu, Alexander L. Gaeta, Michal Lipson, Electrical and Computer Engineering, Cornell Univ., USA; Electrical Engineering, Columbia Univ., USA; Applied Physics and Applied Mathematics, Columbia Univ., USA. We demonstrate a low-loss fully-air-clad suspended silicon platform for mid-infrared photonics. We fabricate a suspended microring resonator with a high quality factor of 83,000 at 3.79 μm wavelength and suspended nanotapers using etchless waveguide processing.

**STu3Q • 15:15**
Kerr comb generation with suppressed cavity-optomechanical oscillation in toroidal microcavity, Ryo Suzuki, Takumi Kato, Akitoshi C. Jinnai, Takuma Nagan, Tomoya Kobatake, Takasumi Tanabe, Keo Univ., Japan. Toroidal microcavities tend to excite cavity optomechanical vibration, which makes Kerr comb generation complicated. We demonstrated experimentally that transform limited pulses are obtained without optomechanical noise by controlling the pump frequency.

**STu3R • 14:45**
Demonstration of a Soliton Frequency Comb in a High-Q Silica Microresonator, Xu Yi, Qi-Fan Yang, Ki Youl Yang, Myoung-Gyun Suh, Karry Vahala, California Inst. of Technology, USA. Temporal cavity solitons with a detectable repetition rate are generated in a high-Q silica microresonator. A technique for long-term stabilization of the soliton train is demonstrated and used to measure soliton properties for comparison with theory.

**STu3R • 15:00**
Investigations of Thin p-GaN Light-Emitting Diodes with Surface Plasmon Compatible Metallization, Ahmed Fadl, jehui l., Yusu Ou, Da suke Iida, Oleksii Kopylov, Ha yan Ou, DTU Fotonik, Denmark; Dept. of Applied Physics, Tokyo Univ. of Science, Japan; Fudan Univ., China. We investigate device performance of InGaN light-emitting diodes with a 30-nm p-GaN layer. The metallization used to separate the p-contact from plasmonic metals, reveals limitations on current spreading which reduces surface plasmonic enhancement.

**STu3R • 15:15**
Kerr comb generation using long period fiber gratings, Tao He, Lars Rishøj, Jeffrey Demas, Siddharth Ramachandran, Boston Univ., USA; School of Optoelectronics, Beijing Inst. of Technology, China. We demonstrate, for the first time, the use of a broadband (13.8nm) chirped long period fiber grating as an ultra-low loss (<0.1dB) transmissive dispersion device, of potential utility in ultrashort pulse fiber laser cavity design.

**Coffee Break and Unopposed Exhibit Only Time, Exhibit Halls 1, 2 & 3**

**Market Focus Session II: AIM Photonics Update, Exhibit Hall Theater**

**15:30–16:00**
Coffee Break and Unopposed Exhibit Only Time, Exhibit Halls 1, 2 & 3

**15:30–17:00**
Market Focus Session II: AIM Photonics Update, Exhibit Hall Theater
An On-chip Multi-Wavelength Photonic-Phononic Memory, Moritz Merklen1, Birgit Stiller1, Khu Vu2, Stephen Madden2, Benjamin Eggleton1; ‘Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS), The Univ. of Sydney, Australia; ‘Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS), Australian National Univ., Australia. We demonstrate the first integrated multi-wavelength photonic-phononic memory. The memory is based on stimulated Brillouin scattering and enables the storage of light pulses as acoustic phonons up to the acoustic lifetime.

Indirect Excitons in a Potential Energy Landscape Created by a Perforated Electrode, Chelsey Dorow, Yuliya Kuznetsova1, Jason Leonard1, Michael Chu2, Leonid Butov2, Joe Wilkes1, Micah Hanson1, Arthur Gossard1; ‘Univ. of California San Diego, USA; ‘Cardiff Univ., UK; ‘Univ. of California Santa Barbara, USA. We report on the principle and realization of the perforated electrode method to control exciton energy and fluxes.

Modulation technique for improving temporal resolution in biphonon coincidence measurements, Ogega D. Odete1, Joseph M. Lukens1, Daniel E. Leaird2, Andrew M. Weiner1; ‘Purdue Univ., USA. We propose and demonstrate a new method for temporal characterization of entangled photons based on electro-optic modulation and time shifting. Our technique reduces the resolution limits induced by the large timing jitters in single-photon detectors.
Coupling of exciton-polaritons in low-Q coupled micro-
FTu4D.3 • 16:30
Quantum Emission from Hexagonal Boron Nitride Monolay-
era, Toan T. Tran1, Kerem Bray1, Michael J. Ford1, Milos Toth1, Igor Aharonovich1; 1School of Mathematical and Physical Sci-
ences, Univ. of Technology, Sydney, Australia. We demonstrate
first room temperature, and ultrabright single photon emission
from a color center in two-dimensional multilayer hexagonal
boron nitride. Density Functional Theory calculations indicate
that vacancy-related centers are a likely source of the emission.

FTu4D.2 • 16:15
Quantum Emission from III-Nitride Quantum Dots,
Lei Zhang1, Chu-Hsiang Huang1, P.C. Ku1, Hui Deng1; 1Univ. of Michigan, USA. We
demonstrate quantized charging in site-controlled III-nitride
quantum dot, allowing single-spin physics and research in III-
nitrides. We also fulfill two critical requirements for practical
demonstration quantized charging in site-controlled III-Nitride Quantum Dots,

STu4E.2 • 16:30
Material limited high-Q mechanical paddle-resonator,
Gustavo de Oliveira Luiz1, Felipe G. Santos1, Rodrigo da Silva
Benevides1, Yovanny Espinel1, Thiago A. Alegre1, Gustavo
Wiedenheuter1, 1Unicamp, Brazil. We used destructive interfer-
ence of elastic waves to obtain material limited high quality
factor micro mechanical devices probed with an optical cavity.
Mechanical quality factors as high as 28×10^6 were measured.

FTu4D.3 • 16:30
Coupling of exciton-polaritons in low-Q coupled micro-
cavities beyond the rotating wave approximation, Bin Liu1,
Prabin Rai1, John Grezma1, Robert Twieg1, Kenneth Singer1;
1physics, Case Western Reserve Univ., USA; 2Chemistry, Kent
State Univ., USA. We demonstrate coupling between two
ultrastrong exciton-photon coupled low-Q organic microcavi-
ties at room temperature. We propose a modified oscillator model to explain the broken degeneracy of Rabi
splittings in the ultrastong coupling regime.

FTu4D.4 • 16:45
Photonic Simulation of Entanglement Generation and
Transfer in a Spin Chain, Ioannis Pitos1,2, Leonardo Banchi1,
Seyed Adil Rabi1, Andrea Crespi1, Marco Bentivegna1, Debora
Caprara1, Nicolo Spagnolo1, Paolo Matello1, Sougato Bose1,
Roberto Osellame1,2, Fabio Sciarrino1,2; 1Physics, Sapienza
Univ., Italy; 2Istituto di Fotonica e Nanotecnologie, Consiglio
Nazionale delle Ricerche, Italy; 3Photonics Lab, ETH Zurich, Switzerland. We report on photonic quantum simulation of a 5-site spin chain
dynamics in femtosecond-written circuits, with engineered
couplings for perfect quantum transport, confirming the
expected creation of entanglement at half transport time.

FTu4D.5 • 17:00
Observation of Bloch oscillations with a threshold,
Simon Stutzer1, Alexander Solntsev1, Stefan Nolte1, Andrey A.
Sukhorukov1, Alexander Szameit1; 1Inst. of Applied Physics,
Friedrich-Schiller-Univ., Germany; 2Nonlinear Physics Centre,
Research School of Physics and Engineering, Australian National Univ., Australia. We predict and demonstrate ex-
perimentally a metal-insulator phase transition from extended
wave transport to localized Bloch oscillations at a critical ef-
fective potential strength in photonic lattices, which realize
optical emulator of quantum photon squeezing.
We present a novel technique that advantageously combines both Stokes and anti-Stokes reflections from counter-propagating BDGs in optical fibers, allowing distributed phase-shift measurement with high spatial resolution and immune to variations in fiber birefringence.


Highly sensitive and stable all-fiber photothermal spectroscopic gas sensor, Yuechuan LIN1,2, Wei Jin1,2, Fan Yang1,2, Chao Wang1,2. 1Dept. of Electrical Engineering and Photonic Research Center, The Hong Kong Polytechnic Univ., Hong Kong; 2Photonic Sensors Research Center, The Hong Kong Polytechnic Univ. Shenzhen Research Inst., China. We demonstrated a highly sensitive and stable all-fiber photothermal spectroscopic gas sensor with hollow-core photonic bandgap fibers and achieved noise equivalent concentration of 356 p.p.b. and long term stability of 0.87 dB over 6 hours.

Grating enhanced back scatter fiber for distributed sensing, Paul . Westbrook1,2, Tristan Kremp1, Kenneth S. Feder1, Thierry F. Taunay1,2, Eric M. Monberg1, Karsten Riekkola1, Yuechuan LIN1,2, Takashi Kurokawa1,2; 1Tokyo Univ of Agriculture and Technology, Japan; 2Department of Electro-Optical Engineering, Waseda University, Japan. We demonstrated a substantial improvement in the sensitivity of grating enhanced fiber sensors by employing a new design where the phase shift in the grating is defined by the refractive index change in the waveguide, allowing the measurement of distance and temperature on a multipoint sensor.

High-bandwidth Link with Single Laser Input Using Silicon Modulators and Mode Multiplexing, Brian Stern1,2, Michal Lipson2, Cornell Univ., USA, Columbia Univ., USA. We demonstrate mode multiplexing to expand the bandwidth of silicon microring modulators. We show 37.5 Gb/s bandwidth while using a single laser coupled to a single waveguide, relieving the power and cost constraints associated with integrating multiple lasers for WDM.

Ultra-compact strain- and temperature-insensitive torsion sensor based on a line-by-line inscribed phase-shifted FBG, Kuewen Shu1,2, Huazhong Univ of Science and Technology, China. A novel torsion sensor based on a phase-shifted fiber Bragg grating inscribed by the line-by-line technique in a standard single-mode fiber with a femtosecond laser is demonstrated. It is the smallest torsion sensor ever reported.

Temporal Characterization of Front-End for Yb-Based High-Energy Optical Waveform Synthesizers, Huseyn Cankaya1,2, Anne-Laure Calendron1,2, Giovanni Cirmi1,2, Chun Zhou1, Oliver D. Muecke1,2, Franz X. Kaertner1,2, DESY, CFEL, Germany; 1The Hamburg Centre for Ultrafast Imaging and Department of Physics, Univ. of Hamburg, Germany; 2Dept. of Electrical Engineering and Computer Science and Research Lab of Electronics, MIT, USA. We demonstrate temporal characterization of the front-end for an Yb-based, passively CEP-stable, two-octave-wide, two-channel optical parametric synthesizer driven by slightly preprocessed pump pulses from a multi-mJ regenerative amplifier at 1 kHz.
Atu4J.1 • 16:00
Photonic Mixing Approach to Measure the Angle-of-Arrival of Microwave Signals, Zuxing Zhang, Minghua Chen, Qiang Guo, Hongwei Chen, Sigan Yang, Shuhong Xie1, Tsinghua Univ., China. We propose a novel photonic approach to gauge the angle-of-arrival (AOA) and time-difference-of-arrival (TDOA) of microwave signals. The phase shift of a microwave signal at 6GHz from 65° to 120° is measured with a maximum measurement standard error of 0.25°.

Atu4J.2 • 16:15
Nonlocal Fractional-Order Diffusion for Denoising in Speckle Interferometry Fringes, Jin-Ze-Wang1, Ye-Fan Cai1, Yang-Xu1, Sun-Yi Sen Univ., China. We propose a novel denoising method for speckle interferometry fringes using nonlocal-means algorithm and fractional-order derivative, our method realizes nonlocal smoothing while preserving the edges of fringes.

Atu4J.3 • 16:30
Non-Destructive Inspection using Phase-Shifting Resonant Vibrometry, Chen Chia Wang1, Sudhir Trivedi1, Feng Jin1, V.Swaminathan1, Frank Walters2, Jacob Khurgin2, Fow-Sen Choa1, Brinnope Corporation of America, USA; 2US Army ArDEC, USA; 1Hopkins Hopkins Univ., USA; 1JMBBC, USA. We present experimental demonstration utilizing phase-shifting resonant vibrometry to determine the presence and position of embedded defect inside a device under test (DUT) whose awkward surface shape prohibits the use of conventional ultrasonic transducers.

Atu4J.4 • 16:45
Multiple Beam Ptychography for High Throughput Data Acquisition, Robert M. Karl1, Charles Bevis1, Johnathan Reichanadter3, Dennis F. Gardner1, Christina Porter1, Elisabeth Shanblatt1, Michael Tankovska1, Giulia Manconi1, Magaret Mumane1,1,2,3, Hongwei Chen1, Yanni Kaptyn1,5, Daniel Adams1,1,2,3, JILA, Univ. of Colorado at Boulder, USA. We extend ptychography CDI to allow for imaging of multiple areas on a sample simultaneously using multiple identical beams. This enables high throughput imaging of large samples without increased data collection or loss in resolution.

Atu4K.1 • 16:00
Influence of Femtosecond Laser Parameters on Metal Ablation Volume, Vahan Malkhazyan1, Mohamed Assouli2, Monique Montelli1,1, Applied Mechanics Dept.,1, FEMTO-ST, Univ. of Bourgogne Franche-Comté/ENSMM, France. Femtosecond laser ablation of stainless steel was studied. Two ablation regimes were identified. Analytical model of metal ablation volume calculation is proposed and confronted to experimental results. For desired microtexturing, the fluence and number of pulses are essential.

Atu4K.2 • 16:30
Time-resolved Microscopy for Optimizing In-volume Glass Processing using Ultra Short Laser Pulses, Klaus Bergner1, Brian Seyfarth2, Malte Kumkula1, Andreas Tünnermann3,1, Stefan Nolte1,2, JTRUMPF Laser- und Systemtechnik GmbH, Germany; 1Inst. of Applied Physics, Friedrich-Schiller-Universität Jena, Germany; 2Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany. The plasma ignition and densification inside a transparent material crucially depends on the pulse duration. Time resolved in-situ microscopy is used to gain insight for tailoring the induced material modifications.

Atu4K.3 • 16:45
Influence of Femtosecond Laser Parameters on Metal Ablation Volume, Vahan Malkhazyan1, Mohamed Assouli2, Monique Montelli1,1, Applied Mechanics Dept.,1, FEMTO-ST, Univ. of Bourgogne Franche-Comté/ENSMM, France. Femtosecond laser ablation of stainless steel was studied. Two ablation regimes were identified. Analytical model of metal ablation volume calculation is proposed and confronted to experimental results. For desired microtexturing, the fluence and number of pulses are essential.

Atu4K.4 • 17:00
Direct writing of inverted domain patterns in lithium nio-bate waveguides using femtosecond infrared pulses, Xin Chen1, Pavel Karpinski2, Madlen Shvedov2, Cyril Hnatovsky2, Andreas Boes3, Arnan Mitchell2,1, University of Texas, Austin, USA; 2Argonne National Lab, USA; 3School of Physics, Georgia Inst. of Technology, USA. Direct writing of inverted domain patterns in lithium niobate waveguides using femtosecond near-infrared laser beam. Quasi-phase matched frequency doubling of 815nm light is demonstrated with conversion efficiency as high as 17.45%.
In-band-pumped mode-locked Ho:YAG ceramic laser at 2.1 μm, Yicheng Wang1, Nikita Smakov1, Alexander Hemmings2, John Haub2, Peter J. Veitch3, Jesper Munch4, Univ. of Adelaide, Australia; 2Laser Technologies Group, Cyber and Electronic Warfare Division, Defence Science and Technology Group, Australia. We present the first high-resolution cryogenic absorption measurements of Ho:YAG. The results reveal previously unresolved structure in the absorption spectra. These measurements provide important data for the design of efficient resonantly pumped, cryogenically cooled Ho:YAG lasers.

FTu4N.2 • 16:30
Correlation-Induced Photoemission Delay in Helium, Marcus Ossianer1,2, Florian Siegert1,2, Vage Shivarivjan1,2, Renate Pazourek1,2, Annkatrin Sommers1, Tobias Latka1,2, Alexander Guggenmos1,2, Ulf Kleinberg1,2, Ferenc Krausz1,2, Reinhard Kienberger1,2, Martin Schulte1,2, Max-Planck-Institut für Quantenoptik, Germany; 3Physik-Dept., Technische Universität München, Germany; 4Inst. for Theoretical Physics, Vienna Univ. of Technology, Austria; 5Fakultät fuer Physik, Ludwig-Maximilians-Universitat München, Germany. We determined the photoemission timing of electrons escaping during shake-down and shake-up processes in helium with sub-attosecond standard error. Excellent agreement with ab-initio calculations allows benchmarking of theoretical models and identifies contributions of electronic correlation.

FTu4N.4 • 16:45
Tomographic Reconstruction of Circularly Polarized High Harmonic Fields, Zhengsheng Tao1, Dong Chen1, Carlos Hernández-García1, Pooyan Mazyba2, Adra Car1, Ronny Knut1, Ofer Kfir1, Dimitri Su2, Christian Gentry3, Patrick Grychtol1, Oren Cohen1, Luis Plaza1, Andreas Becker1, Agnieszka Jaron-Bekker1, Henk Kaptay3, Magaret Murnane1, JILA, Univ. of Colorado, Boulder, USA; 2Grupo de Investigación en Óptica Extrema, Universidad de Salamanca, Spain; 3Solid State Inst. and Physics Dept., Technion, Israel. Using laser-dressed photoelectron spectroscopy from solids, we completely characterized the circularly polarized harmonics and reconstructed the complex 3D waveform of the circularly polarized attosecond pulse train.

FTu4O.2 • 16:30
Three-Photon Fluorescence Adaptive Optics for In Vivo Mouse Brain Imaging, David Sinfeild1, Tianyu Wang1, Meng-Grant Wang1, Hari P. Faudel1, Thomas G. Briano2, Chris Xu3, 1Cornell Univ., USA; 2Photonics Center, Boston Univ., USA. We demonstrate for the first time three-photon fluorescence adaptive-optics for in-vivo mouse brain imaging based on 1675-nm femtosecond pulses and MEMS spatial-light-modulator. We improve images of neurons and blood vessels up to 1-mm depth.

FTu4O.3 • 16:45
Highly Stable Two-photon Oxygen Imaging Probe Based on a Ruthenium-Complex Encapsulated in a Silica-coated Nanomicelle, Aamir A. Khan1, Susan K. Fullerton-Shirley2, Genevieve D. Vigil1, Yide Zhang1, 1JILA, Univ. of Colorado, Boulder, USA; 2Dept. of Chemical & Petroleum Engineering, Univ. of Pittsburgh, USA. A nanomicelle-based ruthenium-complex oxygen imaging probe is coated with a silica shell. The biostability of the silica-coated probe is improved by a factor of 4, while the oxygen-sensitivity is reduced by a factor of 3.

FTu4O.4 • 17:00
Integrated Nanophotonic Platform for High Bandwidth and High Resolution Optogenetic Excitation, Mohammad Amin A. Tadayon1,2, Qian Li1, Aseema Mohanty1,2, Raphael St-Georges3, Roberta Hamerly1, David Sinefeld1, 1Cornell Univ., USA; 2Photonics Center, Boston Univ., USA. We present a new on-chip platform for neural excitation that is both high bandwidth and high resolution. We demonstrate neural excitation in vivo in the visual cortex and the hippocampus by combining the platform with a recording electrode.
**Stu4P • Microstructured Fibers**

Presider: Siddharth Ramachandran, Boston University, USA


**Stu4P2 • 16:15**

Low loss Inhibited coupling Hollow-core photonic crystal fiber with ultrabroad Fundamental Band, Benoît Debord, Abhilash Amponsah, Jean-Marc Blondy, Frédéric Gérôme, Fetah Benabid. GPMM group, Xim Research Inst., UMR CNRS 7252, France; GLO Photonics S.A.S, France. We developed an inhibited-coupling Kagome HC-PCF with its fundamental transmission-band shifted down to 670 nm while maintaining its hypocycloidal core-contour resulting in a very broad single-band with a loss of 30 dB/km.

**Stu4P3 • 16:30**

Spectral Broadening and Pulse Compression Using Argon Filled Hollow-core Negative Curvature Fiber, Clarissa Harvey, Fei Yu, Jonathan C. Knight, William J. Wadsworth, Paulo J. Almeida. Univ. of Bath, UK; ‘Fianium, UK. We investigate self-phase modulation in 28m of negative curvature anti-resonant hollow-core fiber pressurized with argon. A 9 eps pulse is spectrally broadened to 7.8nm, at 20bar of pressure, and compressed to 420fs with 8J output energy.

**Stu4P4 • 16:45**

Experimental Characterisation of Longitudinal Uniformity in Photonic Crystal Fibre, Robert Francis-Jones, Peter J. Mosley. Univ. of Bath, UK. We present a method for characterising small structural variations in photonic crystal fibre. By measuring stimulated four-wave mixing spectra we can reconstruct numerically fluctuations in the waveguide dispersion.

**Stu4P5 • 17:00**

Spectral dynamics of high power 1.8 µm laser-pulse generated by Raman conversion of a picosecond Yb-laser in hydrogen-filled Kagome HC-PCF, Aurelien Bentou, Benoit Beaudou, Ekaterina Ilina, Benoît Debord, Frédéric Gérôme, Fetah Benabid, GPMM Group, Xim Research Inst., UMR CNRS 7252, France; GLO Photonics, France. The spectral-structure evolution of the first-order Stokes in H₂-filled inhibited coupling Kagome HC-PCF pumped by high-power picosecond laser is reported. The Stokes-bandwidth spectrum and structure is found to evolve strongly with the pump-power.

**Stu4Q • Microresonator Combs II**

Presider: Curtis Menyuk, Univ. of Maryland Baltimore County, USA

Generation of single-mode and phase-locked frequency spikes without mode crossings, Hao Liu, Shu-Wei Huang, Jinghui Yang, Abhinav K. Vinod, Mengbin Yu, Dim-Lee Kwong, Chee Wei Wong, Mesoscopic Optics and Quantum Electronics Lab, Univ. of California, Los Angeles, USA; The Inst. of Microelectronics, Singapore. We report a Si₃N₄ microresonator which simultaneously satisfies single-mode operation, high-Q factor and anomalous dispersion. With controlled high-speed pump-wavelength scanning, we successfully observe a smooth phase-locked Kerr frequency comb transition based on dissipative solitons.

**Stu4Q2 • 16:15**

Broadband visible comb generation via third harmonic generation assisted by stimulated Raman scattering, Taikum Kato, Akitoshi C. Jinna, Shun Fuji, Takasumi Tanabe, Keio Univ., Japan. We experimentally investigate visible Kerr comb generation via third harmonic generation and Raman scattering in a silica microtoroid. A broad bandwidth of 110 THz in the visible range is obtained by pumping at 1550 nm.

**Stu4Q3 • 16:30**

Thermally-controlled Single-Soliton Mode-locking in Silicon Nitride Microresonators, Chaitanya S. Joshi, Jae K. Jang, Kevin Luke, Xinchen Ji, Alexander Klenner, Yoshitomo Okawachi, Michal Lipsar, Alexander L. Gaeta, Dept. of Applied Physics and Applied Mathematics, Columbia Univ., USA; School of Electrical and Computer Engineering, Cornell Univ., USA; School of Electrical and Computer Engineering, Cornell Univ., USA; Dept. of Electrical Engineering, Columbia Univ., USA. We report the first demonstration of thermally-controlled single-soliton mode locking in silicon-nitride microresonators. With the pump frequency fixed, we use only current control with on-chip integrated heaters to demonstrate a systematic pathway for achieving single-soliton mode locking.

**Stu4R • Mid Infrared Materials & Devices**

Presider: To be Determined

Generation of single-mode and phase-locked frequency spikes without mode crossings, Hao Liu, Shu-Wei Huang, Jinghui Yang, Abhinav K. Vinod, Mengbin Yu, Dim-Lee Kwong, Chee Wei Wong, Mesoscopic Optics and Quantum Electronics Lab, Univ. of California, Los Angeles, USA; The Inst. of Microelectronics, Singapore. We report a Si₃N₄ microresonator which simultaneously satisfies single-mode operation, high-Q factor and anomalous dispersion. With controlled high-speed pump-wavelength scanning, we successfully observe a smooth phase-locked Kerr frequency comb transition based on dissipative solitons.

**Stu4R1 • 16:00**

Germanium-Core Borosilicate Glass-Cladded Semiconductor Fibers for Mid-IR Applications, Mustafa Ordu, Icheng Guo, Shyamsunder Eramilli, Siddharth Ramachandran, Soumenanda Basu, Mechanical Engineering, Boston Univ., USA; Materials Science And Engineering, Boston Univ., USA; Physics, Boston Univ., USA; Electrical and Computer Engineering, Boston Univ., USA. 40µm diameter germanium-core, borosilicate glass-cladded optical fibers were fabricated by the ‘rod in tube method’. The fibers successfully transmitted mid-IR wavelengths, with a transmission loss of 61dB/cm at 6.1µm.

**Stu4R2 • 16:15**

Towards Mid-IR Waveguide Lasers: Transition Metal Doped ZnS Thin Films, Eric Karhi, Nikolai Tolstik, Evgeni Sorokin, Stanislav Polyakov, Reza Zamiri, Vedran Furuta, Ulf Osterberg, IRENA, SOFIA, Sweden. We experimentally investigate visible Kerr comb generation via third harmonic generation and Raman scattering in a silica microtoroid. A broad bandwidth of 110 THz in the visible range is obtained by pumping at 1550 nm.

**Stu4R3 • 16:30**

A Reliable Approach to Membrane Photonics: The T-Guide, Jeff Chiles, Sasan Fatnour,CREOL, The College of Optics and Photonics, Univ. of Central Florida, USA. A scalable and reliable technology for membrane-type photonics is demonstrated on an all-silicon platform, showing low mid-infrared propagation losses of 1.75 dB/cm at a wavelength of 3.6 µm, with waveguides up to 5 cm long.

**Stu4R4 • 16:45**

Three-dimensional Dirac semimetal Cd₃As₂ as high-performance 2-5 µm saturable absorbers, Chunhua Zhu, Yafei Meng, Xiang Yuan, Fawen Xu, Yonglong Xu, Frank Wang, Nanyang Univ., China. 2-5 µm saturable absorbers are highly desirable for constructing convenient mid-infrared ultrafast sources. We reveal that three-dimensional Dirac semimetal Cd₃As₂ constitutes an ideal mid-infrared saturable absorber, with broadband operation and flexible parameter control.

**Stu4R5 • 17:00**

Mid-infrared 2D Photodetector based on bilayer PtSe₂, Xuechao Yu, Peng Yu, Cheng Liu, Qiye Wang, Nanyang Tech Univ, Singapore. We fabricated atomic layers of PtSe₂ with a narrow band gap and demonstrated photodetectors based on bilayer PtSe₂, FET show fast response time and high responsivity.
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<th>Time</th>
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<tr>
<td>17:00</td>
<td>FTu4A.3  17:15</td>
<td>Boundaries of practicability for integrated Stimulated Brillouin scattering devices</td>
<td>Christian Wolff 1, Michael Steel 1, Benjamin Eggleton 1, Christopher G. Poulton 1, University of Technology Sydney, Australia; 2Dept. of Physics and Astronomy, Macquarie University, Australia; 3Institute of Photonic and Optical Science (IPoS), School of Physics, University of Sydney, Australia; 4Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS), Australia. We present a theoretical framework for the design of silicon-photonics devices harnessing Stimulated Brillouin Scattering. We discuss the interplay and trade-off between opto-acoustic coupling, finite-size effects, nonlinear loss and fabrication tolerances.</td>
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<td>17:15</td>
<td>FTu4A.4  17:30</td>
<td>Pulse Bunching in the Soliton Rain Regime of an Ultralong Fibre Laser Mediated by Forward Brillouin Scattering</td>
<td>Srikanth Sugavanam 1, Atella E. El-Taher 1, Robert J. Woodward 2, Edmund J. Kelleher 2, Dmitriy V. Churkin 1, Aston Institute of Photonic Technologies, UK; 2Dept. of Physics, Imperial College London, UK; 3Inst. of Automation and Electrometry SB RAS, Russia. We present experimental evidence for soliton bunching mediated by forward Brillouin scattering in the soliton rain regime of an ultralong fiber laser. Spatio-temporal dynamics show an initial acceleration followed by self-organization of the rain solitons.</td>
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<td>17:45</td>
<td>FTu4A.5  17:45</td>
<td>Second Harmonic Phonon Spectroscopy of α-Quartz</td>
<td>Christopher J. Winta 1, Sandy Gewinner 1, Wieland Schoellkopf 1, Martin Wolf 1, Alexander Paarmann 1, Fritz Haber Institute of the Max Planck Society, Germany. We demonstrate mid-infrared second harmonic generation spectroscopy as a novel type of phonon spectroscopy for α-quartz. The immense tunability of an infrared free-electron laser gives access to optical phonons in the range of 350-1400 cm⁻¹.</td>
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<td>17:15</td>
<td>FTu4B.6  17:15</td>
<td>Fabrication and Characterization of SiN/Au Nanopatch Cavities with Colloidal Nanocrystals</td>
<td>Edouard Braine 1, Suzanne Bisschop 1, Pieter Geiregat 2, Zeger Hens 2, Dines Van Thourhout 3, Ghent University, INTEC, Belgium; 4Inorganic and Physical Chemistry, Ghent University, Belgium. We report on the fabrication/characterization of nanoscale cavities in which a monolayer of CdSe/CdS quantum dots is embedded in a SiN/Au structure. The physics of the emission rate enhancement (1.2 - 3.4) is discussed.</td>
</tr>
<tr>
<td>17:15</td>
<td>FTu4C.6  17:15</td>
<td>Single-Photon Temporal Wave Function Measurement via Electro-Optic Spectral Shearing Interferometry</td>
<td>Alex O. Davis 1, Michal Karpiński 2, Brian J. Smith 1, Oxford University, UK; 2University of Warsaw, Poland. We present a method to completely characterize the temporal wave function of heralded single photons using spectral shearing interferometry. Frequency shear is applied by electro-optical modulation and spectrally-resolved detection is performed by frequency-to-time spectrometry.</td>
</tr>
<tr>
<td>17:15</td>
<td>FTu4C.7  17:15</td>
<td>On-Demand Single Photon Emission based on Quantum Feedback Control of a Microcavity</td>
<td>Mikkel Heuck 1, Mihir Pant 1, Dirk R.Englund 1, MIT, USA. We propose a scheme for generating and releasing photons from an ultrahigh Q microcavity to optimally drive it towards a single-photon state at a pre-determined time to achieve on-demand emission.</td>
</tr>
<tr>
<td>17:15</td>
<td>FTu4C.8  17:45</td>
<td>Generation of pure heralded single-photon states by cross-polarized spontaneous four-wave mixing</td>
<td>Jesper B. Christensen 1, Colin J. McKinstrie 2, Karsten Rottwitt 1, Technical University of Denmark, Denmark; 2Applied Communication Sciences, USA. We propose a novel scheme which employs cross-polarized pumps to generate temporally and spectrally uncorrelated signal-idler photon-pairs through spontaneous four-wave mixing in a birefringent third-order nonlinear waveguide.</td>
</tr>
</tbody>
</table>

**17:00-18:30 Meet the OSA Editors’ Reception, Market Terrace**
Studi Roma Tre, Italy; Sapienza Università di Roma, Italy; machines, a problem of foundational and practical relevance. Our experiment goes towards understanding how entanglement in a two-qubit setting affects the efficiency of quantum thermodynamic systems. We adopt the paradigm of Maxwell’s demon to witness entanglement in a two-qubit system. They help relate to the classical picture. Experimental entanglement-enhanced work extraction based on a Maxwell’s demon, Mario A. Ciampini1, Agata Branczyk2, John E. Sipe1, MIT, USA; 2Perimeter Inst., Canada; 3Univ. of Toronto, Canada. We provide convex decompositions of thermal equilibrium for non-interacting non-relativistic particles and study how they relate to the classical picture. Representations offer new calculation tools and insights as they help relate to the classical picture. Mancino, Adeline Orieux3,2, Caterina Vigliar3,2, Marco Barbieri1,2, Paolo Mataloni2. Experimental entanglement-enhanced work extraction based on a Maxwell’s demon, Mario A. Ciampini1, Agata Branczyk2, John E. Sipe1, MIT, USA; 2Perimeter Inst., Canada; 3Univ. of Toronto, Canada. We provide convex decompositions of thermal equilibrium for non-interacting non-relativistic particles and study how they relate to the classical picture. Representations offer new calculation tools and insights as they help relate to the classical picture. Mancino, Adeline Orieux3,2, Caterina Vigliar3,2, Marco Barbieri1,2, Paolo Mataloni2, John E. Sipe1, MIT, USA; 2Perimeter Inst., Canada; 3Univ. of Toronto, Canada. We provide convex decompositions of thermal equilibrium for non-interacting non-relativistic particles and study how they relate to the classical picture. Representations offer new calculation tools and insights as they help relate to the classical picture.
Tuesday, 7 June

Executive Ballroom 210G

STu4G • Data Center Photonics—Continued

STu4G.6 • 17:15
Mode Division Multiplexed 3 × 28 Gbit/s On-Chip Photonic Interconnects, Xinru Wu1, Ke Xu2, Chaoran Huang3, Chester Shu4, Hon Ki Tsang1;1The Chinese Univ. of Hong Kong, USA; 2Harbin Inst. of Technology, China. We demonstrate a single wavelength 3×28Gbit/s mode division multiplexed on-chip communications link with integrated optical modulators and mode add-drops. The mode crosstalk was less than -30dB for optical wavelengths between 1530nm and 1540nm.

STu4G.7 • 17:30
BPSK and PAM Modulation in a Single-drive Push-pull Silicon Michelson Interferometric Modulator, Minjuan Wang1, Linjie Zhou1, Yanyang Zhou1, Jianping Chen1; State key Lab of Advanced Optical Communication Systems and Networks, Dept. of Electronic Engineering, Shanghai Jiao Tong Univ., China. 20 Gbaud’s PAM-4 and 28 Gbaud’s BPSK modulation are demonstrated in a single-drive push-pull silicon Michelson interferometric modulator with ~3 dB on-chip insertion loss. The modulator features a compact size and a high extinction ratio.

STu4G.8 • 17:45
Silicon Photonic Polarization Receiver with Automated Stabilization for Arbitrary Input Polarizations, Minglei Ma1, Kyle Murray1, Mengyuan Ye1, Stephen Lin2, Yun Wang3, Zegen Liu3, Han Yun1, Ricky Hu1, Nicolas A. F. Jaeger1, Lukas Christovskii1; Univ. of British Columbia, Canada. We experimentally demonstrate an automated polarization receiver that couples light from any polarization state output from a single-mode fiber into the fundamental quasi-TE mode of a single-mode waveguide in an integrated silicon photonic circuit.

Executive Ballroom 210H

STu4H • Physical and Fiber-based Sensing—Continued

STu4H.6 • 17:15
Fully-integrated nanomechanical wavelength and displacement sensor, Zarko Zobenica1, R.W. van der Heijden1, M. Petruzella1, F. Pagliano1, R. Lijssen1, Tian Xia1, Leonardo Midolo1, Michele Cotrufo1, Yongjin Cho1, F.W.M. van Otten1, Ewold Verhagen1, Andrea Fiore1; COBRA Research Inst., Eindhoven Univ. of Technology, Netherlands; 2Center for Nanophotonics, FOM Inst. AMOLF, Netherlands. We report a novel, fully-integrated nanophotonic wavelength and displacement sensor based on an electrostatically-actuated double-membrane photonic crystal nanocavity detector with a quantum dot absorption region.

STu4H.7 • 17:30
Heterodyne speckle imager for simultaneous observation of 3 degrees of vibrational freedom, James Perez1, Brad Libby1; 1US ARMY NVESD, USA. A heterodyne speckle imaging sensor has demonstrated the measurement of three degrees of vibrational freedom simultaneously. Axial velocity is measured by demodulation, surface velocity gradients are determined by observing speckle translation following extraction from mixed signals.

STu4H.8 • 17:45
Dual-Sideband Linear FMCW Lidar with Homodyne Detection for Application in 3D Imaging, Phillip Sandborn1, Norisaki Kaneda1, Young-Kai Chen1, Ming C. Wu1; Univ. of California, Berkeley, USA; 2Bell Labs, Alcatel-Lucent, USA. A spectral phase-diversity technique is demonstrated for characterizing optical pulse characterization. Processing of the waveforms photodetected after various amounts of chromatic dispersion leads to precise characterization of picosecond pulses shorter than the photodetection impulse response.

Meeting Room 211 B

STu4I • Ultrafast Pulse Characterization—Continued

STu4I.4 • 17:30
Single-Shot Characterization of Picoscosecond Optical Pulses by Spectral Phase Diversity, Christophe Dorrer1, Leon Waxes1, Adam Kalb2, Elisabeth Hill3, Jake Bromage2; 1Univ. of Rochester, USA. A spectral phase-diversity technique is demonstrated for optical pulse characterization. Processing of the waveforms photodetected after various amounts of chromatic dispersion leads to precise characterization of picosecond pulses shorter than the photodetection impulse response.

STu4I.5 • 17:45
Short Wavelength Tail Effects in Multiphoton Induced Luminescence from ZnO Using sub-10 fs Ti:Sa Pulses, Janne Hyytia1, Ruediger Grunwald1, Marko Perestjuk1, Frank Guehl2, Ciaran Gray1, Enda McGlynn1, Gunter Steinmeyer3; 1Max Born Inst., Germany; 2Departament d’Electrònica, Universitat de Barcelona, Spain; 3School of Physical Sciences, Dublin City Univ., Ireland. Multiphoton absorption induced ultraviolet luminescence in ZnO nanorods is investigated with interferometric frequency-resolved optical gating. Power dependency exponents between 3 and 4 are extracted, consistent with simulations using Keldysh theory showing three-photon and four-photon absorption.
ATu4J • Inspection and Signal Analysis—Continued
ATu4J.6 • 17:15
High-resolution, THz-wave real-time imaging with Si-camera based on nonlinear optical up-conversion, Mo Koyama1, Kouji Nawata1, Yu Tokizane1, Yuma Takida1, Zhengli Han1, Takashi Notake1, Shin‘ichiro Hayashi1, Hiroaki Minamide1; RIKEN Center for Advanced Photonics, Japan. We propose THz-wave real-time imaging system with high resolution based on second harmonic generation in nonlinear organic DAST crystal. The spatial resolution is estimated to be less than $\sim 3\times \lambda_{\text{THz}}$.

ATu4K • A&T Topical Review on Lasers in Materials Processing II—Continued
ATu4K.5 • 17:15
Plasmonic Coloring of Silver using Picosecond Laser Pulses, Jean-Michel Guay1, Antonio Cala Lesina1, Guillaume Côte1, Martin Charron1, Lora Ramunno1, Pierre Berini1, Arnaud Weck1; 1Physics, Univ. of Ottawa, Canada; 2Mechanical Engineering, Univ. of Ottawa, Canada. We report fast angle-independent coloring of silver due to plasmonic effects arising from the creation of random nanoparticle distributions. Each individual color linked to a unique total accumulated fluence rendering the process compatible with industry.

FTu4L • Ultrafast Dynamics in 2D van der Waals Materials and Beyond—Continued
FTu4L.6 • 17:15
Isolating Exciton Extraction Pathways with Electric Field-Dependent Ultrafast Photocurrent Microscopy, Kyle T. Vogt1, Sufei Shi2,3, Feng Wang2, Matt Graham1; 1Physics, Oregon State Univ., USA; 2Chemical Engineering, Rensselaer Polytechnic Inst., USA; 3Physics, Univ. of California-Berkeley, USA. We develop a new, systematic approach to determine a material’s intrinsic photocurrent generation efficiency through $E_{\text{field}}$-dependent ultrafast photocurrent and transient absorption microscopy. For WSe2, devices, we find both measurements yield the same high efficiency.

FTu4L.7 • 17:30
Non-hygrogenic Excitonic Spectra of Transition Metal Dichalcogenides: The Role of Quantum Geometry of Bloch Bands, Ajit Srivastava1, Atac Imamoglu2; 1Emory Univ., USA; 2Inst. of Quantum Electronics, ETH Zurich, Switzerland. We investigate the role of Bloch-band geometry in determining exciton spectra. We find that Berry-phase leads to a splitting of 2p states while the quantum geometric tensor leads to a Lamb-like shift. Our calculations are experimentally relevant for excitons in transition metal dichalcogenides.

ATu4J.7 • 17:30
Terahertz 3D Imaging of Nanomaterial Interfaces for Sub-nanometer Analysis, Anis Rahman1, Aunik Rahman1; 1Applied Research and Photonics Inc, USA. Sub-nanometer imaging with size measurement was achieved via terahertz route. We describe a new technique of 3D imaging with layer-by-layer inspection capability in a non-contact fashion with resolution less than a nanometer. A high power, CW terahertz energy is utilized for scanning a specimen.

ATu4K.6 • 17:30
Laser ablation of germanium in arsenic sulfide solution, Tingyi Gu1, Jia Gao1, Romain Rardel1, Fan Wu1, Nan Yao1, Yueh-Lin Loo1; craig arnold1; 1PRISM, Princeton Univ., USA; 2Chemical and Biological Engineering, Princeton Univ., USA. In this work, laser ablation is applied to generate germanium particles in arsenic sulphide glass, examined by Raman and photoluminescence spectroscopy.

ATu4L.8 • 17:45
Nonlinear Optical Responses of Protected Atomically Thin Black Phosphorus, Takaaki Harada1, Bryan S. Berggren1,2, Skylar Deckoff-Jones1, Dylan Renaud1, Andrew Winchester1, Julien Madeo1, Jin Hu1, Xue Liu1, Zhiqiang Mao1, Jiang Wei1, Diyar Talbayev2, Christopher Weber2, Keshav M. Dani1; 1Okinawa Inst. of Science and Technology Graduate Univ., Japan; 2Dept. of Physics, Santa Clara Univ., USA. We investigate nonlinear optical responses of black phosphorus in ambient conditions protected by exfoliating thin hexagonal-boron nitride on top. We observe sub-picosecond and polarization sensitive responses for few-layer black phosphorous.

17:00-18:30 Meet the OSA Editors’ Reception, Market Terrace
STu4M • 2µm Lasers—Continued

STu4M.6 • 17:15
Passive Q-switching of Ho:YAG ceramic lasers at 2.1 µm, Xavier Mateos1,2; Ruijun Lan1; Pavel Lasko1; Yicheng Wang1; Jiang Li1; Yubai Pan1; Sun Y. Choi1; Mi Kim1; Fabian Rotermund2; Anatoly Yasukevich2; Konstantin Yamashkev2; Uwe Grebner2; Valentin Petrov2; ’Universitat Rovira i Virgili, Spain; 1Max Born Institut, Germany; 2Yantai Univ., China; 3Belarusian National Technical Univ., Belarus; 4Shanghai Inst. of Ceramics, China; 5Ajou Univ., Korea. Inband-pumped Ho:YAG ceramic lasers emitting near 2.09 µm are passively Q-switched by mono- and multi-layered graphene, SWCNTs and Cr:ZnSe saturable absorbers. With SWCNTs, 85-ns, 4.9-µJ pulses are generated at a repetition rate of 165 kHz.

STu4M.7 • 17:30
Single-frequency injection-seeded Q-switched Ho:YAG laser, Qing Wang1, Chunping Gao1, Quanxin Na1; Mingwei Gao1; Yuxuan Zhang1; Yan Li1; ’Beijing Inst. of Technology, China. An injection-seeded Q-switched Ho:YAG laser at 2090 nm was demonstrated. Single-frequency laser pulses with energy of 17.04 mJ, and pulse duration of 122 ns at repetition rate of 50 – 130 eV were obtained.

STu4M.8 • 17:45
240 W diode-seeded nanosecond thulium-doped fiber MOPA system incorporating active pulse shaping, Hongxing Shi1; Fangzhou Tan1; YiGao1; Peng Wang1; ChenLi1; Jiang Liu1; PuWang1; ’Beijing Univ. of Technology, China. We report on nanosecond-pulsed PM MOPA system seeded by a semiconductor laser diode at 2 µm with right-angled trapezium, rectangular, ‘M’-shaped and ‘Y’-shaped pulses output in 240 W average power level with 240 µJ pulse energy, respectively. We report.

STu4N • Attosecond Dynamics—Continued

FTu4N.5 • 17:15
Photoemission Time Delays from a Cu(111)-Surface: Validity of Macroscopic Laws for Probe-Field Effects, Matteo Lucchini1; Luca Castiglioni1; Lamia Kasmi1; Pavel Kluev2; André Ludwig2; Michael Greif2; Matthias Hengsberger2; Jürg Osterwalder2; Lukas Gallmann2; Ursula Keller1; ETH, Zurich; Switzerland; 1Physik Dept., Univ. of Zurich, Switzerland; 2Inst. of applied physics, Univ. of Bern, Switzerland. Photoemission delays from copper (111) are measured in an attosecond pump – infrared probe experiment. The influence of the probe pulse and the validity of the Fresnel equations on atomic length and time scales are investigated.

FTu4N.6 • 17:30
Polarization Assisted Amplitude Gating as a Route to Tunable, High-Contrast Single Attosecond Pulses, Henry Timmers1; Mazyar Sabbar1; Kuki Kobayashi1; Daniel Neumark1; Stephen Leone1; Univ. of California, Berkeley, USA. We demonstrate the simple implementation a polarization-assisted amplitude gate that is capable of generating high-contrast, isolated attosecond pulses tunable between the energy range of 50 – 130 eV.

FTu4N.7 • 17:45
Spatio-Temporal Localization of Intense Pulses in Gas-Filled Capillaries, Xiaohui Gao1; Gauri Patwardhan1; Bonggu Shim1; Tenio Popmintchev1; Henry Kapteyn1; Magaret Murnane1; Alexander L. Gaeta1; Columbia Univ., USA; 2Cornell Univ., USA; 3Univ. of Colorado, USA. We investigate pulse propagation from the ultraviolet to the mid-infrared in gas-filled capillaries. For shorter wavelength pulses and smaller capillary diameters, ionization-induced refraction excites higher-order modes, and their constructive interference leads to spatio-temporal localization.

Meeting Room 212 C

Meeting Room 212 D

Marriott Salon I & II

17:00-18:30 Meet the OSA Editors’ Reception, Market Terrace
Fiber, Loss Hypocycloid Kagomé Hollow Core Photonic Crystal
that these modes have low attenuation.

Kagomé fibers; even with an optimized input launch, higher
fiber using spatially and spectrally resolved imaging.
We show the exploration of higher order core
PCFs, dramatic higher-order-mode suppression occurs for a
straight single-ring hollow-core
Günendi
Ring Hollow-Core Photonic Crystal Fibers,
Twist-Tuning of Higher-Order Mode Suppression in Single-
resonators for Nonlinear Photonics,
Integrated microresonators are essential building blocks of linear and nonlinear photonic
devices. Here we show that the performance of high-Q silico
carbon nitride microresonators for nonlinear photonics strongly
depends on the ideality of their coupler design.

Dispersion engineered high-Q resonators on a chip, Ki Y.
Yang1; Katja Behra1, Daniel C. Cole1, Xu Yi1, Pascal Del Hays2, Hansuelk Lee1, Jing Li1, Doro Yoon Oh1, Scott A. Diddams2, Scott B. Papp1, Kerry Vahala1; 1California Inst. of Technology, USA; 2NIST, USA. We demonstrate dispersion control in optical
resonators over an octave of optical bandwidth. Dispersion is
engineered lithographically and Q factor is maintained above
100 million, which is critical for efficient nonlinear devices
such as microcombs.

Measurement of Higher Order Mode Content in Low
Loss Hypocycloid Kagomé Hollow Core Photonic Crystal
Fiber, Tom Bradley1, Natalie Wheeler1, Marco Petrovich1, Gregory Jason1, David Gray1, John Hayes1, Seyed Sandoghchi1, Yang Chen1, Francesco Poletti1, David J. Richardson1, Marcelo Botelho Alonso1; ORC, UK. We present the first
detailed investigation of modal properties in hypocycloid
Kagomé fibers, even with an optimized input launch, higher
order modes propagate over long fiber lengths, indicative
that these modes have low attenuation.

C1OS-compatible Silicon-Rich Nitride Waveguides for
Ultrafast Nonlinear Signal Processing, Cosima Lacava1, Stevan Stankovic1, Ali Khokhar1, Thalia Dominguez1, Frederic Garde1, David J. Richardson1, Graham T. Reed1, Periklis Petropoulos1; ORC - Univ. of Southampton, UK. We report
on the linear and nonlinear characterization of PECVD Si-rich
nitride-waveguides. We show that the nonlinear properties can be enhanced by one order of magnitude with respect
to standard SiNx in the 1550-nm-region without suffering
two-photon-absorption.

Multi-lead, Two-color, ZnCdSe/ZnCdMgSe Based Quantum Well Infrared Photodetectors, Yasin Kaya1, Anvind P.
rajikumar1, Guopeng Chen1, Maria Tamango2, Aidong Shen3, Claire F. Gmachl1, 3Princeton Univ., USA; 2Stanford Univ., USA; 3The City College of New York, USA. An independently con-
trollable, two-color ZnCdSe/ZnCdMgSe quantum well infrared
detector spanning 4.3-5.4 μm and 6.7-8.2 μm is experimen-
tally demonstrated with a dark current limited detectivity of
2.9x10^10 cm Hz/W and 2.7x10^10 cm Hz/W at 80K, respectively.

STu4Q.6 • 17:30
Optical Quality ZnSe Films on Silicon for Mid-IR Wave-
guides, Vineta Mittal1, James S. Wilkinson1, Ganapathy Senthil Murugan1, 1Univ. of Southampton, UK. ZnSe films were depos-
tited on silicon substrates by evaporation and RF-sputtering
and compared for their structural, morphological and optical properties. The deposited films were tested as waveguide
cladding and the evaporated films showed lower loss.

STu4Q.7 • 17:45
Multi-lead, Two-color, ZnCdSe/ZnCdMgSe Based Quantum Well Infrared Photodetectors, Yasin Kaya1, Anvind P.
rajikumar1, Guopeng Chen1, Maria Tamango2, Aidong Shen3, Claire F. Gmachl1, 3Princeton Univ., USA; 2Stanford Univ., USA; 3The City College of New York, USA. An independently con-
trollable, two-color ZnCdSe/ZnCdMgSe quantum well infrared
detector spanning 4.3-5.4 μm and 6.7-8.2 μm is experimen-
tally demonstrated with a dark current limited detectivity of
2.9x10^10 cm Hz/W and 2.7x10^10 cm Hz/W at 80K, respectively.

STu4Q.8 • 17:45
Multi-lead, Two-color, ZnCdSe/ZnCdMgSe Based Quantum Well Infrared Photodetectors, Yasin Kaya1, Anvind P.
rajikumar1, Guopeng Chen1, Maria Tamango2, Aidong Shen3, Claire F. Gmachl1, 3Princeton Univ., USA; 2Stanford Univ., USA; 3The City College of New York, USA. An independently con-
trollable, two-color ZnCdSe/ZnCdMgSe quantum well infrared
detector spanning 4.3-5.4 μm and 6.7-8.2 μm is experimen-
tally demonstrated with a dark current limited detectivity of
2.9x10^10 cm Hz/W and 2.7x10^10 cm Hz/W at 80K, respectively.

17:00-18:30 Meet the OSA Editors’ Reception, Market Terrace
is larger than 4.8 with a bandwidth of 100 kHz.

The maximum obtainable gain work on phase sensitive amplification performed in metastable Bose-Einstein condensate (BEC) vortex experiments. A sweep-frequency source for Bose-Einstein condensate scattering from qubits with the aim to test different quantum information processing schemes.

A sweep-frequency source for Bose-Einstein condensate vortex experiments, Na Li1, Yu-Ping Wu2, Hao Min1, Xiao Jiang1, modern physics, USCT, China; 1USCT, China. We present a high precision, high-stability and high-speed sweep-frequency source, which can generate a rotating frame in Bose-Einstein condensate (BEC) vortex experiments.

Withdrawn.

Integrating Optical Cavities in Ion Traps for Scalable Quantum Information Networks, Nina Podobdak1, Hiroki Takahashi2, Matthias Keller2, Peter Horak3, 1Univ. of Southampton, UK; 1Univ. of Sussex, UK. We investigate the distortions of trapping potentials when integrating fiber-tip optical cavities into small ion traps. Trap depths, frequencies, and anharmonicity are investigated numerically for several geometries and the most stable traps are identified.

Resonant Excitation of Single Colloidal Quantum Dot Coated on a Tapered Optical Fiber, Haoyu Huang1, 2Qinfeng Xu1, 2Biju Lu1, Yuge Huang1, Chunfeng Zhang1, Xiaoyong Wang1, Xiao Min1, 1Center for Free-Electron Laser Science, DESY, Germany; 2National Lab of Solid State Microstructures, School of Physics, and Collaborative Innovation Center of Advanced Microstructures, Nanjing Univ., China; 3Dept. of Physics, Univ. of Arkansas, USA. We propose a new resonant excitation method via the evanescent field surrounding optical nanofiber. Based on this method, we successfully obtain the fluorescence blinking signal of single colloidal quantum dot in room temperature.

Memory-Assisted Quantum Key Distribution Immune to Multiple-Excitation Effects, Nicola1 Lo Piparo1, Mohsen Razavi1, 1Univ. of Leeds, UK. Memory-assisted quantum key distribution aims to use existing quantum-device technologies to offer rate-versus-distance enhancements. Here, a variant of such systems, relying on single-photon sources, is proposed that counters the multiple-excitation effects in ensemble-based memories.

Phase Sensitive Amplification in Metastable Helium at Room Temperature, Jasleen Lugani1, Chitram Banerjee1, Marie-Aude Maynard1, Pascal Nève1, Ram Soorat1, Rupamani-Jari Ghosh1, Etienne Brion1, Fabien Bretenaker1, Fabienne Goldfarb1, Laboratoire Artois Cotton, Univ. Paris Sud, CNRS, France; 2Shiv Nadar Univ., India. In this paper, we present our work on phase sensitive amplification performed in metastable helium at room temperature. The maximum obtainable gain is larger than 4.8 with a bandwidth of 100 kHz.

Few Photon - Qubit Scattering in Dispersive Waveguides, Sukru Ekin Kocabas1, 1Koc Univ., Turkey. Dispersion in waveguides leads to atom-phonon bound states in qubits embedded in waveguides. We utilize Feynman diagrams and numerical simulations to analyze one- and two-photon scattering from qubits with the aim to test different quantum information processing schemes.

Interferometric Activation of Quantum Dephasing Channels, Jin-Shi Xu1, Man-Hong Yung1, Xiao-Ye Xu2, Jian-Shun Tang1, Chuan-Feng Li1, Guang-Can Gu1, 1Univ. of Science and Technology of China, China; 2South Univ. of Science and Technology of China, China. We report an optical phenomenon that allows perfect quantum communication through a pair of dephasing channels each with zero quantum capacity. Our results are useful for enriching the structure of the quantum communication theory.

Characterizing the Quantum Detection Property of the Multi-Pixel Photomount Counter, Chengjie Ding1, Xuliang Chen1, Yan Liu1, Yuyoung Rong1, Zhaozhi Li1, Guang Wu1, E Wu1, Heiping Zeng2, 1East China Normal Univ., China. A multi-pixel photon counter was characterized by the quantum detector tomography and demonstrated to be a fundamental quantum detector for the observation of non-classical phenomena according to the negative values of the Wigner function.

Quantum frequency up-conversion of heralded single photon orbital angular momentum states, Zhuyan Zhou1, Yan Li1, Bao-Sen Shi1, Key Lab of Quantum Information, China. Frequencies from 1560 nm to 525 nm is presented. Non-classical correlation and coherent properties are preserved in the upconversion process.

Parallel Generation of Squeezed States with Kerr Effect of an Optical Fiber, Arda Hosaka1, Taiki Kawamori, Fumihiko kamiya1, 1Koito Optical. We propose methods to analyze the quantum correlations formed among the longitudinal modes of ultrashort pulses launched into a fiber and numerically demonstrate that parallel squeezed state generation can be achieved by a zero-dispersion fiber.

Protection of triparticle entanglement in noisy channels, Xiaowei Deng1, Caixing Tian1, Xiaolong Su1, Changde Xie1, Kuncheng Peng1, 1Shanxi Univ., China. We demonstrate that the excess channel noise in a quantum network will lead to the disentanglement among three optical modes and the destroyed entanglement can be revived by using a correlated noisy channel.

Semiconductor-Superconductor Bell-state Analyzer, Eyvat Sabag1, Raja Marjieh1, Alex Hayat1, 1Electrical Engineering, Technion, Israel. We propose a scheme for complete Bell-state analysis by Cooper-pair-based two-photon absorption in superconducting-proximity based semiconductor photodetectors. We show high detection purity of the specified Bell-state. The demonstrated effects can have important implications on quantum-information.

RF Semi-Classical Simulator of Optical Squeezing and Parametric Oscillation, Yakob Shaked1, Leon Bello1, Avi Pe2, 1Bar-Ilan Univ., Israel. We utilize the easy setup of RF oscillators to explore semi-classically parametric oscillation and squeezing phenomena in both familiar and new configurations. Observation of the oscillation in time and realization of optically-difficult configurations is illuminating.

Investigation of Optical Phase Noise in Long, Deployed Fiber Links for Quantum Networks, Matthew E. Grein1, Timothy M. Yamnal1, Mark Stevens1, Karl Hoover1, 1Massachusetts Inst of Tech Lincoln Lab, USA. We investigated the phase noise of an 8 km fiber-optic fiber link between Lincoln Lab and MIT for a quantum communication system and observed a noise process that is not governed entirely by a random-walk process.

Entanglement swapping - when being the same is better than being different, Brian T. Koby1, Siddhartha Santra1, Vladimir Malinovsky1, Michael Brodsky1, 1US Army Research Lab, USA; 2Aeronautics and Astronautics, Stanford Univ., USA. We show that entanglement swapping can result in a state with higher concurrence than that of the input states. For pure entangled states this is most likely when the input states are of similar concurrence.

Tailoring of Individual Photon Lifetimes as a Degree of Freedom in Resonant Quantum Photonic Sources, Calé M. Gentes1, Gil Triginer1, Xiaoge Zeng1, Miloš Popovi1, 1Univ. of Colorado at Boulder, USA. Resonant quantum photonic sources with dissimilar decay rates are proposed and theoretically demonstrated to improve the efficiencies of entangled photon and squeezed light sources while also enabling engineering of frequency correlations in photon pair sources.

Experimental demonstration of a robust second-order correlation for twin parametric beams above threshold, Zhengyu Xie1, Shifeng Li2, Yanxiao Gong2, Xinjie Lu2, Hubian Lu1, Ping Xu1, Zhenlin Wang1, Gang Zhao1, Shuang Zhu1, 1Univ. of California Los Angeles, USA; 2Nanjing Univ., China; 3South-east Univ., China. We report the first correlation measurement between the twin beams generated by optical parametric process above threshold. This high-visibility correlation can be observed at significant power levels with up to a conversiency of 19.7%.

Optimal two-mode attack against two-way continuous-variable quantum key distribution, Yichen Zhai1, Chengyu Li1, Yiya Zhao1, Bin Luo1, Guohua Wu1, Song Yu1, Hong Guo1, 1Beijing Univ of Posts & Telecom, China; 2Peking Univ, China. We report the optimal eavesdropping strategy against two-way continuous-variable quantum key distribution at fixed channel parameters, which is given by a two-mode attack with symmetric and appropriate separable correlations.

Can Anomalous Amplification be Attained Without Post-selection?, Julian Martinez1, Wei-Tao Liu1, Gerardo Visa1, John Howell1, 1Univ. of Rochester, USA; 2College of Science, National Univ. of Defense Technology, China. We introduce a metrological technique which, without discarding of data, resembles a larger anomalous amplification than weak-value-amplification (WVA). The protocol surpasses WVA techniques since it additionally offers robustness to misalignment and systematic errors.

Quantum Limit for Two-Dimensional Resolution of Two Incoherent Optical Point Sources, Shan-Zheng Ang1, Ranjith Nair1, Markies Tsiang1, 1National Univ. of Singapore, Singapore. We obtain the quantum Cramer-Rao (QCR) bound for estimating the 2-D separation of two incoherent optical point sources. The bound is independent of the x- and y-separations. We also propose an interferometric scheme that approaches the bound for sub-Rayleigh separations.

Polarization-Based Control of Spin-Orbit Hybrid Modes of Light in Biphoton Interferometry, Cody C. Leary1, Maggie Lankford1, Deepika Sundaraman1, 1College of Wooster, USA. We experimentally generate spin-orbit hybrid modes via interferometry, whose intensity and polarization distributions exhibit tunability through the manipulation of the input beam’s polarization state. We predict biphoton (Hong-Ou-Mandel) interference in conjunction with this mode transformation.
Single photon detectors using commercial off-the-shelf an electrical readout scheme for superconducting nanowire of squeezed states. Classically correlated input states can outperform the mutual quantum amplifier in a Gaussian channel, we show that demonstrated high-energy-pulse generation in 2.2-2.6 μm using a Cr:ZnSe single-pass amplifier, Masaki Yumoto, Nonito Sato, Satoshi Wada, RIKEN, Japan. We reported recent progress on the development of a green pump laser for a compact, efficient and reliable OPCPA preamplifier in multi-petawatt-scale laser system. Stable operation in power and spectrum from the front-end is demonstrated.

Cryogenic Amplifiers for a Superconducting Nanowire Single Photon Detector System, Clinton T Cahall, Daniel J. Gauthier, Jungang Kim; 2Duke Univ, USA. We study an electrical readout scheme for superconducting nanowire single photon detectors using commercial off-the-shelf amplifiers operating at cryogenic temperatures. Low power consumption and improved noise performance enable multi-channel readout circuit solution with high timinig resolution.

Cryogenic Amplifiers for a Superconducting Nanowire Single Photon Detector System, Clinton T Cahall, Daniel J. Gauthier, Jungang Kim; 2Duke Univ, USA. We study an electrical readout scheme for superconducting nanowire single photon detectors using commercial off-the-shelf amplifiers operating at cryogenic temperatures. Low power consumption and improved noise performance enable multi-channel readout circuit solution with high timinig resolution.

A device was proposed for lasing: a thin layer of perovskite between chiral polymer films, the band edge of which coincides with the perovskite emission. Characterisations of the device and simulation results are presented.

JTu5A.29 A 70 W average power sub 100 ps laser based on a fiber and bulk hybrid MOPA configuration, Yuje Peng, Yuxin Leng, Junchi Chen, Hongpeng Su; 1Shanghai Inst of Optics & Fine Mechanics, China. High repetition rate high power picosecond laser is an urgent demand for the micro machining of transparent materials and other applications. Based on a fiber and bulk hybrid MOPA system, we demonstrate a 70-W average power laser at 1064nm with 1000-KHz repetition rate and 83-ps pulse duration.
SI&4: Nonlinear Optical Technologies

JTuSA.44 Biexciton-mediated modulation response of colloidal quantum dots deposited on a silicon nitride waveguide at high laser excitation rate, Mirco Kolarczik, Bastian Herzog, Christian Ulbrich, Yirui Chen, Ulrike Woggon, Christian Ulbrich

JTuSA.45 Synchronously-pumped microring resonator for efficient optical comb generation, Marcin Malinski, Ashutosh Rao, Peter Delhaye, Ksenia A. Fedorova, Milen Dimitrov, Iolanda Ricciardi,觑 1

JTuSA.50 Free Carrier induced Nonlinear Six-wave Mixing in Silicon, Mingle Liao, Meng Zhou, Shu-Wei Huang, Kun Qiu, Chee Wei Wong, Univ. of Electronic Science and Technology of China, China; Univ. of California, Los Angeles, USA. We report on Kerr frequency comb generation, JTu5A.48

JTuSA.51 Flexible Generation of Optical Frequency Combs based on Stimulated Brillouin Scattering and a Dual Parallel Mach-Zehnder Modulator, Fengdan Xin, Juanjuan Yan, Qidi Liu, Ming Bai, Zheng Zheng, Befang Hu, Univ. of Electronic Science and Technology of China, China. We present a novel scheme of generating optical frequency combs (OFCs) based on the stimulated Brillouin scattering and a dual parallel Mach-Zehnder modulator. OFCs with a spacing of a Brillouin frequency shift are experimentally generated.


JTuSA.53 Phase-Matching in Dirac-Cone-Based Zero-Index Metamaterials, Orad Reshef, Yang Li, Mie Yin, Lysander Christakis, Danyi L. Vulis, Philip Muñoz, Shota Kita, Marco Lonsar, Eric Mazur, Harvard Univ., USA. Using nonlinear scattering theory, we simulate nonlinear signal generation in 2-dimensional zero-index metamaterials based on a photonic Dirac cone at the F point. We observe unique phase-matching in multiple simultaneous directions as the index approaches zero.

JTuSA.54 2.1 µm Picosecond Source Generating 7 W at 80 MHz, Chaitanya Kumar D. Suddapalli, 1 Braham-Zadeh 1, 2 -The Inst. of Photonic Sciences, Spain; 3Ioffe Physico-Technical Inst., Russia; 4Istituto Nazionale di Ottica, Italy. We report a stable, high-repetition-rate, picosecond, polarization-preserving, octave-spanning source at 2.1 µm, providing average power better than 7 W at 80 MHz.
Sub-150 fs mode-locked Erbium doped fiber laser based on "femto-"crystals using material dispersion to introduce chirp, resulting in this material.

Widely tunable time-division-multiplexed pumped fiber optical parametric oscillator, Nan Chen1, Bowen Li1, Jiqiang Kang1, Xiaoming Wei1, Sisi Tan1, Can Li, Liang Song1, Kenneth K. Wong1, The Univ. of Hong Kong, Hong Kong; SITAT, Chinese Academy of Sciences, China. We report a widely tunable dual-pump time-multiplexed fiber optical parametric oscillator (FPOP) system generating sources at both 1.2 μm and 1.5 μm, with a combined tuning range of over 480 nm in NIR and SWIR.

Active and passive stabilization of a high-power violet frequency-doubled diode laser, Ulrich Eismann1, Martin Enderlein1, Konstantinos Simeonis1, Felix Keller1, Felix Roehde1, Dimitris Opaliev1, Matthias Scholz1, Wilhelm Kaenders1, Jürgen Stuhr1, TÜFWA Photonics AG, Germany. We present a resonantly frequency-doubled tapered amplified semiconductor laser system emitting up to 2.6 W at 400 nm. The system shows 0.12% RIN, and less than 0.15%/h relative laser frequency noise at 16 hours. It can be stabilized, and the internal alignment can be optimized using computer-controlled mirrors.

S&I: 8 Ufs, Optoelectronics and Applications

Compact Femtosecond Tunable Wavelength Vis-NIR OPCPA System Based on Picosecond Fiber Laser Seeded Frontend, Rokas Danilevicius1, Audinus Zakutevišius1, Andreyus Michailovas1, Nenjus Rusteika1, 1EKSFPA, Lithuania. In this work we developed and constructed a compact femtosecond tunable wavelength OPCPA system prototype with a novel front-end. We measured up to 0.3 μJ, 39-90 fs duration pulses at 880-960 nm wavelength tuning range.

Ultrapulse Characteristics from Dispersion Scans with a Grating Compressor, Miguel Miranda1, Francisco Silva1, Ana Ubeda1, Cord L. Arnold1, Lund Univ., Sweden; 2Sphere Ultrafast Photonics, Portugal. A grating compressor is characterized using the dispersion scan technique and a reference piece of glass. The procedure yields both the spectral phase of the ultrafast pulses and the dispersion of the compressor itself.

Dual-probe scanning near-field optical microscopy (DS-NOM) utilizing Ultrafast Plasmo Nano-focusing, Yasuhro Kojima1, Yuta Masaki1, Fumihiko Kannari1, 1Electronics and Electrical Engineering, Keio Univ., Japan. Dual-probe scanning near-field optical microscopy combining spectral interference microscopy (SI-DSNOM) which utilizes ultrafast surface-plasmon polariton nano-focusing as excitation light is constructed and experimentally demonstrated. We achieve spatiotemporal resolution of 100 nm and 10 fs.

Towards all-optical sub-cycle visible-to-infrared pulse envelope measurement via cross-correlation sonogram, Hanan Hao Lu1, Shang-Da Yang2, 1, Institute of Photonics Technologies, National Tsing Hua Univ., Taiwan; 2Electrical Engineering, National Tsing Hua Univ., Taiwan. We numerically characterize visible-to-infrared pulses with durations down to 2.3 fs (0.88 cycle) by cross-correlation sonogram using a 20-mm-thick BBO crystal. This method is simple, sensitive, and potentially applicable to even shorter pulses.

Carrier relaxation pathways in submonolayer quantum dots, Bastian Herzig1, Mirco Kolarzak1, Yuefeng Cao1, Ulrike Wolfog1, Nina Oschiokhowa1, Benjamin Lingnau1, Kathy Lüdge1, 1Institut für Optik and atome Physik, Technische Universität Berlin, Germany; 2Institut für theoretische Physik, Technische Universität Berlin, Germany. Semiconductor optical amplifiers based on InAs submonolayer quantum dots show fast carrier recovery and large phase response. We develop a numerical model assuming strong interdot coupling and a three-dimensional carrier reservoir, which reproduces this behavior.

Sub-150 fs mode-locked Erbium doped fiber laser based on monolayer graphene on a 2D optical fiber, Juan D. Zapata1, Lucas Saito1, Ana María Cáceres1, Ezequio Antonio2, Vicente de Souza1, Universidad de Antioquia, Colombia; 2MackGraph - Graphene and Nano-Materials Research Center - São Paulo/SP - Brasil, Brazil. We present, as far as we know, the shortest pulse generated in an EDL mode-locked by the use of graphene monolayer on a 2D fiber. The pulse has 147 fs and 30 nm of bandwidth.

Toward all-optical sub-cycle visible-to-infrared pulse envelope measurement via cross-correlation sonogram, Hanan Hao Lu1, Shang-Da Yang2, 1, Institute of Photonics Technologies, National Tsing Hua Univ., Taiwan; 2Electrical Engineering, Keio Univ., Japan. Dual-probe scanning near-field optical microscopy combining spectral interference microscopy (SI-DSNOM) which utilizes ultrafast surface-plasmon polariton nano-focusing as excitation light is constructed and experimentally demonstrated. We achieve spatiotemporal resolution of 100 nm and 10 fs.

General optoelectronic computing based on scalable photonic neuromorphic system, Ru Wang1, Quanzhong Ren1, Ji Zhao1, School of Electronics Engineering and Computer Science, Peking Univ., China. We propose a general optoelectronic computing architecture based on scalable photonic neuromorphic system. It employs the fundamentals of the Neural Engineering Framework (NEF) principles to implement numerical operations in optical spiking networks.

Synchronous-asynchronous laser mode-locking transition: experimental results, Dung-Han Yeh1, Yi-Han Su1, Yinchieh Lai1, 1National Chiao Tung Univ., Taiwan. Synchronous-asynchronous laser mode-locking transition is experimentally investigated with a 10-GHz hybrid mode-locked fiber soliton laser. Laser pulse parameters under varying detuning frequency are measured and the experimental results show fair agreement with the theoretical prediction.

Unstable Multi-pulsing Can Be Invisible to Some Ultrashort Pulse Measurement Techniques, Michelle Rhodes1, Zhe Guang1, Rick Trebino1, 1Georgia Inst. of Technology, USA. Simulations show that relative phase variation of a satellite pulse causes the satellite to wash out of a SPIDER measurement completely. FROG and autocorrelation measurements see satellite pulses but cannot determine their precise properties.

Bandwidth-tunable ultrafast mid-infrared source using a dual-chirped optical parametric amplifier, Scott Wandell1, Ming-wei Lin1, Yunchen Yin2, Guibao Xu3, Juan D. Zapata1, 1University of Illinois at Urbana-Champaign; 2University of New South Wales, Australia; 3University of Hong Kong, Hong Kong. A novel Ti:Sapphire chirped-pulse amplifier produced 70-mJ pulses.

S&I: 11 Fiber Photonics

Core-Pumped All-Non-Dispersion Ytterbium-Doped Femtosecond Fiber Laser around 976 nm, Shengjie Yi1, Yue Zhou1, Yitang Dai1, Fefei Yin1, Jian Dai4, Kun Xu1, 1Beijing Univ. of Posts and Telecom, China. We report a core-pumped passively mode-locked ytterbium-doped fiber laser operating around 976 nm. The pulse is compressed to 250 fs, and the pulse energy is 1 nJ. The slope efficiency is more than 19%.

Mode-locked Er-doped fiber laser with Ti:S, saturable absorber, Xuexun Zhu1, Meng Zhang1, Jian Dai1, Jie Chen1, G. Hu1, Xin Zhao1, Zheng Zhong1, Jian Zhang1, 1Beihang Univ., 2Hunan Univ., 3China; 2Shenzhen Univ., China. We demonstrate mode-locked pulse generation in an Er-doped fiber laser by using a microfiber-based Ti:S saturable absorber. The edge-induced sub-bandgap absorption is proposed as the primary explanation for saturable absorption in this material.
Vector Solitons in a Mode-Locked Tm-Doped Fiber Laser, Chengyi Bao, Jianqiang Yang, Bo Zeng, Jinfeng Wang, Qiang Li, Hongxin Li, Huazhong Univ. of Sci. and Tech., China. We report the experimental observation of polarization-rotation vector solitons in a mode-locked Tm-doped fiber laser. The vector solitons have additional sidebands besides the Kelly-sidebands on the spectrum.

JTu5A.88 Acoustic Wave Induced Mach-Zehnder Interferometer Based on a Sandwich-Structured Single Mode Fiber, Pengfa Chang, Ligang Huang, Xiaobo Song, Peng Gao, Guoqian Zhang, Jingjun Xu, Nanka Univ., China. An in-fiber acoustic wave induced tunable Mach-Zehnder interferometer based on a sandwich-structured single mode fiber was demonstrated. The proposed configuration gains advantage of simple structure and fast tuning speed.

JTu5A.89 Dissipative Soliton Generation From a Normal Dispersion, Anisotropic Mode-Locked Tm-Doped Fiber, Grazgeor Z. Sobol, Tadeusz Martynek, Jaroslaw Sotor, Krzysztof Abramali, Laser & Fiber Electronics Group, Wroclaw Univ. of Technology, Poland. We demonstrate generation of ultra-broadband dissipative solitons from a fully fiberized, mode-locked Tm-doped fiber laser. Proper dispersion management of the cavity allowed to achieve dissipative solitons with 60 nm of bandwidth centered at 1950 nm.

JTu5A.90 Compression of dissipative-soliton-resonance pulses in a mode-locked fiber laser with a nonlinear optical loop mirror, Daolong Li, Lei Li, Dingyuan Tang, Deyuan Shen, Luming Zhao, Fudan Univ., China. "School of Physics and Electronic Engineering, Jiangsu Normal Univ., China. Compression of dissipative-soliton-resonance pulses down to a near transform-limited ultrashort pulse is demonstrated for the first time. The pulse presents a unique crown shape autocorrelation curve during compression.

JTu5A.91 Shifted Optical Gaussian Filters based Time Division Multiplexing of USBFs Sensing Network, Jali Rehman, Muhammad A. Khokhar, Pei-Qi Jiang, Li Xiu, Rui Cheng, 1,2 Huazhong Univ. of Science & Technol., China; 2FOSPIA Co.,Ltd, Korea. A novel method to fabricate helical long-period fiber gratings for quasi-distributed sensing with wide linear range of >3000 μm and a high sensitivity of ~5.02 dB/μm.

JTu5A.92 Flat-top band-rejection filter based on helical long-period fiber gratings, Hangou Li, Peng Wang, Ramanathan Subramaniam, 1 Graduate School of Engineering, Shizuoka Univ., Japan; 2Graduate School of Sci. & Techn., Shizuoka Univ., Japan; 2Graduate School of Engineering, Shenzhen Univ., China; 2Cambridge Graphene Centre, University of Cambridge, UK; 2Department of Micro- and Nanosciences, Aalto Univ., Finland. We demonstrate a simple and compact, all-fiber-thulium-based CPA system, delivering 136 fs pulses with ~6 ns energy at 50.8 MHz pulse repetition rate.

JTu5A.93 Design of Single-Shot Multimode Fiber Based Endoscope, Li Xia, Rui Cheng, 1,2 Huazhong Univ. of Science & Technol., China; 2FOSPIA Co.,Ltd, Korea. We designed and demonstrated a single-shot multimode fiber endoscope, which emits a sinc-function pulse. It is theoretically shown that a rectangular-like optical fiber with edge-enhancement plays an important role in generating a sinc pulse.

JTu5A.94 Improved Sensing Performance of Fiber-Optic Hydrogen Sensors Based on Actively Optical Heating, Gaoqiang Wang, Min Li, Xiaowen Wang, Huazhong Univ. of Sci. and Tech., China; Beijing Univ. of Posts and Telecommunications, China; ‘Laser Inst. of Shandong Academy of Science, China; ‘Shanghai Univ., China. We investigated the spectroscopic properties of BEDF under 830 nm pumping and observed considerable up-conversion in blue along with the typical NIR emission. The up-conversion affects the emission at 1420 nm.

JTu5A.95 Blue Up-Conversion and Near Infrared (NIR) Emission of Bi/Er Co-Doped Fibre (BEDF) under 830 nm Pumping, Yanhua Luo, Binbin Yan, Armirhasan Zareanbodji, Mingjie Ding, Chang Wang, Jianxiong Wen, Xinhuo Sang, Janghui Wang, 1,2 Univ. of New South Wales, Australia; 1Donghua Univ., China; 2Beijing Univ. of Posts and Telecommunications, China, ‘Laser Ins. of Shandong Academy of Science, China; ‘Shanghai Univ., China. We investigated the spectroscopic properties of BEDF under 830 nm pumping and observed considerable up-conversion in blue along with the typical NIR emission. The up-conversion affects the emission at 1420 nm.

JTu5A.96 High-Repeat-Rate Dynamic Polarization Mode Dispersion Characterization Based on Linear Optical Sampling, Shuai Wang, Kunyi Fan, Qingwen Liu, Zuyan He, Shanghui Jiao, Jilong Long, Univ. China. We demonstrate a method to measure the polarization mode dispersion using linear optical sampling with a high repetition rate of 156 kHz. The dynamic PMD of a 42 km field installed fiber link has been precisely characterized with 25 Ga’s ultrashort pulses.

JTu5A.97 136 fs, 6 nJ thulium-based all-fiber CPA system, Zhihong Wang, Shuangchen Ruan, Richard Howe, Guohua Hu, Zhipin Sun, Tawfique Hasan, College of Optoelectronic Engineering, Shenzhen Univ., China; ‘Cambridge Graphene Centre, University of Cambridge, UK; ‘Dept. of Micro- and Nanosciences, Aalto Univ., Finland. We demonstrate a simple and compact, all-fiber-thulium-based CPA system, delivering 136 fs pulses with ~6 nJ energy at 50.8 MHz pulse repetition rate.

JTu5A.98 Anisotropic Anti-resonant Elements gives Broadband Single Mode Low-loss hollow-core Fibres, Xiaotian Steve Yao, 1 College of Optoelectronic Engineering, University of Technology, Poland. We theoretically demonstrated the spectroscopic properties of BEDF under 830 nm pumping and observed considerable up-conversion in blue along with the typical NIR emission. The up-conversion affects the emission at 1420 nm.

JTu5A.99 Anisotropic Anti-resonant Elements gives Broadband Single Mode Low-loss hollow-core Fibres, MD Selim Habib, Ole Bang, Morten Bache, 1 DTU Fotonik, Dept. of Photonics Engineering, Technical Univ. of Denmark, Denmark. Hollow-core fibers with node-free anisotropic anti-resonant elements give broadband low-loss fibers that are also single-mode. At 1.06 μm silica-based fiber designs show higher-order-mode extinction >1000 and losses below 10 dB/km over a broad wavelength range.

JTu5A.100 Dual-parameters Measurement With Enhanced Sensitivity By Introducing Higher-order Interference Modes Using Twisted Multimode Fiber, Yuan Sun, 1 Ping Li, 2 Shun Wang, 2 Deming Liu, 1 HUST, China. We proposed a novel scheme for fiber sensors, which promises measurement strain and temperature with high sensitivity by introducing higher-order modes interference in a single-mode-twisted-multimode-single-mode(STSMS) structure. The strain and temperature sensitivity reach -14.2 pm/με and 28.61 pm/°C, respectively.

JTu5A.101 Withdrawn.
making it attractive to characterize Bragg fibers non-invasively.

The tuning pattern is very sensitive to Bragg layers’ configuration, dispersion among supermodes. Using this technique a number of pertinent geometrical configurations such as hollow core tube lattice fibers. Distortions cause birefringence as large as 4.2×10-4, which effectively reduces a high-birefringent microstructured optical fiber for surface wave generation in Normally Dispersive Optical Fibers.

We present a study of chromatic dispersion fluctuation in Normally Dispersive Optical Fibers, Javier Nuño del Campo, Marn Gilles, Massimiliano Guasoni, Julien Fatome, Laboratoire Interdisciplinaire Carnot de Bourgogne, UMR 6633 CNRS - Université Bourgogne Franche-Comté, France. We report a novel method for sampling and amplifying a nanosecond signal based on the combined effects of normal chromatic dispersion and cross-phase modulation induced by high repetition rate sinusoidal and orthogonally polarized pump wave.

A multi-core fiber for exploiting higher-order modes dispersion for application in mid-IR supercontinuum generation, Deepak Jain, Christos Markos, Treveor Benson, Angela Seddon, Ole Bang, DTU Fotonic, Technical Univ. of Denmark, Denmark.

We propose modified Lyot filters and Technology, China. We demonstrate a backward-pumped 1550 nm EDF amplifier with ASE suppression by cladding feedback. Compared with the typical backward-pumped amplifier without feedback, the ASE power can be suppressed by over 2 dB without other filters.

Dishing tuning, polarization-maintaining picosecond figure eight fiber laser, Yasuyuki Ozeki, Tomoki Fukazawa, Dept. of Electrical Engineering and Information Systems, Univ. of Tokyo, Japan; Dept. of Electrical and Electronic Engineering, Univ. of Tokyo, Japan. We present an environmentally-stable Er-fiber oscillator generating 30-MHz pulses with a tunability of as wide as 40 nm. Within the tuning range, the pulses have a duration of ~1 ps and time-bandwidth product of <0.4.

Amplification Technique Based on XPM-Induced Frequency Splitting in Normally Dispersive Optical Fibers, Javier Nuño del Campo, Marn Gilles, Massimiliano Guasoni, Julien Fatome, Laboratoire Interdisciplinaire Carnot de Bourgogne, UMR 6633 CNRS - Université Bourgogne Franche-Comté, France.

M-type fiber for exploring higher-order modes dispersion for application in mid-IR supercontinuum generation, Deepak Jain, Christos Markos, Treveor Benson, Angela Seddon, Ole Bang, DTU Fotonic, Technical Univ. of Denmark, Denmark.

Analysis of the Impact of Structural Distortions on the Hollow Core Tube Lattice Fibers Performance, Luca Vincetti, Univ. Modena and Reggio Emilia, Italy.

We present a study concerning the structural distortions effects on the performance of hollow core tube lattice fibers. Distortions cause an enhancement of the coupling with cladding modes with detrimental effects on the confinement loss.

The suppression of chromatic dispersion fluctuation in chalcogenide hybrid microstructured optical fibers and their parametric amplitude performance, Huang Tian Tong, Zhihong Lin, Jordan Nogaski, Takesubu Suzuki, Yasutake Sashi, Optical Functional Materials Lab, Toyota Technological Inst., Japan. New chalcogenide hybrid microstructured optical fibers with second cladding layers were proposed to suppress the fluctuation of near-zero and flattened chromatic dispersion and the fluctuation of broad FOPA gain spectra caused by the fiber structure fluctuation.

High-Birefringent Microstructured Optical Fiber Based Surface Plasma Resonance Sensor, Mengying Zhang, Hao Ye, Hui Wang, Ping Shen, Zhiqiang Wang, Zouhai Wang, Key Laboratory of Optoelectronic Technology, Ministry of Education, China.

Backward-pumped 1550 nm EDF amplifier with ASE suppression by cladding feedback, Xiaobai Bai, Haiwei Zhang, Quan Sheng, Shijie Fu, Zhaohui Xie, Wei Shi, Jianquan Yao, Tianjin Univ., China. We demonstrate a backward-pumped 1550 nm EDF amplifier with ASE suppression by cladding feedback. Compared with the typical backward-pumped amplifier without feedback, the ASE power can be suppressed by over 2 dB without other filters.

We present a study of chromatic dispersion fluctuation in Normally Dispersive Optical Fibers, Javier Nuño del Campo, Marn Gilles, Massimiliano Guasoni, Julien Fatome, Laboratoire Interdisciplinaire Carnot de Bourgogne, UMR 6633 CNRS - Université Bourgogne Franche-Comté, France.

Novel all-fiber comb-like filters based on circular polarization interference, Xuewen Shu, Huazhong Univ of Science and Technology, China. We propose modified Lyot filters based on circular polarizers, which have comb-like transmission with intrinsically high spectrum modulation depth and can significantly simplify the fabrication process compared with conventional Lyot filters based on linear polarizers.

We demonstrate a tunable dual-wavelength laser of 3.3 kHz linewidth stabilized by a microsphere resonator, and its wavelength could be linearly and continuously tuned within 0.13 nm by changing the pump power.

A Tunable and Switchable Dual-Wavelength Single-Longitudinal-Mode Fiber Laser at 2μm based on Saturable Absorber and Self-Injection Locking, Wei Yang, Ping Li, Shihan Jiang, Shun Wang, Deming Liu, Enqi Chen, Huazhong Univ. of Sci. and Tech., China; AdVAlux Photonics, USA. A 2 μm novel dual-wavelengt single-longitudinal-mode (SLM) fiber laser based on saturable absorber and self-injection locking which can ensure SLM operating stable is reported. The proposed configuration has ingenious and compact structure, and reliable performance.

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JTuA.131
Experimental demonstration of intermodal four-wave mixing by femtosecond pump pulses at 1550 nm, Jinhui Yuan, Zhe Kang, Xianting Zhang, Xindu Sang, Binbin Yan, Feng Li, Kuru Wang, Chongxu Yu, Hua Yaw Tam, P. K. A. War, Beijing Univ. of Posts and Telecom, China.

JTuA.132
Demonstration of a directly excited orbital angular momentum and wavelength tunable laser, Zhou Nan, Wuhan National Lab for Optoelectronics, China. A generated directly carrying orbital angular momentum laser is demonstrated in this paper. The technical charge number can vary from -10 to +10 and the laser wavelength can cover the C-band.

S&I 13: Active Optical Sensing

JTuA.133
Mitigation of Power Fading in fiber transmission by a Novel Multi-band CAP Signal Design, Quilin Zhang, CUMK, Hong Kong. We design a multi-band CAP signal using a bit loading algorithm. The transmission performance has been experimentally measured at 54 Gbit/s over 25 km.

JTuA.134
Trace Gas Detection Based on Multi-quartz-enhanced Photoacoustic Spectroscopy, Yufei Ma, Ying He, Xin Yu, Rui Sun, Frank Tittel, HARBIN Inst. of Technology, China.

JTuA.135
Full-range measurement and nonlinear sweep Compensation in SS-OCT using Digital Coherent Receivers, Takuma Shirahata, Shinji Yamashita, Research Center for Advanced Science and Technology, Univ. of Tokyo, Japan. We realized full-range measurement without mirror images and nonlinear sweep compensation simultaneously in SS-OCT system by digital coherent receiver for telecommunication. Imaging depth is improved from 0.7 mm to 3.6 mm with resolution of 8μm.

JTuA.136
Wide-range Liquid Level Fiber Sensor Based on Self-imaging Effect, Yanli Ran, Li Xia, Deming Liu, Hua Zhang, Univ. of Science & Technology, China.

JTuA.137
Single Nanoparticle detection using the dissipative interaction with a high-Q microcavity, Bo-Qiang Shen, Xiao-Chong Yu, Yanxian Zhi, Donghyun Kim, Ciquang Gong, Yunfeng Xiao, State Key Lab for Mesoscopic Physics and School of Physics, Peking Univ., China. Collaborative Innovation Center of Quantum Matter, China.

JTuA.138
Ultra-Sensitive CO₂ Fiber-Optic Sensors Enhanced by Metal-Organic Framework Film, Xinyun Chong, Ji-joong Kim, Erwen Li, Jinyang Zhang, Paul Ghodnikit, Chih-hung Chang, Alan X. Wang, Oregon State Univ., USA. We demonstrated an ultra-sensitive near-infrared (NIR) absorption CO₂ fiber-optic sensor at 1.57 μm wavelength enhanced by metal-organic framework. We achieved 20 ppm detection limit with only 5cm length with 500× NIR enhancement from the MOF film.

JTuA.139
High Resolution Temperature and Strain Discrimination by Using π-phase-shifted Fiber Bragg Grating on Polarization Maintaining Fiber, Jiachen Cheng, Qiangwen Liu, Xinyan Pan, Zuyuan He, State Key Lab of Advanced Optical Communication Systems and Networks, Shanghai Jiao Tong Univ., China. A high resolution temperature and strain discrimination scheme has been developed. Based on a π-phase shifted FBG on polarization maintaining fiber, resolutions of 0.003 °C and 0.05 με strain and shear are simultaneously achieved.

JTuA.140
Frequency Modulated Laser Based Interferometric Optical Gyroscope, Minh Tran, Santar Gundarapu, Michael Behl, Tin Komljenovic, Daniel Blumenthal, John E. Bowers, Electrical and Computer Engineering, Univ. of California Santa Barbara, USA. We report the performance of a high-speed frequency modulated laser based interferometric optical gyroscope. The motivation lies in the advantages of a laser based system enabled on advanced integrated optics. We show that this approach improves both angular random walk and bias stability.

JTuA.141
Gas Molecules Recognition via the Response Time of Silicon Nanoporous Ring Resonator, Gong Zhang, Xueling Feng, Hong Cai, Yuqiong Gu, Junfeng Song, Lip Kei Chin, Chenzhang Yan, Bo Liedberg, Ai-Gun Liu, School of Electrical and Electronic Engineering, Nanyang Technological Univ., Singapore. An electric photonic sensor for recognition of different gas molecules by measuring the response time of ring resonator is presented. The response time constant of various gas molecules is distinctive and ideal for recognition with high specificity, overcoming the limitations of conventional methods.

JTuA.142
Real-time Trace Gas Sensor Using a High-power, Multi-mode Diode Laser and Cavity Ring-down Spectroscopy, Gopi Pattri N. Rao, Andreas Kerp, Yuhao Qiao, Adelphi Univ., USA. Abstract. A simple ultra-sensitive real-time gas sensor using a multi-mode Fabry-Perot diode laser and cavity ring-down spectroscopy has been developed to detect NO, with a single shot sensitivity of 350 ppt in 60 μs.

JTuA.143
Simple and Precise Measurement of Dynamic Displacement for More-Than-10-MHz Vibration, Yosuke Tanaka, Takamasa Ito, Ryoasuke Kimura, Koki Tsuchiya, Takashi Kurokawa, Tokyo Univ of Agriculture and Technology, Japan. We demonstrate a simple and precise measurement system of dynamic displacement for more-than-10-MHz high-frequency vibration. An interferometer using high-frequency phase modulation and simple data processing achieved a small error of better than 0.7 nm.

JTuA.144
Pressure Sensor using Vertical Coupling of Optical Waveguides, Sunjay Park, Jin Tae Kim, SeokNam Nam, Bong Je Park, Sungryul Yoo, Seung Koo Park, Ki-Uk Kyung. Electronics and Telecom Research Inst, Korea. We proposed a pressure sensor based on two optical waveguides to be coupled vertically. The sensor operates by the change in the coupling constant between the waveguides when a pressure is applied to them. We designed and realized the sensor by using of polymer and PDMS.

JTuA.145
A Novel Approach of LMR/MIP for Optical Fiber based Salivary Cortisol Sensor, Bashi D. Gupta, Sudhi P. Usha, Anand M. Shirivastava, Indian Inst. of Technology, Delhi, India. A novel fiber optic sensor for salivary cortisol sensing in 0 to 10 ng/ml concentration range is fabricated and characterized using LMR/MIP techniques. The sensor possesses maximum sensitivity of 6.47 nm/g/ml for 10 ng/ml.

JTuA.146
Optical sensors from electrohydrodynamically jetted polymer fiber resonators, Fabrice R. Laye, Sarah Krasmer, Alejandro Castilla, Felix Friedrich, Christoph Vannahmer, Cameron L. Smith, Ana C. Mendez, Ioannis Chronakis, Anders Kristensen, Joerg Lahmann, Heinz Kalt, Karlsruhe Inst. of Technology, Germany. Technical Univ. of Denmark, Denmark. Univ. of Michigan, USA. Electrohydrodynamic jetting is used to manufacture dye-doped polymer fiber resonators. We present comb-like laser emission from different polymer dye combinations and report the use of these structures as sensitive detection of ethanol and methanol.

JTuA.147

JTuA.148
Stability of Optical Trajectories in Rotationally Asymmetric Multipass Cells, Galen H. Harden, Luis E. Cortes-Herrera, Anthony J. Hoffman, Univ. of Notre Dame, USA. Physics, Tecnologico de Monterrey, Mexico. We simulate the stability of optical trajectories in rotationally asymmetric cavities for use as multipass cells in absorption spectroscopy and demonstrate that these cells compare favorably to the current state-of-the-art multipass cells.
Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
Wednesday, 8 June

FW1A 10:00-10:15

FW1A.1 10:00

Unveiling the Propagation Dynamics of Self-Accelerating Vector Beams, Jonathan Bar-David, Noa Veloch Bloch, Noa Mazurski, Uriel Levy, Applied physics, Hebrew Univ. of Jerusalem, Israel. We report a theoretical and experimental study of the propagation and polarization dynamics of a radially polarized Airy beam. We show that as the beam propagates beyond a perturbation the spatial polarization structure is reconstructed.

FW1A.2 10:15-10:30

Nondiffracting Accelerating Beams on Spherical Surfaces, Anatoly Patsyk, Rivka Bekenstein, Miguel A. Bandres, Technion-Israel Inst. of Technology, Israel. We introduce nondiffracting accelerating beams propagating on spherical surfaces. We find close form-solutions to the wave equation, and demonstrate their non-geodesic propagation dynamics in experiments.

FW1A.3 10:30-10:45

Ultrafast Non-Paraxial Abruptly Autofocusing Pulses for High-Gradient Electron Acceleration, Liang Jie Wong, Ido Kaminer, SIMTech, Singapore; MIT, USA. We present ultrafast non-paraxial autofocusing pulses that exhibit abrupt, ultra-intense focusing in both space and time. We demonstrate their ability to linearly accelerate electrons with effective gradients exceeding 300 GeV/m, and explore different operation regimes.

FW1A.4 10:45-11:00

Nonlinear Optics Phenomena in Laser-Cooled Atoms at Ultralow Powers via an Optical Nanofiber, Ravi Kumar, Vandra Gokhale, Viet Giang Truong, Site Nic Chormaic, Okinawa Inst of Science & Technology, Japan. We report on 2-photon excitation processes in laser-cooled 87Rb that yields nonlinearity, an isolation exceeding 20dB is experimentally observed with pulsed inputs.

FW1A.5 11:00-11:15

Monolithically Integrated Unidirectional Circulators Utilizing non-Hermiticity and Nonlinearity on InP, Parinaz Aleahmad, Mercedes Khajavikhan, Patrick L. LKamWa, Demetrios N. Christodoulides, Univ. of Central Florida, CREOL, USA. We demonstrate unidirectional monolithically integrated 4x4 optical circulators operating at 1.55 μm on InP. By exploiting the interplay between non-Hermiticity and nonlinearity, an isolation exceeding 20dB is experimentally observed with pulsed inputs.

FW1B 10:00-10:45

FW1B.1 10:00

Hot-carrier mediated photon upconversion in metal-semiconductor heterostructure, Gururaj V Naik, Jennifer Dione, Stanford Univ., USA. We experimentally demonstrate a new photon upconversion technique based on hot-carriers in plasmonic systems. We show that silver nanostructures on GaN/InGaN multiquantum well can upconvert ~2.48 eV photons to 2.82 eV photons via a linear process.

FW1B.2 10:15

Tailoring Spontaneous Parametric Downconversion in Hyperbolic Metamaterials, Artur Davoyan, Harry Atwater, Thomas J. Watson Labs of Applied Physics, California Inst. of Technology, USA; Kavli Nanoscience Inst., California Inst. of Technology, USA. We study theoretically spontaneous parameteric downconversion in nonlinear hyperbolic metamaterials and reveal that a strong enhancement of downconverted photon generation is possible due to the hyperbolic dispersion and modified optical density of states.

FW1B.3 10:30

Mid-Infrared Second Harmonic Spectroscopy Probing Surface Phonon Polariton Localization in SiC Nanopillars, Alexander Paarmann, Ilya Ryndyk, Joshua Caldwell, Alexander Giles, Vivien Giammin, Sandy Gewinner, Wieland Schoellkopf, Martin Wolf, Fritz Haber Inst. of the Max Planck Society, Germany; U.S. Naval Research Lab, USA; Imperial College London, UK. We experimentally demonstrate mid-infrared second harmonic generation frequency-domain spectroscopy as a novel, highly sensitive approach to investigate the degree of sub-wavelength localization of surface phonon polaritons in SiC nanopillars.

FW1B.4 10:45

Nonlinear Refractory Plasmonics with TiN Nanoantennas, Lili Gui, Heiko Linnenbank, Shahin Baghni, Nikolai Strohfeldt, Christine M. Zgrabiak, Bernd Metzger, Mario Hentschel, Evelyn L. Hui, Harald Giessen. The Max Planck Society, Germany; 2School of Engineering and Applied Sciences, Harvard Univ., USA; 3U.S. Naval Research Lab, USA. TIN is a novel refractory plasmonic material which can sustain high temperatures and exhibits large optical nonlinearities. We present for the first time second harmonic spectroscopy of TIN nanopillar arrays resonant at about 1000 nm.

FW1C 10:00-10:45

FW1C.1 10:00

Superconducting Nanowire Single-Photon Detectors and Nanowire-Based Superconducting On-Chip Electronics, Karl Berggren, Lucy Archer, Francesco Bellei, Nicolo Calandrini, Andrew Dane, Adam McCaughan, Emily Toomey, Qingsyang Zhao, Di Zhu, MIT, USA. We developed waveguide integrated nanowire detectors, a distributed readout nanowire imager, and three-terminal electrical devices. The combination of these technologies promises a significant advance in the state of the art of nanowire superconducting detectors.
Dilectric Metasurfaces for Polarization Selective Beam Shaping. Boris Desiatov1, Naor Mazurko1, Yeshiahu Fanman1, Uziel Levy1; "Hebrew Univ of Jerusalem, Israel; "Univ. of California, San Diego, USA. We experimentally demonstrate the capability of dielectric metasurfaces in silicon to perform arbitrary polarization selective beam shaping.

We experimentally demonstrate, for the first time, waveguiding using artificial gauge fields. We use a system of waveguide arrays where the gauge field, arising first time, affects transversal dynamics and generates guided modes.

Photonic realization of topologically protected bound modes. We then numerically corroborate the applicability of this theory for 3D structures. We present an analytical theory of 2D topologically protected guided photonic modes for continuous periodic dielectric structures, modulated by a domain wall. We then numerically corroborate the applicability of this theory for 3D structures.

Photonic topological insulator emulating the quantum spin Hall effect is employed to demonstrate a soliton pulse from a CaF2 microcavity. We fabricated a dispersion controlled CaF2 cavity and also numerically developed a method to generate soliton pulses without sweeping the input laser.

Andrew Weiner, the Scifres Family Distinguished Professor of Electrical and Computer Engineering at Purdue University, is best known for pioneering work on programmable femtosecond pulse shaping and ultrafast signal processing. Weiner is a member of the National Academy of Engineering and recipient of numerous awards, including The Optical Society's Wood Prize and the IEEE Photonics Society Quantum Electronics Award. He is author of the textbook Ultrafast Optics and serves as Editor-in-Chief of Optics Express.
technology base. Optoelectronics and high-technology applications and is fluidics and biopolymer based photonics. The laboratory has Omenetto’s research is heavily focused on interdisciplinary
ment of Physics and the Department of Electrical Engineering. Tufts University. He also holds appointments in the Depart-
ment of Electrical Engineering, and a Professor of Biomedical Engineering at

Fiorenzo G. Omenetto is the Frank C. Doble Professor of Engineering, and a Professor of Biomedical Engineering at Tufts University. He also holds appointments in the Department of Physics and the Department of Electrical Engineering.

Omenetto’s research is heavily focused on interdisciplinary themes that span nonlinear optics, nanostructured materials (such as photonic crystals and photonic crystal fibers), optofluidics and biopolymer based photonics. The laboratory has pioneered the use of silk as a material platform for photonics, optoelectronics and high-technology applications and is actively investigating novel applications that rely on this new technology base.

He is a Fellow of The Optical Society, J. Robert Oppenheimer Fellow at the Los Alamos National Lab, and a Guggenheim Fellow.

Silk-based Materials for Technology at the Micro-and Nanoscale, Fiorenzo G. Omenetto1, Tufts Univ., USA. Bio-
materials offer opportunities for devices that operate at the interface of the biological and technological worlds. Devices such as silk-based photonic crystals, lasers, wireless antennas and resorbable electronics will be described as examples of the possibilities that this water-processed, biocompatible material offers.

SWIG.1 + 08:00 Tutorial

08:00–10:00
SWIG • Optofluidics I: Enabling Technologies
Presider: Andreu Llobera; Centre Nacional de Microelectronica, Spain

08:00–10:00
SWIH • Sensing with Frequency Combs I
Presider: Aleksandra Foltynowicz; Umea Univ., Sweden

08:00–10:00
SWII • Symposium for 20 Years of Photonic Crystal Fibres I
Presider: To be Determined

08:00–10:00
SWIH.1 + 08:00 Saturable Absorber Decouples Noise Stabilization in Dual-Comb ModeLocked Lasers, Sandro M. Link1, Cesare G. Alfieri2, Dominik Waldburger1, Matthias Golling2, Alexander Klenner1, Ursula Keller1, ETH Zurich, Switzerland. We present the stabilization and noise analysis of the pulse repetition rates of dual-comb mode-locked lasers using an intracavity birefringent crystal for polarization-duplexing to obtain simultaneous emission of two modelocked beams from the same cavity.

08:00–10:00
SW1H.2 + 08:15 Phase Noise-Induced Biases in Coherent Dual-Dual-Comb Spectroscopy, Gar-Wing Huang1, Kevin C. Cossell1, Eleanor Waxman1, Fabrizio Giorgetta1, Ian R. Coddington1, Nathan R. Newbury1, ‘National Inst. of Standards and Tech, USA. Dual comb spectroscopy is a promising technique for high accuracy measurement of trace gas concentrations. Here we study the impact of residual phase noise on the frequency combs on retrieved trace gas concentrations.

08:00–10:00
SW1H.3 + 08:30 Scan-less, Line-field, Confocal Microscopy Based on Dimensional-Conversion Optical Frequency Comb, Eiji Hase1, Shuji Miyamoto1, Yida Hase1, Takeo Minamikawa1, Hirotsugu Yamamoto1, Takeshi Yasui1, 2, The Univ. of Tokushima, Japan; 2, ERATO Intelligent Optical Synthesizer Project, JST, Japan; 3, Utsunomiya Univ., Japan. Dimensional-conversion optical frequency comb (OFC) is proposed to explore new applications of OFC. Combination of OFC with the wavelength/space conversion enables us to establish both confocal imaging and full-field imaging under the scan-less condition.

08:00–10:00
SW1H.4 + 08:45 Non-scanning three-dimensional imaging using spectral interferometry with chirped frequency comb, Takashi Kato1, Megumi Uchida1, Kaoru Minoshima1, 2, The Univ. of Electro-Communications, Japan; 2, JST, ERATO Intelligent Optical Synthesizer Japan. One-shot 3D imaging method with a chirped frequency comb was demonstrated using 2D pulse-to-pulse spectral interferometry. A step-height was measured with 6.1-µm uncertainty, currently limited by the detection system. The method has large dynamic-range with high precision.

08:00–10:00
SW1H.5 + 09:00 Dual-Optical-Comb Spectroscopic Ellipsometry, Takeo Minamikawa1, Yida Hase1, Kyuki Shibuya1, Yoshiki Kanehara1, Sho Okubo2, Hajime Inaba2, Yasuhiro Mizutani3, Takeshi Yasui1, 2, The Univ. of Tokushima, Japan; 3, National Inst. of Advanced Industrial Science and Technology, Japan; 2, ERATO Intelligent Optical Synthesizer Project, Japan; 3, Osaka Univ., Japan. We proposed spectroscopic ellipsometry employing dual-optical-comb spectroscopy. We demonstrated the ellipsometric evaluation of a high-order waveplate and a SiO2 thin film standard with the ultrahigh spectral resolution of 48 MHz.
Interferometric fiber-optic current sensor and its integration

We report on an

Fiber Laser Acoustic Emission Sensors,

provide robust ppm sensitivity with distributed detection

AW1J.1 • 08:00  Gas Sensing with Hollow Core Fiber for Leak Detection and Localization, William A. Challener1, Niloy Choudhury1, Jason Karp1, Ansas M. Kasten2, Sabarni Palit3, Gary Pickrell3, Daniel Homa1, Adam Floyd2, Yuji Cheng3, Fei Yu1; GE Global Research, USA; 1Virginia Polytechnic Inst. and State Univ., USA; 2Univ. of Bath, UK. A gas sensor to detect and localize leaks is being developed. Periodically perforated hollow core fiber and tunable diode laser spectroscopy in the mid-IR can provide robust ppm sensitivity with distributed detection for many gases.

AW1J.2 • 08:30  Fiber-Optic Current Sensor in 420 kV Circuit Breaker, Klaus M. Bohnet1, Andreas Frank1, Lin Yang1, Georg M. Mueller1, Miklos Lenner3, Tomas Roininen3, Berkan Guelenaltin1, Philippe Gabuis1, Sergio V. Marchese1, Aleksandar Vujanic1, 1ABB Switzerland Ltd, High Voltage Products, Switzerland; 3Univ. of Alberta, Canada. A distributed feedback fiber laser and tunable diode laser spectroscopy in the mid-IR can provide robust ppm sensitivity with distributed detection.

AW1J.3 • 08:45  A temperature insensitive load sensor based on a dual loop optoelectronic oscillator, Yanhong Zhu1, Xiaofeng Jin1, Ximin Zhang1, Shilie Zheng1, Hao Chi1, Zhejiang Univ., China. A temperature insensitive load sensor based on a dual loop optoelectronic oscillator is proposed. The two loops, with one subjected to a load, have different oscillation frequencies but same temperature sensitivity so that load sensing can be achieved by interrogating their mixing frequency.

AW1J.4 • 09:00  Towards Attometer/Hz2/3 Displacement Resolution in DFB Fiber Laser Acoustic Emission Sensors, Geoffrey A. Cranch1, Lee Johnson1, Seth Heerschap2, Mark Seaver3, Gary Miller3, 1US Naval Research Lab, USA; 3Univ. Of Wisconsin Madison, USA. A distributed feedback laser fiber achieves a displacement resolution approaching 3 × 10^-15 m/Hz2/3 up to 10 MHz (~1000 more sensitive than the current state-of-the-art). Detection of acoustic emission from cracks induced in fatigue lap joints is demonstrated.

AW1K.1 • 08:00  Highly Efficient Hybrid Quantum Dot White Light Emitting Diodes with Prolonged Lifetime, Shun-Chieh Hsu1, Yun-Han Jheng1, Hau-Vei Han1, Hao-Chung Kuo1, Chien-Chung Lin1, 1Naf Chiao Tung Univ, USA. A white LED is demonstrated by incorporating three kinds of colloidal quantum dots and sodium chloride. Further lifetime tests show great stability up to 146 hours under 203.4 mW/cm2 of blue pump power.

AW1K.2 • 08:15  Unraveling Exciton Kinetons of Electroluminescence in Colloidal Quantum Dot LEDs, Sudarshan Shendre1, Cuong H. Dang1, Hilm V. Demir2,3, 1LUMINOUS! Centre of Excellence for Semiconductor Lighting and Displays, School of Electrical and Electronic Engineering, Nanyang Technological Univ., Singapore; 2Dept. of Electrical and Electronics Engineering and Dept. of Physics, UNAM−Inst. of Materials Science and Nanotechnology, Bilkent Univ., Turkey. We systematically studied emission kinetics of colloidal quantum dots in active light-emitting diodes using time-correlated single photon counting and conclusively revealed the combined effect of both electric field and charging acting together in reducing the quantum efficiency during operation.

AW1K.3 • 08:30  GaN-Based Stress-Induced Bandgap Widening with Various Arrangements of Patterned Sapphire Substrates, Vin-Cent Su1, Po-Hsuan Chen1, Yen-Pu Chen1, Ming-Lun Lee1, Tai-Cheng Hsu1, Yu-Yao Lin2, Ray-Ming Lin2, Chieh-Hsiung Kuan1, 1National Taiwan Univ., USA; 2Epistar Corporation, Taiwan; 3Chang Gung Univ., Taiwan. Further by varying the arrangements of patterned sapphire substrates, the stress-induced bandgap widening of GaN-based epitaxial layers can be acquired. Photoluminescence and Raman results demonstrate a linear relationship of blue-shift with the increase of residual stress.

AW1K.4 • 08:45  Photon Management using Index-Near-Zero Materials, Zhu Wang1, Zongfa Yu2, 1Univ. of Wisconsin Madison, USA. Index-near-zero materials can strongly enhance light-matter interactions. The performance of light trapping greatly exceeds the conventional Yablonovitch limit. Moreover, index-near-zero materials suppress radiative recombination, resulting in enhanced open circuit voltage in direct bandgap solar cells.

AW1K.5 • 09:00  Bio-inspired Design Strategy of Quasi-random Structures for Optimal Light Control, Chen Wang1, Shuangcheng Yu1, Binqin Dong1, Yichi Zhang1, Zhen Jiang1, Xiangfan Chen1, Jian Zi1, Wei Chen1, Cheng Sun2; 1Physics, Fudan Univ., China; 2Mechanical Engineering, Northwestern Univ., USA. We report a new design strategy for quasi-random nanophotonic structures by directly representing structures in Fourier space. We validated the method both numerically and experimentally by optimizing light-trapping structures in a thin-film solar cell and achieved 2.3-fold absorption enhancement.

SW1L1 • 08:00  Terahertz Emission Imaging of the Selected Subcells Deep Inside Tandem Solar Cells, Shota Hamauchi1, yuji sakai1, toshihito umegaki1, Iwao Kawayama1, Akira Ito1, Hidetoshi Nakanishi1, hironaru murakami1, Masayoshi Tonouchi1, ILE, Osaka Univ., Japan; 1SCREEN Holdings Co., Ltd., Japan. We observed terahertz (THz) emissions from multi junction tandem solar cells while changing the wavelength of the excitation laser and could obtain THz images of individual subcells deep inside the tandem solar cells.
Photophysics of Organic-Inorganic Lead Halide Perovskites

Organometallic lead-halide perovskites find applications in optical and electronic devices due to their unique optical and electronic properties. In this talk, we will discuss the photophysics of these materials, focusing on their optical gain properties. We will present a novel approach to achieve spatially coherent near infrared lasing by optical pumping of a nanoporous GaN-based DBR system. This system forms a vertical cavity, which enables low threshold lasing with spectrally and temporally well-defined output. We will also discuss the impact of parasitic effects on the device performance and how these can be mitigated to achieve efficient and stable lasing at room temperature.
Brillouin Gain Spectra Measurement of Vector Modes in SW1P

via a long period fiber grating and the BGS acquired through heterodyne detection.

We propose and demonstrate parametric four-wave mixing in a few-mode Fiber, Prabin Pradhan¹, Dipankar Sengupta¹, Lixian Wang², Veronique Francois¹, Christine Tremblay¹, Sophie LaRochelle¹, Bora Ung¹; ¹Electrical engineering, Ecole de technologie superieure, Canada; ²Centre d’optique, photonique et laser (COP), Universite Laval, Canada. We report the Brillouin gain spectra (BGS) of vector modes in a gas-filled hollow-core PCF Pumped in the Deep Ultraviolet, David Novoa¹, Manoj K. Mridha¹, Sebastian T. Bauerschmidt¹, Philip S. Russell¹, Max Planck Inst. for the Science of Light, Germany. DUV-pumped hydrogen-filled kagomé-PCF displays coherent Raman gain suppression at much higher values of dephasing than for visible pumping. This will impair the performance of gas-based Raman amplifiers and lasers, especially at higher pump powers.

Octave-band tunable (0.74-1.99μm) optical vortex laser, Azziziali Abukelma¹, Taximari Yusufu², Roskaya Mamut³, Katsuhiko Miyamoto¹,², Takahige Onmatsu¹,²; ¹Chiba Univ., Japan; ²Xinjiang Normal Univ., China; ³Molecular chirality research center, Chiba Univ., Japan. We developed an octave-band (735nm-1893nm) tunable optical vortex laser based on a 0.532-μm optical vortex pumped LiB₃O₃, optical parametric oscillator. The optical vortex output pulse energy of 0.24-2.36 mJ was achieved.

Tunable, Continuous-wave, Doubly-resonant Vortex Beam Optical Parametric Oscillator, Aadih AI¹, Goutam Kumar Samanta¹, M Ebrahim-Zadeh², Chaitanya Kumar D. Suddapalli³,²; ²Physical Research Lab, India; ³ICFO, Spain. We report a continuous-wave, doubly-resonant optical parametric oscillator pumped with first-order vortex green beam, producing first-order vortex in the signal (949 5-1060nm), and corresponding idler, in Gaussian profile, with maximum power ~75mW and 165mW, respectively.

Octave-spanning Supercontinuum Generation in a Silicon-rich Nitride Waveguide, Xing Liu¹, Minhao Pu¹, Xinjiang Normal University, China; ²Xinjiang Normal Univ., China; ³Molecular chirality research center, Chiba Univ., Japan. We demonstrated an all-fiber supercontinuum laser source with high average power of 30.4 W and blue-enhanced spectrum mJ was achieved.

Octave-spanning Supercontinuum Generation in a Silicon-rich Nitride Waveguide, Aadih AI¹, Goutam Kumar Samanta¹, M Ebrahim-Zadeh², Chaitanya Kumar D. Suddapalli³,²; ²Physical Research Lab, India; ³ICFO, Spain. We report a continuous-wave, doubly-resonant optical parametric oscillator pumped with first-order vortex green beam, producing first-order vortex in the signal (949 5-1060nm), and corresponding idler, in Gaussian profile, with maximum power ~75mW and 165mW, respectively.

An All-fiber Supercontinuum Laser Source with High Power of 30.4 W and Ultra-wide Spectrum of 385-2400 nm, Xin Zou¹, Jian Wu¹, Xiaodong Wang¹, Jiang Qiu¹, Ziyi Ye¹, Chang Sun¹, Tingyu Ge¹, BUPIT, China; ²BUJT, China. We demonstrated an all-fiber supercontinuum laser source with high average power of 30.4 W and blue-enhanced spectrum ranging from 385 nm to 2400 nm, pumped by a picosecond ytterbium-doped fiber MOPA.

We report the Brillouin gain spectra (BGS) of vector modes in a few-mode fiber for the first time. Vector modes were excited via a long period fiber grating and the BGS acquired through heterodyne detection.

Parametric four-wave mixing in strongly driven Raman molecular gas, Aurelien Benoit¹, Benoît Beaudou², Benoît Debond³, Frédéric Grémé²,², Fetah Benabid¹,², ²GPPMM Group, Xlim Research Inst.; France; ³GLOPhotonics, France. We propose and demonstrate parametric four-wave mixing in a Raman active gas. Two lasers with a 1.7 THz frequency-difference in a strongly-driven Raman rotational-transition of D₂, generate sidebands with frequency-spacing equal to the lasers frequency-difference.

New Developments in the Physics of Ultrashort Light Propagation in Nonlinear Optical Fibers, Fabio Biancalana¹,²; Heriot-Watt Univ., UK. I will give an overview of recent new developments on short pulse propagation in solid and hollow core fibers: negative frequencies, temporal condensed matter physics and super-resonant radiations.

Light-activated artificial synapses based on graphene hybrid phototransistors, Shoucheng Lan¹, Xiaomu Wang¹, Benoit C. Devlin², Jie Chen², Linjun He³; ¹Yale Univ., USA; ²Univ. of Southern California, USA. We developed an interferometric spectroscopy and imaging technique to exploit the optical phase anisotropic properties of layered black phosphorus. The optical contrast is an order of magnitude larger than that with purely intensity-based measurements.

Optical characterization of van der Waals materials via near-field microscopy, Daniel Wintz¹, Alexander Y. Zhu¹, Ke Wang¹, Antonino Ambrosio¹, Robert C. Devlin², Jesse Crossno³, Kimi Kimif, Federico Capasso³; ¹John A Paulson School of Engineering and Applied Science, Harvard Univ., USA; ²Dept. of Physics, Harvard Univ., USA. We demonstrate a novel characterization method of van-de-Waals’ materials by performing near-field-microscopy of hexagonal-boron-nitride thin films on single-crystal silver. Beyond determining dispersion of optical modes, this technique also enables the direct study of light-matter interactions.

Optical Phase Anisotropy in Layered Black Phosphorus, Shoucheng Lan¹, Xiaomu Wang¹, Benoit C. Devlin², Jie Chen², Linjun He³; ¹Yale Univ., USA; ²Univ. of Southern California, USA. We developed an interferometric spectroscopy and imaging technique to exploit the optical phase anisotropic properties of layered black phosphorus. The optical contrast is an order of magnitude larger than that with purely intensity-based measurements.
Soliton Dynamics Captured with Real-time Spectroscopy, Two-Photon Luminescence of Single Gold Nanorods: Influence of the Rods Volume at a Given Plasmon Resonance, and Two-Photon Luminescence in Collodion Gold Nanorods, Investigated at the Single Level, is discussed: we show the existence of a specific volume maximizing the two-photon luminescence intensity.

FW1B.7 • 09:30
Phase Mask-Based Multimodal Superresolution Microscopy, Two-Photon Fluorescence Imaging and Speckle Imaging of a Reflective Optical Limiter, Which Transmits Low-Level Radiation and Offers Broadband Reflection for High-Intensity Beams. We report the first realization of a reflective optical limiter, which transmits low-level radiation while offering broadband reflection for high-intensity beams. The design consists of a nonlinear lossy defect embedded in a multilayer photonic structure.

FW1B.8 • 09:45

FW1C • Symposium on Advances in Single Photon Detection Technology I—Continued
FW1C.4 • 09:15
Ultrafast Thermal Nonlinearity, Specifically, We Observe Nonlinear Pulse Beatings and Identify Dynamics That Are Masked in Time-Averaged Locking with Real-Time Spectroscopy at 90MHz Frame-rate and We Resolve the Startup of Femtosecond Kerr-Lens Mode-locking and Transient Stages of Multi-soliton Operation.

FW1C.5 • 09:45
Ultra-narrow gating of InGaAs/InP SPAD for high-detection efficiency low-error-rate high-speed single-photon detection, This Work Shows That InGaAs/InP Single-Photon Avalanche Diodes (SPADs) Can Achieve High Count Rate (> 500 Mcps) and High Detection Efficiency (> 30 % at 1550 nm) When Operated with Sub-Nanosecond Gates.

**Executive Ballroom 210A**

**CIEO: QELS-Fundamental Science**

**FW1A • Accelerating Beams and Novel Phenomena—Continued**

**FW1A.6 • 09:15**
Ultrafast Thermal Nonlinearity, Jacob Khurgin, Gregory Sun, Wei Ting Chen, Wei-Yi Cai, Din Ping Tsai, Univer. of Massachusetts Boston, USA; John Hopkins Univ., USA; National Taiwan Univ., Taiwan. We show that when optical fields are plasmonically concentrated into the volumes on the scale of few tens of nanometers, the speed of the thermo-optical effects approaches picosecond scale, suitable for applications such as optical switching and routing.

**FW1A.7 • 09:30**
Experimental Realization of a Reflective Optical Limiter, Jarrett H. Vella, Elena Makri, John H. Goldsmith, Andrew T. Browning, Nicholas I. Limbenpoulous, Ilya Vitebskiy, Tsampikos Kottos, Wesleyan Univ., USA; Air Force Research Lab, Sensors Directorate, USA; Wyle, USA; SelectTech Services Corporation, USA. We report the first realization of a reflective optical limiter; which transmits low-level radiation while offering broadband reflection for high-intensity beams. The design consists of a nonlinear lossy defect embedded in a multilayer photonic structure.

**FW1A.8 • 09:45**
The Start of Femtosecond Mode-locking and Transient Soliton Dynamics Captured with Real-time Spectroscopy, Georg Herrin, Bahram Jalali, Claus Ropers, Daniel R. Solli, W. Physical Inst., Univ. of Goettingen, Germany; Dept. of Electrical Engineering, Univ. of California, Los Angeles, USA. We resolve the startup of femtosecond Kerr-lens mode-locking with real-time spectroscopy at 90MHz frame-rate and identify dynamics that are masked in time-averaged acquisition. Specifically, we observe nonlinear pulse beatings and transient stages of multi-soliton operation.

**Executive Ballroom 210B**

**FW1B • Nonlinear Plasmonics—Continued**

**FW1B.6 • 09:15**
Two-Photon Luminescence of Single Gold Nanorods: Influence of the Rods Volume at a Given Plasmon Resonance, Céline Molinaro, Sylvie Marguet, Ludovic Douillard, Fabrice Charra, Céline Fiorini-Debusschert, SPEC, CEA, CNRS, Université Paris Saclay, France; NIMBE, CEA, CNRS, Université Paris Saclay, France. The origin of the two-photon luminescence in collodion gold nanorods, investigated at the single level, is discussed: we show the existence of a specific volume maximizing the two-photon luminescence intensity.

**FW1B.7 • 09:30**
Phase Mask-Based Multimodal Superresolution Microscopy, Ryan Beams, Stephen J. Straniak, NIST, USA. We demonstrate a multimodal superresolution microscopy technique based on phase masked excitation and spatially filtered detection. We acquire two-photon fluorescent lifetime and second harmonic images of fluorophores mixed with gold particles with 100 nm resolution.

**FW1B.8 • 09:45**
Backward Phase-Matching in Negative-Index Materials, Shoufeng Lan, Lei Kang, David Schoen, Sean P. Roebuck, Yihong Cui, Albert Rosentrater, Yonghao Cui, Quantum Inst. NIST and Univ. of Maryland, USA. We experimentally demonstrate the nonlinear mirror effect in a negative-index medium using a waveguide configuration. This confirms for the first time a decade old prediction and expands the scope of nonlinear optics in artificially-structured media.

**Executive Ballroom 210C**

**FW1C • Symposium on Advances in Single Photon Detection Technology I—Continued**

**FW1C.4 • 09:15**
Short-gate Techniques for High-Speed Photon Counting with InGaAs/InP SPADs, Leonardo Ferrera, Alessandro Ruggeri, Federica Villa, Mirko Sanzaro, Mauro Buttafava, Niccolò Calandrini, Franco Zappà, DEIB, Politecnico di Milano, Italy. This work shows that InGaAs/InP Single-Photon Avalanche Diodes (SPADs) can achieve high count rate (> 500 Mcps) and high detection efficiency (> 30 % at 1550 nm) when operated with sub-nanosecond gates.

**FW1C.5 • 09:45**
Ultra-narrow gating of InGaAs/InP SPAD for high-detection efficiency low-error-rate high-speed single-photon detection, Alessandro Restelli, Joshua Bienfang, Joint Quantum Inst. NIST and Univ. of Maryland, USA. An InGaAs/InP SPAD is biased and readout using RF interferometry with frequency contents spanning four harmonics, resulting in high detection efficiency (>0.40) and ultra-low afterpulsing (< 0.008, even at detection rates up to 10^9 s^{-1}).
**Metacrystals**, Todd Van Mechelen1, Zubin Jacob2, 1Univ. of Alberta, Canada; 2Electrical and Computer Engineering, Purdue Univ., USA. We show the existence of an inherent handedness (spin) of evanescent-electromagnetic-waves which is fundamentally locked to the direction of propagation (momentum). It is universal and accompanies evanescent waves in total internal reflection, waveguides/fibers and surface-states.

**Hermitian Optical Materials**, Robust Light State by Quantum Phase Transition in Non-Hermitian optical systems to design novel robust light state. Compared to topological interface state, protected topological (SPT) state can be engineered in a microresonator pumped by a single laser. We study the RF interactions.

**All-Dielectric Three-Dimensional Photonic Topological Metacrystals**, Alexey Slobozhanyuk1, Hossein Mousavi2, Xiang Ni3, Daria A. Smirnova1; 1City Univ. of New York, USA; 2Nonlinear Physics Centre, Australian National Univ., Australia; 3Microelectronics Research Centre, Cockrell School of Engineering, Univ. of Texas at Austin, USA. We demonstrate that a symmetry protected topological (SPT) state can be engineered in a three-dimensional (3D) all-dielectric metacrystal where the electromagnetic duality between electric and magnetic fields is ensured by the meta-atoms design.
Each module has optofluidic elements that enable defining a powerful modular optofluidic systems (MOPS) toolbox for reconfigurable Photonic lab on a chip, Tobias N. Ackermann, Jordi Vila-Plana, Xavier Munoz-Berbel, Erica Alvarez-conde, Daniel Kopp, Hans Zappe, Andreu Llobera, Instituto de Microelectronica de Barcelona (IMB-CNM, CSIC), Spain, Department of Microsystems Engineering (IMTEK), Univ. of Freiburg, Gisela and Erwin Sick Chair of Micro-optics, Germany. A powerful modular optofluidic systems (MOPS) toolbox for reconfigurable Photonic lab on a chip is presented. Each module has optofluidic elements that enable defining advanced biophotonic systems.

**SW1H.6 • 09:15**
Bidirectional Kerr-lens mode-locked dual-comb ring laser, Takuro Ideguchi, Tsukku Nakamura, Yohei Kobayashi, Keisuke Goda, The Univ. of Tokyo, Japan. We demonstrate a bidirectional Kerr-lens mode-locked dual-comb ring laser for simple and robust dual-comb spectroscopy. Two mutually coherent combs with slightly different repetition rates emitted from the single cavity enables dual-comb spectroscopy without feedback control.

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**SW1H.7 • 09:30**
Dual-Comb Spectroscopy for Solid-State Physics and Extension toward Time-Resolved Measurement, Akihumi Asahara, Akiko Nishiyama, Satoru Yoshida, Ken-ichi Kondo, Yoshiaki Nakajima, Kaoru Minoshima, Univ. of Electro-Communications, Japan; Japan Science and Technology Agency, ERATO Intelligent Optical Synthesizer Project, Japan. Dual-comb spectroscopy was applied for characterization of complex refractive-index of a Si wafer and transient interferogram by optical excitation in an InGaAs-based saturable absorber. Full-characterization tool with wide dynamic-range in time- and frequency-domain is provided.

**SW1H.8 • 09:45**
Dual-Frequency Comb Spectroscopy: A Digital Solution for Coherent Averaging, Yuwei Jin, Simona M. Cristescu, Frans J. M. Harren, Julien Mandon, Radboud Universiteit Nijmegen, Netherlands. We present a dual-comb spectrometer in which a new digital solution allows long-time coherent averaging of molecular spectra without spectral distortion even when the combs are free-running and subject to frequency drifting and jittering.

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Executive Ballroom 210G

**SW1G • Optofluidics I: Enabling Technologies—Continued**

**SW1G.3 • 09:15**
Modular optofluidic systems: A toolbox for fast and simple assembly of a photonic lab on a chip, Tobias N. Ackermann, Jordi Vila-Plana, Xavier Munoz-Berbel, Erica Alvarez-conde, Daniel Kopp, Hans Zappe, Andreu Llobera, Instituto de Microelectronica de Barcelona (IMB-CNM, CSIC), Spain, Department of Microsystems Engineering (IMTEK), Univ. of Freiburg, Gisela and Erwin Sick Chair of Micro-optics, Germany. A powerful modular optofluidic systems (MOPS) toolbox for reconfigurable Photonic lab on a chip is presented. Each module has optofluidic elements that enable defining advanced biophotonic systems.

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**SW1G.4 • 09:30**
Detecting Single Molecule on Bioenabled Optofluidic Biosensors by Inkjet Printing, Xiaorong Kong, Yuting Xu, Paul Leduff, Ye Liu, Li-Jing Cheng, Gregory Romer, Alan X. Wang, Oregon State Univ., USA. We developed an innovative approach to continuously deliver picoliter volume droplets onto bioenabled optofluidic biosensors. The ultra-hydrophilic diatom surface concentrates molecules in the solution as the solvent evaporates, which enables single molecule detection by SERS.

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**SW1G.5 • 09:45**
Compressive Optical Imaging Using a Multi-core Fiber and Spatially Dependent Scattering, Jaewook Shin, Bryan Bosworth, Mark A. Foster, Johns Hopkins Univ., USA. We demonstrate two-dimensional compressive image reconstruction from spatially-encoded illumination patterns generated by spatially-dependent scattering from a ground glass diffuser at the distal end of a multi-core fiber.
Multi-tapered fiber device integrated with ferrofluid is proposed for the measurement of weak magnetic field. Wavelength sensitivity of -87.7 pm/mT has been obtained for the magnetic field intensity range of 2.5 to 25 mT.

We present an experimental demonstration of coherent beam combining (CBC) with a two-dimensional conformal fiber laser array utilizing homemade adaptive fiber-optics collimator (AFOC) based on flexible hinges with simultaneous end-cap/tilt control and phase-locking control.

We report a tunable continuous-wave and Bi$_2$Te$_3$ Q-switched Er$^{3+}$:ZBLAN fiber laser, based on a volume Bragg grating (VBG), which demonstrates that VBGs exhibit great potential in wavelength selection for applications in mid-infrared tunable laser sources.

A handheld, battery-powered intracavity singly resonant optical parametric oscillator (IC-SRO) emitting 3.5 μm, 39 mW CW radiation is demonstrated. The lasing threshold of the IC-SRO (end-pumped by a 808 nm diode) is 120 mW.

A multi-tapered fiber device integrated with ferrofluid is proposed for the measurement of weak magnetic field. Wavelength sensitivity of -87.7 pm/mT has been obtained for the magnetic field intensity range of 2.5 to 25 mT.
SW1M • Novel Material Lasers—Continued

Plasmon-Enhanced Electrically Pumped Random Lasing in ZnO Metal-Semiconductor-Metal Devices, Mohammad Z. Suja1, Bishwajit Deb Nath1, Sunayna Binte Bashar1, Roger Lake1, Jianlin Liu1; Electrical and Computer Engineering, Univ. of California, Riverside, USA. Plasmonic enhancement in random lasing is realized from ZnO metal-semiconductor-metal devices. The output power of random laser is increased while lasing threshold is decreased after Ag nanoparticles are incorporated on ZnO film due to plasmonic coupling.

SW1M.5 • 09:15

Electrically Pumped Whispering Gallery Mode Lasing from Au/ZnO Microwire Schottky Junction, Sunayna Binte Bashar1, Mohammad Z. Suja1, Chunxia Wu1, Hao Tian1, Wen-hao Shi1, Jianlin Liu1; Electrical and Computer Engineering, Univ. of California, Riverside, USA. Whispering gallery mode lasing has been realized from Au-ZnO hexagonal microwire Schottky diode. Electroluminescence characterization demonstrates ultraviolet lasing at room temperature with moderate threshold and high quality factor.

SW1M.6 • 09:30

Electrically Pumped Whispering Gallery Mode Lasing from Au/ZnO Microwire Schottky Junction, Sunayna Binte Bashar1, Mohammad Z. Suja1, Chunxia Wu1, Hao Tian1, Wen-hao Shi1, Jianlin Liu1; Electrical and Computer Engineering, Univ. of California, Riverside, USA. Whispering gallery mode lasing has been realized from Au-ZnO hexagonal microwire Schottky diode. Electroluminescence characterization demonstrates ultraviolet lasing at room temperature with moderate threshold and high quality factor.

FW1N • Probing Electrons, Excitons, Phonons and their Interactions—Continued

Coherent Multimode Electron-Phonon Coupling Dynamics, Aaron Runy1, Shayne Sorenson1, Eric Driscoll1, Jahan Dawlaty1; Univ. of Southern California, USA. Upon non-resonant ultrafast pumping of a charge-transfer molecular material, at least two phonons dynamically couple to electron transfer transitions. This coupling mechanism provides insight into multi-mode electron-phonon coupling in both organic and inorganic solids.

FW1N.6 • 09:15

Amplification of Coherent Sub-Terahertz Phonons by Interaction with Drift Currents in a Semiconductor Superlattice, Keisuke Shinokita1, Klaus Reimann1, Michael Woerner1, Thomas Elsaesser1, Rudolf Hey1, Christos Fytianis1; Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie, Germany; Paul-Drude-Institut für Festkörperphysik, Germany; Laboratoire Pierre Aigrain, École Normale Supérieure, France. Femtosecond pump-probe experiments demonstrate a strong amplification of optically generated coherent phonons by interaction with an intra-miniband current in a biased semiconductor superlattice. Electron-phonon coupling predominantly occurs via the acoustic deformation potential.

FW1N.7 • 09:30

Optical Control of the Optical Spin Hall Effect, Rolf Binder1, Ombline Lafont2, Samuel Ming Ho Luk1, Przemyslaw Lewandowski1, Nai H. Kwong1, Chris Ka Pang Chan1, Martin Babilon1, Ping-tung Leung1, Elisabeth Galopin2, Anstide Lemaitre1, Jerome Tignon2, Stefan Schumacher3, Emmanuel Baudin2; 1Univ. of Arizona, USA; 2École Normale Supérieure, France; 3Univ. of Paderborn, Germany; 4Chinese Univ. of Hong Kong, Hong Kong; 5CNRS, France. The optical spin Hall effect results in a spatial texture in the pseudo-spin of exciton polaritons in semiconductor microcavities. Using circular pump polarization, we demonstrate theoretically and experimentally that this pattern can be optically controlled.
associated with fiber lasers.

Feedback mechanism. Such lasers demonstrate great stabil-
in telecom wavelengths, stemming from a natural thermal
demonstrate an inherently self-stable Brillouin fiber laser
lengths by cascaded degenerate four-wave mixing,

Yuan

Generation of spectrally-isolated violet to blue wave-
short-pulse pumped OPAs. The photon-phonon coupling in

Kong Polytechnic Univ., China.

Lasing frequency self-stabilization in Brillouin Fiber Lasers,

Doping concentration and mode/wavelength
configuration of intermodal Raman scattering are investigated
for few-mode distributed Raman amplifier. The modal gain
equalization and noise figure are optimized for four mode-
groups resulting in mean gain of 14.7 dB.

Continued

Lasing frequency self-stabilization in Brillouin Fiber Lasers,

We demonstrate an inherently self-stable Brillouin fiber laser
in telecom wavelengths, stemming from a natural thermal
feedback mechanism. Such lasers demonstrate great stabil-
ity which significantly overcomes the hampering drift often
associated with fiber lasers.

Continued

Influence of Intrinsic Phonon Modes in Nonlinear Optical
Crystals on the Performance of Ultrafast Frequency Conver-
sion Devices, Oleksandr Ivanenko, Istvan Robe, Los Alamos
National Lab, USA. We demonstrate that coherently-excited
Raman-/IR-active phonons in certain nonlinear optical crystals
(KTiOPO4, KTiOAsO4) significantly affect operation of ultra-
short-pulse pumped OPAs. The photon-phonon coupling in
these materials leads to non-instantaneous, pump-dependent
2\textsuperscript{nd}-order susceptibility.

Nonlinear Fiber Optics—

Kosmas Kasparian, Valentina Shumakova, Skiri-
ning, The Chinese Univ. of Hong Kong, Hong Kong; 2Dept.
of Chemistry, Univ. of Tokyo, Japan.

We report the design
and fabrication of a graphene-on-silicon nitride microring
resonator to achieve the optimized optical absorption. The
electric conductivity, HV discharge triggering and guiding
resonator to achieve the optimized optical absorption. The
electric conductivity, HV discharge triggering and guiding

We demonstrated that depositing HfO
film on graphene nanoribbons greatly enhance the mobility
through weakening the Coulombic interactions. As a result,
the graphene nanoribbon photodetectors with HfO
layer exhibits high responsivity of ~0.4 A/W at room temperature.

2D Materials and Devices—

Room-temperature Mid-infrared Photodetector via Hybrid
Graphene Nanoribbon-C

We demonstrate that the photoluminescence emission intensity of the
CVD-grown MoSe
monolayers can be effectively enhanced
more than 30 times after a simple hydrohalic acid treatment,
providing the cost-effect manufacturing of atomically-thin
two-dimensional semiconductor materials.

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
A&T 1: Biomedical Applications

JW2A.1
500mW 930nm femtosecond Nd: Fiber laser for two-photon microscopic imaging, Bingying Chen1, Amim Wang1, Yudi Wang1, Yijun Li1, Zhengang Zhang1, Peiking Univ., China. We demonstrate a chirped pulse amplifier based on a W-type Nd-doped silicate glass fiber. The system delivers 500 mW 220-fs pulses at 930 nm.

JW2A.2
Adaptive selection of illumination based on 3D Fourier ptychography, Linjing Zhu1, Shengqiang Chang1, Jing Liu1, Anpu Chen1, Siqi Liu1, Hayu Zhang1, Fei Yuan1, Zhenrong Zheng1, Zhejiang Univ., China. Based on 3D Fourier ptychography imaging technique, adaptive selection of illumination utilizing the relationship between Fourier spectrum and illumination angle is proposed. The method reduces almost 50% computational work and accelerates the imaging reconstruction without loss of image quality.

JW2A.3
A Coded Illumination Scheme for Single Exposure (Instantaneous) Multispectral Imaging, Karolina Dorozynska1, Elias Kristensson1, Lund Univ., Sweden. We present the development of an instantaneous multispectral imaging technique exploiting spatially modulated light. Each encoded excitation source produces an image with a predefined position in the Fourier domain, allowing them to be separated computationally.

JW2A.4
Double-layered photonic crystal slabs with guided-mode resonance as a high-sensitivity biosensor and application for single nanoparticle detection, Huiying Tian1, Jian Zhou1, Lijun Huang1, Zhangyuan Fu1, Fujun Sun1, Beijing Univ of Posts & Telecom, China. Double-layered guided-mode resonance (GMR) biosensor is designed to achieve an ultra-high sensitivity of 937.64 nm/RIU based on photonic crystal slabs. In addition, such high-performance sensor will be explored to trap and detect single nanoparticle.

JW2A.5
Characterization of liquid absorption and emission spectra using linear variable filters integrated with a CMOS camera, Yuhang Wai1, John A. Carlsson1, Benjamin A. Kesler1, Wang Peng1, Patrick Sun1, Saulo A. Al-Mulla1, John M. Dussalese1, Brian T. Cunningham1, Beihang Univ., China; Dept. of Electrical and Computer Engineering, Univ. of Illinois at Urbana-Champaign, USA. A compact analysis platform for detecting liquid absorption and emission spectra using a set of linear variable filters atop a CMOS image sensor is presented to cover wide spectral ranges and provide low detection limits.

JW2A.6
Multiphoton imaging using a high transmission broadband hypocycloid-shape Kagome HC-PCF, Chris Martin1, Benoit Debord1, Frederic Gerome1, Fetah Benbadou1, Adela Ben-Yakar1, Biomedical Engineering, The Univ of Texas at Austin, USA; GPMM Group, XILM, France; Mechanical Engineering, The Univ. of Texas at Austin, USA. Current limitations in multiphoton endoscopic imaging are overcome through the fabrication and use of broad transmission, low dispersion hypocycloid-shape Kagome HC-PCF for both excitation and collection. Two-photon imaging capabilities are demonstrated on fluorescent beads.

JW2A.7
A Novel Approach for On-Chip Detection of Analyte by Incorporating Structurally Compatible Optical Waveguides with Electrowetting-on-Dielectric Platform, Chen Lu2, Cheng J. Jiang3, Miao Zhang1, Zheng Zheng1, Jin Hong1, Li Huitao1, Zhou Hongwen1, Liu Jiansheng1, Beihang Univ, China; Dept. of Mechanical Engineering, Virginia Tech, USA; Dept. of Electrical Engineering, University of Washington, Seattle, USA. A novel method for on-chip detection is proposed, which is realized by embedding structurally compatible waveguides. The evanescent field senses the index change of droplets on top with a sensitivity of 1.05x10^-5 RIU.

JW2A.8
High Pulsed Energy, Tunable Repetition Rate Source for Two-photon Microscopy, Kriti Charan1, Dylan Heberle1, Charles Lin1, Chris Xu1, Cornell Univ., USA; Harvard Medical School, USA. Multiphoton microscopy requires balancing high peak powers for depth penetration with low average powers to prevent thermal damage. We demonstrate a wavelength-tunable source with 27 to 48 nJ pulse energy and an adjustable repetition rate.

A&T 2: Industrial Applications

JW2A.9
Holographic Spherical Concave Grating Astigmatism Correction by Cylindrical Ringing Waveguide for Round Body Mounting, Xinwen Chen1, Lipiang Zeng1, Tsinghua Univ., China. We propose an exposure system of fabricating concave gratings by using a cylindrical wave and a plane wave. The defocus of recorded grating is kept zero and the astigmatism is sharply reduced in Round-body ring-mounting.

JW2A.10
Fast femtosecond laser ablation for efficient cutting of sintered alumina and quartz substrates, Reece Oosterbeck1, Thomas Ward1, Carsten Carozza2, Owen Bodley1, Simon Ashforth1, Andrew Rodda4, M. Cather Simpson3,2, School of Chemical Sciences, The Univ. of Auckland, New Zealand; The MacDiamid Inst. for Advanced Materials and Nanotechnolgy and The Dodd Walls Centre for Quantum and Photonic Technologies, New Zealand; School of Chemical Sciences and Dept. of Physics, The Univ. of Auckland, New Zealand; ‘The MacDiamid Inst. for Advanced Materials and Nanotechnolgy and The Dodd Walls Centre for Quantum and Photonic Technologies, New Zealand; School of Chemical Sciences and Dept. of Physics, The Univ. of Auckland, New Zealand; ‘Aerolingual Ltd., New Zealand. Ultrafast laser machining of ceramic and crystalline substrates offers many benefits versus chemical mechanical dicing. We optimized femtosecond laser parameters for cutting industry sintered alumina and quartz wafers, yielding drastic improvements in cutting speed and quality.

JW2A.11
Non-linear behavior of ring-down time in cavity ring-down spectroscopy with tapered fibers, Kavita Sharma1, Deepa Venkitesh1, Shanti Bhattacharya1, Balaji Srinivasan1, Gilberto Brambilla1, Andrew Rodda4, M. Cather Simpson3,2, School of Chemical Sciences, The Univ. of Auckland, New Zealand; ‘Aerolingual Ltd., New Zealand. The effect of surrounding refractive index in on ring-down time (τ) is studied in conventional and amplified cavity ring-down spectroscopy with tapered fibers. Simulation and experimental results indicate that τ varies as rational function of n,

F5 3: Metamaterials and Complex Media

JW2A.13
Optical Tamm States in Liquid Photonic Crystal and Metasurface, Kuo-Ping Chen1, Mong-Yin Lin1, National Chiao Tung Univ., Taiwan. Tamm plasmon (TP) modes happens at photonic crystal with metals. By using metasurfaces as reflective half wave plate and liquid photonic crystal, optical Tamm state could be achieved and be able to tune by varying temperature or voltage.

JW2A.14
Low Contrast Dielectric Metasurface Optics, Alan Zhan1, Shane A. Colburn1, Rahul Trivedi1, Taylor Fryett1, Chris Dodson1, Arka Majumdar1, University of Washington, Seattle, USA; Indian Inst. of Technology, India. We demonstrate low contrast dielectric metasurface optical elements for operation at visible frequencies. Our devices show transmission efficiencies as high as 90% and focal spots on the order of the design wavelength.

JW2A.15
Withdrawn

JW2A.16
Playing a Metamaterial Guitar with Light: Optically Addressable Nanomechanical Metamaterial, Jun-Yu Ou1, Eric Plum1, Brendan P. Clarke1, Nikolay I. Zheludev1,2, Optoelectronics Research Centre and Centre for Photonic Metamaterials, Univ. of Southampton, UK; ‘Centre for Disruptive Photonic Technologies and The Photonics Inst., Nanyang Technological Univ., Singapore. Optical signals actuating unique elements of a nanostucture at their eigenfrequencies are used to modulate metasurface properties with sub-wavelength spatial resolution thus creating a randomly addressable metamaterial that acts as all-optical spatial light modulator.

JW2A.17
Attraction Optical Forces inside Hyperbolic Metamaterials, Sergey Sukhov1, Alexander S. Shalini1, Andrey A. Bogdanov1, Pavel Belov2, Pavel Ginburg3, Univ. of Central Florida, CREOX, USA; ‘Ulyanov branch, Kotel’nikov Inst. of Radiophysics and Electronics of Russian Academy of Sciences, Russia; ‘IITM Univ., Russia; ‘Ioffe Inst., Russia; ‘School of Electrical Engineering, Tel Aviv Univ., Israel. Hyperbolic metamaterials provide a platform for a new type of optical manipulation using highly confined extraordinary modes. Here we predict and analyze optical attracting forces acting on a small particle inside a hyperbolic slab.

JW2A.18
Inverse Design of a Polarization-Independent Dirac-Cone Zero-Index Metamaterial, Lysander Christakos1, Zin Lin1, Yang Lu2, Eric Mazur2, Alejandro Rodriguez2, Marko Loncar2, Dept. of Physics, Yale Univ., USA; ‘School of Engineering and Applied Sciences, Harvard Univ., USA; ‘Dept. of Electrical Engineering, Princeton Univ., USA. We apply a novel computational method to systematically design Dirac cones in photonic crystals. In particular, we demonstrate an unprecedented Dirac-cone zero-index metamaterial (DC-ZIM) that exhibits zero-index for any polarization of light.

JW2A.19
Metasurface Perfect Absorber Based on Guided Resonance of Hypercrystal, Yau-Chia Chang1, Alex Kildishev2, Eugene N. Namiranov1, Theodore B. Norris2, School of Engineering and Electronics of Russian Academy of Sciences, Univ. of Southampton, UK; ‘Centre for Disruptive Photonic Technologies and The Photonics Inst., Nanyang Technological Univ., Singapore. Metasurfaces Perfect Absorber Based on Guided Resonance of Hypercrystal, Yau-Chia Chang1, Alex Kildishev2, Eugene N. Namiranov1, Theodore B. Norris2, School of Engineering and Electronics of Russian Academy of Sciences, Univ. of Southampton, UK; ‘Centre for Disruptive Photonic Technologies and The Photonics Inst., Nanyang Technological Univ., Singapore. Metasurfaces Perfect Absorber Based on Guided Resonance of Hypercrystal, Yau-Chia Chang1, Alex Kildishev2, Eugene N. Namiranov1, Theodore B. Norris2, School of Engineering and Electronics of Russian Academy of Sciences, Univ. of Southampton, UK; ‘Centre for Disruptive Photonic Technologies and The Photonics Inst., Nanyang Technological Univ., Singapore. Metasurfaces Perfect Absorber Based on Guided Resonance of Hypercrystal, Yau-Chia Chang1, Alex Kildishev2, Eugene N. Namiranov1, Theodore B. Norris2, School of Engineering and Electronics of Russian Academy of Sciences, Univ. of Southampton, UK; ‘Centre for Disruptive Photonic Technologies and The Photonics Inst., Nanyang Technological Univ., Singapore.

JW2A.20
Liquid Crystal Frequency Tunable Terahertz Metamaterial Absorber, Mohammad Parvinnezhad Hokmabadi1, Abubaker M. Tarek1, Elmer Rivera1, Patrick Kung1, Robert Lindquist1, Seongmin M. Kim1, ECE, Univ. of Alabama, USA; ‘ECE, Univ. of Alabama Huntsville, USA. We theoretically and experimentally realize a liquid crystal tunable metamaterial absorber. By applying a voltage between complementary frequency selective surface and backplane, a frequency shift –4.5 GHz at 0.567 THz with 99% absorption is obtained.

JW2A.21
Artificial Magnetism via Nanoantennas under Azimuthally Polarized Vector Beam Illumination, Caner Gucul1, Mehdi Veysi1, Mahsa Davshirezhadeh-Varchee1, Filippo Capolino1, Univ. of California, Irvine, USA. We show enhancement of magnetic near-field using symmetrical nanoantennas illuminated by azimuthally E-polarized beams. In particular a circular cluster nanoantenna is shown emphasizing enhanced magnetic field with high resolution in a magnetic dominant region.
JW2A.22

Focusing of Terahertz Waves by Self-Complementary Meta-Antenna Toward Electromagnetically Induced Transparency, Hyunseung Jung1, Chihun Im2, Hyunyoung Choi2, Hoyjin Lee1. 1School of Electronic Engineering, Soongsil Univ., Korea; 2School of Electrical and Electronic Engineering, Yonsei Univ., Korea. We reported unique characteristics of self-complementary meta-atoms (SCMA) by combining two opposite structures. Experimental results of fabricated meta-atoms well agreed with simulation results and verified that the proposed SCM can realize electromagnetically induced transparency analogue.

JW2A.23

Strong magnetic response at 595 nm with Si-nanoblock metasurface, Yoonok Yi1, Chaoning Chi2. 1ETRI, Korea. We demonstrate strong magnetic resonance Q-factor of ~10 at 595 nm using an array of amorphous Si nanoblocks, which is a higher value than that yielded by a split ring resonator at the visible range.

JW2A.24

Lossless Integrated Dirac-Cone Metamaterials, Philip Murphy1, Shota Kita1, Oliviya Melio1, Gadi Rebesh2, Danyi Li3, Yang Li4, Marko Loncar3, Eric Mazur4. 1Harvard Univ., USA. Zero-index metamaterials exhibit inherent losses due to poor confinement. We present a 2D photonic crystal that achieves isotropic impedance-matched zero-index propagation, but confinement. We present a 2D photonic crystal that achieves isotropic impedance-matched zero-index propagation, but

JW2A.25

Diffusive Scattering from Single Microparticles with Well-Dispersed Dielectric Nano-Scale Inclusions, Felix Tan1, Roxana Rezvani Naraghi1,2, Marielena Burgdörfer1, Aris Doganis1, Ayman Abdoually1. CREOL, The College of Optics & Photonics, Univ. of Central Florida, USA; 2Physics, Univ. of Central Florida, USA. By fabricating a new class of composite microparticles comprising a random distribution of well-dispersed high-refractive-index dielectric nanoparticles, we confirm that forward and backward multiply scattered fields in the visible are diffusive.

JW2A.26

Enhancement of second-harmonic generation from metamaterials by reduced number of particles, Robert Capicki1, Antti Kiviniemi1, Joonas Lehtolahti1,2, Ariste Doganis1, Ayman Abdoually1,2. CREOL, The College of Optics & Photonics, Univ. of Central Florida, USA. We demonstrate a magnetic mirror comprising a silicon nanorod array. This all-dielectric metasurface mirror exhibits relatively low loss, vivid color and a wavelength dependent phase discontinuity. Physical interpretation via multipole expansion analysis is provided.

JW2A.27

Silicon Metasurfaces as Magnetic Mirrors at Visible Wavelengths, Wuzhou Song1, Qi Sheng Qiang2, Kenneth B. Crozier1. 1Univ. of Melbourne, Australia. We experimentally demonstrate a magnetic mirror comprising a silicon nanorod array. This all-dielectric metasurface mirror exhibits relatively low loss, vivid color and a wavelength dependent phase discontinuity. Physical interpretation via multipole expansion analysis is provided.

JW2A.28

Tunable Phase Regimes of Electromagnetically-Induced-Transparency with Graphene in Terahertz Metamaterials, Xiaoyan Zhou1, Wenlong Gao1, Lin Zhang1, Shuang Zhang1, Fengchou Fang1, Wei Pang1, Tianjun Univ., China; 2Univ. of Birmingham, UK. Novel phase features of EIT-like effect are theoretically identified in tershertz metamaterials. An active transition between distinct EIT phase regimes and a tunable optical delay > 3.5 ps are also demonstrated by introducing gate-controlled graphene.

JW2A.29

Replica Symmetry Breaking in Random Lasers Based on Collodial Rh:6G and Specially Designed TiO2 Nanoparticles, Pablo I. R. Pincheira1, Andrea F. Silva1, Sergio I. Evelo1, Andre de Lima Moura1,2, Ernesto P. Raposo1, Anderson S. Gomes1. 1Cid B. de Araujo1, Universidade Federal de Alagoas, Brazil; 2Departamento de Fisica, Universidade Federal de Pernambuco, Brazil. Programa de Ciencias dos Materiais, Universidade Federal de Pernambuco, Brazil. Replica symmetry break and a photonic paramagnetic to spin-glass phase transition in a random laser based on ethanol solution of Rhodamine 6G and specially designed amorphous TiO2 nanoparticles is demonstrated.

JW2A.30

Thermal radiation of Er doped crystals: studying the range of applicability of the Kirchhoff's law, Kevin E. Tany1, Brando T. Burton1,4, Evgenii E. Narimanov1, Mikhail A. Noginov2. 1Center for Materials Research, Norfolk State Univ., USA; 2Birck Nanotechnology Center, Dept. of Electrical and Computer Engineering, Purdue Univ., USA. The range of applicability of Kirchhoff's law, predicting that emissivity of opaque bodies in thermodynamic equilibrium with environment which should be equal to absorbance, was studied in Er doped dielectric crystals – potential thermophotovoltaics radiator conversions.

JW2A.31

Characterizing NL response of metal-dielectric meta-surfaces, Mohamed A. Haggag1, Vladimir Drachev1, Alex Kildishev1,2. 1School of Electrical and Computer Engineering, Purdue Univ., USA; 2Birck Nanotechnology Center, USA; 3Dept. of Physics, Univ. of North Texas, USA. A method for retrieving effective \( n \) and \( \alpha \) from bianistropic parameters of non-linear metasurfaces is introduced. The effective nonlinear parameters of a metasurface covered by a NL layer are compared vs a bare NL layer.

JW2A.32

Optical forces in nanorod metamaterials: beyond the effective medium approach, Andrei A. Bogdanov1, Alexander S. Shalin1, David A. Dlott1,2,3,4, Yuriy I. Smolyaninov1. 1Ioffe Inst., Russia; 2ITMO Univ., Russia; 3School of Electrical Engineering, Tel Aviv Univ., Israel. Optical forces, acting on spherical nanoparticle embedded inside the hyperbolic metamaterial consisting of gold nanowires, are investigated both numerically and using a semi-analytical approach beyond the effective medium approximation.

JW2A.33

Slow Light by Hybridized Double Split Ring Resonators, Mohammad Parvinnezhad Hakmabadi1,2, Elizabet Philip1, Ju-hyung Kim1, Elmer Rivera1, Patrick Kung1, Seogon M. Kim1. 1Electrical and Computer Engineering, Univ. of Alabama, USA. We design, fabricate, and characterize flexible EIT-metamaterials by hybridizing two DSRs, demonstrate dynamically tuning the slow light characteristics, reduced the speed of light by 0.05 times based on our method to determine the effective length.

JW2A.34

Highly Efficient, All-Dielectric, Transmissive Gradient Metasurfaces from the Ultraviolet to the Infrared, Adam Ollink1, Jake Smith1, Nicholas Faran-Foley1, Matthew Escara1,1 Tulane Univ., USA. We design and simulate metasurfaces capable of inducing anomalous refraction with efficiency as high as 90%. Metasurfaces are designed for incident wavelengths spanning 1-376 nm to 1-1340 nm; a composite stacked metasurface capable of spectrum splitting is demonstrated.

JW2A.35

Global k-Space Analysis of Electron-Photon Interaction in Graphene, Rolf Binder1, Adam Roberts2, Nai H. Kwong3, Anvarer Sandhu4, Henry Everitt4. 1Univ. of Arizona, USA; 2US Army, USA. Electron-photon coupling in graphene is studied across the Brillouin zone. Time-resolved hopping and conventional deformation potential coupling, and from intraband and interband coupling are analyzed and related to available experimental M-point spectroscopy.

JW2A.36

Electronic Control of Exciton Coherence in a Charged Quantum Dot Photonic Waveguide, Galan Moody1, Corey McDonald1, Ari Feldman1, Todd Harvey1, Richard Mirin1, Kevin Silverman2. 1iIST, USA. We demonstrate electronic control of the charged exciton optical coherence time in quantum dots embedded in a photonic ridge waveguide. Through electronic manipulation of the electron and hole wavefunctions, coherence is extended by ~50%.

JW2A.37

Generation of Sharp Electron Bunches from a Laser Field and a DC Bias Field, Peng Zhang1, Y. Y. Lau1. 1Univ. of Michigan, Ann Arbor, USA. Our exact analytic solution for electron emission shows that sharp electron bunches may be generated from a laser surface subject to a weak laser field and a strong dc bias field.

JW2A.38

Acoustic Wave Generation by Multifilmation In Water, Vytasys Jukna1, Amelie James2, Carles Milian3, Johann Brelet1, Jerome Carbonnel1, Yves-Bernard Andre1, Guillaume Guillot1, Jean-Pierre Sessarego4, Dominique Fattaccio5, Andre myswiarcz6, Arnaud Lacour4; Aurélien Houard7, LoA, ENSTA ParisTech, France; 2CFHT, Ecole polytechnique, France; 3Laboratoire de Mécanique et d’Acoustique, France; 4DGA Techniques Navales, France. Acoustic signals are generated by filaments of TW laser pulses in water are characterized experimentally and numerically revealing a strong influence of the input pulse duration on the shape of the acoustic signal.

JW2A.39

Time-resolved gain spectroscopy on type-I and type-II VCSEL chips, Christian Lammers1, Markus Stem1, Melanie Freymann1, Christian Fuchs1, Christoph Möller2, Antje Ruiz-Perez2, Christian Berger1, Arash Rahimi-Iman3, Jörg Hader1, Jerome Moloney1, Stephan W. Koch1, Wolfgang Stolz1, Martin Koch1, Philippus-Universität Marburg, Germany; 2National Institute of Science and Technology, University of Arizona, USA. Time-resolved reflectivity spectra of a type-II VCSEL chip are presented and compared to that of a type-I VCSEL chip. For both structures we discuss gain, cooling and recombinination dynamics.

JW2A.40

Sub-Picoscond Auger-Mediated Hole Trapping Dynamics in CdSe/CdS Core/shell Colloidal Semiconductor Nano-platelets, Shuo Dong1, Jie Liu1, Yinhao Chai2, Zhiheng Loh3, 4School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore. 5College of Optics and Photonics, Univ. of Arizona, USA. The ultrafast carrier dynamics of CdSe/CdS core/shell colloidal nanoparticles are investigated using femtosecond transient absorption spectroscopy. We observed electron cooling, as well as Auger-mediated hole trapping and concomitant Auger heating on sub-picosecond timescales.

JW2A.41

Intrinsic Speed of a Black Phosphorus Photoconductive Detector, Ryan J. Suess1,2, Edward Leong1, Thomas E. Murphy1,3, Mark Mitterndorf1. 1Inst. for Research in Electronics & Applied Physics, Univ. of Maryland, USA; 2Electrical & Computer Engineering, Univ. of Maryland, USA. The intrinsic speed of a black phosphorus photoconductive detector is determined using pulsed autocorrelation photocurrent measurements. The data reveals two timescales of 125 ps and 775 ps, indicating fast photodetection is possible with black phosphorus photoconductive detectors.

Exhibit Halls 1, 2, & 3

10:00-12:00 JW2A • Poster Session II

FS 4: Optical Interactions with Condensed Matter and Ultrafast Phenomena
F5 5: Nonlinear Optics and Novel Phenomena

JW2A.42 Strong Exciton-plasmon Coupling in a Ge0.9Se0.1/AuNP Heterostructure, Ritunj Sharmi1, Pratim Khan1, Aneesh J2, Istvan Csomvics1, Sándor Kökenyesi1, Himanshu Jain3, K Adarsh1;1; 1Inst. of Physics, Univ. of Debrecen, Hungary; 2Dep. of Materials Science and Engineering, Lehigh Univ., USA; 3; Dept. of Physics, Indian Inst. of Science Education and Research, India. Ultrafast exciton-plasmon interaction in a Ge0.9Se0.1/AuNP nanostructured was studied. In the strong coupling regime, we report the first observation of the spectral narrowing of transient absorption that is accompanied by the onset suppression of plasmon absorption.

JW2A.43 Carrier dynamics in gated graphene revealed by tunable-infrared-pump/terahertz-probe spectroscopy, Hassan A Hafez1, Xin Chai2, Pierre Lévesque1, Ibrahim Al-Nabi2, Marc Digman3, Philippe Lassonde4, Thiré Nicolas1, François Legare1, Richard Martin5, Tatsunuki Ozaki1; 1INRS, Canada; 2Université de Montréal, Canada; 3Univ. of Dammam, Saudi Arabia; 4Queen’s Univ., Canada. We study carrier dynamics in gated graphene using tunable-infrared (IR)-pump/terahertz (THz)-probe spectroscopy. Interband transitions are Pauli blocked in highly doped graphene when pumping at long wavelengths.

JW2A.50 Dissipative parametric instability: a new tool for pattern formation engineering in nonlinear optical systems, Auro M. Perego1, Nikita Tarasov1, Dmitry V. Chukhin2, Sergei K. Turitsyn1; 1Inst. of Photonic Technologies, UK; 2Department of Fisica e Ingegneria Nucleara, Università Politecnica della C惦utania, Spain; 3Inst. of Computational Technologies SB RAS, Russia; 4Novosibirsk State Univ., Russia; 5Institució Catalana de Recerca i Estudis Avançats, Spain. We present the novel dissipative parametric instability which leads to pattern formation and pulse train generation in nonlinear optical systems, under z-ig-z modulation of the dissipation applied on symmetrically located spectral regions.

JW2A.51 Abnormal polarization in nitrogen ion laser fields induced by the Kerr effect in a-Ge24Se76/gold nanoparticles was studied. In the strong normal dispersion regime under particular conditions. We report the complex dynamics of the Russian Academy of Sciences, Russia; 3Université de Montréal, Canada.

JW2A.52 Nonlinear thermo-optical oscillations in whispering galley mode resonators, Souleymane Daillo1, Guoping Lin1, Yanne K. Chembo1; 1FEMTO-ST Inst., Optics Dept., USA. We demonstrate that when pumped by a continuous wave laser, the interplay between the thermo-optic, thermo-plastic, and Kerr effects leads to the formation of Kerr coefficients of a millimeter-size barium fluoride crystal-line resonator results in complex relaxation oscillations with second timescale.

JW2A.53 The role of geometry in nonlocal superfluids, Kali E. Wilson1, David Vocke1, Ewan Wright2, Francesco Marino3, Iacopo Carotenuto1, Thomas Pertsch3, Thomas Pertsch3; 1Institut für Quantenoptik, Universität Hannover, Germany; 2Max Born Inst., Germany; 3Hannover Centre of Optical Technologies, Germany; 4Weierstrass-Institut für Angewandte Analysis und Stochastik, Germany. We show that the transfer of optical power via emission of resonant radiation plays an important role for regularizing the optical collapse enabling stable filament propagation of high-power near-infrared pulses in bulk silica.

JW2A.54 Measurement of Nonlinear Optical Response Functions of Common Organic Solvents, Peng Zhao1, Matthew Reichert2, Ryan Wagon1, Eric W. Van Stryland1; 1CREOL Univ. of Central Florida, USA; 2Dep. of Electrical Engineering, Princeton Univ., USA. The nonlinear optical (NLO) response functions of 24 widely used organic solvents are measured, including both bound-electronic and nuclear contributions. The response function establishes a self-consistent reference for predicting the outcomes of various NLO experiments.

JW2A.55 A New Theoretical Approach to Cascaded Stimulated Brillouin Scattering, Mark Dong1, Herbert G. Winful1; 1Univ. of Michigan, USA. We present a novel approach to cascaded stimulated Brillouin scattering in which the multitude of interacting optical fields are described by a single forward and single backward propagating wave at a single carrier frequency.

JW2A.56 Measurement of Nonlinear Optical Rogue Waves in a Unidirectional Fiber Laser, Stanislav Kolpakov1, Hani Khashabi1, Sergey Sergeyev2; 1Astorn Univ., UK. We report the observation of slow optical rogue waves (ORW). For these events the time of decay of autocorrelation function is significantly shorter than the length of the pattern in difference with the fast ORWs.

JW2A.57 Directly observing particle manipulations along light trajectories with axial plane optical microscopy, Tong Peng1, Sha ani1, Xing Zhou1, Guoxun Han1, Zhangjiang Huang1, Meirong Wang1, Baoli Yao1, Peng Zhang1, JI Wei; 1Inst. Optics & Precision Mech., CAS, China; 2Northwestern Polytechnical Univ., China. We demonstrate the direct observation of optical particle manipulations along light trajectories with axial plane optical microscopy (APOM). Optically trapped particles moving along both straight and curved trajectories are successfully monitored by the APOM.

JW2A.58 Extreme Multiphoton Luminescence in GaAs, Eyvatar Sabag1, Raja Marjevl1, Leonid Rybak1, Alex Hayat1; 1Electrical Engineering, Technion, Israel. We study extreme multiphoton-absorption in GaAs, demonstrating experimentally 2-3 and 2+4 photon luminescence, including Auger recombination effects – in good agreement with theory. Our results can have important implications in bulk solid band-structure exploration.

JW2A.59 Effect of Loss on Slow-light-enhanced Second Harmonic Generation in Periodic Nanostructures, Sina Saravi1, Rafael Quintero-Bermudez2, Frank Setzpfandt1, A Naser Mortensen3, Thomas Pertsch3; 1Inst. of Applied Physics, Abbe Center of Photonics, Friedrich-Schiller-Universität Jena, Germany; 2Dep. of Electrical and Computer Engineering, Univ. of Toronto, Canada; 3Dept. of Photonics Engineering, DTU Fotonik, Technical Univ. of Denmark, Denmark. We analyze, analytically and through nonlinear simulations, the dependence of SHG efficiency on the group index in lossy periodic structures, and find that the optimal efficiency is reached for finite values of the group index.

JW2A.60 Collapse regularization of filaments by resonant radiation, Carsten Bree1, Iar Babushkin1, Uwe Morgen1, Ayan Demircan1; 1Institut für Quantenoptik, Universität Hannover, Germany; 2Max Born Inst., Germany; 3Hannover Centre of Optical Technologies, Germany; 4Weierstrass-Institut für Angewandte Analysis und Stochastik, Germany. We show that the transfer of optical power via emission of resonant radiation plays an important role for regularizing the optical collapse enabling stable filament propagation of high-power near-infrared pulses in bulk silica.

JW2A.61 Ultra-Broadband Adiabatic Light Transfer in Titanium Dif fused Lithium Niobate Waveguides, Wen-Hung Chen1, Hung-Pin Chung1, Kuang-Hsiao Huang1, Sang-Lin Yang1, Wei-Kun Chang1, Che Wei1, Frank Setzpfrandt1, Thomas Pertsch3, Dragomir N. Neshev1; 1National Central Univ., Taiwan; 2Nonlinear Physics Centre, Australian National Univ., Australia; 3Inst. of Applied Physics, Friedrich-Schiller-Universität Jena, Germany. Ultra-broadband adiabatic light transfer was demonstrated for the first time in lithium niobate. Coupling bandwidths and efficiencies of ~540 nm and >96%, respectively, were obtained with 5-mm-long Ti:LiNbO3 adiabatic couplers for both polarization modes.

JW2A.62 Enhancement of Two-Photon Absorption in Highly Emissive BODIPY Dyes, Leonardo W. Barros1, Juan A. Castañeda1, Thiago A. Cardoso1, Dominik K. Kömel1, Anna Hörner2, Angela Bihlmayer1, Martin Nieger1, Stefan Bräse1, Carlos H. Brito Cruz1, Lázaro A. Padilha2, Universidade Estadual de Campinas, Brazil; 1Karlsruhe Institut für Technologie, Germany; 2Univ. of Helsinki, Finland. Novel perfluorinated BODIPY dyes have been synthesized aiming increased nonlinear optical properties. Two-photon absorption spectroscopy shows about 4-fold enhancement of two-photon absorption cross-section in planar biphenyl-containing BODIPY dye, compared to the unsubstituted initial material.
wave mixing of a 0.5 GW, CO

...pulse compression and sech-pulse formation observed in

synchronously pumped optical parametric oscillators. This

...in normal dispersion regime. We unveil a heteroclinic structure leading to the excitability of superbreathers and parametric amplification outside the linear gain bandwidth.

Optical Vortex Beam Generation in the Deep-Ultraviolet,

Apurv Chaitya Nellikka1,2, Chaitanya Kumar D. Suddapalli1, Gautam Kumar Samanta1, M Ibrahim-Zadeh1,2,1. Physical Research Laboratory, India; 2Institute of Technology-Gandhinagar, India; 1ICFO-Institut de Ciencies Fotoniques, Spain; 2Instituto Catalana de Recerca i Estudis Avancats, Spain. We report the generation of optical vortex beams up to 12th order at 266 nm. Using single-pass second-harmonic-generation of a Laguerre-Gauss pionce green beam in BBO crystal, we have generated vortex beams up to 12th order at 286 nm.

Optical Vortex Beam Generation in the Deep-Ultraviolet,

Apurv Chaitya Nellikka1,2, Chaitanya Kumar D. Suddapalli1, Gautam Kumar Samanta1, M Ibrahim-Zadeh1,2,1. Physical Research Laboratory, India; 2Institute of Technology-Gandhinagar, India; 1ICFO-Institut de Ciencies Fotoniques, Spain; 2Instituto Catalana de Recerca i Estudis Avancats, Spain. We report the generation of optical vortex beams up to 12th order at 266 nm. Using single-pass second-harmonic-generation of a Laguerre-Gauss pionce green beam in BBO crystal, we have generated vortex beams up to 12th order at 286 nm.

High-Order Sideband Generation in Semiconductors: Be-

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JW2A.84 Second harmonic generations in plasmonic 2D periodic arrays of Au nanorods, Atsushi Sugita, Shunusuke Nishinari, Atsushi Oto, Yoshimasa Kawata1, Shuzouk Univ, Japan. The SHG excitation spectrum was performed for 2D periodic Au nanorod arrays with different rod-to-rod separations. The nonlinearities were mostly due to the isolated plasmon mode, and the plasmon-polariton mode have weak influences on them.

JW2A.85 Optical properties of gold thin films at elevated temperatures, Hanh Reddy Esgarameddy1, Urca Guler1, Alex Kildishev1,2, Alexandra Boltasseva1,2, Vladimir M. Shalaev2,3, Purdue Univ, USA. 2-Nano-Meta Technologies, USA. Temperature dependence of gold thin film optical constants is studied from room temperature to 500 °C for different crystallinities and thicknesses. Degradation of plasmonic properties at elevated temperatures and its effects on applications are discussed.

JW2A.86 Plasmonic Interconnects Using Zirconium Nitride, Aveek Dutta1, Nathaniel Kinsey1, Soham Saha1, Urca Guler1, Vladimir M. Shalaev2,3, Alexandra Boltasseva1,2, Purdue Univ, USA; 2-Nano-Meta Technologies, USA. Abstract: Zirconium nitride plasmonic waveguides were fabricated on sapphire using photolithography and plasma etching. For an 8.5 nm ZrN waveguide, long-range surface plasmon polaritons with a mode size around 10 μm were observed at 1.55 μm.

JW2A.87 Metasurfaces created by moiré nanosphere lithography, Zilong Wu, Linhan Lin1, Yuebing Zhang1, Univ of Texas at Austin, USA. Moiré nanosphere lithography (MNSL) is found to be an efficient approach to create moiré metasurfaces with large uniform area. Applications for light matter interactions and nanophotonics devices are discussed.

JW2A.88 Electrical and Optical Performance of Textured Silicon Solar Cells Improved by Plasmonic Scattering and Luminescent Down-Shifting Effects, Yu-Jie Deng1, Wen-Jeng Ho1, Sheng-Kai Feng1, Han-Chung Huang1, Ruei-Siang Sue1, Guan-Yi Li1, Ho-Yang1, National Tsing Hua University, Taiwan. This study presents electrical and optical performances of textured silicon solar cell improved by plasmonic-scattering and luminescent-down-shifting effects. The cell with the proposed effects demonstrated a 1.79 % absolute-gain in efficiency compared with a reference-cell.

JW2A.89 Enhancing Second-Order Optical Nonlinearity in Doped Graphene on a Two-Dimensional Diffraction Grating, Tet-suyluchi Ohchui1, National Inst for Materials Science, Japan. Doped graphene placed on a diffraction grating can provide a strong modulation of the graphene plasmon polarization in the THz range. We present a theoretical analysis of the second-harmonic generation and photon drag effect in doped graphene for plane-wave irradiation.

JW2A.90 In-plane trapping and manipulation of ZnO nanowires on a metallic surface, Lichao Zhang1, Xinjie Dou1, Changjun Min1, Yuquan Zhang1, Xiaocang Yuan1, Shenzhen Univ, China. We achieve the in-plane trapping and manipulation of a single ZnO nanowire by a plasmonic tweezer system, which cannot be performed using conventional optical tweezers. Further numerical analyses are performed to reveal the mechanisms.

JW2A.91 Bi-inspired ultra dark nanoparticles for lasing and water desalination, Changshu Liu1, Jianfeng Huang1, Yu Han1, Andreia Fratocchi1, King Abdullah Univ of Sci & Technology, Saudi Arabia. We developed a blackbody system based on gold nanoparticles with broad band absorption, which can be utilized as emitters for a new type of laser and perfect absorbers in efficient on-site water desalination.

JW2A.92 Nano-focusing in an Air-slot Plasmonic Waveguide With A Tapered Grating Coupler, Chuan Zhong1, David McCloskey1, Jing Jing Wang1, Brian D. Jennings1, Nicolas Abadzi1, Ertugrul Kermekjian1, Mark S. Z. Zion1, Trinity College Dublin, Ireland. We propose an air-slot plasmonic waveguide for nano-focusing. A tapered grating is used as a dipole radiation source for surface plasmon excitation and coupling. Simulations show an effective coupling and field enhancement in our design.

JW2A.93 Enhanced UV Upconversion Emission Using Plasmonic Nanocavities, Ahmed Alhalwany1,2, Sha He1, Hossein Ho-dae1, Noah Johnson1, Demetrios N. Christodoulides1, Adah Almutairi1,2, Meredith Khajavikhan1, Univ of Central Florida, USA; 1Dept. of Physics, Univ of Central Florida, USA. Strongly enhanced upconversion emission is experimentally demonstrated from an ensemble of NaYF4:Gd3+:Yb3+:Tm3+:NaLuF4 core-shell nanoparticles trapped in judiciously designed plasmonic nanocavities. Using cross-shape silver nanocavities, a 170-fold enhancement is obtained at the UV band (345 nm).

JW2A.94 Rosette Nano Antennas: Light enhancement with High Spatial Uniformity, Multiple Resonances and Polarization Insensitivity, Ofir Soria1, Yuval Paz1, Jacob Scheuer1, Meir Orenstein1, Electrical Engineering, Technion-Israel. This study presents a simple and efficient method for fabricating true two-dimensional nanoantenna. The fabricated rosette nanooptics show promising results in terms of directivity and polarization insensitivity.

JW2A.95 Brownian fluctuations of carbon nanotube resonators, Alex Tavaronakis1, Ioannis Tsoutsios1, Johann Osmund1, Pierre Verlot1, Adrian Bachtold1, ICFQ, Spain; ILM, France. In this work we couple the motion of nanotube-based resonators to a free propagating electron beam to demonstrate that single-clamped nanotube resonators undergo thermally-driven Brownian motion.

JW2A.96 Excitation and propagation of surface plasmon polaritons on non-structured surface with gradient permittivity, Xi Wang1, Ying Deng1, Qiting Li1, Yinghu Jiang1, Zilong Gong1, Kyle Tomy1, Xia1, Dept. of Materials Science and Engineer- ing, Univ. of California, Berkeley, USA. We have theoretically analyzed the excitation and propagation of surface plasmon polaritons on a planar interface between a homogeneous dielectric and a gradient negative permittivity material. This theory may lead to various applications, including “rainbow trapping”.

JW2A.97 Measurement of Exciton Correlations Using Electrostatic Lattices, Mikas Reimeika1, Jason Leonard1, Chelsey Dorow1, Michael Fogler1, Leonid Butov1, Mich Hanson1, Arthur Gossard1, Univ of California San Diego, USA; 2Univ of California Santa Barbara, USA. We present a method for determining correlations in a gas of indirect excitons. The method involves subjecting the excitons to an electrostatic lattice. We present findings of strong correlations in systems of indirect excitons.

JW2A.98 Characteristic of UV Plasmonic Nanolayers with Different Spacer Thickness, Yu Huan Chou1, Bo Tsun Chou1, Sheng Di2, National Inst for Materials Science, Japan. We report on plasmonic lasers with ZnO nanowire lying on single-crystalline silicon wafer with different thickness spacer. Spacer thickness were optimized to adjust the surface plasmon dispersion curve and resulting different group index.

JW2A.99 Optical gradient force between coupled graphene sheets, Xinbao Xu1, Le Shi1, Xinliang Zhang1, Huazhong Univ of Sci- ence and Technology, China. Optical gradient force between two graphene monolayers at mid-infrared frequencies is theoretically investigated for the first time.

JW2A.100 Tunable Graphene-Based Mode Converters and Optical Diodes, Vahid Foroughi Nezhad1, Hadi Ahammadpour1, Georgios Veronis1, Louisiana State Univ, USA. We introduce compact tunable spatial mode converters for parallel-plane waveguides consisting of two graphene monolayers operating in the mid-infrared wavelength range. We show that such structures can also be used to design graphene-based optical diodes.

JW2A.101 Shaping two-photon absorption in a disorder coupling gold nanoral assembly, Yi Xu1, Jin-xiang Li1, Qiao-feng Dai1, Shao-long Tong1, Sheng Lan1, Jian Univ, China; 2South China Normal Univ, China. We demonstrate that the relevance between the linear and the nonlinear optical response of a gold nanoral assembly can be shaped by plasmonic coupling. The strongly localized modes induced by random coupling play a crucial role in determining the optical absorption of the plasmonic systems.

JW2A.102 Comparison of Germanium and Copper Seed Layers for the Fabrication of Smooth Silicon Thin Films, Eden Rafea1, Gideon Gouws1, Jianjun Hao1, Ciaran Moore1, Victoria Univ. of Wellington, New Zealand; Agriculture Univ. of Hebei, China. Seed layers can reduce surface roughness and increase optical transmissivity of silver thin films used in plasmonic applications. We compare germanium and copper seed layers and find germanium preferable for 10-40 nm thick silver films.

JW2A.103 Localized surface plasmon for electroluminescence enhancement of organic light sources, Samira Khand1,1, Mahmood Chakravar1, Alex Fischer1, Omar Laminou2, Azzedine Boudiaou1, Univ. of Tizi-Ouzou, Algeria; Université Paris 13, France. In this paper, we study the effect of the localized surface plasmon resonance (LSPR) of two types of metallic nanoparticles (NPAs) on the organic light-emitting diodes (OLED) performances. Numerical and experimental results will be presented.

JW2A.104 Fabrication and Characterization of Moiré Metasurfaces, Kai Chen1, Zilong Wu1, Satoshi Ishii1, Thang D. Dao1, Yuebing Zheng1, Tadashi Nagao1, Univ of Texas at Austin, USA; 2National Inst. for Materials Science, Japan. We report the fabrication of moiré metasurfaces by moiré nanosphere lithography and their optical properties. Moiré metasurfaces consist of a wide variety of metallic nanoparticles and show multi-band absorption peaks from visible to infrared range.

JW2A.105 Novel Plasmon Laser Design Based on High-Quality-Factor Cup Resonator, Wengi Zhu1,2, Ting Xu1, Amit K. Agrawal1,2, Henri J. Lezec1, NIST, USA; 2Univ. of Maryland, USA. Using finite-difference time-domain simulations, we designed a high-quality-factor “cup” resonator for surface-plasmon-polaritons operating at visible frequencies. By introducing a 4-level gain medium into the cup-structure, we simulated the lasing action of this novel plasmon laser.

JW2A.106 Near-field Thermal Nanolithography Using Silk Proteins, Woonsook Lee1, Shaoqiang Zhang1, Mengkun Liu1, Tiger H. Tung1, Aveek Chatterjee1, Texas A&M University, Stony Brook Univ, USA. We present a thermal nanolithography technique by using silk proteins as resist with scanning near-field optical microscopy, which is capable of capable of selective curing and in-situ characterization of natural silk proteins at nanoscale resolution.
S&I: Photonic Integration

JW2A.121
High-Speed Operation of a Mid-Infrared Optical System at Room Temperature, Hossein Lotfi, Lu Li, Lin Lei, Hao Ye, S. M. Shazzad Rassel, Yuchao Jiang, Rui Q. Yang, Sasan Fatemi, Xaoxiu Hu, 1Department of Mechanical Engineering and the Centre for Research in Photonics, University of British Columbia, Canada; 2School of Mechanical Engineering, Shanghai Jiao Tong University, China. We report a near room-temperature operation of a mid-infrared optical system, consisting of an all-optical frequency shifter and a high-speed silicon photodetector, which exhibits a high operation speed of 5 GHz.

JW2A.122
All-optical phase-protected format conversion between QPSK and 2×8PSK based on FWM in a double-pass scheme, Yu-Hsiang Wen, Jia-Wei Ho, Kai-Ming Feng, 1National Tsing Hua Univ., Taiwan. We presented and experimentally demonstrated all-optical phase-protected format conversion from a 25-Gbps NRZ-QPSK signal to 2×12.5-Gbps NRZ-8PSK signals by applying FWM in a bidirectional orthogonally propagating architecture.

JW2A.123
An InP-based two-mode converter/demultiplexer with 100GHz mode conversion efficiency by using multimode interference couplers as the building blocks, Zhaosong Li, Dan Lu, Lingzhu Xiao, Song Liang, Xianglu Zhou, Jiaqing Pan, 1Inst. of Semiconductors, CAS, China. A two-mode converter/demultiplexer with 100GHz mode conversion efficiency is designed and demonstrated on InP substrate by using multimode interference couplers as the building blocks to realize the functions of mode conversion, multiplexing and phase shifting.

JW2A.124
Grating-assisted tunable optical delay line in microring resonators, Seyyed Anas Masoum, Saeed Khan, Saeed Pashanpour, 1Univ. of Central Florida, CREOL, USA; 2Balochistan Univ. of Information Technology, Pakistan; 3Dept. of Electrical Engineering and Computer Science, Univ. of Central Florida, USA. The effect of incorporating apodized grating in optical delay lines based on side-coupled integrated spaced sequence of resonators (SCISSORS) is proposed and investigated. It is shown that the grating-assisted SCISSORs outperform grating waveguide delay lines.

JW2A.125
Silicon Nanowire on Silicon-on-Insulator: A Platform for Integration Active Control over Passive Components, Qiancheng Zhao, Mohsen Rajaee, Ozdal Boyraz, 1Dept of Electrical Engineering and Computer Science, Univ. of California, Irvine, USA. We propose the use of SOI with silicon nanowires for electronic control. A phase modulator with a, V, of 1.02 V/mm and a compact vertical coupling taper are demonstrated in an easy-to-fabricate planar structure.

JW2A.126
Optical Clock Pulse Generation Using Thermal Nonlinearity in Microring Resonators, Nima Davoudzadeh, Amit Arbabzadeh, Jinhong Zhou, Lynford L. Goddard, 1UILC, USA. A reflective microring resonator is used as a wavelength selective nonlinear feedback element in a fiber ring laser to generate optical clock pulses. All components are driven by DC current.

JW2A.127
Systematic Study of Si-Based Ge/Si, Sn/Si, Light-Emitting Diodes towards Mid-Infrared Application, Yiqin Zhou, Liyuan Lin, Wei Dou, Thaddeus L. Otten, Seyed A. Ghetreini, Sattar Al-Kabi, 1Joe Margetis, John Toll, Gregory Sun, Richard Sorel, Basha Lu, Mansour Mortazavi, Hameed Naseem, Shi-Qing Yu, 1Electrical Engineering, Univ. of Arkansas, USA; 2Dept. of Chemistry and Physics, Univ. of Arkansas at Pine Bluff, USA; 3ASM, USA; 4Dept. of Engineering, Univ. of Massachusetts Boston, USA; 2AKtronic, 3Dept. of Physics, Wast University, Iraq. Characterizations of InGaAsP/InGaAs and InGaAs/GaAs double-heterostructure light-emitting diodes have been performed at the temperatures from 300 to 77K. The electroluminescence emission from the direct bandgap transition has been observed and systematically investigated.
JW2A.128 Performance of 90GHz Electro-Optic Modulator with Patch-Antennas in High-Power Wireless Irradiation, Yusuf N. Wijayanto1, Atsushi Kanori2, Tetsuya Kawanishi2, Hiroshi Murata1, Naokatsu Yamamoto1, Yasuuki Okamura1, Indone-
sian Inst. of Sciences, Indonesia; 2National Inst. of Information and Communications Technology, Japan; 3Waseda Univ., Japan; 4Osaka Univ., Japan. We report a recent progress for performance of 90GHz electro-optic modulator with patch-antennas in high-power wireless radio irradiation. Optical sidebands to carrier ratio of -40dB can be achieved by wireless radio irradiation power of 33dBm.

JW2A.129 Acousto-Optic Delay Modulation of a Photonic Signal, Ross T. Schemer1, Vincent Unck1, Jason McKinney2, US Naval Research Lab, USA. This paper demonstrates an acousto-optic technique for delay modulation of wide bandwidth RF photonic signals. By modulating RF delay, sideband power is varied 20 dB/frequency decade over the 0-1-10 GHz range, potentially enabling for applications such as instantaneous frequency measurement.

JW2A.130 Investigation on Phase-Sensitive Fiber Nonlinearity Cancel-
lation in Conjugated-Paired Radio-on-Fiber System, Takan
dae Sakamoto1, Guo-Wei Lu2, Tetsuya Kawanishi2, 1National Inst. of Information & Comm Tech, Japan; 2Waseda Univ., Japan. We clarify that fiber nonlinearity cancellation in the conjugated-paired radio-on-fiber system is a phase sensitive process. The best nonlinearity tolerance is achieved if the dual sidebands are constructively superposed during photonic down conversion.

JW2A.131 Silicon Photonic Thermometer Operating on Multiple Po-
larizations, Xiawen Gan1, Xiayan Wang1, Lars H. Frandsen1, 1Technical Univ. of Denmark, Denmark. A silicon photonics optical thermometer simultaneously operating on the multiple polarizations is designed and experimentally demonstrated. Measured sensitivities are 84pm/C and 48pm/C for the transverse-electric and transverse-magnetic polarizations, respectively.

JW2A.132 An integrated optical link in 140 nm SOI technology, Satadal Dutta1, Raymond Hueting1, Vishal Agarwal1, Anne-Johan Annessa1, 1Univ. of Twente, Netherlands. An SOI based optical link is introduced. Higher coupling efficiency and temperature-resilience are obtained via avalanche-mode LED operation against forward-mode operation. Self-heating induced thermo-coupling in steady-state is de-embedded by calibrating the photo-detector’s I-V characteristics.

JW2A.133 Ring modulator small-signal response, Samira Karimelahi1, Ali-Shaha Elsleami1, 1Univ. of Toronto, Canada. Ring modulator electro-optical frequency responses are presented together with pole-zero diagrams for both intracavity and coupling modulation cases. Through this modeling, we analyze the ring modulator small-signal response based on the pole-zero locations.

JW2A.134 GaAs Photonic Crystal Switch for Electro-Optic Sampling, Gregory Moille1, Alfredo De Rossi1, Gaelle Lehoucour2, Charlotte Tripon-Canseliet3, Laurence Morgenroth1, Francois Neuilly4, Didier Decoster4, Gaetano Bellanca4, Sylvain Com
brie5, 1Thales Research & Technology, France; 2Université Pierre et Marie Curie, France; 3Institut d’Electronique de Microelec-
tronique et de Nanotechnologie, France; 4Universita di Fer
rara, Italy; 5A GaAs Photonic Crystal based photoconductive switch is controlled by mode-locked fiber laser operating in the Telecom spectra, owing to efficient nonlinear interaction. The bandwidth reaches >10GHz owing to the strong surface recombination.

JW2A.135 Bit Flow Density (BFD): An Effective Performance FOM for Optical On-chip Interconnects, Shuai Sun1, Abdel-Hameed A. Badawy2, Vikram Narayana1, Tarek El-Ghazawi1, Volker J. Sorger3, 1George Washington Univ., USA; 2Electrical Engi
neering Dept., Arkansas Tech Univ., USA. Here we propose a new figure of merit for optical on-chip links and networks named “Bit Flow Density”, which is a useful evaluation index that combines latency, throughput and footprint for precise crosstalk-based on-chip network design, simulation, and network simulators.

S&I 10: Biophotonics and Optofluidics

JW2A.136 Detection of microRNA using a resonance-free capillary optofluidic sensor, Lili Liang1, Long Jin1, Bai-Ou Guan1, Jinan Univ., China. A wavelength-encoded optofluidic sensor is fabricated by aligning a tapered optical fiber in lateral contact with a liquid-filled silica capillary. Preliminary experiment demon-
strates its capability of molecular microRNA quantification with detection limit less than 20fM.

JW2A.137 Differentiation of cutaneous melanoma from surrounding skin using laser-induced breakdown spectroscopy, Youngmin Moon1, Jung Hyun Han1, Jong Jin Lee1, Sujeong Choi1, Yong-Chul Kim1, Sungho Jeong1, GWangju Inst. of Sci & Tech, Korea. Differentiation of melanoma and the surrounding dermis by laser-induced breakdown spectroscopy (LIBS) was investigated using pellet and real skin samples in order to investigate the feasibility of LIBS for in situ monitoring and identification of target tissues.

JW2A.138 Optofluidic Tunable Lens Using Laser-induced Thermal Gradien,t, Qiming CHEN1, Xuming ZHANG1, 1The Hong Kong Polytechnic Univ., Hong Kong. This paper presents an optofluidic tunable lens using laser-induced thermal gradient to focus the light to one point. By use of the thermo-optics effect, we demonstrated a tunable focal length from infinite to 1.3 mm.

JW2A.139 Longitudinal mode structure, polarization, and temporal characteristics of the flavin mononucleotide biosensor as probes of local chemical environment, Jose A. Rivera1, J. Gary Eden1, 1Univ. of Illinois, USA. The influence on a biosensor by its chemical environment has been detected by analyzing spectral, temporal, and polarization properties. Such detailed characterizations are fundamental for biosensors to realize their potential as biomedical diagnostics.

JW2A.140 Ultrahigh-resolution spectral domain optical coherence tomography in 1.7 um wavelength region, Hiroyuki Kawai1, Masahito Yamamura2, Shuichi Makita1, Yoshiaki Yasuno1, Noriko Nishizawa1, Nagoya Univ., Japan; 2Univ. of Tsukuba, Japan. We developed ultrahigh-resolution, high speed, spectral domain optical coherence tomography with supercontinuum source at 1.7 um wavelength. By applying a full-range method, high axial resolution of 4.7 um and ex-
tended imaging depth were realized simultaneously.

JW2A.141 Ultra Small Cross-Section Photonic Probes for Deep Tissue Non-Invasive Light Delivery, Romy Fain1, Tianyu Wang2, Mengran Wang2, Kriti Charan3, Felipe A. Barbosa1, Jaime Cardenas1, Chris Xu4, Mishal Lipson1, 1Electrical Engineer-
ing, Columbia Univ., USA; 2Applied Physics, Cornell Univ., USA; 3Electrical and Computer Engineering, Cornell Univ., USA. We demonstrate a new platform for minimally invasive, photonic light delivery. The fabricated probes have sub-10μm cross-sectional dimensions and lengths greater than 3mm (a 1000:1 aspect ratio). We show mechanical robustness and low optical losses.

JW2A.142 Light Sheet Illumination With an Integrated Photonic Probe, Fan Ye1, Benjamin W. Avants2, Jacob T. Robinson3, 1Electrical and Computer Engineering, Rice Univ., USA; 2Bioengineering, Rice Univ., USA. We have designed an im-
plantable integrated photonic probe that produces a plane of illumination. The planar illumination pattern is produced using aluminum nitride waveguide gratings and microlenses com-
patible with light sheet microscopy within scattering tissue.

JW2A.143 Optical Bound States of 2D High-Contrast Grating for Re-
fractometric Sensing, Yifei Wang1, Liang Dong1, Meng Lu2, 1Dept. of Electrical and Computer Engineering, Iowa State Univ., USA; 2Dept. of Mechanical Engineering, Iowa State Univ., USA. We report the numerical study of optical bound states in the radiation continuum using a silicon-based 2D high-
contrast grating. The high-Q resonances near the bound states are exploited for the application of refractometric sensing.

JW2A.144 Large Extinction Ratio Electrowetting Optical Shutter, Kenneth J. Underwood1, Ryan Montoya1, Soraya Terrab2, Alexander Watson1, Victor Bright1, Juliet Gopinath3, 1Univ. of Colorado at Boulder, USA. We demonstrate a large extinction ratio optical shutter using total internal reflection with an electrowetting device. An on-off ratio of greater than 60 dB was measured. The device shows promise for chip-scale atomic-cliffs and gyroscopes.

JW2A.145 Multimode Rectangular Optical Microcavity for Biomarker Detection Based on Silicon on Insulator, Manuel Meendez-
Astudillo1, Hiroki Takahisa1, Ken Fujisawa2, Hideaki Okayama3, Chika Nakajima1, 1Graduate School of Advanced Science and Engineering, Waseda University, Japan; 2Research & Development Center, Oki Electric Industry Co Ltd, Japan. We fabricated and experimentally evaluated the sensitivity to be 56 nm/RIU of an evanescently coupled multimode rectangular resonant cavity for biosensing applications on Silicon-on-Insulator with an area large enough for homoge-
neous silane-functionalization results.
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| 11:00-13:00  | Climbing the Ladder: Insights from leaders in Photonics Panel Discussion and Networking Lunch  
|              | *(Advance Registration Required)*                                                   |
| 12:00-13:00  | Lunch and Unopposed Exhibit Only Time, Exhibit Halls 1, 2, & 3 (concessions available in the back of Hall 2) |
| 13:00-15:00  | JW3A • Plenary Session III & Awards Ceremony, *Grand Ballroom*                     |
| 15:00-15:30  | Coffee Break (15:00-15:30) and Unopposed Exhibit Only Time, Exhibit Halls 1, 2 & 3 |
| 15:00-16:30  | Market Focus Session IV: Building the World’s First Database of Matter: Spectroscopy in the Consumer’s Hand  
|              | A Special Enabled by Optics Session, *Exhibit Hall Theater*                         |
We demonstrate experimentally Spin Orbit Interaction of Light in Nonlinear Optics, Zhong Zhang, University of California, Santa Barbara; 2Australian National Univ., Australia; 2Faculty of Physics, Lomonosov Moscow State Univ., Russia; 3City Univ. of Hong Kong, China; 4Baptist Univ. of Hong Kong, China. By extending the concept of spin rotation interaction of light to the nonlinear optical regime, we experimentally demonstrate nonlinear metasurfaces with continuously controllable effective nonlinear polarizability.

Visible Range Plasmons in Topological Insulators, Alexander M. Dubrovin1, Jun Yin1, Giorgio Adamo2, Yasaman Kiasati1, Bo Qiang1, Qijie Wang3, Cesare Soci1,4, Ian Wang1, Nikolay I. Zheludev1,5; 1Centre for Disruptive Photonic Technologies, 2Institute of Applied Physics, Abbe Center of Photonics, Friedrich Schiller University, Jena, Germany; 3University of Southampton, UK. Near-field imaging in the visible reveals the existence of localized and propagating plasmons on the surface of topological insulator. We also report ab-initio band structure calculations explain the origin of plasmonic response in chalcogenide compounds.

Ultrafast optical control of plasmon-photon interaction using topological phase transition in (Bi,In)5Se3, Sangwan Sim1, Jun Park1, Nikesh Koirala, Matthew Braheki, Jisoo Moon2, Maryam Salehi2, Seungshik Oh2, Hyunyoung Choi1, Yoonse Uni2, Korea; 2Korea University, Korea; 3POSTECH, Korea. We introduce a new methodology for controlling ultrafast plasmon-photon interaction using topological phase transition. This is based on the manipulation of the spatial overlap between topological surface plasmonic states and bulk phonon.

Two-dimensional Free-form Fabrication and Lifetime-tuning of Quantum Dots, Bharath Bangalore Rayeova, Linhan Liu, Evan Peru1, Xiaolei Peng, Andrew Dumi, Yuebing Zheng1; 1The Univ. of Texas at Austin, USA. We perform free-form fabrication of CdSe/ZnS quantum dots (QDs) on a plasmonic substrate using soft-patterned microlithography, with control over the concentration of QDs. We further tune the QD-plasmon interaction to achieve tunable QD lifetime from 80ps to 1 ns.

Significant-Loophole-Free Test of Local Realism with Entangled Photons, Manasa Giustina1,2, Marin Versteegh2, Sören Wengerowski2,3, Johannes Handsteiner2,3, Armin Hochrainer2,3, Kevin Phelan1, Fabian Steinlechner1, Johannes Kofler1, Jan-Ake Larsson1, Carlos Abellan1, Waldimar Amaya3, Valerio Pruneri1,2, Morgan Mitchell1,2, Joshua Bienfang5, Richard Minn1, Emanuel Knill1, Seo-Woo Nam2,3, Mitchell7,8, Joshua Bienfang5, Richard Mirin1, Bradley Christensen3, Evan Meyer-scott1,2; 1The Univ. of Texas at Austin, USA; 2Quantum Optics and Quantum Information, University of Vienna, Austria; 3Max-Planck-Institut für Quantenoptik, Germany; 4Institut de Ciencies Fotoniques, Spain; 5ICFO–Institut de Ciencies Fotoniques, Spain; 6ICREA – Institucio Catalana de Recerca i Estudis Avançats, Spain; 7ICREA – Institucio Catalana de Recerca i Estudis Avançats, Spain; 8ICREA – Institucio Catalana de Recerca i Estudis Avançats, Spain. Our experiment employs polarization measurements on entangled single photons and closes the statistical uncertainty simultaneously. We perform an experimental violation of a Bell inequality with strong statistical significance. Our experiment employs polarization measurements on entangled single photons and closes the locality, freedom-of-choice, fair-sampling, coincidence-time, and memory loopholes simultaneously.
structure of heterogeneous media. basic concepts related to non-universal properties of coher-
fluctuating fields caused by light-matter interaction. We review USA. Optical Society of America, a Fellow of the American Physical
chaired numerous professional meetings. He is a Fellow of the physics, has served in a number of editorial positions, and has
devices and from remote sensing to communications.
electromagnetism and optical waves interactions with com-
reduces avoided modal crossing to enable DKS generation.
ience Federale de Lausanne, Switzerland. Frequency comb
based dispersion in dissipative Kerr solitons (DKS) in micro-
resonators is important for many applications. We show higher
order mode suppression in silicon nitride microresonators that

SWAE.3 • 16:00 Intracavity Characterization of Micro-comb Generation in the Single Soliton Regime, Pei-Hsun Wang, Joie A. Jaramillo-Villegas1,2, Yi Xuan1, Xiaoao Xue1, Yang Liu1, Daniel E. Leard1, Minghao Qi1,2, Andrew M. Weiner1,2, Purdue Univ., USA. We use a drop-port geometry to characterize the intracavity waveform of an on-chip microcavity soliton. In contrast to the through-port output, the intracavity field shows efficient power transfer from the pump into the comb.

SWAE.4 • 16:15 Measuring the Degree of Coherence of Microresonator Frequency Combs, Karen E. Webb1, Jae K. Jang1, Jeesienta Anthony1, Stephane Coen1, Miro J. Erkintalo1, Stuart G. Murdoch1, The Univ. of Auckland, New Zealand. We use spectral interferometry to experimentally measure the degree of coherence across the full bandwidth of microresonator-based frequency combs. Our results show distinct coherence characteristics for two different frequency combs, supporting previous theoretical findings.

SWAE.5 • 16:30 Coexistence of Temporal Cavity Solitons and Modulation Instability in a Passive Kerr Cavity, Miles Anderson1,2, Francois Leo1, Miro J. Erkintalo1, Stephanie Coen1, Stuart G. Murdoch1, The Univ. of Auckland, New Zealand. We experimentally demon-
strate the simultaneous coexistence of two independent nonlinear states in a passive Kerr cavity operated at high power. Our experimental observations are shown to be in excellent agreement with simulation and theory.

SWAF • Multiply Scattering Media
SWAF.1 • 15:30 Record Length (13.4km) Pulse Propagation in OAM States, Patrick Gregg1, Paul Kristensen1, Siddharth Ramachandran1, Electrical and Computer Engineering, Boston Univ., USA; 2QPS-File, Denmark. We demonstrate 13.4km propagation of OAM l=7 fiber modes with record low 0.8dB/km loss via a circulating fiber loop experiment. For well-designed fibers, we demonstrate that OAM modes can travel distances relevant for large-scale data centers.

SWAF.2 • 15:45 Experimental Demonstration of Orbital Angular Momentum (OAM) Modes (De)Multiplexing and Transmission in 2-Km Fiber with Nyquist 32-QAM Coherent Detection Signals, Jian Wang1, Long Zhu1, Kaiheng Zou1, Yixiao Zhu1, Jun Liu1, Fang Zhang1, Qi Mo1, Cheng Du1, Huazhong Univ of Science and Technology, China; 2Peking Univ., China; 3Fiberhome Telecommunication Technologies, China. We experimentally demonstrate orbital angular momentum (OAM) modes (de)multiplexing/transmission in 2-km few-mode fiber with 10-Gbaud Nyquist 32-QAM coherent detection signals without using MIMO. Favorable BER performance is achieved with low mode crosstalk <-25dB.

SWAF.3 • 16:00 Orbital Angular Momentum Mode Division Multiplexing over 1.4 km RCF Fiber, Reza Mirzaei Nejad1,2, Yi Xuan1,3, Xiaoxiao Xue1, Karen Allahverdyan1, Pravine Vasty2, Siamak Amiralizadeh1, Charles Brunet1, Younès Messaddeq1, Sophie LaRoche1, Leslie Rusch1, Université Laval, Canada. We demonstrate the mode division multiplexing system using two orbital angular momentum modes over 1.4 km RCF fiber. We also use a new mode demultiplexing scheme enabling us to do electrical polarization demultiplexing.

SWAF.4 • 16:15 Orbital Angular Momentum (OAM) based Optical Routing using Reconfigurable Optical Vortex Grating, Ting Lei1, Xiaocang Yuan1, Shenzhen Univ., USA. We propose and demonstrate routing of multiple free space optical communication channels labeled by OAM states through a dynamic grating. Data exchange and multicast among 49 OAM channels are demonstrated with bit error rate measurements.

SWAF.5 • 16:30 Demonstration of using Passive Integrated Phase Masks to Generate Orbital-Angular-Momentum Beams in a Commu-
nications Link, Zhe Wang1, Yan Yan1, Amir Arbabi1, Cong Liu1, Guodong Xie1, Zhe Zhao1, Yangxiong Ren1, Long Li1, Nisar Ahmed1, Asher Willner1, Ehsan Arbabi2, Andrea Farao1, Nima Ashrafi1, Solyman Ashrafi1, Moshe Tur1, Alan Willner1, USC, USA; 2California Inst. of Technology, USA; 3NxGen Partners, USA; 4School of Electrical Engineering, Tel Aviv Univ., Israel. We demonstrate high-efficient polarization insensitive OAM generation using integrated phase masks and measure their tolerance to the misalignment of incident beams. An 80 Gbit/s communication link of two OAM channels by using phase masks is demonstrated.

Aristide Dogariu has published extensively in the broad area of optical
Dogariu has published extensively in the broad area of optical physics, has served in a number of editorial positions, and has
chair field-of view changes associated with material sciences to
to biology and from remote sensing to communications.
Dogariu is a Fellow of the Optical Society of America, a Fellow of the American Physical Society, and he is the recipient of the SPIE G. G. Stokes Award.
**Time-resolved Flow Cytometry for Lifetime Measurements**

We quantitated circulating tumor cells of whole blood from the vein of mice using a high-speed video-rate laser-scanning confocal microscope. By utilizing custom-designed software, we were able to visualize fast-flowing cells with high accuracy.

**In vivo Quantitation of Circulating Tumor Cells by High-speed Intravital Laser-scanning Confocal Microscopy**

We developed a novel technique for quantitating circulating tumor cells in vivo using a high-speed intravital laser-scanning confocal microscope. Our technique allows for high-accuracy measurements of circulating tumor cells in real-time.

**Coherent Multiheterodyne Spectroscopy using Optical Frequency Comb Generators**

We demonstrated the use of coherent multiheterodyne spectroscopy for high-accuracy measurements of atmospheric transmission. Our technique allows for precise spectroscopic analysis over a broad range of frequencies.

**Mid-Infrared Frequency-Agile Dual-Comb Spectroscopy with Doppler-Limited Resolution**

We reported the development of a mid-infrared frequency-agile dual-comb spectroscopy system with enhanced Doppler-limited resolution. Our system provides unprecedented accuracy in the measurement of atmospheric gases.

**Massively Parallel Dual-Comb Molecular Spectroscopy with Broadband Detection**

We developed a technique for massively parallel dual-comb molecular spectroscopy with broadband detection. Our system allows for rapid and accurate identification of a wide range of molecules.
AW4J.2 • 15:45
Probing melt pool dynamics and particle ejection using high speed optical diagnostics, Sonny Ly1, Alexander Rubenchuck1, Gabe Guss1, saad Khairallah1, Matthew Corrigan1, Natascia de Leo1, Lucia Napiorkowski1, Silvano Donati1, Marinello1, 2Dept. of oncology, Univ. of Turin, Italy; 3Fraunhofer Inst. for Biomedical Engineering, Germany; 4Air Force Research Lab, USA; 5New Mexico State University, USA; 6Quantum Research Labs & Nanofacility, Florida Tech, USA. The melt flow at the focal zone is a key parameter in the laser melting process, and the dynamics of the melt pool can affect the final part quality. In this work, we present experimental results on melt pool dynamics and particle ejection associated with selective laser melting. High speed optical diagnostics are used to probe morphological changes for SS316L. Data is compared to simulations.

AW4J.3 • 16:00
Lens Thickness Measurement and Axial Positioning Method Based on the Frequency-shifted Confocal Feedback, Yingdong Tan1, Kai-Yu Zhou1, Shuang Zhang1, Tinghua Univ. of China, China. We describe a new method for lens thickness measurement and axial positioning based on the frequency-shifted confocal feedback. The heterodyne modulation is utilized and the detection sensitivity is improved prominently by the frequency-shifted feedback effect.

AW4J.4 • 16:15
Tutorial
Optical Sensing with All-Dielectric Photonic Crystals, Emiliano Descov1, 2, Angela Angelini1, Ricardo Rizzo1, Francesca Frascella1, serena riccardi1, Peter Munzer1, Norbert Danz2, Stefan Schmiider1, Frank Sonntag1, Maria Alvaro1, Lucia Naponi1, Paola Rivolo1, Natalia de Leo1, Ulrich Joros1, Francesco Michelotti1, Federico Bussolino1, Politecnico di Torino, Italy; 1Dep. of Optics, Univ. of Turin, Italy; 2Fraunhofer Inst. -IF, Germany; 3Fraunhofer Inst. -WS, Germany; 4SAPIENZA Univ. of Rome, Italy; 5Quantum Research Labs & Nanofacility Piemonte, Istituto Nazionale di Ricerca Metrologica -INRIM, Italy; 6Univ. of Siegen, Germany. Dielectric multilayered structures are introduced here as building blocks of disposable chips for sensing applications. Some experimental configurations are illustrated wherein flat or patterned multilayers are employed for sensing in either label-free, spectroscopic or fluorescence operational modes. In particular, the possibility to enhance and control the emission from fluorescence markers on the chip surface is demonstrated to improve the detection limit in bio-assays for cancer diagnostics.
**CLEO: Science & Innovations**

**Meeting Room 212 C**

**15:30–17:30**  
**SW4M • Single Mode Lasers**  
President: Hideki Hirayama; RIKEN, Japan

**SW4M.1 • 15:30**  
**DWDM Source Based on Monolithic Side-Wall Sample Grating DBR Laser Array**, Liangping Hou, Junjie Xu, Lian Ed-die, Liangshun Han, Hongliang Zhu, John Marsh, 1Univ. of Glasgow, UK; 2Inst. of Semiconductors, China; 33CST Global Ltd, UK. We report side-wall sampled grating and quantum well intermixing techniques to fabricate a full function 4-channel DWDM source with excellent wavelength precision (residuals <0.13 nm) and high yield. Output power was >10 mW.

**SW4M.2 • 15:45**  
**An 8 kHz Linewidth, 50 mW Output Wavelength Tunable DFB LD Array over the C-band with Self Optical Feedback**, Keisuke Kasai, 1Univ. of Michigan, USA. The key to achieving such high quality tunability is based on a novel side wall sampled DBR LD structure combined with a self optical feedback loop. We have demonstrated an excellent linewidth of < 8 kHz, over a 10 nm tuning range while maintaining a high output power of > 50 mW.

**SW4M.3 • 16:00**  
**Room Temperature InGaAs/InP Distributed Feedback Laser Directly Grown on Silicon**, Zhechao Wang, 1Bin Tian, 1Marianna Pantouvaki, 2Joris Van Campenhout, 3Clement Merckling, 3Dries Van Thourhout, 1Photonics Research Group, Ghent Univ.-imec, Belgium; 2Center for Nano- and Biophotonics (NB-Photonics), Ghent Univ., Belgium; 3IMEC, Belgium. We report an optically pumped room-temperature O-band DFB laser, based on the buffer-less epitaxial growth of high quality InGaAs/InP waveguides directly on silicon wafer.

**SW4M.4 • 16:15**  
**Gain Control using Graphene Plasmons in Aperiodic DFB lasers**, Thomas Falland, 1Owen Marshall, 2Y.-J Kim, 3Kostya Novoselov, 4Subhasish Chakraborty, 1Univ. of Manchester, UK. We integrate tunable graphene plasmons into a THz laser waveguide with an aperiodic hologram lattice. This allows us to control the cavity photon lifetime and hence modulate round trip gain by doping the graphene layer.

**SW4M.5 • 16:30**  
**80 nm tunable semiconductor disk lasers in DBR-free geometry**, Zhou Yang, 1Alexander Albrecht, 2Jeffrey Cederberg, 1Mansoor Sheik-Bahae, 1Univ. of New Mexico, USA; 2Sandia National Labs, USA. We report an 80 nm tunable DBR-free semiconductor disk laser with 6 W CW output power. We attributed such wide tunability to the broad effective gain bandwidth allowed by the DBR-free geometry.

**Meeting Room 212 D**

**15:30–17:30**  
**FW4N • Coherent Multidimensional Spectroscopy**  
President: Ilias Perakis, Univ. of Alabama, Birmingham, USA

**FW4N.1 • 15:30**  
**Coherent Spectroscopy of Semiconductors**, Steven T. Cundiff, 1Univ. of Michigan, USA. Coherent spectroscopy, including multidimensional approaches, overcomes the effects of inhomogeneous broadening and can reveal coupling between resonances, effects that occur in semiconductors due to structural disorder in nanostructures and many-body effects.

Steven T. Cundiff is the Harrison M. Randall Collegiate Professor of Physics at the University of Michigan. Prior to joining the University of Michigan in 2015, he spent 17 years at JILA, a joint institute between the National Institute of Standards and Technology and the University of Colorado.

**FW4N.2 • 16:30**  
**Coherent ultrafast polaron pair formation in a conjugated polymer at room temperature**, Antonietta De Sio, 1Ephraim Sommer, 1Filippo Troiani, 2Julien Rehault, 3Margherita Maiuri, 1Univ. of Michigan, USA. Coherent ultrafast polaron pair formation in a conjugated polymer at room temperature, Antonietta De Sio, 1Ephraim Sommer, 1Filippo Troiani, 2Julien Rehault, 3Margherita Maiuri, 1Univ. of Michigan, USA. Coherent ultrafast polaron pair formation in a conjugated polymer at room temperature.

**FW4N.3 • 16:45**  
**Coherent ultrafast polaron pair formation in a conjugated polymer at room temperature**, Antonietta De Sio, 1Ephraim Sommer, 1Filippo Troiani, 2Julien Rehault, 3Margherita Maiuri, 1Univ. of Michigan, USA.

**Marriott Salon I & II**

**15:30–17:30**  
**AW4O • Medical Technology & Devices**  
President: Kristina Irsch, Johns Hopkins Univ., USA

**AW4O.1 • 15:30**  
**Investigating ultrashort laser pulses as a LASer Scalpel for Orthopedic Surgery (LASSOS)**, Simon Ashforth, 1Reece Costerbeek, 2Owen Bodley, 1M. Cather Simpson. 1School of Chemical Sciences, The Univ. of Auckland, New Zealand; 2The MacDermid Inst. for Advanced Materials and Nanotechnology and The Dodd Walls Centre for Quantum and Photonic Technologies, New Zealand; 3School of Chemical Sciences and Dept. of Physics, The Univ. of Auckland, New Zealand. We investigate ultrashort laser pulses for orthopedic surgery upon two species of fresh, unaltered bone. Ablation thresholds and rates are determined and we explore non-conventional beam types to optimize ablation efficiency and feature properties.

**AW4O.2 • 15:45**  
**3-D endoscopic imaging using plenoptic camera**, Hanh N. Le, 1Ryan Decker, 2Justin Opleman, 2Peter Kim, 3Axel Krieger, 2Jin U. Kang, 1Johns Hopkins Univ., USA; 2Children’s National Health System, USA. Three-dimensional endoscopic imaging using plenoptic technique combined with F-Matching algorithm has been pursued in this study. A custom relay optics was designed to integrate a commercial surgical straight endoscope with a plenoptic camera.

**AW4O.3 • 16:00**  
**SPAD cameras for biomedical imaging: promises and problems**, Barmak Heshmat, 1Genevieve Gariepy, 2Jonathan Leach, 1Ramesh Raskar, 2Daniele Faccio, 2MIT, USA; 3School of Engineering and Physical Sciences, Heriot-Watt Univ., UK. We experiment with single-photon avalanche diode array cameras for biomedical imaging through thick samples. The drawbacks and potentials are discussed for this application. Early results show successful imaging through hand and 10 cm tissue phantom.

**AW4O.4 • 16:15**  
**Metasurface-based freeform optics for biosensing and augmented reality systems**, Shane A. Colburn, 1Alan Zhan, 2Arka Majumdar, 1MIT, USA; 2School of Electrical and Computer Engineering, Ben-Gurion Univ., Israel; 3Dept. of Biomedical Engineering, Tel-Aviv Univ., Israel. Reduced tissue disruption and enhanced ablation efficiency are demonstrated using a pulsed 355nm laser. This was achieved by improving the evanescence of the end face of the delivering fiber to stir pressure transients initiated during ablation.
Roy Taylor commenced his research career in 1971 working on pulsed dye lasers. He established the Femtosecond Optics Group at Imperial College in 1986 and over his career has published more than 400 papers and co-authored over 450 conference presentations. His work and contributions in various aspects of laser research, photonics, ultrafast optics, optical fibres and non-linear optics has been recognized by the Carl Zeiss Research Award, the Institute of Physics Thomas Edsall Medal and the Royal Society's Rumford Medal.

**Marriott Salon III**

**15:30-17:30**

**SW4P • Nonlinear Fiber Optics II**

*President: Sze Yun Set; Univ. of Tokyo, Japan*

**SW4P1 • 15:30**

Fibre-Integrated, Non-Linear Manipulation of Pulsed Fibre Lasers, J. R. Taylor1,2; Imperial College London, UK. All-fibre seeded master-oscillator power fibre amplifiers, pumping integrated non-linear fibres and crystals allows spectral versatility through Raman, parametric and second harmonic generation as well as via solitonic and supercontinuum generation processes and allows pulse width and repetition rate selectivity at multi-watt level average powers. The performance of numerous systems will be described.

**SW4Q • New Frequency conversion Technologies**

*President: Jay Sharping; Univ. of California Merced, USA*

**SW4Q.1 • 15:30**

High-power 355-nm UV generation in CsLiB2O6 crystal, Masahide Yoshimura1,2,3; Yuki Suwa1,2, Takahashi1,2, Yoshinori Takahashi1,2, George Okada1,2, Yusuke Mori1,2; Osaka Univ., Japan. A 30-kW output power at 355 nm is generated in CsLiB2O6 crystal using a hybrid picosecond MOPA seeded by a gain-switched LD. The conversion efficiency from the fundamental source to the third harmonic reaches 48.1%.

**SW4Q.2 • 15:45**

2.9 W picosecond ultraviolet source at 266 nm based on walk-off compensated single-pass fourth harmonic generation in b-BaB2O4:Lu3+; Chattayan Kumar D. Suddapalli1,2, Josep Canals Casals3, Xujiang Wei1, Kavita Devi1, M. Brahimi-Zadeh1,2; 1CFIO-The Inst. of Photonics Sciences, Spain; 2Insti- tuto Catalana de Recerca i Estudis Avançats (ICREA), Paseig Lluís Companys 23, Spain. We report a stable picosecond ultraviolet source based on single-pass walk-off compensation scheme in BBO, providing up to 2.9 W of average UV power at ~80 MHz repetition rate in high beam quality.

**SW4Q.3 • 16:00**

Fiber-Laser-Based, 80-MHz Picosecond UV Source Generating Multi-Tens of Milliwatt Output Power Across 329-348 nm, Kavita Devi1, Chattayan Kumar D. Suddapalli1, M. Brahimi-Zadeh1,2; 1CFIO-The Inst. of Photonics Sciences, Spain; 2Insti- tuto Catalana de Recerca i Estudis Avançats (ICREA), Spain. We report a fiber-laser-based 80-MHz picosecond UV source, tunable across 329-348 nm, providing 115 mW at 339.9 nm, with passive power stability of ~2.9% rms (1 min) and 6.5% rms (2 hours), in high beam quality.

**SW4Q.4 • 16:15**

Autoresonant Three-Wave-Mixing in Non-Uniform Second-Order Nonlinear Bulk Crystals, Andrej Markov1, Anna Mazhorova1, Oded Yaakobi2, Matteo Clerici1, Daniele Modotto3, Ottavia Jedrkiewicz4, Paolo Trapani4, Arcady Major5; 1ICFO -The Inst. of Photonic Sciences, Spain; 2Insti- tuto Catalana de Recerca i Estudis Avançats (ICREA), Spain; 3Dipartimento di Ingegneria dell’Informazione, Università di Palermo, Italy; 43Dipartimento di Ingegneria dell’Informazione, Università di Brescia, Italy; 5ICFO -The Inst. of Photonic Sciences, Spain. We demonstrate linear and nonlinear optical transmission results in which the spectral region of negative refraction can be switched from near infra-red to visible.

**SW4Q.5 • 16:30**

Photon Efficient Electro-Optic Conversion via a Micromechanical Oscillator, Konrad W. Lehner1, Cindy A. Regal1, Robert W. Peercy1,2,3,4, Andrew P. Higginbotham5; 1Univ. of Colorado at Boulder JILA, USA. We describe the design and testing of an efficient and bidirectional electro-optic converter. The device exploits electromechanical and optomechanical transduction to moving information between the optical and electrical domains.
Wednesday, 8 June

FW4A • Metasurfaces & Metamaterials—Continued

FW4A.5 • 16:45
Ultrafast Optical Tuning of Epilayer-Near-Zero Thin Films, Clayton DeVault1, Nathaniel Krevey1, Jongbum Kim1, Awek Dutta2, Marcello Ferrera3, Vladimir M. Shalaev1, Alexandra Boltasseva1; 1Purdue Univ., USA; 2Inst. of Photonics and Quantum Sciences, UK. Large and ultra-fast transient reflectivity and transmissivity are recorded via pump (∼325 nm) and probe (∼1300 nm) experiments on aluminum-doped zinc oxide thin films engineered to possess ultra-fast electron-hole recombination and epilayer-near-zero behavior in the NIR.

FW4A.6 • 17:00
A Chiral Metamaterial for Chiral Responsive Optoelectronic Transduction, Sean P. Rodrigues1, Lei Kang1, Shoufeng Lin1, Yonghao Cui1, Yongmin Liu2, Douglas Werner2, Wenshan Cai3; 1Georgia Inst. of Technology, USA; 2Northeastern Univ., USA; 3Pennsylvania State Univ., USA. Chiral-selective nonlinear optics and optoelectronic signal generation are demonstrated in an electrically-active photonic metamaterial. The metamaterial reveals significant chiroptical responses in both harmonic generation and photon drag, correlating to the resonance in the linear regime.

FW4A.7 • 17:15
Metasurface Holographic Light Sources Driven by Electron Beam, Brendan P. Clarke1, Guanhui Li1, Jin-Kyu So1, Kevin Macdonald1, Nikolay I. Zheludev1; 1Optoelectronics Research Centre and Centre for Photonic Metamaterials, Univ of Southampton, UK; 2National Key Lab for Infrared Physics, Shanghai Inst. of Technical Physics, China; 3Centre for Disruptive Photonic Technologies & The Photonics Inst., Nanyang Technological Univ., Singapore. We apply holographic principles to tailor light emission resulting from the injection of free electrons into a nanostructured surface and demonstrate robust control over the direction, divergence wavelength and topological charge of radiation emission.

FW4A.8 • 17:15
Coherent Control of Plasmonic Spin-Hall effect, Shiyi Xiao1, Fan Zhong1, Hui Liu1, Shining Zhu1, Jensen Li1; 1anjing Univ., China; 2Univ. of Birmingham, UK. We demonstrate coherent control of SPP orbitals for the two opposite spins using multiple rings of nano-slots with properly designed orientations on a metasurface. This scheme provides us to achieve arbitrary plasmonic spin-Hall effect.

FW4B • Novel Plasmonic and Nanophotonic Materials and Phenomena—Continued

FW4B.6 • 16:45
Collective plasmonic oscillations in nanostrips arrays and continuous sine-wave gratings. Comparative study, Natalya Noginova1, Sohelia Mashhad2, Vincent Ronot2, Matthew LePain1, Maxim Durach1; 1Georgia Southern Univ., USA; 2Norfolk State Univ., USA. Gold nanostrip arrays exhibit collective plasmonic oscillations analogous to surface plasmon-polaritons in continuous films with a spatially modulated profile. Similarities and differences in optical behavior of continuous and discontinuous systems are studied experimentally and theoretically.

FW4B.7 • 17:00
Emergence of transverse spin in optical modes of semiconductor nanowires, Hassein Alizadeh1, Bjorn Reinhard1; 1Boston Univ., USA. Here we demonstrate the generation of transverse spin angular momentum by the weakly-guided mode of semiconductor nanowires. The evanescent field of these modes in combination with the transversality condition accounts for the transverse spin.

FW4B.8 • 17:15
Coherent Control of Plasmonic Spin-Hall effect, Shiyi Xiao1, Fan Zhong1, Hui Liu1, Shining Zhu1, Jensen Li1; 1anjing Univ., China; 2Univ. of Birmingham, UK. We demonstrate coherent control of SPP orbitals for the two opposite spins using multiple rings of nano-slots with properly designed orientations on a metasurface. This scheme provides us to achieve arbitrary plasmonic spin-Hall effect.

FW4C • Symposium on Advances in Single Photon Detection Technology II—Continued

FW4C.4 • 17:00
High-efficiency UV Superconducting Nanowire Single-photon Detectors from Amorphous MoSi, Emma E. Wollman1, Varun Verma1, Ryan M. Briggs1, Andrew D. Beyer1, Richard Minin1, Sae Woo Nam1, Francesco Marsili1, Matthew D. Shaw2, 1Jet Propulsion Lab, USA; 2NST, USA. We demonstrate high-efficiency detection of 370 nm photons using superconducting nanowire single-photon detectors. The detectors employ amorphous MoSi (bulk Tc = 6.8 K) to enable operation on a compact cryocooler system.

FW4C.5 • 17:15
High-Operating-Temperature Superconducting Nanowire Single Photon Detectors, Angel Velasco1, Daniel P. Cunnane1, Narendra Acharya2, Ryan M. Briggs1, Andrew D. Beyer1, Matthew Shaw1, Boris S. Krasik2, Matthais A. Wolak1, Xiaoqing Xi1, Francesco Marsili1, 1Jet Propulsion Lab, USA; 2NST, USA. We report on 5 nm thick, 100 nm wide MgB2 nanowires with single-photon sensitivity at 635 nm wavelength in the operating-temperature range 3 - 10 K.
Wednesday, 8 June

16:30–18:30  Happy Hour in the Exhibit Hall, Exhibit Halls 1, 2 & 3

18:30–20:00  OSA’s Light the Future with Ray Kurzweil, Grand Ballroom

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
microring array 120nm-radius polystyrene particle using a 2 × 2 coupled proof-of-concept experiments show a detection of single waveguide with light-scattering pattern recognition. Our silicon nitride two-dimensional coupled-resonator optical waveguide towards an in-fiber flow cytometer. The system represents a first step through fluorescence particles flowing at high rate and inertially focused in a capillary. The system represents a first step towards an in-fiber flow cytometer.

Optofluidics in microstructured fibers combining particle elasto-inertial focusing and fluorescence, Sebastian Elchevery1,2; Fredrik Laurell1; Muhammad Asim F Faridi1, Harisha Ramachandrasah1, Walter Margulis1,2; Aman Russom1,2; Division of Proteomics and Nanobiotechnology, SciLifeLab, KTH, Sweden; 2Dept. of Fiber Optics, Acreo Swedish ICT, Sweden; 3Dept. of Applied Physics, Umea University, Sweden; 4Inst. of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus Univ. in Torun, Poland; 5IMRA America, Inc., USA. We measure broadband H₂O and OH spectra in a flame using near-infrared cavity-enhanced Fourier transform spectroscopy, we retrieve temperature and OH concentration, and compare water spectra to an improved line list.

On-chip Wavelength Multiplexing Detection of Cancer DNA Biomarkers in Blood Serum, Hong Cai1, Matthew A. Stott2, Damla Ozcelik1, Aaron Hawkins2, Holger Schmidt1; 1Univ. of California Santa Cruz, USA; 2Dept. of Electrical and Computer Engineering, Brigham Young Univ., USA. We used spectral multiplexing produced by MMI waveguides to detect and identify two types of melanoma cancer DNA on an optofluicid platform. Cancer DNA biomarkers in blood serum were isolated using a solid-phase extraction method.
**AW4J • Sensing for Manufacturing—Continued**

Emiliano Descrovi is Associate Professor at the DISAT-Politecnico di Torino (Italy). In 1999, he obtained his Master Degree Physics. In 2005, he got the Ph.D. degree in Microtechnology at the Institute of Microtechnology of the University of Neuchatel (Switzerland). His research interests are focused on nanophotonics applied to sensing applications.

**AW4K • Remote Sensing Technology and Incoherent Spectroscopic Tools—Continued**

Remote Backward-Propagating Water Lasing in Atmospheric Air, Arthur Dogariu, Tat Loon Cheng, Richard Miles; Princeton Univ., USA. We demonstrate backwards lasing from atmospheric air humidity. The 656nm stimulated emission is obtained via two-photon excitation of atomic hydrogen created from water dissociation. The hydrogen lasing can be used for standoff optical gas detection.

**AW4K.6 • 17:00**

Design and Simulation of Efficient Narrowband Thermal Emitter with 3 $\mu m$ wavelength, Jon Olav Grepstad, Jo Gjessing, Hallvard Angelås, Zeljko Stokic, Thor Bakke, Aina K. Herbjørnrød; MiNaLab, ICT, SINTEF, Norway. A low-power infrared source based on a silicon photonic-crystal membrane has been designed. Temperature distribution and reflection spectrum has been simulated. Large narrowband IR absorption is obtained with optimal material doping.

**AW4K.7 • 17:15**

Near-Infrared On-Chip Spectroscopy for Greenhouse Gas Detection, Xinyuan Chong, Erwen Li, Alan X. Wang; Oregon State Univ., USA. We demonstrated ultra-compact near-infrared on-chip gas spectroscopy using high resolution plasmonic filter array. We experimentally achieved ~10nm spectral resolution, which successfully resolved the two symmetric vibrational bands of CO$_2$ at 2.0$\mu m$ wavelength.

**SW4L • Laser Nano Fabrication—Continued**

Second Harmonic Generation in Poled Laser-Written Fused Silica Waveguides with Periodic Laser Erasure, Jason C. Ng, Li Qian, Peter R. Herman; Dept. of Electrical and Computer Engineering and the Inst. for Optical Sciences, Univ. of Toronto, Canada. Second harmonic generation is reported for the first time in femtosecond laser written, thermally-polished silica glass. Poling was periodically erased by the same laser, yielding a quasi-phase-matching SHG efficiency of 2.3×10$^{-5}$ %/W at 768.4 nm.

**SW4L.5 • 17:15**

Monocrystalline silicon needle formation by optical vortex illumination, Fuyuto Takahashi, Honami Fujiwara, Kai Izumisawa, Katsuhiko Miyamoto, Hirofumi Hidai, Ryuji Morita, Takashige Omatsu; Chiba Univ., Japan; Molecular chirality research center, Chiba Univ., Japan. Optical vortex illumination enables the creation of silicon needles with a height of ~14 $\mu m$ and a thickness of ~2 $\mu m$. Silicon needle formation requires an optical vortex pulse with a pulse duration of 10–20 ps, so as to create thermally-melted silicon with fewer heat diffusion effects.
SW4M • Single Mode Lasers—Continued

**SW4M.6 • 16:45**
High power surface-grating stabilized narrow-stripe broad area lasers with beam parameter product < 2 mm×mrad, Jonathan Decker1, Jörg Fricke1, Andre Maassdorff1, Götz Erbert1, Paul Crump1; 1Ferdinand Braun Inst. Berlin, USA.

Narrow-stripe (30 μm aperture) broad area lasers with monolithically integrated DFB-surface-gratings deliver 5 W optical output per emitter with 50% conversion efficiency, spectral width ≤ 1 nm from 970...980 nm, and beam parameter product < 2 mm×mrad.

**FW4N • Coherent Multidimensional Spectroscopy—Continued**

**FW4N.3 • 16:45**
2D Electronic Stark Spectroscopy, Anton D. Loukianov1, Andrew Niednigbus1, Jie Pan1, Jennifer Ogilvie1; 1Univ. of Michigan, USA.

We describe a novel nonlinear spectroscopy method that combines the high sensitivity of background-free heterodyne-detected 2D electronic spectroscopy with Stark spectroscopy for observation of ultrafast charge-transfer kinetics. We demonstrate the method on the photosystem II reaction center.

**FW4N.4 • 17:00**
Many-body Effects and the Role of Indirect Excitons in Asymmetric InGaAs/ GaAs Double Quantum Wells, Christopher L. Smallwood1, Matthew W. Day1, Fauzia Jabeen1, Steven T. Cundiff1; 1JILA, Univ. of Colorado/NIST, USA; 2Physics, Univ. of Michigan, USA; 3Physics, Univ. of Colorado, USA; 4Lab of Quantum Optoelectronics, Ecole Polytechnique Federale de Lausanne, Switzerland.

The emergence of spatially indirect excitons is observed in asymmetric InGaAs/GaAs double quantum well heterostructures via optical multidimensional coherent spectroscopy. Origins of coupling between wells include many-body effects and electron tunneling.

**FW4N.5 • 17:15**
Rotational Symmetry Breaking in Coherent Dynamics of GaN Excitons Excited by Radially Polarized Pulses, Kyohui Shigematsu1, Masato Suzuki1, Keisaku Yamane1, Ryuji Morita1; 1Hokkaido Univ., Japan.

We performed four-wave-mixing (FWM) spectroscopy using radially polarized pulses on uniaxially strained GaN excitons. The FWM dynamics show a deformation of the polarization distributions attributable to the rotational symmetry breaking in the exciton coherent dynamics.

**FW4N.6 • 17:45**
Design and Fabrication of Printed Optical Phantoms for Deep Tissue Imaging, Brian Bentz1, Dergan Lin1, Kevin J. Webb2, Anna Bowen2, Dustin Houston2, Daniel Ysselstein2, Jean-Christophe Rochet2; 1Purdue Univ., USA; 2Univ. of Notre Dame, USA.

We demonstrate optical imaging in physiologically realistic phantoms with controlled optical properties fabricated using 3D printing. Our method is adaptable to many optical imaging methods, and can be used for calibration of live animal data.

**AW4O • Medical Technology & Devices—Continued**

**AW4O.6 • 16:45**
Cell and Tissue Response to Modified by Laser-induced Periodic Surface Structures Biocompatible Materials for Dental Implants, Iaroslav Gnilitsky1, Maksim Pogorelov2, Dusan Dobrota1, Roman Viter1, Leonardo Orazi1, Oleg Mischenko1; 1UNIME, Italy; 2Sumy State Univ., Ukraine; 3PP Exima, Ukraine; 4Jessenius Faculty of Medicine in Martin, Comenius Univ. in Bratislava, Slovakia; 5Inst. of Atomic Physics and Spectroscopy, Univ. of Latvia, Latvia.

The use of femtosecond laser-induced periodic surface structures (LPSS) for dental implants surface modification for improving cell adhesion and proliferation is reported. Results demonstrated higher response of cells on modified surface compared to untreated ones.

**AW4O.7 • 17:00**
Design and Fabrication of Printed Optical Phantoms for Dental Implants, Brian Bentz1, Dergan Lin1, Kevin J. Webb2, Anna Bowen2, Dustin Houston2, Daniel Ysselstein2, Jean-Christophe Rochet2; 1Purdue Univ., USA; 2Univ. of Notre Dame, USA.

We demonstrate optical imaging in physiologically realistic phantoms with controlled optical properties fabricated using 3D printing. Our method is adaptable to many optical imaging methods, and can be used for calibration of live animal data.

16:30–18:30 Happy Hour in the Exhibit Hall, Exhibit Halls 1, 2 & 3

18:30–20:00 OSA’s Light the Future with Ray Kurzweil, Grand Ballroom
Detailed Characterization of Continuous-Wave and Pulsed-Pump Four-Wave Mixing in Nonlinear Fibers, Mads Lilieholm¹, Michael Galili¹, Lars Grüner-Nielsen¹, Leif K. Oxenløwe¹; ¹Technical Univ. of Denmark, Denmark; ²OFS, Denmark. We explore the parametric gain differences for continuous-wave and pulse-pumped four-wave mixing, using various highly nonlinear fibers. Detailed simulations support our findings that the dispersion slope determines the experimentally observed differences, limiting the pulsed-pump performance.

Nonlinear phase added by a Raman fiber amplifier to a single-frequency seed laser, Philippe Benoit¹, Nicolas Cézard¹, Arnaud Musso², Alexandre Kudlinski³, Guillaume Canat¹; ¹ONERA, France; ²IRCICA, PhLAM, France. We report on analysis of phase perturbation in single-frequency Raman fiber amplifiers. Nonlinear phase is added by Raman gain and cross-phase modulation. A simple relation is derived and has been verified experimentally.

Open-Cavity Spun Fiber Raman Lasers with a Polarized Output, Javier Nuño del Campo², Giuseppe Gallazzi¹, Francesco Gallazzi¹, Francisco Prieto¹, Maria Concepción Pulido-De-Torres¹, Pedro Correders¹, Stefan Walzbieta, Juan D. Aina-Castaron¹; ¹Instituto Interdisciplinar de Optica, 'Daza de Valdes', Spain; ²Laboratoire Interdisciplinaire Carnot de Bourgogne, UMR 6303 CNRS - Université Bourgogne Franche-Comté, France; ³Instituto De Optica 'Daza De Valdes', Spain. We experimentally study the polarization properties of the outputs of different open-cavity Raman fiber lasers based on spun fiber and a highly polarized pump, demonstrating controlled output polarization and improved threshold.

Third harmonic generation is demonstrated in a novel dielectric mirror made of aperiodic layers of Al₂O₃ and SiO₂. One percent conversion has been measured with 70-fs pulses and efficiencies larger than ten percent seem possible.

Kathleen Richardson is currently Professor of Optics and Materials Science and Engineering at CREOL/College of Optics and Photonics at the University of Central Florida, where she runs the Glass Processing and Characterization Laboratory (GPCL). Most recently at Clemson University, she and her research team carried out synthesis and characterization of novel glass and glass ceramic materials for optical applications, examining the role of structure/property relationships in resulting optical function and performance in bulk, planar and fiber optical materials. She is a recognized world leader in infrared glass research and education, and as a result of these efforts, currently holds the rank of Fellow, in the American Ceramic Society, the Society of Glass Technology (UK), SPIE and The Optical Society. Since 2006, she has served as a member of the Board of Trustees at Alfred University.

Wednesday, 8 June
16:30–18:30 Happy Hour in the Exhibit Hall, Exhibit Halls 1, 2 & 3
18:30–20:00 OSA’s Light the Future with Ray Kurzweil, Grand Ballroom
We show that non-Hermitian bipartite optical lattices, which display a spontaneous phase transition from a regime of entirely real spectrum to a complex one. This work broadens the scope of non-Hermitian optics beyond PT-symmetry.

Universal sign-control of evanescent coupling, Matthias Heinrich1, Robert Keil2, Charles Poli3, Jake Akinstil1, Gregor Wehr1, Henning Schomerus1, Alexander Szameit1, Friedrich-Schiller-Universität Jena, Germany; 2Universität Innsbruck, Austria; 3Lancaster Univ., UK. We present a new class of ultra-sensitive PT-symmetric photonic molecules based on higher-order exceptional points. Methods to realize such sensitive structures are explored in InGaAsP arrangements by appropriately controlling the perturbations in the system.

We present a new class of ultra-sensitive PT-symmetric photonic molecules based on higher-order exceptional points. Methods to realize such sensitive structures are explored in InGaAsP arrangements by appropriately controlling the perturbations in the system. We present a new class of ultra-sensitive PT-symmetric photonic molecules based on higher-order exceptional points. Methods to realize such sensitive structures are explored in InGaAsP arrangements by appropriately controlling the perturbations in the system.

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FTh1D.1 • 08:00
Highly Efficient Polarization Insensitive Holograms Based on Dielectric Metasurfaces, Katie E. Chong1, Lei Wang2, Isabelle Staude1, Sergey Kruk1, Anthony James1, Jason Dominguez2, Gnanapathi S. Subramaniam1, Manuel Decker1, Igal Brener1, Dragomir N. Neshev1, Yuri S. Kivshar1, Nonlinear Physics Centre, Research School of Physics and Engineering, The Australian National Univ., Australia; 1Inst. of Applied Physics, Abbe Center of Photonics, Friedrich-Schiller-Univ. Jena, Germany; 2Center for integrated Nanotechnologies, Sandia National Labs, USA, 3Sandia National Labs, USA. We demonstrate polarization-insensitive holographic Huygens\' metasurfaces based on silicon resonant meta-atoms capable of complex wavefront control at telecommunication wavelengths. We achieve over 82% transmittance efficiencies, with further optimization suggesting the efficiency exceeding 90%.

FTh1D.2 • 08:15
Metafilm: Metamaterial Array Embedded in Organic Thin Film, Tomo Ameayama1, Toru Kanazawa1, Tatsuyuki Urakami2, Atsushi Ishikawa3, Naoya Hojo4, Akio Yasaki2, Nobuhiro Nakao5, Takuo Tanaka6, Shigehisa Arui1. 1Tokyo Inst. of Technology, Japan; 2RIKEN, Japan; 3Mitsubishi Chemicals, Inc., Japan; 4Okayama Univ., Japan. A flexible metamaterial device consisting of metal split rings embedded in a transparent polymer film is demonstrated. The device is useful to construct three-dimensional metamaterial systems to develop novel terahertz- and photonic applications.

FTh1D.3 • 08:30
High Efficiency Near Diffraction-Limited Mid-Infrared Flat Lenses Based on Metasurface Reflectarrays, Shuyan Zhang1, Myoung-hwan Kim1, Francesco Aieta1, Alan She1, Tobias Mansuri1, Ivan Gabay1, Mohammadreza Khorsaninajad2, David Roussot2, Xiaojun Wang3, Mariano Troccoli4, Nanfang Yu5, Federico Capasso6, 1Harvard Univ., USA; 2Columbia Univ., USA; 3LEIA 3D, USA; 4Univ. of Waterloo, Canada; 5AdOptics, USA; 6Dept. of Physics, Univ. of Texas Rio Grande Valley, USA. We report the first mid-infrared flat lens based on the reflectarrays with focusing efficiency (70%), which is the highest reported so far for reflectarray-based lenses. Experiments and simulations show that the focusing is near diffraction-limited.

FTh1D.4 • 08:45
Planar Lens at Visible: Metasurface versus Refractive Optics, Mohammadreza Khorsaninajad1, Wei-Ting Chen1, Robert C. Devlin1, Jinewon Oh2, Federico Capasso3, 1Harvard Univ., USA; 2Univ. of Waterloo, Canada. We demonstrate planar lenses in the visible range (λ= 405nm, 532nm, and 680nm) with superior performance over a commercially-available objective. Planar lenses have focusing efficiencies as high as 86% with a numerical aperture of 0.8.

FTh1E.1 • 08:00 Invited
Shaping Light with Nonlinear Metasurfaces, Shay Keren-Zuri1, Oh Avayu2, Lior Michaeli1, Tal Ellenbogen1, 1Tel-Aviv Univ., Israel. Nonlinear metasurfaces introduce new ways to generate and control light. Here we demonstrate how to engineer the nonlinear interaction and shape the nonlinear emission by precisely tailoring the spatial distribution of the metasurface nonlinearity.

FTh1E.2 • 08:30
Active dielectric antenna for phase only spatial light modulation, Yu Horie1, Amir Arbabi1, Ehsan Arbabi1, Seyyedeh M. Kamali1, Andrei Faraon1, 1California Inst. of Technology. USA. We demonstrate an active dielectric antenna based on reflective high-contrast subwavelength gratings for phase modulation of reflected light by nearly 2π. Large-scale integration of such antennas will enable high-speed low-cost phased-array space light modulators.

FTh1E.3 • 08:45
Super-Dispersive Off-Axis Meta-Lenses for High Resolution Spectroscopy, Wei-Ting Chen, Mohammadreza Khorsaninajad, Jinewon Oh, Federico Capasso, Harvard Univ., USA; 1Tel of Waterloo, Canada. We demonstrate compact and highly efficient off-axis meta-lenses in the telecom region. Focusing at large angles, as high as 80°, while having a diffraction-limited focus spot enables resolving wavelength differences down to 200 picometers.

FTh1E.4 • 09:00
Electromechanically tunable 3D nano-split-ring array for dynamic control of light, Yifei Mao1, Weihua Zhang2, Meng-Gen Lin3, Jun-Xu1, 1Peking Univ., China; 2Nanjing Univ., China. We present an electromechanically controlled metasurface, consisting of an array of three-dimensional nano-split-rings. By applying voltage, its resonance can be tuned from 5.5 mm to 10 mm, with 110% reflectivity change and enormous optical rotations.

FTh1E.5 • 09:00
Multi-Stratum Resources Optimization for Cloud-based Radio over Fiber Networks, Hui Yang1, Wei Bai2, Yuanlong Tan1, Yongli Zhao1, Jie Zhang1, Yuefeng Ji1, Young Lee1, Beijing Univ. of Posts & Telecom, China; 2Huawei Technologies Co., Ltd, China. We present a multi-stratum resources optimization architecture for cloud-based radio over fiber networks with software defined networking. The overall feasibility and efficiency of the proposed architecture are experimentally verified on our testbed.
Thursday, 9 June

Executive Ballroom 210G

08:00–10:00
STh1G • Photodetectors
Presider: Adam Cook; Lockheed Martin, USA

STh1G.1 • 08:00
Invited
Low Excess Noise AlInAsSb, (x: 0.3–0.7) Avalanche Photodiodes, Min Ren1, Scott J. Maddox1, Madison Woodson1, Yooja Chen2, Seth Bank3, Joe Campbell3; Dept. of Electrical and Computer Engineering, Univ. of Virginia, USA; 2Electrical and Computer Engineering, Univ. of Texas at Austin, USA. We report avalanche photodiodes fabricated from AlInAsSb, (x:0.3–0.7), with low excess noise corresponding to k = 0.03–0.05. The new materials system promises an innovative alternative to Si for detection across the visible and near-infrared wavelengths.

STh1G.2 • 08:30
Wide Bandwidth (30 GHz) Slab-Coupled Optical Waveguide Photodiodes, Sva Yegnanarayanan1, Jason Plant1, Doug Oakley2, Antonio Napoleon2, Frederic O’Donnell3, Leo Missaggia4, Mark Hollis5, Paul Joodawiski6; Massachusetts Inst of Tech Lincoln Lab, USA. We describe design enhancements to increase the bandwidth of variable-confinement slab-coupled optical waveguide photodiodes to 30 GHz while maintaining good external responsivity (0.5 A/W), high 1-dB compression current (> 25 mA), and high linearity (OIP3 > 30dBm).

STh1G.3 • 08:45
Design and Fabrication of a Multispectral Infrared Material Detector, John Montoya1; Electrical and Computer Engineering, Duke Univ., USA. Infrared imagers require new technologies at the pixel level to provide enhanced spectral sensitivity. In this work, we demonstrate the use of metamaterial absorbers to enhance the quantum efficiency of an infrared interband cascade detector from 6.1% to 18.6% at 6.14um and 4.1% to 14.7% at 7.13um.

STh1G.4 • 09:00
Waveguide Integrated Balanced MUTC Photodiode, Patrick Runge1, Gen Zhou1, Shahrab Keyavanna1, Sten Seifert1, Willi Ebert1, Angela Seeger1, Qinglong Li2, Andreas Beling2; Fraunhofer Institut, Germany; 2Univ. of Virginia, USA. We demonstrate a monolithic InP-based highly linear and high-speed waveguide integrated balanced modified uni-traveling carrier (MUTC) photodiode chip. The chip has a 3dB-bandwidth of 80GHz and generates 2dBm RF output power at this frequency.

Executive Ballroom 210H

08:00–10:00
STh1H • Standoff and Remote Detection
Presider: President Fleisher; NIST, USA

STh1H.1 • 08:00
Invited
Broadband, High-Resolution Quantum Cascade Laser Multi-Heterodyne Spectroscopy for In-Situ and Remote Chemical Detection, Gerard Wysocki1,2; Princeton Univ., USA. Recent progress in broadband high-resolution quantum cascade laser multi-heterodyne spectroscopy for in-situ and remote detection of narrow- and broad-band absorbers. Broadband as well as high-resolution spectroscopic sensing capabilities will be presented.

STh1H.2 • 08:30
2-µm Direct Detection Differential Absorption Lidar For Multi-Species Atmospheric Sensing, Erwan Cadiou1, Baptiste Dherbecourt1, Guillaume Gori1, Myriam Raybaut2, Jean-Michel Melkonian2, Antoine Godard1, Jacques Pelon3, Michel Lefebvre1; ONERA, France; LATMOS, France. A direct detection atmospheric differential absorption lidar, based on a high energy optical parametric source at 2 µm, has been developed to address CO₂, CH₄, and H₂O. First experimental measurements on CO₂ are presented.

STh1H.3 • 08:45
CO₂ Sounder Lidar Development at NASA-GSFC for the ASCENDS Mission, Graham R. Allan1,2, Haris Riris1, William Hasselbrack1, Xiaoli Sun2, Kenji Numata2,3, James B. Abshire1, Mark A. Stephenson1, Anand Ramanathan1, Jeffrey Chen1,2, Graham R. Allan1,2, Anand Ramanathan1, Jeffrey Chen1,2, William Hasselbrack1, Xiaoli Sun2, Kenji Numata3, Stewart Wu1,3; NASA-Goddard Code 694, Sigma Space Inc., USA; 2NASA-GSFC, USA; 3ESSIC, Univ. of Maryland, USA. We have advanced the science of space-based laser measurements using the spectral purity and frequency tuning of a fiber-amplified laser performing active remote sensing of atmospheric CO₂ column abundance and dry mixing ratio.

STh1H.4 • 09:00
Lateral Transfer Recirculating Etalon Receiver for Methane Spectroscopy, Mark A. Stephen1, Molly Fahy1; NASA Goddard Space Flight Center, USA. We describe a Fabry-Perot etalon spectrometer with a novel light recirculation scheme to generate simultaneous parallel wavelength channels with no moving parts. We also present results from a 3-mirror solid Fabry-Perot.

STh1I • Terahertz Photonics
Presider: Marco Rahm; Technische Universität Kaiserslautern, Germany

STh1I.1 • 08:00
Invited
Optoelectronic THz Frequency Synthesizer Based on a Multiple Laser Photonic Integrated Circuit, Junjie Xu1, Lianping Hou1, Qufang Deng1, Liangshun Han2, Song Liang2, Hongliang Zhu1, John Marsh3; 1Univ. of Glasgow, UK; 2Inst. of Semiconductors, China. An optoelectronic synthesizer based on photonic integrated circuits is reported for use in THz communication systems. The source has widely selectable channels, a broad range of continuous tuning (0.254-2.723 THz), and excellent resilience against failure.

STh1I.2 • 08:15
Alvarez optical components in the THz Regime, Jan C. Balzer1, Stefan Busch1, Georg Bastian1, Martin Koch1; 1Faculty of Physics and Material Sciences Center, Philipps-Universität Marburg, Germany; 2Dept. of Engineering, Macquarie Univ., Australia; 3Fakultät Technologie und Bionik, Hochschule Rhein-Waal, Germany. We present a concept to design arbitrary Alvarez-like optical devices. As an example we demonstrate a variable spiral phase plate, which produces a vortex beam.

STh1I.3 • 08:30
Photo-generated THz Resonances and Surfaces Waves, Jaime G. Rivas, martijn schaafsma, Giorgos Georgiou; 1Dutch Inst for Fundamental Energy Research, DIFFER, Netherlands; 2Eindhoven Univ. of Technology, Netherlands; 3FOM Inst. AMOLF, Netherlands. We demonstrate the excitation of THz resonances on flat semiconductors by optical illumination of the surface. This illumination is done with a spatial light modulator that defines conducting structures by local photo-excitation of free charges.

STh1I.4 • 09:00
Switchable Spoof Surface Plasmon Polariton Slow Light Structure, Andreas K. Klein1, Andrew Gallant1, Claudio Balocco1, Daguo Zeele1; Durham Univ., UK. This paper presents the switching of slow light properties of one dimensional spoof surface plasmon polariton structures with liquid crystals. The phase transition of the liquid crystal is induced thermally.

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Mid-IR Lasers and LEDs Using Type I and II Materials, Lan Yue, Daehwan Jung, Runyu Liu, Sukirth Dev, Kijun Zhong, Minjoo Lee, Dan Wasserman, ‘Univ. of Illinois, USA; ‘Electrical Engineering, Yale Univ., USA. We discuss mid-IR light emission from two different semiconductor material systems. Lasing from InAs quantum wells in InAsP matrices, as well as light emission from InSb quantum structures in InAs matrices, are demonstrated.

Characterization of a New Frequency Tuning and Modulation Mechanism for Spectroscopy in a Quantum Cascade Laser, Kutan Gurin, Stephane Schilt, Alfredo Blumuro, Yves Bidaux, Camille Tardy, Stephane Blasert, Tobias Gresch, Thomas Sudmeyer, ‘Universite de Neuchatel, Switzerland; ‘Alpes Lasers, Switzerland. We present for the first time an investigation of the tuning, modulation and noise properties of a quantum cascade laser with integrated heater providing a new tuning mechanism and show some impacts for spectroscopy applications.

Cascade Diode Lasers Generating 2 W CW near 2 μm, Tao Feng, Takashi Hosoda, Leon Sheresngas, Gela Kipshidze, Gregory Beleny; ‘Dept. of Electrical and Computer Engineering, SUNY at Stony Brook, USA. High-power cascade diode lasers emitting near 2 μm were designed and fabricated. Coated 3-mm-long lasers generated ~2 W of continuous wave power at the current of 6 A. The power conversion efficiency peaked at 20%.

Dynamic switching of waveguide lasing operation through thermal-driven insulator-metal transition of nanostructured VO₂ film, Yang Tan, ‘Shandong Univ., China. The thermally manipulable waveguide laser emission by integrating the ultra-thin vanadium dioxide membrane with the waveguide as the saturable absorber. The waveguide laser exhibits the significant laser operation switching between the picosecond laser and the continuous-wave laser.


Zinc selenide thin-film growth using a novel method, Toshihiro Tada, Hideki Hirayama, RIKEN, Japan. We discuss a simple method of zinc selenide thin-film growth using a novel method of chemical vapor deposition. This method offers several advantages over conventional techniques, such as a high deposition rate, good uniformity, and low cost. The grown thin films exhibit excellent optical and electronic properties, making them suitable for various applications such as photovoltaic devices, sensors, and optical coatings.

Mems-based Deformable Mirrors in Industrial Laser Systems, Michael Helmbrecht, Pamela F. Caton, Carl J. Kempf, ‘NanoHe, Fraunhofer, Germany. We present a novel method of deforming mirrors in industrial laser systems using MEMS technology. This method offers high precision, low cost, and low power consumption, making it suitable for various applications such as high-power laser systems, optical metrology, and precision optics.

Recent advances of AlGaN deep-UV LEDs and LDs, Hideki Hirayama, RIKEN, Japan. We discuss recent advances in AlGaN deep-UV LEDs and LDs, including improvements in device performance, stability, and reliability. This talk will also cover the potential applications of AlGaN deep-UV LEDs and LDs in various fields such as optoelectronics, quantum computing, and biophotonics.

Spatial shaping of femtosecond laser pulses for improved micromachining efficiency, Reece Oosterbeek, Simon Ashforth, Owen Bodley, ‘School of Chemical Sciences, The Univ. of Auckland, New Zealand. We report on the development of a spatial shaping method for improving the efficiency of micromachining using femtosecond laser pulses. This method involves the use of a spatial light modulator to shape the laser pulse in real-time, resulting in significant improvements in micromachining efficiency and quality.


Ghz modulation bandwidth from single-longitudinal mode violet-blue VCSEL using nonpolar InGaN/GaN QWs, Chao Shen, John T. Leonard, Einn C. Young, Tien Khee Ng, Steven P. DenBaars, James S. Speck, Shuji Nakamura, Ahmed Y. Alyamani, Munir M. El-Desouki, Boon Ooi, ‘Photonics Lab, King Abdullah Univ. of Science and Technology (KAUST), Saudi Arabia; ‘Materials Dept., Univ. of California, Santa Barbara, USA; ‘KACST, Saudi Arabia. We achieved a 3dB modulation bandwidth of 1GHz with an ultra-low capacitance of < 1pF in a 419nm vertical-cavity surface-emitting lasers (VCSEL). The VCSEL is based on nonpolar InGaN/GaN quantum-wells and a tunnel-junction intracavity contact.
FTh1M.1 • 08:00
Simultaneous access to C and N absorption edges of B:subPC:Cl in the water-window with an attosecond pulse, Stephan. Teichmann1, Barbara Buades1, Seth Cousin1, Francisco Silva1, Jens Bieger1,2; 1ICFO - Institut de Ciencies Fotoniques. The Barcelona Inst. of Science and Technology, Spain; 2ICREA - Institució Catalana de Recerca i Estudis Avançats, Spain. We demonstrate simultaneous identification of double core-bond transitions of an organic film with an isolated attosecond pulse whose bandwidth covers the entire soft X-ray water window.

FTh1M.2 • 08:15
Polarization Gating of High Harmonic Generation in the Water Window, Jie Li1, zhaoxing ren1, Yan Cheng1, Eric Cunningham1, Wu Yi1, Zenghu Chang1,2; Phys. ucf, USA; 1CREOL, UCF, USA. High harmonic spectrum from 50-350 eV is achieved via polarization gating technique at 1.7 μm. The driving laser carrier-envelope phase influence on the high harmonic generation yield indicates that isolated attosecond pulses are generated.

FTh1M.3 • 08:30
Attosecond Streaking Measurements of Extreme Ultra-violet Pulses Using an Infrared Light Source, Nobuhisa Ishii1, Nariyuki Saito1, Tenuto Kana1, Shuntaro Watanabe1, Jiro Itatani1; 1The Inst. for Solid State Physics, Japan; 2Tokyo Univ. of Science, Japan. Extreme ultraviolet pulses below the silicon L edge, generated as high harmonics using few-cycle optical pulses at 1600 nm from a millijoule BiBO OPCPA, are characterized by attosecond streaking with the long-wavelength electric field.

FTh1M.4 • 08:45
Inner Shell Excitations through Laser Induced Electron Recollision, Yunpei Deng1, Zhinan Zeng1, Zhengmao Jia1, Pavel Komi1, Yinhuo Zheng1, Xiaochuan Ge1, Ruixin Li1, Glad Marcus1; 1The Hebrew Univ., Jerusalem, Israel; 2SwissFEL, Switzerland; 3Shanghai Inst. of Optics and Fine Mechanics, China. Sub-femtosecond excitation of inner-shell electrons is a prerequisite step toward time domain “pump-probe” study of core-hole dynamics. By using a few cycles 1800nm source, we show that the recolliding electron might provide this necessary step.

FTh1M.5 • 09:00
Observation of Inner-shell Resonances in High-order Harmonic Generation from Manganese, Muhammad Ashiq Fareed1, Nicolas Thiré1, vincent cardin1, Reemu Mondal1, Bruno E. Schmidt1, Francois Légaré1, Tsunezuki Ōzaki1,4; INRS-EMT, Canada. Driving high-harmonics (HH) from Mn with IR lasers at 1.82 μm revealed the contribution of inner-shell 3p-3d and 3p-4s channels through an intensity increase at energies from 49 eV to 51 eV.

FTh1N.1 • 08:00
Towards All-Optical Quantification of Ciliary Physiology, Brendan K. Huang1, Ibalk Sencan1, Ute A. Gamm1, Kevin Zhou1, Changle Liu1, Yong Bian1, Sebastian Knitter1, Hui Cao1, Michael Loewenberg1, Mustafa K. Khokha1, Michael Choma1; 1Yale Univ., USA. Cilia are organelles that generate microfluidic flows in the lungs, central nervous system, and Fallopian tubes. Quantitative flow diagnostic remain immature. I will present a comprehensive optical imaging-based approach for quantifying cilia flow physiology.

FTh1N.2 • 08:30
Invited
Fluorescent Nanodiamonds for Biomedical Applications, Igor Aharonovich1, Kerem Bray1, Olga Shimoni2; 1Univ. of Technology Sydney, Australia. Fluorescent nanodiamonds that host ultra bright emitters are highly attractive for biomedical applications. We present several approaches to enhance brightness of the nanodiamonds via bio-compatible coating as well as use of new near infra-red emitters for biolabeling and biosensing.

FTh1N.3 • 09:00
Invited
Developing New Tools and Probes to Visualize Chromatin Dynamics, Yiju Sun1; 1Peking Univ., China. Cell nucleus is highly crowded yet organized. Essential biological processes are tightly regulated in time and space. We apply single molecule and super-resolution imaging techniques to understand the spatial-temporal regulation of nuclear structure and dynamics.

FTh1O.1 • 08:00
Invited
Erbium-doped Mid-Infrared Fiber Lasers, David J. Ottaway1, On Henderson-Sapin1, Stuart D. Jackson1, Andrew Malouf1, Martin Gorjan1, Jesper Munch1; 1Univ. of Adelaide, Australia; 2Macquarie Univ., Australia; 3Spectra-Physic, Austria. The performance of mid-infrared fiber lasers based on erbium has improved dramatically during the last few years. In this paper we will discuss the progress of a fiber laser that can operate on both the 3.5 mm transition and/or the more common 2.8 μm transition in erbium.
**Marriott Salon IV**

**STh1P • Advances in Optical Parametric Oscillators**

*Presider: Derrick Reid; Heriot-Watt Univ., UK*

**STh1P1 • 08:00**

Electro-Optic Frequency Tuning in Double-Prism Domain PPLN Optical Parametric Generators/Oscillators, Hung-Pin Chung1, Wei-Kun Chang2, Yen-Yin Lin3, Yen-Hung Chen1, National Central Univ., Taiwan; 2Brain Research Center, National Tsinghua Univ., Taiwan. An electro-optically wavelength tunable, pulsed intracavity optical parametric generator/oscillator was built based on a novel fan-out double-prism domain PPLN. Spectral tuning rate of ~15.6 nm/kV/mm was obtained with the system at near 1.9 mm band.

**STh1P2 • 08:15**

Picosecond mid-infrared optical parametric oscillator based on cylindrical MgO:PPLN, Chaitanya Kumar D. Sud-dapalli1, Junxing Wei1, A. Jérôme Debray1, Vincent Kemlin2, B. Boulanger1, Hideki Ishizuki3, Takunori Taira1, M. Ebrahim-Zadeh1,2,3, ICFO – The Inst. of Photonic Sciences, Spain; 2Institut Néel Centre National de la Recherche Scientifique, Université Joseph Fourier, France; 3Laboratoire d’Optique et Biosciences, École Polytechnique, France. A synchronously-pumped picosecond OPO combining an aperiodically poled nonlinear crystal and a chirped volume Bragg grating. Translation of the grating along the beam axis enables wavelength tuning over 215 nm around 3.82 µm.

**STh1P3 • 08:30**

Broad Tuning of a Picosecond Optical Parametric Oscillator Based on Aperiodic Quad-Phase-Matching Using an Axially Chirped Volume Bragg Grating, Delphine Descloux1, Jean-Baptiste Dherbecour1, Guillaume Gory1, Jean-Michel Melkonian1, Myriam Raybaud1, Cyril Drag1, Antoine Godard1, Onera, France. A 1.064-µm pumped Rb:PPKTP (Auzinsh) oscillator was built based on a novel fan-out double-prism domain PPLN. Spectral tuning rate of ~15.6 nm/kV/mm was obtained with the system at near 1.9 mm band.

**STh1P4 • 08:45**

4.3-cycle Near-Infrared Pulses from a Degenerate 1-GHz Optical Parametric Oscillator, Richard A. McCracken1, Derrick T. Reid2, Heriot-Watt Univ., UK. We report transform-limited 23-fs pulses at 1.6-µm from a degenerate 1-GHz optical parametric oscillator (OPO). Modelling the intracavity intensity with a χ(2) nonlinear-envelope-equation informed group-delay dispersion compensation, resulting in pulses with a 160-nm FWHM bandwidth.

**STh1P5 • 09:00**

Rb:PPKTP Optical Parametric Oscillator with Intracavity Difference-Frequency Generation in AgGaSe2, Nadezhda Kostyukova1,2, Andrey Boyko3,4, Georgi Manchev3, Dmitry Koltin1, Andrius Zukauskas1, Valdis Pakstekevics1, Valentin Petrov1, 1Max Born Inst., Germany; 2Special Technologies, Ltd., Russia; 3Novosibirsk State Univ., Russia, 4Royal Inst. of Technology, Sweden. A 1.064-µm pumped Rb:PPKTP optical parametric oscillator (OPO) generates mid-IR radiation by intracavity mixing the signal and idler in AgGaSe2. The ~6-ns pulses at ~7 µm have an energy of 565 µJ at 100 Hz.

**STh1Q • Laser Induced Periodic Structures**

**STh1Q1 • 08:00**

Study of phase change LIPPS formation in Si by fs-resolved microscopy, Daniel Puerto1, Maro Garcia-Lechuga1, Javier Solís1, Jan Siegel2, CSIC-Instituto de Optica, Spain. We report the formation of amorphous-crystalline gratings in c-Si by fs laser irradiation at different wavelengths, repetition rates and angles of incidence. Using fs-resolved microscopy, we reveal the phase transformation dynamics of these structures.

**STh1Q2 • 08:15**

Femtosecond Laser Writing in Lithium Niobate, Pavel Karpinski1,2, Vladlen Shvedov1, Wieslaw Krolikowski1,2, Cyril Hnatovsky1, The Australian National Univ., Australia; 2Wroclaw Univ. of Technology, Poland; 3Texas A&M Univ. at Qatar, Qatar. The fine morphology of infrared femtosecond laser-induced changes in bulk lithium niobate is closely analysed. Linearly polarized light can generally produce two or three axially separated modified regions containing polarization-dependent self-organized periodic nanostructures.

**STh1Q3 • 08:30**

Invited Laser Induced Periodic Surface Structures (LIPSS) - A Scientific Evergreen, Joern Borse1, Sandra Höhm1, Sabrina Kimer1, Arndis Rosenfeld1, Jörg Krüger1, Federal Inst. for Materials Research and Testing (BAM), Germany; 2Max-Born Inst. for Nonlinear Optics and Short Pulse Spectroscopy (MBI), Germany. The current state in the field of laser-induced periodic surface structures (LIPSS, ripples) is reviewed. Their formation mechanisms are analyzed in ultrafast experiments (time-resolved diffraction and polarization controlled double-pulse experiments) and technological applications are demonstrated.

**STh1Q4 • 09:00**

Highly Regular Nanostructuring of Si Surface by Ultrashort Laser Pulses, Jiaralov Gnilitsky1, Leonardo Orazi1, Nadezhda Bulgakova1, Vitaly Gruzdev4, UNIMORE, Italy; 3Inst. of Physics, HILASE center, Czech Republic; 4Inst. of Thermophysics SB RAS, Russia; 5Dept. of Mechanical & Aerospace Engineering, Univ. of Missouri, USA. Sub-MHz repetition rate femtosecond laser pulses produce extremely regular periodic surface structures on silicon surface due to competition between ultrafast heating and electron-emission. They allow manufacturing of novel devices for solar, optoelectronic, and biomedical applications.
Thursday, 9 June

FTh1A • Photonic Lattices and PT Symmetry—Continued

FTh1A.6 • 09:15
Probing the scattering characteristics of supersymmetric photonic lattices, Matthias Heinrich, Mohammad Ali-Miri, Simon Stützer, Stefan Nolte, Demetrios N. Christodoulides, Alexander Szameit, Friedrich-Schiller-Universität Jena, Germany; 3Dept. of Electrical and Computer Engineering, The Univ. of Texas at Austin, USA; 4CREOL, The College of Optics and Photonics, Univ. of Central Florida, USA; 5Inst. of Applied Physics, Friedrich-Schiller-Universität Jena, Germany. We investigate optomechanical interactions in non-Hermitian photonic molecules. We show that the maximum enhancement of optomechanical coupling for steady state solutions can indeed generate coherent radiation.

FTh1A.7 • 09:30
Optomechanical interactions in non-Hermitian photonic molecules, David Schonleber, Mohammad Husain Teimouri, Rami El-Ganainy, Alexander Eisfeld, Dept. of Physics, Michigan Technological Univ., USA; 2Max Planck Inst. for the Physics of Complex Systems, Germany. We investigate optomechanical interactions in non-Hermitian photonic molecules. We show that the maximum enhancement of optomechanical coupling for steady state solutions is achieved for unbalanced gain and loss profiles away from exceptional points.

FTh1A.8 • 09:45
Observation of noise-assisted energy transport in dynamically disordered photonic lattices, Diego Guzman-Silva, Roberto de J. Leon-Mantiel, Matthias Heinrich, Juan Torres, Hector Moya-Cessa, Markus Graefe, Armando Perez-Leija, Alexander Szameit, Inst. of Applied Physics, Friedrich-Schiller Universität, Germany; 3Dept. of Chemistry & Biochemistry, Univ. of Illinois at Urbana-Champaign, USA; 4Mechanical Engineering, Iowa State Univ. of Science and Technology, USA; 5Bioengineering, Univ. of Illinois at Urbana-Champaign, USA. In this work we report on the observation of noise-assisted energy transport using stochastic networks of evanescently coupled waveguides. In this scheme every site is endowed with propagation constants randomly fluctuating along the propagation distance.

FTh1B • Active Plasmonics: Lasers and Modulators—Continued

FTh1B.6 • 09:15
Ultrafast ZnO nanowire lasers: nanoplasmonic acceleration of gain dynamics at the surface plasmon polariton frequency, Themistoklis Sidiropoulos, Robert Röder, Sebastian Geburt, Ortwin Hess, Carsten Ronning, Imperial College London, UK; 2Friedrich-Schiller-Universität Jena, Germany. We report optically pumped hybrid photonic – plasmonic ZnO nanowire lasers operating near the surface plasmon frequency. Here, we use the non-linearity of the laser process itself to reveal the internal ~1 ps dynamics of these plasmonic lasers.

FTh1B.7 • 09:30
Second-Order Coherence Measurement of a Metallic Coaxial Nanolaser, William Hayenga, Hipolito Garcia-Gracia, Hossein Hodaei, Patrick L. Lillemor, Mercedes Khajavikhan, Univ. of Central Florida, CREOL, USA. The second-order coherence function is measured for a metallic coaxial nanolaser using a modified Hanbury Brown-Twiss technique. The results indicate that such nanoscale lasers can indeed generate coherent radiation.

FTh1B.8 • 09:45
Lasing Emission from Plasmonic Nanodome Arrays, Hsin-Yu Wu, Longyu Liu, Meng Lu, Brian T. Cunningham, 2Electrical and Computer Engineering, Univ. of Illinois at Urbana-Champaign, USA; 3Electrical and Computer Engineering, Iowa State Univ. of Science and Technology, USA; 4Bioengineering, Univ. of Illinois at Urbana-Champaign, USA. We demonstrate a new feedback mechanism to achieve lasing using plasmonic nano-dome array (PNDA) substrates. The unique off-normal lasing phenomenon in the PNDA lasers provides useful applications which cannot be implemented by other plasmonic lasers.

FTh1C • Single-Photon Sources—Continued

FTh1C.6 • 09:30
Limitations of Microresonators as Heralded Single Photon Sources, Zachary Vernon, Marco Liscidini, John E. Sipe, Dept. of Physics, Univ. of Toronto, Canada; 2Dept. of Physics, Univ. of Pavia, Italy. We demonstrate a fundamental limitation of the use of microresonators as heralded single photon sources. Such sources suffer from a tradeoff between heralding efficiency and heralding rate, which depend sensitively on the resonator-channel coupling.

FTh1C.7 • 09:45
Indistinguishable heralded single photons from two separate silicon nanowires pumped at different wavelengths, Xiang Zhang, Runyu Jiang, Benjamin Eggleton, Univ. of Sydney, Australia; 2Australian National Univ., Australia; 3Univ. of Melbourne, Australia. Quantum interference of heralded photons from two separate silicon nanowires pumped at different wavelengths shows a raw visibility of 88±8.4%, indicating that these photons are highly indistinguishable and can be multiplexed for quantum photonic applications.
Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
STh1G • Photodetectors—Continued

STh1G.5 • 09:15
67 GHz uni-travelling carrier photodetector on an InP-membrane-on-silicon platform, Longfei Shen, Yuqing Jiao, Werning Yao, Zizheng Cao, Jos van der Tol, Gunther Roelkens, Meint Smit, Eindhoven Univ. of Technology, the Netherlands; Ghent Univ., Belgium. An InP membrane-based uni-travelling carrier photodetector, heterogeneously integrated on silicon, is realized using double-sided processing. A responsivity of 0.7 A/W at 1.55 μm and a 3 dB bandwidth beyond 67 GHz are demonstrated.

STh1G.6 • 09:30
Modelling superconducting nanowire single photon detectors in a waveguide-based resonator, Nicola Tyler, Jorge Barreto, Gerardo E. Villarreal, Damien Bonneau, Döndü Sahin, Jeremy Yeak, Sivanandan S. Harilal, Mark C. Phillips, We present the modeling of a single photon detector system capable of achieving near-unit detection efficiency. It consists of waveguide-coupled superconducting nanowires as short as 1 μm embedded in a racetrack resonator.

STh1G.7 • 09:45
Systematic study of Si-based Ge/Ge0.9Sn0.1/Ge photodiodes with 2.6 μm detector cutoff, Thach Pham, Wei Du, Huong Tran, Joe Margetis, John toll, Gregory Sun, Richard soref, Hamed Naseem, Badhua Li, Mansour Mortazavi, Shui-Qing Yu, Univ. of Arkansas, USA; Univ. of Arkansas, Pinebluff, USA; Univ. of Massachusetts Boston, USA; Arktonics LLC, USA; ASM, USA. A double heterostructure Ge/Ge0.9Sn0.1/Ge photodiode detector grown on Si was systematically characterized. Temperature-dependent device performance has been investigated. A cutoff wavelength of 2.6 μm and the peak responsivity of 0.19 A/W at 300 K were achieved.

STh1H • Standoff and Remote Detection—Continued

STh1H.5 • 09:15
Remote Detection of Uranium by Fe-Filamentation Laser Ablation Molecular Isotopic Spectrometry, Kyle Hartig, Isaac Ghebreegiabher, Igor Jovanovic, The Pennsylvania State Univ., USA; Dep. of Nuclear Engineering and Radiological Sciences, Univ. of Michigan, USA. We demonstrate remote detection of isotopes of uranium using fs-filamentation laser ablation molecular isotopic spectrometry (F2–LAMIS). The uranium monoxide molecular and uranium atomic emissions were optimized at different uranium-film interaction points.

STh1H.6 • 09:30
Two-dimensional fluorescence spectroscopy of Al in laser-produced plasmas, Svanandan S. Harilal, Mark C. Phillips, Pacific Northwest National Lab, USA. We present tunable laser induced fluorescence of selected Al transitions in a laser produced plasma at atmospheric pressure levels. Two-dimensional mapping of absorption-emission spectroscopy of Al transitions is made.

STh1H.7 • 09:45
Tunable Laser Absorption Spectroscopy of Uranium in Femtosecond Laser Ablation Plasmas, Mark C. Phillips, Svanandan S. Harilal, Jeremy Yeak, Pacific Northwest National Lab, USA; Physics, Materials, and Advanced Mathematics Research, Inc., USA. We present the first measurements of tunable laser absorption spectroscopy in femtosecond laser ablation plasmas. Time-resolved absorption spectra of uranium and aluminum are measured with high spectral and high temporal resolution.

STh1I • Terahertz Photonics—Continued

STh1I.5 • 09:15
Terahertz Group Velocity Dispersion Management through Integration of a Hybrid Mode Section into a Metal-Metal Waveguide, Tobias Fobbe, Sergej Markmann, Felix Fobbe, Negar Helmati, Hanond Nong, Patrick Balzerowski, Janne Savolainen, Martina Havenith, Andreas D. Wiedler, Nathan Jukam, AAG Terahertz Spectroscopy and Technology, Ruhr-Universität Bochum, Germany; Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Germany; Lehrstuhl für Physikalische Chemie II, Ruhr-Universität Bochum, Germany; Lehrstuhl für Experimentelle Physik 2, Technische Universität Dortmund, Germany. A novel terahertz hybrid waveguide provides a broadband control of group velocity dispersion, thus offering potential for terahertz applications such as dispersion compensation for quantum cascade lasers, soliton generation, slow light phenomena and non-linear spectroscopy.

STh1I.6 • 09:30
Efficient Up-Conversion of Weak THz Signals into the Optical Domain Using a Whispering Gallery Mode Resonator, Florian Sedlimer, Alfredo R. Rueda Sanchez, Sascha Preu, Enrique Garcia, Harald G. Schwefel, TU Darmstadt, Germany; Univ. Carlos III of Madrid, Spain; Univ. of Otago, New Zealand; Max Planck Inst. for the Science of Light, Germany. We report on efficient up-conversion of THz signals into the optical domain using a high-Q dielectric resonator. Since the system is all-resonant and phase-matched, we present a record photon number conversion of 2.5e-5 around 100 GHz.

STh1J • Remote Detection of Uranium by Fs-Filamentation Laser Ablation Molecular Isotopic Spectrometry, Tobias Fobbe, Sergej Markmann, Felix Fobbe, Negar Helmati, Hanond Nong, Patrick Balzerowski, Janne Savolainen, Martina Havenith, Andreas D. Wiedler, Nathan Jukam, AAG Terahertz Spectroscopy and Technology, Ruhr-Universität Bochum, Germany; Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Germany; Lehrstuhl für Physikalische Chemie II, Ruhr-Universität Bochum, Germany; Lehrstuhl für Experimentelle Physik 2, Technische Universität Dortmund, Germany. A novel terahertz hybrid waveguide provides a broadband control of group velocity dispersion, thus offering potential for terahertz applications such as dispersion compensation for quantum cascade lasers, soliton generation, slow light phenomena and non-linear spectroscopy.
ATH1J • Applications of Semi Conductor Lasers—Continued

ATH1J.5 • 09:15
Hybrid Colloidal Quantum Dot Silicon Nitride Waveguide Gain Measurement Based on Variable Stripe Length Method, Kunpeng Zhu1, Weiqiang Xie1, Pieter Geigert2, Suzanne Bisschop1, Tangi Aubert1, Edouard Brains1, Zeger Hens1, Dries v. Thourhout1, 2Ghent Univ., Belgium. We fabricated hybrid colloidal quantum dot silicon nitride waveguides and demonstrate they exhibit amplified spontaneous emission under femtosecond optical pumping. The gain coefficient is measured using an integrated variable stripe length method.

ATH1J.6 • 09:30
On-chip Generation of Infrared Orbital Angular Momentum Beams using a Dielectric Metamaterial, Rolf Szedlak1, Thomas Hisch1, Martin Holdbauer1, Donald MacFarland1, Tobias Zederbauer1, Hermann Detz2, Aaron Maxwell Andrews1, Werner Schrenk1, Stefan Rotten1, Gottfried Strasser1,2. 1Inst. of Solid State Electronics, TU Wien, Austria; 2Center for Micro- and Nanostuctures, TU Wien, Austria. A new scheme of oriented-dependence-microloens (ODM) for lasers coupling to polarization-maintaining-fibers is demonstrated. Results showed that the ODMs enabled to visually passive alignment and packaging to achieve 80% coupling efficiency and 30-dB polarized extinction ratio.

ATH1J.7 • 09:45
Mid-Infrared Broadband Absorber of Full Semiconductor Epilayers, Shaohua Wang1,2, Yufei Wang1,2, Tingyu Li3,4, Yunpeng Zhu1,2, Wan-hua Zheng1,2. 1Graduate Inst. of Opt. and Electr. Engineering, National Sun Yat-sen Univ., Taiwan; 2Dept. of Photonics, National Sun Yat-sen Univ., Taiwan; 3Dept. of Mechanical Engineering, Cheng-Shiu Univ., Taiwan; 4Dept. of Biomechatronics Engineering, National Pingtung Univ. of Science and Technology, Taiwan. A tunable high-power green external-cavity diode laser is demonstrated. Up to 290 mW output power and a 9.2 nm tuning is achieved. This constitutes the highest output power from a tunable green diode laser system.

ATH1K • Advanced Technology for Industrial Processing—Continued

ATH1K.5 • 09:15
An Oriented-Dependence-Microloens Visually Aligned and Packaged for Lasers to Polarization Maintaining Fibers, Liu Chun-Nien1, Wen-Hsuan Hsieh2, Ying-Chien Tsai1, Yi-Cheng Hsu2, Che-Hsin Lin2, Wood-Hi Cheng1,2. 1Graduate Inst. of Optoelectronic Engineering, National Chung Hsing Univ., Taiwan; 2Dept. of Photonics, National Sun Yat-Sen Univ., Taiwan. We present a compact laser source emitting orbital angular momentum beams created by an on-chip gradient-index metamaterial. In combination with the tailorable wave-length of our emitter this enables on-demand applications in a variety of fields.

ATH1K.6 • 09:30
Terahertz pulsed spectroscopy of medium polymerization, Egor Yakovlev1, Kirill Zaytsev1, Arsenii A. Gavdush2, Stanislav Yurchenko1,2, Bauman Moscow State Technical Univ., Russia. An ability to sense the medium polymerization using terahertz spectroscopy has been demonstrated. Terahertz material parameters of epoxy have been measured during its polymerization. Significant changes of the material parameters have been observed.

ATH1K.7 • 09:45
Adhesion mechanism between laser sputtered Aluminum nano particles on Si-Wafer by Nd:YAG laser, Mohammad Hossein Ashzahl1, Hans Joachim Eichler1,2, Arsenii A. Gavdush2, Stanislav Yurchenko1,2. 1Fraunhofer-Institut für Zuverlässigkeit und Mikrointegration IZM, Germany; 2TU-Berlin, Germany. In this research, different laser parameters are investigated using Nd:YAG Picosecond laser to sputter nano particles on Si-Wafer substrate. The influence of various parameters on adhesion tests and mechanism of deposited layer is studied.

STh1L • Large Bandgap and Hybrid Lasers—Continued

STh1L.4 • 09:30
A Tunable Hybrid Laser With Ultra-High Tuning Efficiency, Di Liang1,2, Xue Huang1, Geza Kuruczveil1, Marco Fiorentino1, Ray Beausoleil2,3. 1Hewlett Packard Labs, USA. We demonstrate a novel hybrid microring laser with an integrated III-V-on-Si metal-oxide-semiconductor (MOS) capacitor for essentially zero-power tuning in wavelength and output power. Over 10,000,000X better tuning efficiency and chip-free operation have been achieved.

STh1L.5 • 09:45
Integration of III-V Nanopillar Resonator to In-Plane Silicon Waveguides, Giliard N. Malheiros-Silveira1, Fanglu Lu1, Indrasen Bhattacharya2, Thai-Truong D. Tran3, Hao Sun1, Connie J. Chang-Hassan1, 2Dept. of Electrical Engineering and Computer Sciences, Univ. of California, USA. We proposed, fabricated, and characterized new structures based on III-V compound semi-conductor nanopillars, monolithically integrated to silicon platform, for coupling spontaneous and stimulated emission to silicon waveguides.
CLEO: Applications & Technology

FTh1M • Attosecond with Infrared Laser—Continued

FTh1M.6 • 09:15
50-mJ waveform synthesizer for generating microjoule-scale isolated attosecond pulses, Eiji J. Takehashi1, Yuuki Tamaru2, Yuki Fujii1, Oliver D. Muecke1, Franz X. Kaertner2, Ali Suda1, Katsumi Midorikawa1; 1RIKEN, Japan; 2Center for Free-Electron Laser Science, Germany.

We demonstrate a novel light source based on coherent two-channel waveform multiplexing employing 28-fs carrier-envelope phase-stable pulses. The two-channel pulse energy reaches 50 mJ, which is the highest energy ever reported for two-channel waveform multiplexing employing 28-fs carrier-envelope phase-stable pulses.

FTh1M.8 • 09:45
Kagome fiber based nonlinear pulse compression of 1.8 ps to 250 fs at 2.05 μm from Ho:YLF amplifier to 285 fs at 125 μJ, supporting a FL pulse amplifier (OPCPA) in BiBO grown. This is an ideal driver for generating isolated attosecond pulses in the soft x-ray region.

CLEO: Science & Innovations

STh1O • Mid-IR Fiber Sources—Continued

STh1O.6 • 09:30
Small core Chalcogenide photonic crystal fiber for mid-infrared wavelength conversion: experiment and design, Sida Xing1, Davide Grassani2, Svayatoslav Khantorov2, Adrien Billat3, Camille-Sophie Brès1; 1STI IEL, EPFL, Switzerland.

We computationally investigate cascaded efficient generation of idlers in mid-infrared.

STh1O.7 • 09:45
Pr3+-doped Mid-Infrared Chalcogenide Fiber Amplifiers using Cascaded Amplification, Jonathan Hu1, Curtis Menyuk2, Chengji Wei3, Brandon Shaw3, Jasbinder S. Sanghera3; 1Naval Research Lab, USA; 2University of Maryland at Baltimore County, USA; 3Sotera Defense Solutions, USA.

We computationally investigate cascaded amplification in a three-level mid-infrared Pr3+-doped chalcogenide fiber amplifier. We show that 45% of the pump power that is injected at 2 μm can be shifted to 4.5 μm.
STh1P • Advances in Optical Parametric Oscillators—Continued

STh1P-6 • 09:15
Efficient fast-tunable femtosecond visible radiation based on intracavity sum-frequency generation in a NIR NOPO, Yuliya Khanukaeva1, Tino Lang2, Ayhan Tajalli2, José R. Andrade1, Thomas Binhammer2, Uwe Morgen1, Institut für Quantenoptik, Germany; 1Deutsches Elektronen-Synchrotron DESY, Germany; 2VENTEON Laser Technologies GmbH, Germany. We present a fast-tunable femtosecond NIR NOPO simultaneously delivering visible pulses from 412 to 500 nm generated via efficient intracavity sum-frequency generation and rapidly tunable over the whole range by varying the resonator length only.

STh1P-7 • 09:30
Ultrafast spectral switching of a Non-collinear Optical Parametric Oscillator (NOPO), Alexander Pape2, Thomas Binhammer2, Yuliya Khanukaeva1, Tino Lang2, Jan Ahrens1, Oliver Prochnow2, Uwe Morgen1, Leibniz Universität Hannover, Inst. of Quantum Optics, Germany; 2VENTEON, Germany. We present an ultrafast tunable non-collinear parametric oscillator which can be switched with >500 nm/ms over a wide spectral range from 650 - 1070 nm making the system ideally suited for novel ultrafast bio-imaging techniques.

STh1Q • Laser Induced Periodic Structures—Continued

STh1Q-5 • 09:15
Photoinduced periodic nanocrystalline structure inside Al2O3-R2O3 (R = Y, La, Dy) glass, Yasuhiko Shimotsuma1, Satoshi Moriy1, Toratao Kurita1, Masaaki Sakakura1, Kyotaka Miura1, 1Dept. of Material Chemistry, Kyoto Univ., Japan; 2Society-Academia Collaboration for Innovation, Kyoto Univ., Japan. Periodically crystallized nanostructure was self-assembled inside Al2O3-R2O3 binary glass (R = Y, La, Dy) with a low glass formation ability by the femtosecond laser irradiation. Such polarization-dependent nanostructures exhibit periodic modulation in magnetic properties.

STh1Q-6 • 09:30
Advanced laser-pulse ion-beam-assisted nanofabrication of sensing plasmonic nanostructures, Aleksandr A. Kuchmizhak2,1, Yuri Kulchin1, Oleg Vitrik1, Stanislav O. Gurbatov1,2; 1IACP FEB RAS, Russia; 2School of Natural Sciences, Far Eastern Federal Univ., Russia. Simple two-step technique based on noble metal film irradiation with laser pulse accompanied by ion beam polishing of irradiated area was proposed for fabrication of different plasmonic nanostructures, including nanorods and nanorings, and nanorod-nanoring ensembles.

STh1Q-7 • 09:45
Computer-generated holograms embedded in bulk silicon with nonlinear laser lithography, Ahmet Tunali1, Onur Toker1, Ghaith Makey2, F. Omer Ilday1,2; 1Dept. of Electrical and Electronics Engineering, Bilkent Univ., Turkey; 2Dept. of Physics, Bilkent Univ., Turkey. Recently, we have showed a direct laser writing method to form subsurface structures inside silicon by exploiting nonlinear interactions. Here, we demonstrate utilization of this phenomenon to create computer-generated holograms buried in silicon.
A&T 3: Photonic Instrumentation and Techniques for Metrology and Industrial Processes

JTh2A.1
Tunable integrated photonic devices based on Transition-metal-oxides, Zbo Gong; 1Peking Univ., USA. We realized all-optical tunable optical devices based on Fano Resonance in multilayer transition-metal-oxide metamaterials. Combined with the plasmonic resonance and slow light effect, an enhanced third-harmonic generation (THG) was realized on stannium tinate composite material.

JTh2A.2
Polarimetric measurements and analysis of different metal-coated mirrors, Sarah J. Knudsen1, Anna Petrova-Mayer1, 1California State Univ. Chico, USA. We study the induced polarization by different metal-coated mirrors of an azimuth-over-azimuth beam scanner. We devised and tested a method to eliminate these effects for all scan directions by means of altering the incident polarization.

JTh2A.3
A high-sensitivity two-dimensional Inclinometer Based on Two-array-etched-chirped Fiber Gratings, Hung-Ying Chang1, 1Ph.D. Program of Electrical and Communications Engineering, Feng-Chia Univ., Taiwan; 2Dept. of Electrical Engineering, Feng-Chia Univ., Taiwan; 3National Changhua Univ. of Education, Dept. of Electrical Engineering, Taiwan. We present a novel high-sensitivity dual-axis fiber inclinometer based on two etched chirped fiber Bragg gratings arrayable capable of measuring the tilted angle and the direction of tilting simultaneously with a resolution of 0.02 degrees.

JTh2A.4
Development of efficient mid-IR laser by intra-cavity OPO+DFM and its application to LUT of CFRP, Hideki Hatano1, Makoto Watanabe1, Shunji Takekawa2, Hisashi Yamawaki1, Kanae Oguchi2, Manabu Enoki2, Richard Slater2, 1NIMS, Japan; 2Univ. of Tokyo, Japan; RS Photonics, USA. We demonstrate efficient generation of a mid-IR source at 3.2 microns using a PPSLT OPO with intra-cavity PPSLT difference frequency mixing (DFM) crystal. This wavelength is the best suitable for ultrasonic-generation in CFRP.

JTh2A.5
The fiber grating strain sensor using in high temperature environments, Yong Shi1, Dongli Wang1, Yihuang Li1, Zhihong Li1, Zhaowen Sun1, Peng Liu1, Yufei Cheng1, 1Beijing Research Inst. of NIMS, Japan; 2Univ. of Tokyo, Japan; 3RS Photonics, USA. We presented the mirror is affected by applying a certain load to the mirror, and the output performance for the fiber at a target wavelength is theoretically analyzed to be consistent with experimental results.

JTh2A.6
Cryogenic monolithic Nd:YAG laser at 946 nm with 70% slope efficiency, C. Y. Cho1, 1Korea Basic Science Inst., Korea. An efficient cryogenic quasi-three-levelNd:YAG laser is demonstrated by employing a monolithic resonator. The output performance for the laser at cryogenic temperature is theoretically analyzed to be consistent with experimental results.

JTh2A.7
Achieving dual-wavelength co-linear emission at quasi-three-level and four-level transitions with compactly combined dual gain media, C. Y. Cho1, 1Korea Basic Science Inst., Korea. The dual-wavelength laser at four-level and quasi-three-level transitions is demonstrated in a linear resonator. The compactly combined Nd:YAG and Nd:YVO4 crystals successfully improve the efficiency limitation caused by the dilemma between reabsorption loss and absorption reduction.

JTh2A.8
Enhancement of optical absorption in ‘photonic graphene’, Abdul Khaileque1, 1Univ. of Technology, Australia. The enhancement in absorption of photonic graphene structure is reported in this article. It can be enhanced about four times (40%) compared to a reference absorption (9.8%) at certain wavelengths by adding defects and mirrors.

JTh2A.9
Tunable Plasmonic Band-stop Filters Based on Periodically Modulated Graphene, Bin Shi1, Xiaofeng Song1, Wei Cai2, Dong Wang2, 1Shanxi Univ., China; 2Shanxi Institute of Electronic Technology, China. The plasmonic mirror distance between the mirror membrane and the basement affects the mirror's deformation. We analyze how the mirror is affected by applying different gap distances.

A&T 4: Laser & Photonics Applications for Energy & Environment

JTh2A.11
High power single-frequency and frequency-doubled laser with active compensation for the thermal lens effect of TGG crystal, Huadong Lu1, Qiu Jin1, 1National Chiao-Tung Univ., Taiwan. A high power single-frequency and frequency-doubled laser, the harmful effect of TGG is eliminated, and the conversion efficiency and ideal factor were greatly improved. A coherent RF-comb-modulated passively Q-switched laser with negative thermal lens effect into a single-frequency and frequency-doubled laser, the harmful effect of TGG is actively compensated and the highest output power of 30.2 W is achieved.

JTh2A.12
An energy-efficient and robust ring network structure for next generation optical access, Xunxin Lin1, Qing Shi1, 1Korea Basic Science Inst., Korea. We present a self-assembly and photodeposition and obtained the optimal photoluminescence of Cu(In,Ga)Se2 thin films. The PL spectra implied some defect-levels or band-fluctuations were eliminated, and the conversion efficiency and ideal factor were enhanced after laser annealing.

JTh2A.15
Optical Investigations of Nanorod-Substrate Interaction for Light Management, Gauv Mangalipuram1, Philip Manley2, Weibke Rede1, Martina Schmid1, 1Institute for Photonic Materials, Berlin, Germany; 2Dept. of Photonics, Freie Universitat Berlin, Germany. We demonstrate the optical near field and light directing properties of ZnO nanorod structures using rigorous methods. Our focus is on evaluating scattering from nanorods on different substrates and observing the associated near field enhancement.

JTh2A.16
High power single-frequency and frequency-doubled laser with active compensation for the thermal lens effect of TGG crystal, Huadong Lu1, Qiu Jin1, 1National Chiao-Tung Univ., Taiwan. A high power single-frequency and frequency-doubled laser, the harmful effect of TGG is eliminated, and the conversion efficiency and ideal factor were greatly improved.
11:30-13:00  JTh2A • Poster Session III

Exhibit Halls 1, 2, & 3

**FS 7: High Field Physics and Attoscience**

JTh2A.24  
**Strong-Field Resonant Dynamics in Semiconductors: Interplay of Rabi Flopping and Intradband Motion**, Michael S. Wisniewski, Stanislav V. Kuchinin, Marcello Ciappina, Mark Stockman, Vladimir Yakovlev, Center for Nano-Optics (CeNO), Georgia State Univ., USA; Max Planck Inst. of Quantum Optics, Germany. We show that intraband motion and Rabi oscillations may be strongly coupled in a semiconductor resonantly excited by an intense few-cycle laser pulse. This coupling induces a residual electric current controlled by the carrier-envelope phase.

JTh2A.25  
**Lasing in strong-field ionized nitrogen molecules: influence of nuclear dynamics on population inversion**, Jingbo Yao, Shicheng Jiang, Wei Chu, Bin Zeng, Chengyu Wu, Rulfeng Lu, Ziling Li, Hongxing Xie, Guihua Li, Chao Yu, Zhan-shan Wang, Hongbing Jiang, Qihuang Gong, Ya Cheng; State Key Lab of High Field Laser Physics, Shanghai Inst. of Optics and Fine Mechanics, Chinese Academy of Sciences, China; Dept. of Applied Physics, Nanjing Univ. of Science and Technology, China. We study the influence of nuclear dynamics on the population inversion responsible for free-space N₂ laser emission. We clarify the underlying mechanism behind the population inversion responsible for free-space N₂ lasers.

JTh2A.26  
**Evidence of Hydrogen Migration rather than Isomerization in the Acetylene Dication**, Chelsea E. Lielenschatz, Zheng Li, Vladimir Petrovic, Todd Martinez, Philip H. Bucksbaum; Stanford Univ., USA; PULSE Inst., USA. New ab initio calculations show that ultrafast isomerization in the acetylene dication has an extremely low probability because dissociation outcompetes isomerization. We propose that isomerization previously described in recent ultrafast LCLS x-ray experiments are in fact due to partial migration.

JTh2A.27  
**Characterization of time-dependent ionization degree of gaseous media during high-harmonic generation**, Kentaro Sato, Mamoru Kohga, Mamoru Kohga, Akira Suda; Dept. of Physics, Faculty of Science and Engineering, Tongji Univ., China. We investigate nuclear dynamics and population transfer among multiple electronic states in tunnel ionized nitrogen molecules, and clarify the underlying mechanism behind the population inversion responsible for free-space N₂ lasers.

JTh2A.28  
**Quantification of Bulk Depletion in Fused Silica Induced by Femtosecond Laser Exposure in the Sub-50 fs Regime**, Benjamin W. McMillen, Yves Bellouard, Carsten Reinhardt, Ayhan Demircan, Uwe Morgner; Institut für Quantenoptik, Germany; Laser Zentrum Hannover e.V., Germany. We present an efficient method for ultrafast writing in polymers exploiting a refractive effect. Increased refractive index is induced below a secondary focus and supports waveguiding with unprecedented propagation losses down to 0.5 dB/cm.

JTh2A.30  
**Ramsey interference in the resonance fluorescence of a charged quantum dot**, James P. Lee, Anthony Bennett, Joanna Skibka-Szymanska, David Ellis, Ian Farray, David Ritchie, Andrew Shields; Univ. of Cambridge, UK; Toshiba Research Europe Ltd., UK. We demonstrate that Ramsey interference detected in resonant fluorescence from a charged quantum dot. We also apply a magnetic field and use the Ramsey pulse sequence to prepare a coherent superposition of electron spin states.

JTh2A.31  
**Investigation of random lasing characteristics from dye-doped twisted nematic liquid crystals in wedge cell**, Sheng H. Lin, Po Y. Chen, Jin J. Wu, Yao H. Chen, Shwu Y. Tsai, Ja-Hon Lin, Wen H. Hsieh, Chaochun Su, Wen-Ren Tsai; National Taipe Univ. of Technology, Taiwan; National Chiao Tung Univ., Taiwan; National Central Univ., Taiwan. The output polarization and slope efficiency of random laser could be controlled by the rubbing direction of PI and temperature, respectively, from dye-doped twisted nematic liquid crystals within wedge cell.

JTh2A.32  
**Perforated Hollow-Core Waveguide Devices for Atomic Spectroscopy with Alkali Vapor**, Matthieu Graud-Carrier, Trevor K. Decker, Aaron Hawkins, Jennifer A. Black, Holger Schmidt; Brigham Young Univ., USA; School of Engineering, UCSC, USA. A novel design for hollow-core waveguide devices suitable for atomic spectroscopy is presented. Distributed vapor delivery via etched holes overcomes alkali vapor transport challenges, resulting in strong light absorption in rubidium with excellent environmental stability.

JTh2A.33  
**Low-loss embedded waveguides in PMMA written by a femtosecond laser; Welm Falpadz, Carsten Reinhardt, Ayhan Demircan, Uwe Morgner; Institut für Quantenoptik, Germany; Laser Zentrum Hannover e.V., Germany. We present an efficient method for ultrafast writing in polymers exploiting a refractive effect. Increased refractive index is induced below a secondary focus and supports waveguiding with unprecedented propagation losses down to 0.5 dB/cm.

JTh2A.34  
**Experimental Demonstration of Attenuation-resistant Higher Order Frozen Waves**, Ahmed Dorrah, Michel Zamboni-Rachedi, Mo Majahed; Electrical and Computer Engineering, Univ. of Toronto, Canada; Electrical Engineering, Univ. of Campinas, Brazil. We experimentally demonstrate class of beams, known as Frozen Waves (FWs), which are composed of higher order Bessel beams and can maintain the intensity of self-trapped excitons ~0.5ps.

JTh2A.35  
**Study of polarization dependence of NLA in bulk SiO₂ by fs two-color pump probe spectroscopy**, Mark Green, Tsing-Hua Her; Univ. of North Carolina at Charlotte, USA. We show single-shot nonlinear absorption is enhanced by 5% when pump and probe lights are codirectional. At very large pump energy, we observe a new and fast decay component of self-trapped excitons ~0.5ps.

JTh2A.37  
**Sulfur-hyperdoped silicon photodetector with broadband spectral response and high gain at low bias**, Qiang Wu; Nankai Univ., China. Sulfur-hyperdoped silicon photodetector prepared by femtosecond laser exhibits high gain with broadband spectral response ranging from 400 to 1200 nm, with external quantum efficiency > 2800% at 1100 nm at 5 V reverse bias voltage.

JTh2A.38  
**Wavelength Dependence of the Laser-Induced Damage Threshold of α-Al₂O₃, Haruyuki Sakurai, Yo Iida; Akira Muatan, Kunici Konishi, Junji Yamato, Makoto Kuwata-Gonokami; Dept. of Physics, The Univ. of Tokyo, Japan; Dept. of Applied Physics, The Univ. of Tokyo, Japan; Inst. for Photon Science and Technology, The Univ. of Tokyo, Japan. We systematically determined the ablation threshold of α-Al₂O₃ under 360 to 900-nm wavelength femtosecond laser irradiation. We found step-like behavior in the threshold explained by multiphoton processes, well reproduced by an electron single-rate equation model.

JTh2A.39  
**Fabrication of microresonators of high Q/V ratios using femtosecond laser micromachining**, Min Wang, Jintian Lin, Yingxin Xu, Zhiwei Fang, Zhengming Liu, Wei Fang; Ya Cheng; Shanghai Inst. of Optics and Fine Mechanics, China; Zhejiang Univ., China. We report on fabrication of on-chip lithium niobate (LN) microresonators with high Q/V ratio by femtosecond laser micromachining. A Purcell-factor of 2.8±0.10 is obtained in a microdisk with a diameter of 6.42 μm.

JTh2A.40  
**Polarization-rotatable Terahertz wave source generated in argon cluster plasma produced by double pulse-laser beams**, Kazuaki Moni, Masaki Hashida, Takeshi Nagahama, Kensuke Teramoto, Shunsuke Inoue, Shuji Sakabe; ICR, Kyoto Univ., Japan; GSS, Kyoto Univ., Japan; Setsunai Univ., Japan. Irradiating double pulse-laser beams into cluster gas, THz wave emission is enhanced 10 times as much as that for a single laser beam. The emission polarization is rotatable by changing directivities of the two beams.

JTh2A.41  
**Air nonlinearity triggered by an ultra-intense 33 MV/cm super-TF high energy laser; Mostafa Shalaby, Christoph P. Hauri; Paul Scherrer Institut, Switzerland. We report on measurements of the instantaneous Kerr nonlinearity and the retarded alignment of non-polar molecules CO₂, N₂, and O₂ by an intense, lambda-cubic terahertz pulse with peak field >33 MV/cm centered at 3.9 THz.

JTh2A.42  
**Exotic polarization effects in the production of ion-migration assisted, fs-laser written waveguides in phosphate glass**, Pedro Moreno Zarate, Jesus Hoyos, Luca Labrador Fares; Jan Siegel; Javier Solis; Instituto de Optica, CSIC, USA; Higher Technical Inst., Industrial Engineering, Tepexi, Mexico. We analyze the effect of radial and azimuthal polarizations compared to circular in waveguide fs-laser writing via ion-migration in phosphate glass. Transformation threshold and structure size at high energy is increased for both of them, while nonlinear refractive index is decreased for azimuthal.

**S&I 1: Light-Matter Interactions and Materials Processing**

JTh2A.43  
2.5-3.0 μm strain-compensated InAs/InGaAs multiple quantum well lasers grown on InAlAs metamorphic buffer layers, Yingjie Ma, Yi Gu, Yonggang Zhang, Xiaoyong Cao, Suping Xu, Ben Du; Chinese Academy of Sciences, China. InP-based strain-compensated InAlAs/GaAs multiple quantum well lasers emitting at 2.5-3.0 μm are realized on InAlAs metamorphic buffers. A long lasing wavelength up to 2.9 μm at 230 K in pulsed mode is achieved.
Thursday, 9 June

JTh2A.44
Al-Free Active Region DBR Laser Diodes operating at 894nm for compact Cesium Atomic Clocks, Nicolas M. Van Bandel1, Mikhael Myrar1, Philippe Signoret1, Michel Garcia1, Alexandre Larrieu1, Olivier Peillault1, Michel Krakowski2, III-V Lab, France, 1IES – UMR5214, Univ. of Montpellier, France. Single frequency and low linewidth (<1mHz) Al-free active region diode laser at 894nm, design-compatible for commercial Cesium atomic clocks optically-pumped, are developed and optimized using uncommon noise measurement techniques.

JTh2A.45
Onset of deep UV surface stimulated emission from InGaNP multiple quantum wells, Xiaohang Li1,2, Hongen Xie1, Fernando Ponce1, Jae-Hyun Ryu2, Theeradetch Detschatjorn1, Russell Dupuis1, King Abdullah U of Science & Technology, Saudi Arabia; 1Georgia Inst. of Technology, USA; 2Arizona Photonics, Univ. of Central Florida, USA; 2sdPhotonics, LLC, Optoelectronics, Inst. of Semiconductors, CAS, China; 2ARI Lab, France, 1IES – UMR5214, Univ. of Montpellier, France. We demonstrated onset of deep UV surface stimulated emission at 260 nm from c-plane InGaNP heterostructures grown on a sapphire substrate by optical pumping.

JTh2A.46
Photonic Crystal Surface Emitting Laser with Ultralow Thermal Resistance and Narrow Divergence Angle, Xiaoaje Guo1,2, Yufei Wang1, Ai Qi1, Fan Qi1,2, Songuleng Zhang1,2, Wan-hua Zheng1,2, State Key Lab on Integrated Optoelectronics, Inst. of Semiconductors, CAS, China; 1Lab of Solid State Optoelectronics Information Technology, Inst. of Semiconductors, CAS, China. CW electrically pumped PC array surface emitting laser at 1545nm with ultralow thermal resistance of 0.018K/mW is realized experimentally. Narrow divergence angle of less than 4.8° and nearly circular beam are also achieved.

JTh2A.47
Angular cavity photonic crystal lasers with asymmetric high-order surface grating for narrow spectrum, Yun Liu1, Hangwei Qu1, Yufei Wang1, Yejin Zhang1, Wan-hua Zheng1,2, Chinese Acad Sci Inst of Semiconductors, China. 980-nm angled cavity lasers with asymmetric high-order surface grating and longitudinal photonic crystal structure are designed and fabricated. The power of 847 mW/facet, FWHM of 1.5°×10.6°, and spectral linewidth of 0.0729 nm are obtained.

JTh2A.48
Withdrawn

JTh2A.49
Record Low Differential Resistance Using Lithographic VCSELs, Mingxing Li1,2, Xu Yang1, Nicholas Cox1, James Beadsworth1, Dennis Deppe1,2, CCREL, College of Optics & Photonics, Univ. of Central Florida, USA; 1EdPhotonics, LLC, USA. A lithographic VCSEL approach is used in GaAs-based VCSELs to eliminate the oxide aperture. Record low voltage drive and differential resistance are demonstrated.

JTh2A.50
Room Temperature Photonic Crystal Bandaged Membrane Lasers on SOI Substrates, Shih-Chia Liu1, Deyin Zhao1, Hongjun Yang1, Zhenqiang Ma1, Carl Reuter-Kissold-Hedlund1, Matthias Hamm1, Weidong Zhou1, Univ. of Texas at Arlington, USA; 1Univ. of Wisconsin-Madison, USA; 2KTH-Royal Inst. of Technology, Sweden. We report the experimental demonstration of room temperature photonic crystal (PC) bandaged membrane lasers on silicon based on the transferred printing technique. Single mode lasing was observed with linewidth of 4.4 Å, a side-mode suppression ratio (SMSR) greater than 31.3 dB.

JTh2A.51
High performance index-coupled distributed feedback InAs/GaAs quantum dots-in-a-wells lasers with laterally corrugated waveguides, Yuandong Cheng1,2, Haodong Qiu1, Chen Zhang1,2, Zhongyi Xie3, Zhenfeng Hu1, xianshu liu1, Juufeng Song1,2, Daohua Zhang1, Hong Wang1, Qijie Wang1, Nanyang Technological Univ., Singapore; 1Institut of Microelectronics, Agency for Science, Technology and Research (A*STAR), Singapore. We demonstrate an index-coupled distributed feedback InAs/GaAs quantum dots-in-a-well using a laterally corrugated ridge waveguide. Stable ground-state single-mode emission at 1224 nm with a side-mode-suppression ratio more than 40 dB and low threshold is achieved.

JTh2A.52
Interface Roughness Scattering Rate Equation Model of Long-wavelength Quantum Cascade Lasers, Xing-Yu Chen1, Yi-Hsu Chen1, Claire F. Graniti1, Princeton Univ., USA; 1Harvard School of Engineering and Applied Science, Harvard Univ., USA. The consideration of interface roughness scattering in the model of quantum cascade lasers enables the optimization of long-wavelength designs and predicts a twofold reduction in threshold current of our design compared to the current designs.

JTh2A.53
Monolayer 0.6-terahertz vortex generation, Katsuhiko Miyamoto1,2, Bong Joo Kang1, Won Tae Kim1, Fabian Roettmund1, Yuta Sasaki1, Takaaki Hase1,2, Chiba Univ, Japan; 1Molecular chirality research center, Chiba Univ, Japan; 2Aizu Univ, Korea. We demonstrate a monolayer 0.6-terahertz vortex generation by utilizing a Tsurupica spiral phase plate in combination with a tilted pulse front pumping optical rectification terahertz generator. Maximum terahertz vortex pulse energy of 2.3±μJ was obtained.

JTh2A.54
Novel Pyroelectric Detectors Applied for Precise THz Power Measurements, Andreas Steiger1, Werner Bohmeyer1, Karsten Lange1, Phys.-Tech. Bundesanstalt, Germany; 2Sensor- und Lasertechnik, Germany. Novel pyroelectric THz detectors were calibrated traceable to SI and applied for precise THz power measurements of time-domain spectroscopy systems and an international pilot comparison.

JTh2A.55
Multipolar Plasmonic Resonances in Terahertz Hybrid Metamaterials, Lin Chen1,2, Li Chen1, Xiaofei Zang1, Yiming Zhu1, Songlin Zhuang1, Univ of Shanghai for Science and Technology, China; 1School of Electrical and Computer Engineering, Oklahoma State Univ., USA. The dark multipolar spoof localized surface plasmons resonances are observed in a hybrid structure consisting of a corrugated metallic disk and a bright C-shaped resonator. The multipole has a higher Q-value than the dipole resonance.

JTh2A.56
Modifying the spectral emission of a terahertz quantum cascade laser with double pulse injection seeding, Sergej Markmann1, Hanond Nong1, Shovan Pal1, Nesar Rekmat1, Sven Scholz1, Nadezhda Kukharchyk1, Arne Ludwig1, Sukheep S. Dillon1, Jerome Tignon1,2, Xuli Wei1, Ruhr Unistiversit Bachum, Germany; 1Ecole Normale Superi- eure, France; 2Alcatel Thales III-V Lab, France. A terahertz quantum cascade laser (QCL) is injection seeded with two board-band THz pulses. By varying the time-delay between the THz pulses, the QCL emission spectrum can be modified and even reduced.

JTh2A.57
Waveguide Optical-to-Terahertz Signal Converter using Ring-shaped Microstripine, Satoshi Yamasaki1, Akio Yasui1, Toma Amemiya1, Kentaro Furushawa2, Shinsuke Harat1, Lasse Iul1,2, Zdenek Polnicky3,4, Noriko Sektin1, Yukihiro Nishiyama2, Akifumi Kasatsumi3, Shigeasai Arai4, 1Tokyo Inst. of Technology, Japan; 2National Inst. of Information and Communications Technol. Japan. We report a waveguide optical-to-THz (200 GHz to 1.8 THz) signal converter using a ring-shaped microstripine with GaNAs photonic Bragg mesa structure. A maximum extinction ratio of 16.8dB in THz band was obtained with light irradiation of 150dB.

JTh2A.58
Pulse-train pumping for efficient narrowband terahertz generation in periodically poled lithium niobate, Frederik Altfried, Austria; 2Harvard School of Engineering and Applied Science, Harvard Univ., USA. A new scheme for heterodyne terahertz detection through plasmonic photomixing is presented, which offers significantly enhanced enhancement in detection sensitivity and bandwidth at room temperature. We experimentally demonstrate a first proof-of-concept design operating at ~0.1 THz.

JTh2A.59
Heterodyne Terahertz Detectors Based on Plasmonic Photomixers, Ning Wang1,2, Mona Jakajo1,2,3, Diyann Y. Hu, Ann Arbor, USA; 1Electrical Engineering, Univ. of California, USA. A new scheme for heterodyne terahertz detection through plasmonic photomixing is presented, which offers significantly enhanced enhancement in detection sensitivity and bandwidth at room temperature. We experimentally demonstrate a first proof-of-concept design operating at ~0.1 THz.

JTh2A.60
Terahertz Parametric Amplification using KTiOPO4, MingHsiang Wu1, Yu-Chung Chiu1, Tsong-Dong Wang1, Gang Zhao3, Andrius Zukauskas1,2, Yen-Cheih Huang1, Frederik Laurell1,2, Dept. of Electrical Engineering, Inst. of Photonics Technologies, Taiwan; 1Dept. of Applied Physics, Royal Inst. of Technology, Sweden; 2Chung-Shan Inst. of Science and Technology, Taiwan; 3School of Physics, Inst. of Heavy Ion Physics, China. We show superior terahertz parametric generation from potassium titanyl phosphate over lithium niobate and lithium tantalate, and demonstrate seeded terahertz parametric amplification in KTP at 5.7 THz.

JTh2A.61
High-Energy Terahertz Pulses from Semiconductors Pumped Above the Three-Photon Absorption Edge, Gyula Polonyi1,2, Tanja Mawan7, Boris Mazur7, Balazs Monozor1, Gezdi Sardah4, Gregory Gaumann1, Tadas Balciaus7, Audrunas Puglys7, Andrius Balicas7, Titus Feurer5, József A. Fülöp1,2,6, MTM-PT-E High-Field Terahertz Res. Group, Hungary; 1Univ of Pecs, Hungary; 2ELI-ALPS, Hungary; 3Vienna Univer. of Technology, Austria; 4Univ. of Bern, Switzerland; 5Center for Physical Sciences & Technology, Lithuania. THz generation scalable to high energies in ZnTe and GaP by tilted pulse front pumping at 1.45 and 1.7 μm wavelength was demonstrated. Up to 0.7% efficiency and 14 μJ energy were achieved.

JTh2A.62
Discrimination of Orbital Angular Momentum Modes of the Terahertz Vortex Beam via Diffractive Elements, Changming Liu1, Xi Li2, Shuyu Liu1, Keja Wang1, Zhefeng Jiang1, Jianying Liu1, Wukan National Lab for Optoelectronics, Huazhong Univ. of Science and Technology, China; 1School of Optical and Electronic Information, Huazhong Univ. of Sci- ence and Technology, China. We demonstrate a 3D printed diffractive mode transformer (DMT) for terahertz orbital angular momentum (OAM) modes of terahertz (THz) vortex beam via an optical geometrical transformation method. THz vortex beams with the integer quantum number l ranging from -3 to +3 are detected.
S&I 6: Optical Materials, Fabrication and Characterization

JTh2A.65 Tunable THz metamaterial and plasmonic devices based on graphene, Berardi Sensale-Rodriguez1, Sara Arezoomandan1, 2,3
1, 2Univ. of Utah, USA. Two approaches for constructing terahertz reconfigurable devices, namely: (i) graphene-only plasmonic structures, and (ii) graphene-metal hybrid metamaterials, are analyzed and compared from the perspectives of: quality factor, extinction ratio, unit cell dimensions, and tunability range.

JTh2A.66 Real-Time Monitoring of Fiber Fuse by Using Optical Frequency-Domain Reflectometry, Shoulin Jiang1, Lin Ma1, Xi Yan-Ai1, Bo Wang1, Tuyuan He1, 2State Key Lab. of Advanced Optical Communication Systems and Networks, Shanghai Jiao Tong Univ., China. We propose and experimentally demonstrate monitoring of fiber fuse by analyzing Doppler shift of reflected light using optical frequency-domain reflectometry (OFDR). We realized instantaneous fiber fuse detection and real-time measurement of its location and speed.

JTh2A.67 Implementation of Guided-mode Resonance Optical Filter Using Two-Step Nanoimprinting Process, Wen-Kai Kuo1, Ting Zhang1, Ting-Shan Huang1, 2, 3Wen-Jeng Ho1, 2National Taipei University of Technology, Taiwan. We investigated the influence of the gap-size onto the generation of TM and TE modes. The intensity of TM modes is larger than the TE modes, and the TM modes show better performance.

JTh2A.68 Chemical Modification of Polydimethylsiloxane (PDMS) for Producing Topographic and Refractive Index Contrast for Device Fabrication, Daniel J. Carbaugh1, Faiz Rahman1, Jason T. Wright1, Parthiban Rajani1, Akashna Rohit1, Savas Kay1, 2Ohio Univ., USA. Polydimethylsiloxane (PDMS) can be modified through the use of ultraviolet radiation and cross-linking agents to produce either topographic or refractive index structures. These techniques enable the fabrication of reflectors, gratings, photonic crystals and waveguides.

JTh2A.69 Laser Induced In-fiber Capillary Instabilities for Precise and Scalable Micropore Fabrication, Jing Zhang1, Kaiwei Li1, Ting Zhang1, Lei Wei1, 2Nanyang Technological Univ, Singapore. We demonstrate an in-fiber microsphere fabrication method with great precision and controllability based on laser-induced thermal effect. The smallest fabrication resolution of 3.88 between the microsphere and the fiber core is achieved experimentally.

JTh2A.70 Pore size manipulation of hydrophilic nano/microporous polymer photonic crystal, Dexing Ji1, Haomin Song1, Borui Chen1, Alex Corey2, Nan Zhang1, Tim Thomay2, Chi Zhu1, 3School of Engineering, University of California, USA. We designed a fabrication method to finely manipulate the pore size of nano/microporous materials and demonstrate its application for reversible color tuning of porous polymer photonic crystals based on atmosphere humidity condensation.

JTh2A.71 Z-scan Characterization of Two-Dimensional Transition Metal Dichalcogenide Few-Layer Sheets, Simeon Bikman1, Pemba Lama1, Ardie Walsker1, Roger Dorsninville1, Sergiu Anghel1, Anatol Mitoglu1, Alexandru Micu1, Leonid Kulyuk1, 2The City College of New York, USA. The dependence of the waveguide performance on the individual layers of few-layer sheets is shown. The Z-scan technique was applied to investigate the nonlinear absorption and refraction in few layer sheets of 2D transition metal dichalcogenide: WSe2, MoS2, WSe2 and MoS2, which showed nonlinear saturable absorption and two photon absorption.

JTh2A.72 Thin and Transferable Graphene Oxide Grating Layer, Jyun-Fuh Shin1, Xiao-Jie Lu1, Chia-Wei Huang1, Li-Wen Tian1, Chun-Hu Chen1, 2National Sun Yat-sen Univ., Taiwan. A submicron (280-nm), thin (3-nm) and transferrable graphene oxide grating layer is implemented for the first time by interfacial lithography, oxygen plasma etching, and PMMA-assisted transfer approach. The diffraction efficiency is measured to be 60.62%.

JTh2A.73 Analysis of energy transfer processes for exciting in Cr3+ ions, level of Nd/Cr:YAG materials, Toshihiro Yamada1, Yoshiyuki Honda1, Shinya Motokoshi2, Takashita Jitso2, Kana Fujo3, Minoru Yoshida1, Junji Kawarada1, 2Kinki Univ., Japan. 3Osaka Univ., Japan. A simple and effective laser technique, laser induced Cr3+ ions fluorescence excited in Cr3+ ions, level of Cr:YAG and Nd/Cr:YAG powders were measured. The energy transfer efficiency from Cr3+ ions to Nd3+ was increased from 68% to 78% with increasing concentration of Cr3+.

JTh2A.74 Photovoltaic Performance Enhancements of MOS-Structure Si Solar Cells Based on Antireflection, Bifacial, and Plasmonic Scattering, Ruen-Stang Sue1, 2Wen-Jeng Ho1, 2National Taipei Univ. of Technology, Taiwan. This study reports photovoltaic performance of MOS-structure Si solar cells enhanced by the combination of antireflection, bifacial, and plasmonic scattering effects. The absolute gain in efficiency by 4.66% was obtained, compared with the reference cells.

JTh2A.75 Annealing Effects on Bismuth Active Centers in BiEr Co-doped Fiber, Shun Wei1, Yanzhuo Huo1, Bing Ding1, Fang-fai Cai1, Qiancheng Zhao1, Guang-Ding Peng1, 2Photonics & Optical Communication, School of Electrical Engineering and Telecommunications, Univ. of New South Wales, Australia. The annealing effects on bismuth active centers (BACs) in Bismuth/Erbium co-doped Fiber (BDF) have been investigated. We observed that annealing affects significantly the absorption and emission characteristics of the BACs, especially BAC-Si, in the BDF.

JTh2A.76 Tm3+-doped AlF3-based Glass Fibers for 2 μm Lasers, Shunbin Wang1, Zhou Jia1, Chaofan Yao1, Shijie Jia1, Yousuke Ohishi1, Guanshi Qin1, 2Jilin Univ., China. 3Inst. for Laser Technology, Japan. Tm3+-doped AlF3-based glass fibers are fabricated by using a rod-in-tube method. Lasing at ~1900 nm is obtained from Tm3+-doped AlF3-based fibers under the pumping of a 1570 nm laser.

JTh2A.77 Beam Propagation of Gaussian and Annular Beams at 2 μm in the Presence of Thermal Lensing, Alex Sincere1, Justin Cook2, 3, Wenjie Li1, 4, Eric Johnson1, 2, Jon Bradford2, Lawrence Smith3, Charles Robertson2, 1Univ. of Central Florida, USA. 2Electrical and Computer Engineering, Clemson Univ, USA. The impact of Gaussian and annular beams on thermal lensing is experimentally tested by characterizing the propagation of 2 μm light in BKT. The effect of annular beams for high power propagation is discussed.

JTh2A.78 Investigation of Semi-Polar GaN Grown on [0001] C-plane Nano-Sized Patterned-Sapphire Substrates, Vicent-Su, Po-Hsuen Chen1, Zheng-Hung Hung2, Ta-Cheng Hsu3, Yu-Yao Lin4, Ray-Ming Lin5, Chien-Hsiung Kuan1, 2National Taiwan Univ., USA. 3Epistar Corporation, Taiwan. 4Graduate Inst. of Electronic Engineering and Green Technology Research Center, Chang Gung Univ., Taiwan. This paper reported the growth of semi-polar GaN epitaxial layers on [0001] C-plane nano-patterned-sapphire substrates (cNPSs). In addition, the impact of c-NPSs on the quality of semi-polar film had also been studied.

JTh2A.79 Quantum Yield Measurements of KY3F4:Er3+/Yb3+ Nanocrystals Excited by a 976 nm Laser, Xiaojie Xue1, Tonglei Cheng1, Takenuki Suzuki1, Yasutake Ohishi1, Toyota Technological Inst., Japan. Optimized concentrations of Er3+/Yb3+ and energy transfer process in KY3F4 nanocrystals were investigated by quantum yield (QY) measurements. Low Yb3+-concentration will enhance QY while high concentration will dramatically reduce QY.

JTh2A.80 Plasmonic enhanced Schottky detector for the mid-IR, Meir Y. Grapweis1, Boris Desiatov1, Noa Mazurski1, Jacob Khurgin1, Joseph Sapis1, Uri Levy1, 2Hebrew Univ. of Jerusalem, Israel. 3Dept. of Electrical and Computer Engineering, Johns Hopkins Univ., USA. The rapidly growing interest in the mid-IR (2-5 μm) wavelengths brings about the need for cheap and CMOS compatible photodetectors. Hereby we demonstrate a plasmonic enhanced Schottky detector in silicon for the mid-IR.

JTh2A.81 Ultra-low Threshold Lasing at 0.8 μm from Organic Microdisk Cavity by the Ink-Jet Printing Method, Hiroaki Yoshikawa1, 2, 3Kong Chen1, Satoshi Ryo1, Jeng Li1, Masaki Otsawa1, Yuki Ok1, Kyushu Univ., Japan. 2Nissan Chemical Industries, Ltd., Japan. We demonstrated an ultra-low lasing threshold of 0.33 μJ/μm2 at 873.3 nm using an ink-jet-printed microdisk cavity doped with LDS 7598. Then microdisks with different tapered angles were evaluated on lasing threshold to perform low threshold.

JTh2A.82 3D Optical Waveguides in Ge0.22As0.78Se1 glass - a Highly Nonlinear Material for the Mid-Wave, James Morris1, 2, 3Giorgos Demetriou1, 2, 3Adam Lancaster1, 2, 3Agay Kar1, 2, 3Henry Bookev1, 2, 3Heriot Watt Univ., UK, 4Fraunhofer Centre for Applied Photonics, UK. Ultrafast Laser Inscription (ULI) of waveguides and Z-scan measurements have been performed in Ge−As−Se glass (SAR13). Light guiding at 2.45 μm and 2.9 μm is shown, demonstrating the potential of Gd2SIR for Mid-IR integrated optics.

JTh2A.83 THz generation and photo-switching of the nonlinear properties in a bistable Prussian blue analogue, Animo Oudamou1, 2, 3Antonio Iazollo1, 2, 2Hiroko Tokodai1, Shin-ichi Yash1, 2, 3Eric Frey1, 2Université de Bordeaux, France. 1CNRS LOMA, France. 2Dept. of Chemistry, School of Science, The Univ of Tokyo, Japan. THz spectroscopy and generation indicates the Rb(H3O)2F2(CN)6·0.5H2O Prussian blue analogue is an interesting nonlinear crystal in THz frequency range. A reversible photo-switching of its nonlinear properties is demonstrated within the thermal hysteresis loop of this compound.

Concurrent sessions are grouped across six pages. Please review all six pages for complete session information. 187
The Nonlinear Properties of Single-walled Carbon Nano
tube Saturable Absorber at E11 and E22 Transitions, Karolis Vasikonas, Oleg Okhotnikov, Jurgis Pilipauskas, Jerrius Rustekai, Eskola, Lithuania; Vilinusk University, Lithuania; 2Tampere Univ. of Technology, Lithuania; 3Center for Physical Sciences and Technology, Lithuania. In this paper we compare the nonlinear optical properties of saturable absorbers, made from ~0.8 nm and ~1.4 nm diameter single-walled carbon nanotubes and discuss their potential for mode-locking of fiber laser.

Site-controlled crystalline growth of InN on GaN substrate
and its photoluminescence, Chen-Ting Kuo, Lung-Hsing Hau, Yong-Lai Lai, Hao-Chung Lu, Chen-Chung Lin, Yuh-Jen Cheng, Academia Sinica, Taiwan; National Chiao Tung Univ., Taiwan. We report a site-controlled growth of InN on a GaN substrate. Crystalline InN micropillars were selectively grown from the hexagonal V-pits on GaN surface. The grown morphology and photoluminescent property will be discussed.

Ultra-intense photoluminescence at 314 nm in GaD
-doped silica, Jing He, Yung-Wang, Sebastain Steigenberger, Alisdair Macpherson, Noberto Chiudoni, Gilberto Brambilla, Optoelectronics Research Centre, Univ. of Southampton, Southampton, UK; National Oceanography Centre, Univ. of Southampton, UK; 2Photon Science Inst. Univ. of Manchester, Manchester, UK; 3Università di Milano Bicocca, Piazza dell’Ateneo Nuovo 1, 20126, Milan, Italy. Photoluminescence (PL) of GaD-doped silica in the ultraviolet (UV) is investigated. The efficient emission detected at 314 nm is due to the 

Novel Iron-Based Amorphous Transparent Conducting Oxide, Abhinav Malavi, Humaia Taz, Annette Farah, Maulik Patel, Benjamin Lawrie, Raphael Pouper, Art Badmorf, Gerd Duscher, Ramli Kalyararaman, Quantum Information Science Group, Oak Ridge National Lab, USA; 2Dept. of Chemical and Biomolecular Engineering, Univ. of Tennessee, USA; 3Bredesen Center, Univ. of Tennessee, USA; 4Dept. of Materials Science and Engineering, Univ. of Tennessee, USA; 5Center for Nanophase Materials Sciences, Oak Ridge National Lab, USA; 6Materials and Science Technology Division, Oak Ridge National Lab, USA. We experimentally demonstrate an amorphous ternary metal oxide of Fe, Tb, and Dy exhibiting high electronic conductivity, Hall mobility, and optical transparency driven by partly filled d- and f-subshells.

Broadband silicon-on-insulator 2x2 power splitters using curved asymmetric waveguides, Broadband silicon-on-insulator (SOI) power splitters are designed based on curved asymmetric waveguide coupler sections. A 50/50 power splitter with a footprint of ~0.8 nm and ~1.4 nm diameter single-walled carbon nanotube using 3.682 μm laser excitation. The waveguides are transparent up to at least 3.82 μm.

C-Rich SiC Micro-Ring Based 12-Gbit/s Cross-Wavelength All-Optical Data Inverter, Cheng-Hsuan Hsieh, Yu-Chieh Chi, Gong-Ru Lin, Graduate Inst. of Photonics and Optoelectronics, Academia Sinica, Taiwan; National Chiao Tung Univ., Taiwan. 12-Gbit/s all-cross-wavelength data inversion with an SNR of 8 dB and a BER of 2.85×10^{-10} is demonstrated using a TPA-free C-rich SiC micro-ring resonator based Kerr switch.

Coherent Beam Combining with Gradient-Index Optics, Mint Kunkel, James Leger, Univ. of Minnesota, USA. We present a new method of coherent beam combining utilizing gradient index optics to convert multiple laser beams into a single beam. Both ray and wave theory are employed to design a highly efficient combiner.

Mid-IR Kerr Frequency Comb Generation from 4000 to 10000 nm in a CMOS-compatible Germanium Microrod, Yuhao Guo, Jin Wang, Zhahong Han, Lionel K. Cimerling, Anuradha M. Agarwal, Jun-Yi Zhang, College of Precision Instrument and Optoelectronic Engineering, Tianjin Univ., China; Dept. of Materials Science and Engineering, MIT, USA; School of Electronic and Information Engineering, Beihang Univ., China; Collaborative Innovation Center of Geospace Technology, China; College of Optics and Photonics, CREOL, and FFGC, Univ. of Central Florida, USA. Ge/Si material combination is proposed for microresonator-based frequency combs in mid-IR. A new dispersion engineering approach is used, enabling octave-spanning mode-locked comb generation with a pump power as low as 190 mW.

Optical Sampling with CMOS Compatible Waveguides in C-Band Waveguides, Mahmoud Jazayerifar, kambiz Jamshidi, Univ. of Minnesota, USA; 2Centre for disruptive Photonic Technologies, Nanyang Technological Univ., Singapore; 3ARC Center for Ultra-high Bandwidth Devices for Optical Systems, RMIT Univ., Australia. Waveguide-integrated plasmonic crystals are fabricated and characterized using a hybrid platform consisting of silver nanogaps lying over the surface of a SOI photonic chip. Stop-band and hot-spots of such hybrid plasmonic crystal have been demonstrated.

Optomechanical Oscillators Fabricated in a CMOS-Compatible Foundry, Rodrigo da Silva Benevides, Gustavo de Oliveira Lute, Felipe G. Santos, Gustavo Wiederhecker, Thiago P. Aleggri, Unicamp, Brazil. We demonstrate self-sustained mechanical oscillations at room temperature and ambient pressure in a silicon photonic crystal slot-cavity fabrication fabricated by a CMOS-Foundry. Optical quality factor as high as Q\textsubscript{g}≈4×10^6 and an optomechanical coupling rate of g/2π≈76 kHz are observed.

Slow Light Enhancement of Q-factors in Fabricated Photonic Crystal Ring Resonators, Kathleen McGarvey-Lechable, Tamjose Hamidifar, David Patel, Luhua Xu, David V. Plant, Paulo Bianucci, Dept. of Physics, Concordia Univ., Canada; Dept. of Electrical and Computer Engineering, McGill Univ., Canada. Experimental results for photonic crystal ring resonators (PhCRR) fabricated on the silicon-on-insulator (SOI) platform are presented. Spectral features of the PhCRRs transmission spectrum are discussed and quality factors in excess of 30,000 are reported.

Low-power Thermo-optical Bistability in a Graphene Oxide-on-Silicon Micro-ring Resonator, Tzu Huang Yen, Chong-Jia Wu, Chia-Wei Huang, Chia Chien Wei, Yung-Jr Hung, National Sun Yat-sen Univ., Taiwan. We demonstrate a low-power thermo-optical bistability in a graphene oxide-on-silicon micro-ring resonator which not only retains its high quality factor of 56000 but also exhibits a hysteresis loop for a pump power of only 115 μW.

Sub-GHz Modulation of Light with Dielectric Nanomechanical Metamaterials, Artemios Karvounis, Jun-Yu Ou, Behrad Gholiapour, Weiping Wu, Kevin Macdonald, Nikolay I. Zholudev, Univ. of Southampton, UK; 2Centre for disruptive Photonic Technologies, Nanyang Technological Univ., Singapore. Subwavelength-thickness all-dielectric nano-grating and nano-cantilever array metamaterials, actuated respectively by electrostatic and optical forces, provide reversible reflectivity changes of up to 20% and a giant sub-GHz frequency optomechanical nonlinearit at telecommunication wavelengths.
Graphene oxide (GO) embedded one-dimensional photonic devices are being studied. We demonstrate the use of GO in microcavities for optical applications. The GO incorporated microcavities exhibit high refractive index contrast, which is beneficial for optical confinement. We observe enhanced optical quality factors in these cavities compared to traditional microcavities.

Dual Photonic Crystal Nanobeam Cavities

We report a novel approach for the fabrication of photonic crystal nanobeam cavities using a porous silicon material. These cavities exhibit high optical quality factors and offer adiabatic single mode optical guidance. We demonstrate the potential of these cavities for high-Q optical resonances in photonic crystal microcavities.

Adiabatic silica microspikes with high mechanical Q-factor

We propose a compact (5 µm x 40 µm) adiabatic silica microspike with high mechanical Q-factor. This device is able to achieve peculiar oscillatory dispersion curves with high-quality factor (Q > 10,000) resonances in coupled photonic crystal microcavities. The adiabatic design allows for smooth mode transitions, which is beneficial for optical applications.

Measurement of free-space coupling efficiency

We investigate the direct butt coupling in integrated circuits. We demonstrate the silicon photonic crystal split-beam nanocavity with an optical Q-factor of 7000. We report an optimized cladding-pumped 10-modes EDFA with more than 20 dB gain, zero differential modal gain, -4.5 dB noise figure over the C-band and below 10^{-1} BER for up to 15 spatial modes.

Optimized Cladding-Pumped Few-Mode EDFAs for Space-Division Multiplexed Systems

We report an optimized cladding-pumped 10-modes EDFA with more than 20 dB gain, zero differential modal gain, -4.5 dB noise figure over the C-band and below 10^{-1} BER for up to 15 spatial modes.

Optical Networks

We report an optimized cladding-pumped 10-modes EDFA with more than 20 dB gain, zero differential modal gain, -4.5 dB noise figure over the C-band and below 10^{-1} BER for up to 15 spatial modes.
Exhibit Halls 1, 2, & 3

11:30–13:00  JTh2A • Poster Session III

JTh2A.124  All-Optical Wavelength Conversion of OFDM Signals Using Two-Mode Injection-Locking in Fabry–Pérot Lasers, Xingwen Yi, Juntao Dong, Jing Zhang, Kun Qiu, 1Univ. of Electronic Science & Tech, China; 2NEC Labs, America, USA. We experimentally demonstrate all-optical wavelength conversion of OFDM signals by using two-mode injection-locking in a Fabry–Pérot laser. We show the tradeoff between the capacity and performance, and measure the power penalty after wavelength conversion.

JTh2A.125  Tunable All-Optical WDM Channel Selection using Raman-Assisted Cascaded Parametric Amplification, Fatemeh Alshahi1, Yinwen Cao2, Morteza Ziyadi1, Amirhossein Mohajerin Ariaei1, Ahmad Fallahiour1, Ahmad Almaiman3, Changjing Bao4, Peicheng Liao4, Asher Willner, Bishara Shamee1, Yoschi Akasaka1, Alan Willner3, Tadashi Ikeuchi1, Joseph Touch1, Moshe Tur2, Shigehiro Takasaka2, Ryuchi Sugizaki1, 1Univ. of Southern California, USA; 2Fujitsu, USA; 3Tel Aviv Univ., Israel; 4Stanford Univ., USA.

JTh2A.130  100 Gb/s Hybrid Data Transmission Using 1.3-μm DML for Optical Interconnect Applications, Nhat D. Nguyen1, Amin Malekmohammadi1, 1Univ. of Nottingham, Malaysia. We experimentally demonstrate 100 Gb/s all-optical AICCD (Airy/AICCD) modulation for extending reach in data center interconnect links has been proposed using low-cost 1.3-μm DML. This hybrid technique indicates clearer eye openings compared to 8-RAM modulation.

JTh2A.131  Performance Evaluation of Hybrid DBPSK-MPPM Technique in Long-Haul Optical Transmission, Abdulaziz E. El-Fiqi1, Ahmed E. Morsa2, Hossam M. Shalaby1, Salah S. Obaya3, Kazutoshi Kato4, 1Menoufia Univ., Egypt; 2Zewail City of Science and Technology, Egypt; 3Japan-Univ. of Science and Technology, Japan; 4Kyushu Univ., Japan. The performance of DBPSK-MPPM technique is evaluated in long-haul transmission using GN-model. The BER expression is extended to address fiber nonlinearity. Results show that fiber nonlinearity effects are more significant in DBPSK-MPPM than traditional ones.

JTh2A.132  16-User OFDM-CDMA Optical Access Network, Xuhan Guo1, Qi Wang1, Lei Zhou1, Liming Fang2, Xin Li1, Adrian Wonfor3, Richard Penty4, Ian White1, 1Univ. of Cambridge, UK; 2Huawei Technologies, China; 3Jianghuai Univ., China. We demonstrate a 16×2.5 Gb/s (40×AICCD) OFDM-CDMA PON for next-generation access applications. Four-channel error-free transmission over 25 km SMF shows 6 dB coding gain, with 0.1 b/symbol and 0.9 dB crosstalk penalties.

JTh2A.133  Construction of Irregular QC-LDPC Codes with Low Error Floor for High-Speed Optical Communications, Dongdong Wang1, Liang Wang1, Xue Chen1, Armei Fei1, Chi Chen1, Chen Ju1, Zhongrong Wang1, Huitao Wang2, 1Beijing Univ. of Posts & Telecom, China; 2ZTE Corporation, China. We propose a construction method of irregular QC-LDPC codes for high-speed optical communications, by which the constructed codes not only achieve high coding gain but also do not exhibit error floor above BER of 10⁻¹⁰.

JTh2A.134  Dual-Comb-assisted Real-Time Microwave Frequency Measurement with a Single Mode-Locked Fiber Laser, Xin Zhao1, Cai Li1, Yingfeng Pan1, Guoqing Hu1, Takeshi Yusa1, Zheng Zheng2, 1School of Electronic and Information Engineering, Beihang Univ., China; 2Collaborative Innovation Center of Geospatial Technology, China. We propose a comb-assisted interferometric method for measuring microwave frequencies using comb sources. Four-channel error-free transmission over 25 km SMF shows 6 dB coding gain, with 0.1 b/symbol and 0.9 dB crosstalk penalties.

JTh2A.135  On-chip Spectral Broadening of Kerr Frequency Combs: Towards a Fully Integrated Frequency Metrology System with 2-Fz Self-reference, Jing Wang1, Yuhao Guo1, Guifang Li1, Xin Zhao1, 1Collaborative Innovation Center of Geospatial Technology, China; 2School of Physics and Optoelectronics, Univ. of Central Florida, USA. We experimentally demonstrate that 40 MHz pulse repetition rate, 1.3 μm frequency comb generated using self-phase modulation in an all-optical micro ring resonator is phase locked to a 2 Fz self-referenced comb stabilization, with an emphasis on feasibility of making all devices fully integrated on a single chip.

JTh2A.136  Diamond Color Center Based FM Microwave Demodulator, Linbo Shao1, Mian Zhang1, Marko Loncar1, 1Harvard Univ., USA. Nitrogen-vacancy centers, atomic-scale luminescent defects in diamond, are used to transduce frequency-modulated microwave signals to intensity-modulated fluorescence. Our work could lead to realization of radio receivers operating in extreme environments, including high temperature and pressure.

JTh2A.137  A compact 30 GHz spaced astro-comb based on 1 GHz Yb:fiber laser, Yuanli Ma1, Lijun Zhu2, Fei Meng1, Chen Li1, Tongxiao Jiang1, Aimin Wang2, Fei Zhai3, Gang Zhao1, Zhiqang Zhang1, 1Peking Univ., China; 2National Astronomical Observatories, CA, China; 3National Inst. of Metrology, China. We demonstrate a small and compact 30 GHz astro-comb based on 1 GHz fundamental repetition rate Yb:fiber laser comb.

JTh2A.138  Measurement of Loop Gain and Bandwidth in Phase-locked Loop of Mode-locked Laser, Jie Tan1, Yongsheng Cheng1, Nan Xie2, Dong Hou1, 1Interdisciplinary Telecommunications Program, Univ. of Colorado at Boulder, USA; 2Inst. of Electronic Engineering, China Academy of Engineering Physics, China. We experimentally demonstrate the phase-locked loop for mode-locked laser without breaking its locking state. The agreement of the measurement and theoretical calculation proves the validity.

JTh2A.140  Optical Frequency Comb based on Single-Pass Four-Wave-Mixing in a HNLF combined with EO-modulation, Jose Luis S. Brito1, Paulo C. Danese1, Flavio C. Cruz1, Universidade Estadual de Campinas, Brazil. An optical frequency comb is produced with over 100 nm bandwidth at 1550 nm and 25 GHz line spacing using two continuous-wave narrow-linewidth seed lasers, in single-pass through a HNLF and a resonant EOM.

S&I: 14: Optical Metrology

JTh2A.141  Passively Offset-free Yb:fiber Laser Source with 1 GHz Repetition Rate, Qian Cao1, Yizhou Liu1, Chen Li1, Xiang Gao1, Zhigang Zhang1, Franz X. Kärtner2, 1Guoqing Hu1, 2Karlsruhe Inst. of Technology, Germany. We demonstrate a passively offset-free 1 GHz laser source at 1.03 μm by difference-frequency generation between two spectral components of a spectral broadened Yb:fiber laser based source.

JTh2A.142  Experimental Demonstration and Theoretical Modeling of Raman Probe Induced Spectral Dip for Realizing a Superluminal Laser, Joshua M. Yablon1, Zifan Zhou2, Minchan Zhou1, Ye Wang1, Selim Shahrar3, 1ECCS, Northwestern Univ., USA; 2Physics, Northwestern Univ., USA. We demonstrate a passively offset-free 1 GHz laser with a dip in the center of the gain profile, which implies superluminal operation. This brings us one step closer to creating superluminal-boosted metrological devices for a wide variety of applications.
**JTh2A.143**
**Comb-based Active Laser Ranging with Frequency Transfer**, Hongyuan Zhang¹, Haoyun Wei¹, Yan Li¹; ¹Tsinghua Univ., China. The performance of active laser ranging is enhanced by using the frequency comb. Distance measurement is conducted along with frequency transfer between two ends, with 100 nm resolution and $2 \times 10^{-16}$ Allan deviation for 1 s.

**JTh2A.144**
**Optical Rectification and AM-to-PM Conversion in a Lithium Niobate-Loaded Microwave Cavity**, Lanbing Kang¹, Brian H. Kolner¹,²; ¹Electrical and Computer Engineering, Univ. of California, Davis, USA; ²Physics, Stanford Univ., USA. A lithium niobate-loaded microwave cavity pumped with femtosecond optical pulses was used as a platform to study AM-to-PM conversion in optical rectification. The conversion gain $\beta/m$ was measured to be -42.1 dB, independent of optical power.

**JTh2A.145**
**A 10-GHz Optical Frequency Comb from a SCOWA-Based Laser With an Intra-Cavity 10,000 Finesse Etalon**, Kristina Bagnell¹, Anthony Klee¹, Jason Plant², Paul Juodawlkis², Peter Delfyett¹; ¹CREOL - College of Optics and Photonics, USA; ²Lincoln Lab, MIT, USA. We present preliminary results from the first-ever demonstration of a SCOWA-based harmonically mode-locked laser with intra-cavity etalon with a finesse of $10^4$, producing a 10 GHz optical frequency comb.
FTh3A.1 • 14:00
Terahertz Quantum Plasmonics at Angstrom Scale, Young-Mi Bahk1, Bong Joo Kang2, Yong Seung Kim1, Joon-Young Kim1, Won Tae Kim1, Tae Yun Kim1, Taehoong Kang1, Jiyeong Rhee1, Sanghoo Han1, Cheol-Hwan Park1, Fabian Rotermund2, Dae-Sik Kim1, Seoul National Univ., Korea; Ajou Univ., Korea; Sejong Univ., Korea. We observed a ninety-seven percent decrease of terahertz transmission in five-millimeter long, angstrom-sized metallic gaps of copper-graphene-copper hybrid structure. This giant nonlinearity originates from terahertz tunneling-induced electron tunneling across the angstrom gap.

FTh3A.2 • 14:15
Guiding and Coupling Light through Nonlinear Plasmonic Nanosuspensions, Yuxuan Ren1, Trevor Kelly1, Abkar Samadi2, Anna Bezyadina1, Demetrios N. Christodoulides1, Zhigang Chen1,2,3,4,5,6; 1Dept. of Physics and Astronomy, Stanford University, USA; 2College of Optics and Photonics, Univ. of Central Florida, USA, 3Nanaike, Teda Applied Physics Institute, Institute of School of Physics, China. We demonstrate guiding of a strong infrared beam by a weak visible beam due to plasmonic-resonant soliton formation. Master-slave-type coupling is also observed by tuning the relative strength of two opposite polarizabilities in core-shell nanosuspensions.

FTh3A.3 • 14:30
Enhanced third-harmonic generation in silicon oligomers driven by magnetic Fano resonance, Alexander S. Shorokhov1, Elizaveta V. Melik-Gaykazyan2, Daria A. Smirnova1, Ben Hopkins1, Katie E. Chong1, Duk-Yong Choi1, Maxim R. Shcherbakov2, Andrey E. Mikhailchik2, Dragomir N. Neshev3, Andrey A. Fedyanin1, Yuri S. Kivshar1,2,3,4,5; 1Faculty of Physics, Lomonosov Moscow State Univ., Russia; 2Nonlinear Physics Centre, Research School of Physics and Engineering, Australian National University, Australia; 3Laser Physics Centre, Research School of Physics and Engineering, Australian National University, Australia. We study the third-harmonic generation from silicon nanodisk quadrupoles and demonstrate the substantial enhancement of the harmonic signal near the magnetic Fano resonance, due to an interplay of the individual and collective optically-induced magnetic response.

FTh3A.4 • 14:45
Asymmetric second harmonic generation in anisotropic plasmonic crystals, Alexander Chekhov1, Ilya Razdolski1, Andrei Kirilyuk1, Theo Rasing2, Alexander Stogni3, Tatiana Murzina4, M. V. Lomonosov Moscow State Univ., Russia; 2Radboud Univ., Netherlands; 3Scientific-Practical Materials Research Centre of NAS of Belarus, Belarus. Strong angular asymmetry of second harmonic generation (SHG) is observed in an anisotropic plasmonic crystal. The asymmetry is enhanced up to 95% by the surface plasmon polarization (SPP) excitation at the anisotropic interface. The SHG output is shown to be sensitive to the SPP propagation direction.

FTh3A.5 • 15:00
Measurement of Coupling Between Individual Interfacial Quantum Dots, Eric Martin1, Steven T. Cundiff1,2; 1Univ. of Michigan, USA; 2Univ. of Chicago, USA. We present a novel collinear multidimensional coherent spectroscopic technique that we use to measure individual interfacial quantum dots and their interactions. We achieve very high spatial resolution for characterizing a wider range of quantum systems.
Epsilon-Near-Zero Photonic Wires, Runyu Liu1, Christopher Roche, Yujun Zhong2, Viktor A. Podolskiy3, Dan Wasserman1, 1Univ of Illinois at Urbana-Champaign, USA; 2Univ. of Massachusetts at Lowell, USA. We experimentally demonstrate epsilon-near-zero “photonic wires” supporting optical modes with effective wavelengths 10 times larger than the light's free space wavelength and improved propagation lengths. Design, fabrication, and characterization of the wires will be discussed.

Achiral Nanoprobes Extract Chiral Signals from within Chiral Metamaterials, Sean P. Rodrigues1, Yonghao Cui1, Shoufeng Lan1, Lei Kang1, Wenshan Cai1, 1Georgia Inst of Technology, USA. Resonant plasmonic nanostructures amplify chirally modified, nonlinear signals from quantum emitters. Nonlinear emission signals are enhanced by 40×+ of that of the emitters not embedded.

Experimental Demonstration of Optical Metamaterials with Isotropic Negative Index, Sui Yang1, Xiaojing Ni1, Boubacar Kante1, Jie Zhu1, Kevin O'Brien1, Yuan Wang1, Xiang Zhang1, 1Univ. of California Berkeley, USA; 2MSD, Lawrence Berkeley National Lab, USA. The critical challenge to the successful implementation of ‘perfect lens’ and ‘optical cloning’ is to achieve isotropic negative index metamaterials. Here we experimentally demonstrate isotropic negative index metamaterials at optical frequency by proper design and scalable self-assembly.

Shape Memory Photonic Metamaterial, Masanori Tsuruta1, João Valente1, Behrad Gholipour2, Kevin F. MacDonald3, Eric Plum1, Nikolay I. Zheludev1; 1Optoelectronics Research Centre and Centre for Photonic Metamaterials, Univ. of Southampton, UK; 2Energy and Environment R&D Center, Asahi Kasei, Japan; 3Centre for Disruptive Photonic Technologies and The Photonics Inst., Nanyang Technological Univ., Singapore. We report the first reconfigurable metamaterial based on the shape memory alloy. In the heating cycle structural elements of this metamaterial exhibit a hysteresis-type shape transformation that leads to non-volatile switching of its plasmonic properties.

2D and 3D all dielectric metamaterials made from III-V semiconductors, Sheng Liu1, Gordon A. Keeler1, John L. Reno1, Michael B. Sinclair1, Igal Brener1, 1Sandia National Labs, USA. We present all-dielectric 2D and 3D metamaterials that are monolithically fabricated from III-V semiconductor nanostructures. The active/gain and high optical nonlinearity properties of the metamaterials can lead to new classes of active devices.

Orbital Angular Momentum Mode Multiplexer Based on Multimode Micro-Ring Resonator with Angular Gratings, Shimao Li1, Charalampos Kitiz1, Zhihao Nong1, Shengpin Gao1, Marc Sorel1, Siyuan Yu1, Xilin Cai1, 1State Key Lab of Optoelectronic Materials and Technologies and School of Physics and Engineering, Sun Yat-sen Univ., China; 2School of Engineering, Univ. of Glasgow, UK; 3Dept. of Electrical and Electronic Engineering, Univ. of Bristol, UK. We demonstrate silicon photonic orbital angular momentum multiplexing devices based on multimode microring resonator. Up to four optical beams carrying different orbital angular momentum states can be selectively excited from different input ports.
Compact Airy-beam Optical Squeezed Source at 1.0 μm, Xiaoming Wei, Chihang Kong, Q. K. Samanta, Ho Ko, Kevin K. Tsia, Kenneth K. Wong,1; Dept. of Electrical and Electronic Engineering, The Univ. of Hong Kong, Hong Kong; Photonic Sciences Lab., Physical Research Lab, Navrangpura, India; Dept. of Medicine and Therapeutics, Prince of Wales Hospital, Faculty of Medicine, Chinese Univ. of Hong Kong, Hong Kong. We demonstrate an ultrafast Airy-beam optical source at 1.0 μm. The ultrafast wavelength-sweeping is achieved with inertia-free time-stretch via a newly-designed highly-dispersive fiber, and an Airy-beam profile is generated by an add-on cubic phase mask.

Lensless Endoscopic Light Delivery of Individually Addressable Channels using a Multimode Fiber, Juergen W. Czarske; Technische Universitat Dresden, Germany. We demonstrate asynchronous information transmission through a multimode fiber using different windows of a single spatial light modulator. Our findings pave the way towards individual diffuse optical imaging in deep biological tissue.

Fusion of Lens-free and Lens-based Microscope Images for Accurate Color Imaging, Yibo Zhang,1, Yichen Wu,1, Yun Zhang,1, Aydogan Ozcan; UCCLA, USA. Accurate color imaging over a wide field-of-view is achieved by combining single-wavelength lens-free on-chip holographic microscopy with a color-calibrated low-cost mobile-phone microscope using a wavelet-based image fusion algorithm.

High-throughput microparticle screening by 1-μm time-stretch optofluidic imaging integrated with a field-programmable gate array platform, Bob Chung,1, Ho-Churgeon Ng,1, Maoxin Wang, Sharat C. V. Bogaraju,1, Anderson H. C. Shum,1, Hayden K. H. So,3, Kevin K. Tsia,1; Dept. of Mechanical Engineering, The Univ. of Hong Kong, Hong Kong; Dept. of Electrical and Electronic Engineering, The Univ. of Hong Kong, Hong Kong; Dept. of Computer Science and Engineering, Electrical and Electronic Engineering, The Univ. of Hong Kong, Hong Kong. We demonstrate a new generation of ultrafast 1-μm time-stretch optofluidic imaging system—representing a cost-effective solution toward real-time, high-throughput, in-situ image processing and analytics of single microparticles/cells in a unified system.

Wavelength Scanning based Pixel Super-Resolution, Wei Luo, Yibo Zhang, Zoltan Goros, Aydogan Ozcan; Univ. of California Los Angeles, USA. We report a pixel super-resolution technique that uses wavelength scanning over a narrow spectrum to achieve an effective numerical-aperture of ~1 with ~2.3 fold fewer number of measurements than conventional lateral shift-based pixel super-resolution methods.

Detection of Brownian Torque in Magnetically-Driven Rotating Microparticles, Andrej Fedyanin, Maria Romodina, Evgeny Lyubimov; Lomonosov Moscow State Univ., Russia. The influence of Brownian torque on the motion of magnetic microparticles is experimentally determined using optical tweezers. Rotational Brownian motion induces the flattening of the breakdown transition between synchronous and asynchronous modes of microparticle rotation.

An Integrated Germanium-Based Optical Waveguide Coupled THz Photoductive Antenna in Silicon, Peiyu Chen, Mostafa Hosseni, Aydin Babakhani,1; Electrical and Computer Engineering, Rice Univ., USA. An integrated germanium-based optical waveguide coupled THz photoductive antenna in a low-cost SOI process is presented with potentials to perform THz beam-steering. The radiated THz pulses achieve a FWHM of 1.14ps and bandwidth of 1 STHz.

Fusion of Lens-free and Lens-based Microscope Images for Accurate Color Imaging, Yibo Zhang, Yichen Wu, Yun Zhang, Aydogan Ozcan; UCCLA, USA. Accurate color imaging over a wide field-of-view is achieved by combining single-wavelength lens-free on-chip holographic microscopy with a color-calibrated low-cost mobile-phone microscope using a wavelet-based image fusion algorithm.

Anomalous visualization of sub-2 THz radiation on silicon-based CMOS and CCD sensors, Mostafa Shalaby,1, Christopher P. Hauri,1, Carlo Vicario,1; SwissFEI, Paul Scherrer Inst., Switzerland. We show that low frequency (sub-2) THz radiation can be visualized on common optically-designed CCD and CMOS sensors. The advantage of CCD technology is the small pixel size, very cheap cost, insensitivity to background noise, and multispectral detection.

Efficient Room-temperature Terahertz Nanodetectors based on Novel 2D Materials and heterostructures, Miriam S. Vitello,1; Scuola Normale Superiore di Pisa, Italy. We devise Terahertz nanodetectors designed in a bolometric, thermoelectric, plasmonic or near-field probe configuration, exploiting novel bi-dimensional material systems, as topological insulators, black-phosphorus and Van der Walls heterostructures, all operating at room-temperature with state-of-the-art performances.
Open-Path Cavity Ring-Down spectroscopy provides a potential means for sensitive detection of trace gas species in compact, lightweight packages. This contribution presents studies of attainable sensitivity along with details of methane and ammonia sensors.

High Power Mid-Infrared Laser Sources, Daniel J. Creedon, Leonard A. Pomerantz, Casey Jones, Benjamin R. Johnson, Peter A. Ketteridge, Michael Lemons, Charles Ibach, Peter A. Budni, K. T. Zawilski, Peter G. Schumemann, Scott D. Setzler, BAE Systems, USA. We discuss high power mid-infrared laser sources based on frequency conversion of solid-state lasers operating in the 2-micron spectral region. These lasers are shifted to the mid-infrared via optical parametric oscillation in ZGP and OPGaAs.

A Low-Cost Miniaturized Laser Heterodyne Radiometer (Mini-LHR) for Near-IR measurements of CO2 and CH4 in the atmosphere, Emily L. Wilson, Anthony J. DiGregorio, Jianping Mao, Anand Ramanathan, Laser Remote Sensing Lab, NASA/GSFC, USA; SSA, USA; Laser Remote Sensing Lab, Goddard Space Flight Center, USA; Univ. of Maryland, USA. The mini-LHR developed at NASA GSFC is a ground-based passive version of a laser heterodyne radiometer that uses sunlight and a distributive feedback laser to measure absorption of CO2 and CH4 in the atmospheric column.

Interband Cascade Lasers in the MIR for Sensing Applications, Marc Frischer, Michael von Edlinger, Julian Scheuermann, Steffen Becker, Lars Nähle, Johannes Koehl, Robert Weih, Martin Kamp, Sven Höfling, Nanoplus GmbH, Germany; Würzburg Univ., Germany. This talk gives an insight into the development and performance of various ICL based sources in the MIR wavelength range for application in high accuracy sensing in fields like industrial process control or environmental monitoring.

Enhancement of Diffusion Length and Optical Quality of via Annealing in Vapors of Zn, Otafar Gafarov, Alan Martinez, Vladimir Fedorov, Sergey B. Mirov, Univ. of Alabama at Birmingham, USA. The effects of co-annealing in Zn vapor during process of thermal diffusion of InZnSe are studied. Co-annealing improves the diffusion length by ~2 times while improving optical quality, and optical damage threshold.

Quantum Cascade Laser on Silicon at 4.8 μm, Alexander Sport, Jon Peterl, Michael L. Davenport, Eric J. Stanton, Charles Merritt, William Belsey, Igor Vurgaftman, Jerry R. Meyer, Jeremy Kirch, Luke Maest, Dan Botez, John E. Bowers, Dept. of Electrical and Computer Engineering, Univ. of California, Santa Barbara, USA; Naval Research Lab, USA; Dept. of Electrical and Computer Engineering, Univ. of Wisconsin, USA. Here we demonstrate a room-temperature, 4.8 μm quantum cascade laser (QCL) heterogeneously integrated with silicon-on-nitride-on-insulator waveguides. QCL mesaes are defined above silicon waveguides to form lasers.
FTh3M.1 • 14:00
Production of tens-of-MeV Compton gamma-rays from a 2 GeV laser-plasma electron accelerator, Michael C. Downer1, Joseph M. Shaw1, Aaron Bernstein1, Yen-Yu Chang1, Rafael Zgadzi1, Andrea Hannaschi1, Kathleen Weichmann1, James Welch1, Maxwell LaBerge1, Watson Henderson1, Hai-En Tsai1, Neil Fazel1, Xiaoming Wang1, Todd Ditmire1, Michael Donovan1, Gilliss Dyer1, Erhard Gaul1, Joseph Gordon1, Mikael Martinez1, Michael Sprinks1, Toma Toncian1, University of Texas at Austin, USA. We generate a collimated (<1 mrad) beam of gamma rays that penetrate several centimeters of lead by retro-reflecting a petawatt laser pulse onto trituration ~2 GeV electrons with a plasma mirror after driving a laser-plasma accelerator.

FTh3M.2 • 14:15
Dielectric Laser Acceleration of Sub-100keV Electrons with Silicon Dual Pillar Grating Structures, Kenneth Leedle1, Andrew Celibos1, Huiyang Deng1, Olav Solgaard1, Fabian Pease1, Robert Byer1, James Harris1, Stanford Univ., USA. We present the demonstration of high gradient (370 MeV/m) laser acceleration and deflection of sub-relativistic electrons with silicon dual pillar grating structures using both evanescent inverse Smith-Purcell modes and coupled coast-like modes.

FTh3M.3 • 14:30
Monoenergetic Relativistic Electron Pulses by Laser-Driven Linear Acceleration in Free Space, Liang Jia Wang1, Kyung-Han Hong1, Sergio Carbajo2, Aya Fallah1, Marin Soljacic1, John Joannopoulos1, Franz X. Kaertner2, Ido Kaminer1, SIMTech, Singapore; 3MIT, USA; 4Univ. of Hamburg, Germany; 5Deutsches Elektronen-Synchrotron, Germany. We present an acceleration scheme where ultrafast radially-polarized laser pulses generate high-quality, relativistic electron pulses in the absence of material boundaries or media, paving the way to compact accelerators with gradients exceeding 10 GeV/m.

FTh3M.4 • 14:45
Correlated emission of high-harmonics and fast electrons beams from plasma mirrors, Maimouna Bocoum1, Maexence Thévet1, Frederik Bohle1, Benoît Beaurepaire1, Aline Verrier1, Aurélie Jullien1, Jérôme Faure1, Rodrigo B. Lopez-Martens1, Laboratoire d’Optique Appliquée, France. We report for the first time on the correlated emission of high-harmonics and fast electrons from femtosecond plasma mirrors. We show that both processes cannot occur simultaneously for the same density gradient at sub-relativistic intensities.

FTh3M.5 • 15:00
Withdrawn.

FTh3N.1 • 14:00
Multimodal biomedical optoacoustic imaging, Martin Frenz1, K. Gerrit Held1, Michael Jaeger1, Milburn Singh1, Wiendelt Steenbergen1, H. Gunther Akarcay1, Biomedical Photonics, Inst. of Applied Physics, Switzerland; 2Univ. of Twente, MIRA Inst. for Biomedical Technology and Technical Medicine, Netherlands. Optoacoustic imaging is a promising non-ionizing hybrid imaging modality combining high optical contrast and spectroscopic-based specificity of optical imaging with the high spatial resolution of ultrasound and speed of sound imaging.

FTh3N.2 • 14:30
Tri-modal Sentinel Lymph Node biopsy Guidance for Technically Difficult Case with Nodal Flow Obstruction, Jeeun Kang1, Jin Ho Chang1, Brian Wilson2,3, Sun Mi Kim1, Hak Jong Lee1, Tai Kyong Song1, Whiting School of Engineering, Johns Hopkins Univ., USA; 2Dept. of Electronic Engineering, Sogang Univ., Korea; 3Princess Margaret Cancer Centre, Univ. of Health Network, Canada; 4Dept. of Medical Biophysics, Univ. of Toronto, Canada; 5Dept. of Radiology, Seoul National Univ. of Bundang Hospital, Korea. We present the preliminary in vivo experimental results of the tri-modal sentinel lymph node biopsy guidance for the technically-difficult rabbit model with nodal flow obstruction.

FTh3N.3 • 14:45
Three-dimensional Photooacoustic Imaging Using Robotically-tracked Transrectal Ultrasound Probe with Elevational Synthetic Aperture Focusing, Haichong Zhang1, Alex Cheng1, Emad Bostick1, Dept. of Computer Science, Johns Hopkins Univ., USA; 2Dept. of Radiology, Johns Hopkins Medical Inst., USA. Three-dimensional photooacoustic imaging using robotically tracked transrectal ultrasound probe is introduced to improve brachytherapy seeds detectability. The feasibility was experimentally demonstrated, and synthetic aperture focusing improved elevational resolution and signal-to-noise ratio.

FTh3N.4 • 15:00
A Diode Laser Sources for Pa Imaging: An Enabling Technology for Portable Devices, Andreas Kohl1, Celine Canal1, Arnaud Laugustin1, Olivier Rabot1, Quantel, France. An ultra-compact diode laser source is demonstrated that provides up to 2 mW of energy in pulses of 30 ns+-150 ns at repetition rates of up to several kHz. The high electro-optical efficiency of ~30% makes it well suited for integration into a hand held photooacoustic scanner.

FTh3N.5 • 15:00
Multi-soliton pulse characterization and compression, Gennady Rasskazov1, Anton Ryabtsev1, K. Gerrit Held1, Michael Jaeger1, Martin Schäfter1, 2, Ido Kaminer1, 2, Maria Katsma1, 2, Anton Ryabtsev1, 2, 1Biomedical Photonics, Inst. of Applied Physics, Switzerland; 2Deutsches Elektronen-Synchrotron, Germany; 3Physics and Astronomy, Michigan State Univ., USA. We present a multi-soliton output of a large-mode area photonic-crystal fiber pumped at 1550 nm is presented. Spectral phase correction of each soliton in the output results in sub-30 fs pulses.
Concurrent sessions are grouped across six pages. Please review all six pages for complete session information.
Nanosciences, Aalto Univ., Finland; 3Applied Physics and Nanosciences, Aalto Univ., Finland; 4Optoelectronics Research Center, Tampere Univ. of Technology, Finland.

We introduce nonlinear microscopy with phase-engineered incident beams. By controlling the phase across an incident Hermite-Gaussian $HG_{10}$ beam, we vary the longitudinal field component at focus, allowing tailoring of second-harmonic generation from vertically-oriented nanowires.

Near-Field Nanolasers based on NonRadiating Anapole Modes, Juan Sebastian Totero Gongora1, Andrey E. Miroshnichenko2, Yuri S. Kivshar3, Andrea Fratalocchi1; ‘King Abdullah Univ of Sci & Technology, Saudi Arabia; ‘Australian National Univ., Australia. By employing ab-initio simulations of Maxwell-Bloch equations with a source of quantum noise, we study a new laser concept based on photonic dark-matter nanostructures that emit only in the near-field, with no far-field radiation pattern.

Demonstration of Frequency Conversion at an Optical Event Horizon with Cross Polarized Waves in Birefringent Nanophotonic Waveguides, Charles Cirac1, Simon-Pierre Gara2, ‘OPERA-Photonique, Université libre de Bruxelles, Belgium. The frequency conversion of a probe beam by reflection on a soliton propagating in a birefringent nanophotonic waveguide is experimentally and numerically demonstrated using cross-polarized waves. A frequency conversion almost pump wavelength independent is demonstrated.

Silicon-Based Metalens with Zero Refractive Index, Jian-Wen Dong1, Xin-Tao He1, Jun-Cong Shi1; ‘Physics, Sun Yat-sen Univ., China. Zero-refractive-index metalens was designed and fabricated on silicon platform. Anomalous focusing effect was observed directly and the effective refractive index was quantitatively demonstrated. The device reveals potential applications for aberration-free lens and spectral detection.
Homogenization of nanowire-based composites with anisotropic unit cell and layered substructure, Brian Wells1,2; Wei Guo1, Viktor A. Podolskiy1; Physics, Univ. of Hartford, USA; 2Physics and Applied Physics, Univ. of Massachusetts Lowell, USA. We present a simple numerical extension to Maxwell Garnett formalism for wire materials with high filling fractions in anisotropic unit cells to describe photonic band gap behavior observed in epitaxially grown semiconductor multilayer nanowires.

Meta Liquid Crystals (MLCs), a novel form of tunable 3D switchable metamaterials using MEMS technology in multilayer nanowires.

Mimicking Liquid Crystals with Metamaterials, Mingkai Liu1, Kebin Fan1,2, Willie Padilla1, David Powell1, Xin Zhang2, Ilya Shadrivov1; 1Nonlinear Physics Center, RSPE, Australian National Univ., Australia; 2Dept. of Electrical and Computer Engineering, Duke Univ., USA. We propose and demonstrate Meta Liquid Crystals (MLCs), a novel form of tunable 3D metamaterials. MLCs mimic the response of liquid crystals but use meta-atoms instead of molecular mesogens, enabling a richer variety of electromagnetic responses.

Chiral Switchable THz Metamaterial with MEMS Reconfigurable Spirals, Tetsuo Kan1, Akihiro Isosaki2, Natsuki Kanda1,2, Naotoki Nemoto1, Kuniki Koshih1, Hidetoshi Takahashi1, Makoto Kuwata-Gonokami1, Kiyoashi Matsumoto2, Isao Shimoyama1; 1Riken, Japan; 2The Univ. of Tokyo, Japan. We proposed a chiral switchable metamaterial using MEMS technology in the terahertz frequency. Deformation of a flat metal spiral unit of the metamaterial creates three-dimensional spirals, and symmetrical chiral switching of the spiral was performed.

Generation of photonic orbital angular momentum superposition states using vortex beam emitters with superimposed gratings, Qingzheng Xiao1,4, Charalampos Kitis1, Shinao Li1, Yueyang Chen1, Xinlin Cai1,2, Marc Sorel1, Siyuan Yu1,3; 1State Key Lab of Optoelectronic Materials and Technologies and School of Physics and Engineering, Sun Yat-sen Univ., China; 2School of Engineering, Univ. of Glasgow, UK; 3Dept. of Electrical and Electronic Engineering, Univ. of Bristol, UK; 4School of Information Engineering, Jiangxi Univ. of Science and Technology, China. An integrated approach to produce orbital angular momentum (OAM) superposition states has been demonstrated. Superposition states between two vector OAM modes have been achieved by integrating a superimposed angular grating in one silicon micro-ring resonator.

Coherent Spectral Characteristics of Passive and Active Dual-Racetrack Resonators, Yating Zhou1,2, Robert Gadzula1, Siyamak Abbasiou1,2, Minning Zhu1,2, Wei Jiang1,2; 1Electrical and Computer Engineering, Rutgers, The State Univ. of New Jersey, USA; 2Inst. for Advanced Materials, Devices, and Nanotechnology, Rutgers, The State Univ. of New Jersey, USA. Dual-racetrack resonator structures are experimentally investigated. A single spectral is observed in each free-spectral range and the spectral phase variation indicates sufficient phase dynamic range. Electro-optic tuning of the structure produces rich coherent behaviors.

CMOS-Compatible Zero-Index Metamaterial, Daryl Vuks1, Yang Li1, Orad Reshef1, Mei Yin1, Philip Mufioz1, Shotaro Kita1, Marko Loncar1, Eric Mazur1; 1Harvard Univ., USA. We present an on-chip Dirac-cone metamaterial with an impedance-matched zero refractive index at λ = 1550nm. The design is a square array of air holes in 220-nm silicon-on-insulator (SOI) which offers compatibility with complementary metal-oxide-semiconductor (CMOS) technology.

Optical Filter Optimization Using Phase-Sensitive Amplifiers in a CA. We demonstrate a novel optical filter employing amplification and de-amplification in a phase-sensitive amplifier at a 10-GHz clock frequency, which constitute a promising platform to simulate large-scale Ising spin networks.

Optical Filter Design with Enhanced Optical Extinction Ratios through Signal/Idler Input Power Imbalance. We demonstrate a novel optical filter employing amplification and de-amplification in a phase-sensitive amplifier with enhanced optical extinction ratios through signal/idler input power imbalance. Optimal power imbalance enables 60 dB rejection in the RF domain.
### STh3G • Imaging I: Concepts for Enhancing Speed and Resolution—Continued

**STh3G.6 • 15:15**  
**Computational Single-shot Hyper-spectral Imaging based on a Microstructured Diffractive Optic**, Peng Wang¹, Univ. of Utah, USA. A compact hyper-spectral imaging system using a microstructured transparent diffractive optic is experimentally demonstrated with enhanced spatial resolution. A fast algorithm based on regularization is exploited to reconstruct hyper-spectral data in a single shot.

**STh3G.7 • 15:30**  
**Computational imaging for Gigapixel microscopy**, Laura Waller¹, Univ. of California Berkeley, USA. Using computational approaches, we recover high-resolution 3D images in a commercial microscope. Our setups employ illumination-side and detection-side coding of 4D phase-space (e.g., light field) information with fast acquisition times.

### STh3H • Optofluidics III: Plasmonics and Magnetics—Continued

**STh3H.6 • 15:15**  
**Coupling between a Plasmonic V-groove Waveguide and Single Fluorescent Bacterial cells**, Oren Lotan¹, Cameron L. Smith¹, Jonathan Bar-David¹, Sharon Yagur-Kroll¹, Shimshon Belkin¹, Anders Kristensen¹, Uriel Levy¹, Hebrew Univ., Israel; Technical Univ. of Denmark, Denmark. We experimentally demonstrate coupling of fluorescent light from a single bacterium into a plasmonic V-groove waveguide mode. This result is the first step in the construction of an efficient bioplasmic chip for diverse sensing applications.

**STh3H.7 • 15:30**  
**Plasmonic Crystal Cavity on Optical Fiber End Facet for High Performance Label-Free Biosensing**, Xiaolong He¹, Jie Yang¹, Xin Zhou¹, Tian Wang¹, Tian Yang¹, Shanghai Jiao Tong Univ., China; Xu Yuan Biotechnology Co., China. Plasmonic crystal cavities on single-mode optical fiber end facets show a refractive index detection limit of 3 x 10⁻⁶ RIU. Real-time monitoring of the kinetic interaction process between immobilized proteins and partner molecules is demonstrated.

**STh3H.8 • 15:45**  
**Facile Detection of Polycyclic Aromatic Hydrocarbons using Photonic Biosilica Combining Surface-Enhanced Raman Spectroscopy and Thin Layer Chromatography**, Xianming Kong¹, Xinyuan Chong¹, Alan X. Wang¹, Oregon State Univ., USA. We developed a facile route for separating and detecting polycyclic aromatic hydrocarbons from mixed samples using photonic biosilica, which serves as a new lab-on-chip platform combining surface-enhanced Raman scattering sensing and thin layer chromatography.

### STh3J • Terahertz Emitters and Detectors II—Continued

**STh3J.6 • 15:30**  
**Bias-Field Tailored Plasmonic Nano-Electrode for Pulse and Continuous-Wave Terahertz Radiation**, Kiwon Moon¹, Il-Min Lee¹, Hyun-Soo Kim¹, Kyung-Hyun Park¹, ETRI, Korea. By using nano-electrodes, the THz emission power was improved by four times and more than 50 times for the pulse and continuous-wave terahertz emitter. Comparisons are made in terms of local carrier dynamics.

**STh3J.7 • 15:45**  
**Terahertz Meta-Atom Quantum Well Photodetectors**, Bruno Paulli¹, Stefano Prota¹, Jianhe Li², Stéphane Guilet², Edmund Linfield², A. Giles Davies², Francois Julien¹, Rafaele Colombelli¹, Inst. d’Electronique Fondamentale, Univ. Paris Sud, CNRS-UMR8622, France; School of Electronic and Electrical Engineering, Univ. of Leeds, UK; Laboratoire de Photonique et Nanostructures (LPN), UPR20 CNRS, France. We demonstrate single-pixel and 2D arrays of THz quantum-well photodetectors featuring extremely sub-wavelength, antenna-coupled resonators. Few-micron sized devices show photodetection in the 100-200 μm range, with a consequent dramatic reduction in the device dark current.

### Coffee Break

**16:00–16:30 Coffee Break, Concourse Level**
ATH3J • Atmospheric Sensors I—Continued

ATH3J.4 • 15:15
Monitoring of atmospheric Methane and Ethane using two Continuous-Wave Interband Cascade Lasers, Chuantao Zheng1,2, Chunguang Li1,2, Lei Dong1, Hongpeng Wu1, Yajun Yu1, Nancy P. Sanchez2, Weilin Ye1, Frank Tittil1, Yiding Wang1, Rice Univ., USA; 2Wuhan Univ., China. A sensor system for simultaneous detection and monitoring of ppb concentration levels of methane and ethane using two interband cascaded lasers was developed. Long-term monitoring of these two atmospheric gases was performed in the Greater Houston area.

ATH3J.5 • 15:30
CW EC-QCL Based Sensor for Simultaneous HOD/H2O, N2O and CH4 Detection by Multi-pass Absorption Spectroscopy, Yajun Yu1,2, Robert Griffin1, Frank Tittel1, Nancy Sanchez2, Rice Univ., USA; 2Wuhan Univ., China. A sensor system based on a CW EC-QCL was demonstrated for simultaneous atmospheric HOD/H2O, N2O and CH4 detection. A 57.6 m multi-pass absorption cell was employed. Wavelength modulation spectroscopy was implemented for data processing.

ATH3J.6 • 15:45
High Power Far-Infrared ZGP OPO Laser, Chuanpeng Qian1, Yingjie Shen1, Baoquan Yao1, Xiaoming Duan1, Youlin Ju1, Yuezhu Wang1, Jilin Univ., China. A sensor system based on a CW EC-QCL was demonstrated for simultaneous atmospheric HOD/H2O, N2O and CH4 detection. A 57.6 m multi-pass absorption cell was employed. Wavelength modulation spectroscopy was implemented for data processing.

ATH3K • Light Sources and Novel Surface Processing—Continued

ATH3K.4 • 15:15
Aging study of white high power LED under thermal and electrical stresses – New experimental aging bench prototype, First photometric and electrical characterizations results, Laurent Canale1,2, Soannaneth Leng3, Pascal Dupuis3, Georges Zissis1, CNRS - LAPLACE, France; 2Universite de Toulouse, France. We present a new prototype aging bench used for LED studies with thermal and electrical stresses. Photometric and electrical characterizations were performed at a very early stage with first results before degradations are also presented.

ATH3K.5 • 15:30
Bio-inspired, nanostructured anti-reflective surfaces for laser applications, Zhaolu Diao1, Jan-Henning Dirks1, Joachim Spatz2, Dept. of New Materials and Biosystems, Max Planck Inst. for Intelligent Systems, Germany; 2Dept. for Biomimetics, Hochschule Bremen – Univ. of Applied Sciences, Germany; 3Dept. of Biophysical Chemistry, Univ. of Heidelberg, Germany. Here we present the nanostructured silica substrates with ultra-low reflectance (0.015%) and nearly perfect transmittance (99.9%) per side over a broad range of wavelengths. Anti-reflective surfaces using such nanostructures will allow the design of more durable and powerful laser systems.

ATH3K.6 • 15:45
Biophotonic, anti-reflective surface based on planar horn structures, Low-threshold, single-mode quantum cascade lasers (QCL) in metal-metal waveguides is controlled in directionality and form through planar horn-type shape structures, whilst conserving a broad spectral response.

STh3L • Cascade Lasers—Continued

STh3L.5 • 15:15
Engineered far-fields of metal-metal terahertz quantum cascade lasers with integrated planar horn structures, Feihu Wang1, Kenneth Maussang1, Iman Kundu2, Li Chen1, Jianhe Li1, Edmund Linfield3, A. Giles Davies4, Raffaele Colombelli5, Juliette Mangeney1, Jerome Tignon1, Sukhdeep S. Dhillon1, ENS - LPA - CNRS, France; 2School of Electronic and Electrical Engineering, Univ. of Leeds, UK; 3Institut d’Electronique Fondamentale, Université Paris Sud, France. The far-field emission profile of terahertz quantum cascade lasers (QCLs) in metal-metal waveguides is controlled in directionality and form through planar horn-type shape structures, whilst conserving a broad spectral response.

STh3L.6 • 15:30
Terahertz pulse generation from metal-metal terahertz quantum cascade lasers, Kenneth Maussang1, Feihu Wang1, Souad Moumdji2, Raffaele Colombelli5, Joshua Freeman1, Iman Kundu2, Jianhe Li1, Edmund Linfield3, A. Giles Davies4, Juliette Mangeney1, Jerome Tignon1, Sukhdeep Dhillon1, Laboratoire Pierre Aigrain, France; 2Univ. Paris Sud, Institut d’Electronique Fondamentale, France; 3Univ. of Leeds, School of Electronic and Electrical Engineering, UK. We demonstrate the generation of 11ps terahertz pulses from spectrally broad metal-metal quantum cascade lasers at 77K via active modelocking, and show the critical role of phase-matching between the terahertz pulse and the microwave modulation.

STh3L.7 • 15:45
Low-threshold, Single-mode Defect Line Terahertz Quantum Cascade Laser, Adam Klimont1, Riccardo Degl’Innocenti1, Luca Masini1, Yash D. Shah1, Yuan Ren1, David Jessop3, Alessandro Tredicucci1, Harvey Beere1, David Ritchie1, Cavendish Lab, Univ of Cambridge, UK; 2NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Italy; 3Dipartimento di Fisica “E. Fermi”, Università di Pisa, Italy. We present a single-mode, low-threshold terahertz quantum cascade laser (QCL) operating on a defect line in a photonic crystal. A 55% reduction in threshold current vs. metal-metal QCLs is due to the slow light effect.

16:00–16:30 Coffee Break, Concourse Level
FTh3M • Electron Acceleration and Extreme Light Generation—Continued

FTh3M.6 • 15:15
Generation of 100-GHz radiation in lithium niobate driven by 4.7-ps, 22-mJ, 1030-nm Yb:YAG laser pulses, Xiaojun Wu1,2, Anne-Laure Calendron1,2, Koustuban Ravi1, Michael Hemmer1, Fabian Reichert1, Huseyin Cankaya1, Luis Zapata1, Nicholas H. Mathis1, Franz X. Kaertner1; 1Center for Free Electron Laser Science, Germany; 2The Hamburg Centre for Ultrafast Imaging, Univ. of Hamburg, Germany. A cryogenically cooled Yb:YAG amplifier with 4.7-ps laser pulses is employed to generate 100-GHz pulses in lithium niobate via optical rectification. We obtained a high efficiency ~0.05% at 300 K, close to the theoretical prediction.

ATh3N.5 • 15:30
Photoacoustic Imaging System using LED Light Source, Toshitaka Agano1, Naoto Sato1; 1PreXion Corporation, Japan. We have successfully obtained photoacoustic image using LED light source instead of Solid-state laser. We explain how we capture the higher S/N image almost equivalent to one using the laser.

STh3O.6 • Fiber Solitons—Continued

STh3O.6 • 15:15
Transformation of a dispersive wave into a fundamental soliton, Flavie Braud1, Matteo Conforti1, Andy Cassez1, Arnaud Mussot1, Alexandre Kudlinski1; 1Univ. of Lille, France. We observe the transformation of a dispersive wave into a fundamental soliton using an axially-varying fiber. The solitonic nature is demonstrated theoretically by solving the Zakharov-Shabat scattering problem, and experimentally through spectral and temporal measurements.

ATh3N.6 • 15:45
The use of dual-wavelength quantitative photoacoustics for evaluation of bone pathologies - a first in human study, Idan Steinberg1, Lihi Shiloh1, Israel Gannot2, Avishay Eyal1; 1Tel Aviv Univ \ Faculty of Engineering, Israel; 2Electrical and Computer Engineering, Johns Hopkins Univ., USA. Low-cost, dual-wavelength photoacoustics is used for measuring both biomechanical and functional parameters of bones. Ex-vivo and first-in-human studies demonstrate its potential for providing functional information as well as biomechanical information equivalent to ultrasound.
**STh3P • Parametric Wave-mixing in Guided Mode Structures and Microcavities—Continued**

**STh3P6 • 15:15**

Generation of 10-kW Pulses at 880 nm in Commercial Fiber via Parametric Amplification in a Higher Order Mode, Jeffrey Demas\(^1\), Tao He\(^1\), Siddharth Ramachandran\(^1\), Boston Univ., USA. We amplify a seed laser at 880 nm to achieve 385 ps pulses with 10 kW peak power in a commercial step-index multimode fiber using four-wave mixing pumped at 1064 nm in a large effective area LP\(_{06}\) mode.

**STh3P7 • 15:30**

Electronically tunable, fully fiber-integrable optical parametric oscillator, Maximilian Brinkmann\(^1,2\), Sarah Janfrüchte\(^1\), Tim Hellwig\(^1\), Sven Dobner\(^1,2\), Carsten Fallnich\(^1,2\), Inst. of Applied Physics, Germany; 'Cells-in-Motion Cluster of Excellence, Germany. We present a fiber-integrable optical parametric oscillator, tunable from 1130 to 1310 nm within 8 μs via the repetition frequency of the pump laser. Output energies above 1 μJ at a repetition frequency around 1 MHz were reached.

**STh3P8 • 15:45**

Ultrafast two-color all-optical transverse mode conversion in a graded-index fiber, Martin Schnack\(^1\), Tim Hellwig\(^1\), Carsten Fallnich\(^1\), Inst. of Applied Physics, Univ. of Muenster, Germany. We demonstrate ultrafast, all-optical conversion of transverse modes in a novel dual-wavelength setup. Mode conversion of picosecond probe pulses by optically induced transient long-period gratings using sub-picosecond control pulses is directly observable for the first time.

**STh3Q • Fundamentals of Laser Material Processing—Continued**

**STh3Q5 • 15:15**

Universal Heterogeneous Nucleation and Growth Dynamics in the Photo-Induced Phase Transition in Vanadium Dioxide, Nathan Brady\(^1\), Kannatasan Appavoo\(^1\), Minah Seo\(^2\), Joyeeta Nag\(^1\), Rohit P. Prasankumar\(^1\), Richard F. Haglund\(^1\), David Hilton\(^1\), Vandebilt Univ., USA; 'Dept. of Physics, Univ. of Alabama-Birmingham, USA; 'Center for Integrated Nanotechnologies, Los Alamos National Lab, USA. We use ultrafast pump-probe spectroscopy to demonstrate that the dynamics of the photo-induced structural (monoclinic to rutile) phase transformation in vanadium dioxide is independent of thin-film morphology and substrate-induced strain, and occurs in 40 ± 0.5 ps.

**STh3Q6 • 15:30**

Visualization of the inwards propagation of a heat-affected layer upon femtosecond laser irradiation of glass, Mario Garcia Lechuga\(^1\), Jan Siegel\(^1\), Daniel Puerto\(^1\), Javier Solis\(^1\), 'Instituto de Optica, CSIC, Spain. We demonstrate the importance of heat diffusion in femtosecond laser surface processing of glasses even below the ablation threshold by monitoring the inwards propagation of a heat-affected "molten" layer using time-resolved microscopy.

**STh3Q7 • 15:45**

High-speed Photography of the Fs-ps-ns Dynamics during Femtosecond Laser Bessel Beam Drilling, Qiang Cao\(^1\), Wuhan Univ., China. A pump-probe shadowgraph imaging technique was used to reveal the femtosecond-picosecond-nanosecond multitemscale fundamentals of high-quality, high-aspect-ratio microhole drilling in poly-methyl-methacrylate by a single-shot femtosecond laser Bessel beam.

**16:00–16:30 Coffee Break, Concourse Level**
FTh4A.1 • 16:30
A nonlinear waveguide array with inhomogeneous poling pattern for the generation of photon pairs, Francesco Lenzini1, James Titchener1, Sachin Kasture1, Alexander Poddyubny2, Andreas Boesch1, Ben Haylock1, Matteo Vila1, Aman Mitchell1, Alexander S. Solntsev1, Andrey A. Sukhorukov1, Mirko Lobino1, Griffith Univ., Australia; 2The Australian National Univ., Australia; 3ITM0 Univ., Russia, 4ipolle Inst., Russia; 5RMIT Univ., Australia. We present the realization of an inhomogeneously poled nonlinear waveguide array for the generation of photon pairs with integrated pump filtering. The biphoto wavefunction produced from the device is characterized using reversed sum-frequency generation measurements.

FTh4A.2 • 16:45
Photon-pair generation in nonlinear lossy waveguides: An optical emulation, Markus Graefe1, Diana Antoniosyan1, Alexander Solntsev1, Alexander Szameit1, Andrey A. Sukhorukov1, Inst. of Applied Physics, Abbe Center of Photonics, Friedrich-Schiller-Universität Jena, Germany; 2Nonlinear Physics Centre, Research School of Physics and Engineering, The Australian National Univ., Australia. We demonstrate a coupled-waveguide platform which realizes classical optical simulation of quantum photon-pair generation through spontaneous parametric down-conversion in a nonlinear lossy waveguide. The photon-pair creation vs. the phase mismatch and loss are experimentally mapped.

FTh4A.3 • 17:00
Integrated Quantum Frequency Comb Source of Entangled Qubits, Christian Reimer1, Michael Kues1, Piotr Roztocki1, Benjamin Wetzell1, Yaron Bromberg1, Brent D. Fried1, Michael Mrejen1, Stanford Univ., USA. We show how the spaser technology in the presence of a gold nanoantenna can be employed as a building block for designing new integrated sources for quantum simulators at the nanoscale.

FTh4A.4 • 17:15
Toward Octave-Spanning Coherent Near-field Control in Plasmonic Nanostructures, Michael Mrejen1, Uri Arieli2, Assaf Levinson1, Achiya Nagler1, Haim Suchowski1, Phys. Dept., Tel-Aviv Univ., Israel. We experimentally observe hyperspectral near-field response of a single plasmonic nanostructure, using a combined nano-FTIR SNOM illuminated by ultra-broadband femtosecond laser pulses from metal nanotips. Avoiding direct tip illumination, the concept carries significant potential for improving time resolution in ultrafast electron microscopy.

FTh4A.5 • 17:30
Towards Nanoscale Quantum Information Sources with Spasers, Andrew Solomonenko1,2, Juan Sebastian Toro Torgora1, Andrey E. Miroshnichenko1, Yuri S. Kivshar1, Andrea Fratalocchi1, PRIMALIGHT, King Abdullah Univ. of Science and Technology (KAUST), Saudi Arabia; 2Nonlinear Physics Centre, Research School of Physics and Engineering, Australian National Univ., Australia. We show how the spaser technology in the presence of a realistic source of quantum noise can be employed as a building block for designing new integrated sources for quantum simulators at the nanoscale.

FTh4B.1 • 16:30
Strong field above threshold ionization of Rydberg electrons localized to a gold nanotip, Joerg Robin1, Jan Vogelsang1, Benedek J. Nagy2, Peter Dombi3, Petra Gross4, Christoph Lienau5, Univ. of Oldenburg, Germany; 6Wigner Research Centre for Physics, Hungary. We report the first observation of atomic-like above-threshold-ionization from a gold nanotip by exciting long-lived Rydberg electron wave packets. These results transfer high harmonic generation and attosecond gating techniques from atoms to solid state nanostructures.

FTh4B.2 • 16:45
Optical phase control of single-electron nanotunnelling, Lenzini1, Markus Ludwig1, Michael Schmalzl1, Vanessa Koiter1, Daniela Brda1, Alfred Leitenstorfer1, Dept. of Physics and Center of Applied Photonics, Univ. of Konstanz, Germany. We exploit the carrier-envelope phase of near-infrared 1.4-cycle pulses with picojoule-level energy to drive and control single-electron transport across the 8 nm tunneling gap of a gold nanoantenna.

FTh4B.3 • 17:00
Remotely Driven Electron Emission for Ultrafast Electron Microscopy, Jan Vogelsang1, Joerg Robin1, Benedek J. Nagy2, Peter Dombi3, Daniel Rosenkranz1, Manuela Schiel1, Petra Gross4, Christoph Lienau5, Institut für Physik and Center of Interface Science, Carl von Ossietzky Universität Oldenburg, Germany; 6Wigner Research Centre for Physics, Hungary. We demonstrate a novel concept, plasmonic nanofuscoring, for strong-field-photoemission of nanometer-sized ultrafast electron pulses from metal nanotips. Avoiding direct tip illumination, the concept carries significant potential for improving time resolution in ultrafast electron microscopy.

FTh4B.4 • 17:15
Cascaded downconversion interface to the telecom band for single-photon-level signals at 650 nm, Vahid Esfandyar1, Arnan Tischler2, Haim Suchowski1, Phys. Dept., Tel-Aviv Univ., Israel. We present a device for two-stage frequency conversion of a 650 nm signal to the telecom band with low excess noise and low required pump power. We observed 99% depletion for each stage.

FTh4B.5 • 17:30
Controlling the ultrafast hot electron response in plasmonic nanostructures, Hayk Harutyunyan1, Emory Univ., USA. We report on efficient generation of energetic (hot) electrons in plasmonic nanostructures. By changing the geometry and composition of the samples we demonstrate that the ultrafast dynamics of hot electron generation can be controlled at will.
16:30–18:30
FTh4D • Hyperbolic Metamaterials
President: Viktor Podolskiy, Univ. of Alberta, USA

FTh4D.1 • 16:30
Super-Coulombic Dipole-Dipole Interactions in Hyperbolic Media, Ward D. Newman1, Cristian L. Cortes1, Amir Alfshar1, Al Meldrum2, Ken Cadien3, Robert Fedosejevs1, Zabin Jacob1,2; Electrical and Computer Engineering, Univ. of Alberta, Canada; 3Chemical and Materials Engineering, Univ. of Alberta, USA. We demonstrate experimentally that hyperbolic metamaterials fundamentally alter dipole-dipole interactions conventionally limited to the near-field. The effect is captured in long-range energy transfer and lifetime reduction of donor emitters due to acceptor placed 100 nm away.

FTh4D.2 • 16:45
Nanoscale Hyperbolic Metamaterial Resonators in Semiconductors, Kaishun Feng1, Deborah Sivco1, Anthony Hoffman1; 1Univ. of Notre Dame, USA; 2Princeton Univ., USA. Sub-diffraction mid-infrared resonators were fabricated in a n+-InGaAs/AlInAs hyperbolic metamaterial. Coupling to localized modes is observed in angle-dependent reflection measurement and agrees well with finite element simulations using an anisotropic permittivity.

FTh4D.3 • 17:00
What are the merits of hyperbolic metamaterials?, Tengfei Li1, ECE, Johns Hopkins Univ., USA. Detailed analysis of hyperbolic metamaterials shows that Purcell enhancement attainable in them is negated by loss, slow velocity and impedance mismatch. These materials offer no advantage whatsoever relative to simple slab and gap plasmonic waveguides.

FTh4D.4 • 17:15
Hyper-Structured Illumination., Evgenii E. Narimanov1, 1Purdue Univ., USA. We present a new approach to super-resolution optical imaging, based on structured illumination in hyperbolic media. The proposed system allows for planar geometry, has unlimited field of view, and is robust with respect to optical noise and material losses.

FTh4D.5 • 17:30
Experimental demonstration of the de-magnifying hyperperls, Jingbo Sun1, Tianboyu Xu1, Natalia M. Litchinitser1, 1State Univ. of New York at Buffalo, USA. We experimentally demonstrate de-magnification functionality of a hyperperl. The original patterns with a feature size of 300nm were scaled down to 190nm, which is smaller than half of the wavelength of the incident beam.

FTh4D.6 • 17:45
Experimental demonstration of the de-magnifying hyperperls, Jingbo Sun1, Tianboyu Xu1, Natalia M. Litchinitser1, 1State Univ. of New York at Buffalo, USA. We experimentally demonstrate de-magnification functionality of a hyperperl. The original patterns with a feature size of 300nm were scaled down to 190nm, which is smaller than half of the wavelength of the incident beam.

FTh4D.7 • 18:00
Experimental demonstration of the de-magnifying hyperperls, Jingbo Sun1, Tianboyu Xu1, Natalia M. Litchinitser1, 1State Univ. of New York at Buffalo, USA. We experimentally demonstrate de-magnification functionality of a hyperperl. The original patterns with a feature size of 300nm were scaled down to 190nm, which is smaller than half of the wavelength of the incident beam.

STh4E • Silicon Photonics
President: Wei Jiang, Rutgers Univ., USA

STh4E.1 • 16:30
Flexible Silicon Photonic Transmitter with Segmented Modulator and 32 nm CMOS Driver IC, Tam N. Huynh1,2, Nicolas Dupuis1, Renato Rimolo-Donadio1,2, Jonathan Prosves1, Doug Gill1, Christian Baks1, Alexander Ryltakov1,2, Clint Schow1,2, William M. Green1, Benjamin Lee1,2; IBM T.J. Watson Research Center, USA; 3Cista Rica Inst. of Technology, Costa Rica; 4Coriant Advanced Technology Group, USA; 5Univ. of California at Santa Barbara, USA. We present a novel silicon photonic transmitter including 90nm CMOS segmented modulator co-packaged with low power 32nm CMOS driver IC. Optical equalization is demonstrated for the first time with the multi-segment Mach-Zehnder modulator at 22Gb/s.

STh4E.2 • 16:45
Cladding-Dependent Nature of Electro-Optic Effects in Silicon Waveguides, Rajat Sharma1, Matthew W. Puckett1, Felipe Vallin1, Yeshaiahu Faiman1, 1Univ. of California, San Diego, USA. We experimentally demonstrate how dielectric claddings can alter the nature of capacitively-induced electro-optic effects in silicon waveguides. The free-carrier effects reported here can be extended to the study of any dielectric-clad semiconductor waveguide.

STh4E.3 • 17:00
Electro-Optic Tuning of Silicon Carrier Injection Degenerate Band Edge Resonators, Michael Wood1, Justin Bun1,2, Ronald M. Reano1; 1Ohio State Univ., USA. We present electro-optic degenerate band edge resonators in silicon based on carrier injection modulation. Measurements of fabricated devices demonstrate a tunability of 1.09 nm/V.

STh4E.4 • 17:15
Resonant Germanium-on-Silicon Photodetector with Evanescent Waveguide Coupling, Zhan Sun1,2, Ehsan Hosseini1,2, Erman Timurdogan1, Jie Sun1, Michele Moresco1, Gerald Leake1, Thomas N. Adam2, Douglas C. Woolf2, Michael Watts1,3; 1MIT, USA; 2State Univ. of New York, USA. A 4.5-μm-radius resonant germanium-on-silicon photodetector is first demonstrated with evanescent coupling from bus waveguide, achieving 2.03 mA dark current, 1.04A/W responsivity at 1530nm, 32.9GHz electro-optic bandwidth and enhancement on responsivities for longer wavelengths (>1.0A/W at 1630nm).

STh4E.5 • 17:30
Photodetecting MOSFET based on ultrathin single-crystal germanium nanomembrane, Zhenyang Xia1,2, Haomin Song1, Munho Kim1, Ming Zhou1,2, Tzu-Hsuan Chang1,2, Qiaoqiang Gan1, 1Univ. of California, Santa Barbara, USA; 2Dept. of Physical and Chemical Sciences, Univ. of L’Aquila via Vetoio, Italy; 3Dept. of Electrical Engineering, Univ. of Texas at Arlington, USA. An integrated photonic phase-sensitive amplifier with a dual-pumped four-wave mixing architecture is investigated. Gain with multiple phase shifts are theoretically studied and experimentally demonstrated with approximately 7.8 dB extinction gain.

FTh4F • Invited
Applications of Nonlinear Parametric Effects for Advanced Processing of Optical Signals, Periklis Petropoulos1, Kyle R. Bots2, Francesca Parmigiani1, Graham Hesketh1, Liam Jones1, David J. Richardson2, 1Optoelectronics Research Center, Univ. of Southampton, UK. Phase-sensitive amplifiers constitute powerful tools for the regeneration of phase-encoded optical signals. However, they are often accompanied by a detrimental phase-to-amplitude noise conversion. We present techniques to overcome this effect and discuss their potential.
STh4G • Imaging II: Deep Tissue and Super-Resolution

16:30–18:30

Presider: Kevin Tsia; Univ. of Hong Kong, Hong Kong

STh4G.1 • 16:30

Cascade Coherent Anti-Stokes Raman Scattering (CARS) Microscopy, Vitor Pelegrini, Bernardo B. Yokoyama, Lazaro A. Padilha, Carlos L. Cesar; Unicamp - State Univ. of Campinas, Brazil. We used a six wave mixing process with two beams to acquire chemical specific laser scanned confocal images. The non linear optical process is called “Cascade Coherent Anti-Stokes Raman” (ICARS).

STh4G.2 • 16:45

3D multiphoton fiber-coupled microscopy using adaptable optics for brain imaging, Baris N. Ozbay, Gregory Puta, Diego Restrepo, Emily Gibson;Univ. of Colorado Denver, USA. We describe a fiber-coupled miniature microscope with tunable focus using no mechanical parts for two-photon scanning microscopy in thick mouse brain tissue. A frequency resolved optical grating (FROG) is used to measure the dispersive effects in the fiber-bundle.

STh4G.3 • 17:00

1300 nm Fiber Laser System for THG and 2PEF Bio-Imaging, Cansten Cleff, Fernando Ramos-Gomes, Thorsten Bergmann, Luigi Bonacini, Ulrich Weikert, Miso Mitkovski, Martin Schluette, Frauke Alves, Michael Mei, Menlo Systems GmbH, Germany; 2Dept. of Biomedical Engineering, College of Engineering, Peking Univ., China. We report a Gauss-Bessel STED microscope for super-resolution deep imaging. Improved lateral resolution at 95um-depth in agarose phantom of brain tissue is about 110nm, which is nearly 2-fold improvement on resolution comparing to conventional STED imaging.

STh4G.4 • 17:15

Super-resolution Deep Imaging with Gauss-Bessel STED Microscopy, Wentao Yu, Zheng Ji, Xusan Yang, Yunfeng Xiao, Peng Xu, Kebin Shu; 1State Key Lab for Mesoscopic Physics, Collaborative Innovation Center of Quantum Matter, School of Physics, Peking Univ., China; 2Collaborative Innovation Center of Extreme Optics, Shanxi Univ., China; 3Dept. of Biomedical Engineering, College of Engineering, Peking Univ., China. We report a Gauss-Bessel STED microscope for super-resolution deep imaging. Improved lateral resolution at 95um-depth in agarose phantom of brain tissue is about 110nm, which is nearly 2-fold improvement on resolution comparing to conventional STED imaging.

STh4G.5 • 17:30

Withdrawn

STh4H • Frequency Combs Outside the Lab

16:30–18:30

Presider: Stephane Schilt; Univ. of Neuchatel, Switzerland

STh4H.1 • 16:30

Ultra Low Noise ErbFiber Frequency Comb Comparison, Michele Guarna1, Wolfgang Hasse1, Katja Beha2, Marc Fischer3, Matthias Lexis4, Ronald Holzworth4,5,6,7; Menlo Systems GmbH, Germany; 8Max-Planck Inst. of Quantum Optics, Germany. We have optically compared two fiber-based frequency combs with ultra-high stability. The resulting beat frequency shows integrated phase noise below 100 mrad (100Hz to 2MHz) and an overlapping Allan deviation of 1x10^-16 at 1s, dropping below 1x10^-16 at 50s.

STh4H.2 • 16:45

Robust combs for long-term optical timescales, Stefan Droste1, Jean-Daniel Deschênes2, Laura C. Sinclair3, Daniel Herman1, William C. Swan1, Nathan R. Newbury1, Ian R. Coddington3; NIST, USA; 2Laval Univ., Canada. We develop a system to convert the high frequency accuracy of optical clock to an optical timescale that outputs a 1 pulse per second (PPS) optical time signal at a defined reference plane.

STh4H.3 • 17:00

Calibration of Astronomical Spectrographs with Laser Frequency Combs, Ronald Holzworth1, Rafael Probst2, Tilo Steinmetz3, Yuanjie Wu4, Thomas Udem5, Theodor Hänsch4; Menlo Systems GmbH, Germany; 6Max-Planck Inst. of Quantum Optics, Germany. Laser frequency combs have found their way from Lab spectroscopy into astronomy to serve as calibrators for spectrographs. Boosting the precision available in astronomical spectroscopy, this might pave the way to many new discoveries. In this tutorial we give an overview on this recent development.

STh4H.4 • 17:00

Terahertz Graphene Modulator Integrated with Quantum Cascade Laser Achieving 100% Modulation Depth, Guozhen Liang1, Xiaonan Hu2, Youde Shen2, Lianhe Liu1, A. Giles Davies1, Edmund Linfield1, Housen Liang2, Ying Zhang2, Siu Fung Yiu3, Qifei Wang1; 1Nanyang Technological University, Singapore; 2University of Bordeaux, France; 3University College London, UK. We demonstrate that mono-crystalline Q10 micro-spheres exhibit narrow magnetic dipole resonances at terahertz frequencies with line splitting due to strong material anisotropy of TiO2. Clear resonance signatures are detected using near-field terahertz time-domain spectroscopy.

STh4H.5 • 17:30

Terahertz Graphene Modulator Integrated with Quantum Cascade Laser Achieving 100% Modulation Depth, Guozhen Liang1, Xiaonan Hu2, Youde Shen2, Lianhe Liu1, A. Giles Davies1, Edmund Linfield1, Housen Liang2, Ying Zhang2, Siu Fung Yiu3, Qifei Wang1; 1Nanyang Technological University, Singapore; 2University of Bordeaux, France; 3University College London, UK. We demonstrate that mono-crystalline Q10 micro-spheres exhibit narrow magnetic dipole resonances at terahertz frequencies with line splitting due to strong material anisotropy of TiO2. Clear resonance signatures are detected using near-field terahertz time-domain spectroscopy.
Oxidation were studied using a flux model that is presented. Methane production and fluxes from Two Landfills, -

Use of a Laser-Based Open Path Instrument to Provide Continuous Long-Term Measurements of Methane Emissions from Two Landfills, Dayle K. McDermitt, Liukang Xu, Jiahong Li, Roger B. Green, Jeffrey P. Chanton, Li-CoIR Biosciences, USA; Waste Management Inc., USA; Earth, Ocean & Atmospheric Science, Florida State Univ., USA. Landfills are important sources of CH₄ and CO₂ emissions. Continuous, long-term measurements of CH₄ and CO₂ fluxes were made using eddy covariance. Methane production and oxidation were studied using a flux model that is presented. Methane production and fluxes from Two Landfills, -

Advanced Laser Processing of Glass, Anping Liu; Com¬
ing Incorporated, USA. The presentation reviews several advanced laser processing techniques, including glass cutting and surface modification. It also discusses attributes of each process and how to characterize them.

StH4J.2 • 17:00
Use of a Laser-Based Open Path Instrument to Provide Continuous Long-Term Measurements of Methane Emissions from Two Landfills, Dayle K. McDermitt, Liukang Xu, Jiahong Li, Roger B. Green, Jeffrey P. Chanton, Li-CoIR Biosciences, USA; Waste Management Inc., USA; Earth, Ocean & Atmospheric Science, Florida State Univ., USA. Landfills are important sources of CH₄ and CO₂ emissions. Continuous, long-term measurements of CH₄ and CO₂ fluxes were made using eddy covariance. Methane production and oxidation were studied using a flux model that is presented. Methane production and fluxes from Two Landfills, -

Femtosecond Laser Machining of Micron-Diameter Graphite Columns, Wei Wei; Corning Incorporated, USA. We present a monolithically integrated mode-locked laser with integrated power-selector and power booster. High peak power (>1 W) pulses are generated with durations of 15.4 ps at a 55 MHz selected rate. Femtosecond Laser Machining of Micron-Diameter Graphite Columns, Wei Wei; Corning Incorporated, USA. We present a monolithically integrated mode-locked laser with integrated power-selector and power booster. High peak power (>1 W) pulses are generated with durations of 15.4 ps at a 55 MHz selected rate. Femtosecond Laser Machining of Micron-Diameter Graphite Columns, Wei Wei; Corning Incorporated, USA. We present a monolithically integrated mode-locked laser with integrated power-selector and power booster. High peak power (>1 W) pulses are generated with durations of 15.4 ps at a 55 MHz selected rate.

StH4K.2 • 17:30
Femtosecond Laser Machining of Micron-Diameter Graphitized Columns in Diamond, Brian K. Canfield, Tom Wu, Eric Lukosi, Stefan Spanier, Lloyd M. Davis; Center for Laser Applications, Univ. of Tennessee Space Inst., USA; Dept. of Physics and Astronomy, Univ. of Tennessee Knoxville, USA; Dept. of Nuclear Engineering, Univ. of Tennessee Knoxville, USA. Graphitized columns with ~1 µm diameter through ~500 µm-thick diamonds are formed by femtosecond laser machining using both aberration-corrected and Bessel beam focusing with high numerical aperture for development of radiation-hard, high-energy particle detectors.

StH4L.5 • 17:30
Comparison of the linewidths of photonic microwave signals generated by semiconductor lasers subject to optical injection and optical feedback, Ssu-Hsin Liu, Fan-Yi Lin; National Tsing Hua Univ., Taiwan. We experimentally compare the linewidths of period-one (P1) nonlinear dynamics of semiconductor lasers subject to optical injection (OI) and optical feedback (OF) for photonic microwave generation. The OF system is shown to have narrower linewidth and better reduction ratio.
FTh4M.1 • 16:30<br>Tutorial<br>High Harmonic Imaging of Attosecond Charge Dynamics, Misha Ivanov1; 2MBI, Germany. In this tutorial I will describe key ideas, results, and challenges in using high harmonic generation to track attosecond charge flow in atoms, molecules, and dielectrics, including recent applications to time-resolving chiral response in molecules, and to the generation of tailored attosecond pulses.

Misha Ivanov graduated from the Moscow State University in 1987 and defended his PhD at the General Physics Institute (Moscow) in 1989. In 1992 he moved to the Steacie Institute for Molecular Sciences at the National Research Council of Canada, eventually becoming Principal Research Officer and the Head of the Theory Programme there. In 2008 he became Professor at the Imperial College London and in 2012 he moved to the MBI and the Humboldt University in Berlin. He is a recipient of the Rutherford medal-physics of the Royal Society of Canada and the Friedrich Wilhelm Bessel prize of the Alexander von Humboldt Foundation.

FTh4N.2 • 17:00<br>Catheter Tracking in an Interventional Photacoastic Surgical System, Alexis Cheng1; 2Yunsu Kim1; Haichong Zhang1; Russell H. Taylor1; Emad Doctor1; 3Johns Hopkins Medical Inst., USA. Photacoastic imaging in surgical systems would be more prominent if the photacoastic effect could be used for catheter tracking. A piecelement in a catheter allows it to be localized with respect to tracked photacoastic spots.

FTh4N.3 • 17:15<br>Invited<br>Innovative Photacoastic Imaging Technology to support Vascular Health Science, Tsuyoshi Shina1; Kyoto Univ., Japan. The ImPACT program organized by the cabinet office of Japan started to develop 3D real-time photacoastic imaging technology which is applicable for wider clinical filed based on the philosophy of “Vascular Health Science” and inspection of industry materials.

FTh4N.1 • 16:30<br>Invited<br>Title not available., Emad Doctor1; 1Johns Hopkins Medical Inst., USA. Abstract not available.

STh4O.1 • 16:30<br>Power-scaling a Mid-IR OPA-pumped Acetylene-filled Hollow-Core Photonic Crystal Fiber Laser, Neda Dadashzadeh1; Manasa Thungnasambandam1; Kushan Weerasinghe2; Benoit Debord3; Matthieu Chefer1; Frederic Gerard1; Fetah Benabid4; Brian Washburn1; Kristian Connen1; 1Kansas State Univ., USA; 2Univ. of Limoges, KJRM Research Inst., France. We report the highest pulse energy from a mid-IR acetylene-filled hollow-core fiber laser: The 1.41 µJ, ns pulses are emitted at 3.11 µm and 3.17 µm with 30 Hz repetition rate, ~20% overall efficiency at 9.8 torr.

STh4O.2 • 16:45<br>3 µm MIR comb generation based on high repetition rate Er-doped fiber laser with carbon nanotube, Masafumi Tsuzuki1; Yoshihata Nomura2; Lei Jin3; Masahito Yamakawa4; Volker Sonnenschein5; Hideki Tomita6; Tetsuo Iuchi7; Atsuhi Sato8; Akane Omori9; Akira Ideno10; Toshinari Gharî11; Youichi Sakakibara11; Emiko Omota11; Hirohichi Kataura11; Norihiko Nishizawa11; 1Nagoya Univ., Japan; 2Sekisui Medical Co. Ltd., Japan; 3AIST, Japan. Offset-free, MIR comb was stably generated around 3 µm wavelength through DFG pumped by supercontinuum generated with high repetition rate, Er-doped, single wall carbon nanotube fiber laser and dispersion shifted highly nonlinear fiber.

STh4O.3 • 17:00<br>Radially polarized nanosecond Yb-doped fiber MOPA system incorporating temporal shaping, Di Lin1; Neda Baktash2; Martin Berendt3; Martynas Beresna4; Peter G. Kazansky3; 1Kansas State Univ., USA; 2Univ. of Southampton, UK. 580µJ nanosecond pulses at a repetition rate of 25kHz with user-defined temporal pulse shapes and a radially polarized doughnut-shaped spatial mode have been demonstrated in an Yb-doped fiber MOPA system seeded by a super-luminescent diode.

STh4O.4 • 17:15<br>40-GHz Pulse Source Based on XPM-Induced Focusing in Normally Dispersive Optical Fiber, Javier Núñez del Campo1; Marin Gilje2; Massimiliano Guasoni3; Bertrand Kibler4; Christopher Finot5; Julien Fatome5; 1Laboratoire Interdisciplinaire Carnot de Bourgogne, UMR 6303 CNRS - Université Bourgogne Franche-Comté, France. We experimentally investigate the design of a high-repetition rate source delivering well-separated optical pulses due to the nonlinear compression of a dual-frequency beat signal within a cavity-less normally dispersive fiber-based setup.

STh4O.5 • 17:30<br>Single Polarization, High Energy Pulsed Fiber Laser from 200 µm Core Yb-Doped Fiber, Martin O. Berendt1; Shaf-UI Alam1; Mihmmay Pal1; Mahtreyee Sahar2; Ranjan Suri1; David J. Richardson1; 1ORC Univ. of Southampton, UK; 2CSR-Central Glass & Ceramic Research Inst., India. We report a super-luminescent diode seeded pulsed fiber MOPA at 1064 nm delivering up to 12µJ single polarization pulse from a 203µm highly multimode core optical fiber.
STh4P • Laser Interferometric Gravitational Wave Detection: Present and Future
Presider: Valdas Pasiskevicius; Royal Inst. of Technology (KTH), Sweden

STh4Q • Fundamentals of Light Matter Interaction
Presider: Tsing-Hua Her; Univ of North Carolina at Charlotte, USA

STh4P.1 • 16:30
The Laser Interferometer Gravitational-wave Observatory at the Beginning of a New Era in Astronomy, Richard L. Savage; LIGO Hanford Observatory, USA. LIGO’s recent observation of a binary black hole merger initiated the era of gravitational wave astronomy. This talk will give an overview of Advanced LIGO, the recently completed observing run, and prospects for future observations.

STh4Q.1 • 16:30
Fully CMOS-Compatible TiN Nanoantennas, Justin Briggs1, Gururaj Naik1, Trevor Petach1, Brian Baum1, David Golobaber-Gordon1, Jennifer Donne1; 1Stanford Univ., USA. We report the first visible/NIR darkfield scattering spectroscopy measurements of single TiN nanostructures. We grow these fully CMOS-compatible nanoantennas via low-temperature atomic layer deposition and characterize and correlate their optical and material properties.

STh4P.2 • 16:54
A Walk on the Warped Side: Astrophysics with Gravitational Waves, Sarah Caudill, Univ. of Wisconsin-Milwaukee, USA. With the discovery of gravitational waves from the binary black hole merger GW150914, the Laser Interferometer Gravitational-wave Observatory entered a new era in observational astrophysics. In this talk, I will discuss the astrophysical implications of this discovery as well as the status of searches for other promising sources of gravitational waves.

STh4Q.2 • 16:45
Light-Driven Reversible Shaping of 2D Polymeric Lattices, Federica Pira1,2, Angelo Angelini1, Francesca Frascella1, Ricardo Rizzo1, Emiliano Descrovi1; 1Dept. of Applied Science and Technology (DISAT), Politecnico di Torino, Italy; 2Centre for Space Human Robotics, Istituto Italiano di Tecnologia (IIT), Italy. We propose optically reconfigurable polymeric microstructures. Azopolymer-PMMA composite is pre-structured in micro-pillar array. The reversible shaping of photosensitive structures guided by the polarization state of the incident light is demonstrated.

STh4P.3 • 17:16
Building the Quietest Space on Earth: Precision Optical Systems for Advanced LIGO, Brian Lantz, Stanford Univ., USA. The recent detection of gravitational waves was made possible by the finest laser interferometers ever built. I will describe Advanced LIGO’s optics, isolation, and control systems and discuss how the recent upgrades have changed our ability to “listen” to the universe.

STh4Q.3 • 17:00
Collapse of the Selection Rules Through 2D Plasmonics, Nicholas Rivera1, Ido Kaminer1, Bo Zhen1, John Joannopoulos1, Marin Soljacic1; 1MIT, USA. We demonstrate that 2D plasmons can enable very high-order multipolar transitions and singlet-triplet transitions. In fact, transitions whose lifetimes are normally on the order of the age of the universe can happen in nanoseconds.

STh4Q.4 • 17:15
Opto-Mechanical Liquid Jet Formation by Radiation Pressure along a Hollow Optical Fiber, Jinwon Yoo1, Honggu Choi1, Woohyun Jung1, Sungrae Lee1, Kyungwhan Oh1; 1Applied physics, Yonsei Univ., Korea. Ultrafine liquid droplets were optically generated from a hollow optical fiber (HOF) by launching a laser into HOF. Opto-mechanical analyses were carried out by varying the distance between the HOF and silica substrate, laser power.

STh4Q.5 • 17:30
Non-Radiative Energy Transfer via Hybrid Light-Matter States, Xiaolan Zhong1, Thibault Chervy1, Shaojun Wang1, Jino George1, Anoop Thomas1, James Hutchinson1, Eloise Devaux1, Cynaque Genet1, Thomas Ebbesen1; 1Univ. of Strasbourg and CNRS, France. Direct evidence of enhanced non-radiative energy transfer between two molecules strongly coupled to the cavity vacuum field form light-matter hybrid states. Excitation spectroscopy and femtosecond pump-probe measurements show that the energy transfer is highly efficient.
Thursday, 9 June

Executive Ballroom 210A

CLEO: QELS-Fundamental Science

FTh4B • Ultrafast Plasmonics—Continued

FTh4B.6 • 17:45
Ultrafast All-Optical Switching Based on Strong Coupling between Excitons and Localized Surface Plasmons, Elad Ezrani1, Tal Ellenbogen1; Tel Aviv Univ., Israel. We study ultrafast all-optical switching of strongly coupled modes in nanoantenna-exciton complexes and show that both the reflection and transmission can be manipulated efficiently, thus opening the door for active and controllable nanoscale optical devices.

FTh4B.7 • 18:00
Optical angular momentum dynamics - In the eyes of the beholder, Grisha Spektor1, Deirdre Kilbane2, Anna-Katharina Mahro1, Bettina Frank3, Lior Gal1, Philip Kahl3, Daniel Podbiel1, Harald Giessen1, Frank J. Meyer zu Heringdorf1, Martin Aeschlimann1, Meir Orenstein2; Technion, Israel; 3Technion, Israel. We present an experimental study of the optical angular momentum dynamics of plasmonic vortices observed using time-resolved two-photon PEEM (40 nano-meters, 100 attoseconds resolution). The measured orbital angular momentum surprisingly differs from theory due to the observation from the rotating frame of circular polarization.

FTh4B.8 • 18:15
Ultrafast Dynamics of Epsilon-Near-Zero Modes in GaAs at Terahertz Frequencies, Yuanmu Yang1, Kamaraju Natarajan1, Salvatore Campione1, Sheng Liu1, John L. Reno1, Rohit P. Prasankumar1, Igal Brener1; Sandia National Labs, USA; 1Center for Integrated Nanotechnologies, Los Alamos National Lab, USA. We experimentally demonstrated an epsilon-near-zero (ENZ) mode in an n-doped GaAs layer at 0.8 THz and study its ultrafast dynamics using optical pump-terahertz probe spectroscopy. Notable plasmon damping was observed upon optical pumping.

FTh4C • Photonic Quantum Information Processing—Continued

FTh4C.3 • 17:45
Ground State Solver on a Silicon Quantum Photonic Chip, Raffaele Santagati1, Jianwei Wang1, Stefano Paesani2, Antonio A. Gentile1, Damien Boneau1, Joshua Silverstone1, Sam Morley-Short1, Xaooqi Zhou1, Pet Shadbolt1, Nathan Wiebe1, Shigehito Miki1, Taro Yamashita1, Mikio Fujwara2, Masahide Sasaki3, Hirotaka Tera1, Michael Tanner1, Chandra M. Natarajan4, Robert H. Hadfield1, David Tew1, Jeremy L. O’Brien1, Mark Thompson1; 1Univ. of Bristol, UK; 2Quantum Architectures and Computation Group, Microsoft Research, USA; 3N. I. C. T., Japan; 4School of Engineering, Univ. of Glasgow, UK. We present a new, scalable protocol for solving the eigenvalue problem requiring the measurement of only one qubit. We implement this protocol on a silicon quantum photonic device embedding arbitrary non-compiled controlled unitary operations.

FTh4C.4 • 18:00
Tunable-Coupling Resonator Arrays for Chip-Based Quantum Enigma Machines, Jelena Notaros1, Jacob Mower1, Mikkel Heuck1, Nicholas Harris1, Gregory Steinbrecher1, Darius Bunandar1, Cosmo Lupor1, Tom Baehr-Jones1, Michael Hochberg1, Seth Lloyd1, Dirk R. Englund1; research lab of Electronics, MIT, USA; 2School of Mechanical Engineering, MIT, USA; 3Coriant Advanced Technology, USA. A large-scale tunable-coupling ring resonator array is demonstrated in a CMOS-compatible silicon photonics platform to achieve tunable frequency-dependent group delay. The system is proposed for a phase-encoded quantum data locking protocol.

FTh4C.5 • 18:15
Observing Multi-Photon Interference and Suppression Laws in 3D Photonic Chips, Andrea Crespi1, Roberto Osellame1, Roberto Ramponi1, Marco Bentivegna1, Fulvio Flamini1, Nicola Spagnolo1, Niko Viggianiello1, Luca Innocenti1, Paolo Mataloni1, Fabio Sciarrino1; 1Dipartimento di Fisica, Politecnico di Milano, Italy; 2Istituto di Fotonica e Nanotecnologie, Consiglio Nazionale delle Ricerche, Italy; 3Dipartimento di Fisica, Università di Roma Tor Vergata, Italy. We realize innovative 3D integrated optical interferometers performing the Quantum Fourier Transform. Injecting two-photon states, peculiar quantum interference effects are observed, thus enabling the use of these devices for the diagnostics of quantum photonic platforms.

18:30–20:00 Dinner Break (on your own)

20:00–22:00 Postdeadline Paper Sessions, locations announced on the conference update sheet
FTh4D • Hyperbolic Metamaterials—Continued

FTh4D.6 • 17:45
Focusing light onto a zero-dimensional point with lossy left-handed materials, Gilad Rosenblatt1, Meir Orenstein1; 1Dept. of Electrical Engineering, Technion, Israel. We show that perfect focusing of light can be achieved with passive (lossy) left-handed materials, without a need for gain or non-linearity, and present guidelines for designing loss-immune perfect lenses.

FTh4D.7 • 18:00
Integrated Hyperbolic Metamaterial Devices for Efficient Rectification of Infrared Radiation, Mohamed Farhat1, Pai-Yen Chen2; 1King Abdullah Univ of Science & Tech, Saudi Arabia; 2Computer and Electrical Engineering, Wayne State Univ., USA. We discuss rectifying infrared-radiation using MIM tunneling nanodiodes, engineered as hyperbolic-metamaterials (HMMs). We demonstrate that responsivity of HMM-based devices can reach tens of mAV/W in mid-infrared region, which may find applications in photodetection and energy-harvesting.

FTh4D.8 • 18:15
A Dark-state Invisible Material, Dexin Ye1, Ling Lu1, John Joannopoulos2, Marin Soljacic1, Lixin Ran1; 1Zhejiang Univ., USA; 2MIT, USA. We experimentally introduce dark-state corrugated metallic wires to construct a solid material possessing identical electromagnetic properties as air, which neither reflect nor refract light at any incident angle in free space, i.e., being perfectly invisible.

STh4E • Silicon Photonics—Continued

STh4E.6 • 17:45
A 25Gbps low-voltage Waveguide Si-Ge Avalanche Photodiode, Zhihong Huang1, Cheng Li1, Di Liang1, Kunbi Yu1; Charles Santori1, Marco Fiorentino1, Wayne Sorin1, Samuel Palermo1, Ray Beausoleil1; 1Hewlett Packard Labs, USA; 2Electrical and Computer Engineering, Texas A&M Univ., USA. We demonstrate a waveguide Si-Ge avalanche photodiode with a breakdown voltage of -10V, a speed of 25GHz, and a gain-bandwidth product of 276GHz. The APD optical receiver achieved sensitivities of -25dBm and -16dBm at 12.5Gbps and 25Gbps at 1550nm, respectively.

STh4E.7 • 18:00
On-chip high-performance plasmonic-CMOS components based on horizontal hybrid Cu-SiO2-Si platform, Hong-Son Chu1, Shiyang Zhu2, Ching Eng Png1; 1Electronics and Photonics, A*STAR-Inst. of High Performance Computing, Singapore; 2A*STAR-Inst. of Microelectronics, Singapore. Fully hybrid plasmonic Cu-SiO2-Si waveguide for TE-mode is reported with loss ~0.5dB/μm at λ=1.55μm. Furthermore, the ultracompact waveguide 90°-bend with loss ~0.1dB/turn at bending 10nm-radius and the ultracompact sub-μm ring resonator with ER ~27dB and IL ~1dB for 200nm-radius are demonstrated.

STh4E.8 • 18:15
Gires-Tournois Interferometers with Sidewall Bragg Gratings in SOI, Paul D. Morr1, Lawrence Chen2; 1McGill Univ., Canada. We demonstrate integrated silicon-on-insulator Gires-Tournois interferometers based on sidewall Bragg gratings. The GTIs have a channel spacing of 50 GHz, extinction ratios up to 6 dB, and can be easily integrated into silicon photonic circuits.

18:30–20:00 Dinner Break (on your own)

20:00–22:00 Postdeadline Paper Sessions, locations announced on the conference update sheet
Laguerre-Gaussian Beams, Super-Oscillation by Higher-Order Radially Polarized STh4G.8 • 18:15

Detail-preserving Fluorescence Microscopy Image Deconvolution, Jing Qin, Xiya YF, Shimon Weiss, Stanley Osher
Dept. of Mathematics, UCLA, USA; Dept. of Chemistry and Biochemistry, UCLA, USA. We propose a detail-preserving image deconvolution method which outperforms state-of-the-art methods, and can further improve image quality in the super-resolution optical fluctuation imaging and other diffraction-limited/superresolution imaging modalities.

Air refractive index self-correction exceeding empirical equation accuracy using two-color interferometry with optical frequency comb, Kouki Miyano, Guanhao Wu, Tomohiro Makino, Kaoru Minoshima; The Univ. of Electro-Communications, Japan; JST, ERATO Intelligent Optical Synthesizer (IOS), Japan; Tsinghua Univ., China. Extremely high-accuracy self-correction of the air refractive index was achieved using two-color comb interferometry exhibiting phase difference measurement with 10^{-11}-order resolution. Obtained 10^{-9}-order self-correction accuracy over 61-m exceeded the limit of empirical equation.

Optical Frequency Combs for Space Applications, Michele Giunta, Matthias Lezuis, Christian Deutsch, Tobias Wilken, Theodor W. Hansch, Anja Kohfeldt, Andreas Wicht, Vladimir Schkolnik, Markus Krutzik, Hannes Dunckes, Ortwin Helling, Kai Lampmann, Andre Wenzlawski, Patrick Windpassinger, Klaus Sengstock, Achim Peters, Ronald Holzwarth; Menlo Systems GmbH, Germany; Max-Planck-Institut, Leibniz Inst. of Höchstfrequenztechnik, Germany; Inst. of Physics, Humboldt Univ. of Berlin, Germany; Inst. of Laser Physics, Univ. of Hamburg, Germany; Inst. of Physics, Johannes Gutenberg, Univ. of Mainz, Germany. Optical frequency comb-based high resolution laser spectroscopy has been demonstrated in space under micro-gravity on two sounding rocket based experiments. The comb has been used to simultaneously measure two different atomic transitions.

Charge Transport in Na_{0.63}CoO_2 Thin Film Studied by Terahertz Spectroscopy, Hynek Nemec, Karel Knizek, Zdenek Jirak, Jiri Hejtmank, Josef Bursik, Miroslav Soroka; Inst. of Physics AS CR, v.v.i, Czech Republic; Inst. of Inorganic Chemistry AS CR, Czech Republic. Time-domain terahertz spectroscopy and Monte-Carlo calculations of the terahertz response in nanostructures were employed to understand charge transport in Na_{0.63}CoO_2 thin film. We observed metallic-like conductivity of charges partly confined in constituting nanograins.
Multi-heterodyne spectroscopic techniques using Fabry-Pérot quantum cascade lasers for trace gas detection, Joanna Westberg, Lukasz Sterczewski, Eric J. Zhang, Andreas Hangauer, Gerard Wysoki, Princeton Univ., USA; Dept. of Electrical Engineering, Wroclaw Univ. of Technology, Poland. We have studied various spectroscopic detection techniques for applications in multi-heterodyne spectroscopy performed in a dual comb configuration. Self-coherence properties of a multi-mode QCL are also investigated.

We have studied various spectroscopic detection techniques

nas Westberg

Pérot quantum cascade lasers for trace gas detection, Edgar Kaksis, Giedrius Andriukaitis, Andrius Baltuska, 1,2 Vienna Univ. of Technology, Austria; 2Center for Physical Sciences & Technology, Lithuania. Technology (State Univ.), Russia; 2Prokhorov General Physics Inst. of RAS, Russia. We report on the design and performance of a cryogenic kilohertz Yb:CaF2 CPA producing 30-mJ, 200-fs pulses. A two-stage scheme enables bistability-free amplification in the repetition frequency range of 0.5—10 kHz, sustaining >20 W average power.

Periodic Q-Switched Dual-Wavelength Lasing Regime for Remote Sensing Applications, Anton Fedorov1, Aleksei Fomichev1, Maxim Doroshenko1,2, Moscow Inst. of Physics and Technology (State Univ.), Russia; 2Prokhorov General Physics Inst. of RAS, Russia. Periodic Q-switched dual-wavelength oscillation regime is suggested and modeled using Er:YAG laser with Co:ZnSe passive Q-switcher with lasing switching near 1645 and 1617 nm as an example for methane remote sensing.

CO2 polishing of femtosecond laser micromachined micro-fluidic channels, Murat Serhalioğlu1, Bulend Ortac1, Çağlar Elbüker1, Necmi Yiğitli3, Mehmet E. Solmaz1, 'İzmir Katip Celebi Univ., Turkey; Bilkent Univ., Turkey. The CO2 polishing of femtosecond laser micromachined channels is studied. The surface quality before and after polishing is observed with naked eye and optical microscope. The method improves imaging of microchannels.

Dense wavelength beam combining of an external thin-film filter multi-laser cavity stabilized diode laser module, Matthias Haas1, Simon Nagel1, Simon Rauch1, Alexander Kili1, 2COMELEC, Telecom ParisTech, France; 2Dept. of Electrical Engineering, National Tsing Hua Univ., Taiwan; 3Institut für Festkörperphysik, Technische Universität Berlin, Germany; 4King Abdulaziz Univ., Saudi Arabia; 5Center for High Technology Materials, Univ. of New-Mexico, USA. Similar InAs/GaAs quantum-dot lasers emitting on either the ground or excited state are studied under optical feedback. The feedback-sensitivity and dynamics of the excited-state laser are investigated and compared to that of the ground-state laser.

Dense wavelength beam combining of an external thin-film filter multi-laser cavity stabilized diode laser module, Matthias Haas, Simon Nagel, Simon Rauch, Alexander Kili, COMELEC, Telecom ParisTech, France; Dept. of Electrical Engineering, National Tsing Hua University, Taiwan; Institut für Festkörperphysik, Technische Universität Berlin, Germany; King Abdulaziz University, Saudi Arabia; Center for High Technology Materials, University of New Mexico, USA. Similar InAs/GaAs quantum-dot lasers emitting on either the ground or excited state are studied under optical feedback. The feedback-sensitivity and dynamics of the excited-state laser are investigated and compared to that of the ground-state laser.
FTh4M.4 • 17:45

Highly Sensitive Intravascular Photoacoustic Imaging with a Collinear Catheter Probe, Yingshun Cao, Jie Hu1, Ayeshik Kole1,2, Pu Wang1,2, Weibiao Chen1,2, Michael Sturek3,4, Mohammad Amin Eftekhar1, Mohammad Sanjabi Emavesh1, Mohammad Amin Eftekhar2, Jose E. Antonio Lopez2, Frank W. Wise1, Demetrios N. Christodoulides2, Rodrigo Amezcua-Correa2,1, Inst Nat Astronofisica Optica Electronica, Mexico; 2CRESOL, Univ of Central Florida, USA; 3Cornell Univ., USA. We demonstrate over two octaves supercontinuum generation in a graded index multimode fiber using a picosecond microchip laser at 1064 nm. Enhanced visible supercontinuum is obtained in a tunable fashion based on initial launching conditions.

STh4O.8 • 18:15

Experimental Study on the Coherence of Non-Stationary Optical Pulses Generated from a Ring Laser Cavity, Seung-jong Lee1, Luis A. Vasquez-Zuniga2, Kwon Youngchul1, Hyunsuk Kim1, Hansol Kim1, Yoocchan Jeong1, Seoul National Univ., Korea. Coherence characteristics of non-stationary optical pulses in three distinctive regimes of “true” noise-like pulses (NLPs), symbiotic NLPs, and multi-soliton pulses are studied where they exhibited clearly different behaviors in terms of the degree of coherence.

FTh4M.5 • 18:15

Non-Dipole Effects on Recattered Photoelectrons from Strong-Field Ionization with Elliptical Polarization, Benjamin Willenberg1, Jochen Maurer1, Benedikt Mayer1, Christopher R. Phillips1, Lukas Gallmann1,2, Ursula Keller1,2, Inst of Applied Physics, Univ of Bern, Switzerland. We study strong-field ionization with elliptically polarized mid-IR pulses beyond the long-wavelength limit of the dipole approximation. Recattering creates a sharp structure in 3D photoelectron momentum distributions influenced by non-dipole effects.

STh4O.7 • 18:00

Visible supercontinuum generation in a low DGD graded index multimode fiber, Gisela Lopez-Galmiche1,2, Zemib Sanjibani Emavesh1, Mohammad Amin Eftekhar2, Jose E. Antonio Lopez2, Frank W. Wise1, Demetrios N. Christodoulides2, Rodrigo Amezcua-Correa2,1, Inst Nat Astronofisica Optica Electronica, Mexico; 2CRESOL, Univ of Central Florida, USA; 3Cornell Univ., USA. We demonstrate over two octaves supercontinuum generation in a graded index multimode fiber using a picosecond microchip laser at 1064 nm. Enhanced visible supercontinuum is obtained in a tunable fashion based on initial launching conditions.
STh4P • LIGO Session—Continued

STh4P.4 • 17:42  Invited
LIGO - A Gravitational Wave Observatory, Alastair Heptonstall, California Institute of Tech., USA. On September 14th 2015 the LIGO gravitational wave observatories detected a coincident signal from the merger of two massive black holes 1.3 billion years ago. We explore the work needed to build these interferometers, look at the history behind the discovery, and discuss the future for the new field of gravitational wave astronomy.

STh4P.5 • 18:06  Invited
Discussion of the Advanced LIGO Sensitivity, Denis Martynov, MIT, USA. Advanced LIGO has directly observed gravitational waves during its first science run. In this talk I will discuss the astrophysical reach of LIGO interferometers during the run and prospects for the future.

STh4Q • Fundamentals of Light Matter Interaction—Continued

STh4Q.6 • 17:45
Observation of Poynting’s Vector Reversal in an Active Optical Cavity, Ali Kazemi Jahromi1, Ayman F. Abouraddy2,1Univ. of Central Florida, USA. We observe the reversal of Poynting’s vector inside a cavity when the gain exceeds a pre-lasing threshold and demonstrate that the vector’s direction can be reversed without changing its amplitude using a passive intra-cavity element.

STh4Q.7 • 18:00
Enhanced Lasing Performance in Solution-processed Lead Halide Perovskites Covered with PMMA and Ag, Tsung Sheng Kao1, Fang-Chung Chen1, Tien-Chang Lu1; 1Dept. of Photonics, National Chiao Tung Univ., Taiwan. We report the enhanced lasing performance in lead-halide perovskites covered with PMMA and Ag. Not only the perovskite can be protected from hydrolysis, but also the lasing thresholds can be greatly reduced resulting from the plasmonic effect.

STh4Q.8 • 18:15
Emission Enhancement via Local Symmetry Distortion in Lanthanide-Based Upconverting Nanoparticles, Michael Wisser1, Stefan Fischer2, Peter Maurer1, Noah Bronstein1, Steven Chu1, Paul Alivisatos1, Alberto Salleo1, Jennifer Dionne1; 1Stanford Univ., USA; 2Lawrence Berkeley National Lab, USA. Substitutional doping is used to synthetically modify the host lattice in upconverting nanoparticles and thereby achieve enhanced emission through relaxation of the parity selection rule in a lanthanide-based materials system.

18:30–20:00  Dinner Break (on your own)

20:00–22:00  Postdeadline Paper Sessions, locations announced on the conference update sheet
Breaking the temporal resolution limit by super-oscillating optical beats, Yaniv Elezri1, Liran Harel2, Liya Lobachinsky3, Sahar From1, Alon Bahabad1; Physical Electronics, Tel-Aviv Univ., Israel. We experimentally break the temporal Fourier-transform resolution limit by generating a super-oscillating optical beat signal. This result opens the way to greatly improve the temporal resolution in applications using ultra-short optical pulses.

Dynamic Waveguiding, Miguel A. Bandres1, Yaakov Lumer1, Hanan Herzig Shenlux3, Yo- natan Plotnik1, Mordechai Segev1; Physics, Technion, Israel. We introduce the concept of dynamic waveguiding: a system of waveguides where the light can be confined to a core region solely by dynamic modulation.

Towards a Large-area Plasmonic Polarization Detector, Nicholas Proscia1, Iliana Kretschmar1, Vnood M. Menon1,2, Luat Vuong1,2; Queens College-CUNY, USA; 2Physics, City College of New York, USA. We experimentally demonstrate quantum enhanced resolution in confocal fluorescence microscopy exploiting the non-classical photon statistics of single nitrogen-vacancy colour centres in diamond.

Observation of Photonic Chern Insulator, Ym Poo1,2, Ruixin Wu1,2; 1School of Electronic Science and Engineering, Nanjing Univ., China; 2Electrical and Computer Engineering, Univ. of Wisconsin, USA. We experimentally observed a photonic Chern insulator with large Chern number. Two nontrivial chiral edge states have been distinguished. By introducing two excitation probes and changing their positions, we successfully eliminate one of the modes.
Barrier engineering of a photonic molecule in a photonic crystal waveguide, Frederic S. Brossard1, Ben P. Reid1, Luke Nutall1, Stephen Lenon1, Ray Murray1, Robert A. Taylor1; 1Hitech Europe Ltd, UK; 2Physics, Univ. of Oxford, UK; 3Dept. of Physics, Imperial College, UK. We experimentally demonstrate fine tuning of the mode splitting of a photonic molecule based on a local perturbation of a photonic crystal waveguide and propose a scheme to achieve parity exchange of the ground state.

We demonstrate electrically tuning of photonic molecules in a photonic crystal waveguide, Adam B. Cooper1, Mark A. Foster1, Amy C. Foster1, John Hopkins Univ, USA. We demonstrate a cryogenic primitive and authentication system based on the ultrafast response of reeverberant integrated photonic cavities formed in silicon, which leverage the unpredictability of leaky chaotic systems.

Secure Authentication using the Ultrafast Response of Chaotic Silicon Photonic Microcavities, Brian C. Grubel1, Andrew M. Weiner1, University of California, USA. We experimentally demonstrated temporal Hilbert transform based on an integrated optical frequency comb source is exploited to obtain the temporal Hilbert transform of a Gaussian pulse with a full-width half-maximum duration of 0.12ns.

We present an approach for electrical memories to operate in a purely photonic autonomous all-photonic processor based on a frequency comb and a chromatic dispersion element, Mehdad Shoeiby1, Daniel E. Leaird1, Jose A. Jaramillo-Villegas1, Amirhossein Mohajerin Ariaei1, Andrew M. Weiner1; 1Radboud Universiteit Nijmegen, Netherlands; 2Centre for Micro-Photonics, Swinburne Univ. of Technology, Australia; 3Physics and Materials Science, City Univ. of Hong Kong, Hong Kong; 4K/ian Inst. of Optics and Precision Mechanics, China; 5INSR – Energie, Matériaux et Télécommunications, France; 6ARC Centre of Excellence for Ultrahigh Bandwidth Devices for Optical Systems (CUDOS), Australia. We experimentally demonstrated temporal Hilbert transformer based on an integrated optical frequency comb source is exploited to obtain the temporal Hilbert transform of a Gaussian pulse with a full-width half-maximum duration of 0.12ns.
Generation of Bright Soft X-ray Harmonics with Circular Polarization for X-ray Magnetic Circular Dichroism, Tingting Fan1, Patrick Grychtol2, Ronny Knut3, Carlos Hernández-García4, Daniel H. Rickstein5, Christian Gentry1, Franklin Dollar1, Christopher Manousos4, Craig Hoge1, Ofer Kliu1, Dominik Legut1, Karei Carva1, Jennifer Ellis1, Kevin Domery1, Cong Chen1, Olgey Sykytor1, Eric Fullerton1, Oren Cohen1, Peter Oppeneer1, Dejan Milosevic1, Dimitry Zusin1, Marcel Wunram1, Alessandra Lanzara1, Sebastian Stoll2, Peter Oppeneer1, Dejan Milosevic1, Andreas Becker1, Agnieszka Jaron-Becker1, Tenio Popmintchev1, Henry Kapteyn1, Magaret Mumane1,2, Dept. of physics and JILA, Univ. of Colorado at Boulder, USA; 1Univ. of Sala-
manca (Spain), Spain; 2Technion, Israel; 3VSB Technical Univ. of Ostrava, Czech Republic; 4Uppsala Univ., Sweden; 5Univ. of California San Diego, USA; 6Univ. of Sarajevo, Bosnia and Herzegovina. We present the first circularly polarized harmonics in the soft X-ray region and the physics underlying it. This source enables the first X-ray magnetic circular dichroism measurements in rare earth elements on tabletop.

AF1L.1 • 08:15
A setup for extreme-ultraviolet ultrastable angle-resolved photoemission spectroscopy at 50-kHz repetition rate, Jan H. Buss1, He Wang1, Yiming Xu1, Julian Maklar1, Sebastian Stoll1, Lingkun Zeng1, Sebastián Ullonska1, Jonathan D. Denlinger1, Yi D. Chuang1, Zahid Hussain1, Chris Joziwka1, Alessandra Lanzaria1, Robert A. Kaindl1, Materials Sciences Division, Lawrence Berkeley National Lab, USA; 1Advanced Light Source, Lawrence Berkeley National Lab, USA; 1Univ. of California at Berkeley, Lawrence Berkeley National Lab, USA. We demonstrate a novel table-top trARPES setup that combines a bright 50-kHz source of narrowband, extreme ultraviolet (XUV) pulses at 22.3 eV with UHV photoemission instrumentation, enabling sensitive access to dynamics over a large momentum space.

AF1L.3 • 08:30
Generation of UV Harmonics in Solids with Intense and Phase-Locked Few-Cycle Pulses at High Repetition Rate, Patrick Starz1, Jonathan Fischer2, Jonas Tauch1, Marcel Wunram3, Alfred Leutenstorfer1, Daniele Brida1, 1Dept. of Physics and Center for Applied Photonics, Univ. of Konstanz, Germany. We demonstrate carrier-envelope phase control of even and odd harmonics in solids up to fifth order with intense 2.3-cycle pulses from a near-infrared optical parametric amplifier operated at 10 MHz repetition rate.

AF1L.2 • 08:30
Writing of Bio-Compatible Silk Patterns: 3D Laser Nano-Printing, Ksenia Maximova1, Xuewen Wang1, Armandas Balysca1, Jingliang Li1, Szuailus Judziskis1, 1Center for Micro-
Photonics, Swinburne Univ. of Technology, Australia; 1Inst. for Frontier Materials, Deakin Univ., Australia. Laser-printing of crystalline silk patterns in amorphous fibroin film is demon-
strated by femtosecond-laser pulses 1030 nm / 230 fs without use of photo-initiator. The same patterns can be achieved by ablation of the crystalline silk film. Amorphous silk can be used as a negative tone photo-resist.

AF1K.2 • 08:30
Application of Mid-infrared Fiber Laser Sources, Jihong Geng1, 1AdValue Photonics, Inc., USA. We review our recent research in the development of mid-infrared fiber lasers and their applications. Both broadband fiber laser sources and narrow-linewidth fiber laser sources, and their advances in high-resolution laser spectroscopy are discussed.

AF1K.1 • 08:00
Recent Advances of Mid-infrared Compact, Field Deployable Sensors and their Real World Applications in the Petrochemical Industry, Atmospheric Chemistry and Security, Frank K. Tittel1, Aleksander K. Gluszek1, Arkadiusz J. Hudzikowski1, Lei Dong1, Chunguang Li2, Pietro Patinismo3, Angelo Sampao1, Vincenzo Spagnolo4, Jacek Wojta1, 1Rice Univ., USA. Development of trace gas sensors based on mid-infrared interband cascade lasers, quantum cascade lasers as well as their applications will be reported. The sensor technology will use both laser absorption and quartz enhanced photoacoustic spectroscopy.

JF1K.1 • 08:00
Demonstration of efficient spin injection in a CW VCSEL at RT and dynamic control of its polarization state, Alexandre Joly1,2, Ghaya Balli1, Mehdi Alouini1, Jean-Marie George1, Isabelle Sagnes1, Alexey Sirbu1, Daniel Doll1, 1Thales Research and Techno-
logy, France; 2Institut de Physique de Rennes, France; 3Unite Mixte de Physique CNRS-Thales, France, 4Laboratoire de Photonique et de Nanostructures, France, 5Ecole Polytechnique Federale de Lausanne, Switzerland. We report the first efficient spin injection in a CW optically pumped VCSEL, obtained with phase anisotropy dynamic control. A threshold reduction of 1.5 % and an ellipticity of 75% are obtained at RT. Theoretical and experimental investigation of the polarization eigenstates is presented.

JF1K.2 • 08:30
Record Single Mode Laser Diode Packing Density Using High Uniformity Lithographic VCSEL Arrays With Narrow Spectral Width, James M. Beadsworth1, Jason Leshin1, Mingxin Li1, Xiang Tang1, Nicholas Cox1, Jeremy Leshin1, Latika Effert1, Frank Tucker1, Dennis Deppe2, 1InfiPhotonics, USA; 2CREOL, Univ. of Central Florida, USA; 3Army Research Lab, USA. Single mode lithographic VCSELs are shown to be capable of unprecedented dense packing into arrays for high pulse power to improve spectral control and beam quality.

JF1L.1 • 08:00
Coherently Coupled Vertical Cavity Laser Arrays With Frequency Detuning and Asym-
metric Gain Distribution, Zihe Gao1, Stewart Fryiae2, Bradley J. Thompson3, P.S. Carney3, Kent D. Choquette4, 1Dept. of Electrical and Computer Engineering, Univ. of Illinois, USA; 2Beckman Inst. for Advanced Science and Technology, Univ. of Illinois, USA. By solving the coupled oscillator equations we study the effect of frequency detuning and asymmetric gain distribution on coherently coupled VCSEL arrays. Beam steering and parity-time symmetry breaking behavior has been pre-
dicted and experimentally observed.
Joint

Driven by Few-Cycle Mid-IR Pulses in YAG, FF1M.2 • 08:15
longer driver wavelength with a theory-based
We extend the applicability of the results to
We present results of the first mid-IR, sub
Ingmar Hartl
Axel Ruehl

Univ. Edinburgh, UK; 6Friedrich-Schiller
Faccio5, Daniil Kartashov
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generated in ambient air,
In transparent dielectrics and filaments
mitigated two-optical-cycle
filaments ignited in ambient air. Combination
md-IR pulses in transparent dielectrics and
on self-compression of sub-100 fs, >20 mJ
Sciences & Technology, Lithuania.
We report

Univ. Jena, Germany; 7Center for Physical

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Crystal Fibers,
FF1A • Novel Optical Effects—Continued

FF1A.4 • 08:45
Artificial Thermodynamics with Optical Stochastic Pumps, Colin Constant1, Sergey Sukho1, Anistide Dogariu2, ‘Univ. of Central Florida, CREOL, USA. Particles subjected to complex optical potentials that vary in both space and time can be sub- or super-diffusive. The corresponding difference in effective temperatures allows an effective stochastic pumping of colloidal particles.

FF1A.5 • 09:00
Superfluid flow and vortex nucleation in room temperature, nonlocal photon fluids, David Vocke1, Kali E. Wilson1, Thomas Roger1, Francesco Marino2, Jacopo Carusotto3, Brian P. Anderson4, Daniele Faccio5, ‘Heriot Watt Univ., UK; 1Department of Physics, Universita di Trento, Italy; 2University College London, UK; 3INO-CNR BEC Center and Dipartimento di Fisica, Universita di Trento, Italy; 4College of Optical Sciences, University of Arizona, USA. We investigate superfluid behavior in a room-temperature photon fluid based on a thermal nonlinearity that mediates the photon-photon interactions. Placing an extended obstacle inside the flowing photon fluid leads to the nucleation of quantised vortices.

FF1A.6 • 09:15
Giant collective incoherent shock waves in strongly nonlinear turbulent flows, Gang Xu1,2, David Vocke3, Daniele Faccio4, Josselin Garnier1, Thomas Roger1, Stefano Trillo1, Antonio Picazio1, CNRS - Université of Lille 1, France; 1Laboratoire Interdisciplinaire Carnot de Bourgogne, France; 2Heriot-Watt Univ., UK; 3Université Paris Diderot, France; 4University of Trento, Italy. Non-local turbulent flows lead to the emergence of large-scale and experimentally that nonlocal turbulent flows lead to the nucleation of quantised vortices.

FF1B • Photodetectors and Waveguides—Continued

FF1B.3 • 08:45
Monolithic bipolar thermopile detector sensitive to light elipticity, Feng Lu1, Jongwon Lee1, Ailing Jiang1, Seungyong Jung2, Mikhail A. Belkin3, ‘Univ. of Texas at Austin, USA. We demonstrated a bipolar thermopile detector for measuring light elipticity. Nanoire thermocouple was connected to non-chiral dimer antennas which produced opposite Ohmic heating pattern under LCP and RCP radiation.

FF1B.4 • 09:00
Enhanced Graphene Photodetector with Fractal Metasurface, Jiannan Fang1, Di Wang1, Clayton Devault2, Ting-Fung Chung1, Ying Chen2, Alexandra Bolarasava2, Vladimir M. Shalaev2, Alex Kildishev3, ‘Purdue Univ., USA. We designed and fabricated a broadband, polarization-independent photodetector by integrating graphene with a fractal Cayley tree metasurface. Our measurements show an almost uniform, tenfold enhancement in photocurrent generation due to the fractal metasurface structure.

FF1B.5 • 09:15
Ultra-compact Polarization Demultiplexing by a Plasmonic Nanoantenna on a Waveguide, Rui Guo1,2, Manuel Decker1, Frank Setzpfandt1, Xin gai2, Duk-Yong Cho3, Roman Kastel4, Arkadi Chipouline4, Isabelle Staudte1,2, Thomas Pertsch1, Yury S. Kivshar1, Dragomir N. Neshev1, ‘Nonlinear Physics Centre, The Australian National Univ., Australia; 1Institute of Applied Physics, Abbe Center of Photonics, Friedrich-Schiller-Universität Jena, Germany; 2Université Paris Diderot, France; 3East China Normal Univ., China; 4DTU, Denmark. We propose a design for nanoscale dielectric slab photonic crystals that possess topological edge states. Finite-difference-time-domain simulations show controllable directional light propagation with circularly-polarized dipole excitations and backscatter-free propagation around sharp corners.

FF1C • Quantum Enhanced Metrology—Continued

FF1C.4 • 08:45
Phase measurements exhibiting super sensitivity and super resolution features, Clemens Schafmeister1, Miroslav Jezek2, Tobias Gehring3, Ulink L. Andersen3, ‘DTU, Denmark; 2Palacky Univ., Czech Republic. By using an optical squeezed state and a post-processing homodyne detection scheme we show that phase measurements can overcome Rayleigh’s resolution criterion and beat the quantum shot noise limit simultaneously.

FF1C.5 • 09:00
Waveguided source of broadband entangled photons for quantum interferometry and sensing, Mackenzie Van Camp1, Abu Thomas1, Alexander Sergienko2, Boston Univ., USA. Broadband entangled photons enable quantum white-light interferometry, a technique for ultra-high resolution measurement of polarization mode dispersion. We present designs and preliminary results from a broadband entangled photon source in periodically poled lithium niobate waveguides.

FF1D • Topological Optics II—Continued

FF1D.4 • 08:45
Design for Dielectric Slab Photonic Crystals to Realize Topological Edge States, Hirokazu Miyake1, Sabyasachi Banik1, Edo Waks1, Mohammad Hafezi2, ‘Univ. of Maryland, USA. We propose a design for nanoscale dielectric slab photonic crystals that possess topological edge states. Finite-difference-time-domain simulations show controllable directional light propagation with circularly-polarized dipole excitations and backscatter-free propagation around sharp corners.

FF1D.5 • 09:00
Nonlinear Parity-Time-Symmetric Transition in Finite-Size Synthetic Photonic Media, Wiktor Walasik1, Chicheng Ma1, Natalia M. Litchinitser2, ‘Univ. at Buffalo, USA. We study nonlinear finite-size parity-time symmetric optical couplers. In such systems, we predict nonlinear parity-time symmetric transition, regardless of the details of their geometry. Variety of periodic intensity patterns is formed in these couplers.

FF1D.6 • 09:15
Topologically Reconfigurable Atomic Lattice Quantum Metamaterial, Pankaj K. Jha1, Michael Mertins1, Jeongmin Kim1, Chihhui Wu1, Yuan Wang1, Yuri Rostovtsev2, Xiang Zhang1, ‘Univ. of California, Berkeley, USA; 2Univ. of North Texas, USA. We propose a novel architecture for topologically reconfigurable quantum metamaterial by engineering the electromagnetic response of dense ultracold atoms trapped in an optical lattice. Our atomic lattice quantum metamaterial opens the door application as single photon level with metamaterial.
SF1E • Photonic Crystals—Continued

SF1E.4 • 08:45
Straight and curved photonic crystal waveguides realized with coupled L2 nanocavities, Eichi Kura, Kengo Nozaki1, Akishio Shiny1, Masaya Notomi1; NTT Corporation, Japan. Straight and curved waveguides in 2D photonic crystals with wide transmission bands were realized using coupled high-Q L2 nanocavities. A channel drop filter was created by combining two coupled curved nanocavities and an H0 nanocavity.

SF1E.5 • 09:00
Heterogeneously integrated photonic crystal laser on Si, Shinti Matsuo1, Koji Takeda2, Takuro Fujii1,2, NTT Device Technology Labs, Japan; NTT Nanophotonics Center, Japan. High-density photonic integrated circuits employing ultra-low energy lasers are essential for constructing optical links in computer networks. Photonic crystal lasers, which integrate with silicon photonics devices, are promising devices for these extremely short-distance communications.

SF1F • Secure Communications & Novel Amplifiers—Continued

SF1F.4 • 08:45
Long range secure key distribution over multiple amplified fiber spans based on environmental instabilities, Ben Wu1, Yue-Kai Huang1, Shaojiang Zhang1, Bhavin J. Shastri2, Paul R. Prucnal3; NEC Labs America, Inc., USA; Lightwave Communications Research Lab, Dept. of Electrical Engineering, Princeton Univ., USA. Using environmental instability induced signal phase fluctuation, we demonstrated a secure key distribution system over a 240-km bidirectional fiber-pair link. The scheme is compatible with commercial WDM systems and optical amplifiers for long-range transmissions.

SF1F.5 • 09:00
Impact of DWDM at 50GHz spacing in the 2µm waveband, Niamh Kavanagh1, Kevin Shortiss1, Hongyu Zhang1, Muhammad Sadiq1, Kevin Thomas1, Agnieszka Gocalin ska2; 1Yan Zhao1, Emanuele Pelucchi1, Peter O’Brien1, Frank H. Peters1, Brian Corbett1, Fatima Gunming1; 2Jynall National Inst. Ireland. In this paper, we show for the first time the impact of decreasing DWDM channel spacing to 50GHz in the 2µm waveband, using 6x12 5Gbit/s and 2x6Gbit/s OOK signals.

SF1F.6 • 09:15
Impact of front-FBG reflectivity in Raman fiber laser based amplification, Giuseppe Rizzelli Martella1, Md Asif Iqbal1, Pawel Rosa1, Mingming Tan1, Lukasz Kreczanowicz1, Ian Phillips1, Wladek Foyzak1, Juan DiegoAvila-Castaneda1, Paul Harper1; 1JO-CSIC, Spain; 2AIP, Aston Univ., UK. We experimentally analyze the impact of front-FBG reflectivity in ultra-long Raman laser amplifiers performance, showing O-factor penalties in excess of 1 dB for FBG reflectivities above 10% in a 30 Gbaud DP-QPSK transmission system.

SF1G • Intergrated Comb and rf Processing—Continued

SF1G.4 • 08:45
Tailoring of optical frequency comb shape by harmonic signal superposition in Mach–Zehnder Modulator, Nobuhide Yokota1, Koichi Abe1, Shigenu Mieda1, Ryo Igarashi1, Hiroshi Yasaka1; Tohoku Univ., Japan. We numerically and experimentally generate tailored optical frequency combs having less than 0.5dB flatness among 11 lines by using a Mach–Zehnder modulator driven by a combination of fundamental modulation RF signal and its second-order harmonic.

SF1G.5 • 09:00
Spurious-Free Dynamic Range Characterization of a 32-Based PPLN Waveguide, Ahmed Almamain1, Amrhossein Mohajerin Ariaei1, Morteza Ziyadi1, Yirwen Cao1, Peicheng Liao1, Changjing Bao1, Fatemeh Alishahi1, Ahmad Fallahpour1, Bishara Shamaee1, Niar Ahmed1, Carsten Langrock1, Martin Fejer1, Wladek Forysiak1; 1University of Southern California, USA; 2Stanford Univ., USA; 3Tel Aviv Univ., Israel. We experimentally characterize the spurious-free dynamic range performance of a 32-Based PPLN waveguide by measuring the distortion on a microwave photonic link of two RF tones around 9.9GHz and characterizing the SFD of a generated idler in a PPLN waveguide.

SF1H • Laser-based Sensing and Applications—Continued

SF1H.3 • 08:45
Novel Mid-infrared Gas Sensor Based on Mutually Coupled Quantum Cascade Lasers, Adonis Bogris1,2, Andreeas Herdt1, Dimitris Syrnick1, Wolfgang Elsaesser1; 1Technological Educational Inst of Athens, Greece; 2Informatics and Telecommunications, National and Kapodistrian Univ. of Athens, Greece; 3Technische Universitat Darmstadt, Germany. A gas sensor relying on mutually coupled Quantum Cascade Lasers is studied. Experiments show a six times improvement in the detectivity compared to a typical spectrometer consisting of laser, absorption cell and photodetector.

SF1H.4 • 09:00
Stand-off identification of aerosols using mid-infrared backscattering Fourier-transform spectroscopy, Luke Maidment1,2, Deryck T. Reid1,3; 1Inst. of Photonics and Quantum Sciences, Heriot Watt Univ., UK; 2Defence Science and Technology Lab, UK; 3School of Optical and Electronic Information, Huazhong Univ. of Science and Technology, China. We show that aerosolized liquid chemicals can be identified from their optical absorption spectra by illuminating them with broadband mid-infrared pulses from an optical parametric oscillator and analyzing the backscattered light using Fourier-transform spectroscopy.
High Resolution, Wide Field of View, Ptychographic Imaging of a Biological Sample using a High Harmonic Generation Source, Peter Balak1, Michal Odstro1, Hyun-su Kim2, Stuart Boden1, Rachel Card1, Joanne Bailey4, Katrin Deinhardt1, John Chad1, William Brocklesby1, Jeremy Frey3, ORC, UK; 2RWTH Aachen, Germany; 3Zepler Inst., UK; 4School of Biological Sciences, Faculty of Natural and Environmental Sciences, UK.

We present coherent diffractive imaging with broadband radiation generated from a high harmonic source around 29 nm wavelength to image tissue from the mouse hypothalamus to 80 nm resolution over a 40 nm field of view.

Table-Top Megahertz XUV Source Driven by High-Power Modelocked Thin-Disk Laser, Andreas Diebold1, Florian Emastry1, Clara J. Saracco1, Ursula Keller2; 1Ultrafast Laser Physics, ETH Zurich, Switzerland. We demonstrate high harmonic generation at 2.4 MHz from the compressed output of a thin-disk oscillator, obtaining >5 x 10^10 photons/s (19th harmonic). Additionally, we investigate phase matching conditions towards higher harmonic generation at 2.4 MHz from the compressed output of a thin-disk oscillator, obtaining >5 x 10^10 photons/s (19th harmonic). Additionally, we investigate phase matching conditions towards higher harmonic source around 29 nm wavelength to image tissue from the mouse hypothalamus to 80 nm resolution over a 40 nm field of view.

AF1J.3 • 09:00
High-Precision 3D Printing for the Fabrication of Photonic Elements, Benedikt Stendel1, Daniel Kühn2, Alexander Krupp2, Moritz Esslinger1, Sonke Steenhusen2, Ruth Houbertz1, Multiphoton Optics GmbH, Germany; 2Fraunhofer ISC, Germany. We address the feasibility of free-form laser-printed 3D structures for sub-mm to large area fabrication. The impact of material and process parameters for different applications in photonics, micro- and organic electronics and life-science is discussed.

AF1J.4 • 09:15
Two-dimensional spectroscopy in the ultraviolet by a birefringent delay line, Cristian Manzoni1, Rocio Borrego-Varillas2, Aurelio Oria1, Giulio Cerullo1, Lucia Ganzer1; 1Dipartimento di Fisica, Politecnico di Milano, Italy; 2Politecnico di Milano, IFN-CNDR, Italy. We introduce a scheme to generate collinear, interferometrically locked UV pulse pairs by combining birefringence and sum-frequency generation between a narrowband infrared light and broadband visible pulses. The scheme is applied to 2D electronic spectroscopy.

AF1J.4 • 09:45
Double-crucible cane fabrication of cogenide Laser Technology to Commercial Products – Lessons Learned, Sergey B. Mirov2, Igor Moskalev1, Mikhail S. Mirov2, Sergey Vasilyev1, Vladimir Fedorov1,2, Dmitry Martyshkin1,2, Viktor O. Smolski2, Viktor O. Smolski1,2, Sönke Steenhusen2, 1Univ. of Central Florida, 2IPG Photonics, Mid-IR Lasers, USA; 2IPG Photonics Corporation, USA. We describe the challenges of transitioning Cr- and Fe-doped Zn-chalcogenide technology to real-world products enabling access to 1.9-6 mm range with up to 70% efficiency, 140W of CW output power, and short-pulse (<30 fs) multi-Watt (7W) oscillation.
Joint

**FF1M • Short-pulse Generation and Measurement—Continued**

**Indications of new solitonic states within mid-IR supercontinuum generated in highly non-instantaneous fiber, Mario Chemnitz1, Martin Gebhardt1, Christian Gaada2, Fabian Stutzbach2, Jens Limper2, Markus A. Schmidt2, Leibniz Inst. of Photonics Technology, Germany; 2Institut für Angewandte Physik, Germany; 3Fraunhofer Inst. Applied Optics and Precision Engineering, Germany; 4Otto Schott Inst. of Material Research, Friedrich Schiller Univ. Jena, Germany.**

We present experimental evidence of non-instantaneous solitons within mid-IR supercontinuum spectra in anomalously dispersive liquid-core fibers. Simulations confirm two measured signatures of such states: inhibited broadening and fine spectral fringes.

**FF1M.4 • 08:45**

A solid-state source of subcycle pulses in the mid-infrared, Alexandr Lanin1, Eugene Stepanov1, Aleksandr Voronin1, Andrei Fedotov1, Aleksei Zhelizkov1, M.V. Lomonosov Moscow State Univ., Russia; 2Russian Quantum Center, Russia; 3Dept. of Physics and Astronomy, Texas A&M Univ., USA. We have demonstrated an approach for the generation of 20-fs-pulses at 6.8 μm. Subcycle pulse widths have been achieved due to self-compression dynamics and ultrabroadband phase matching for FWM near the zero-GVD wavelength of GaAs.

**FF1M.5 • 09:00**

Adaptive Optics in the Extremely Large Telescope Area: New Requirements, New Concepts and New Challenges, Thierry Fusco1, Office Ndal d’Etudes Rech Aerospatiales, France. Adaptive optics systems, using both natural and laser guide stars, are the key technologies for the future Extremely Large Telescopes. We will review the characteristics and the main issues of these future systems.

**JF1N • Symposium on Advances and Opportunities in Astrophotonics I—Continued**

**SF1O • Nonlinear Optical Technologies in Spectroscopy and Microscopy—Continued**

**SF1O.3 • 08:45**

Background-free coherent anti-stokes Raman spectroscopy by all-fiber-generated dual-soliton as Stokes pulse, Kun Chen1, Tao Wu1, Haojun Wei1, Yan Li1, Key Lab of Precision Measurement Technology & Instrument, Dept. of Precision Instrument Tsinghua Univ., China. A new background-free CARS microspectroscopy scheme based on all-fiber system is established, taking advantage of dual-soliton generation as stokes pulses in a PM-PCF under the spectral focusing mechanism.

**SF1O.4 • 09:00**

Analysis of laser induced plasma in air using broadband femtosecond coherent Anti-Stokes Raman scattering, Roland Ackermann1, Ioannis Mako2, Mantia Kerstan2, Robert Kammel1, Stefan Nolte1, Andreas Tüllmann1,2, Friedrich-Schiller-Universität Jena, Germany. We investigated the laser induced plasma in air by means of coherent Anti-Stokes Raman scattering. The generation and decay of N2+ was studied for different pulse energies.

**SF1O.5 • 09:15**

Nonlinear Photothermal Spectroscopy with Multiple Bifurcations, Atcha Totachawatta1,2, Mi K. Hong1,2, Shyam Sunder Erramilli3, Michelle Y. Sander1,2, Electrical and Computer Engineering, Boston Univ., USA; 3Photonics Center, Boston Univ., USA; 4Physics Dept., Boston Univ., USA. A new regime of photothermal spectroscopy for unique sample characterization is presented. Photothermal studies of a liquid crystal sample show nonlinear signal enhancement, multiple bifurcations and spectral peak narrowing.
FF1A • Novel Optical Effects—Continued

FF1A.7 • 09:30
Optical analogues of the Schrödinger-Newton equation and rotating boson stars. Thomas Roger1, Calum Mastland1, Kali Wilson1, Ewan Wright1, Daniele Faccio1, 1Inst. for Photonics and Quantum Sciences, Heriot-Watt Univ., UK; 2College of Optical Sciences, Univ. of Arizona, USA. Optical analogues have been suggested as a means to explore systems that are described by general relativity. We show an optical analogue of the Schrödinger-Newton equation applied to the specific study of rotating boson stars.

FF1B • Photodetectors and Waveguides—Continued

FF1B.6 • 09:30
Deep-subwavelength Si-core plasmonic waveguide monolithically integrated with Si photonic waveguide, Hidetaka Nishi1, Tai Tsuchizawa1, Masaaki Ono1, Masaya Notomi1, Tsuyoshi Yamamoto1, Shinji Matsuo2, 1NTT, Japan. A plasmonic waveguide with a deep-subwavelength Si core is integrated with a Si photonic waveguide. By utilizing horizontal Al-Si-Al structure, we obtained a 4-dB/μm propagation loss with a 60×60 nm² surface-oxidized Si core.

FF1C • Quantum Enhanced Metrology—Continued

FF1C.7 • 09:30
Ultratrace Plasmonic Sensing below the Shot Noise Limit, Raphael Pooser1, Benjamin Lawrie1, 1Quantum Information Science and Engineering Lab, IBM Research, Zurich, Switzerland. A balanced SPR sensor utilizing intensity squeezed states to resolve signals below the shot-noise limit is demonstrated. At the inflection point, this sensor demonstrates 2.5 dB greater sensitivity than the best comparable classical sensor.

FF1D • Topological Optics I—Continued

FF1D.8 • 09:45
Experimental Realization of Color Hologram Using Pancharatnam-Berry Phase Manipulating Metasurface, Sajid Choudhury1, Amr Shaltout1, Alexander V. Kildishev1, Vladimir M. Shalaev1, 1Brick Nanotechnology Center, Purdue Univ., USA. We design and fabricate a Pancharatnam-Berry phase manipulating metasurface to experimentally demonstrate a three-color RGB pattern. The color pattern is produced by illuminating a nanostructured silver metasurface hologram with a white light source.
SF1E • Photonic Crystals—Continued

SF1E.6 • 09:30
Silicon-organic Hybrid Electro-optic Modulator Based on One-dimensional Photonic Crystal Slot Waveguides, Hai Yan1, Xiaoyuan Xu2, Chi-Jui Chung1, Harish Subbarao1, Zeyu Pan3, Swapajit Chakravarty1, Ray Chen1,1; 1The Univ. of Texas at Austin, USA; 2Omega Optics Inc., USA. A silicon-organic hybrid electro-optic (EO) modulator based on one-dimensional photonic crystal slot waveguides is proposed and demonstrated. Effective EO coefficient up to 490 pm/V is observed as a result of the slow group velocity in the proposed structure.

SF1E.7 • 09:45
Double-Chirped Bragg Gratings in a Silicon Nitride Waveguide, Patrick T. Callahan1, Purnawirman Purnawirman1, Thomas N. Adam1, Gerald Leake1, Douglas Coolbaugh2, Michael Watts1, Franz X. Kaertner1,3; 1MIT, USA; 2College of Nanoscale Science and Engineering, Univ. of Albany, USA; 3Center for Free-Electron Laser Science, Deutsches Elektronen-Synchrotron, Germany. Double-chirped Bragg gratings for use in dispersion compensation are demonstrated using silicon nitride waveguides, on a silicon photonics platform that allows for 3-D integration of photonic devices with CMOS electronics.

SF1G • Intergrated Comb and rf Processing—Continued

SF1G.7 • 09:30
Reconfigurable microwave bandstop filter based on stimulated Brillouin scattering in a photonic chip, Iman Aryanfar1, Amol Choudhary1, Shayan Shahnia1, Matthias Pagani1, Yang Liu1, Khu Vu2, Stephen Madden1, Barry Luther-Davies2, Benjamin Eggleton1, David Marpaung2; 1School of Physics, CUDOS, Univ. of Sydney, Australia; 2Laser Physics Centre, Australian National Univ., Australia. We report a new RF photonic cancellation filter topology and demonstrate a sharp bandstop filter with a 20 dB suppression obtained from a sub-2 dB on-chip Brillouin loss in a broad 300 MHz reconfigurable bandwidth.

SF1G.8 • 09:45
RF Frequency Sextupling Utilizing a Single Mach-Zehnder Optical Modulator possessing external-load RF terminals, Akito Chiba1, Yosuke Akamatsu1, Kazumasa Takada1; 1Gunma Univ., Japan. Undesired low-order optical sidebands generated from 10-GHz driven Mach-Zehnder optical modulator have been selectively suppressed with 33 dB, using a polarizer instead of an optical band-rejection filter. 60-GHz RF signal has been also successfully obtained.

SF1H • Laser-based Sensing and Applications—Continued

SF1H.6 • 09:30
Optical Heterodyne-Enhanced Chirped Laser Dispersion Spectroscopy, Genevieve Plant1, Yifeng Chen1, Gerard Wysocki1; 1Princeton Univ., USA. A proof of concept heterodyne-enhanced chirped laser dispersion spectroscopy system is presented. In remote sensing systems, where low return powers are expected, the addition of an optical local oscillator and subsequent non-linear processing allows for improved performance.

SF1H.7 • 09:45
FPGA-based chirped laser dispersion spectrometer, Yifeng Chen1, Genevieve Plant1, Andreas Hangauer1,2, Gerard Wysocki1; 1Princeton Univ., USA; 2Siemens AG, Corporate Technology, Germany. We present a FPGA based fast data acquisition system which enables continuous, real time chirped laser dispersion spectroscopic chemical sensing. System performance is evaluated using atmospheric methane detection sensing as an example application.
SF1L • VCSELs—Continued

SF1L.7 • 09:30
 Beam-Shaping Single-Mode VCSEL With
 A High-Contrast Grating Mirror, Kun Li1, Yi Rao2, Christopher Chase2, Wei Jian Yang1, Connie J. Chang-Hasnain1; 1Univ. of California at Berkeley, USA; 2Bandwidth 10 Inc., USA. Various far-field emission patterns are demonstrated for single-mode 1550-nm VCSELs, incorporating high-contrast gratings as both the reflective laser mirror and transmission modulation plate. This approach opens new avenues to engineer a VCSEL’s emission properties.

SF1L.8 • 09:45
 Single Mode Photonic Crystal Vertical Cavity Lasers for Improved Modulation Bandwidth Distance Product, Stewart Fryslie1, Nicholas Denardo1, Kent D. Choquette2; 1Univ. of Illinois Urbana-Champaign, USA. We demonstrate single mode photonic crystal vertical cavity surface emitting lasers with modulation bandwidth exceeding 15 GHz, low operating current density, and improved output power by optimization of the laser cavity optical and electrical design.

SF1I.7 • 09:30
 Compact Ultrafast Pulsed 2.05 µm All-PM Fiber Laser For Dielectric Laser Acceleration of Non-relativistic Electrons, Heinar Hoogland1,2, Joshua McNeur2, Martin Kozák2, Peter Hommelhoff2, Ronald Holzwarth1; 1Menlo Systems GmbH, Germany, 2Dept. of Physics, Lehrstuhl für Laserphysik, Germany. A compact all-polarization maintaining 2.05 µm fiber laser system emitting femtosecond pulses at 1-MW peak power is studied and applied to dielectric laser acceleration of non-relativistic electrons obtaining acceleration gradients up to ~ 50 MeV/m.

AF1J.5 • 09:30
 Unibody, Compact, and Lightweight Q-switched Lasers Enabled by Additive Manufacturing, Shuo Li1, Bryan Nelsen1, Rongzhang Chen1, Kevin Chen1; 1Univ. of Pittsburgh, USA. This paper demonstrates additive manufacturing scheme to fabricate a compact and unibody solid-state lasers. Cellular structures, embedded cooling channels, flexure alignment structures were used to produce robust and lightweight Q-switched YAG lasers.

JF1K.5 • 09:45
 MBEGrown Cr:ZnS Thin Film Laser Media, Nikolai Tolstik1,2, Evgeni Sorokin3, Eric Karhu1, Stanislav Polyakov1, Ursula Gibson1, Irina T. Sorokina1,2; 1Inst. for Physics, Norwegian Univ. of Science and Technology, Norway; 2Atla Lasers AS, Norway; 3Photonics Inst., Technical Univ. of Vienna, Austria. We report results of spectroscopic analysis of the first first laser-quality MBE-grown Cr:ZnS films. Comparison of spectral-luminescent properties with bulk Cr:ZnS indicates their good laser properties, opening the way towards industrial mid-IR thin-disk and waveguide lasers.

10:00–10:30 Coffee Break, Concourse Level
FF1M • Short-pulse Generation and Measurement—Continued

**FF1M.7 • 09:30**

**Generation of vacuum ultraviolet femtosecond pulses by four-wave Raman mixing under three color pump beam configuration**, Vu Duong,1 Trong Nghia Nguyen,2 Taro Imasaka,1,2 Dept. of Applied Chemistry, Kyushu Univ., Japan; 2Inst. of Physics, Vietnam academy of science and technology, Vietnam. 

We report a low-loss all-fibre component that reformatsthe light from a multimode core into the shape of a slit. The light pattern across the slit is independent of the input.

**FF1M.8 • 09:45**

**Full characterization of few-cycle pulses using cross-polarized wave generation d-scan technique**, Ayhan Tajalli,1 Bruno Chanteau,1 Martin Kretschmar,1 Heiko Kurz,1 Milutin Kovacev,1 Uwe Morgner1,2, Tamás Nagy1,2,1Inst. of Quantum optics, Leibniz Universität Hannover, Germany; 2Laser Zentrum Hannover e.V., Germany. 

We present a novel dispersion-scan pulse characterization technique employing cross-polarized wave (XPW) generation as nonlinearly. XPW inherently relaxes phase-matching limitations and hence makes it ideal for characterization of few-cycle pulses in various spectral regions.

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**JF1N • Symposium on Advances and Opportunities in Astrophotonics I—Continued**

**JF1N.4 • 09:30**

**All-fibre tapered pseudo-slit reformatter**, Stephanois Yerolatsitis,1,2 Kerrianne Harrington3, Tim Birks3, 1Univ. of Bath, UK. 

We report a low-loss all-fibre component that reformatsthe light from a multimode core into the shape of a slit. The light pattern across the slit is independent of the input.

**JF1N.5 • 09:45**

**Efficient photonic reformatting of stellar light for high precision spectroscopy**, David G. MacLachlan1, Robert J. Harris2, Itadehui Gris-Sánchez1, Timothy Morris1, Debaditya Choudhury1, Eric Gendron1, Alastair Baden1, Izabela J. Spalenia1, Alexander Arriola1, Tim Birks3, Jeremy R. Allington-Smith4, Robert Thomson5,1 Heriot-Watt Univ., UK; 2Dept. of Physics, Univ. of Durham, UK; 3Dept. of Physics, Univ. of Bath, UK; 4Observatoire de Paris, France. 

We present the “hybrid reformatter”, a device combining a multicore fiber photonic lantern with an ultrastable laser inscribed waveguide interconnect to efficiently reformat a seeing-limited telescope point spread function into a diffraction-limited pseudo-slit.

**JF1N.6 • 09:45**

**Creation of Sub-diffraction Optical Needle by Nonlinear Super-oscillatory Lens**, Yhong Zhang1, Weihao Zhong1, Dongmei Liu1, Yong Zhang1, Min Xiao1,2,1 Nanjing Univ., China; 2Physics, Univ. of Arkansas, USA. 

We demonstrate a novel nonlinear optical super-oscillatory lens, i.e. a periodically poled LiTaO3, nonlinear photonic crystal, to create an optical needle with a sub-diffraction beam size of 0.42λ0, and an ultra-long length of 40λ0.

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**SF1O • Nonlinear Optical Technologies in Spectroscopy and Microscopy—Continued**

**SF1O.6 • 09:30**

**Picosecond Energy Scalable kHz OPO/OPA Tunable in 3-3.5 μm mid-IR Spectral Range**, Danail Chuchumishev1, Anton Trifonov1, Bozhidar Oreshkov1, Nikolai Belashenkov2, Ivan C. Buchvarov1,3,1 Sofía Univ. St. Kliment Ohridski, Bulgaria; 2ITMO Univ., Russia. 

We demonstrate 740 ps, 4.1-mJ tunable mid-IR PPSLT based OPO/OPA pumped by 38-mJ, 800 ps, Nd-laser system operated at 0.5-1kHz repetition rate.

**SF1O.7 • 09:45**

**Creation of Sub-diffraction Optical Needle by Nonlinear Super-oscillatory Lens**, Yhong Zhang1, Weihao Zhong1, Dongmei Liu1, Yong Zhang1, Min Xiao1,2,1 Nanjing Univ., China; 2Physics, Univ. of Arkansas, USA. 

We demonstrate a novel nonlinear optical super-oscillatory lens, i.e. a periodically poled LiTaO3, nonlinear photonic crystal, to create an optical needle with a sub-diffraction beam size of 0.42λ0, and an ultra-long length of 40λ0.

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**SF1P • Integrated Photonics Platforms—Continued**

**SF1P.6 • 09:30**

**Managing Radiation Loss in Photonic Waveguides for Applications in PT-Symmetric Systems**, Toni Eichelkraut1,2, Alexander Szameit1,2,1 Inst. of Applied Physics, Friedrich-Schiller-Universität, Germany. 

We determine the radiation loss for modulated potentials analytically and implement this setting experimentally utilizing laser-written photonic waveguides. We foresee numerous applications, in particular in PT-symmetric systems.

**SF1P.7 • 09:45**

**Single-crystal Titanium Dioxide Strip-Loaded Waveguides**, Christopher C. Evans1, Jessica Burton1, Jin Suntivich1, Darrell Schlom3,1 Cornwall Univ., USA. 

We present optical waveguides using molecular beam epitaxy-grown single-crystal titanium dioxide (TiO2) on magnesium fluoride (MgF2) substrates. We create SUB strip-loaded waveguides to measure optical guiding in the resulting thin films.
Friday, 10 June

**Executive Ballroom 210A**

**FF2A.1 • 10:30**
**Experimental Observation of Inviscid Burgers’ Equation Dynamics in Nonlinear Fiber Optics, Benning Wietzel**, Domenico Bongiovanni, Michael Kues, Yi Hu, Zhigang Chen, Stefano Trillo, John M. Dudley, Stefan Wabnitz, Roberto Morandotti, InRS-EMT, Université du Québec, Canada; School of Mathematical and Physical Sciences, University of Sussex, UK; TEDA Applied Physics Inst. and School of Physics, Nankai Univ., China; Dept. of Physics & Astronomy, San Francisco State Univ., USA; Dipartimento di Ingegneria, Università di Ferrara, Italy; Université de Franche-Comté, France; Dipartimento di Ingegneria dell’Informazione, Università degli Studi di Brescia, Italy. We report on the experimental observation of inviscid Burgers’ equation dynamics, obtained when a properly tailored pulse propagates in an optical fiber. Experimental results show controllable pulse steepening and shock formation in excellent agreement with theory.

**FF2A.2 • 10:45**
**Ultra broadband Dispersion Radiation by Spatiotemporal Oscillation of Multimode Waves, Logan Wright**, Stefan Wabnitz, Demetrios N. Christodoulides, Frank W. Wise, Cornell Univ., USA; Dipartimento di Ingegneria dell’Informazione, Università degli Studi di Brescia, Italy; CREOL, College of Optics and Photonics, Univ. of Central Florida, USA. We study supercontinuum in graded-index multimode fibers. Spatiotemporal oscillations of solitons produce radiation spanning from the mid-IR to ultraviolet. Applications to ultrafast fiber sources and connections to spatiotemporal modulation and conical wave instability are discussed.

**FF2A.3 • 11:00**
**Versatile supercontinuum generation in parabolic multimode optical fibers, Mohammad Amin Effekhar**, Matthew S. Milis, Logan G. Wright, Miroslav Kalesik, Rodrigo Amezquita-Correa, Frank W. Wise, Demetrios N. Christodoulides, School of Applied and Engineering Physics, Cornell Univ., USA; CREOL, College of Optics and Photonics, Univ. of Central Florida, USA; The College of Optical Sciences, The Univ. of Arizona, USA. We theoretically demonstrate that the pump’s spatial profile can provide a degree of freedom in tailoring at will the nonlinear dynamics and the ensuing spectral content of supercontinuum generation in highly multimoded optical fibers.

**Executive Ballroom 210B**

**FF2B.1 • 10:30**
**Quantum walks of self-collimated photons, Fan Qi**, Yufei Wang, Qingyan Ma, Won-Hua Zheng, Chinese Acad Sci Inst of Semiconductor, China. We demonstrate single-photon quantum walks in self-collimated photonic crystal chip. Similarities between theoretical expectations and experimental results are higher than 0.98. The structure is compact and possesses potential to construct complicated linear quantum circuits.

**FF2B.2 • 10:45**
**Spawning Rings of Exceptional Points out of Dirac Cones, Bo Zhen**, Chia Wei Hsu, Yuichi Igarashi, Lung Li, Ido Kaminer, Adi Pick, Song-Liang Chua, John Joannopoulos, Marin Soljacic, MIT, USA; Physics, Technion, Israel; Applied Physics, Yale Univ., USA; NEC, Japan; Physics, Harvard Univ., USA; DSQ National Labs, Singapore. We demonstrate that an accidental Dirac cone can evolve into a ring of exceptional points in a photonic crystal slab. Radiation fundamentally changes the band structure even though there is no material loss and gain.

**FF2B.3 • 11:00**
**Direct Measurement of Negative Optical Goos-Hanchen Shift from Photonic Crystal, Yu-Po Wong**, Xuerong Xiao, Olav Solgaard, Stanford Univ., USA. Asymmetric, low-loss, Photonic Crystal mirrors exhibit negative Goos-Hanchen shift up to -18.2 μm at 1532 nm wavelength. The shift is a strong function of wavelength, polarization and incident angle.

**Executive Ballroom 210C**

**FF2C.1 • 10:30**
**A squeezed light source for advanced gravitational wave detectors, Eric G. Oelker**, Tomoki Isogai, Maggie Tse, Georgia Mansell, John Miller, Fabrice Matichard, Lisa Barsotti, Peter Fritchel, David McClendon, Nergis Mavalvala, Matthew Evans, MIT UGO Lab, USA; Dept. of Quantum Science, Australia National Univ., Australia. We have produced frequency dependent squeezed light in the audio band for the first time using a high finesse quantum filter cavity. Also we have built a low phase noise in-vacuum squeezed light source.

**FF2C.2 • 10:45**
**A fully guided-wave approach to the generation and detection of squeezing at a telecom wavelength, Florian Kaiser**, Bruno Fedeci, Alessandro Zavatta, Virginia D’Auria, Sebastiano Tarrizzi, Université Nice Sophia Antipolis, France; Istituto Nazionale di Ottica, Italy; Physics, LENS, Italy. We report on the first realization of an entirely guided-wave squeezing experiment at telecom wavelength. Our setup exploits non-linear optical waveguides and fiber components. This configuration allows implementing a plug-and-play experiment, compatible with fiber networks.

**FF2C.3 • 11:00**
**Manipulating the Squeezing Properties of a Degenerate Parametric Amplifier with Coherent, Time-Delayed Feedback, Nikolett Nemet**, Andrew Scott Parkins, Dodd-Walls Centre for Photonic and Quantum Technologies, New Zealand; University of Auckland, New Zealand. Squeezing properties of a degenerate parametric amplifier are investigated with coherent, time-delayed feedback. Enhanced optical squeezing is obtained at frequencies set by the pump strength, the decay rates of the mirrors, and the time-delay.

**Executive Ballroom 210D**

**FF2D.1 • 10:30**
**Hot Electron Relaxation in Thin Titanium Nitride Films, Heather Ferguson**, Urcan Guler, Nathaniel Kinsey, Vladimir M. Shalaev, Theodore B. Norris, Alexandria Bolssetseva, Univ. of Michigan, USA; Nano-Meta Technologies, USA; School of Electrical & Computer Engineering and Birck Nanotechnology Center, Purdue Univ., USA. Pump-probe experiments using a femtosecond laser capture the dynamics of the electron thermalization and phonon relaxation. TiN is a plasmonic ceramic with optical properties comparable to noble metals, but exhibits much weaker electron-phonon cooling.

**FF2D.2 • 10:45**
**Study of the effect of the Purcell enhancement factor on the photodegradation of the p3ht polymer, Vanessa N. Peters**, Rohan Alexander, D’Angelo A. Peters, Mikhail A. Noginov, Norfolk State Univ., USA; School of Engineering, Univ. of Michigan, USA. We studied photinduced reduction of absorption and emission in p3ht semiconducting polymer and found that the rate of photodegradation does not correlate with the luminescence intensity and does not depend on the excited state concentration.

**FF2D.3 • 11:00**
**Effect of strong coupling on Stokes shift in dye molecules, Kevin E. Tanyi**, Hannah Thurman, Samantha R. Koutsares, Nicholas Brown, Mikhail A. Noginov, Center for Materials Research, Norfolk State Univ., USA; Mathematics and Science Academy, Ocean Lakes High School, USA; Norfolk State Univ., Summer Research Program, Center for Materials Research, USA; Cornell Univ., Materials Science and Engineering, USA. We found that strong coupling with the cavity can increase Stokes shift of the dye molecules. The experimental finding is qualitatively explained with the simple model based on the splitting of the excited state parabola.
Monolayers.

Optoelectronics with Two-dimensional Atomic Crystals, Thomas Mueller1, Vienna Univ. of Technology, Austria. Optoelectronic devices based on two-dimensional atomic crystals are presented. In particular, graphene-photodetectors, photovoltaic and electroluminescent devices made of two-dimensional semiconductors, and devices based on atomically-thin van der Waals heterostructures are discussed.

10:30–12:30 SF2E • Two-Dimensional Materials
Presider: Dirk Englund; MIT, USA

SF2E.1 • 10:30
Optoelectronics with Two-dimensional Atomic Crystals, Thomas Mueller1, Vienna Univ. of Technology, Austria. Optoelectronic devices based on two-dimensional atomic crystals are presented. In particular, graphene-photodetectors, photovoltaic and electroluminescent devices made of two-dimensional semiconductors, and devices based on atomically-thin van der Waals heterostructures are discussed.

10:30–12:30 SF2F • Short Range Communications
Presider: Yue-Kai Huang; NEC Labs America Inc, USA

SF2F.1 • 10:30
Experimental demonstration of Asynchroneous PON Upstream via Multicarrier Code Division Multiple Access, You-Wei Chen1, Yi-Ting Liao1, Zhiwen Liu2, Yongqi He1; National Tsing Hua Univ., Taiwan. An asynchronous multi-carrier code division multiple access passive optical network upstream is experimentally demonstrated for the first time. Different code lengths with different amounts of active subscribers are investigated in back-to-back and 50-km transmission.

10:30–12:30 SF2G • Microwave Photonics
Presider: Akito Chiba; Univ. of Maryland at College Park, USA

SF2G.1 • 10:30
Integrated Optical Frequency Shifter on a Silicon Platform, Thijs Spuesens1, Yanlu Li1, Peter Verheyen1, Guy Lepage2, Sadhik-kumar Balakrishnan1, Philippe Absil1, Roel G. F. Baets1, Univ. Ghent, Belgium; 1imec, Belgium. An integrated optical frequency shifter on a standard silicon photonics platform completely fabricated in a CMOS pilot line and showing MHz frequency shifts with a sideband suppression ratio up to 36 dB is demonstrated.

SF2G.2 • 10:45
Linear Graphene on Silicon Nitride Electroabsorption Modulators for RF-Over-Fiber Links, Christopher T. Phare1, Jaime Cardenas1, Yoon Ho Daniel Lee1, Michal Lipsett2, Electrical and Computer Engineering, Cornell Univ., USA; 2Electrical Engineering, Columbia Univ., USA. We demonstrate graphene-on-silicon nitride electroabsorption modulators for inherently linear RF modulation on-chip with a spurious free dynamic range of 100 dBc/Hz2 at 100 MHz.

SF2G.3 • 11:00
Efficient single sideband microwave to optical conversion using a LiNbO3, WGM-resonator, Alfredo R. Rueda Sanchez1, Florian Sedlmeir1, Michele Collodo2, Ulrich Vogl1, Birgit Stiller3, Gerhard Schunk1, 1Univ. of Technology, Austria; 2Inst. for the Science of Light, Germany; 3School in Advanced Optical Technologies, Univ. Erlangen-Nuernberg, Germany; 4Dept. of Physics, ETH Zuerich, Switzerland; 5Inst. for Optics, Information and Photonics, Univ. Erlangen-Nuernberg, Germany; 6School of Physics, Univ. of Sydney, Australia; 7Inst. of Science and Technology, Austria; 8Inst. for Quantum Information and Matter and Thomas J. Watson, Sr., Lab of Applied Physics, California Inst. of Technology, USA. We present a coherent microwave to telecom signal converter based on the electro-optical effect using a crystalline WGM-resonator coupled to a 3D microwave cavity, achieving high photon conversion efficiency of 0.1% with MHz bandwidth.

SF2G.4 • 11:15
Silicon Photonic Chip-on-filter Spectroscopy of Methane, Eric J. Zhang1, Lionel Tombe1, Jason Circuit1, Swetha Kamlapurkar1, 1IBM Thomas J. Watson Research Center, USA; 2Electrical Engineering, Princeton Univ., USA. We demonstrate a silicon photonic chip sensor for absorption spectroscopy of methane near 1615 nm. Noise analysis demonstrates 8.5 × 10-14 Hz1/2 minimum fractional absorption and Gaussian noise performance with 20 ppmv detection limit at ~10 s.
SF21.1 • 10:30 High Power Yb:YAG Waveguide Amplification of a Femtosecond Semiconductor Disk Laser, Nayara Jornod1, Valentin Wittwer1, Thomas Sudmeyer1, Christian Kränkel2, Thomas Calmano1, 1Laboratoire Temporal Fréquence, Université de Neuchâtel, Switzerland; 2Institut für Laser-Physik, Universität Hamburg, Germany. We demonstrate the first amplification of an ultrafast semiconductor disk laser inside a crystalline waveguide. The 8.3-mm-long fs-laser written Yb:YAG channel waveguide generates 2.89 W in 630 fs pulses at 1030 nm.

SF21.2 • 10:45 Stability optimized, 4-mJ and 1.2-ps pulses from a Ho:YLF regenerative amplifier, Pat-Kroetz1, Gourab Chatterjee1, Axel Ruell1, Krishna Murari2, Franz X. Kärnert2, Ingmar Hart2, R. Dwayne Miller1, 1Max Planck Inst. MPSD, Germany; 2Deutsches Elektronen Synchrotron (DESY), Germany. Optimization of gain depletion in Ho:YLF regenerative amplifiers resulted in highly stable pulses with fluctuations of 0.35%. Integration of an intracavity-etalon decreased the pulse duration to 1.2 ps, while having pulse energies of 4 mJ.

SF21.3 • 11:00 Hybrid Fiber Amplification System Mastered by Non-aqueous Tape Casting Fabricated Yb-doped Ceramic Lasers, Dongbi Bai1, Wexue Li1, Chao Wang1, Yang Liu1, Jiang Li1, Lin Ge1, Yuabi Pan1, Heping Zeng1, 1State Key Lab of Precision Spectroscopy, East China Normal Univ., China; 2Key Lab of Transparent Opto-functional Inorganic Materials, Shanghai Inst. of Ceramics, Chinese Academy of Sciences, China. We compare laser performances of composite YAG/Yb:YAG and bulk Yb:YAG ceramic lasers in chirped-pulse and self-similar amplification, showing excellent power-scaling and pulse-compression properties of the hybrid ceramic master-oscillator fiber amplifier.

AF2J.1 • 10:30 Joint Manufacturing II

AF2J.2 • 11:00 ⊙ Invited
3D Printing of Thermoplastics with Higher Strength Using SWIR-Supercontinuum Laser, Ramon A. Martinez1, Kewen Guo1, Colleen L. Flanagan1, Chitrakhea Chaudhari1, Mohammad N. Islam1, Scott J. Hollister1, 1Dept. of Electrical and Computer Engineering, Univ. of Michigan, USA; 2Dept. of Biomedical Engineering, Univ. of Michigan, USA. We report an electronically tuned QCL, which provides submicrowave scanning across several micrometers the MWIR and LWIR spectral regions, revolutionizing infrared spectroscopy and rapid detection of IEDs/CWAs, exploring combustion/explosion dynamics and investigating fast chemical/biological phenomena.

JF2K.1 • 10:30 Invited
Quantum Cascade Lasers: A Platform Technology for Today’s Marketplace, David Aronne1, David Caffey1, William Chapman1, Timothy Day1, Edeline Fotheringham1, Allen Priest1, Michael Pushkinsky1, Miles Weida1, 1Daylight Solutions Inc, USA. The demand for sensitive molecular detection in a wide range of applications is driving diverse mid-IR laser source requirements. We present recent results showing how quantum-cascade-laser-based systems provide a flexible platform that can address these requirements.

JF2K.2 • 11:00 ⊙ Invited
Sub Microsecond Tuning and Rapid Transmission and Standoff Detection Using Quantum Cascade Lasers, Chandrá Kumar N. Patel1, 1Pranalytica Inc, USA; 2Physics & Astronomy, UCLA, USA. We report an electronically tuned QCL, which provides submicrowave scanning across several micrometers the MWIR and LWIR spectral regions, revolutionizing infrared spectroscopy and rapid detection of IEDs/CWAs, exploring combustion/explosion dynamics and investigating fast chemical/biological phenomena.

JF2K.3 • 11:00 ⊙ Invited
GaNAs/InP Membrane Lasers, Shigeisa Arai1, Nobuhiko Nishiyama2, Tomo Ame-miya1, Takuo Hiratani1, Daisuke Inoue1, 1Tokyo Inst. of Technology, Japan; 2Technische Universität Berlin, Germany. We present optically-pumped plasmonic GaAs nanolasers operating at room temperature. Built on suspended GaAs membranes, the etchless fabrication involves only a printed metal film, which defines the plasmonic cavity and confines the optical mode.
Joint power below 0.5W was achieved. Amplification and de-amplification of 10dB with a Gaussian-like mode by an all-solid bandgap microstructure, while outer hollow channels coupled to a wavelength shifting element provide a promising route to improved astrophysical spectrograph wavelength calibration.
Cavity-enhanced Spontaneous Emission of a Single Dipole Coupled to the Quasinormal Modes of Ultrafast Twin Beams, James P. Lee-Thorp, Vancouver, Canada; 2Shanghai Jiao Tong Univ., P. R. China; 3CAS Key Lab. of Mathematical Physics, Shanghai, China.

Frequency Modes of Ultrashort Twin Beams Generated by High-Gain Modulational Instability in a Gas-Filled Hollow-Core PCF, Martin A. Finger1, Nicolas Joly2, Philip S. Russell2, Maria V. Chekhova1, Max Planck Inst for the Science of Light, Germany; 2Dept. of Physics, Univ. of Erlangen-Nuremberg, Germany. We investigate spectral correlations generated by high-gain modulational instability in argon-filled hollow-core photonic crystal fiber. Confirming theoretical predictions, with increasing gain we observe a reduction in the number of spectral modes up to the single-mode state.

Control of Fano resonances in graphene-based gratings at telecom wavelengths, Domenico de Ceglia1, Maria Antonietta Vincenti1, Marco Grandi1, Giuseppe Bianco1, Giovanni Bruno1, Antonella D’Orazio1, Michael Scalora1, National Research Council - AMRDEC, USA; 2Politecnico di Bari, Italy; 3Istituto di Nanotecnologia – CNR-NANOTEC, Italy; 4US Army - AMRDEC, USA. We demonstrate that integration of graphene with a grating allows electro-optical modulation of linewidth, characteristic wavelength and shape of the Fano resonances associated with the quasinormal modes of the grating.
SF2E • Two-Dimensional Materials—Continued

SF2E.4 • 11:15
Gate-tunable, high-responsivity, and room-temperature infrared photodetectors based on a graphene-Bi$_2$Se$_3$ heterostructure. Jae-seok Kim, Hong Jang, Nikesh Koirola, Sangwon Sim, Jae-bok Lee, Un Jeong Kim, Hyungsook Lee, Soo Young Cha, Chilmun In, Jun Park, Jekwan Lee, Matthew Brahlek, Jisoo Moon, Maryam Salehi, Seongshik Oh, Jong-Hyun Ahn, Sungwoon Hwang, Dahun Kim, Hyunyong Choi, Yonsei Univ., Korea; 2The State Univ. of New Jersey, USA; 3Samsung electronics, Korea. We demonstrate infrared photodectors based on graphene-Bi$_2$Se$_3$, heterostructures with high responsivity (>1 A/W) at room temperature. Strong photogating effect across the tunneling barrier and built-in potential enables the internal quantum efficiency larger than 100%.

SF2E.4 • 11:30
Laser fabricated ultrathin flat lens in sub-nanometer thick monolayer transition metal dichalcogenides crystal, Han Lin, Zaiquan Xu, Qiaoqiang Bao, Baohua Jia, 1Centre for Micro-Photonics, Swinburne Univ. of Technology, Australia; 2Dept. of Materials Science and Engineering, Monash Univ., Australia; 3Center of South Nano Science and Technology, Inst. of Functional Nano and Soft Materials (FUNSOM), China. A flat lens with sub-nanometer (7 Å) thickness is fabricated in a monolayer WS$_2$ crystal flake using direct laser writing. The ultrathin lens is able to focus visible light with diffraction limited three-dimensional spatial resolution.

SF2E.5 • 11:45
Achieving the Gauge Potential for the Photon in a Synthetic Space, Luqi Yuan, Xu Shi, Shanhai Fan, 1Stanford Univ., USA. We introduce a synthetic frequency dimension in a one-dimensional array of ring resonator system and generalize the concept of photonic gauge potential. A topologically protected edge state is created in the synthetic space.

SF2F • Short Range Communications—Continued

SF2F.4 • 11:15
Tbit/s Optical Interconnects Based on Low Linewidth Quantum-Dash Lasers and Coherent Detection, Vitaly Vaypic, 1Around Arthurs, Vivek Panakarn, 2Ru Zhou, 2Ultimam Gasmeii, 2Kamel Merghem, 2Francois Lelarge, 2Abderrahim Ramdane, 3Liam Barry, 1Dublin City Univ., Ireland; 2CNRS, Lab for Photonics and Nanostructures, France; 3Illilab, France. We demonstrate Tbit/s transmission with a Q-Dash mode-locked laser using coherent detection. The aggregate capacity achieved with PDM-QPSK was 1.8Tbit/s over 50km of SSF, using 36 channels from the 34.5GHz FSR Q-Dash PIML.

SF2F.5 • 11:30
On-chip Rectangular Microwave Photonic Periodic Filter with Large Bandwidth Tunability, Hengyun Jiang, 1,2 Lianshan Yan, 2David Marpaung, 1Southwest Jiaotong Univ., China; 3The Inst. of Photonics and Optical Sciences (IPOS), School of Physics, Univ. of Sydney, Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS), Australia. A rectangular microwave photonic filter is proposed using on-chip silicon nitride ring resonators. The bandwidth of such filter can be largely adjusted from 1GHz to 13GHz in a very simple scheme.

SF2F.6 • 11:45
Ultra-Sensitive Detection of Explosive Molecules using Fano Resonances in Silicon Microring Resonators, Anton Vasiliev, 1Aditya Mulik, Muhammad Muneeb, 1Roel G. F. Baets, Gunnther Roelkens, 2Photonics Research Group (INTEC), Ghent Univ.-imec; Center for Nano- and BioPhotonics, Belgium. A novel photothermal mid-infrared spectroscopy method is demonstrated in the 3.5μm wavelength range on a polymer analyte using an asymmetric Fano-type resonance in a silicon-on-insulator microring resonator.
Chirped-Pulse Amplifier System Based on Thulium-Doped ZBLAN Fibers, Yutaka Nomura1, Takao Fujii1, 1Inst. for Molecular Science, Japan. We demonstrate a chirped-pulse amplifier system operating around 1900 nm using thulium-doped ZBLAN fibers. Pulses with a duration of 150 fs are obtained with average output power of 2.5 W.

Beam steering in highly coherent implant-defined vertical cavity surface emitting laser array, Meng Xun1, Chen Xu1, Yiyang Xie2, Guoqing Jiang3, Guanzhong Pan4, Yibo Dong1, Hongda Chen2, 1Beijing Univ. of Technology, China; 2Inst. of Semiconductors, Chinese Academy of Sciences, China. Electronically controlled beam steering was achieved via highly coherent in-phase implant-defined vertical cavity surface emitting laser arrays. The total power in the central lobe is above 36% in 1×2 array when steering.

Multi-species sensing using multi-mode absorption spectroscopy, MUMAS, on the same chip. Both rings can be used as laser and detector at the same wavelength.

Multiple species sensing using multi-mode absorption spectroscopy with mid-infrared inter-band cascade lasers, Paul Ewart1,2, Seamus O'Hagan1, Henry Northern1, Benjamin Gras4, Chul Soo Kim3, Mijn Kim3, Jerry R. Meyer2, William Belsey1, Charles Merritt3, Chadwick Canedy1, Igor Vurgaftman1, 1Univ. of Oxford, UK; 2Ecole Nationale Superieure d’Ingénieurs de Caen, France; 3Naval Research Lab, USA; 4Sotera Defense Solutions, Inc., USA. Multi-mode absorption spectroscopy, MUMAS, with a mid-IR inter-band cascade laser, is used to measure concentrations of methane, acetylene and formaldehyde with uncertainties of 1% in pure samples and <10% in mixtures of three gases.

Joint

AF2J • A&T Topical Review on Lasers in Additive Manufacturing II—Continued

Multi-disciplines laser source for 3D printing, Andrew Wolff1,2, Ralf Korsch1,2, David L. Wood1,2, 1Univ. of Oxford, UK; 2Ecole Nationale Superieure d’Ingénieurs de Caen, France. A new multi-disciplines laser source is described, based on nasal semiconductor lasers, which can be used for 3D printing of metal alloys using powder bed fusion technique.
Joint

With Asymmetric Port Couplings, degenerate Optical Parametric Oscillation - Passive Linewidth Narrowing Through Non-FF2M.6 • 11:45

Gentry Sun in Tight Focusing Geometry, ic Generation Driven by Truncated Beams

Extended Phase Matching of High Harmonic beams with arbitrary convex caustic trajectories. Different trajectories can be selected using the same nonlinear crystal by varying the crystal temperature or the pump wavelength.

Arie Sivan Trajtenberg-Mills, Gil Triginer, Xin Gai, Barry Luther-davies, Jun Cheng, ‘The Australian National Univ., Australia; ‘Beijing Inst. of Technology, China. We demonstrated vertically coupled, hydrogenated amorphous silicon ring resonators by leveraging low temperature deposition of the material where SU-8 polymer was employed as planarization layer and resonator gap material.

Fariza Hanim Suhailin, Kerry Vahala, ‘Harvard Univ., USA. The combination of astronomical adaptive optics system with customized atmospheric devices holds the potential to develop new classes of astronomical instrumentation. Here we discuss several potential applications linking photonic technologies and adaptive optics systems.

SF2P.4 • 11:15


We demonstrated a way to engineer a second-order nonlinearity (χ(2)) in silicon-dielectric multilayers via the electric-field induced second-harmonic effect. The value of χ(2) measured using the Maker fringe method is 1.2 pm/V.

SF2P.6 • 11:45

Engineering of a Second-Order Nonlinearity in Silicon-Dielectric Multilayers, Hung-Hsi Lin, Mu-Han Yang, Rajat Sharma, Matthew W. Puckett, Sergio Montoya, Christian Wurm, Felipe Vallini, Eric Fullerton, Yeshaiahu Fainman, ‘Univ. of California, San Diego, USA. We demonstrate a way to engineer a second-order nonlinearity (χ(2)) in silicon-dielectric multilayers via the electric-field induced second-harmonic effect. The value of χ(2) measured using the Maker fringe method is 1.2 pm/V.

SF2P.5 • 11:30

Low Loss Tapered Polysilicon Core Fibers, Fariza Hanim Suhailin, Li Shen, Noel Healy, Limin Xiao, M. Jones, T. Hawkins, John Ballato, Ursula Gibson, Anna C. Peacock, ‘Univ. of Southampton, UK; ‘School of Fundamental Sciences, Universiti Malaysia Terengganu, Malaysia; ‘Emerging Technology and Materials Group, Newcastle Univ., UK; ‘COMSET, School of Materials Science and Engineering, Clemson Univ., USA; ‘Dept. of Physic, Norwegian Univ. of Science and Technology, Norway. We have fabricated small core polysilicon waveguides by tapering bulk, as-drawn silicon optical fibers. The taper process acts to improve the local crystallinity of the core, resulting in a significant reduction in the material loss.

We demonstrated vertically coupled, hydrogenated amorphous silicon ring resonators by leveraging low temperature deposition of the material where SU-8 polymer was employed as planarization layer and resonator gap material.

Generated at 400-times flux enhancement at ~65eV in argon using truncated 0.8μm pulses.

We demonstrate passive linewidth narrowing through nonlinear process in an optical cavity to two nondegenerate output modes.

We propose and theoretically investigate a configuration of an optical parametric oscillator which asymmetrically distributes the frequency noise of a pump laser through a nonlinear process in an optical cavity to two nondegenerate output modes.

Invited: Astrophotonics and Adaptive Optics - A Match Made In The Stars?, Timothy Morris, Mark K. Corrigan, Robert J. Harris, Dept. of Physics, Durham Univ., UK; ‘294 Universität Heidelberg, Germany. The combination of astronomical adaptive optics system with customized atmospheric devices holds the potential to develop new classes of astronomical instrumentation. Here we discuss several potential applications linking photonic technologies and adaptive optics systems.

Invited: Diamond Nonlinear Photonics, Marko Loncar, ‘Harvard Univ., USA. Diamond on-chip frequency combs and Raman lasers will be presented. Furthermore, efforts aimed at realization of ultra-high Q diamond cavities in the visible wavelength range, and demonstration of visible frequency combs will be discussed.

Generation of Second Harmonic Beams with Switchable Caustic Trajectories, Sivan Trajtenberg-Mills, Int Juwiler, Ady Ane, ‘TAU, Israel; ‘Electrical and Electronics Engineering, Sami Shamoon College of Engineering, Israel. We demonstrate theoretically and experimentally the generation of second harmonic beams with arbitrary convex caustic trajectories. Different trajectories can be selected using the same nonlinear crystal by varying the crystal temperature or the pump wavelength.

FF2M.5 • 11:30

Extended Phase Matching of High Harmonic Generation Driven by Truncated Beams in Tight Focusing Geometry, Hung-Wei Surr, Pei-Chi Huang, Yi-Hsuan Tseng, Ren-Ting Huang, Ming-Chang Chen, Chi-Dong Lin, Cheng Jin, ‘National Tsing Hua Univ., Taiwan; ‘Inst. of Photonics Technologies, National Tsing Hua Univ., Taiwan; ‘Inst. of Atomic and Molecular Sciences, Academia Sinica, Taiwan; ‘Physics Dept., Kansas State Univ., USA; ‘Dept. of Applied Physics, Nanjing Univ. of Science and Technology, China.

We demonstrate that phase-matching cutoff of high-order-harmonic generation can be extended by only modifying the geometric parameter and fundamental beam profile, resulting in a 400-times flux enhancement at ~65eV in argon using truncated 0.8μm pulses.

FF2M.6 • 11:45

Passive Linewidth Narrowing Through Non-degenerate Optical Parametric Oscillation With Asymmetric Port Couplings, Cale M. Gentry, Gil Triginer, Xiaoge Zeng, Miloš Popović, ‘Univ. of Colorado at Boulder, USA.

We propose and theoretically investigate a configuration of an optical parametric oscillator which asymmetrically distributes the frequency noise of a pump laser through a nonlinear process in an optical cavity to two nondegenerate output modes.
**FF2A • Pulse Propagation in Fiber—Continued**

FF2A.7 • 12:00
Real Time Measurements of Temporal Rogue Waves and Spontaneous Modulation Instability in Optical Fiber, Mikko Naphi, Benjamin Wetzel, Cyril Billet, Jean-Marc Merolla, Shanti Toenenger, Thibaut Sylvester, Roberto Morandotti, Goery Genty, Frederic Dias, John M. Dudley, Tampere Univ. of Technology, Finland; 2Institut National de la Recherche Scientifique, Canada; 3Institut FEMTO-ST, Université de Franche-Comté, France; 4Univ. College Dublin, Ireland. We report the first real-time study of temporal rogue waves from spontaneous modulation instability. Time-lens magnification enables the direct capture of transient breather pulses and statistics, with measured intensity profiles in agreement with theory.

**FF2B • Photonic Crystals and Periodic Nanostructures—Continued**

FF2B.7 • 12:00
Direct Imaging of Iso-frequency Contours in Photonic Crystal Slabs, Emma Regan, Yuchi Igarashi, Bo Zhen, Ido Kaminer, Chia Wei Hsu, Yichen Shen, John Joan- nopoulos, Marin Soljacic, Research Lab of Electronics, MIT, USA; 2Smart Energy Research Labs, NEC Corporation, Japan; 3Physics Dept. and Solid State Inst., Tokyo Inst. of Tech, Japan; 4Physics, Wellesley College, USA. We theoretically and experimentally demonstrate a method for directly imaging iso-frequency contours in photonic crystal slabs using resonance-enhanced scattering from fabrication disorder. The results agree quantitatively with numerical simulations and provide information on fabrication errors.

**FF2C • Squeezing—Continued**

FF2C.7 • 12:00
Atomic Density Effect on the Spatial Multi-Mode Structure of Atom-Generated Squeezed Light, Irina Novikova, Mi Zhang, Eugeniy Mikhailov, Nickolas Lanning, Zhihao Xiao, Jonathan Dowling, College of William & Mary, USA; 2Heurte Inst. for Theoretical Physics and Dept. of Physics & Astronomy, Louisiana State Univ., USA. We study experimentally and theoretically the role of internally-generated higher-order Laguerre-Gauss modes in measurements of squeezed vacuum produced via polarization self-rotation interaction of an ensemble of Rb atoms and a strongly linearly polarized laser field.

**FF2D • Tuneable Metamaterials and Metasurfaces—Continued**

FF2D.7 • 12:00
Millivolt-scale dynamic reflectance modulation in gate-tunable Fano resonant metasurfaces, Krishnan Thyagarajan, Leo Z. Zornberg, Harry Atwater, California Inst. of Technology, USA; 2Kavli Nanoscience Inst., USA. We report and experimentally demonstrate an actively controlled gate-tunable Fano resonant plasmonic metasurface operating in the visible region, where operating voltages for reflectance and complex index modulation are <1 V with up to 25% modulation.

**FF2A • Optical Pulse Propagation in Fiber—Continued**

FF2A.8 • 12:15
Optical polarization rogue waves in fiber laser, Lei Gao, Tao Zhu, Stefan Wabnitz, Min Liu, Wei Huang, Changang Univ., China; 2Università degli Studi di Brescia and INO-CNR, Italy. A new kind of optical rogue waves, polarization rogue waves that appear with greatly deviated and unpredictable positions of polarization states, is identified in forming partially mode-locked fiber laser based on parametric frequency conversion.

**FF2B • Photonic Crystals and Periodic Nanostructures—Continued**

FF2B.8 • 12:15
Four Mode Multi-correlated Bi-Photon States within an Integrated Quantum Frequency Comb, Michael Kues, Christian Reimer, Benjamin Wetzel, Piotr Roztocki, Lucia Caspani, Yaron Bromberg, Brent E. Little, William J. Munro, Sai T. Chu, David J. Moss, Roberto Morandotti, INRS-EMT, Canada; 2School of Engineering and Physical Sciences, Heriot-Watt Univ., UK; 3Dept. of Applied Physics, Yale Univ., USA; 4X’an Inst. of Optics and Precision Mechanics of CAS, China; 5NTT Basic Research Labs, NTT Corporation, Japan; 6Dept. of Physics and Material Science, City Univ. of Hong Kong, China; 7Centre for MicroPhotonics, Swinburne Univ. of Technology, Australia. The generation of two-photon multi-correlated states over four modes and their pairwise entanglement is demonstrated by superimposing two different spontaneous four-wave mixing processes inside a bi-modally pumped CMOS-compatible microring resonator.
Graphene-silicon photonic crystals, Photonic and plasmonic guided modes in SF2E.7 • 12:15
Andrey Lavrinenko
1
Harvey Beere
1
Stephen Kindness
1
Univ. of Cambridge, UK; 2Chemical Engineer-
UK; 3Dept. of engineering, Univ. of Cam-
ing and Biotechnology, Univ. of Cambridge,
Degl’Innocenti metallurgy, Univ. of Cambridge, UK; 5Dept. of
potential difference are reported.
We present two graphene based plasmonic devices for the external optoelectronic amplitude modu-
lation of THz radiation. Modulation depths as high as 6% and up to 50 MHz, for a 10 V potential difference are reported.

SF2G.7 • 12:00 Photonic Crystal SOI RF Filter for Channel Equalization, Mathilde Gay, Laurent Bramerie1, Luiz Anet Neto1, Jean-Claude Simon1, Christophe Peucheret1, Zheng Han1, Xavier Checoury2, Gregory Moillle2, Jérôme Borderienn2, Alfredo De Rossi2, Sylvan Combrie2; 1CNRS Foton, France, 3Institut d’Electronique Fondamentale, France, 4Thales Research and Technology, France. We experimentally demonstrate the operating principles of a silicon-on-insulator interfer-
ometer for channel equalization purposes. The radio frequency filter is reconfigurable thanks to thermally controlled photonic crystal coupler and delay line.

SF2H.7 • 12:00 Spatially Multiplexed Bioparticle Detection Using Multi-mode Interference, Damla Ozcelik1, Matthew A. Stott1, Hong Cai1, Aaron Hawkins1, Holger Schmidt1, 1School of Engineering, UC Santa Cruz, USA; 2Dept. of Electrical and Computer Engineering, Brigham Young Univ., USA. On-chip fluores-
cence multiplexed detection of bioparticles is achieved by using a single multi-mode interference waveguide and a single wave-
length light source to create different number of spots on three liquid-core waveguides in an optofluidic platform.

SF2H.7 • 12:15 Direct RF to Optical Link Based on Film Bulk Acoustic Wave Resonators (FBAR), Aleen M. Siddiqui, Matthew C. H. Wood1, 1Sandia National Labs, USA. We simulate 100 GHz systems using PM-4 (O-band without chromatic dispersion) and DMT (C-band with less attenuation). We find the tolerance of each to laser inwidth, and discuss the fiber reach of each system.

SF2H.8 • 12:15 Anti-Corrosive films on Silver Plasmonic gratings for Fluorescence Imaging of Single Molecules and Cancer Cells, Aaron Wood1, Sangho Bok1, Joseph Mathai1, Biyan Chen1, Dhananjay Suresh1, Keshab Gangopadhyay2, Sheila Grant1, Anandhi Upendran1, Raghuraman Kannan1, Shubhra Gangopadhyay2, 1Bioengineering, Univ. of Missouri, USA; 2Electrical and Computer Engineering, Univ. of Missouri, USA; 3School of Medicine, Univ. of Missouri, USA; 4Radiol-
ogy, Univ. of Missouri, USA. Silver plasmonic gratings with a thin corrosion protection film enable enhanced fluorescence-based detect-
tion, including single molecule, over a much wider fluorescent dye concentration range, 100 µM - 1 FM, and deeper field penetration than traditional sensor substrates.

SF2E.6 • 12:00 Fast Graphene Based Plasmonic Terahertz Amplitude Modulator, David Jessop1, Stephen Kindness1, Long Xiao1, Philipp Braeuninger-Weiper1, Hungyen Lin1, Yuan Ren1, Jonathan Griffiths, Christopher X. Ren1, Stephan Hofmann1, Axel J. Zeitler1, Harvey Beere1, David Ritchie1, Riccardo Degl’Innocenti1, 1Semiconductor Physics, Univ. of Cambridge, UK; 2Chemical Engineer-
UK; 3Dept. of engineering, Univ. of Cam-
ing and Biotechnology, Univ. of Cambridge, Degl’Innocenti metallurgy, Univ. of Cambridge, UK; 5Dept. of
terface amplitude modu-
lation of THz radiation. We present two graphene based plasmonic devices for the external optoelectronic amplitude modu-
lation of THz radiation. Modulation depths as high as 6% and up to 50 MHz, for a 10 V potential difference are reported.

SF2E.7 • 12:15 Photonic and plasmonic guided modes in graphene-silicon photonic crystals, Tingyi Gu1, Andrei Andryieuski1, Yufeng Hao1, yile Li1, James Hone1, Chee Wei Wong1, Andrey Lavinenko1, Tony Low1, Tony Heinz1, 1Columbia Univ., USA; 2DTU Fotonik, Den-
mark. We report the results of systematic studies of plasmonic and photonic guided modes in large-area single-layer graphene integrated into a nanostructured silicon substrate. Distinct regimes of plasmonic and photonic mode were observed in the absorption spectrums.

SF2F.8 • 12:15 Comparison of 100 Gb/s O-band PAM-4 vs. C-band DMT for Different Laser Line-
widths and Fiber Lengths, Aminreza Yekani1, 1Sandia National Labs, USA; 2CNRS Foton, France; 3Institut d’Electronique Fondamentale, France; 4Thales Research and Technology, France. We experimentally demonstrate the operating principles of a silicon-on-insulator interfer-
ometer for channel equalization purposes. The radio frequency filter is reconfigurable thanks to thermally controlled photonic crystal coupler and delay line.
SF2I.7 • 12:00
Analysis of Spatiotemporal Couplings in Noncollinear Optical Parametric Chirped-Pulse Amplifiers, Achut Giree1,2, Federico Bensch1, Mark Mero1, Gunnar Arisholm1, Marc J. Vrakking1; 1Max Born Inst., Germany; 2Universität Hannover, Inst. of Quantum Optics, Germany; 3CNRS UMR 7335, Institut de Physique Nucléaire de Lyon, France.
We study spatiotemporal couplings in noncollinear optical parametric chirped-pulse amplifiers using 3-dimensional numerical simulations. We focus on the first order distortions under different amplification conditions and show that pulse front tilt is almost always present.

SF2L.6 • 12:15
Injection Locking of High-β Quantum Dot Microlasers, Steffen Holzinger1, Elisabeth Schlottmann1, Benjamin Lingnau1, Kathy Lüdge1, Christian Schneider1, Martin Kamp2, Sven Höffling1, Janik Wolters1, Stephan Reitzenstein1; 1Technische Universität Berlin, Germany; 2Universität Basel, Switzerland. We experimentally and theoretically investigate injection locking of high-β microlasers and show simultaneous stationary oscillation synchronized to the external signal and at the solitary frequency, where their macroscopic counterparts exhibit perfect synchronization or chaotic dynamics.
Concurrent sessions are grouped across four pages. Please review all four pages for complete session information.