CLEO: QELS-Fundamental Science

08:00–10:00
QTh1A • Novel Phenomena in Complex Media
Presider: Vera Smolyaninova; Towson University, United States

QTh1A.1 • 08:00
Photonic Floquet Topological Insulators, Yonatan Plotnik[1], Julia Zeuner[2], Mikael C. Rechtsman[1], Yaakov Lumer[1], Mordechai Segev[1], Alexander Szameit[2]; *[1]Technion Israel Institute of Technology, Israel; [2]Friedrich-Schiller-Universität, Germany.* We present the first experimental observation of a Floquet Topological Insulator in any physical system. We realize optical topologically-protected unidirectional edge states, without magnetic fields, using honeycomb photonic lattice of helical waveguides.

QTh1A.2 • 08:15
Weyl points and line nodes in 3D photonic crystals, Ling Lu[1], Liang Fu[1], Marin Soljacic[1], John D. Joannopoulos[1]; *[1]Massachusetts Institute of Technology, USA.* We present theoretical discoveries of frequency-isolated Weyl points and line nodes, 3D linear point- and line-degeneracies, in gyroid photonic crystals. The associated surface states exhibit topological-protection and flat bands realizable from microwave to optical frequencies.

QTh1A.3 • 08:30
Ultra-Strong Light-Matter Interaction with Mid-infrared Metamaterials, Alexander Benz[1,2], Salvatore Campione[3], Ines Montano[2], Sheng Liu[1,2], John Klem[2], Michael B. Sinclair[2], Filippo Capolino[3], Igal Brener[1,2]; *[1]Center for Integrated Nanotechnologies (CINT), Sandia National Laboratories, USA; [2]Sandia National Laboratories, USA; [3]Electrical Engineering and Computer Science, University of California, Irvine, USA.* We present ultra-strong light-matter interaction of a metamaterial mode and an intersubband transition for normal incidence radiation in the Mid-infrared spectral region. The anti-crossed lines show a splitting of 15% of the central frequency.

QTh1A.4 • 08:45
Ultrafast control of near field coupling in terahertz metamaterials, DIBAKAR ROY CHOWDHURY[1], Ranjan Singh[1], Hou-Tong Chen[1], Antoinette Taylor[1], Abul K. Azad[1]; *[1]LOS ALAMOS NATIONAL LABORATORY, USA.* We demonstrate ultrafast optical control of near field coupled metamaterial resonances. We observed dynamical transition of the metamaterial resonances to change its state from coupled to decoupled, and back to the coupled state under photoexcitation.

08:00–10:00
QTh1B • Active Plasmonics & Graphene
Presider: Timothy Davis, CSIRO Materials Science and Engineering, Australia

QTh1B.1 • 08:00 Invited
Graphene Nano-optoelectronics, Frank Koppens[1]; *[1]ICFO - The Institute of Photonic Sciences, Spain.* In this talk I will review the new and strongly emerging field of graphene nanophotonics. In particular, we use the remarkable nano-optical properties of graphene for inducing strong light-matter interactions and to study quantum phenomena at the level of single photons and plasmons.

QTh1B.2 • 08:30
Graphene Micro- and Nano-Plasmonics, Parinita Nene[1], Jared Strait[1], Wei Min Chan[1], Christina Manolatou[1], Joshua W. Kevek[2], Sandip Tiwari[1], Paul L. McEuen[2], Farhan Rana[1]; *[1]School of Electrical Engineering and Computer Science, Cornell University, USA; [2]Department of Physics, Cornell University, USA.* We present experimental and theoretical results of confined plasmons in graphene micro- and nano-structures. We present a FDTD technique to accurately model the measured data and demonstrate the importance of interactions between plasmonic structures.

QTh1B.3 • 08:45
Broad electrical tuning of graphene-loaded optical antennas, Yu Yao[1], Mikhail Kats[1], Patrice Genevet[1], Nanfang Yu[1,3], Yi Song[2], Jing Kong[2], Federico Capasso[1]; *[1]School of Engineering and Applied Sciences, Harvard University, USA; [2]Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology, USA; [3]Department of Applied Physics and Applied Mathematics, Columbia University, USA.* We demonstrate electrical tuning of graphene-loaded optical antennas over a broad wavelength range (~650 nm, 10% of the resonance frequency) and optical intensity modulation with a bandwidth of 600 nm in the Mid-infrared wavelength range.

CLEO: Science & Innovations

08:00–10:00
CTh1C • Microresonators III
Presider: Hiroshi Yasaka; Tohoku University, Japan

CTh1C.1 • 08:00
Linearized Silicon Modulator, Jaime Cardenas[1], Paul A. Morton[2], Jacob Khurgin[3], Austin Griffith[1], Carl B. Poitras[1], Michal Lipson[1,4]; *[1]Cornell University, USA; [2]Morton Photonics, USA; [3]Johns Hopkins University, USA; [4]Kavli Institute at Cornell, USA.* We demonstrate a linearized ring assisted Mach-Zehnder interferometer (L-RAMZI) modulator in a miniature silicon device. We measure a high degree of linearization, with a Spurious Free Dynamic Range (SFDR) of 105 dB/Hz$^{2/3}$ at 1GHz.

CTh1C.2 • 08:15
Modulating Silicon Resonators beyond the Linewidth Limit, Lawrence D. Tzuang[1], Mohammad Soltani[1], Michal Lipson[1,2]; *[1]School of Electrical and Computer Engineering, Cornell University, USA; [2]Kavli Institute at Cornell, Cornell University, USA.* We overcome the resonance linewidth limit in silicon ring modulators using photonic transitions between neighboring resonances. As an example, we demonstrate a silicon ring modulated at >20 GHz beyond its resonance linewidth of 11.5 GHz.

CTh1C.3 • 08:30
High-speed Digital and Analog Charge-Discharge Microring Modulator Not Limited by Q-factor, Anna Kodanev[1], Meir Orenstein[1]; *[1]Electrical Engineering, Technion, Israel.* A new Charge-Discharge microring modulator configuration having RF-bandwidth and extinction ratio not limited by Q-factor is presented. Digital and linear analog modulation bandwidth over 50GHz are shown to be feasible.

CTh1C.4 • 08:45
Integrated Control of Silicon-photonic Microresonator Wavelength with Balanced Homodyne Locking, Jonathan A. Cox[1], Douglas C. Trotter[1], Andrew L. Starbuck[1]; *[1]Sandia National Laboratories, USA.* We present a new method for active control of photonic micro-resonator modulator and filter wavelength that is insensitive to environmental and optical perturbations and readily integrated on-chip. Experimental results demonstrating precise filter locking are shown.

CLEO: QELS-Fundamental Science

08:00–10:00
QTh1D • Strong-field Interactions
Presider: John NEES, University of Michigan, USA

QTh1D.1 • 08:00
Probing Sub-Cycle Dynamics of Virtual States with Attosecond Transient Absorption, Michael Chini[1], Xiaowei Wang[1,2], Yan Cheng[1], Yi Wu[1], Di Zhao[3,4], Dmitry Telnov[3,5], Shih-I Chu[3], Zenghu Chang[1]; *[1]CREOL and Dept. of Physics, University of Central Florida, USA; [2]Dept. of Physics, National University of Defense Technology, China; [3]Dept. of Chemistry, University of Kansas, USA; [4]Dept. of Applied Physics, Xi'an Jiaotong University, China; [5]Dept. of Physics, St. Petersburg State University, Russian Federation.* Isolated attosecond pulses with continuum spectra extending below 15 eV are used to probe the sub-cycle energy shifts and splitting of helium excited states. Additionally, new absorption features appear far from the 1snp absorption lines.

QTh1D.2 • 08:15
Controlling dielectric properties with light fields, Martin Schultze[2,5], Elisabeth M. Bothschafter[1,4], Annkatrin Sommer[1], Simon Holzner[1], Wolfgang Schweinberger[1], Reinhard Kienberger[1,4], Vadym Apalkov[3], Mark Stockman[3], Ferenc Krausz[1,2], Vladislav S. Yakovlev[1,2]; *[1]Laboratory for Attosecond and High-Field Physics, Max-Planck-Institut für Quantenoptik, Germany; [2]Fakultät für Physik, Ludwig-Maximilians-Universität, Germany; [3]Department of Physics, Georgia State University, USA; [4]Physik-Department, Technische Universität München, Germany; [5]Department of Chemistry, UC Berkeley, USA.* This work reports on the attosecond real-time observation of the electron processes underlying the ability of ultrastrong few-cycle laser pulses to turn a dielectric solid from an insulating into a conducting state

QTh1D.3 • 08:30
Tunneling Time in Ultrafast Science is Real and Probabilistic, Jochen Maurer[1], Alexandra S. Landsman[1], Matthias Weger[1], Robert Boge[1], André Ludwig[1], Sebastian Heuser[1], Claudio Cirelli[1], Lukas Gallmann[1], Ursula Keller[1]; *[1]Department of Physics, ETH Zurich, Switzerland.* We present experimental results and approach of an angular streaking experiment with elliptically polarized intense few cycle laser pulses that exhibit a real tunneling time in tunnel ionization.

QTh1D.4 • 08:45
Electron Shell Ionization of Atoms with Classical, Relativistic Scattering, Nagitha Ekanayake[1], Sui Luo[1], Patrick Grugan[1], Willow Crosby[1], Arielle Camilo[1], Caitlin McCowan[1], Rosie Scalzi[1], Anthony Tramontozzi[1], Lauren Howard[1], Sarah Wells[1], Chris Mancuso[1], Teddy Stanev[1], Matthew Decamp[1], Barry C. Walker[1]; *[1]Department of Physics and Astronomy, University of Delaware, USA.* Forward scattering of ionization from noble gases in ultrahigh intensities of 2×10^19 W/cm^2 is investigated. The observed strongly forward scattered photoionization is in agreement with classical field scattering employing the full non-paraxial laser field.

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

08:00–10:00
QTh1E • Quantum Photonics
Presider: Alexander Gaeta; Cornell University, United States

QTh1E.1 • 08:00
Correlated Photon-Pair Generation in the Low-Raman Window of a Chalcogenide Ge11.5As24Se64.5 nanowire, Chunle Xiong[1], Jiakun He[1], Alex S. Clark[1], Matt J. Collins[1], Xin Gai[2], Duk-Yong Choi[2], Steve J. Madden[2], Barry Luther-Davies[2], Benjamin J. Eggleton[1]; *[1]Physics, University of Sydney, Australia; [2]Physics, Australian National University, Australia.* We experimentally demonstrate a 10 times enhancement to the coincidence-to-accidental ratio of a correlated photon-pair source from a chalcogenide Ge11.5As24Se64.5 nanowire. This improvement is enabled by the low-Raman window of the device.

QTh1E.2 • 08:15
Photon pair generation in nonlinear adiabatic waveguiding structures, Che Wen Wu[1], Alexander Solntsev[1], Dragomir N. Neshev[1], Andrey A. Sukhorukov[1], Yuri S. Kivshar[1]; *[1]Nonlinear Physics Centre,Research School of Physics and Engineering, Australian National University, Australia.* We propose a novel scheme for broadband generation of spatially entangled photon-pair states combined with efficient spatial pump filtering. This is achieved through spontaneous parametric down-conversion in a system of nonlinear adiabatically coupled waveguides.

QTh1E.3 • 08:30 Invited
Four-wave mixing and generation of correlated photon pairs in silicon ring resonators and photonic molecules, Stefano Azzini[1], Davide Grassani[1], Michael John Strain[2], Philippe Velha[2], Marc Sorel[2], Lukas G. Helt[3], John E. Sipe[3], Dario Gerace[1], Marco Liscidini[1], Matteo Galli[1], Daniele Bajoni[4]; *[1]Dipartimento di Fisica, Universita degli Studi di Pavia, Italy; [2]School of Engineering, University of Glasgow, United Kingdom; [3]Department of Physics and Institute for Optical Sciences, University of Toronto, Canada; [4]Dipartimento di Ingegneria Industriale e dell'Informazione, Universita degli Studi di Pavia, Italy.* We study, both theoretically and experimentally, emission of correlated photon-pairs by spontaneous four-wave-mixing in silicon integrated resonators. We show that the number of generated pairs in the quantum experiment is predicted by a classical experiment.

08:00–10:00
CTh1F • Four-wave Mixing & Frequency Comb Generation
Presider: Jeremy O'Brien; University of Bristol, United Kingdom

CTh1F.1 • 08:00 Invited
Nanophotonic Structures for Extreme Nonlinearities On-chip, Michal Lipson[1]; *[1]Cornell Univ., USA.* We show unprecedented strong nonlinear response from high confinement nanophotonic waveguides from the NIR to the Mid IR spectral range, by controlling the dispersion and the effective nonlinearities though novel nanofabrication techniques and novel materials.

CTh1F.2 • 08:30
Mid-infrared Generation by Frequency Down-Conversion Across 1.2 Octaves in a Normally-Dispersive Silicon Wire, Bart Kuyken[1], Peter Verheyen[2], Pamela Tannouri[3], Joris Van Campenhout[2], Roel Baets[1], Gunther Roelkens[1], William M. Green[3]; *[1]Photonics Research Group, Ghent University, Belgium; [2]imec, Belgium; [3]IBM T.J. Watson Research Center, USA.* Using four-wave mixing in normally-dispersive Mid-infrared silicon nanophotonic waveguides, we demonstrate the conversion of light across more than 1.2 octaves, from the telecom band to a wavelength of 3630 nm

CTh1F.3 • 08:45
Hybrid Electro-Optic Microcombs and Frequency Domain Analysis of Modelocking in Microresonators, Pascal Del'Haye[1], Scott B. Papp[1], Scott Diddams[1]; *[1]NIST, USA.* We present a hybrid electro-optically modulated microcomb system for stabilization of frequency comb repetition rates beyond 100 GHz at the 10^{-15} level. Moreover, we present frequency domain measurements on mode-locked states in microrod resonators.

08:00–10:00
CTh1G • Microdisks, Microrings & DFB's
Presider: Dominic Siriani, MIT Lincoln Laboratory, USA

CTh1G.1 • 08:00
Widely tunable laser with Dual Ring Resonator and Delayed Interferometer pairs, realized in generic InP technology, pieter kuindersma[1], Xaveer Leijtens[1], Johan van Zantvoort[1], Huug de Waardt[1]; *[1]TUE,COBRA INSTITUE, Netherlands.* A new widely and continuously tunable ring laser contains an integrated series filter with a Vernier pair of Ring Resonators (RR) and a pair of identical Delayed Interferometers (DI). Tuning currents of only a few mA yield tuning ranges of 2000 GHz.

CTh1G.2 • 08:15
AlGaInAs/InP Waveguide-Coupled Unidirectional-Emission Microspiral Lasers for On-Chip Optical Interconnects, Yue-De Yang[1,2], Yu Zhang[1], Yong-Zhen Huang[2], Andrew W. Poon[1]; *[1]Photonic Device Laboratory, Department of Electronic and Computer Engineering, The Hong Kong University of Science and Technology, Hong Kong; [2]State Key Laboratory on Integrated Optoelectronics, Institute of Semiconductors, Chinese Academy of Sciences, China.* We demonstrate AlGaInAs/InP waveguide-coupled unidirectional-emission microspiral lasers. Our experiments reveal room-temperature continuous-wave electrically injection lasing for 30μm-radius microspiral lasers, with a side-mode-suppression ratio exceeding 30 dB.

CTh1G.3 • 08:30
Graphene-contact electrically driven microdisk lasers, Yoon-Ho Kim[1], Soon-Hong Kwon[2], Jung Min Lee[3], Min-Soo Hwang[1], Ju-Hyung Kang[1], Won il Park[3], Hong-Gyu Park[1]; *[1]Department of Physics, Korea University, Republic of Korea; [2]Department of Physics, Chung-Ang University, Republic of Korea; [3]Division of Materials Science and Engineering, Hanyang University, Republic of Korea.* We demonstrated an electrically driven microdisk laser using a transparent graphene electrode. Lasing operation was achieved with a low-threshold current of ~300 μA at room temperature.

CTh1G.4 • 08:45
Nine-Channel Wavelength Tunable Single Mode Laser Array Based on Slots, Wei-Hua Guo[1], Qiaoyin Lu[2], Marta Nawrocka[2], Azat Abdullaev[2], James O'Callaghan[3], John Donegan[2]; *[1]Department of Electrical & Computer Engineering, University of California Santa Barbara, USA; [2]School of Physics, Trinity College Dublin, Ireland; [3]Tyndall National Institute, Ireland.* We present a 9-channel wavelength-tunable single-mode laser array based on slots. Stable single-mode operation is observed with output-power >35mW and side-mode-suppression-ratio >50dB. A quasi-continuous tuning range >27nm is obtained over 35°C (from 10°C to 45°C).

08:00–10:00
CTh1H • Ultrafast Laser Sources I
Presider: Bruno Schmidt; Institut National de la Recherche Sci., Canada

CTh1H.1 • 08:00 Invited
Atomic Inner-Shell X-Ray Lasers pumped by XFEL sources, Nina Rohringer[1,2], Clemens Weninger[1,2], MIchael Purvis[3], Duncan Ryan[3], Gregory Brown[4], Felicie Albert[4], James Dunn[4], Alexander Graf[4], Stefan Hau-Riege[4], John Bozek[5], Christoph Bostedt[5], Richard London[4], Jorge Rocca[3]; *[1]Max Planck Insitute for the Physics of Complex Systems, Germany; [2]Center for Free-Electron Laser Science, Germany; [3]NSF ERC for Extreme Ultraviolet Science and Technology, Colorado State University, USA; [4]Lawrence Livermore National Laboratory, USA; [5]SLAC National Accelerator Laboratory, USA.* We present results on the realization of an atomic inner-shell x-ray laser in neon at 1.46 nm wavelength, by photo-ionization pumping and, alternatively, stimulated resonant Raman scattering with an x-ray free-electron laser source.

CTh1H.2 • 08:30
Watt-level Kerr-Lens Mode-Locked Cr:ZnS Laser at 2.4 μm, Nikolai Tolstik[1], Irina T. Sorokina[1], Evgeni Sorokin[2]; *[1]Institute of Physics, Norwegian University of Science and Technology, Norway; [2]Institut für Photonik, TU Wien, Austria.* Power scaling of Kerr-lens mode-locked Cr:ZnS femtosecond oscillator allows reaching 1 W output power and pulse energies over 8 nJ. Soliton and chirped-pulse regimes result in 68 fs and 0.8-2 ps pulses, respectively.

CTh1H.3 • 08:45
Kerr lens mode-locking of a high-average-power thin-disk ring oscillator, Abdolreza Amani Eilanlou[1], Yasuo Nabekawa[1], Makoto Kuwata-Gonokami[2,3], Katsumi Midorikawa[1,2]; *[1]Laser Technology Laboratory, RIKEN Advanced Science Institute, Japan; [2]Photon Science Center, The University of Tokyo, Japan; [3]Graduate School of Science, The University of Tokyo, Japan.* We have generated 16.5-MHz, 400-fs pulses with a power of 490 W in a thin-disk ring oscillator under development for intra-cavity high-order harmonic generation.

CLEO: Applications & Technology

08:00–10:00
ATh1I • Environmental Sensing
Presider: John McManus; Aerodyne Research Inc, United States

ATh1I.1 • 08:00
Detection of the Mass of Particles in Air in an Optical Sensor utilizing Laser Beam Divergence and inertia-dependent Particle Trajectories, Robert Schrobenhauser[1,2], Rainer Strzoda[1], Maximilian Fleischer[1], Alexander Hartmann[1], Markus-Christian Amann[2]; [1]*Siemens, Germany;* [2]*Tech. Univ. Munich, Germany.* We present a new method to measure particle mass based on a shaped, divergent laser beam using the inertia-dependent particle movement inside an optical light scattering measurement chamber.

ATh1I.2 • 08:15
Application of Faraday Rotation Spectroscopy for Quantifying HO_2 Radicals in Combustion Processes, Brian Brumfield[1], Wenting Sun[2], Gerard Wysocki[1], Yiguang Ju[2]; [1]*Electrical Engineering, Princeton University, USA;* [2]*Mechanical and Aerospace Engineering, Princeton University, USA.* Faraday rotation spectroscopy has been used for in situ quantification of HO_2 generated from an atmospheric flow reactor. HO_2 species concentrations are determined by non-linear fitting of the experimental data to a signal model.

ATh1I.3 • 08:30 Invited
Airborne Atmospheric Laser Spectroscopy, Dirk Richter[1], Petter Weibring[1], James G. Walega[1], Alan Fried[1]; [1]*Institute of Arctic and Alpine Research, University of Colorado, USA.* Many important atmospheric constituents can be detected with infrared laser absorption spectroscopy. This talk reviews the engineering challenges, opportunities, and selected scientific results from recent airborne campaigns.

CLEO: Science & Innovations

08:00–10:00
CTh1J • Fabrications and Applications I
Presider: Sunao Kurimura; National Institute for Materials Science, Japan

CTh1J.1 • 08:00 Invited
Nanostructured optical polymer surfaces by imprinting and injection moulding, Anders Kristensen[1], Jeppe Clausen[2], Alexander B. Christiansen[1], Emil Højlund-Nielsen[1], Claus H. Nielsen[3], Claus Fogh Hansen[4], Tommy Kristiansen[4], Erik Lyngsø Simonsen[4], Per Høvsgaard[4], N. Asger Mortensen[2]; [1]*DTU Nanotech, Danmarks Tekniske Universitet, Denmark;* [2]*DTU Fotonik, Danmarks Tekniske Universitet, Denmark;* [3]*DTU Danchip, Danmarks Tekniske Universitet, Denmark;* [4]*LEGO System A/S, Denmark.* Nanostructured polymer surfaces with optical functionality are fabricated by up-scalable methods, nanoimprinting and injection moulding. The fabrication and performance of nanostructured polymer surfaces with anti-reflective functionality are discussed.

CTh1J.2 • 08:30
Silicon Nanomembrane Based Photonic Devices on Foreign Substrates, Xiaochuan Xu[1], Harish Subbaraman[2], Amir Hosseini[2], Ray T. Chen[1]; [1]*University of Texas at Austin, USA;* [2]*Omega Optics, Inc., USA.* We demonstrate transferring 2cm x 2cm unpatterned nanomembrane onto glass substrates. A photonic crystal waveguide is patterned together with subwavelength grating couplers on the transferred nanomembrane. Group index up to 26.5 is experimentally demonstrated.

CTh1J.3 • 08:45
III-As Pillar Arrays by Metal-Assisted Chemical Etching for Photonic Applications, Parsian Mohseni[1], Pan Lei[1], Xiang Zhao[1], Seung Hyun Kim[1], Karthik Balasundaram[1], Jeong Dong Kim[1], James Coleman[1], Xiuling Li[1]; [1]*Electrical and Computer Engineering, University of Illinois, USA.* Ordered arrays of GaAs/InGaAs micro and nanopillars are formed by metal-assisted chemical etching (MacEtch). The dependence of morphology and etch rate upon temperature, etchant composition, and doping concentration are explored and optical characteristics are discussed.

08:00–10:00
CTh1K • THz Waveguides and Resonators
Presider: Marco Rahm; Technische University Kaiserslautern, Germany

CTh1K.1 • 08:00
Terahertz plasmonic waveguide based on periodically structured silicon surface, Mohammad M. Jadidi[1], Gagan Kumar[1], Shanshan Li[1], Thomas E. Murphy[1]; [1]*Institute for Research in Electronics and Applied Physics, University of Maryland, USA.* We experimentally investigated terahertz (THz) plasmonic waveguides on heavily doped silicon surface structured with sub-wavelength pillars. We study the propagation properties of the resonant modes and their dependence on dopant concentration and structural parameters.

CTh1K.2 • 08:15
Complex Geometry Plasmonic Terahertz Waveguides Created via 3D Printing, Shashank Pandey[1], Barun Gupta[1], Ajay Nahata[1]; [1]*University of Utah, USA.* We demonstrate the applicability of 3D printing for creating complex terahertz waveguide geometries that are difficult to fabricate using other approaches. We will describe the properties of linear waveguides, y-splitters and spiral waveguides.

CTh1K.3 • 08:30
A 2D Maxwell's Fish Eye Lens using Waveguide-based Inhomogeneous Artificial Dielectrics, Jingbo Liu[1], Rajind Mendis[1], Daniel Mittleman[1]; [1]*Rice University, USA.* We realize a 2D Maxwell's fish eye lens using waveguide-based inhomogeneous artificial dielectrics. The lens images a source at the perimeter to a diametrically opposite location, regardless of the direction of the input illumination.

CTh1K.4 • 08:45
Plasmonic Two Wire Terahertz Fibers with Highly Porous Dielectric Support, Andrey Markov[1], Stephan Gorgutsa[1], Hang Qu[1], Maksim Skorobogatiy[1]; [1]*Engineering Physics, École Polytechnique de Montréal, Canada.* A practical plasmonic THz fiber is described that features two metallic wires held together by the porous dielectric cladding. High porosity is required in order to guarantee low loss and low dispersion of guided modes.

CLEO: QELS-Fundamental Science

08:00–10:00
QTh1L • Optical Memories and Atomic Ensembles
Presider: James Thompson; University of Colorado at Boulder JILA, United States

QTh1L.1 • 08:00 Invited
Solid-state Quantum Memory for Quantum Communication, Mikael T. Afzelius[1]; [1]*Group of Applied Physics, University of Geneva, Switzerland.* Optical quantum memories are essential components of future quantum technologies. Here we show experimental results of heralded quantum entanglement between two memories, storage of single-photon polarization qubits and milliseconds spin-wave storage using rare-earth doped crystals.

QTh1L.2 • 08:30
A Reversible Optical Memory for Twisted Photons, Lucile Veissier[1], Adrien Nicolas[1], Lambert GINER[1], Dominik Maxein[1], Alexandra Sheremet[2], Elisabeth Giacobino[1], Julien Laurat[1]; [1]*Laboratoire Kastler Brossel, Université Pierre et Marie Curie, Ecole Normale Supérieure, CNRS, France;* [2]*Department of Theoretical Physics, State Polytechnic University, Russian Federation.* We report on an experiment in which orbital angular momentum is mapped at the single photon level into and out of an atomic ensemble, opening the possibility to the storage of qubits encoded in OAM.

QTh1L.3 • 08:45
Simultaneous observation of super-Heisenberg scaling and spin squeezing in a nonlinear measurement of atomic spins, Robert Sewell[1], Mario Napolitano[1], Naeimeh Behbood[1], Giorgio Colangelo[1], Ferran Martin Ciurana[1], Morgan W. Mitchell[1,2]; [1]*Institut de Ciencies Fotoniques, Spain;* [2]*ICREA, Spain.* We report a nonlinear alignment-to-orientation conversion measurement of atomic spins that simultaneously shows super-Heisenberg scaling and achieves projection-noise limited sensitivity of 990 spins, 20 dB more sensitive than the previous best nonlinear measurement.

CLEO: Science & Innovations

08:00–10:00
CTh1M • Next Generation Photovoltaics

Presider: Jonathan Wierer; Sandia National Laboratories, United States

CTh1M.1 • 08:00

Limits on nanophotonic solar cell light trapping in the presence of parasitic losses, Aaswath Raman[1], Shanhui Fan[2]; [1]*Applied Physics, Stanford University, USA;* [2]*Ginzton Laboratory, Stanford University, USA.* We rigorously determine the effect of parasitic loss on the achievable absorption enhancement in nanophotonic, plasmonic light trapping schemes. We show that, even in the presence of parasitic loss, opportunities exist to exceed conventional limits.

CTh1M.2 • 08:15

Light Trapping Using Silicon Nanostructures for Solar Cells, nche fofang[1,2], Ting S. Luk[1,2], Murat Okandan[1], Gregory Nielson[1], Igal Brener[1,2]; [1]*Sandia National Laboratories, USA;* [2]*Center for Integrated Nanotechnologies, Sandia National Laboratories, USA.* Silicon nanostructures are used for efficiency enhancement in Silicon solar cells. A 2 μm thick solar cell with silicon nanostructures on the front and back surfaces show photocurrent of 26.7 mA/cm2 (77% of the Yablonovitch limit).

CTh1M.3 • 08:30 Invited

III-V Compound Semiconductor Nanowire Solar Cells, Takashi Fukui[1], Masatoshi Yoshimura[1], Eiji Nakai[1], Katsuhiro Tomioka[1,2]; [1]*RCIQE, Hokkaido Univ., Japan;* [2]*JST-PRESTO, Japan.* Core-multi-shell InP/AlInP nanowire-array solar cells were fabricated using selective-area metal-organic vapor phase epitaxy. The wider-bandgap outer shell layer passivates InP nanowires effectively, increasing conversion efficiency to 6.35%.

CLEO: Applications & Technology

08:00–10:00
ATh1N • Clinical Applications

Presider: Nicusor Iftimia; Physical Sciences Inc., United States

ATh1N.1 • 08:00 Invited

OCT-Guided Anterior Eye Surgery, David Huang[1]; [1]*Casey Eye Institute, Oregon Health and Science Univ., USA.* Optical coherence tomography can accurately map corneal, epithelial, stromal thicknesses, and measure corneal curvatures. It's useful in planning LASIK, calculating intraocular lens power, guiding phototherapeutic keratectomy, and managing corneal transplantations.

ATh1N.2 • 08:30

An Automated Raman Device for Gout Diagnosis, Bolan Li[1]; [1]*Mechanical and Aerospace Engineering, Case Western Reserve University, USA.* This study reports an automated Raman device to identify crystals in synovial aspirates from patients with gout symptoms. Combined with sample preparation, the device could diagnose monosodium urate monohydrate crystals in a point-and-shoot sense.

ATh1N.3 • 08:45

Optimization of Illumination Frequency and Preclinical Validation of a Wide-field Structured Illumination Microscope Designed for Imaging in situ Tumor Margins, Henry L. Fu[1], Jenna L. Mueller[1], Melodi Javid[2], David Kirsch[2,3], Nimmi Ramanujam[1], J. Quincy Brown[4]; [1]*Biomedical Engineering, Duke University, USA;* [2]*Pharmacology & Cancer Biology, Duke University, USA;* [3]*Radiation Oncology, Duke University, USA;* [4]*Biomedical Engineering, Tulane University, USA.* We present a widefield structured illumination microscope for imaging surgical tumor margins in situ. The impact of frequency and turbidity on optical section thickness and SNR was characterized to determine the optimal imaging frequency.

08:00–10:00
ATh10 • Symposium on The Path to Sustainable Energy: Laser Driven Inertial Fusion EnergyAlternative Laser ICF Concepts

Presider: Christopher Barty; Lawrence Berkeley National Laboratory, United States

ATh10.1 • 08:00 Invited

Fast Ignition With Laser-Driven Ion Beams: Progress On Ignitor Beam Development Based On A New Relativistic Laser-Plasma Regime, J.C. Fernandez[1]; [1]*Los Alamos National Laboratory, USA.* Requirements for fast ignition (FI) are explained. Relativistically-transparent plasmas (a new regime) enable suitable laser-driven ignitor ion beams. Progress on generating and understanding these beams, plus the laser and target requirements for FI, are discussed.

ATh10.2 • 08:30 Invited

Implosion and heating experiments of fast ignition targets by Gekko-XII and LFEX lasers, Hiroyuki Shiraga[1]; [1]*Inst. of Laser Eng., Osaka Univ., Japan.* Implosion and heating experiments of fast ignition targets has been performed with Gekko-XII and LFEX lasers, and neutron enhancement was demonstrated. Goal of the FIREX-1 project is to achieve fuel heating up to 5 keV.

CLEO: QELS-Fundamental Science

QTh1A • Novel Phenomena in Complex Media—Continued

QTh1A.5 • 09:00
Electromechanically Switchable Diamagnetism for Efficient Terahertz Modulation, Mehmet Unlu[1,2], Christopher W. Berry[1], Shenglin Li[1], Shang Hua Yang[1], Mohammed Reza Hashemi[1], Mona Jarrahi[1]; *[1]Electrical Engineering and Computer Science, University of Michigan, USA; [2]Electronics and Communication Eng. Dept., Yildirim Beyazit University, Turkey.* A meta-surface with electromechanically switchable diamagnetic terahertz meta-molecules is presented and experimentally demonstrated, which enables record-high modulation depths and modulation bandwidths at terahertz frequencies without a compromise on modulation speed and modulation voltage.

QTh1A.6 • 09:15
Enhanced electro-optic modulation in a single split-ring resonator, Dmitry Shchegolkov[1], Matthew Reiten[1], Dibakar Chowdhury[1], Antoinette Taylor[1], Abul K. Azad[1]; *[1]Los Alamos National Laboratory, USA.* We study experimentally and numerically the electro-optic (EO) effect in a single split-ring-resonator (SRR) fabricated on a ZnTe-substrate resonating at 3 GHz. Measured EO signals at SRR-gap show an order of magnitude enhancement at resonance.

QTh1A.7 • 09:30
A Subwavelength Plasmonic Metamolecule Exhibiting Magnetic-Based Optical Fano Resonance, Farbod Shafiei[1], Francesco Monticone[1], Khai Le[1], Xingxiang Liu[1], Tom Hartsfield[1], Andrea Alu[1], Xiaoqin Li[1]; *[1]University of Texas at Austin, USA.* We demonstrate that a subwavelength plasmonic metamolecule consisting of four nanoparticles supports a magnetic response spectrally overlapped with the electric dipole resonance. Small structural asymmetries lead to interference and thus a Fano resonance in scattering.

QTh1A.8 • 09:45
Time Domain Modeling of Tunable Response of Graphene, Ludmila J. Prokopeva[1], Naresh K. Emani[1], Alexandra Boltasseva[1,2], Alexander Kildishev[1]; *[1]School of Electrical and Computer Engineering and Birck Nanotechnology Center, Purdue University, USA; [2]Department of Photonics Engineering, Technical University of Denmark, Denmark.* We present a causal numerical model for time domain simulations of the optical response of graphene. The dielectric function is approximated with a conductivity term, a Drude term and a number of the critical points terms.

QTh1B • Active Plasmonics & Graphene—Continued

QTh1B.4 • 09:00
Large Modulation of Mid-infrared Light Using Graphene-Metal Plasmonic Antennas, nanfang yu[1]; *[1]Department of Applied Physics and Applied Mathematics, Columbia University, USA.* We show theoretically that large modulation of the amplitude and phase of Mid-infrared light can be achieved by dynamically shifting the resonance of graphene-metal plasmonic antennas via electrical tuning of the optical conductivity of graphene.

QTh1B.5 • 09:15
Electrical Control of Optical Plasmon Resonance with Graphene, Jonghwan Kim[1], Hyungmok Son[1], David Cho[1], Baisong Geng[1], Will Regan[1], Sufei Shi[1], Kwanpyo Kim[1], Alex Zettl[1], Yuen-Ron Shen[1], Feng Wang[1]; *[1]UC Berkeley, USA.* We demonstrate efficient control of optical plasmon resonance in gold nanorod with graphene by electrical gating. We observe that electrical gating of graphene efficiently modulates all aspects of the plasmon resonance

QTh1B.6 • 09:30
Graphene-doped Polymer Optical Nanofibers, Chao Meng[1], Limin Tong[1]; *[1]Optical Engineering, Zhejiang University, China.* By means of doping the initial dissolved polymer, we have successfully fabricated optical-quality graphene-doped polymer nanofibers by a physical drawing technique. Using a waveguiding scheme, single graphene-doped polymer nanofibers exhibit broadband saturable absorbance (transmission change~10%).

QTh1B.7 • 09:45
Electrically Tunable Plasmonic Absorber Enabled by Indium Tin Oxide, fei yi[1], Euijae Shim[1], Alexander Zhu[1], Hai Zhu[1], Jason Reed[1], Ertugrul Cubukcu[1]; *[1]Materials Science and Engineering, University of Pennsylvania, USA.* We demonstrate an optical antenna absorber with unity absorption based on gold nanostrip antenna with optical back mirror. Indium Tin Oxide is used as the active material to electrically tune the optical spectra.

CLEO: Science & Innovations

CTh1C • Microresonators III—Continued

CTh1C.5 • 09:00
Parallel-Coupled Adiabatic Resonant Microring (ARM) Filter with Integrated Heaters, Michele Moresco[1], Ehsan S. Hosseini[1], Erman Timurdogan[1], Douglas D. Coolbaugh[2], Gerald Leake[2], Michael R. Watts[1]; *[1]Research Laboratory of Electronics, Massachusetts Institute of Technology, USA; [2]College of Nanoscale Science and Engineering, University at Albany, USA.* Add-drop filters based on parallel adiabatic resonant microrings (ARMs) are demonstrated. The ARM design permits synthesis of maximally flat characteristics up to a FWHM of 54 GHz while keeping the ripple amplitude below 1 dB

CTh1C.6 • 09:15
On-Chip Mode-Division Multiplexer, Lian-Wee Luo[1], Lucas H. Gabrielli[1], Michal Lipson[1,2]; *[1]School of Electrical and Computer Engineering, Cornell University, USA; [2]Kavli Institute at Cornell for Nanoscale Science, Cornell University, USA.* We demonstrate micron-scale on-chip mode-division multiplexing device with low crosstalk using add-drop silicon ring resonators array. We taper the bus waveguide width to selectively phase-match the different bus waveguide modes to the ring mode.

CTh1C.7 • 09:30
Integrated Cascaded Linear Microcavity Filters, Marcel W. Pruessner[1], Peter G. Goetz[1], Todd H. Stievater[1], William S. Rabinovich[1], Vincent J. Urick[1]; *[1]US Naval Research Laboratory, USA.* We experimentally demonstrate cascaded microcavities for enhanced bandwidth and extinction. The cavities are integrated into waveguides by etching three sets of quarter-wavelength trenches, each set forming a reflector. Experiments compare well with transfer matrix predictions.

CTh1C.8 • 09:45
Low Tuning Voltage Hybrid Silicon and Lithium Niobate Optical Microring Resonator with Integrated Electrodes, Li Chen[1], Michael Wood[1], Ronald M. Reano[1]; *[1]Electrical and Computer Engineering, Ohio State University, USA.* We present a silicon microring resonator with a lithium niobate top cladding and integrated tuning electrodes. The silicon ring functions as an optically transparent conductor to yield a DC tunability of 12.5 pm/V.

CLEO: QELS-Fundamental Science

QTh1D • Strong-field Interactions—Continued

QTh1D.5 • 09:00
Cavity enhancement of ps pulses with 30 000 finesse, Fabian Zomer[1]; *[1]LAL/IN2P3, France.* We report on the first demonstration of the locking of a 28000 finesse cavity in picosecond regime. Besides, we have unambiguously measured the CEP drift of 2 ps pulses and characterized its effect on cavity locking

QTh1D.6 • 09:15
Self-compression of Femtosecond Laser Pulses in Ionization-Induced Plasmas from a Free Flow Gas Jet at Relativistic Intensities, Zhaohan He[1], John A. Nees[1], Bixue Hou[1], Karl Krushelnick[1], Alec Thomas[1]; *[1]Center for Ultrafast Optical Science, University of Michigan, USA.* We measure self-compression of femtosecond laser pulses in an experiment using simple geometrical focusing onto a 100 μm gas plume at relativistic intensities. Stable and uniform self-compression from 36 fs to 16 fs is measured using second-harmonic-generation frequency-resolved optical gating.

QTh1D.7 • 09:30
Generation of coherent N_2^+ emissions in a plasma string with two-color laser fields, Jinping Yao[1], Guihua Li[1], Jielei Ni[1], Huailiang Xu[2], Haisu Zhang[1], Bin Zeng[1], Wei Chu[1], Chenrui Jing[1], Hongqiang Xie[1], Ya Cheng[1], See Leang Chin[3], Zhizhan Xu[1]; *[1]State Key Laboratory of High Field Laser Physics, Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, China; [2]State Key Laboratory on Integrated Optoelectronics, College of Electronic Science and Engineering, Jilin University, China; [3]Center for Optics, Photonics and Laser (COPL) & Department of Physics, Engineering Physics and Optics, Université Laval, Canada.* We report on the generation of coherent N_2^+ emissions in a plasma string driven by two-color laser fields and measure their temporal structures. It is confirmed that the coherent emissions originate from seed-injected amplification.

QTh1D.8 • 09:45
Spatio-temporal phase-contrast imaging of tenuous laser plasma structures, Zhengyan Li[1], Yen-Yu Chang[1], Michael C. Downer[1]; *[1]University of Texas at Austin, USA.* We demonstrate a pump-probe phase-contrast method that reconstructs the spatio-temporal profile of plasma structures at density as low as 10^16 cm^-3. The method is compatible with very thin, very long, even turbulent media.

09:30–12:30 Technology Transfer Program, *Exhibit Hall 2*

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

10:00–15:00 Exhibits Open, *Exhibit Halls 1 and 2*

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

QTh1E • Quantum Photonics—Continued

QTh1E.4 • 09:00
A down-conversion source of positively spectrally correlated and decorrelated telecom photon pairs, Thomas Lutz[1], Piotr L. Kolenderski[1], Thomas Jennewein[1]; [1]*Physics, Institute for Quantum Computing, Canada.* We experimentally characterize a spontaneous parametric down-conversion source, based on a Beta-Barium-Borate crystal capable of emitting photons with positive or no spectral correlations. Our system employs a carefully designed detection method exploiting two InGaAs detectors.

QTh1E.5 • 09:15
Enhanced transmission for ultra-low-power nonlinear optics experiments using tapered optical fibers in Rubidium vapor, Todd B. Pittman[1], Meimei Lai[1], James D. Franson[1]; [1]*University of Maryland Baltimore County, USA.* We have studied transmission degradation for sub-wavelength diameter Tapered Optical Fibers in Rubidium vapor. A heating strategy is shown to reduce degradation, thereby enhancing the ability to perform ultra-low-power nonlinear optics experiments.

QTh1E.6 • 09:30
Bell's Measure as a Quantitative Tool in Classical Optical Coherence of Electromagnetic Fields, Kumel Kagalwala[1], Giovanni Di Giuseppe[1,2], Ayman F. Abouraddy[1], Bahaa Saleh[1]; [1]*CREOL, The College of Optics and Photonics, University of Central Florida, USA;* [2]*School of Science and Technology, University of Camerino, Italy.* We demonstrate an experimental measurement of Bell's inequality for a classical optical beam with two binary degrees of freedom: polarization and spatial parity; and illustrate the usefulness of this measure as a quantitative tool in classical optical coherence theory.

QTh1E.7 • 09:45
Experimental super resolved phase measurements at the shot noise limit, Lior Cohen[1], Hagai Eisenberg[1], Daniel Istrati[1], Liat Dovrat[1]; [1]*Racah Institue of Physics, Hebrew University of Jerusalem, Israel.* Using photon-number resolving detectors, we directly measure the parity of coherent states in a Mach-Zehnder interferometer. Phases are super resolved by a factor of 150 and shot noise limited measurements are demonstrated with 200 photons.

CTh1F • Four-wave Mixing & Frequency Comb Generation—Continued

CTh1F.4 • 09:00
On-chip Mode-locking in Microresonator Frequency Combs without Spectral Filtering and Shaping, Pei-Hsun Wang[1], Jian Wang[1,2], Yi Xuan[1,2], Leo T. Varghese[1,2], Li Fan[1,2], Yang Liu[1], Xin Zhao[3], Daniel E. Leaird[1], Minghao Qi[1,2], Andrew M. Weiner[1,2]; [1]*School of Electrical and Computer Engineering, Purdue University, USA;* [2]*Birck Nanotechnology Center, Purdue University, USA;* [3]*School of Electronic and Information Engineering, Beihang University, China.* We observe passive mode-locking behavior of an optical frequency comb generated in a silicon nitride microresonator. With the drop geometry, a femtosecond pulse could be generated without shaping and filtering the spectrum.

CTh1F.5 • 09:15
Pump Equalization and Saturation of Microresonator Frequency Combs with Drop Geometry, Pei-Hsun Wang[1], Yi Xuan[1,2], Leo T. Varghese[1,2], Li Fan[1,2], Jian Wang[1,2], Daniel E. Leaird[1], Minghao Qi[1,2], Andrew M. Weiner[1,2]; [1]*School of Electrical and Computer Engineering, Purdue University, USA;* [2]*Birck Nanotechnology Center, Purdue University, USA.* We report the spectral pump equalization of on-chip microresonator frequency combs in the drop-port geometry. A smoother comb spectrum is obtained and a saturation behavior of the optical pump in the microresonator is observed.

CTh1F.6 • 09:30
Efficient continuous-wave four-wave mixing in SOI waveguides with active carrier removal, Junrong Ong[1], Ranjeet Kumar[1], Shayan Mookherjea[1]; [1]*University of California San Diego, USA.* Silicon-on-insulator rib waveguides with low loss of -0.74 dB/cm and free-carrier lifetime reduction via reverse biased P/N diodes are used to show highly efficient CW four-wave mixing with conversion efficiency of -8 dB.

CTh1F.7 • 09:45
Optimum micro-optical parametric oscillators based on third-order nonlinearity, Xiaoge Zeng[1], Milos Popovic[1]; [1]*University of Colorado at Boulder, USA.* We show that optimum designs of optical parametric oscillators require different pump and signal/idler coupling, suggesting novel microphotonic geometries. Normalized models with linear/nonlinear loss show that Si can oscillate at 1550nm below certain free-carrier-to-cavity-photon-lifetime ratios.

CTh1G • Microdisks, Microrings & DFB's—Continued

CTh1G.5 • 09:00
Monolithic Narrow Linewidth Laterally-Coupled 1.55 µm DFB Laser and Optical Amplifier, Lianping Hou[1], Mohsin Haji[1], John H. Marsh[1]; [1]*University of Glasgow, United Kingdom.* We present a laterally-coupled 1.55 µm AlGaInAs/InP DFB laser monolithically integrated with an optical amplifier, providing an output power of 210 mW with single mode operation exhibiting a record low linewidth of 64 kHz.

CTh1G.6 • 09:15
Tunable Microwave Signal Generation with an Optically-Injected 1310nm Quantum Dot Distributed-Feedback Laser, Antonio Hurtado[1,2], Jesse Mee[1], Mohsen Nami[1], Ian D. Henning[2], Michael J. Adams[2], Luke Lester[1]; [1]*Center for High Technology Materials, University of New Mexico, USA;* [2]*School of Computer Science and Electronic Engineering, University of Essex, United Kingdom.* Tunable microwave signal generation with frequencies ranging from below 1 GHz to over 40 GHz is demonstrated experimentally using the period-1 dynamics induced in a 1310-nm Quantum Dot Distributed-Feedback laser under external optical injection.

CTh1G.7 • 09:30
Hertz relative linewidth DFB laser with high-finesse cavity external optical feedback, Yang Zhao[1,2], Qiang Wang[1,2], Fei Meng[1], Yige Lin[1], Shaokai Wang[1], Jianping Cao[1], Zhanjun Fang[1], Tianchu Li[1], Erjun Zang[1,2]; [1]*Division of Time and Frequency Metrology, National Institute of Metrology, China;* [2]*Department of Precision Instruments and Mechanology, Tsinghua University, China.* We report Hertz level relative linewidth DFB diode lasers with optical feedback technique. And laser noise is suppressed to a white phase noise plateau of -124.4 dBc/Hz higher than the Fourier frequency of 17 kHz.

CTh1G.8 • 09:45
Possibility for Breaking the Unity Efficiency Barrier: Semiconductor Laser Optically Pumped by an Integrated Light Emitting Diode, Xiaohang Liu[1], Yu Zhang[1], Guowei Zhao[1], Dennis G. Deppe[1]; [1]*CREOL, the College of Optics and Photonics, University of Central Florida, USA.* Experimental results and calculations are presented demonstrating a semiconductor laser integrated with a spontaneous light emitting diode optical pump that can also act as a heat pump. Simulation shows this device could break unity efficiency.

CTh1H • Ultrafast Laser Sources I—Continued

CTh1H.4 • 09:00
Pushing the limits of high-power modelocked thin disk lasers by operating in a vacuum environment, Clara J. Saraceno[1], Florian EMAURY[1], Oliver H. Heckl[1], Cyrill R. Baer[1], Martin Hoffmann[1], Cinia Schriber[1], Matthias Golling[1], Thomas Südmeyer[1,2], Ursula Keller[1]; [1]*ETH Zurich, Switzerland;* [2]*Physics, University of Neuchatel, Switzerland.* We present an Yb:YAG modelocked thin-disk laser with a record-high average output power of 275 W, a pulse duration of 583fs and a pulse energy of 16.9µJ. Furthermore, we present first experiments towards higher pulse energies.

CTh1H.5 • 09:15
Broadband mode-locking with phase-matched output couplers, Shih-Hsuan Chia[1], Li-Jin Chen[2], Franz X. Kärtner[1,2]; [1]*Center for Free-Electron Laser Science, DESY, Germany;* [2]*Electrical Engineering and Computer Science and Research Laboratory of Electronics, Massachusetts Institute of Technology, USA.* A phase-matched output coupler is introduced and used to improve broadband modelocking of a Ti:sapphire laser with a tunable enhancement of >15dB at long wavelengths while maintaining a good beam profile.

CTh1H.6 • 09:30
High-bandwidth, single-pole control of intracavity power in a mode-locked laser based on co-doped gain medium, Chien-Chung Lee[1], Thomas R. Schibli[1,2]; [1]*Department of Physics, University of Colorado at Boulder, USA;* [2]*JILA, National Institute of Standards and Technology and University of Colorado, USA.* An intracavity, low-insertion-loss graphene electro-optic modulator enables more than two orders of magnitude higher bandwidth for modulating the intracavity power in a laser based on co-doped gain medium than traditional pump power modulation.

CTh1H.7 • 09:45
Mode Locking At and Below the CW Threshold, Shai Yefet[1], Avi Pe'er[1]; [1]*Bar-Ilan University, Israel.* We explore experimentally a new regime of operation for mode locking in a Ti:Sapphire laser with enhanced Kerr nonlinearity, where the threshold for pulsed operation is lowered below the threshold for continuous-wave operation.

09:30–12:30 Technology Transfer Program, *Exhibit Hall 2*

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

10:00–15:00 Exhibits Open, *Exhibit Halls 1 and 2*

CLEO: Applications & Technology

ATh1I • Environmental Sensing—Continued

ATh1I.4 • 09:00
Long open-path high precision quantum cascade laser methane sensing at Toolik Lake, Alaska, David Miller[1,2], Anna Michel[2,3], Levi Stanton[1,2], Kang Sun[1,2], Lei Tao[1,2], Mark A. Zondlo[1,2]; *[1]Princeton University, USA; [2]Center for Mid-Iinfrared Technologies for Health and Environment, Princeton University, USA; [3]Applied Ocean Physics & Engineering, Woods Hole Oceanographic Institution, USA.* A long path quantum cascade laser atmospheric methane sensor is demonstrated in an Arctic environment. The sensor has 0.5% precision for methane in 1s and an in-line N2O reference cell to account for system drift.

ATh1I.5 • 09:15
Measurement of Water Vapor Isotopes in the Urban Environment Using a Quantum Cascade Laser-Based Analyzer, Wen Wang[1,2], Anna Michel[2,3], Mary Lynn Baeck[2,4], James Smith[2a], Gerard Wysocki[1,2]; *[1]Electrical Engineering, Princeton University, USA; [2]Center for Mid-infrared Technologies for Health and the Environment, Princeton University, USA; [3]Princeton Institute for the Science and Technology of Materials, Princeton University, USA; [4]Civil and Environmental Engineering, Princeton University, USA:* A QC laser-based water vapor isotope analyzer for fast, real-time measurement of d18O in the urban environment with 1s accuracy of 0.74‰ was developed. The sensor was laboratory tested and the time series of d18O in ambient outdoor air is presented.

ATh1I.6 • 09:30
Sulfur dioxide detection using 7.4 µm DFB-QCL based cavity enhanced absorption spectroscopy, Jan Tarka[1,2], Mohammad Jahjah[1], Rafal Lewicki[1], Przemyslaw Stefanski[1b2], Frank K. Tittel[1c], Stephen So[3]; *[1]Electrical & Computer Engineering Department, Rice University, USA; [2]Laser and Fiber Electronics, Institute of Telecommunications & Acoustics, Wroclaw University of Technology, Poland; [3]Sentinel Photonics Inc., USA.* A quantitative measurements of sulfur dioxide using CW, RT DFB-QCL based cavity-enhanced absorption spectroscopy and 2f wavelength modulation detection technique will be reported. Detection limits of 130ppbv (1σ) were achieved with a 0.4-sec averaging time.

ATh1I.7 • 09:45
Spectroradiometric Monitoring of Open Algal Cultures, Thomas A. Reichardt[1], Aaron M. Collins[2], Jerilyn A. Timlin[2], Robert C. McBride[3], Craig A. Behnke[3]; *[1]Sandia National Labs, USA; [2]Sandia National Labs, USA; [3]Sapphire Energy, USA.* The outdoor culturing of green algae is monitored with a dual-channel spectroradiometer. The measured reflectance provides information regarding growth rate and light usage, demonstrating potential to meet the monitoring needs for algal biofuel production.

CLEO: Science & Innovations

CTh1J • Fabrications and Applications I—Continued

CTh1J.4 • 09:00
Direct-Write Laser Scanning Holography for Size-Scalable 3D Photonic Crystal Integrated Optofluidics, Liang Yuan[1,2], Peter R. Herman[1,2]; *[1]Electrical and Computer Engineering, University of Toronto, Canada; [2]Institute for Optical Sciences, University of Toronto, Canada.* Laser scanning of diffractive optical masks is developed towards flexible direct-writing of 3D photonic crystal and optofluidic structures for seamless and size-scalable integration into lab-on-a-chip devices with beam size as a processing dimension.

CTh1J.5 • 09:15
Thermal nanoimprint fabrication of chalcogenide glass waveguide resonators, Yi Zou[1], Hongtao Lin[1], Lan Li[1], Sylvain Danto[2], J. David Musgraves[2], Kathleen Richardson[2], Juejun Hu[1]; *[1]Department of Materials Science and Engineering, University of Delaware, USA; [2]College of Optics & Photonics (CREOL), University of Central Florida, USA.* We demonstrated thermal nanoimprint fabrication of low loss waveguides and micro-ring resonators in thermally evaporated and solution processed chalcogenide glass films. A high micro-ring quality factor of 75,000 is achieved at 1550 nm wavelength.

CTh1J.6 • 09:30
Fabrication of high-purity single-crystal diamond nano-slabs for photonic applications, Luozhou Li[1], Jonathan Hodges[1,5], Edward H. Chen[2,4], Matthew Trusheim[2,4], Ophir Gaathon[1,4], Ming Lu[3], Igal Bayn[1,4], Tim Schröder[1,4], Xiaolong Hu[1,4], Dirk Englund[1,4]; *[1]Electrical Engineering, Columbia University, USA; [2]Applied Physics and Applied Mathematics, Columbia University, USA; [3]Center for Functional Nanomaterials, Brookhaven National Laboratory, USA; [4]Electrical Engineering and Computer Science, Massachusetts Institute of Technology, USA; [5]MITRE Corp., USA.* We present a mass fabrication method of diamond nanoscale slabs by alternating plasma etching and mask deposition. These slabs support NV- spins with long coherence times and are suitable for a range of nanophotonic devices.

CTh1J.7 • 09:45
Zinc Selenide Synthesis in Fiber Draw, Chong Hou[1,2], Xiaoting Jia[2,3], Lei Wei[2,3], Alexander M. Stolyarov[2,3], Ofer Shapira[2,3], John D. Joannopoulos[3,4], Yoel Fink[1,2]; *[1]Department of Materials Science and Engineering, Massachusetts Institute of Technology, USA; [2]Research Laboratory of Electronics, Massachusetts Institute of Technology, USA; [3]Institute of Soldier Nanotechnology, Massachusetts Institute of Technology, USA; [4]Department of Physics, Massachusetts Institute of Technology, USA.* We demonstrate a high-throughput method for synthesizing zinc selenide (ZnSe) in situ during fiber drawing. Direct atomic-level compositional and structural analysis of the produced compound is performed, and a ZnSe-based in-fiber heterojunction device is achieved.

CTh1K • THz Waveguides and Resonators—Continued

CTh1K.5 • 09:00
Origins of dispersive terahertz pulse propagation in tapered parallel plate waveguides, Raimund Mueckstein[1], Miguel Navarro-Cía[2], Oleg Mitrofanov[1]; *[1]Electronic & Electrical Engineering, University College London, United Kingdom; [2]Electrical and Electronic Engineering, Imperial College London, United Kingdom.* Unexpected dispersion of the TEM mode in tapered parallel plate waveguides is investigated experimentally and numerically. The TE02 mode that adiabatically converts into the TEM mode interferes with the genuine TEM and explains this behavior.

CTh1K.6 • 09:15
Low Dispersion Propagation of Broadband THz Pulses in a Two-Wire Waveguide, Manoj K. Mridha[1], Anna Mazhorova[1], Maxime Daneau[1,2], Matteo Clerici[1,3], Marco Peccianti[4], Pierre-Luc Lavertu[1], Xavier Ropagnol[1], Francois Vidal[1], Roberto Morandotti[1]; *[1]INRS-EMT, Canada; [2]University of Ottawa, Canada; [3]School of Engineering and Physical Sciences, Heriot-Watt University, United Kingdom; [4]Institute for Complex Systems - CNR, Italy.* Undistorted propagation of broadband terahertz pulses is required to enhance several applications, such as high-sensitivity spectroscopy. Here, we demonstrate the low dispersive guided propagation of a THz pulse over 20cm in a two-wire waveguide.

CTh1K.7 • 09:30
Impact of thin AgI coatings on modes in cylindrical metallic waveguides for THz applications, Miguel Navarro-Cía[1,2], Carlos Bledt[3], Jeffrey Melzer[3], Miriam S. Vitiello[4], Harvey Beere[5], David Ritchie[5], James Harrington[3], Oleg Mitrofanov[1]; *[1]UCL, United Kingdom; [2]Imperial College London, United Kingdom; [3]Rutgers Univ., USA; [4]NEST, CNR and Scuola Normale Superiore, Italy; [5]University of Cambridge, United Kingdom.* We applied THz near-field space-time mapping, continuous wave far-field imaging and numerical eigenmode calculations to determine the impact of thin dielectric coatings on the main modes in flexible cylindrical metallic waveguides for THz waves.

CTh1K.8 • 09:45
Evanescent Wave Coupling in Terahertz Waveguide Arrays, Kimberly S. Reichel[1], Naokazu Sakoda[2], Rajind Mendis[1], Daniel Mittleman[1]; *[1]Electrical and Computer Engineering, Rice University, USA; [2]Kobe Steel, Ltd., Japan.* We experimentally study THz energy coupling among an array of identical parallel-plate waveguides in close proximity, with their unconfined sides facing each other. We observe stronger coupling with larger plate separations and longer propagation paths.

CLEO: QELS-Fundamental Science

QTh1L • Optical Memories and Atomic Ensembles—Continued

QTh1L.4 • 09:00
Spin cooling via incoherent feedback in an ensemble of cold Rb atoms, Naeimeh Behbood[1], Ferran Martin Ciurana[1], Giorgio Colangelo[1], Mario Napolitano[1], Robert Sewell[1], Morgan W. Mitchell[1,2]; *[1]ICFO - The Institute of Photonic Sciences, Spain; [2]ICREA - Institucio Catalana de Recerca i Estudis Avancats,, Spain.* We report an experimental study of a new technique for spin cooling an ensemble of ultracold atoms via quantum non-demolition (QND) measurement and incoherent feedback.

QTh1L.5 • 09:15
Generation of planar quantum squeezing in an atomic ensemble, Giorgio Colangelo[1], Naeimeh Behbood[1], Ferran Martin Ciurana[1], Graciana Puentes[1], Robert Sewell[1], Morgan W. Mitchell[1,2]; *[1]ICFO - Institut de Ciencies Fotoniques, Spain; [2]ICREA - Institució Catalana de Recerca i Estudis Avançats, Spain.* We extend the covariance-matrix description of atom-light quantum interfaces to spin-1 systems including technical noise and decoherences. We use this description to predict and produce a planar squeezed state in a cold 87Rb ensemble.

QTh1L.6 • 09:30
Narrowband source of correlated photon pairs via four-wave mixing in a cold atomic ensemble, Bharath Srivathsan[1], Gurpreet Kaur Gulati[1], Mei Yuen Brenda Chng[1], Gleb Maslennikov[1], Dzmitry Matsukevich[1,2], Alessandro Cerè[1], Christian Kurtsiefer[1,2]; *[1]Center for Quantum Technologies, Singapore; [2]Department of Physics, National University of Singapore, Singapore.* We demonstrate a bright and narrowband source of time-correlated photon pairs of wavelength 762nm and 795nm generated via four-wave mixing in cold Rubidium-87 atoms using a cascade decay level scheme.

QTh1L.7 • 09:45
Sensitive absolute polarization measurement using vector light shifts in cold atoms, Kunyan Zhu[1], Neal Solmeyer[1], Cheng Tang[1], David S. Weiss[1]; *[1]Physics Department, The Pennsylvania State University, USA.* By measuring the vector light shift in spin-polarized Cs atoms trapped in a cavity built-up optical lattice, we have demonstrated linear polarization that is pure to within $2x10^{-8}$ in fractional intensity.

CLEO: Science & Innovations

CTh1M • Next Generation Photovoltaics—Continued

CTh1M.4 • 09:00
Angle Dependant Scattering by Dielectric Nanostructures for Light Management in Thin Film Photovoltaics, Brian Roberts[1], Qi Chen[1], Pei-Cheng Ku[1]; [1]*University of Michigan, USA.* Optical scattering properties of nanoporous anodized aluminum oxide films are investigated and applied to improving absorption in thin film photovoltaics. Angle dependent scattering properties improve performance in semitransparent systems and could reduce solar tracking dependence.

CTh1M.5 • 09:15
Light-trapping: From Order to Disorder in Thin-film Silicon Solar Cells, Marco Liscidini[1], Angelo Bozzola[1], Piotr Kowalczewski[1], Lucio C. Andreani[1]; [1]*Universita degli Studi di Pavia, Italy.* We investigate-light trapping in thin-film crystalline silicon solar cells with rough interfaces and engineered disordered photonic structures. The general aspects of the optical properties are discussed, demonstrating broad band absorption close to the Lambertian limit.

CTh1M.6 • 09:30
Simulations and Experiments of Tunable GaN Microdomes for Broadband Omnidirectional Antireflection, Lu Han[1], Tyler A. Piedimonte[1], Matthew R. McGoogan[1], Ian V. Kidd[2], Roger French[2], Hongping Zhao[1]; [1]*Department of Electrical Engineering and Computer Science, Case Western Reserve University, USA;* [2]*Department of Material Science and Engineering, Case Western Reserve University, USA.* GaN microdomes are studied as a broadband omnidirectional anti-reflection structure for high efficiency multi-junction concentrated photovoltaics. Simulation and experiment studies indicate a significant reduction of reflectance from the GaN mcirodomes.

CTh1M.7 • 09:45
Temperature-Dependent Carrier Transport in a p-GaN/i-InGaN/n-GaN Solar Cell Heterostructure using Ultrafast Spectroscopy, Blair Connelly[1], Nathaniel Woodward[1], Grace D. Metcalfe[1], Lee E. Rodak[1], Naresh C. Das[1], Meredith Reed[1], Anand V. Sampath[1], Hongen Shen[1], Michael Wraback[1], Robert M. Farrell[2], Michael Iza[2], Samantha Cruz[2], Jordan Lang[2], Nathan Young[2], Yutaka Terao[2], Carl Neufeld[2], Stacia Keller[2], Shuji Nakamura[2], Steven P. DenBaars[2], Umesh Mishra[2], James S. Speck[2]; [1]*US Army Research Laboratory, USA;* [2]*University of California, Santa Barbara, USA.* Temperature-dependent carrier transport is investigated using ultrafast spectroscopy in a p-GaN/i-InGaN/n-GaN solar cell with heavily-doped layers to compensate for polarization charges at the heterointerface. We observe a flip in the transport direction at 110 K.

CLEO: Applications & Technology

ATh1N • Clinical Applications—Continued

ATh1N.4 • 09:00 Invited
Fluorescence Lifetime Spectroscopy and Imaging for Clinical Diagnostics, Laura Marcu[1]; [1]*Univ. of California Davis, USA.* This presentation provides an overview of clinically compatible time-resolved fluorescence techniques including a fast scanning fluorescence lifetime imaging (FLIm) technique. We will present applications of these techniques in diagnosis of cancer and atherosclerotic cardiovascular disease.

ATh1N.5 • 09:30
Diagnosis of hepatic fibrosis using a multi-photon nonlinear optical microspectroscopy imaging system, JANG HYUK LEE[1], Jong Chul Kim[2], Giyoong Tae[2], Myoung-kyu Oh[3], Do-Kyeong Ko[1]; [1]*Department of Physics and Photon Science, Gwangju Inst of Science & Technology, Republic of Korea;* [2]*School of Materials Scienee and Engineering and Department of Nanobio Materials and Electronics, Gwangju Inst of Science & Technology, Republic of Korea;* [3]*Advanced Photonics Research Institute, Gwangju Inst of Science & Technology, Republic of Korea.* A photonic crystal fiber (PCF)-based multimodal multiphoton nonlinear microspectroscopy imaging system was developed and applied to hepatic fibrosis tissue. Multiphoton images and CARS spectrum at C-H vibration stretching differentiate liver fibrosis from normal liver tissue.

ATh1N.6 • 09:45
Cellphone Polarizing Microscopy for Malaria Detection, Itay Remer[1], Alberto Bilenca[1,2]; [1]*Biomedical Engineering, Ben-Gurion University of the Negev, Israel;* [2]*Ilse Katz Institute for Nanoscale Science and Technology, Ben Gurion University of the Negev, Israel.* We developed a cellphone polarizing microscope for detection of minute concentrations of hemozoin - the malaria pigment - in human blood samples. 0.75 μg/ml hemozoin concentration was detectable, allowing for malaria detection at 0.25% parasitemia.

ATh1O • Symposium on The Path to Sustainable Energy: Laser Driven Inertial Fusion EnergyAlternative Laser ICF Concepts—Continued

ATh1O.3 • 09:00 Invited
Shock-ignition OMEGA Experiments and Target Design for the NIF, Kenneth S. Anderson, *Laboratory for Laser Energetics, Univ. of Rochester, USA:* Shock ignition (SI) offers the potential for high gains at low laser energies using a single laser system. SI physics is being validated experimentally on OMEGA. A polar-drive design for the NIF is presented.

ATh1O.4 • 09:30 Invited
Studies on Shock Ignition Targets for Inertial Fusion Energy, Stefano Atzeni[1], Alberto Marocchino[1], Angelo Schiavi[1], Guy Schurtz[2], [1]*Dipartimento SBAI, Universita' di Roma La Sapienza, Italy;* [2]*CELIA, Universite' Bordeaux 1, France.* Studies on targets for laser fusion shock ignition will be reviewed, including earlier target designs, analytical models for target scaling and analysis of sensitivity to asymmetries, instabilities and target defects. Ways to increase target robustness will be discussed.

09:30–12:30
Technology Transfer Program,
Exhibit Hall 2

10:00–11:30
Coffee Break (10:00–10:30) and Unopposed Exhibit Only Time,
Exhibit Hall 1 and 2

10:00–15:00 Exhibits Open,
Exhibit Halls 1 and 2

JOINT

11:30–13:00
JTh2A • POSTER SESSION III: Light-Matter Interactions, ultrafast & Quantum Optics

JTh2A.01
Withdrawn

JTh2A.02
Surface damage reduction on UV direct-write domains engineered LiNbO3, Andreas Boes[1], Tristan Crasto[1], Hendrik Steigerwald[1], Vijay Sivan[1], Elisabeth Soergel[2], Arnan Mitchell[1]; *[1]Electrical and Computer Engineering, RMIT University, Australia; [2]Institute of Physics, University of Bonn, Germany.* Thin-film coating of LiNbO3 crystals with chromium was found to greatly enhance the usefulness of UV direct-written domains: the surface damage is strongly reduced thus improving the quality of the, moreover deeper and wider domains.

JTh2A.03
High Longevity Rubidium Packaging Method Suitable for Integrated Optics, Matthieu Giraud-Carrier[1], John F. Hulbert[1], Thomas Wall[1], Aaron Hawkins[1], Holger Schmidt[2], Jennifer A. Black[2]; *[1]Electrical Engineering Dept., Brigham Young University, USA; [2]School of Engineering, University of California, Santa Cruz, USA.* We present a construction approach to long-lasting rubidium (Rb) atomic vapor cells compatible with integrated photonic platforms. Indium solder seals did not exhibit any decrease in optical atomic density after being held at 95 °C for thirty days.

JTh2A.04
Thomson scattering from aluminum laser plasmas in air, Yuan Liu[1], Bruno Bousquet[2], Martin Richardson[1], Matthieu Baudelet[1]; *[1]University of Central Florida, CREOL, USA; [2]LOMA, UMR 5798, University of Bordeaux 1, France.* Thomson scattering is reported for the first time to measure the electron density and temperature of aluminum laser plasma in air. Electron and excitation temperatures are compared to discuss local thermodynamic equilibrium in such plasmas

JTh2A.05
Real-Time Depth Monitoring of Galvo-Telecentric Laser Machining by Inline Coherent Imaging, Y. Ji[1], Cole Van Vlack[1,2], Paul J. Webster[1,2], James M. Fraser[1]; *[1]Physics, Engineering Physics & Astronomy, Queen's University at Kingston, Canada; [2]Laser Depth Dynamics Inc., Canada.* We achieve in situ, micron-scale tracking of laser machining through a galvo-telecentric beam delivery system using coherent imaging. We collect both high speed intrapulse and interpulse morphology changes as well as overall sweep-to-sweep depth penetration.

JTh2A.06
Uniformity of GaN Nanorods on Silicon Substrates studied by Ultrafast Acoustic Phonon Spectroscopy, Chi-Yuan Yang[1,2], Chih-Ta Chia[2], Hung-Ying Chen[3], Shangjr Gwo[3], Kung-Hsuan Lin[1]; *[1]Institute of Physics, Academia Sinica, Taiwan; [2]Department of Physics, National Taiwan Normal University, Taiwan; [3]Department of Physics, National Tsing Hwa University, Taiwan.* We studied acoustic breathing modes of GaN nanorods on silicon substrates by ultrafast acoustic phonon spectroscopy. This technique could be utilized to nondestructively inspect uniformity of nanorods within the area of optical spot.

JTh2A.07
Backside Surface Machining of Silicon Wafers Using a Nanosecond Tm:fiber MOPA System, Lawrence Shah[1], Tobias Bonhoff[2], Ashraf F. El-Sherif[3,1], Pankaj K. Kadwani[1], Martin Gebhardt[4,1], Christian Gaida[4,1]; *[1]CREOL, The College of Optics and Photonics, The University of Central Florida, USA; [2]Fraunhofer Institute for Laser Technology, Germany; [3]Military Technical College, Egypt; [4]Institute of Applied Optics, Friedrich-Schiller University Jena, Germany.* We report on selective machining of the back surface machining of double-side polished silicon wafers, using a high peak power nanosecond Tm:fiber master oscillator power amplifier with a photonic crystal fiber based power amplifier.

JTh2A.08
Creation of Optical Gain and Absorption via a Virtual Single photon Transition, Jens Herrmann[1], Matthias Weger[1], Reto Locher[1], Mazyar Sabbar[1], Paula Rivière[2,3], Ulf Saalmann[3], Jan-Michael Rost[3], Lukas Gallmann[1], Ursula Keller[1]; *[1]Department of Physics, Institute of Quantum Electronics, ETH Zurich, Switzerland; [2]Departamento de Química, Universidad Autónoma de Madrid, Spain; [3]Max Planck Institute for the Physics of Complex Systems, Germany.* We present the creation and control of optical gain by interrupting the temporal evolution of the dipole response of a quantum-mechanical two-level system. Our theoretical analysis is verified by transient absorption spectroscopy in helium.

JTh2A.09
Laser Driven Proton Acceleration Experiment with Micro-Structured Target at the Texas Petawatt Laser Facility, Donghoon Kuk[1], Gilliss Dyer[1], Samuel Feldman[1], Craig Wagner[1], Chunhua Wang[1], Manuel Hegelich[1], Todd Ditmire[1]; *[1]Center for High Energy Density Science, The University of Texas, USA.* Experiment of laser driven proton acceleration with a micro structured solid target irradiated with ultra-short and ultra-intense laser has been studied at the Texas Petawatt Laser Facility.

JTh2A.10
Quasi-phasematched Laser Wakefield Acceleration In a Corrugated Plasma Channel, Sung J. Yoon[1], John Palastro[1], Daniel F. Gordon[2], Howard Milchberg[1]; *[1]Institute of Research in Electronics and Applied Physics, University of Maryland, USA; [2]Plasma Physics Division, Naval Research Laboratory, USA.* Plasma wakefields driven by laser pulses can accelerate electrons to relativistic energies. The energy saturates when electrons outrun the wakefield's accelerating phase. Quasi-phasematching, enabled by corrugated plasma channels, is applied to overcome this limitation.

JTh2A.11
Shape Resonance and Cooper Minimum in High Harmonic Generation from Strongly Aligned Nitrogen, Xiaoming Ren[1], Varun Makhija[1], Anh-Thu Le[1], Jan Tross[1], Sudipta Mondal[1], Cheng Jin[1], Carlos Trallero[1], Vinod Kumarappan[1]; *[1]Physics, Kansas State University, USA.* High harmonic generation from strongly aligned nitrogen molecules is shown to directly reveal angle-dependent features in the XUV photoionization cross section of the highest occupied molecular orbital both in pump-probe delay and angle scans.

JTh2A.12
Observation of collective deceleration of laser driven plasma wakefield electrons, Shao-wei Chou[1,2], Jiancai Xu[1], Konstantin Khrennikov[2,1], Laszlo Veisz[1], Stefan Karsch[2,1]; *[1]Max-Planck-Institut fur Quantenoptik, Germany; [2]Physics, Ludwig-Maximilians-Universität, Germany.* With the maturity of the technology of laser-wakefield-acceleration, a compact radiological safety solution has become an issue. By exploiting the unique property of such electron source, we have observed experimental indication of collective electron deceleration.

JTh2A.13
The ELI-ALPS secondary sources: a getaway to scientific excellence, Cord L. Arnold[2], Fernando Brizuela[2], A. Borot[3], Francesca Calegari[4], Dimitrios Charalambidis[1,5], T. Cowan[6], Zs. Diveki[1,7], P. Dombi[1,8], J. Fulop[1,9], J. Hebling[9,10], Christoph M. Heyl[2], Anne L'Huillier[2], Dino A. Jaroszynski[11], Per Johnsson[2], V. Malka[3], M. Kalashnikov[1,12], M. Kaluza[13,14], R. Lopez-Martens[1,3], Mauro Nisoli[4], Karoly Osvay[1,15], G. Paulus[14,15], Fabien Quéré[16], E. Racz[1,17], A. Rouzée[12], Piotr Rudawski[2], Ch. Spindloe[18], M. Tolley[18], P. Tzallas[5], Mark Vrakking[12]; *[1]ELI-HU NKft., Hungary; [2]Lund University, Dept Phys, Sweden; [3]Laboratoire d'Optique Appliquee, ENSTA ParisTech, Ecole Polytechnique CNRS, France; [4]Politecnico di Milano, Dept. Physics, Italy; [5]FORTH, Greece; [6]Helmholtz-Zentrum Dresden-Rossendorf, Germany; [7]Imperial College, United Kingdom; [8]Wigner Research Centre for Physics, Hungary; [9]MTA-PTE High-Field THz Research Group, Hungary; [10]University of Pecs, Hungary; [11]Univ Strathclyde, Dept Phys, Scottish Univ Phys Alliance, United Kingdom; [12]Max-Born-Institut, Germany; [13]Friedrich-Schiller-University, Germany; [14]Helmholtz-Institute, Germany; [15]University of Szeged, Hungary; [16]CEA, IRAMIS, Service des Photons Atomes et Molécules, France; [17]Obuda University, Hungary; [18]STFC Rutherford Appleton Laboratory, United Kingdom.* The essence of ELI-ALPS, the laser driven secondary sources ranging from X-ray and X-UV to THz with duration as short as tens of attoseconds, are designed to be available for users from 2016.

JTh2A.14
Development of a Pump Laser for a Multi-TW OPCPA Component Test Laboratory, Waseem Shaikh[1], Tom Critchlow[1], Alexis Boyle[1], Steve Blake[1], Sonya Chapman[1], Andrew Frackewicz[1], M. Galimberti[1], Steve Hancock[1], I. Musgrave[1], David Pepler[1], Tevor Winstone[1], C. Hernandez-Gomez2[1]; *[1]CLF, CCLRC, United Kingdom.* We present the laser architecture that will be constructed as a pump laser for a Multi-TW OPCPA component test laboratory using glass rod amplifiers and a regenerative amplifier seeded by a modulated fiber laser source

JTh2A.15
Carrier-Envelop Phase Noise of Ultrashort Pulses in a Ti:Sapphire Amplifier, A. Borzsonyi[1,2], Roland S. Nagymihály[1], Peter Jojart[1,2], Karoly Osvay[1,3]; *[1]Department of Optics and Quantum Electronics, University of Szeged, Hungary; [2]CE Optics Kft., Hungary; [3]ELI-Hu Nkft, Hungary.* The relative carrier-envelop phase (CEP) of pulses are measured at different repetition rates, gain, and saturation levels of a three-pass amplifier, resulting in an increase of <100mrad CEP noise depending on the amplification conditions.

JTh2A.16
New, Simplified Algorithm for Cross-Correlation Frequency Resolved Optical Gating, Daniel J. Kane[1]; *[1]Mesa Photonics, LLC, USA.* I present a new cross-correlation frequency resolved optical gating (X-FROG) algorithm, based on the principal components generalized projections (PCGP) algorithm that is fast, robust, and simple.

JTh2A.17
Compact 325 MHz Er:fiber ring laser with dispersion inversed gain fibers, Hongxia Qi[1], Jian Zhang[1], Gengji Zhou[1], Aimin Wang[1], Guizhong Wang[1], Zhigang Zhang[1]; *[1]Perking University, China.* We demonstrate an Er:fiber ring laser operated at the fundamental repetition rate of 325 MHz. Two gain fibers with opposite dispersion were combined both for compactness and intra-cavity dispersion compensation.

JTh2A.18
Chirped Pulse Amplification Scaling in Thulium-Doped Fiber Lasers, Robert A. Sims[1], Alex Sincore[1], Pankaj Kadwani[1], Lawrence Shah[1], Martin Richardson[1]; *[1]University of Central Florida, CREOL, USA.* We will report on our effort to scale the pulse energy and peak power from ultrashort pulse Tm doped fiber laser systems, with >1 μJ pulse energy within 300 fs duration after compression.

JTh2A.19
Two-photon induced tuning of an ultracompact SOI Fabry-Pérot resonator via the thermo-optic effect, Shawn M. Sederberg[1], Abdulhakem Y. Elezzabi[1]; *[1]University of Alberta, Canada.* We experimentally investigate the nonlinear response of an ultracompact silicon-on-insulator Fabry-Perot resonator. Two-photon absorption, free-carrier absorption, and the thermo-optic effect act to red-shift the device resonance by 7.57nm and attenuate its amplitude by 66%.

JTh2A.20
760-nm Semiconductor Passively Mode-Locked Monolithic Laser for Picosecond Pulse Generation, Huolei Wang[2], Liang Kong[1], David Bajek[1], Stephanie Haggett[1], Xiaoling Wang[3], Bifeng Cui[3], Jiaoqing Pan[2], Ying Ding[1], Maria Ana Cataluna[1]; *[1]School of Engineering, Physics and Mathematics, University of Dundee, United Kingdom; [2]Institute of Semiconductors, Chinese Academy of Sciences, China; [3]Key Laboratory of Opto-electronics Technology, Ministry of Education, Beijing University of Technology, China.* We report a novel semiconductor passively mode-locked edge-emitting laser based on a multi-quantum-well structure, emitting at 766 nm and enabling the generation of a stable 19.4 GHz pulse train with a pulse duration of ~5 ps.

JTh2A.21
Temporal phase zone plates for linear optical pulse compression, Bo Li[1,2], Ming Li[1], Shuqin Lou[2], Jose Azana[1]; *[1]Institut National de la Recherche Scientifique - Energie, Matériaux et Télécommunications (INRS-EMT), Canada; [2]School of Electronic and Information Engineering, Beijing Jiaotong University, China.* We demonstrate linear optical pulse compression by using temporal phase zone plates based on electro-optic phase modulation, achieving experimental time-bandwidth products (or equivalent time compression factors) > 150 using phase-modulation amplitudes of only π radians.

JTh2A.22
1.2-GHz Repetition Rate, Diode-Pumped Femtosecond Yb:KYW Laser Mode-Locked by a CNT Saturable Absorber, Heewon Yang[1], Chur Kim[1], Sun Young Choi[2], Guang-Hoon Kim[3], Yohei Kobayashi[4], Fabian Rotermund[2], Jungwon Kim[1]; [1]*Korea Advanced Inst of Science & Tech, Republic of Korea;* [2]*Ajou Univ, Republic of Korea;* [3]*KERI, Republic of Korea;* [4]*Univ of Tokyo, Japan.* We demonstrate a 1.2-GHz repetition rate, diode-pumped, carbon nanotube (CNT)-mode-locked Yb:KYW laser with 168 fs pulse duration. To our knowledge, this corresponds to the highest repetition rate from CNT-mode-locked femtosecond bulk solid-state lasers.

JTh2A.23
Wide range wavelength and repetition rate tunable tens of GHz sub-picosecond pulse source, Tadashi Nishikawa[1], Miho Yamazaki[1,2], Nuremy Binti[1,2], Atsuhi Ishizawa[2], Kenichi Hitachi[2], Katsuya Oguri[2], Tetsuomi Sogawa[2]; [1]*Department of Electrical and Electronic Engineering, Tokyo Denki University, Japan;* [2]*NTT Basic Research Laboratories, NTT Corporation, Japan.* A wide range wavelength and repetition rate tunable tens of GHz sub-picosecond pulse source is demonstrated based on optical modulators. A wavelength tunable range of 1530-1575 nm and a repetition rate tunable range of 18-26 GHz were achieved.

JTh2A.24
Application of Hybrid Optoelectronic Correlator to Gabor Jet images for Rapid Object Recognition & Segmentation, Mehjabin Sultana Monjur[1], Shih Tseng[1], Adnan Mujahid[3], Nasir Rajpoot[3,4], Selim M. Shahriar[1,2]; [1]*Department of Electrical Engineering and Computer Science, Northwestern University, USA;* [2]*Department of Physics and Astronomy, Northwestern University, USA;* [3]*Computer Science and Engineering Department, Qatar University, Qatar;* [4]*Department of Computer Science, University of Warwick, United Kingdom.* We propose an image recognition system using a Hybrid Optoelectronic Correlator where the reference and query images are Gabor Jet Images for individual pixels produced by Gabor filtering, for rapid object recognition and segmentation.

JTh2A.25
Control of Phonon Polariton Propagation in LiNbO3 Single Crystals, Ikufumi Katayama[1], Yuki Ikegaya[1], Yasuo Minami[1], Jun Takeda[1]; [1]*Yokohama National University, Japan.* We demonstrated control of E-mode phonon polariton propagation in LiNbO3 single crystals by using double pump excitation. Either forward or backward travelling phonon polariton could be selectively excited by tuning the delay between two pump pulses.

JTh2A.26
Time-Resolved Measurements of Near-Infrared Pulse Induced Ultrafast Optical Modulation of Quantum Cascade Lasers, Hong Cai[1,2], Sheng Liu[1,2], Elaine Lalanne[2], Dingkai Guo[3,2], Xing Chen[3,2], Xiaojun Wang[4], Fow-Sen Choa[2,3], Anthony M. Johnson[1,2]; [1]*Physics, University of Maryland Baltimore County, USA;* [2]*CASPR, University of Maryland Baltimore County, USA;* [3]*CSEE, University of Maryland Baltimore County, USA;* [4]*AdTech Optics Inc., USA.* We temporally resolve ultrafast modulation of quantum cascade lasers (QCLs) using a near-infrared pump Mid-infrared probe technique. We compare interband and intersubband transition mechanism assisted modulation of QCLs by using different pump wavelengths.

JTh2A.27
Cross-Correlator for the Diagnostics of 3D Ellipsoidal Shaped UV Laser Pulses for XFEL Ultra Low-Emittance Photoinjector, Efim A. Khazanov[1], Alexey Andrianov[1], Ekaterina Gacheva[1], Grigory Gelikonov[1], Victor Zelenogorsky[1], Sergey Mironov[1], Anatoly Poteomkin[1], Mikhail Martyanov[2], Eugeny Syresin[3], Mikhail Krasilnikov[4], Frank Stephan[4]; [1]*Institute of Applied Physics, Russian Federation;* [2]*European Organization for Nuclear Research, Switzerland;* [3]*Joint Institute for Nuclear Research, Russian Federation;* [4]*Photo Injector Test Facility at Deutsches Electronen-Synchrotron, Germany.* The cross-correlator described below excels in its high speed (>1500cm/s) and high amplitude of the diagnostic channel delay. Such characteristics allow the cross-correlator to scan pulses inside 300-microsecond long pulse trains, repeated with the frequency of 10Hz.

JTh2A.28
Subfemtosecond Synchronization between Yb-fiber and Er-fiber Lasers by Controlling the Relative Injection Timing, Wei-Wei Hsiang[1], Bo-Wei Tsai[1], Chieh Hu[2], Shang-Ying Wu[3], Yinchieh Lai[3,4]; [1]*Dep. of Physics, Fu Jen Catholic Univ., Taiwan;* [2]*Laser Lightwave Technology Department, Laser Application Technology Center, ITRI, Taiwan;* [3]*Department of Photonics & Institute of Electro-Optical Engineering, National Chiao-Tung University, Taiwan;* [4]*Research Center for Applied Sciences, Academia Sinica, Taiwan.* The relative timing between the injection and slave pulses is found to be the key factor to achieve sub-fs timing jitter (0.87 fs, 1.9 MHz bandwidth) between Yb-fiber and Er-fiber fs lasers with hybrid synchronization.

JTh2A.29
A resonator-based time-stretch oscilloscope with variable magnification, Stefan Weber[1,2], Christoph Reinheimer[1,2], Georg von Freymann[1,2]; [1]*Physics Department and Research Center OPTIMAS, Technische Universität Kaiserslautern, Germany;* [2]*Department Terahertz Measurement and Systems, Fraunhofer Institute for Physical Measurement Techniques, Germany.* We present a resonator-based approach to time-stretch electrical signals with variable temporal magnification up to M=100 and a time-aperture up to 800 ps. Experimental results agree well with numerical calculations.

JTh2A.30
Generation of femtosecond laser pulse at 1053 nm with contrast ratio of 10^11 by optical-parametric amplification, Zhongwei Shen[1], Zhaohua Wang[1], Wei Zhang[1], Qing Wang[1], Haitao Fan[1], Hao Teng[1], Zhiyi Wei[1]; [1]*Key Laboratory of Optical Physics, The Institute of Physics, Chinese Academy of Sciences(CAS)., China.* We demonstrated a high contrast 1053 nm femtosecond laser by exchanging the signal and idler in two stages non-collinear optical-parametric amplifier, 60 μJ idler with measurement-limited contrast of 2.3×10^11 was obtained within scale of sub-10 ps.

JTh2A.31
Ultrashort laser pulse characterization from dispersion scans: a comparison with SPIDER, Miguel Miranda[1], Piotr Rudawski[1], Chen Guo[1], Francisco Silva[2], Cord L. Arnold[1], Thomas Binhammer[3], Helder Crespo[2], Anne L'Huillier[1]; [1]*Department of Physics, Lund University, Sweden;* [2]*Department of Physics and Astronomy, Porto University, Portugal;* [3]*Venteon Laser Technologies GmbH, Germany.* We investigate the performance of the recently introduced "d-scan" technique for the characterization of ultrashort laser pulses by comparing it with a well-established technique (SPIDER). Good agreement is obtained from the two different measurements.

JTh2A.32
Near-Infrared Laser Pulse Induced Amplitude Modulation of Terahertz Quantum Cascade Lasers, Yohei Sakasegawa[1], Shingo Saito[1], Norihiko Sekine[1], Masaaki Ashida[2], Iwao Hosako[1]; [1]*National Institute of Information and Co, Japan;* [2]*Graduate School of Engineering Science/Osaka University, Japan.* We have demonstrated amplitude modulation of terahertz quantum cascade lasers by means of the injection of near-infrared laser pulses. Injected 770nm and 1350nm laser pulses both strongly suppressed the output power.

JTh2A.33
Frequency Dispersion and Damping Mechanisms of Terahertz Plasmons in Graphene Transistor Structures, Akira Satou[1], Victor Ryzii[1], Fedir T. Vasko[2], Vladmir V. Mitin[2], Taiichi Otsuji[1]; [1]*Tohoku University, Japan;* [2]*University at Buffalo, USA.* We numerically study frequency dispersion and damping mechanisms of plasmons in graphene transistor structures. We investigate the gate-voltage tunability of plasmon frequencies and the damping due to the carrier scattering with disorders and acoustic phonons.

JTh2A.34
Terahertz time-domain measurement of non-Drude conductivity in silver nanowire thin films, Jaeseok Kim[1], Inhee Maeng[1], Jongwook Jung[2], Hyunjoon Song[2], Joo-Hiuk Son[3], Kilsuk Kim[4], Jaeik Lee[4], Chul-Hong Kim[4], Geesung Chae[4], Myungchul Jun[4], YongKee Hwang[4], Su Jeong Lee[5], Jae-Min Myoung[5], Hyunyong Choi[1]; [1]*School of Electrical and Electronic Engineering, Yonsei university, Republic of Korea;* [2]*Department of Chemistry, Korea Advanced Institute of Science and Technology, Republic of Korea;* [3]*Department of Physics, University of Seoul, Republic of Korea;* [4]*Material R&D Department, LG Display Co., Republic of Korea;* [5]*Department of Materials Science and Engineering, Yonsei University, Republic of Korea.* We study the complex conductivity of silver nanowire thin films using terahertz time-domain spectroscopy. The measured conductivity shows a characteristic non-Drude response and it is explained by the Gans approximation and the Drude-Smith model

JTh2A.35
Theory of 2D photon echo spectroscopy on quantum well intersubband dynamics, Thi Uyen-Khanh Dang[1], T. Sverre Theuerholz[1], Marten Richter[1]; [1]*Institut für Theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin, Germany.* Intersubband transitions in semiconductor quantum wells are inspected with light in meV range. For low densities electron-phonon interaction dominates the relaxation processes. We theoretically inspect relaxation processes visible in 2D photon echo experiments.

JTh2A.36
Doping Position Control of Nitrogen-vacancy Centers in Diamond using Nitrogen-doped Chemical Vapor Deposition on Micropatterned Substrate, Tomohiro Gomi[1], Syuhei Tomizawa[1], Kohei Ohashi[1], Kohei M. Itoh[1], Junko Ishi-Hayase[1], Hideyuki Watanabe[2], Shinichi Shikata[2], Hitoshi Umezawa[2]; [1]*Department of Applied Physics, Keio University, Japan;* [2]*Diamond Research Laboratory, Advanced Industrial Science and Technology (AIST), Japan.* We demonstrate lateral position control of nitrogen-vacancy centers doped near the surface of diamond substrate using micropatterned substrate for nitrogen-doped isotopically-enriched chemical vapor deposition.

JTh2A.37
Carrier Relaxation Dynamics in MoS2 Measured by Optical/THz Pump-Probe Spectroscopy, Jared Strait[1], Parinita Nene[1], Haining Wang[1], Changjian Zhang[1], Farhan Rana[1]; [1]*Cornell University, USA.* We present results on the relaxation dynamics of photoexcited carriers in MoS2 using optical-pump terahertz-probe spectroscopy. Our measurements indicate that carrier recombination is accelerated at low temperatures where defect-assisted recombination becomes more efficient.

JTh2A • POSTER SESSION III: Light-Matter Interactions, ultrafast & Quantum Optics—Continued

JTh2A.38
Photocurrent Generation in a Microdisk Resonator Integrated with Interleaved P-N Junctions, Haike Zhu[1], Linjie Zhou[1], Xiaomeng Sun[1], Jingya Xie[1], Xinwan Li[1], Jianping Chen[1]; *[1]Electronic Engineering, shanghai jiao tong university, China.* We investigate two-photon absorption (TPA) induced photocurrent generation in a microdisk resonator embedded with interleaved p-n junctions. Free-carrier recombination rate is considerably reduced leading to an increased photocurrent.

JTh2A.39
E-mode Phonon-Polariton Dispersion in LiNbO3 Probed via Frequency-Resolved Coherent Phonon Spectroscopy, Takefumi Takizawa[1], Ikufumi Katayama[1], Yasuo Minami[1], Masahiro Kitajima[2], Jun Takeda[1]; *[1]Yokohama National University, Japan; [2]National Defense Academy, Japan.* Dispersion of E-mode phonon-polariton has been investigated in LiNbO3 via coherent phonon spectroscopy with sub-10 fs laser pulses. By spectrally resolving the probe pulses, we could successfully determine the dispersion curves up to 16 THz.

JTh2A.40
Withdrawn

JTh2A.41
THz Acoustic Attenuation of Silica studied by Ultrafast Acoustic Phonon Spectroscopy, Kung-Hsuan Lin[1], Dzung-Han Tsai[1], Kuan-Jen Wang[1], Sheng-Hui Chen[2], Kai-Lun Chi[3], Jin-Wei Shi[3], Po-Cheng Chen[4], Jinn-Kong Sheu[4]; *[1]Institute of Physics, Academia Sinica, Taiwan; [2]Department of Optics and Photonics, National Central University, Taiwan; [3]Department of Electrical Engineering, National Central University, Taiwan; [4]Department of Photonics, National Cheng Kung University, Taiwan.* We demonstrated ultrafast acoustic phonon spectroscopy up to 1.5 THz, and measured the acoustic signals up to 1 THz after they travelled through silica. Acoustic properties of silica films were characterized in sub-THz regime.

JTh2A.42
Withdrawn

JTh2A.43
STRONGLY COUPLED HYBRID FRENKEL WANNIER-MOTT EXCITON POLARITONS IN A HIGH Q MICROCAVITY, Niccolo Somaschi[1,2], Simos Tsintzos[2], Dave Coles[4], David G. Lidzey[4], Zacharia Hatzopoulos[5], Pavlos Lagoudakis[1], Pavlos Savvidis[2,3]; *[1]University of Southampton, United Kingdom; [2]FORTH, Greece; [3]Material Science, University of Crete, Greece; [4]University of Sheffield, United Kingdom; [5]Physics and Astronomy, University of Crete, Greece.* We fabricate and study a high Q planar microcavity containing QWs and molecular J-aggregate dye. Hybridization of Frenkel and Wannier-Mott excitons is achieved through cavity photons. Polariton formation is observed in strong coupling regime.

JTh2A.44
Second Harmonic Generation of Topological Insulator Bi2Se3 Surfaces, Chia-Lin Chang[1], Raman Sankar[1], Fang-Cheng Chou[1], Yu-Ming Chang[1]; *[1]National Taiwan University, Taiwan.* Azimuthal angle-dependent second harmonic generation is carried out to reveal the near surface band bending due to the surface state induced by Se vacancy in Bi2Se3. The surface band bending can be removed by tuning the Se molar ratio.

JTh2A.45
Observation of Pseudogap above Tc in 122 and 111 Iron-based Superconductors by Ultrafast Optical Spectroscopy, Kung-Hsuan Lin[1], Kuan-Jen Wang[1], Chung-Chieh Chang[1], Yu-Chieh Wen[1], Dzung-Han Tsai[1], Yu-Ruei Wu[1], Yao-Tsung Hsieh[1], Mingjye Wang[1], Bing Lv[2], Ching-Wu Chu[2], Maw-Kuen Wu[3,1]; *[1]Institute of Physics, Academia Sinica, Taiwan; [2]Texas Center for Superconductivity, University of Houston, USA; [3]Department of Physics, National Dong Hwa University, Taiwan.* We studied optimally-doped $(Ba_{0.6}K_{0.4})Fe_2As_2$ and LiFeAs by using ultrafast optical spectroscopy. Our temperature-dependent experimental results revealed that pseudogap exists above superconducting state in both materials.

JTh2A.46
Resonant Enhancement of Coherent High-Order Phonons in Single-Walled Carbon Nanotubes, Kenji Sato[1], Ikufumi Katayama[1], Keisuke Tahara[1], Yasuo Minami[1], Jun Takeda[1], Kazuhiro Yanagi[2], Masahiro Kitajima[3]; *[1]Department of Physics, Yokohama National University, Japan; [2]Department of Physics, Tokyo Metropolitan University, Japan; [3]Department of Applied Physics, National Defence Academy, Japan.* Coherent phonons dynamics in metallic carbon nanotubes has been investigated by pump-probe spectroscopy using 7.5-fs laser. High-frequency coherent phonons up to 100 THz have been observed including second-order modes due to the strong electronic resonances.

JTh2A.47
A Terahertz Time-Domain Polarization Spectrometer with High Angular Resolution and Its Application, Zhihui Lü[1], Dongwen Zhang[1,2], Zengxiu Zhao[1], Jianmin Yuan[1]; *[1]Physics Department, National University of Defense Technology, China; [2]Institute for Research in Electronics and Applied Physics, University of Maryland, American Samoa.* A time-domain polarization spectrometer with ultra-broad band (0.3~30THz) and high angular resolution (up to several minutes) has been set up based on terahertz air photonics. Its construction, performances and applications are introduced.

JTh2A.48
Intracavity THz Generation inside Stacked GaP Plates as Output Coupler of Optical Parametric Oscillator, Pu Zhao[1], Xiaomu Lin[1], Yujie J. Ding[1], Xiaodong Mu[2], Huai-Chuan Lee[2], Stephanie K. Meissner[2], Helmuth Meissner[2]; *[1]Lehigh University, USA; [2]Onyx Optics Inc., USA.* We have implemented a THz source based on intracavity difference frequency generation in stacked GaP plates as an output coupler of an optical parametric oscillator. The total THz output peak power approaches 200 W.

JTh2A.49
Microwave Synthesis From a Continuous-wave Terahertz Oscillator Using a Photocarrier Terahertz Frequency Comb, Shigeo Nagano[1], Motohiro Kumagai[1], Hiroyuki Ito[1], Masatoshi Kajita[1], Yuko Hanado[1]; *[1]National Institute of Information and Communications Technology, Japan.* A low-phase-noise microwave signal was synthesized from 0.3THz radiation using a photocarrier frequency comb in a photoconductive antenna. This technique potentially transfers the phase information of THz radiation into accessible microwave region.

JTh2A.50
Ultrafast Plasmonic Photoconductors for High Sensitivity Terahertz Detection, Ning Wang[1], Christopher W. Berry[1], Mohammed Reza Hashemi[1], Mona Jarrahi[1]; *[1]Electrical Engineering and Computer Science, University of Michigan, USA.* A photoconductive terahertz detector based on plasmonic contact electrodes is experimentally demonstrated. Incorporating plasmonic contact electrodes mitigates inherent tradeoff between high quantum-efficiency and ultrafast operation, enabling over 30 times higher terahertz detection sensitivities.

JTh2A.51
Dual THz emissions of GaAsBi for THz photoconductive switching, Barmak Heshmat[1], Mostafa Masnadi-Shirazi[1,2], Ryan Burton Lewis[2,3], Thomas Tiedje[1], Thomas E. Darcie[1]; *[1]Electrical and computer Engineering, University of Victoria, Canada; [2]Electrical and computer Engineering, University of British Columbia, Canada; [3]Department of Physics and Astronomy, University of British Columbia, Canada.* We have measured dual THz emissions and their variations with growth condition (Bi content and annealing temperature) for GaAsBi-based THz photoconductive switches. Results reveal the opposing effects of such property in emission and detection.

JTh2A.52
Study of efficient optical parametric generation in KTP crystal as pump source for DAST-DFG, Kouji Nawata[1], Yoshiki Miyake[1,2], Shin'ichiro HAYASHI[1], Takashi Notake[1], Hiroshi Kawamata[1], Takeshi Matsukawa[1], Feng Qi[1], Hiroaki Minamide[1]; *[1]RIKEN, Japan; [2]Tohoku Institute of Technology, Japan.* We have developed injection-seeded KTP optical parametric generator for DAST-DFG terahertz-wave source. Using a microchip Nd:YAG laser, the energy conversion efficiency of 10% and peak-power output of 2.5 MW were obtained at 1300 nm.

JTh2A.53
Bridging the THz to RF gap by four-wave mixing in a highly nonlinear fiber, Antoine Rolland[1], Lucien Pouget[1], Marc Brunel[1], Goulc'hen Loas[1], Mehdi Alouini[1]; *[1]Optique et Photonique, Universite de Rennes I, France.* Down-conversion from a THz beat generated by a two-frequency solid-state laser to a RF intermediate frequency is performed with a zero dispersion-slope fiber. The two interleaved four-wave mixing spectra contain more than 75 harmonics.

JTh2A.54
Terahertz Characterization via an All-Optical, Ultra-Thin-Knife-Edge Technique, Sze Phing Ho[1,2], Mostafa Shalaby[1], Marco Peccianti[3], Matteo Clerici[1,4], Alessia Pasquazi[1], Yavuz Ozturk[1,5], Jalil Ali[2], Roberto Morandotti[1]; *[1]INRS-EMT, University of Quebec, Canada; [2]Nanophotonics Research Alliance, Universiti Teknologi Malaysia, Malaysia; [3]Institute for Complex Systems- CNR, Italy; [4]School of Engineering and Physical Sciences, Heriot-Watt University, United Kingdom; [5]Ege University, Turkey.* An all-optical, terahertz characterization based on a ultra-thin-knife-edge is demonstrated employing an ultraviolet-pulse to project the image of a blade on a ZnTe crystal, where the free carriers excited on a blade-shaped area act as a field-shield.

JTh2A.55
Withdrawn

JTh2A.56
Anisotropic Structure Induced Electrical Properties of A-plane InN, Pang-Hsian Chang[1], Jhe-Wei Chia[1], Shangjr Gwo[2], Hyeyoung Ahn[1]; *[1]National Chiao Tung University, Taiwan; [2]National Tsing Hua University, Taiwan.* Terahertz spectroscopy reveals that the anisotropic electrical properties of nonpolar InN film along in-plane c-axis and in-plane m-axis are determined by the orientation of narrow and thin stacking faults, not by the density of defects.

JTh2A.57
Enhanced Terahertz Generation from InGaN/GaN Dot-in-a-Wire Light Emitting Diodes, Guan Sun[1], Ruolin Chen[1], Yujie J. Ding[1], Hieu P. Nguyen[2], Zetian Mi[2]; *[1]Electrical and Computer Engineering. Lehigh University, USA; [2]Electrical and Computer Engineering, McGill University, Canada.* Efficient Terahertz output is generated from InGaN/GaN dot-in-a-wire light emitting diodes (LEDs) grown on Si(111). Under reverse bias, the THz output power is enhanced more than 4 times.

JTh2A.58
Demonstration of Coherent Interference of THz Waves Simultaneously Generated by Frequency Mixing, Xiaomu Lin[1], Xingquan Zou[1], Zhaojun Liu[1], Yujie J. Ding[1], Xiaodong Mu[2], Huai-Chuan Lee[2], Stephanie K. Meissner[2], Helmuth Meissner[2]; *[1]Lehigh University, USA; [2]Onyx Optics Inc., USA.* By mixing three nearly-even-spaced optical frequencies generated by coupled optical parametric oscillators based in KTP stacks and bulk KTP in a nonlinear medium, we demonstrate coherent interference of THz waves.

JTh2A.59
High Efficiency Coupling into Tapered Parallel Plate Terahertz Waveguides, Marko Gerhard[1], Michael Theuer[2], Marco H. Rahm[1], René Beigang[2]; *[1]Department of Electrical and Computer Engineering and Research Center OPTIMAS, University of Kaiserslautern, Germany; [2]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Germany.* We present efficient coupling of focused broadband terahertz radiation into tapered metal parallel plate waveguides of sub-wavelength gap widths. The achieved amplitude coupling ratio of more than 70 % is investigated for different polarizations.

JTh2A • POSTER SESSION III: Light-Matter Interactions, ultrafast & Quantum Optics—Continued

JTh2A.60
Impacts of Side Strips and Ridge Width on Terahertz Quantum Cascade Lasers with Metal-Metal Waveguides, chao xu[1], Simon Ferre[1], Dayan Ban[1]; [1]*ECE, Uwaterloo, Canada.* Effects of side uncovered strips and ridge width on terahertz quantum cascade laser performance are investigated numerically and experimentally. Results show substantial performance degradation with shrinking ridge width. An optimal strip width is obtained.

JTh2A.61
Comparing the Sensitivity of Four Laser Induced Damage Tests at 266 nm and 532 nm, Tamas Somoskoi[1], Csaba Vass[1], Mark Mero[1], Robert Mingesz[2], Zoltan Bozoki[1], Karoly Osvay[1,3]; [1]*Department of Optics and Quantum Electronics, University of Szeged, Hungary;* [2]*Department of Technical Informatics, University of Szeged, Hungary;* [3]*ELI-Hu Nkft., Hungary.* The techniques of visual inspection, scattered light measurement, and shock wave detection in air and in the sample material have been tested simultaneously on high reflector laser mirrors with ns laser pulses.

JTh2A.62
Enhancing the pulse shaping precision of energetic high aspect ratio infrared pulses in the National Ignition Facility laser system, Eyal Feigenbaum[1], Richard A. Sacks[1], Mike J. Shaw[1]; [1]*Lawrence Livermore National Laboratory, USA.* NIF's ability to deliver precise, high-contrast pulses is limited by the fidelity of our numerical model. Model fidelity is enhanced by fitting small-signal gain and saturation parameters to measurements and by including temporal overlap effects.

JTh2A.63
High Stability, Single Frequency 136ps Laser Pulse Generation Based on Stimulated Brillouin Scattering, Xuehua Zhu[1], Zhiwei Lu[1], Yulei Wang[1], Xiwen An[1], Mu Li[1]; [1]*National Key Laboratory of Science and Technology on Tunable Laser, Harbin Institute of Technology, China.* We obtained a single-frequency laser pulse with energy of 300-mJ and duration of 136-ps based on stimulated Brillouin scattering using an 8-ns pulse width Q-switched Nd:YAG laser. The achieved pulse duration stability is about 4.1%.

JTh2A.64
High-energy 266-nm picosecond pulse generation from a narrow spectral bandwidth gain-switched LD MOPA, Yosuke Orii[1], Yuichi Takushima[1], Mieko Yamagaki[1], Asa Higashitani[1], Shoji Matsubara[1], Shinichi Murayama[1], Takeshi Manabe[1], Isao Utsumi[1], Daisuke Okuyama[1], George Okada[1]; [1]*Spectronix Corporation, Japan.* We generated 45-μJ 266-nm picosecond optical pulses at 100kHz repetition rate by fourth-harmonic generation of 150-μJ, 72-ps, 1064-nm optical output from a narrow spectral bandwidth hybrid MOPA seeded by a gain-switched laser diode.

JTh2A.65
Efficient amplification of tunable Ti:sapphire laser seeded with single longitudinal mode laser at 1 kHz repetition rate, Rui Wang[1], Hao Teng[1], Nan Wang[1], Peng He[2], Dehua Li[1], Zhiyi Wei[1]; [1]*Optics Physics, Institute of physics, CAS, China;* [2]*School of Technical Physics, Xidian University, China.* Tunable Ti:sapphire laser amplifier covered from 765 nm to 835 nm was demonstrated by using a 1-kHz single longitudinal mode laser as seed. Maximum output power of 6.9 W with <200 MHz linewidth was obtained.

JTh2A.66
An all-solid-state Argon ion laser replacement, Tobias Beck[1], Benjamin Rein[1], Thomas Walther[1]; [1]*Institute of Applied Physics, TU Darmstadt, Germany.* We present a solid-state laser system at 1028 nm. It is frequency doubled and quadrupled to 514 nm and 257 nm, respectively. The system is applicable as a tunable narrowband replacement for Argon ion lasers.

JTh2A.67
Radially polarized Bessel-Gauss beams in ABCD optical systems and fiber-based generation, Damian N. Schimpf[1,2], William P. Putnam[1], Michael D. Grogan[3], Siddharth Ramachandran[3], Franz X. Kärtner[1,2]; [1]*Research Laboratory of Electronics, Massachusetts Institute of Technology, USA;* [2]*Center for Free-Electron Laser Science, DESY, Germany;* [3]*Photonics Center ECE, Boston University, USA.* We derive solutions for radially polarized Bessel-Gauss beams in ABCD optical systems by superimposing decentered Gaussian beams with linear polarization states. We experimentally confirm the expression by employing a fiber-based mode-converter.

JTh2A.68
ISO compliant M-square measurement using a quadriwave lateral shearing interferometer wave front sensor, Benoit Wattellier[1], Ivan Doudet[1]; [1]*PHASICS, France.* We validate the use of a quadriwave lateral shearing Wave Front Sensor (WFS) to make an ISO compliant M-square measurement. We compare measurements made following the ISO standard method with those made with the WFS.

JTh2A.69
Withdrawn

JTh2A.70
Effect of Interatomic Separation and Spatial Spread of Individual Atoms in a Collective State Interferometer, Resham Sarkar[1], May E. Kim[1], Yanfei Tu[1], Selim M. Shahriar[1]; [1]*Northwestern University, USA.* We establish the precise role of interatomic distance and the irrelevance of free propagation broadening of atomic wavepacket in determining the fidelity of collective excitation in an ensemble based atom interferometer with high Compton frequency.

JTh2A.71
Simultaneous Unbalanced Shared Local Oscillator Heterodyne Interferometry (SUSHI) for high SNR, minimally destructive dispersive detection of time-dependent atomic spins, Mary Locke[1], Chad Fertig[1]; [1]*Physics and Astronomy, University of Georgia, USA.* We demonstrate a method for 2-arm, quantum limited dispersive detection with probes between 650 pW and 230 uW, based on simultaneous heterodyne interferometery. SUSHI is suited to continuous observations of Rabi flopping in cold atoms.

JTh2A.72
Superradiance in Parametric Fluorescence, Marco Liscidini[1], Tatsuhiro Onodera[2], Lukas G. Helt[2,3], John E. Sipe[2]; [1]*Physics, Universita degli Studi di Pavia, Italy;* [2]*Physics, University of Toronto, Canada;* [3]*Physics and Engineering, Macquarie University, Australia.* We show that the pair generation rate in spontaneous four-wave-mixing in a sequence of N resonators can scale quadratically with N as a result of a quantum interference in analogy with Dickie superradiant spontaneous emission.

JTh2A.73
Scattering of a Bose-Einstein Condensate from an Oscillating Barrier, Megan K. Ivory[1], Andrew J. Pyle[1], Tommy Byrd[1], Kevin Mitchell[3], John Delos[1], Kunal Das[2], Seth Aubin[1]; [1]*College of William & Mary, USA;* [2]*Kutztown University, USA;* [3]*University of California at Merced, USA.* We experimentally and theoretically investigate the scattering of a Bose-Einstein condensate from a single amplitude-modulated potential barrier as a first step towards a turnstile quantum pump.

JTh2A.74
Indistinguishable Particles and their Correlations in Non-Hermitian Lattices, Markus Gräfe[1], René Heilmann[1], Roert Keil[1], Toni Eichelkraut[1], Matthias Heinrich[2], Stefan Nolte[1], Alexander Szameit[1]; [1]*Diamond-/carbon based optical systems, Institute of Applied Physics; Friedrich-Schiller-Universität Jena, Germany;* [2]*CREOL, The College of Optics & Photonics, University of Central Florida, USA.* A novel approach to investigate the dynamics of indistinguishable particles in non-Hermitian lattice systems exhibiting loss is presented. Especially analyzed are two-particle dynamics in quasi-parity-time-symmetric systems for a variety of input states.

JTh2A.75
Field-Field and Photon-Photon Correlations of Light Scattered by Two Solid-State Emitters, kumarasiri konthasinghe[1], Manoj Peiris[1], Ying Yu[2], Mifeng Li[2], Jifang He[2], Haiqiao Ni[2], Zhichuan Niu[2], Chih-Kang K. Shih[3], Andreas Muller[1]; [1]*Physics, USF, USA;* [2]*Institute of Semiconductors, China;* [3]*Physics, University of Texas at Austin, USA.* We report the measurements of one-photon and two-photon interference of light scattered by two quantum dots, separated by 40 μm. We show how fringe contrasts are strongly affected by spectral diffusion.

JTh2A.76
Coherent Transfer and Retrieval of Terahertz-bandwidth Single Photon Pulses to a Quantum Dot Ensemble at Telecommunication Wavelengths, Kazumasa Suzuki[1], Koichi Akahane[2], Junko Ishi-Hayase[1]; [1]*Keio University, Japan;* [2]*National Institute of Information and Communications Technology (NICT), Japan.* We demonstrate the coherent transfer and on-demand retrieval of quantum state of telecom-wavelength terahertz-bandwidth single photon pulse to a collective excitation of a large number of quantum dots using photon-echo technique.

JTh2A.77
Tailoring single photon emission from diamond using nano-structures, Sebastian Knauer[1,2], John Patrick Hadden[2], Nikos Sergis[1], Jake Kennard[2], Jeremy L. O'Brien[2,1], John G. Rarity[1,2]; [1]*Department of Electrical and Electronic Engineering, University of Bristol, United Kingdom;* [2]*Center for Quantum Photonics, H.H. Wills Physics Laboratory, University of Bristol, United Kingdom.* We describe fabrication methods for making nano-cavities in pure diamond centered around light emitting color centers. We will present results showing how nearby structures change the emission and spin properties.

JTh2A.78
Diamond Nitrogen-Vacancy Centers Creation with Helium-Ion Microscope, Zhihong Huang[1], Wen-Di Li[1,2], Charles M. Santori[1], Victor M. Acosta[1], Andrei Faraon[1,3], R. Stanley Williams[1], Raymond G. Beausoleil[1]; [1]*Hewlett Packard Laboratories, USA;* [2]*Department of Mechanical Engineering, The University of Hong Kong, Hong Kong;* [3]*Applied Pysics and Material Science, California Institute of Technology, USA.* We investigate a method to create nitrogen-vacancy (NV) centers in diamond using a focused-helium-ion-microscopy. Near-surface NV centers can be created with spatial resolution below 0.6um. NV center spectral linewidths at various optical and microwave frequencies were also studied.

JTh2A.79
Towards Lasing Without Inversion in mercury at 253.7 nm, Benjamin Rein[1], Thomas Walther[1]; [1]*Institute for Applied Physics, TU Darmstadt, Germany.* We report on the status of the first implementation of lasing without inversion (LWI) where the lasing wavelength will be significantly shorter than the laser radiation used to create the coherence.

JTh2A.80
Full Solid Angle Ion-Light Interface, Martin Fischer[1,2], Robert Maiwald[1,2], Andrea Golla[1,2], Marianne Bader[1,2], Markus Sondermann[1,2], Gerd Leuchs[1,2]; [1]*Institute of Optics, Information and Photonics, Germany;* [2]*Max Planck Institute for the Science of Light, Germany.* We present an optical system covering 81% of the solid angle into which an ion emits light. With this configuration we focus light close to the diffraction limit, while also approaching optimal light matter coupling.

JTh2A.81
Two-photon absorption in an Atomic Cladding Wave Guide, Liron Stern[1], Ilya Goykhman[1], Boris Desiatov[1], Uriel Levy[1]; [1]*Applied Physics, Hebrew University of Jerusalem, Israel.* We experimentally demonstrate two-photon Doppler free interactions on a chip-scale platform consisting of a silicon nitride waveguide integrated with rubidium vapor cladding. We obtain absorption lines having widths of 300 MHz, using low power levels.

JTh2A • POSTER SESSION III: Light-Matter Interactions, ultrafast & Quantum Optics—Continued

JTh2A.82
Persistent Multipartite Entanglement in a Quantum Spin System, Jiang Zhou[1], Hong Guo[1]; [1]*The State Key Laboratory of Advanced Optical Communication Systems and Networks, School of Electronics Engineering and Computer Science, and Center for Computational Science and Engineering, Peking University, China.* We find the very eigenspaces where multipartite entanglement is more persistent than the bipartite entanglement and can even evolve into a specific constant in a model many-spin systems decohered by a thermal bath.

JTh2A.83
Time-dependent Multiphoton Emission from a Quantum Dot, Sergey Polyakov[1,2], Edward B. Flagg[1,2], Tim Thomay[1,2], Glenn Solomon[1,2]; [1]*Joint Quantum Institute, UMD, USA;* [2]*National Inst of Standards & Technology, USA.* We discuss features seen in a time-resolved experimental measurement of statistical properties of non-classical light from a quantum dot. We present a model that describes properties of a quantum dot excitation via carrier reservoirs.

JTh2A.84
Self-stabilized Quantum Optical Fredkin Gate Enabled by the Raman Effect, Jonathan Hu[1], Yu-Ping Huang[2], Prem Kumar[2]; [1]*Baylor University, USA;* [2]*EECS, Northwestern University, USA.* We demonstrate a quantum optical Fredkin gate in an all-fiber setup, which is self-stabilizing against pump fluctuations owing to stimulated Raman scattering occurring naturally in such a system.

JTh2A.85
A Fast, Low Loss, Electro-optic Single Photon Switch, Matthew S. Bigelow[1], Philip Battle[1], Tony D. Roberts[1]; [1]*ADVR Inc, USA.* We demonstrate a fast, low loss electro-optic (EO) deflector operating as a single photon switch. The device is based on electro-optically controlled prisms engineered into a ferroelectric substrate.

JTh2A.86
Efficient, low-noise, single-photon frequency conversion, Paulina S. Kuo[1,2], Jason S. Pelc[3], Oliver Slattery[1], Yong-Su Kim[1], M. M. Fejer[3], Xiao Tang[1]; [1]*Information Technology Laboratory, National Inst of Standards & Technology, USA;* [2]*Joint Quantum Institute, USA;* [3]*E. L. Ginzton Laboratory, Stanford University, USA.* We demonstrate simultaneous low-noise and efficient frequency conversion in a periodically poled LiNbO3 waveguide with spectral filtering. We achieve >50% external conversion efficiency and 600 noise counts per second at peak conversion.

JTh2A.87
Experimental Controlled-Swap Operation for Direct Measurement of the Overlap between Photonic States, Hee Su Park[1], Sang Min Lee[1], Sang-Kyung Choi[1]; [1]*Korea Research Inst of Standards & Sci, Republic of Korea.* A controlled-swap operation for photons using two optical paths as a control qubit is demonstrated. The overlap between the input states can be directly evaluated by measuring the interference fringe visibility of the control qubit.

JTh2A.88
Robust Phase Estimation of Squeezed State, Shibdas Roy[1], Ian R. Petersen[1], Elanor H. Huntington[1]; [1]*School of Engineering and Information Technology, University of New South Wales, Australia.* Optimal phase estimation of a phase-squeezed quantum state of light has been recently shown to beat the coherent-state limit. Here, the estimation is made robust to uncertainties in underlying parameters using a robust fixed-interval smoother.

JTh2A.89
Fiber-Based Multichannel Correlated Photon-Pair Source with High Efficiency and Low Crosstalk, Yu-Zhu Sun[1], Yu-Ping Huang[2], Neal N. Oza[2], Prem Kumar[1, 2]; [1]*Physics and Astronomy, Northwestern University, USA;* [2]*Electrical Engineering and Computer Science, Northwestern University, USA.* We present a fiber-based multichannel source of correlated photon pairs in the telecommunication O-band. Coincidence-to-accidental ratios >100 (~1) are measured between the paired (unpaired) signal-idler channels.

JTh2A.90
Post-Selection-Free Mode-Locked Two-Photon State for High-Dimensional Hyperentanglement Generation, Zhenda Xie[1], Tian Zhong[2], Xinan Xu[1], Dirk Englund[1], Jeffrey H. Shapiro[2], Franco N.C. Wong[2], Chee Wei Wong[1]; [1]*Columbia University, USA;* [2]*Massachusetts Institute of Technology, USA.* We report realization of high-dimensional hyperentanglement in frequency and polarization from a postselection-free mode-locked two-photon state. Quantum-interference dips and revivals are observed with 97.8% visibility and a Bell inequality is violated in polarization.

JTh2A.91
Continuous wave correlated photon pairs generation in quasi-phase-matched superlattice AlGaAs waveguides, Peyman Sarrafi[1], Eric Y. Zhu[1], Ksenia Dolgaleva[1], Barry Holmes[2], David Hutchings[2], J. Stewart Aitchison[1], Li Qian[1]; [1]*Electrical and Computer Engineering, University of Toronto, Canada;* [2]*School of Engineering, University of Glasgow, United Kingdom.* We report the first demonstration of CW-pumped correlated photon-pair generation in an AlGaAs waveguide with a coincidence-to-accidental ratio > 100. This is about two orders of magnitude greater than previously reported in AlGaAs waveguides.

JTh2A.92
Photonic Quantum Digital Signatures: An Experimental Test-Bed, Robert J. Collins[1], Patrick J. Clarke[1], Vedran Dunjko[1,2], Ross J. Donaldson[1], John Jeffers[3], Erika Andersson[1], Gerald S. Buller[1]; [1]*Institute of Photonics and Quantum Sciences, Heriot-Watt University, United Kingdom;* [2]*School of Informatics, University of Edinburgh, United Kingdom;* [3]*Department of Physics, University of Strathclyde, United Kingdom.* We have built and tested the first experimental demonstration of a photonic quantum digital signature test-bed. We will present a case for quantum digital signatures, overview of the protocol, description of the system and results.

JTh2A.93
Object Identification Using Correlated Orbital Angular Momentum States, Andrew Fraine[1], Nestor Uribe-Patarroyo[1], David Simon[2], Olga Minaeva[3], Alexander Sergienko[1,4]; [1]*Dept. of Electrical and Computer Engineering, Boston University, USA;* [2]*Dept. of Physics and Astronomy, Stonehill College, USA;* [3]*Dept. of Biomedical Engineering, Boston University, USA;* [4]*Dept. of Physics, Boston University, USA.* A technique for object identification using pairs of correlated photons is presented. The detection of rotational symmetries by measuring the joint orbital angular momentum spectrum demonstrates a sparse sensing technique relevant to remote sensing applications.

JTh2A.94
Many-Body Effects in Terahertz Quantum Well Infrared Photodetectors, Simon Ferré[1], Seyed Ghasem Razavipour[1], Chao Xu[1], Dayan Ban[1]; [1]*ECE, University of Waterloo, Canada.* A study on many-body effects on Terahertz Quantum Well Photodetectors is reported. Absorption frequency differs by more than 20% when taking many-body effects into account. The phenomenon is critical in designs with small barrier height.

JTh2A.95
Characterization of Hybrid Entanglement via a Photonic Basis Converter, Jonathan Hodges[1], Stephen P. Pappas[1], Yaakov S. Weinstein[1], Gerald Gilbert[1]; [1]*Quantum Informaiton Science Group, MITRE Corp., USA.* Photonic entanglement interconversion between time-bin and polarization bases has application to quantum communication, computation and memories. We characterize hybrid-basis entanglement between a pair photons obtained through such interconversion and show that non-classical correlations persist.

JTh2A.96
Reducing spin decoherence in a Tm^{3+}:YAG crystal by dynamical decoupling, Tongning Robert-Christopher[1], Pascual-Winter Maria Florencia[1], Chanelière Thierry[1], Le Gouët Jean-Louis[1]; [1]*Laboratoire Aimé Cotton, Université Paris-Sud, France.* We extend Tm^{3+} nuclear spin coherence lifetime to ~230 ms. This 450-fold gain is achieved within the quantum memory context, involving spin hyperpolarization by optical pumping, dynamical decoupling and optical detection of Tm^{3+} ions.

JTh2A.97
Joint Spectral Measurements at the Hong-Ou-Mandel Interference Dip, Gerrits Thomas[1], Francesco Marsili[1], Varun Verma[1], Martin J. Stevens[1], Jeffrey A. Stern[2], Matthew D. Shaw[2], Richard P. Mirin[1], Sae Woo Nam[1]; [1]*National Inst of Standards & Technology, USA;* [2]*Jet Propulsion Laboratory, USA.* We measure the joint spectral probability distribution of correlated photons at the output ports of a Hong-Ou-Mandel interferometer. Simultaneous measurement of all frequency components shows an evolution from bunching to anti-bunching at the beampsplitter outputs.

JTh2A.98
Transverse Entanglement of Biphotons, Felix Just[1], Andrea Cavanna[1], Maria V. Chekhova[1], Gerd Leuchs[1]; [1]*Max-Planck-Gesellschaft, Germany.* We study the transverse entanglement of biphotons generated via parametric downconversion as they propagate from the near to the far field. We obtain the Fedorov ratio and the Schmidt number and compare the results.

JTh2A.99
Measurement of third-order dispersion in a Hong-Ou-Mandel interferometer, Adrian Quarterman[1], John Carroll[1], Adrian Wonfor[1], Richard Penty[1], Ian H. White[1]; [1]*Department of Engineering, University of Cambridge, United Kingdom.* The effect of third-order dispersion in a Hong-Ou-Mandel interferometer is investigated using a ZnSe crystal as a dispersive medium. A value for the TOD coefficient of ZnSe is extracted which is consistent with literature values.

JTh2A.100
Entanglement Dynamics in the Presence of Unital Noisy Channels, Assaf Shaham[1], Assaf Halevy[1], Liat Dovrat[1], Eli Megidish[1], Hagai Eisenberg[1]; [1]*Racah Institute of Physics, The Hebrew University of Jerusalem, Israel.* The entanglement level of two initially entangled qubits, subjected to an uncorrelated unital noisy channel is simply manifested by the radii of its Bloch sphere mapping. We demonstrate this relation experimentally using an all-optical setup.

JTh2A.101
Nonlocal Cancellation of Multi-Frequency-Channel Dispersion Yields Double Coincidence Peaks, Xiaolong Hu[1], Xiang Mao[1], Jacob Mower[1], Catherine Lee[1], Prashanta Kharel[1], Zhenda Xie[2], XinAn Xu[2], Chee Wei Wong[2], Dirk Englund[1]; [1]*Electrical Engineering, Columbia University, USA;* [2]*Mechanical Engineering, Columbia University, USA.* We have observed that temporally-correlated photon pairs, experiencing multi-frequency-channel, opposite dispersion, yield double coincidence peaks. We present and compare theoretical and experimental results.

JTh2A.102
Near Infrared light emitting from InN/InGaN/GaN Dot-in-a-Nanorod Heterostructure, Moon-Deock Kim[1], Song-Gang Kim[2], Woo-chul Yang[3], Sang-Tae Lee[1], Hyo-Seok Choi[1], Byung-Guon Park[1], Kyung-Jin Kim[1]; [1]*Physics, Chungnam National University, Republic of Korea;* [2]*Information and Communications, Joongbu University, Republic of Korea;* [3]*Physics, Dongguk University, Republic of Korea.* We report on the light emitting of InN/InGaN/GaN dot-in-a-nanorods heterostructure grown on Si(111) substrates using plasma-assisted molecular beam epitaxy. Sharp and isolated single exciton emission line in the near infrared spectral range was observed.

JTh2A.103
Superconducting Nanowire Single Photon Detectors with High System Detection Efficiency at Telecom Wavelengths, Francesco Marsili[1], Varun Verma[1], Jeffrey A. Stern[2], Sean D. Harrington[1], Adriana E. Lita[1], Thomas Gerrits[1], Igor Vayshenker[1], Burm Baek[1], Matthew D. Shaw[2], Aaron Miller[3], Richard P. Mirin[1], Sae Woo Nam[1]; [1]*National Inst of Standards & Technology, USA;* [2]*Jet Propulsion Laboratory, California Institute of Technology, USA;* [3]*Department of Physics, Albion College, USA.* We report on a fiber-coupled eight-channel single-photon-detection system employing superconducting nanowire single-photon detectors (SNSPDs) based on amorphous tungsten silicide (WSi) with system detection efficiency ranging from 81 to 89 % at 1550 nm wavelength.

JOINT

JTh2A • POSTER SESSION III: Light-Matter Interactions, ultrafast & Quantum Optics—Continued

JTh2A.104
Evaluation of Tunable Microwave Signals Generated by Monolithic Two-section Distributed Feedback Lasers, Chien-Chung Lin[1], Chen-Yu Chien[1], Yu-Chang Wu[1], Hao-chung Kuo[2], Chun-Ting Lin[1]; *[1]Institute of Photonic System, National Chiao Tung University, Taiwan; [2]Department of Photonics, National Chiao Tung University, Taiwan.* We demonstrated a two-section 1.55μm laser with an air gap in the middle section. When two DFB lasers are powered together, an optical heterodying operation can produce microwave signals up to 44 GHz.

JTh2A.105
Asymmetric MQW Semiconductor Optical Amplifier for Next-Generation Optical Access Networks, Julie Nkanta[1], Ramon Maldonado-Basilio[1], Abdessamad Benhsaien[1], Kaiser Khan[1], Sawsan Abdul-Majid[1], Jessica Zhang[2], Trevor J. Hall[1]; *[1]Center for Research in Photonics, University of Ottawa, Canada; [2]CMC Microsystems, Canada.* A broadband and low polarization sensitive MQW SOA with an asymmetric structure is reported for operation in E-band wavelength range. A peak gain of 13.5dBm for >50nm bandwidth and polarization sensitivity of 0.5dB are measured.

JTh2A.106
Blue GaN-based surface-emitting lasers incorporating a sub-wavelength high contrast grating, Tzeng-Tsong Wu[1], Shu-Hsien Wu[1], Hao-Wen Chen[1], Tien-Chang Lu[1], Shing-Chung Wang[1]; *[1]Department of Photonics and Institute of Electro-Optical Engineering,, National Chiao Tung University, Taiwan.* Blue GaN-based surface-emitting lasers incorporating a sub-wavelength high contrast grating were reported. The laser characteristics such as threshold energy, degree of polarization and divergence angle were measured to be 0.56 mJ/cm2, 73% and 12°.

JTh2A.107
Rate Equation Analysis of Three Phonon-Photon-Phonon Terahertz Quantum Cascade Lasers, Seyed Ghasem Razavipour[1], Emmanuel Dupont[2], Saeed Fathololoumi[1,2], Zbig Wasilewski[1,2], Sylvain Laframboise[2], H.c Liu[3], Dayan Ban[1]; *[1]Electrical and Computer, University of Waterloo, Canada; [2]National Research Council of Canada, Canada; [3]Department of Physics, Shanghai Jiao Tong University, China.* A rate equation model is presented to analyze the performance of terahertz quantum cascade lasers based on consecutive phonon-photon-phonon emissions. Devices lased up to 128.5, 138, and 144 K at 2.5, 3.2 and 2.6 THz, respectively.

JTh2A.108
Measurements of Optical Mode-Linewidth and Mode-frequency drift of a Mode-Locked Laser using Coherent Intradyne-Detection, Christophe Gosset[1], Fausto Gomes-Agis[2], XIn You[1], Laurent Bramerie[2], Philippe B. Gallion[1]; *[1]Centre National de la Recherche Scientifique, Télécom ParisTech,Ecole Natl Sup des Telecommunications, France; [2]Centre National de la Recherche Scientifique, ENSSAT, France.* We propose a time-resolved technique based on coherent intradyne-detection to measure the short-term optical spectral line width and the long-term mode-frequency of a single-mode in a mode-locked laser. Aliasing inherent in self-delayed homodyne technique is avoided.

JTh2A.109
Toward an Efficient Germanium-on-Silicon Laser: Ultimate Limits of Tensile Strain and n-Type Doping, David Sukhdeo[1], Donguk Nam[1], Ze Yuan[1], Birendra (Raj) Dutt[2,3], Krishna C. Saraswat[1]; *[1]Electrical Engineering, Stanford University, USA; [2]APIC Corporation, USA; [3]PhotonIC Corporation, USA.* We investigate the ultimate limits of tensile strain and n-type doping for improving germanium lasers. These ultimate limits occur around 2.3-3.7% biaxial strain and 10^18-10^19 cm^-3 electrically-active doping. >1000x threshold reductions are possible.

JTh2A.110
Wavelength Tunable Selectively Intermixed Quantum Well Laser, Abdullah J. Zakariya[1], Patrick L. Likamwa[1]; *[1]University of Central Florida, USA.* We demonstrate a monolithic Fabry-Pérot laser in which the wavelength is tuned by electrically steering the laser beam over a gain medium consisting of three laterally adjacent selectively intermixed quantum well regions

JTh2A.111
Lateral Current Density Distribution and Spatial Hole Burning in Quantum Cascade Lasers, Xue Huang[1], Yamac Dikmelik[2], Claire F. Gmachl[1]; *[1]Princeton University, USA; [2]Johns Hopkins University, USA.* We have investigated non-uniformity of the lateral current density and lateral hole burning in Quantum Cascaded lasers, e.g., the current density in the mode center is 1.8 times that in the edge region.

JTh2A.112
Dynamics of Split-Pulsing in a Two-Section Passively Mode Locked Quantum Dot Laser, Ravi Raghunathan[1], Alexandre Braga[1], Mark Crowley[2], Jesse Mee[1,3], Luke Lester[1]; *[1]Center for High Technology Materials, University of New Mexico, USA; [2]BinOptics Corporation, USA; [3]AFRL/RVSE, Air Force Research Laboratory, Kirtland AFB, USA.* The measured dynamics of split-pulsing in a mode-locked quantum dot laser have been studied using a numerical model. This is important to understand the origin of such parasitic dynamical effects, and to minimize their occurrence in practical devices.

JTh2A.113
Long Photon Lifetime from Microdisk Cavity Laser with Type II GaSb/GaAs Quantum Dots, Kung shu Hsu[1,2], Chih Chi Chang[1], Wei Hsun Lin[1], Min-Hsiung Shih[1,2], Shih Yen Lin[1,2], Yia Chung Chang[1,2]; *[1]Research Center for Applied Sciences (RCAS), Academia Sinica, Taiwan; [2]Photonics, National Chiao Tung University, Taiwan.* Microdisk lasers with active region made of type II GaSb/GaAs quantum dots on the GaAs substrate have been demonstrated. Lasing wavelengths near 1μm was achieved and longer photon lifetime from type II structure also observed.

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

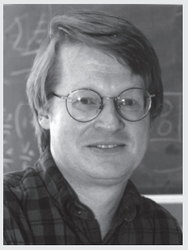
CLEO: QELS-Fundamental Science

14:00–16:00
QTh3A • Particle Acceleration by Lasers

Presider: Csaba Toth; Lawrence Berkeley National Laboratory, United States

QTh3A.1 • 14:00 Tutorial

Laser Plasma Acceleration of Electrons and Plasma Diagnostics at High Laser Fields, Michael C. Downer[1]; [1]*Univ. of Texas at Austin, USA.* Laser-plasma acceleration is now entering an era of petawatt lasers, tenuous plasmas and multi-GeV electron energies. I will review initial results in this regime, and discuss plasma diagnostics needed to understand, optimize and scale them.



Mike Downer is College of Natural Sciences Distinguished Professor of Physics and Distinguished University Teaching Professor at the University of Texas at Austin. He earned a Ph.D. in 1983 from Harvard University under Nicolaas Bloembergen. During postdoctoral work at AT&T Bell Laboratories, he contributed to the early development of femtosecond light sources and spectroscopy. Since joining the faculty at the University of Texas in 1985, he has supervised 32 Ph.D. and 20 M.S. dissertations on topics ranging from laser-plasma particle accelerators to nonlinear optical spectroscopy of semiconductor interfaces. He has published over 150 articles in refereed journals. Professor Downer has served as Topical Editor of the Journal of the Optical Society of America B, General Chair of the 2005 QELS conference and Chair of the 2012 Advanced Accelerator Concepts workshop. He is a Fellow of the American Physical Society and the Optical Society of America.

14:00–16:00
QTh3B • Thermal & Optomechanical Metamaterials

Presider: Frank Koppens , Institut de Ciencies Fotoniques, Spain

QTh3B.1 • 14:00

Phonon Polariton Spectroscopy in the Thermal Near-Field, Brian O'Callahan[1], Markus B. Raschke[1]; [1]*Physics, Chemisty, JILA, University of Colorado at Boulder, USA.* Using scattering near-field spectroscopy with heated tips and substrates we characterize the distinct spatial, spectral, and coherence properties of the resonantly enhanced thermal near-field, and the optical antenna mediated projection into far-field emission.

QTh3B.2 • 14:15

High Temperature Plasmonics, Yu Guo[1], Zubin Jacob[1]; [1]*University of Alberta, Canada.* We propose an approach for controlling Wein's displacement law in the near-field leading to a narrowband, tunable, spatially-coherent high temperature thermal source. Our approach utilizes engineered plasmonic states of metals with a high melting point.

QTh3B.3 • 14:30

Temporal Coupled mode theory for thermal emission from a single emitter, Linxiao Zhu[1], Sunil Sandhu[2], Clayton R. Otey[1], Michael B. Sinclair[3], Ting S. Luk[3], Shanhui Fan[2]; [1]*Applied Physics, Stanford University, USA;* [2]*Electrical Engineering, Ginzton Laboratory, Stanford University, USA;* [3]*Sandia National Laboratories, USA.* We propose a temporal coupled mode theory for thermal emission from a single emitter. We validate the coupled mode theory formalism by a direct numerical simulation of the emission properties of single emitters.

QTh3B.4 • 14:45

Strong Chiral Optical Response using Phase-shifts in a Planar Plasmonic Metamaterial, Fatima Eftekhari[1,2], Timothy J. Davis[1,2]; [1]*Materials Science and Engineering, CSIRO, Australia;* [2]*Melbourne Centre for Nanofabrication, Australia.* The chiral optical response is an ability to distinguish between states of circular polarization. We show theoretically and experimentally how to obtain a strong chiral response by exploiting phase shifts in arrays of subwavelength-scale plasmonic structures.

14:00–16:00
QTh3C • Photon Pair Sources and Entanglement

Presider: Kevin Resch; University of Waterloo, United States

QTh3C.1 • 14:00

Engineered Photon-Pair Generation through Dual-Pump Spontaneous Four-Wave Mixing, BIN FANG[1], Offir Cohen[1,2], Jamy B. Moreno[1], Virgina O. Lorenz[1]; [1]*Physics and Astronomy, University of Delaware, USA;* [2]*National Institute of Standards and Technology & University of Maryland, USA.* We show one can engineer the spectral correlations of photon-pairs pro- duced in optical fibers by employing the temporal walk-off between two distinct pumps in spontaneous four-wave mixing to create completely factorable states without spectral filtering.

QTh3C.2 • 14:15

Photon pair generation and manipulation in an integrated silicon chip, Damien Bonneau[1], Josh W. Silverstone[1], Robert H. Hadfield[3], Val Zwiller[4], Kazuya Ohira[2], Nobuo Suzuki[2], Haruhiko Yoshida[2], Norio Iizuka[2], Mizunori Ezaki[2], John G. Rarity[1], Jeremy L. O'Brien[1], Mark G. Thompson[1]; [1]*Centre for Quantum Photonics, University of Bristol, United Kingdom;* [2]*Corporate Research & Development Center, Toshiba Corporation, Japan;* [3]*School of Engineering, University of Glasgow, United Kingdom;* [4]*Kavli Institute of Nanoscience, TU Delft, Netherlands.* Quantum photonics is a promising technology for implementing quantum information tasks. We demonstrate integration of multiple photon pair sources together with a circuit enabling creation and manipulation of photon pairs in a monolithic silicon-on-insulator chip

QTh3C.3 • 14:30

Don't worry, be happy: A look at undesirable nonlinear effects in integrated photon pair sources based on spontaneous four-wave mixing, Lukas G. Helt[1,2], Michael J. Steel[2], John E. Sipe[1]; [1]*Physics, University of Toronto, Canada;* [2]*Physics and Astronomy, Macquarie University, Australia.* We theoretically demonstrate that if pump powers are kept low enough to suppress multi-pair events in integrated photon pair generation via spontaneous four-wave mixing, many other nonlinear effects are often also constrained to negligible levels.

QTh3C.4 • 14:45

1.5 μm Polarization Entanglement Generation based on Polarization Maintaining All-fiber Scheme, Qiang Zhou[1], Wei Zhang[1], Feng Zhu[1], Tianzhu Niu[1], Shuai Dong[1], Yidong Huang[1], Jiangde Peng[1]; [1]*Department of Electronic Engineering, Tsinghua University, China.* 1.5 μm polarization entanglement generation is experimentally demonstrated utilizing off-the-shelf components based on polarization maintaining all-fiber scheme. Quantum state tomography is performed, achieving an entanglement fidelity of 0.94±0.03, indicating its potential in quantum information.

14:00–16:00
QTh3D • Graphene Optics and Photonics

Presider: Robert Kaindl; Lawrence Berkeley National Laboratory, United States

QTh3D.1 • 14:00 Tutorial

Optical Properties and Photonics Applications of Graphene, Tony F. Heinz[1]; [1]*Depts of Physics and Electrical Engineering, Columbia University, USA.* The optical response of graphene, a single atomic layer of carbon, exhibits distinctive properties from the THz to the ultraviolet. We review these features and describe recent advances in incorporating graphene into diverse photonic devices.

Tony Heinz is the Rickey Professor in the Departments of Physics and Electrical Engineering at Columbia University. His research interests lie in the area of nonlinear optics and ultrafast spectroscopy, particularly as applied to surfaces, interfaces, and nanoscale materials. He has recently worked extensively on the optical properties and applications of nanoscale carbon in the form of nanotubes and graphene. Heinz received his BS degree in Physics from Stanford University and a PhD degree, also in Physics, from the UC Berkeley in 1982. Prior to joining Columbia University in 1995, Heinz was with the IBM Research Division in Yorktown Heights, NY. His research has been recognized by Optics Prize of the International Commission for Optics, a Research Award of the von Humboldt Foundation, and the Julius Springer Prize for Applied Physics. Heinz is a Fellow of the OSA and APS. He served as President of the OSA in 2012.

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

14:00–16:00
QTh3E • Plasmonic Nanostructures
Presider: Minghao Qi; Purdue University, United States

QTh3E.1 • 14:00 Tutorial

Strong-field Effects in Metallic Nanostructures, Claus Ropers[1]; [1]*Georg-August-Universite Gottingen, Germany.* Local field enhancements in metallic nanostructures enable the study of various highly nonlinear optical processes in nanoscopic volumes. In this talk, the prominent examples of strong-field photoemission and extreme ultraviolet light generation will be discussed.

Claus Ropers studied physics at the University of Göttingen and the University of California at Berkeley. Conducting his doctoral studies at the Max Born Institute, he received a PhD from the Humboldt University in Berlin in 2007. He was appointed Assistant Professor at the Courant Research Centre "Nano-Spectroscopy and X-Ray Imaging" (2008) and Associate Professor at the Institute of Materials Physics (2011), both at the University of Göttingen. His research focuses on ultrafast processes in solids, nanostructures and at surfaces. To this end, his group develops novel experimental tools for the study of ultrafast structural and electronic dynamics. For his scientific achievements, he was awarded the Carl-Ramsauer Prize, Nanoscience Prize (awarded by AGeNT-D) and Walter-Schottky Prize by the German Physical Society.

14:00–16:00
CTh3F • Nonlinear Optics in Nanophotonic Devices
Presider: Alexander Gaeta; Cornell University, United States

CTh3F.1 • 14:00

Ultralow-threshold Continuous-wave Raman Silicon Laser Using a Photonic Crystal High-Q Nanocavity, Yasushi Takahashi[1,2], Yoshitaka Inui[3], Takashi Asano[3], Susumu Noda[3]; [1]*Osaka Prefecture University, Japan;* [2]*Japan Science and Technology Agency, Japan;* [3]*Kyoto University, Japan.* We report a unique design of a Raman silicon laser using a photonic crystal high-Q nanocavity without the reverse-biased p-i-n diode, which leads to the continuous-wave lasing operation with ultralow threshold power of ~1 uW.

CTh3F.2 • 14:15

Multi-color visible light generation by self-frequency doubling in photonic crystal nanocavity quantum dot lasers, Yasutomo Ota[1], Katsuyuki Watanabe[1], Satoshi Iwamoto[1,2], Yasuhiko Arakawa[1,2]; [1]*Nanoquine, University of Tokyo, Japan;* [2]*IIS, University of Tokyo, Japan.* We report multi-color visible light generation from photonic crystal nanocavity lasers exhibiting broadband quantum dot gain in the near infrared. The visible emission is produced though self-frequency doubling, which efficiently occurs within the high Q nanocavities.

CTh3F.3 • 14:30

Low-noise microwave generation using an on-chip Brillouin laser, Jiang Li[1], Hansuek Lee[1], Kerry J. Vahala[1]; [1]*California Institute of Technology, USA.* An on-chip Brillouin microwave source is demonstrated. Phase noise of -106 dBc/Hz at 100kHz offset frequency (21.6 GHz carrier signal) is measured. A record low white phase noise floor for a microcavity-based source is demonstrated.

CTh3F.4 • 14:45

Ultrafast Optical Switching in Amorphous Silicon Microring Resonators, Jason Pelc[1], Kelley Rivoire[1], Charles M. Santori[1], Raymond G. Beausoleil[1]; [1]*Hewlett Packard Labs, USA.* We demonstrate Kerr-effect-based optical switching of amorphous Si microring resonators with full-width-at-half-maximum switching times of 14.8 ps at 1550 nm; low two-photon absorption reduces the creation of free carriers which would inhibit fast switching.

14:00–15:45
CTh3G • Photonic Crystal Lasers
Presider: Kent Choquette, Univ. of Illinois, Urbana-Champaign, USA

CTh3G.1 • 14:00 Tutorial

Photonic Crystal Lasers, Susumu Noda[1,2]; [1]*Electronic Science and Engineering, Kyoto Univ., Japan;* [2]*Photonics and Electronics Science and Engineering Center, Kyoto Univ., Japan.* I will review progresses of photonic crystal lasers, which are now recognized as an unprecedented type of lasers that can operate coherently in broad area, produce a tailored beam on demand, realize a beam steering functionality, etc.

Susumu Noda received B.S., M.S., and Ph.D. degrees from Kyoto University, Kyoto,Japan, in 1982, 1984, and 1991, respectively, all in electronics. In 2006, he has received an honorary degree from Gent University, Gent, Belgium. From 1984 to 1988, he was with the Mitsubishi Electric Corporation, and he joined Kyoto University in 1988. Currently he is a Professor with the Department of Electronic Science and Engineering and a director of Photonics and Electronics Science and Engineering Center (PESEC), Kyoto University. His research interest covers physics and applications of photonic and quantum nanostructures including photonic crystals and quantum dots. He received several awards including the IBM Science Award (2000), the Japan Society of Applied Physics Achievement Award on Quantum Electronics (2005), and OSA Joseph Fraunhofer Award/Robert M. Burley Prize (2006), IEEE Fellow (2008), IEEE Nanotechnology Pioneering Award (2009) and Leo Esaki Award (2009). From 2003 to 2005, he served as IEEE/LEOS Distinguished Lecturer. From 2007, he has served as a Chair of IEEE/Photonics Society Kansai Chapter.

14:00–16:00
CTh3H • Ultrafast Laser Sources II
Presider: Clara Saraceno, ETH Zurich, Switzerland

CTh3H.1 • 14:00

Four-Wave Optical Parametric Amplification in a Gas towards an Octave Amplification Bandwidth, Yuichiro Kida[1], Totaro Imasaka[1,2]; [1]*Department of Applied Chemistry, Graduate School of Engineering, Kyushu University, Japan;* [2]*Division of Optoelectronics and Photonics, Kyushu University, Japan.* Four-wave optical parametric amplification in a gas allows amplification of an octave-spanning supercontinuum. As a proof-of-principle experiment, amplification of a continuum in a spectral range of 520-700 nm with a gain exceeding thirty is demonstrated.

CTh3H.2 • 14:15

An Off-Axis, Single-Pass, Radial-Group-Delay Compensator Design Using an Offner Triplet for a Broadband OPCPA Laser, Seung-Whan Bahk[1], Jake Bromage[1], Jonathan D. Zuegel[1], Robert K. Jungquist[1]; [1]*University of Rochester, USA.* An off-axis, single-pass, radial-group-delay compensator was designed using an Offner triplet and two negative lenses for a broadband (810~1010-nm) optical parametric amplifier laser. It reduces radial group delay from 270 fs to 0.7 fs.

CTh3H.3 • 14:30

Millijoule-Level Parametric Synthesizer Generating Two-Octave-Wide Optical Waveforms for Strong-Field Experiments, Oliver D. Mücke[1,3], Shaobo Fang[1,3], Giovanni Cirmi[1,3], Shih-Hsuan Chia[1,3], Franz X. Kaertner[2,4], Cristian Manzoni[5], Paolo Farinello[5], Giulio Cerullo[5]; [1]*Center for Free-Electron Laser Science, Deutsches Elektronen-Synchrotron DESY, Germany;* [2]*Physics Department, University of Hamburg, Germany;* [3]*The Hamburg Center of Ultrafast Imaging, Germany;* [4]*Department of Electrical Engineering and Computer Science and Research Laboratory of Electronics, Massachusetts Institute of Technology, USA;* [5]*IFN-CNR, Dipartimento di Fisica, Politecnico di Milano, Italy.* We demonstrate a phase-stable, 3-channel parametric synthesizer generating a 2-octave-wide spectrum (0.52-2.4μm). After two amplification stages, the combined 125-μJ output supports 1.9-fs waveforms. The third stage of the IR degenerate OPA yields 1.7-mJ octave-spanning spectra.

CTh3H.4 • 14:45

21.4 kW peak power from a gigahertz multimode-diode-pumped solid-state laser with carrier-envelope offset frequency detection, Alexander Klenner[1], Matthias Golling[1], Ursula Keller[1]; [1]*IQE, ETH Zurich, Switzerland.* A gigahertz multimode-diode-pumped Yb-doped solid-state laser delivers 121 fs pulses at an average power of 3.33 W, resulting in 21.4 kW peak power. The carrier envelope offset frequency was detected with 30 dB S/N ratio.

CLEO: Science & Innovations

14:00–16:00
CTh3I • Biosensors
Presider: Michael Previte; Illumina, United States

CTh3I.1 • 14:00
High-throughput screening of blood samples based on structured illumination on-chip imaging, Serap A. Arpali[1], Caglar Arpali[1], Ahmet F. Coskun[1], Hsin-Hao Chiang[1], Aydogan Ozcan[1,2]; [1]*Electrical Engineering Department, University of California, Los Angeles, USA;* [2]*California NanoSystems Institute, University of California, Los Angeles, USA.* We demonstrate a high-throughput fluorescent on-chip imaging platform, using structured illumination that can rapidly screen large volumes of scattering media such as undiluted blood samples (e.g., ~0.3-0.7mL) for detection of fluorescent micro-objects at low concentrations.

CTh3I.2 • 14:15
High-performance refractometric nanosensor using circular plasmonic interferometer arrays, Yongkang Gao[1], Zheming Xin[1], Beibei Zeng[1], Qiaoqiang Gan[2], Xuanhong Cheng[3], Filbert J. Bartoli[1]; [1]*ECE Department, Lehigh University, USA;* [2]*EE Department, University at Buffalo, The State University of New York, USA;* [3]*MSE Department, Lehigh University, USA.* We report novel circular plasmonic interferometers for refractometric sensing with detection limit of 8.7×10^-7 RIU using a multispectral sensing method. The efficient light suppression through destructive interference also allows low-background intensity-based detection with FOM* exceeding 140.

CTh3I.3 • 14:30
Plasmonically Enhanced Biofilm Photobioreactors, Matthew Ooms[1,2], David Sinton[1,2]; [1]*Mechanical & Industrial Engineering, University of Toronto, Canada;* [2]*Centre for Sustainable Energy, University of Toronto, Canada.* Au nano-particles on the bottom surface of a photobioreactor are used as scattering elements and are shown to enhanced oxygen evolution rates in cultures of cyanobacteria by increasing the light path length through the culture.

CTh3I.4 • 14:45
Bio-Inspired Plasmonic Sensors by Diatom Frustules, Fanghui Ren[1], Jeremy Campbell[2], Dihan Hasan[1], Xiangyu Wang[1], Greg L. Rorrer[2], Alan X. Wang[1]; [1]*Electrical Engineering and Computer Science, Oregon State University, USA;* [2]*Chemical, Biological & Environmental Engineering, Oregon State University, USA.* We investigate bio-inspired plasmonic sensors based on the interactions between Ag nanoparticles and diatom biosilica. The strongly coupled optical resonances lead to 2× higher optical extinction and 4~6× improvement of sensitivity in surface-enhanced Raman scattering.

14:00–16:00
CTh3J • Fabrications and Applications II
Presider: Iila Goykhman, The Hebrew University, Jerusalem, Israel

CTh3J.1 • 14:00
Nanoimprinted Plasmonic Nanocavity Arrays, Kevin J. Webb[1], Minghao Qi[1], Sangsik Kim[1], Yi Xuan[1], Vladimir P. Drachev[2]; [1]*Electrical and Computer Engineering, Purdue University, USA;* [2]*Physics, University of North Texas, USA.* We demonstrate the resonant absorption of visible light with plasmonic nanocavity arrays fabricated by resistless nanoimprinting in metal (RNIM). The nanocavities are efficiently excited using normally incident light, and numerical simulations confirm the experimental data.

CTh3J.2 • 14:15
Liquid Deposition Photolithography for Photonic Device Fabrication, Adam Urness[1], Robert McLeod[1]; [1]*Department of Electrical, Computer, and Energy Engineering, University of Colorado, USA.* We describe a novel fabrication method, liquid deposition photolithography (LDP), for the creation of polymer photonic devices. We demonstrate LDP's ability to fabricate photonic devices by fabricating a waveguide array and gradient index lens.

CTh3J.3 • 14:30
Stimulated Brillouin Scattering Amplification in Directly Written As2S3 Glass Waveguides, Shahar Levy[1], Victor Lyubin[2], Matvei Klebanov[2], Jacob Scheuer[3], Avi Zadok[1]; [1]*Faculty of Engineering, Bar-Ilan University, Israel;* [2]*Department of Physics, Ben-Gurion University, Israel;* [3]*Faculty of Engineering, Tel-Aviv University, Israel.* Stimulated Brillouin scattering amplification is demonstrated in 1 cm-long chalcogenide glass waveguides. The waveguides are directly written using a Ti:Sapphire laser operated at 810 nm wavelength. A Brillouin frequency shift of 7.45 GHz is observed.

CTh3J.4 • 14:45
Correlated Optical and Electrical Detection of Single Nanoparticles on a Nanopore-Optofluidic Chip, Shuo Liu[1], Yue Zhao[2], Aaron Hawkins[2], Holger Schmidt[1]; [1]*School of Engineering, University of California, Santa Cruz, USA;* [2]*Department of Electrical and Computer Engineering, Brigham Young University, USA.* A nanopore is integrated into an optofluidic chip, enabling simultaneous optical and electrical detection of single nanoparticles. The cross correlation coefficients between the optical and electrical signals for 200nm and 500nm nanoparticles are as high as 0.9327 and 0.7435, respectively.

CLEO: Applications & Technology

14:00–15:30
ATh3K • Ultrafast Laser Design and Applications
Presider: Eric Mottay; Amplitude Systemes, France

ATh3K.1 • 14:00 Invited
Laser micro-fabrication systems for consumer electronics device manufacturing, Haibin Zhang[1], Hisashi Matsumoto[1], Glenn Simenson[1], Qian Xu[1], Mark Unrath[1], Martin Orrick[1], Michael Darwin[1], Robert F. Hainsey[1]; [1]*Electro Scientific Industries, Inc., USA.* Laser based micro-fabrication tools have become default choices for critical processes in consumer electronics. Smart beam delivery and system design enables high quality low cost manufacturing of several key components in mobile devices.

ATh3K.2 • 14:30
Free z-focus control laser processing via ultra-high speed axial scanning, Marti Duocastella[1], Craig B. Arnold[1]; [1]*Mechanical and Aerospace Engineering, Princeton University, USA.* An ultra-high speed axial scanner is used to enhance the depth of field of a laser system without sacrificing lateral resolution. This new approach eliminates the classic constraint of precise z-focus control in laser processing.

ATh3K.3 • 14:45
High Q SpiritTM Laser Systems for Industrial Micro Processing Applications, Victor Matylitsky[1], Frank Hendricks[1], Juerg Aus der Au[1]; [1]*High Q Laser GmbH, Austria.* Unique advantage of solid material processing with femtosecond lasers is high ablation efficiency and processing accuracy. We will show aspects of HighQ SpiritTM femtosecond laser system performance and give overview of its actual applications.

CLEO: Science & Innovations

14:00–16:00
CTh3L • Photodetectors I
Presider: Takahiro Nakamura; PETRA, Japan

CTh3L.1 • 14:00 Tutorial
Recent Advances in Photodetectors: Ultraviolet to Mid-Wave Infrared, Joe C. Campbell[1]; [1]*University of Virginia, USA.* This talk will describe recent work on photodetectors. The discussion on avalanche photodiodes (APDs) will include novel linear-mode low-noise structures and recent advances in single photon detection. The presentation on p-i-n photodiodes will concentrate on high-speed, high-power, high-linearity and Si photonics.

Joe C. Campbell is the Lucian Carr Professor of Electrical and Computer Engineering at the University of Virginia. Professor Campbell's technical area is photodetectors. At present he is actively involved in single-photon-counting APDs, Si-based optoelectronics, high-speed low-noise avalanche photodiodes, high-power high-linearity photodiodes, ultraviolet analanche photodiodes, and solar cells. He has coauthored ten book chapters, 400 articles for refereed technical journals, and more than 350 conference presentations. Professor Campbell teaches graduate and undergraduate courses on lasers and optoelectronic components. In 2002 Professor was inducted into the National Academy of Engineering.

CLEO: Science & Innovations

14:00–16:00
CTh3M • Fiber Parametric Amplifiers

Presider: Shenping Li; Corning Incorporated, United States

CTh3M.1 • 14:00 Tutorial

Fiber Optical Parametric Amplifiers in Optical Communication, Michel E. Marhic[1]; [1]*Swansea Univ., United Kingdom.* Features of parametric amplifiers desirable for optical communication (low noise figure, phase conjugation, large gain bandwidth, etc.) are presented. Recent experimental demonstrations are reviewed, and prospects for further development are discussed.

Michel E. Marhic received a Ph.D in EE from UCLA. He was on the faculty of the Department of Electrical Engineering at Northwestern University (1974-1998), and Consulting Professor in the Department of Electrical Engineering at Stanford University (1998-2006). He is currently Chair Professor at the Institute of Advanced Telecommunications, College of Engineering, Swansea University, Wales, U.K. Over the past 30 years, his research has been in several areas of applied optics, including nonlinear interactions in plasmas; optical fiber measurements; hollow infrared waveguides; holography and phase conjugation; fiber networks. Over the past 25 years, emphasis has been on optical communication systems, and on nonlinear optical interactions in fibers. He has written the first book on fiber optical parametric amplifiers, published by Cambridge University Press in 2007. He is the author or coauthor of over 330 journal and conference papers. He is a fellow of OSA

CLEO: Applications & Technology

14:00–16:00
ATh3N • LEDs for Energy Efficiency

Presiders: Christian Wetzel; Rensselaer Polytechnic Institute, United States

ATh3N.1 • 14:00 Invited

Semipolar Faceting for InGaN-based Polychromatic LEDs, Mitsuru Funato[1], Yoichi Kawakami[1]; [1]*Kyoto University, Japan.* Toward the next generation solid state lighting, three-dimensional InGaN light emitting diodes (LEDs) are a new trend. Grown through a re-growth technique, they show semipolar faceting, which enables polychromatic and efficient emission.

ATh3N.2 • 14:30

A Study of Mechanical Lift-Off Technology for High-Efficiency Vertical LEDs Using Micro-Porous GaN Template, Chia Yu Lee[1], Da-Wei Lin[1], Che-Yu Liu[1], Shih-Chieh Hsu[2], Hao-chung Kuo[1], Shing-Chung Wang[1], Chun-Yen Chang[3]; [1]*Photonics and Institute of Electro-Optical Engineering, National Chiao Tung University, Taiwan;* [2]*Chemical and Materials Engineering, Tamkang University, Taiwan;* [3]*Electronics, National Chiao Tung University, Taiwan.* The high efficiency vertical light emitting diodes (V-LEDs) using mechanical lift-off were demonstrated. The light output of V-LEDs are greatly enhanced by 100% compared with Conventional-LEDs at an operating current of 20mA

ATh3N.3 • 14:45

Deep Ultraviolet (DUV) Light-Emitting Diodes (LEDs) to Maintain Freshness and Phytochemical Composition During Postharvest Storage, Steven Britz[1], Ignas Gaska[2], Igor Shturm[2], Yuri Bilenko[2], Max Shatalov[2], Remis Gaska[2]; [1]*Food Components and Health, U.S. Dept. Agriculture, USA;* [2]*Sensor Electronic Technology, Inc., USA.* Low-irradiance, long-term UV treatment using DUV-LEDs extended the cold storage shelf life of strawberries up to 2-fold as based on weight, moisture content, anthocyanin concentration, soluble solids, titratable acidity, visible damage, and mold growth.

14:00–16:00
ATh3O • Symposium on The Path to Sustainable Energy: Laser Driven Inertial Fusion Energy – ICF Target Design and Fabrication/Future Perspectives Kick-off

Presider: J.C. Fernandez; Los Alamos National Laboratory, United States

ATh3O.1 • 14:00 Invited

NIF Target Fabrication, Alex Hamza[1]; [1]*Lawrence Livermore National Laboratory, USA.* NIF targets are complicated assemblies, often requiring novel materials. Creating these targets requires innovative materials science and precise engineering. Components are machined to 1 micrometer tolerances and capsule surfaces are smooth to a few nanometers.

ATh3O.2 • 14:30 Invited

Target Fabrication for NIF and Inertial Fusion Energy, Abbas Nikroo[1]; [1]*General Atomics, USA.* We discuss progress in fabrication of NIF targets, including cryogenic target platforms and we will update target technology developments for IFE.

CLEO: QELS-Fundamental Science

QTh3A • Particle Acceleration by Lasers—Continued

QTh3A.2 • 15:00
Utilization of a Few-Cycle Probe Beam to Study Relativistic Laser-Plasma Interaction, Oliver Jäckel[1,2], Alexander Sävert[2,1], Matthew Schwab[2,1], Maria Nicolai[2,1], Maria Reuter[1,2], Jens Polz[2,1], M. Kaluza[2,1]; [1]*Helmholtz-Institut Jena, Germany;* [2]*Institut of Optics and Quantum Electronics, Germany.* A spectrally broadened and compressed fraction of the 30 fs JETI-pulses is utilized for imaging the laser-plasma interaction with 6 fs time resolution. In case of LWFA the direct visualization of the plasma wave became possible.

QTh3A.3 • 15:15
Diffraction of Electron Pulses Generated in a Laser-Wakefield Accelerator at 0.5 kHz, Zhaohan He[1], Alec Thomas[1], Benoît Beaurepaire[2], John A. Nees[1], Bixue Hou[1], V. Malka[2], Karl Krushelnick[1], Jérôme Faure[2]; [1]*Center for Ultrafast Optical Science, University of Michigan, USA;* [2]*Laboratoire d'Optique Appliquée, ENSTA-CNRS-Ecole Polytechnique, France.* We demonstrate electron diffraction from a polycrystalline aluminum foil using 100 keV electron bunches from a high repetition rate laser wakefield accelerator. Our proof-of-principle experiment shows the potential of such source for ultrafast electron diffraction applications.

QTh3A.4 • 15:30
Laser Driven Neutron Generation at the Texas Petawatt, ishay pomerantz[1], Joel Blakeney[1], Gilliss Dyer[1], Lindsay Fuller[1], E. Gaul[1], Donald Gautier[2], Daniel Jung[2], Alex R Meadows[1], Rahul Shah[2], Chunhua Wang[1], J.C. Fernandez[2], Todd Ditmire[1], Manuel Hegelich[1]; [1]*Center for High Energy Density Science, The University of Texas, USA;* [2]*Los Alamos National Laboratory, USA.* A bright laser-driven neutron source was demonstrated at the Texas Petawatt laser facility. Neutron yields in excess of 109 neutrons/shot with a fairly isotropic distribution were measured.

QTh3A.5 • 15:45
Generation of Quasi-monoenergetic 2 GeV Electrons by Laser Wakefield Acceleration, Xiaoming Wang[1], Rafal Zgadzaj[1], Neil Fazel[1], Watson Henderson[1], Zhengyan Li[1], Rick Korzekwa[1], Yen-Yu Chang[1], Chi-Hao Pai[1], Hai-En Tsai[1], Austin Yi[1], Vladimir Khudik[1], Xi Zhang[1], Hernan Quevedo[1], Gilliss Dyer[1], E. Gaul[1], Aaron Bernstein[1], Ted Borger[1], Michael Spinks[1], Mikael Martinez[1], Mikael Martinez[1], Michael Donovan[1], Gennady Shvets[1], Todd Ditmire[1], Michael C. Downer[1]; [1]*University of Texas at Austin, USA.* We report self-injected quasi-monoenergetic (5% spread FWHM) acceleration of electrons to 2.0 ± 0.1 GeV by 0.6 PW-laser-driven wakefield acceleration in pure He plasma of density 5x10^17 cm^-3. Electron bunches diverge ~0.5mrad, and contain ~60 pC.

QTh3B • Thermal & Optomechanical Metamaterials—Continued

QTh3B.5 • 15:00
Epsilon-Near-Zero Subwavelength Optoelectronics: Electrically Tunable ENZ Strong Coupling, Young Chul Jun[1,2], John L. Reno[1], Michael B. Sinclair[2], Igal Brener[1,2]; [1]*Center for Integrated Nanotechnologies, Sandia National Laboratories, USA;* [2]*Sandia National Laboratories, USA.* We demonstrate a new type of electrically tunable strong coupling between a planar metamaterial layer and an ultra-thin epsilon-near-zero layer made of a doped semiconductor. This can find novel applications in chip-scale infrared optoelectronic devices.

QTh3B.6 • 15:15
Near-field cavity optomechanical probing of nanomechanics, Aaron C. Hryciw[1], Behzad Khanaliloo[2], Marcelo Wu[2], Chris J. Healey[2], Paul Barclay[1,2]; [1]*NRC National Institute for Nanotechnology, Canada;* [2]*Institute for Quantum Science and Technology, University of Calgary, Canada.* An optical fiber taper placed in the near field of a "split-beam" photonic crystal nanobeam cavity with a physical gap at the cavity center breaks the system's vertical dielectric symmetry, enabling selective optomechanical coupling to cantilever resonances using a single optical nanocavity mode.

QTh3B.7 • 15:30
Experimental demonstration of resonant optical trapping and back-action effects in a hollow photonic crystal cavity, Nicolas Descharmes[1], Ulagalandha Perumal Dharanipathy[1], Zhaolu Diao[1], Mario Tonin[1], Romuald Houdré[1]; [1]*Laboratoire d'Optoélectronique Quantique, Ecole Polytechnique Fédérale de Lausanne, Switzerland.* The first experimental demonstration of resonant optical trapping of dielectric particles in a hollow photonic crystal cavity is reported. The existence of mutual interaction between the confined field and the particle is revealed.

QTh3B.8 • 15:45
Nanostructured Transparent Conductive Oxide Films for Plasmonic Applications, Jongbum Kim[1], Yang Zhao[2], Gururaj V. Naik[1], Naresh K. Emani[1], Urcan Guler[1], Alexander Kildishev[1], Andrea Alu[2], Alexandra Boltasseva[1,3]; [1]*School of Electrical and Computer Engineering and Birck Nanotechnology Center, Purdue University, USA;* [2]*Department of Electrical and Computer Engineering, The University of Texas at Austin, USA;* [3]*Department of Photonics Engineering, Technical University of Denmark, Denmark.* Transparent conductive oxides (TCOs) as substitutes to metals could offer many advantages for low-loss plasmonic and metamaterial (MM) applications in the near infrared (NIR) regime.

QTh3C • Photon Pair Sources and Entanglement—Continued

QTh3C.5 • 15:00
Effects of birefringence and detuning on entanglement generation in poled fibers: How much is too much?, Eric Y. Zhu[1], Li Qian[1], Lukas G. Helt[2], Marco Liscidini[2,3], John E. Sipe[2], Costantino Corbari[4], Albert Canagasabey[4], Morten Ibsen[4], Peter G. Kazansky[4]; [1]*Electrical & Computer Engineering, University of Toronto, Canada;* [2]*Physics, University of Toronto, Canada;* [3]*Dipartimento di Fisica "A. Volta", University of Pavia, Italy;* [4]*Opto-electronics Research Centre, University of Southampton, United Kingdom.* Birefringence in poled fiber enables the direct (compensation-free) generation of broadband polarization-entangled photon pairs. However, birefringence and pump detuning also affect the entangled state, a subject we investigate in this work theoretically and experimentally.

QTh3C.6 • 15:15
Generation of Photon-Number States Using Repetitive Parametric DownConversion and Conditional Measurement, Boris L. Glebov[1]; [1]*National Inst of Standards & Technology, USA.* In a Monte Carlo simulation, we feedback with conditional measurements and multiple-step SPDC process to generate number-squeezed photonic states with sub-Poissonian variance. A 12-photon state demonstrated with a success rate of 30%.

QTh3C.7 • 15:30
Entangled photon triplets, Deny Hamel[1], Krister Shalm[1,2], Hannes Hübel[1,3], Zhizhong Yan[1], Christoph Simon[4], Kevin Resch[1], Thomas Jennewein[1]; [1]*Institute for Quantum Computing and Department of Physics & Astronomy, University of Waterloo, Canada;* [2]*National Institute of Standards and Technology, USA;* [3]*Department of Physics, University of Stockholm, Sweden;* [4]*Institute for Quantum Information Science and Department of Physics and Astronomy, University of Calgary, Canada.* We demonstrate entangled photon triplets from cascaded downconversion. First, we establish the presence of tripartite energy-time entanglement using a new entanglement criterion. Then we show a new source of three photon polarization GHZ states, verifying its quality with an entanglement witness.

QTh3C.8 • 15:45
Anderson Colocalization of anti-correlated Entangled Photon Pairs in Disordered Photonic Waveguide Arrays, Lane Martin[1], Giovanni Di Giuseppe[1,2], Armando Perez-Leija[1], Alexander Szameit[3], Ayman F. Abouraddy[1], Demetrios N. Christodoulides[1], Bahaa Saleh[1]; [1]*CREOL, The College of Optics and Photonics, University of Central Florida, USA;* [2]*School of Science and Technology, Physics Division, University of Camerino, Italy;* [3]*Institute of Applied Physics, Friedrich-Schiller-Universität, Germany.* The evolution of spatially extended, entangled, anti-correlated two photon states in photonic waveguide arrays that induce classical transverse Anderson localization is theoretically and experimentally investigated.

QTh3D • Graphene Optics and Photonics—Continued

QTh3D.2 • 15:00
Dynamic zero balance of the oscillator-strength sum in graphene, Jaeseok Kim[1], Seongchu Lim[2], Inhee Maeng[1], Younghwan Choi[1], Taeyong Kim[1], Young Hee Lee[2], Hyunyong Choi[1]; [1]*School of Electrical and Electronic Engineering, Yonsei University, Republic of Korea;* [2]*Institute of Basic Science, Center for Integrated Nanostructure Physics, Department of Energy Science, Sungkyunkwan University, Republic of Korea.* We study the relativistic zero balance of the oscillator strength sum rule in a single-layer graphene. The full energy-dependent characteristics are studied by ultrafast THz spectroscopy and optical spectroscopy.

QTh3D.3 • 15:15
Disordered Photonic Graphene, Julia M. Zeuner[1], Mikael C. Rechtsman[2], Stefan Nolte[1], Alexander Szameit[1]; [1]*Institute of Applied Physics, Germany;* [2]*Technion - Israel Institute of Technology, Israel.* We experimentally demonstrate the impact of disorder on edge states in photonic graphene and find strong evidence that not only chirality but also the vanishing of the density-of-states at zero-energy is preserved under structural disorder.

QTh3D.4 • 15:30
Electronic Cooling in Multilayer Epitaxial Graphene, Momchil Mihnev[1,2], John Tolsma[3], Charles Divin[1,2], Claire Berger[4], Walt de Heer[4], Allan MacDonald[3], Theodore Norris[1,2]; [1]*Department of Electrical Engineering and Computer Science, University of Michigan, USA;* [2]*Center for Ultrafast Optical Science, University of Michigan, USA;* [3]*Department of Physics, The University of Texas at Austin, USA;* [4]*School of Physics, Georgia Institute of Technology, USA.* Using ultrafast optical-pump terahertz-probe spectroscopy, we measure the low-temperature electronic cooling in multilayer epitaxial graphene and develop a theory of hot-carrier equilibration based on interlayer energy transfer via screened Coulomb interactions

QTh3D.5 • 15:45
Hot-Fermi carrier multiplication in monolayer graphene, Soonyoung Cha[1], Seongchu Lim[2], Jeongmook Choi[1], Young Hee Lee[2], Hyunyong Choi[1]; [1]*School of electrical and electronic engineering, Yonsei university, Republic of Korea;* [2]*Department of physics, Sungkyunkwan university, Republic of Korea.* We report observation of thresholdless carrier multiplication in a monolayer graphene, where the carrier multiplication is driven by hot-carrier thermalization process, by utilizing ultrafast optical-pump terahertz-probe spectroscopy,

16:00–16:30 Coffee Break, *Exhibit Halls 1 and 2*

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

QTh3E • Plasmonic Nanostructures—Continued

QTh3E.2 • 15:00
Third harmonic spectroscopy of complex plasmonic Fano structures, Bernd Metzger[1], Mario Hentschel[1,2], Thorsten Schumacher[1,2], Markus Lippitz[1,2], Harald W. Giessen[1]; *[1]Universität Stuttgart, Germany; [2]Max Planck Institute for Solid State Research, Germany.* We perform third harmonic spectroscopy of complex plasmonic nanoantennas which exhibit EIT-like Fano resonances in their linear extinction spectrum. Strong third harmonic emission is found at the lower energy mode of the coupled plasmonic system.

QTh3E.3 • 15:15
Nonlinear Optical Properties of Plasmonic Nanoparticles: The Influence of Material, Size, Shape and Solvent, Vladimir Liberman[1], Michael Sworin[1], Richard Kingsborough[1], Kimberly Hamad[1], Albert Swiston[1], Geoffrey Geurtsen[1], Mordechai Rothschild[1]; *[1]Chemical Sensing and Synthetic Materials Group, Massachusetts Institute of Technology Lincoln Laboratory, USA.* Suspensions of Au and Ag plasmonic nanoparticles, irradiated with 532-nm, ns-long pulses, exhibit nonlinear absorption, nonlinear scattering and saturable absorption. Laser-induced damage is suppressed by >100x when the solvent is toluene instead of water.

QTh3E.4 • 15:30
The Role of Plasmonic Current Loops in Nanosphere Extinction Spectra: Theory and Experiment, Matthew Moocarme[1,2], Navindra D. Singh[1], Luat Vuong[1,2]; *[1]Physics, CUNY Queens College, USA; [2]Physics, CUNY Graduate Center, USA.* We derive the linear and nonlinear changes to a sphere's refractive index addressing polarization-dependent magneto-optic effects, which manifest with plasmonic current loops. The experimentally-measured extinction spectra are in good agreement with our corresponding analytical results.

QTh3E.5 • 15:45
Generation of ultrashort acoustic pulses in cobalt by ballistic electrons in gold, Oleksandr Kovalenko[1], Viktor Shalagatskyi[1], Thomas Pezeril[1], Vitalyi Gusev[1], Vasily V. Temnov[1], Denys Makarov[2], Luyang Han[2], Oliver Schmidt[2]; *[1]Institut des Molécules et Matériaux du Mans, CNRS, France; [2]Institute for Integrative Nanosciences, IFW Dresden, Germany.* Ballistic hot electrons in fs-laser-excited gold are used to generate ultrashort (2 ps long) acoustic pulses in cobalt. The exponential dependence of the acoustic amplitude on gold thickness provides the electron mean-free-path of 120 nm.

CTh3F • Nonlinear Optics in Nanophotonic Devices—Continued

CTh3F.5 • 15:00
Brillouin dynamic grating on a photonic chip, Ravi Pant[1], Enbang Li[1], Christopher G. Poulton[2], Duk-Yong Choi[3], Steve J. Madden[3], Barry Luther-Davies[3], Benjamin J. Eggleton[1]; *[1]CUDOS School of Physics, University of Sydney, Australia; [2]CUDOS, University of Technology Sydney, Australia; [3]CUDOS Laser Physics Centre, Australian National University, Australia.* We demonstrate an on-chip dynamic grating using stimulated Brillouin scattering in a 6.5cm long chalcogenide waveguide. The measured grating reflectivity is comparable to that measured in tens-of-meter long fiber and the On-Off ratio is ~28dB.

CTh3F.6 • 15:15
Strong Stimulated Brillouin Scattering in an On-Chip Silicon Slot Waveguide, Raphaël Van Laer[1], Dries Van Thourhout[1], Roel Baets[1]; *[1]Photonics Research Group - Department of Information Technology, Ghent University, Belgium.* We analyzed the enhancement of the forward Brillouin gain in a silicon slot waveguide. The calculations predict a gain of $3.6\times10^5\ W^{-1}m^{-1}$, which is an order of magnitude larger than in a silicon wire.

CTh3F.7 • 15:30
Brillouin actuation of whispering-gallery modes on microfluidic optomechanical oscillators, Gaurav Bahl[1], Kyu Hyun Kim[2], Wonsuk Lee[2,3], Jing Liu[3], Xudong Fan[3], Tal Carmon[2]; *[1]Mechanical Science and Engineering, Univ of Illinois at Urbana-Champaign, USA; [2]Electrical and Computer Engineering, University of Michigan, USA; [3]Biomedical Engineering, University of Michigan, USA.* We experimentally actuate mechanical whispering-gallery modes and wineglass modes in ultra-high-Q microfluidic optomechanical resonators by means of the electrostrictive Brillouin scattering nonlinearity.

CTh3F.8 • 15:45
Highly Efficient Broadly Tunable Four-Wave Mixing in AlGaAs Nanowires, Ksenia Dolgaleva[1], Peyman Sarrafi[1], Pisek Kultavewuti[1], J. Stewart Aitchison[1], Li Qian[1], Maite Volatier[2], Richard Ares[2], Vincent Aimez[2]; *[1]Department of Electrical and Computer Engineering, University of Toronto, Canada; [2]Institut Interdisciplinaire dInnovation Technologique, Universite de Sherbrooke, Canada.* We report what we believe to be the first experimental demonstration of four-wave mixing in AlGaAs nanowires with the efficiency -38 dB and conversion range 100 nm.

CTh3G • Photonic Crystal Lasers—Continued

CTh3G.2 • 15:00
Electrically Driven Nanobeam Photonic Crystal Laser, Kwang-Yong Jeong[1], You-Shin No[1], Ju-Hyung Kang[1], Soon-Hong Kwon[2], Min-Kyo Seo[3], Yong-Hee Lee[3], Hong-Gyu Park[1]; *[1]Department of Physics, Korea University, Republic of Korea; [2]Department of Physics, Chung-Ang University, Republic of Korea; [3]Department of Physics, KAIST, Republic of Korea.* We report room-temperature lasing in a photonic crystal nanobeam cavity. The electrical current pulse is injected through the central post placed underneath the nanobeam. A lasing action is observed at a wavelength of ~1470 nm with a threshold of ~ 9μA.

CTh3G.3 • 15:15
Two-dimensional Beam-steering Achieved Using Photonic-crystal Lasers, Toshiyuki Nobuoka[1], Kyoko Kitamura[1,2], Seita Iwahashi[1], Tsuyoshi Okino[1], Yong Liang[1], Susumu Noda[1]; *[1]Department of Electronic Science and Engineering, Kyoto University, Japan; [2]The Hakubi Center for Advanced Research, Kyoto University, Japan.* We demonstrate two-dimensional beam-direction control using photonic-crystal lasers, which promises to greatly enhance the range of possible laser-scanning applications.

CTh3G.4 • 15:30
Multi-Color Arrays of III-Nitride Photonic Crystal Nanowire Lasers on a Single Chip, Jeremy B. Wright[1,2], Sheng Liu[1], George T. Wang[1], Qiming Li[1], Daniel D. Koleske[1], Ping Lu[1], Huiwen Xu[2], Luke Lester[2,4], Ting S. Luk[1,3], Igal Brener[1,3], Ganapathi S. Subramania[1,4]; *[1]Sandia National Laboratories, USA; [2]Center for High Technology Materials, The University of New Mexico, USA; [3]Center for Integrated Nanotechnology, Sandia National Laboratories, USA; [4]Department of Electrical and Computer Engineering, The University of New Mexico, USA.* We have demonstrated a multi-color array of photonic crystal lasers on a single chip. By lithographically defining the geometrical properties of the photonic crystals we have achieved tuning from 376-435 nm using a single epitaxial growth.

CTh3H • Ultrafast Laser Sources II—Continued

CTh3H.5 • 15:00
High Energy and Average Power Femtosecond Laser for Pumping mid-IR OPAs, Pavel Malevich[1], Audrius Pugzlys[1], Giedrius Andriukaitis[1], Tobias Flöry[1], Aart Verhoef[1], Alma Fernández[1], Skirmantas Ališauskas[1], Andrius Baltuska[1], Lihao Tan[2,4], Chern Fei Chua[3], Poh Boon Phua[2,4]; *[1]Photonics Institute, Vienna University of Technology, Austria; [2]School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore; [3]Temasek Laboratories, Nanyang Technological University, Singapore; [4]DSO National Laboratories, Singapore.* Femtosecond Tm-fiber-pumped Ho:YAG room-temperature CPA system delivering scalable multi-mJ multi-kHz pulses with a bandwidth exceeding 12 nm and the average power of 15 W is developed. Recompressed 530-fs pulses are suitable for broadband WL generation in transparent solids.

CTh3H.6 • 15:15
Fourier Plane Optical Parametric Amplification enables simultaneous up-scaling laser pulse energy and bandwidth, Bruno E. Schmidt[1], Nicolas Thire[1], Maxime Boivin[1], Antoine Laramée[1], François Poitras[1], Guy Lebrun[1], Tsuneyuki Ozaki[1], Jean-Claude Kieffer[1], Heide Ibrahim[1], François Légaré[1]; *[1]Institut National de la Recherche Sci., Canada.* Employing parametric amplification in the Fourier domain rather than in time domain circumvents phase mismatch and damage threshold limitations of laser amplifiers and enabled CEP stable, 1.43mJ, sub-two cycle pulses at 1.8μm

CTh3H.7 • 15:30 Invited
Coherent Synthesis of Ultra-broadband Optical Parametric Amplifiers, Cristian Manzoni[1], Shu-Wei Huang[2], Giovanni Cirmi[3], Paolo Farinello[1], Jeffrey Moses[2], Sandro De Silvestri[1], Franz X. Kärtner[2,3], Giulio Cerullo[2]; *[1]Istituto di Fotonica e Nanotecnologie, CNR, Italy; [2]Department of Electrical Engineering and Computer Science and Research Laboratory of Electronics, MIT, USA; [3]Center for Free-Electron Laser Science, DESY, Germany.* We report on coherent synthesis of outputs from two ultra-broadband optical parametric amplifiers; their timing is locked to sub-30-as by a balanced cross-correlator. Synthesised pulses have octave-spanning (500-1000 nm) spectra and nearly single-cycle 3.8-fs duration.

16:00–16:30 Coffee Break, *Exhibit Halls 1 and 2*

CLEO: Science & Innovations

CTh3I • Biosensors—Continued

CTh3I.5 • 15:00
Self-growing of Plasmonic Optofluidic Network, Hui Liu[1], Yajian Zheng[1], Shining Zhu[1]; *[1]Nanjing University, China.* We will report a new self-assembly method to produce an plasmonic optofluidic network. Various topology structural networks are obtained in the process to mimic biological liquid channel systems.

CTh3I.6 • 15:15
Self-Assembled Nanolens Formation for Widefield Computational Imaging of Nanoparticles on a Chip, Euan McLeod[1,2], Onur Mudanyali[1,2], Wei Luo[1,2], Alon Greenbaum[1,2], Ahmet F. Coskun[1,2], Yves Hennequin[3], Cedric P. Allier[3], Aydogan Ozcan[1,2]; *[1]Electrical Engineering, University of California, Los Angeles, USA; [2]Bioengineering, University of California, Los Angeles, USA; [3]MINATEC, CEA-Leti, France.* Individual unlabeled nanoparticles are observed within a >0.2-9 cm^2 field-of-view by surrounding particles with self-assembled nanolenses and imaging them with super-resolved lensfree holographic computational microscopy. Nanolens formation, topology, and impact on contrast are discussed.

CTh3I.7 • 15:30 Invited
Transparent Micro-Optrode Arrays for Simultaneous Multichannel Optical Stimulation and Electrical Recording, Joonhee Lee[1], Yoon-Kyu Song[2], Ilker Ozden[1], Arto Nurmikko[1]; *[1]School of Engineering, Brown University, USA; [2]Department of Nano Science and Technology, Seoul National University, Republic of Korea.* We have developed two dimensional, fully transparent, micro-optrode arrays from conductive n-ZnO single crystal semiconductors for intracortical implantation. Neural recording capability under optical stimulation was demonstrated in a transgenic mouse model.

CTh3J • Fabrications and Applications II—Continued

CTh3J.5 • 15:00
High Sensitivity Fluorescence Detection with Multi-spot Excitation Using Y-splitters, Damla Ozcelik[1], Joshua W. Parks[1], Lynnell U. Zempoaltecatl[2], Kealyn Leake[1], Jennifer A. Black[1], Yaeji Lim[2], Holger Schmidt[1], Aaron Hawkins[2]; *[1]Electrical Engineering, University of California Santa Cruz, USA; [2]Brigham Young University, USA.* Fluorescence detection with enhanced sensitivity is demonstrated on liquid-core waveguide chips using Y-splitters to create multiple excitation spots and applying a single signal processing step. The signal-to-noise ratio is enhanced by 200 times.

CTh3J.6 • 15:15
Optical Spectroscopy of Excitons and Trions in Single Layer MoS2, Changjian Zhang[1], Haining Wang[1], Farhan Rana[1]; *[1]School of Electrical and Computer Engineering, Cornell University, USA.* Our study reveals temperature dependent optical properties of excitons and trions in monolayer MoS2 using absorption and photoluminescence (PL) spectroscopy. The extremely large trion binding energy is directly extracted from our data.

CTh3J.7 • 15:30
Micro-Raman Spectroscopic Imaging of He+-Irradiation Changes in LiNbO3, Hsu-Cheng Huang[1], Jerry I. Dadap[1], Ophir Gaathon[1], Irving P. Herman[1], Richard M. Osgood[1], Sasha Bakhru[2], Hassaram Bakhru[2]; *[1]Columbia University, USA; [2]SUNY at Albany, USA.* We use micro-Raman spectroscopy to image ion-induced changes in LiNbO3 during ~MeV He+-irradiation and show high modal-intensity contrast across an implant-patterned surface. Striking image changes in implant regions after annealing are demonstrated.

CTh3J.8 • 15:45
A New Scheme for Improvement of Index of Refraction Detection Limit in 2D Photonic Crystals, Hooman Akhavan[1], Wah Tung Lau[2], Costa Nicholaou[1], Ryan Schilling[1], Raanan Gad[1], Ofer Levi[1]; *[1]ECE, university of toronto, Canada; [2]physics, university of toronto, Canada.* We experimentally demonstrate a new 2D photonic crystal design with index of refraction detection limit of 1×10-7 [RIU]. This new type of photonic crystal opens new avenues for label-free bio-sensing applications.

CLEO: Applications & Technology

ATh3K • Ultrafast Laser Design and Applications—Continued

ATh3K.4 • 15:00
Yb fiber oscillator developed for laser-induced breakdown spectroscopy, Bai Nie[1], Greg Parker[1], Vadim V. Lozovoy[1], Marcos Dantus[1]; *[1]Department of Chemistry, Michigan State University, USA.* A 2 MHz Yb fiber oscillator producing 320 nJ per pulse is developed. The laser is ideal for laser-induced breakdown spectroscopy, due to a low ablation threshold and clean atomic emission spectra.

ATh3K.5 • 15:15
100 µJ, 20 W Femtosecond Fiber Laser for Precision Industrial Micro-Machining, Michael M. Mielke[1], Kyungbum Kim[1], Xiang Peng[1], Wangkuen Lee[1], Xinhua Gu[1], Gordon Masor[1], Sangyoun Gee[1], Mathew Hamamoto[1], Richard Lu[1], David M. Gaudiosi[1], Michael Shirk[1], Eric Juban[1], Sri Srinivas[1]; *[1]Raydiance Inc, USA.* We describe femtosecond fiber laser systems optimized for high value applications in precision industrial micromachining. Unprecedented system performance and reliability enable unique manufacturing capabilities for touch screen displays and other difficult-to-machine parts.

CTh3L • Photodetectors I—Continued

CTh3L.2 • 15:00
Uncooled Low-Bias Uni-Traveling Carrier Photodetectors, Wei Liu[1], Richard Cendejas[2], Hongjun Cao[2], Qingling Hang[2], Zhenli Ji[2], Anguel Nikolov[2]; *[1]PhotonIC Corporation, USA; [2]APIC Corporation, USA.* We demonstrate state-of-the-art uncooled photodetectors for low-bias (2-4V) operation with high responsivities, high saturation currents, and broad bandwidths. High responsivity (1.09A/W), high bandwidth (39GHz) and the OIP3 (47dBm) were achieved at -3V bias.

CTh3L.3 • 15:15
CMOS Compatible Argon-Ion-Implanted C-Band Silicon Waveguide Photodetector, Brian Souhan[1], Richard Grote[1], Jeffrey Driscoll[1], Hassaram Bakhru[2], Richard M. Osgood[1]; *[1]Columbia University, USA; [2]University of Albany, USA.* Extrinsic Si waveguide photodiodes created through Ar+ implantation are shown to be stable up to 350°C with 0.29 A/W internal quantum efficiency and 10 GHz frequency response. Similar Si+ implantation defects anneal out at 300°C.

CTh3L.4 • 15:30
Error-Free Operation of an All-Silicon Waveguide Photodiode at 1.9 µm, Brian Souhan[1], Christine Chen[1], Richard Grote[1], Jeffrey Driscoll[1], Noam Ophir[1], Keren Bergman[1], Richard M. Osgood[1]; *[1]Columbia University, USA.* Error-free detection at 1 Gb/s is demonstrated with a Si ion-implanted waveguide photodiode operating at 1.9 µm. The measured 0.14 A/W responsivity corresponds to a 5 dB decrease in photocurrent compared to operation at 1.55 µm.

CTh3L.5 • 15:45
Vertical Silicon Nanowire Photodetectors: Spectral Sensitivity via Nanowire Radius, Hyunsung Park[1], Yaping Dan[2], Kwanyong Seo[1], Young J. Yu[3], Peter K. Duane[3], Munib Wober[3], Kenneth B. Crozier[1]; *[1]School of Engineering and Applied Sciences, Harvard University, USA; [2]University of Michigan - Shanghai Jiao Tong University Joint Institute, China; [3]Zena Technologies Inc., USA.* We demonstrate that vertical silicon nanowires function as photodetectors whose spectral sensitivities are controlled by choice of nanowire radius. The measured external quantum efficiencies of fabricated devices are compared to electromagnetic simulations.

16:00–16:30 Coffee Break, *Exhibit Halls 1 and 2*

CLEO: Science & Innovations

CTh3M • Fiber Parametric Amplifiers—Continued

CTh3M.2 • 15:00
High power fiber optic parametric amplifier at 1 µm wavelength based on a large area high order mode, Paul Steinvurzel[1], Jeffrey Demas[1], Boyin Tai[1], Yuhao Chen[1], Siddharth Ramachandran[1]; [1]*Boston University, USA*. We demonstrate parametric amplification at 1.064 µm with a 600 µm2 fiber mode, with 94 nm gain bandwidth, cascade products over 315 nm bandwidth, and 6 kW peak power in the Stokes and anti-Stokes lines.

CTh3M.3 • 15:15
Comparison of Amplitude Noise of a Fiber Optical Parametric Oscillator and a Supercontinuum Source, Leily S. Kiani[1], Thompson Lu[2], Jay E. Sharping[1,2]; [1]*School of Natural Sciences, University of California Merced, USA*; [2]*School of Engineering, University of California Merced, USA*. We show improvement in relative intensity noise (RIN) for a fiber optical parametric oscillator (FOPO) as a function of input power and of wavelength, an attractive alternative to supercontinuum (SC) for nonlinear optical microscopy.

CTh3M.4 • 15:30
Polarization and Reflectivity Effects on Fiber Optical Parametric Oscillator Output Power, Thompson Lu[1], Leily S. Kiani[1], Jay E. Sharping[1]; [1]*University of California, Merced, USA*. We report on polarization and reflectivity effects in FOPO output coupling. Polarization-based output coupling improves output power. Linear polarization and output coupling of 0.35 to 0.48 yields optimum output power with the current setup.

CTh3M.5 • 15:45
Amplification of ultrashort optical pulses in a two-pump fiber optical parametric chirped pulse amplifier, Patrick Beaure d'Augères[1], Emmanuel Hugonnot[1], Lea Stroiazzo[2], Alexandre Kudlinski[2], Arnaud Mussot[2]; [1]*Centre d'Etudes Scientifiques et Techniques d'Aquitaine, Commissariat à l'Energie Atomique et aux Énergies Alternatives, France;* [2]*PhLAM/IRCICA, Université Lille 1, France.* Numerical simulations show that FOPCPA is able to amplify 50fs pulses and that saturation regime allows reducing pulse duration down to 15 fs. Preliminaries experimental results confirm that a flat and broad gain bandwidth is obtained.

CLEO: Applications & Technology

ATh3N • LEDs for Energy Efficiency—Continued

ATh3N.4 • 15:00 Tutorial
UV-Nitride Semiconductor Lasers, Noble Johnson[1]; [1]*Palo Alto Researeh Center, USA*. Nitride semiconductors offer the potential to realize a compact UV laser source. Three approaches will be described: (1) InGaN VECSEL for frequency doubling, (2) photo-pumped AlGaN lasers (to 237 nm), and (3) AlGaN laser diodes.

Dr. Noble Johnson is Research Fellow and Manager of the Optoelectronic Materials and Devices Group at the Palo Alto Research Center (a Xerox Company). He received his Ph.D. degree from Princeton University under a National Defense Graduate Fellowship and has been at PARC since 1976. He has conducted experimental research in the general area of electronic materials and devices, has published over 415 research papers in technical journals and conference proceedings, and is a co-inventor on over fifty patents. As Manager of the Optoelectronic Materials and Devices program he has guided the activities of a world-class R&D team that has successfully developed visible and ultraviolet lasers and LEDs and which has made major contributions to the fundamental understanding of the materials and devices. Dr. Johnson is a fellow of the American Physical Society and a fellow of the Institute of Electrical and Electronics Engineers.

ATh3O • Symposium on The Path to Sustainable Energy: Laser Driven Inertial Fusion Energy – ICF Target Design and Fabrication/Future Perspectives Kick-off — Continued

ATh3O.3 • 15:00 Invited
Hohlraum Designs for High Velocity Implosions on NIF, Nathan Meezan[1]; [1]*Lawrence Livermore National Laboratory, USA*. Experiments measuring the velocity of hohlraum-driven implosions on the National Ignition Facility (NIF) are described, including a demonstration of the required fusion-fuel velocity Vfuel > 350$ km/s with a 520 TW, 1.86 MJ laser pulse.

Future Perspective of ICF as Sustainable Energy Source

ATh3O.4 • 15:30 Invited
HiPER, The European Approach to Inertial Fusion Energy, Laser Driver Studies, Jean-Christophe Chanteloup[1]; [1]*Centre National Recherche Scientifique, France*. HiPER (High Power Laser Energy Research) is a European project aiming at exploring laser inertial fusion. An overview of the program with its time schedule is presented while emphasis is given on the laser driver studies.

16:00–16:30 Coffee Break, *Exhibit Halls 1 and 2*

CLEO: QELS-Fundamental Science

16:30–18:30
QTh4A • Engineering Light-Matter Interactions
Presider: Alexandra Boltasseva; Purdue University, United States

QTh4A.1 • 16:30 Invited

Robust Interface States in Two Dimensional Photonic Crystals with Dirac Cone Dispersions, Xueqin Huang[1], Meng Xiao[1], Che Ting Chan[1]; [1]*Depatment of Physics, Hong Kong University of Science and Technology, Hong Kong.* We found that there always exist localized states in the interface created by two semi-infinite photonic crystals with parameters slightly perturbed from the Dirac-like cone condition. This robustness of such states is explored and explained

QTh4A.2 • 17:00

Metamaterial-Based Approach to Enhance Optical Gradient Forces, Vincent Ginis[1], Philippe Tassin[2], Costas Soukoulis[2], Irina Veretennicoff[1]; [1]*Applied Physics Research Group, Vrije Universiteit Brussel, Belgium;* [2]*Ames Laboratory & Dept. of Physics, Iowa State University, USA.* We show how transformation optics can enhance optical forces between two optical waveguides by several orders of magnitude by altering the perceived distance between the waveguides. This transformation can be implemented using single-negative metamaterial films.

16:30–18:30
QTh4B • Nanoemitters & Lasers and Spasers
Presider: Harold Giessen, Univ. Stuttgart, Germany

QTh4B.1 • 16:30

Fiber-coupled dual-rail nanobeam lasers, Hee-Jin Lim[1], Chang-Min Lee[1], Byeong-Hyeon Ahn[1], Yong-Hee Lee[1,2]; [1]*Physics, KAIST, Republic of Korea;* [2]*School of Nanoscience and Technology (WCU), KAIST, Republic of Korea.* The one-dimensional resonant cavity is formed by contacting a curved microfiber to the dual-rail nanobeam. Experimentally we measure the spontaneous emission factor of the nanobeam laser of 0.16 and fiber-coupling efficiency of 30%.

QTh4B.2 • 16:45

Spontaneous emission enhancement via guided resonance modes in GaN nanorod-array LEDs, Patrick Anderson[1], Chenxi Lin[1], Michelle Povinelli[1]; [1]*Ming Hsieh Department of Electrical Engineering, University of Southern California, USA.* We demonstrate strong correspondence between the emission characteristics of core-shell GaN nanorod array LEDs and guided resonance modes. We identify a nanorod array which produces 26 times more total brightness than an equivalent slab.

QTh4B.3 • 17:00

Ultrafast Charge Carrier Dynamics and Upconversion Lasing from ZnSe Nanowires, Guichuan Xing[1], Jingshan Luo[1], Hongxing Li[1], Bo Wu[1], xinfeng Liu[1], Cheng Hon Alfred Huan[1], Hongjin Fan[1], Tze Chien Sum[1]; [1]*Physics and Applied Physics, Nanyang Technological University, Singapore.* A clear picture of ultrafast charge carrier dynamics, exciton-phonon interactions and frequency upconverted lasing properties in ZnSe nanowire was established through a comprehensive pump-fluence and temperature dependent two-photon-excitation study.

16:30–18:30
QTh4C • Quantum Optics with Atoms and Molecules
Presider: Leticia Tarruell; ETH Zurich, Switzerland

QTh4C.1 • 16:30 Invited

A Cold-atom Laser with <1 Intracavity Photon, James Thompson[1]; [1]*JILA, NIST, and Dept. of Physics, University of Colorado, USA.* We will discuss a cold-atom Raman laser that operates quasi-continuously with as few as 0.2 photons on average inside the cavity. This proof-of-principle demonstration may point the way to future hybrid and ultrastable lasers.

QTh4C.2 • 17:00

Absolute frequency of cesium 6S-8S hyperfine transition by two-photon interfered spectrum, Chien-Ming Wu[1,2], Tze-Wei Liu[1], Ray-Kuang Lee[2], Wang-Yau Cheng[1]; [1]*Department of Physics, National Central University, Taiwan;* [2]*Institute of Photonics Technologies, National Tsing-Hua University, Taiwan.* We present a novel two-photon spectrum in which the transition amplitude was interfered with phase-modulated radiation. We demonstrate the application of our resolved spectrum by determining the absolute frequency of cesium 6S-8S hyperfine transitions.

16:30–18:30
QTh4D • High Field Effects and X-rays Probes
Presider: Alfred Leitenstorfer; Univ. of Konstanz, Germany

QTh4D.1 • 16:30

Sub-Cycle Strong-Field Induced Modification of the Optical Properties of SiO2, Elisabeth M. Bothschafter[1,2], Annkatrin Sommer[1], Wolfgang Schweinberger[1], Michael Jobst[1,3], Tobias Latka[1], Clemens Jakubeit[1], Alexander Guggenmos[1,2], Vladislav S. Yakovlev[1,2], Reinhard Kienberger[1,3], Martin Schultze[1,2], Ferenc Krausz[1,2]; [1]*Max-Planck-Institut für Quantenoptik, Germany;* [2]*Fakultät für Physik, Ludwig-Maximilians-Universität, Germany;* [3]*Physik-Depatment, Technische Universität München, Germany.* Highly nonlinear, but reversible changes in the refractive index of SiO2 induced by strong near-infrared light fields are probed with wave-cycle resolved optical reflectivity and attosecond streaking characterization of the transmitted field.

QTh4D.2 • 16:45

Quantum Interference and Control of the Dynamic Franz-Keldysh Effect: Generation of THz Space-Charge Fields, Arthur L. Smirl[1], Rui Wang[1,2], Paul Jacobs[1], Hui Zhao[2]; [1]*Photonics & Quantum Electronics Lab, University of Iowa, USA;* [2]*Department of Physics and Astronomy, University of Kansas, USA.* Dynamic Franz-Keldysh effects are produced and controlled in GaAs by quantum interference techniques. The ~3 THz transient plasma oscillations and the anisotropies that they cause are temporally (~100 fs) and spatially (~1 nm) resolved.

QTh4D.3 • 17:00

Carrier-envelope phase effects observed on strong-field photoemitted electrons from metallic tips, Bjoern Piglosiewicz[1,2], Slawa Schmidt[1,2], Doo Jae Park[1,2], Jan Vogelsang[1,2], Petra Gross[1,2], Cristian Manzoni[3], Paolo Farinello[3], Giulio Cerullo[3], Christoph Lienau[1,2]; [1]*Insitut fuer Physik, Carl V. Ossietzky Univ Oldenburg, Germany;* [2]*Center of Interface Science, Carl von Ossietzky University, Germany;* [3]*Dipartimento di Fisica, Politecnico di Milano, Italy.* We report on the first observation of pronounced carrier-envelope-phase effects on strong-field photoemission of electrons from nanometric gold tips and present a new way to steer and control the motion of electrons around metallic nanoparticles.

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

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

16:30–18:30
QTh4E • Integrated Nonlinear Photonics
Presider: Roberto Morandotti; INRS-EMT, Canada

QTh4E.1 • 16:30
Microresonator-Based Parametric Frequency Comb Generation Without an External Pump Laser, Adrea R. Johnson[1], Yoshitomo Okawachi[1], Michael Lamont[1,2], Jacob S. Levy[2], Michal Lipson[2,3], Alexander L. Gaeta[1,3]; [1]*Applied and Engineering Physics, Cornell University, USA;* [2]*Electrical and Computer Engineering, Cornell University, USA;* [3]*Kavli Institute, Cornell University, USA.* We demonstrate frequency comb generation spanning 900 nm by utilizing a fiber-microresonator dual-cavity design. Such a scheme eliminates the need for tuning an external pump laser to the microcavity resonance.

QTh4E.2 • 16:45
Phase Noise Spectrum and Carrier Power Modeling of High Performance Optomechanical Oscillators, Alejandro Grine[1], Karen E. Grutter[1], Tristan Rocheleau[1], Niels Quack[1], Turker Beyazoglu[1], Ziwei Zheng[1], Inderjit Jutla[1], Ming C. Wu[1], Clark T. Nguyen[1]; [1]*EECS, UC Berkeley, USA.* We present a model for phase noise that fits experimentally observed trends in our high performance optomechanical oscillators (OMO) demonstrating a phase noise of -102dBc/Hz at 1kHz offset from a 74MHz carrier.

QTh4E.3 • 17:00
Soliton mode-locking in optical microresonators, Tobias Herr[1], Victor Brasch[1], John D. Jost[1], Christine Y. Wang[1], Nikita M. Kondratiev[2], Michael Gorodetsky[2], Tobias J. Kippenberg[1]; [1]*Ecole Polytechnique Federale de Lausanne, Switzerland;* [2]*M.V. Lomonosov Moscow State University, Russian Federation.* We demonstrate soliton mode-locking in continuously pumped, non-linear optical MgF2 microresonators, resulting in low noise frequency comb spectra and ultra-short pulses of 200 fs duration with a repetition rate of 35.2 GHz.

16:30–18:30
CTh4F • Waveguides and Passive Components
Presider: Misha Sumetsky; OFS Laboratories, United States

CTh4F.1 • 16:30
3-D Flexible Glass Photonics, Lan Li[1], Hongtao Lin[1], Yi Zou[1], Sylvain Danto[2], J. David Musgraves[2], Kathleen Richardson[2], Juejun Hu[1]; [1]*Department of Materials Science & Engineering, University of Delaware, USA;* [2]*College of Optics & Photonics (CREOL), University of Central Florida, USA.* We demonstrate monolithic fabrication of 3-D photonic structures on flexible substrates. Strain-optical coupling behavior of the flexible devices is quantified through in-situ optical measurements and is successfully accounted for using nanomechanical finite element analysis.

CTh4F.2 • 16:45
L-Shaped Resonant Microring (LRM) Filter with Integrated Thermal Tuner, Erman Timurdogan[1], Ehsan S. Hosseini[1], Gerald Leake[2], Douglas D. Coolbaugh[2], Michael R. Watts[1]; [1]*Research Laboratory of Electronics, Massachusetts Institute of Technology, USA;* [2]*College of Nanoscale Science & Engineering, University at Albany, USA.* A new filter, an L-Shaped Resonant Microring (LRM), is introduced in the application of a highly efficient (3.3-μW/GHz) thermal tuner that enables electrical contact while maintaining single-mode operation and a large 4-THz spur-free FSR.

CTh4F.3 • 17:00
An Integrated, Silica-Based, MEMS-Actuated, Tunable-Bandwidth Optical Filter with Low Minimum Bandwidth, Karen E. Grutter[1], Anthony Yeh[1], Alejandro Grine[1], Ming C. Wu[1]; [1]*Electrical Engineering and Computer Science, University of California, Berkeley, USA.* We present a MEMS-actuated tunable-bandwidth filter implemented in phosphosilicate glass (PSG). Tuning range is 0.8 to 8.5GHz. Based on performance of our stand-alone PSG resonator, minimum bandwidth in PSG can be as low as 30MHz.

16:30–18:30
CTh4G • Defect & Quantum Dot Emitters
Presider: Lynford Goddard, Univ. of Illinois, Urbana-Champaign, USA

CTh4G.1 • 16:30 Invited
Electrically driven single photon source at room temperature by using single NV center in diamond, Norikazu Mizuochi[1]; [1]*Osaka University, Japan.* We show the realization of a stable room temperature electrically driven single-photon source based on a single NV centre in a diode structure, which is a crucial step towards elaborated quantum information devices.

CTh4G.2 • 17:00
High Performance InAs/InP Quantum Dot C-Band Coherence Frequency Comb Lasers, Zhenguo Lu[1], Jiaren Liu[1], D. Poitras[1], P. Poole[1], P. Barrios[1], Chungying Song[1], Shoude Chang[1], C. Flueraru[1], Heping Ding[1], Siegfried Janz[1]; [1]*Information and Communications Technologies, National Research Council Canada, Canada.* We have experimentally demonstrated several InAs/InP quantum dot C-band coherence frequency comb lasers with the frequency spacing from 10 GHz up to 100 GHz with the total output power of up to 50 mW.

16:30–18:30
CTh4H • Fiber Devices & Sensors
Presider: Siddharth Ramachandran; Boston University, United States

CTh4H.1 • 16:30 Invited
Optical Excitation of Metal Nanoparticles by Optical Fiber Cladding Mode Wavelength Combs, Jacques Albert[1], Anatoli Ianoul[1], Sean T. Barry[1], Christophe Caucheteur[2]; [1]*Carleton University, Canada;* [2]*Université de Mons, Belgium.* The wavelengths and amplitudes of narrowband polarized cladding mode resonances in tilted fiber Bragg gratings provide high-Q probes of the anisotropic optical properties of various metal and semiconducting nanoparticle coatings and of their surroundings.

CTh4H.2 • 17:00
Femtosecond refractive-index tailoring of an optical fiber and phase retrieval from far-field measurements, Juha-Matti Savolainen[1], Lars Grüner-Nielsen[2], Poul Kristensen[2], Peter Balling[1]; [1]*Department of Physics and Astronomy, Aarhus University, Denmark;* [2]*OFS Fitel Denmark Aps, Denmark.* A refractive-index change is written inside an optical fiber close to the end face by femtosecond laser light. The induced phase change is measured by analyzing the far-field intensity profiles before and after the irradiation.

Papers are available online for download. Visit www.cleoconference.org and click on the **Download Digest Papers** button.

Presentations selected for recording are designated with a ▶. Access these by visiting www.cleoconference.org and clicking on the **View Presentations** button.

CLEO: Science & Innovations

16:30–18:30
CTh4I • Thermal Challenges for High Average Power Lasers II
Presider: Nicolas Forget; FASTLITE, France

CTh4I.1 • 16:30
200 J Nd:glass Laser with Pulse Repetition Rate of 0.02 Hz, Efim A. Khazanov[1], Alexey Kuzmin[1], Oleg Kulagin[1], Andrey Shaykin[1]; *[1]Institute of Applied Physics, Russian Federation.* Thermally induced distortions in Nd:glass rods 4.5cm in diameter have been measured and compensated by phase conjugate mirror and linear optics technique. Thermal loads in the rods are by factor 5 below thermal fraction limit.

CTh4I.2 • 16:45
Orthogonally Polarized Dual-Wavelength Operation of a CW Yb:KGW Laser Induced by Thermal Lensing, Haitao Zhao[1], Arkady Major[1]; *[1]Department of Electrical and Computer Engineering, University of Manitoba, Canada.* We report on orthogonally polarized dual-wavelength operation of a continuous-wave Yb:KGW laser. Gain equalization of the two wavelengths with the Nm- and Np-polarizations was attributed to the effect of anisotropic thermal lensing.

CTh4I.3 • 17:00
Pulse Energy Increase by Emission Cross-Section Control in Passively Q-switched Nd:YVO4/Cr4+:YAG Laser, Arvydas Kausas[1], Takunori Taira[1]; *[1]Laser Research Center, Institute for Molecular Science, Japan.* Emission cross-section dependence on temperature was observed experimentally in passively Q-switched Nd:YVO4/Cr4+:YAG laser. Heating the crystal, Q-switch pulse energy increase and duration decrease was observed at 100 Hz and 1 kHz QCW pump

16:30–18:30
CTh4J • Photodetectors II
Presider: Avi Zadok; Bar-Ilan University, Israel

CTh4J.1 • 16:30
Flexible Photodetector Based on Carbon Nanotube Fibers, xuan wang[1], Sebstian Nanot[1], Xiaowei He[1], Colin Young[2], Dmitri Tsentalovich[2], Natnael Behabtu[2], Matteo Pasquali[2], Junichiro Kono[1]; *[1]Electrical and Computer Engineering, Rice Univeristy, USA; [2]Chemical and Biomolecular Engineering, Rice University, USA.* We have developed a flexible photodetector by connecting two carbon nanotube fibers with different doping levels. This device combines the excellent properties of nanotube fibers with their ability to absorb light in a broad range.

CTh4J.2 • 16:45
Solution-processed Photodetectors using Non-toxic, Colloidal ZnS-AgInS2 Nanoparticles, Erin Sanehira[1], Chang-Ching Tu[1,2], Lih Y. Lin[1]; *[1]Electrical Engineering, University of Washington, USA; [2]LumiSands, USA.* Non-toxic, colloidal ZnS-AgInS2 (ZAIS) nanoparticles (NPs) were used as the active material in a photodetector for the first time. This demonstrates the optoelectronic properties of ZAIS NPs, and proves its viability in other optoelectronic devices.

CTh4J.3 • 17:00
Room Temperature and High Responsivity Short Wavelength II-VI Quantum Well Infrared Photodetector, Arvind Pawan Ravikumar[1], Guopeng Chen[2], Kuaile Zhao[2], Yue Tian[1], Paul R. Prucnal[1], Maria C. Tamargo[3], Claire F. Gmachl[1], Aidong Shen[2]; *[1]Electrical Engineering, Princeton University, USA; [2]Electrical Engineering, The City College of New York, USA; [3]Chemistry, The City College of New York, USA.* We experimentally demonstrate a short wavelength ZnCdSe/ZnCdMgSe quantum well infrared photodetector (QWIP) with a room temperature responsivity of over 30 A/W. The dark-current limited detectivity at 80 K was measured to be 2x10^9 cm√Hz/W.

CLEO: Applications & Technology

16:30–18:30
ATh4K • Advanced Sensing & Metrology
Presider: Michael Mielke , Raydiance Inc., USA

ATh4K.1 • 16:30 Invited
Precision Inertial Measurements with Atoms near Absolute Zero, Philippe Bouyer[1]; *[1]Institut d'Optique, France.* The ability to cool atoms near zero has lead to recent development of extremely precise inertial sensors, with applications from inertial navigation to underground survey. The paper presents the recent development of such commercial devices.

ATh4K.2 • 17:00
Two-Photon Laser-Assisted Device Alteration in Silicon Integrated Circuits using a 1.28-µm Femtosecond Raman-Soliton Fiber Laser, Keith Serrels[1], Dan Bodoh[2], Derryck Reid[3], Carl Farrell[3], Neel Leslie[4], Ted Lundquist[1], Praveen Vedagarbha[1], Kent Erington[2]; *[1]DCG Systems, USA; [2]Freescale Semiconductor, USA; [3]Heriot-Watt University, United Kingdom.* By inducing two-photon absorption to perturb the switching characteristics of sensitive transistors located within the active layer of a proprietary 28-nm silicon test chip, we demonstrate time-resolved nonlinear laser-assisted device alteration.

CLEO: Science & Innovations

16:30–18:30
CTh4L • Novel Components and Applications
Presider: Yeshaiahu Fainman; Univ. of California San Diego, United States

CTh4L.1 • 16:30
A Timing Jitter Insensitive Logic Gate Using Tunable Gain Dynamics in an SOA and Optical Thresholding, Yue Tian[1], Mable P. Fok[2], Paul R. Prucnal[1]; *[1]Princeton University, USA; [2]University of Georgia, USA.* We experimentally demonstrate a reconfigurable and timing-jitter insensitive AND/NOT gate based on tunable gain dynamics in a semiconductor optical amplifier and optical thresholding. The measured jitter tolerance is up to ±50 ps or ±25 ps for the AND/NOT gate.

CTh4L.2 • 16:45
All-optical clock recovery for 40 Gb/s NRZ-QPSK signals using an amplified feedback DFB laser, liqiang yu[1], Yan Li[2], Dan Lu[1], Lingjuan Zhao[1], Jizhao Zang[2], Deming Kong[2], Jiaoqing Pan[1], Jifang Qiu[2], Shile Wei[2]; *[1]Key Laboratory of Semiconductor Materials Science, Institute of semiconductors, CAS, China; [2]Key Laboratory of Information Photonics and Optical Communications, Beijing University of Posts and Telecommunications, China.* All-optical clock recovery for 40 Gb/s NRZ-QPSK signals is demonstrated experimentally using an amplified feedback DFB laser. Low timing jitter (<370 fs) optical clock is obtained with low injection power (<6 dBm)

CTh4L.3 • 17:00
Nanoscale Integrated Planar Multispectral Image Sensors, Krishna Coimbatore Balram[1], David A.B. Miller[1]; *[1]Electrical Engineering, Stanford University, USA.* We propose and demonstrate planar multispectral image sensors with individual pixel sizes down to 2.5 µm x 575 nm, and whose resonant wavelength can be tuned by varying the width of the pixel.

CLEO: Science & Innovations

16:30–18:30
CTh4M • Attoseconds and CEP Control

Presider: Takao Fuji; National Institutes of Natural Sciences, Japan

CTh4M.1 • 16:30 Tutorial

Attosecond molecular electron dynamics, Mark Vrakking[1]; [1]*Max Born Institute, Germany.* Using attosecond light sources based on high-harmonic generation (HHG), pump-probe experiments can be performed where electron dynamics is studied on its natural timescale, providing insight into the fundamental role that electrons play in photo-induced processes. The tutorial will present first applications in molecular science.

Prof. Marc Vrakking studied physics at the Eindhoven University of Technology in the Netherlands, and completed his Phd at the University of California at Berkeley in 1992. Following postdoctoral appointments in Berkeley and at the National Research Council in Ottawa, he led a scientific group at the FOM Institute for Atomic and Molecular Physics (AMOLF) in Amsterdam until the middle of 2011. While at AMOLF, he developed a research program focusing on the use of ultrashort (femtosecond and attosecond) extreme-ultra-violet (XUV) and X-ray laser pulses for studies of time-resolved atomic and molecular dynamics. Since March 1st 2010 he is a director at the Max-Born Institut in Berlin in charge of the newly established Attosecond Science Division, and a professor at the Freie Universität Berlin. Marc Vrakking is the coordinator of the EU-funded training network ATTOFEL ("Ultrafast Dynamics using ATTOsecond and XUV Free Electron Laser Sources").

CLEO: Applications & Technology

16:30–18:30
ATh4N • Energy from the Sun

Presiders: Christian Wetzel; Rensselaer Polytechnic Institute, United States

ATh4N.1 • 16:30 Invited

Pushing Solar Cell Efficiencies Even Higher, Rebecca Jones-Albertus[1]; [1]*Solar Junction, USA.* Multijunction solar cells stack individual solar cells to more efficiently convert sunlight into electricity. With our high quality, lattice-matched material, Solar Junction has set new world records for solar cell efficiency, most recently at 44.0%.

ATh4N.2 • 17:00

Dual Use of One-Dimensional, Long-Pitch Metallic Gratings for Polarization-Diverse Light Absorption Enhancement in Organic Photovoltaic Structures, Rabin Dhakal[1], Yifen Liu[1], Vikram Dalal[1], Jaeyoun Kim[1]; [1]*Department of Electrical and Computer Engineering, Iowa State University, USA.* We report an organic PV structure that can trap incident light in all polarization states in 1D, long-pitch (>1000 nm) gratings. Experiment showed optical enhancements in all polarization states and translate into 15~25% increase in efficiency.

16:30–18:30
ATh4O • Symposium on The Path to Sustainable Energy: Laser Driven Inertial Fusion Energy – Future Perspective of ICF as Sustainable Energy Source

Presider: Constantin Haefner; Lawrence Livermore National Laboratory, United States

ATh4O.1 • 16:30 Invited

Prospects and Time Frame for Inertial Fusion Energy, Robert Byer[1]; [1]*Applied Physics, Stanford University, USA.* I report on the recently released National Academy study on Inertial Fusion Energy and on the recent progress toward demonstration of inertial fusion in the laboratory, a prerequisite for the development of IFE.

ATh4O.2 • 17:00 Invited

Design of the LIFE Power Plant: Laser Inertial Fusion Energy, Mike Dunne[1]; [1]*Lawrence Livermore National Laboratory, USA.* The Laser Inertial Fusion Energy approach to generating gigawatt levels of electrical power will be discussed. Integrated requirements and design solutions for the laser source (384 beams, each delivering 5.7kJ at 351nm, 15 Hz) will be presented.

CLEO: QELS-Fundamental Science

QTh4A • Engineering Light-Matter Interactions—Continued

QTh4A.3 • 17:15
Forces in Random Electromagnetic Fields, Kyle M. Douglass[1], Sergey Sukhov[1], Aristide Dogariu[1]; [1]*University of Central Florida, CREOL, USA.* We explore the nature of forces induced by random electromagnetic fields on microscopic polarizable matter. Particle-field coupling is considered for a single and multiple interacting particles. We also discuss new experiments for controlling disordered systems.

QTh4A.4 • 17:30
Experimental Demonstration of Birefrigent Transformation Optics Devices, Vera Smolyaninova[1], Kurt Ermer[1], Alex Piazza[1], David Schaefer[1], Igor Smolyaninov[2]; [1]*Towson University, USA;* [2]*ECE, University of Maryland, USA.* We have studied wavelength and polarization dependent performance of waveguide based birefrigent transformation optics devices, which perform useful and different functions for mutually orthogonal polarization states of light.

QTh4A.5 • 17:45
Experimental Demonstration of a Broadband Array of Invisibility Cloaks in the Visible Frequency Range, Vera Smolyaninova[1], Kurt Ermer[1], Igor Smolyaninov[2]; [1]*Towson University, USA;* [2]*ECE, University of Maryland, USA.* We report experimental realization of an array of broadband invisibility cloaks, which operates in the visible frequency range. Wavelength and angular dependencies of the cloak array performance have been studied.

QTh4B • Nanoemitters & Lasers and Spasers—Continued

QTh4B.4 • 17:15
Coherence-Enhanced Surface Plasmon Polariton Propagation Length, Pankaj K. Jha[1], Xiaobo Yin[1,2], Xiang Zhang[1,2]; [1]*Mechanical Engineering, University of California, USA;* [2]*Materials Science Division, Lawrence Berkeley National Laboratory, USA.* We theoretically demonstrate, an order of magnitude enhancement in propagation length of SPPs (visible wavelength) along a metal-phaseonium interface via quantum coherence. Such coherence effects hold promise for quantum control in the field of nanophotonics.

QTh4B.5 • 17:30
Unidirectional lasing with symmetry broken core-shell nanoparticle, Urcan Guler[1], Xiangeng Meng[1], Vladimir M. Shalaev[1], Alexander Kildishev[1]; [1]*School of Electrical & Computer Engineering and Birck Nanotechnology Center, Purdue University, USA.* We propose a plasmonic laser with unidirectional power outflow based on a symmetry broken core-shell nanoparticle. A detailed study of the emission mechanism of the sub-wavelength, directional light source is provided.

QTh4B.6 • 17:45
Quest for low-threshold stimulated emission of surface plasmons polaritons, Thejaswi Tumkur[1], John K. Kitur[1], Mikhail A. Noginov[1]; [1]*Norfolk State University, USA.* The stimulated emission threshold of SPPs can be reduced by an order of magnitude if the operation range is changed from visible to near-IR and metamaterial substrates are used instead of silver films.

QTh4C • Quantum Optics with Atoms and Molecules—Continued

QTh4C.3 • 17:15
Discriminating between the Autler-Townes Splitting and the Electromagnetically-Induced Transparency Models : a Tool for Probing the Medium Properties, Lambert GINER[1], Lucile Veissier[1], Benjamin M. Sparkes[2], Alexandra Sheremet[1,3], Adrien Nicolas[1], Oxana S. Mishina[4], Michael Scherman[1,5], Sidney Burks[1], Itay Shomroni[6], Dmitriy V. Kupriyanov[3], Ping Koy Lam[2], Elisabeth Giacobino[1], Julien Laurat[1]; [1]*Laboratoire Kastler Brossel, Université Pierre et Marie Curie, Ecole Normale Supérieure, CNRS, France;* [2]*Centre for Quantum Computation and Communication Technology, Australian National University, Australia;* [3]*Department of Theoretical Physics, State Polytechnic University, Russian Federation;* [4]*Universität des Saarlandes, Theoretische Physik, Germany;* [5]*ONERA, The French Aerospace Lab, France;* [6]*Chemical Physics Department, Faculty of Chemistry, Weizmann Institute of Science, Israel.* We investigated a method that allows for objectively discerning between the Autler-Townes splitting and the electromagnetically-induced transparency models. We demonstrated the suitability of the test and additionally show its sensitivity to the medium properties.

QTh4C.4 • 17:30
Rydberg Spectroscopy in Hollow-Core Photonic Crystal Fiber, Georg Epple[1,2], Kathrin Kleinbach[2], Tijmen G. Euser[1], Robert Löw[2], Philip Russell[1]; [1]*Max Planck Institute for the Science of Light, Germany;* [2]*University of Stuttgart, 5th Institute of Physics, Germany.* We present the first room-temperature results on a three-photon excitation of Rydberg states in cesium atoms placed inside a kagomé-style hollow-core photonic crystal fiber.

QTh4C.5 • 17:45
Optical Interfacing a Single Molecule with Sodium Vapor, Petr Siyushev[1], Guilherme Stein[1], Joerg Wrachtrup[1,2], Ilja Gerhardt[2]; [1]*3. Physikalisches Institut, University of Stuttgart and Stuttgart Research Center of Photonic Engineering (SCoPE), Pfaffenwaldring 57, Stuttgart, D-70569, Germany, Germany;* [2]*Max Planck Institute for Solid State Research, Heisenbergstrasse 1, D-70569 Stuttgart, Germany, Germany.* A single molecule-based single photon source on the sodium D-lines transitions is presented. We achieve 6x10[5] detected cps and a line-width of 30MHz. This exhibits the first integration of single molecules research and atomic spectroscopy.

QTh4D • High Field Effects and X-rays Probes—Continued

QTh4D.4 • 17:15
Ultrafast Electron Transfer in an Amino Acid Induced by Attosecond Pulses, Louise Belshaw[1], Francesca Calegari[2], Martin Duffy[1], Andrea Trabattoni[2], Fabio Frassetto[3], Luca Poletto[3], Mauro Nisoli[2], Jason Greenwood[1]; [1]*Queen's University Belfast, United Kingdom;* [2]*Physics, Politecnico di Milano, CNR-IFN, Italy;* [3]*CNR-IFN, Italy.* We investigated the ultrafast charge-migration in the amino-acid phenylalanine. By measuring the yield of a doubly-charged ion vs. delay between a 1.5-fs XUV pulse and a 6-fs pulse, a 30-fs charge migration process was measured.

QTh4D.5 • 17:30 Invited
Optical-field-induced current in dielectrics, Tim Paasch-Colberg[1], Agustin Schiffrin[2], Nicholas Karpowicz[1], Vadym Apalkov[3], Daniel Gerster[4], Sascha Mühlbrandt[1,4], Michael Korbman[1], Joachim Reichert[4], Martin Schultze[1,5], Simon Holzner[1], Johannes V. Barth[4], Reinhard Kienberger[1,4], Ralph Ernstorfer[6], Vladislav S. Yakovlev[1,5], Mark Stockman[3], Ferenc Krausz[1,5]; [1]*Max-Planck-Institut fur Quantenoptik, Germany;* [2]*University of British Columbia, Canada;* [3]*Georgia State University, USA;* [4]*Technische Universität München, Germany;* [5]*Ludwig-Maximilians-Universität, Germany;* [6]*Fritz-Haber-Institut der Max-Planck-Gesellschaft, Germany.* The conductivity of a dielectric is reversibly increased by several orders of magnitude on a femtosecond timescale by exploiting the instantaneous electric field of intense few-cycle near-infrared laser pulses leading to measurable ultrafast electric currents.

CLEO: QELS-Fundamental Science

CLEO: Science & Innovations

QTh4E • Integrated Nonlinear Photonics—Continued

QTh4E.4 • 17:15
Broad-bandwidth Near-IR Parametric Amplification in Amorphous Silicon Waveguides, Ke-Yao Wang[1], Amy C. Foster[1]; *[1]Electrical and Computer Engineering, Johns Hopkins University, USA.* We report broad-bandwidth optical parametric amplification using a 6-mm-long hydrogenated amorphous silicon (a-Si:H) waveguide. Amplification is obtained over more than 55 THz (~440 nm) centered at telecommunication wavelengths.

QTh4E.5 • 17:30
Nonlinear optical effects of ultrahigh-Q wavelength-sized silicon disk cavities immersed in superfluid helium, Xiankai Sun[1], Xufeng Zhang[1], Carsten Schuck[1], Hong X. Tang[1]; *[1]Yale University, USA.* Wavelength-sized silicon disk cavities in superfluid helium exhibit blue-shifted bistability near the λ-point when subject to high optical input power. At lower temperature, we observe symmetric lineshapes and obtain a large intracavity photon number of 40,000.

QTh4E.6 • 17:45
Non-Instantaneous Optical Nonlinearities in a-Si:H Nanowire Waveguides, Vincent R. Pagan[1,2], Jeremiah J. Wathen[1,3], Ke-Yao Wang[5], Amy C. Foster[5], Thomas E. Murphy[2,4]; *[1]Laboratory for Physical Sciences, USA; [2]Department of Electrical and Computer Engineering, University of Maryland, USA; [3]Department of Physics, University of Maryland, USA; [4]Institute for Research in Electronics and Applied Physics, University of Maryland, USA; [5]Department of Electrical and Computer Engineering, Johns Hopkins University, USA.* We report measurements of the non-instantaneous nonlinear response of hydrogenated amorphous silicon nanowire waveguides at telecommunications wavelengths. We compare the results to those obtained with similar crystalline silicon nanowires.

CTh4F • Waveguides and Passive Components—Continued

CTh4F.4 • 17:15
Silicon-on-Nitride Optical Waveguides for Mid- and Near-Infrared Integrated Photonics, Saeed Khan[1,2], Jeff Chiles[1], Jichi Ma[1], Sasan Fathpour[1,2]; *[1]CREOL, The College of Optics and Photonics, University of Central Florida, USA; [2]Department of Electrical Engineering and Computer Science, University of Central Florida, USA.* Silicon-on-nitride waveguides are demonstrated at mid- and near-infrared wavelengths. The fabrication is based on bonding silicon to silicon-on-insulator dies coated with low-stress silicon nitride. At 3.39 μm wavelength, the measured propagation loss is ~5 dB/cm.

CTh4F.5 • 17:30
Mid-infrared Microphotonics Using Air-clad Silicon Pedestal Structures, Pao T. Lin[1], Vivek Singh[1], Yan Cai[1], Lionel Kimerling[1], Anu Agarwal[1]; *[1]Massachusetts Institute of Technology, USA.* Towards Mid-infrared silicon microphotonic circuits, we demonstrate broadband on-chip silicon structures including straight, bent waveguides, and beam splitters, utilizing a novel air-clad pedestal configuration. Transmission loss of 2.7 dB/cm is obtained at λ=3.7 um.

CTh4F.6 • 17:45
Chalcogenide glass waveguides for the Mid-infrared, Barry Luther-Davies[1], Pan Ma[1], Steve J. Madden[1], Duk-Yong Choi[1], Zhiyong Yang[1], Rongping Wang[1]; *[1]CUDOS, Australian National University, Australia.* We report low loss air clad Ge11.5As24Se64.5 chalcogenide glass rib waveguides fabricated on MgF2 crystal substrates for applications as optical sensors. Losses as low as 0.5dB/cm in the 4.7-5.4μm band have been obtained.

CTh4G • Defect & Quantum Dot Emitters—Continued

CTh4G.3 • 17:15
Wavelength Selection and Temperature Tuning in Dual-λ QD lasers, Peter M. Smowton[1], Sam Shutts[1], Andrey Krysa[2]; *[1]Cardiff University, United Kingdom; [2]Sheffield University, United Kingdom.* Electrically injected dual wavelength lasers are demonstrated with wavelength separation as large as 66nm with temperature tuning of the difference wavelength at 0.11nm / K (61GHz / K)

CTh4G.4 • 17:30
Self-stabilization of mode-locked quantum-dot lasers by time-delayed opto-electronic feedback, Lukas Drzewietzki[1], Stefan Breuer[1], Wolfgang Elsässer[1]; *[1]Technische Universität Darmstadt, Germany.* A novel stabilization scheme for passively mode-locked lasers is demonstrated. By electrical absorber-modulation via the time-delayed laser output, a significant broadband reduction of phase noise is achieved. A comparison with all-optical feedback stabilization is given.

CTh4G.5 • 17:45
Expanded Operational Range in Quantum Dot Passively Mode-Locked Lasers with Low Unsaturated Absorption, Jesse Mee[1,2], Ravi Raghunathan[2], David Murrell[2], Mark Crowley[3], Luke Lester[2]; *[1]Air Force Research Labs, USA; [2]University of New Mexico, USA; [3]BinOptics Corp, USA.* A previously unreported correlation is presented between reduced values of unsaturated absorption at the laser gain peak and low measured time-bandwidth-product (TBP) values of optical pulses emitted from monolithic quantum dot passively mode-locked lasers.

CTh4H • Fiber Devices & Sensors—Continued

CTh4H.3 • 17:15
Fabrication of a micro-ridge long-period fiber grating inscribed on a photonic crystal fiber, Myung-Jun Shin[1], Oh-Jang Kwon[1], Young-Geun Han[1]; *[1]Hanyang University, Republic of Korea.* Micro-ridge long-period fiber grating (MRLPFG) inscribed on a photonic crystal fiber was proposed and experimentally demonstrated. Transmission characteristics of the PCF-based MRLPFG with variations in strain and temperature were measured.

CTh4H.4 • 17:30
Fabrication of Highly Birefringent H-shaped Microfiber, Min-Seok Yoon[1], Myung-Jun Shin[1], Young-Geun Han[1]; *[1]Hanyang University, Republic of Korea.* A novel fabrication technique of H-shaped highly birefringent (Hi-Bi) microfiber is proposed. The birefringence of fabricated H-shaped microfiber was improved by a factor of 20 higher than that of a conventional birefringent fiber.

CTh4H.5 • 17:45
Differential pulse-width pair BOTDA using simultaneous frequency domain interrogation, Asher Voskoboinik[1], Zhiyong Zhang[1], Ahmed Almaiman[1], Alan E. Willner[1], Moshe Tur[2]; *[1]Ming Hsieh Department of Electrical Engineering, USC, USA; [2]School of Engineering, Tel Aviv University, Israel.* A modified differential double pulse Brillouin sensing technique is demonstrated where both the wide and somewhat narrower pulses are launched simultaneously, rather than sequentially, using different frequency carriers.

CLEO: Science & Innovations

CTh4I • Thermal Challenges for High Average Power Lasers II—Continued

CTh4I.4 • 17:15
Thermally Induced Beam Distortions in Sesquioxide Class m3 Ceramics, Anton G. Vyatkin[1]; Efim A. Khazanov[1]; [1]*Institute of Applied Physics of the Russian Academy of Sciences, Russian Federation.* Theory of thermally induced polarization and phase beam distortions in laser ceramics was improved and extended to the case of class 23 and m3 cubic crystals.

CTh4I.5 • 17:30
Discussions on the pump absorption efficiency under hot-band pumping of Nd:YAG, Yoichi Sato[1], Takunori Taira[1]; [1]*Institute for Molecular Science, Japan.* Reduction of absorption coefficient due to heat-up in hot-band pumped Nd:YAG was studied, and it was much smaller than cold-band pumping. In addition, the necessity of correction in the traditional model for line-bandwidth became clear.

CTh4I.6 • 17:45
High Average Power, Kilowatt Bursts of 6 ps Pulses, Bozhidar Oreshkov[1], Veselin Aleksandrov[1], Hristo Iliev[1], Anton Trifonov[1], Ivan Buchvarov[1]; [1]*Physics Departament, Sofia University, Bulgaria.* We report generation of bursts of ps pulses at 0.5-kHz with variable macro-pulse duration (10-μs-100-μs), scalable energy and average power using MOPA architecture of diode pumped Nd-laser.

CTh4J • Photodetectors II—Continued

CTh4J.4 • 17:15
Manipulating the optical properties of vertically-aligned silicon nanowires for photovoltaic applications, Yung-Jr Hung[1], San-Liang Lee[1], Hong-Jhang Syu[2], Ching-Fuh Lin[2]; [1]*Department of Electronic Engineering and Graduate Institute of Electro-Optical Engineering, National Taiwan Univ of Science & Tech, Taiwan;* [2]*Department of Electronic Engineering and Graduate Institute of Photonics and Optoelectronics, National Taiwan University, Taiwan.* Optical engineering of vertically-aligned silicon nanowires (SiNWs) by modifying their surface morphology and composition can reduce the surface reflectivity and sub-bandgap absorption, leading to improved performance in SiNW-based solar cell.

CTh4J.5 • 17:30
Investigation of CuZn Point Defect on the Photovaltaic Performance of the RF-Sputtered Cu2ZnSnSe4-Based Thin Film Solar Cell, Shou-Yi Kuo[1], DAN HUA HSIEH[2], Jui-Fu Yang[1,3], Fang-I Lai[3], Hao-chung Kuo[2]; [1]*Electronic Engineering, Chang Gung University, Taiwan;* [2]*Electro-Optical Engineering, National Chiao Tung University, Taiwan;* [3]*Photonics Engineering, Yuan-Ze University, Taiwan.* A 4.4 % RF-sputtered Cu2ZnSnSe4 thin film solar cell was studied by transmittance electron microscopy (TEM) and photoluminescence (PL). The result reveals non-uniform elemental distribution and large potential fluctuation mainly induced by CuZn defect.

CTh4J.6 • 17:45
Silicon Pyramids for Plasmonic Enhanced Schottky Photodetectors, Boris Desiatov[1], Ilya Goykhman[1], Noa Mazurski[1], Joseph Shappir[1], Uriel Levy[1]; [1]*Hebrew University of Jerusalem, Israel.* We demonstrate the design, fabrication and characterization of plasmonic enhanced free space Schottky detector for telecom wavelength. Unique fabrication technique, simulation and measurement results will be presented and discussed.

CLEO: Applications & Technology

ATh4K • Advanced Sensing & Metrology—Continued

ATh4K.3 • 17:15
A Tunable Add-Drop Filter Based on Active Microsphere Resonator, Faraz Monifi[1], Sahin K. Ozdemir[1], Lan Yang[1]; [1]*Electrical and System Engineering, Washington University in St. Louis, USA.* We have fabricated an Add-Drop filter using an Erbium-Ytterbium co-doped microsphere resonator side-coupled to two tapered fibers. By optically pumping this active resonator below its lasing threshold, we have demonstrated bandwidth reduction, drop-efficiency increase and crosstalk suppression.

ATh4K.4 • 17:30
High-accuracy Thermal Expansion Measurement by Laser Beam Diffraction off a Patterned Surface, Alain Haché[1], Son Tran Vinh[1]; [1]*Universite de Moncton, Canada.* Laser beam diffraction on a patterned surface is investigated theoretically and experimentally as a powerful tool to measure thermal expansion in various materials. Coefficients as small as 10E-8 on small samples can be measured for temperature rises of only tens of degrees Celsius.

ATh4K.5 • 17:45
Wavelength-beat integrated micro Michelson fiber interferometer based on core-cladding mode interferences for real-time moving direction determination, Nan-Kuang Chen[1,2], Kuan-Yi Lu[1], YUNG-HSIANG CHANG[1]; [1]*Electro-Optical Engineering, NATIONAL UNITED UNIVERSITY, Taiwan;* [2]*Optoelectronics Research Center, NATIONAL UNITED UNIVERSITY, Taiwan.* We demonstrate integrated micro Michelson interferometer with a spliced-end hollow-core fiber as sensing head. This simple device with cost-effective low-coherent lightsources can be used to determine the real-time moving direction based on core-cladding mode interferences.

CLEO: Science & Innovations

CTh4L • Novel Components and Applications—Continued

CTh4L.4 • 17:15
Miniature Bragg Reflector Waveguide Beam Deflector for Full C-band Wavelength Demultiplexing with Low Polarization Dependence and High Resolution, Xiaodong Gu[1], Kensuke Nakamura[1], Akihiro Matsutani[2], Fumio Koyama[1]; [1]*Photonics Integration System Research Center, P&I Lab., Tokyo Institute of Technology, Japan;* [2]*Semiconductor and MEMS Processing Center, Technical Department, Tokyo Institute of Technology, Japan.* A Bragg reflector waveguide beam deflector with large angular dispersion was demonstrated for full C-band wavelength demultiplexing. Low polarization-dependence and potential in large channel-count were shown in compact devices with an effective length of 100μm.

CTh4L.5 • 17:30
Creation of Vortex Beam based on Integrated Ring-shape Bragg Reflector Waveguide, Shota Mochizuki[1], Xiaodong Gu[1], Akihiro Matsutani[1], Fumio Koyama[1]; [1]*Tokyo Institute of Technology, Japan.* We demonstrate the creation of a vortex beam by using GaAs-based ring-shape Bragg reflector waveguide functioning as an angular diffraction element. A tunable ring-far field patterns can be clearly shown with wavelength tuning.

CTh4L.6 • 17:45
Wavelength Selective 3D Topology Optimized Photonic Crystal Devices, Lars H. Frandsen[1], Yuriy Elesin[2], Ole Sigmund[2], Jakob S. Jensen[2], Kresten Yvind[1]; [1]*Photonics Engineering, DTU Fotonik, Technical University of Denmark, Denmark;* [2]*Mechanics Engineering, DTU Mekanik, Technical University of Denmark, Denmark.* A compact photonic crystal drop filter has been designed using 3D topology optimization and fabricated in silicon-on-insulator material. Measurements and modeling are in excellent agreement showing a low-loss ~11nm 3dB bandwidth of the filter.

CLEO: Science & Innovations

CLEO: Applications & Technology

CTh4M • Attoseconds and CEP Control—Continued

CTh4M.2 • 17:30
Acoustic frequency combs for unconditionally stable long-term carrier-envelope phase stabilization, Bastian Borchers[1], Mark Mero[1], Gunter Steinmeyer[1]; [1]*Max Born Institute, Germany.* A novel scheme for low-jitter feed-forward stabilization of the carrier-envelope phase of stabilized lasers is presented, which is virtually immune against slow drift effects and beam pointing variation.

CTh4M.3 • 17:45
Acousto-optic Fastscan Delay for Ultrafast Photonics with sub-20-Attosecond Precision and Scan Rates exceeding 30 kHz, Olaf Schubert[1], Max Eisele[1], Vincent Crozatier[2], Nicolas Forget[2], Daniel Kaplan[2], Rupert Huber[1]; [1]*Department of Physics, University of Regensburg, Germany;* [2]*Fastlite, France.* We demonstrate a fastscan-delay with a precision of 20 as and scan rates exceeding 30 kHz. The fiber-compatible device is based on an acousto-optic programmable dispersive filter and is ideally suited for pump-probe experiments.

ATh4N • Energy from the Sun—Continued

ATh4N.3 • 17:15
Low Temperature a-SiGe:H Near-IR Sensor and Photovoltaic Devices for Flexible Multi-functional Panel, Ming-Hsuan Kao[2,1], Chang-Hong Shen[1], Jia-Min Shieh[1,2], Pei-Chen Yu[2], Hao-chung Kuo[2], Ching-Ting Lee[3], Fu-Liang Yang[1]; [1]*National Nano Device Laboratories, Taiwan;* [2]*Institute of Electro-Optical Engineering, Institute of National Chiao Tung University, Taiwan;* [3]*Institute of Microelectronics, Department of Electrical Engineering, National Cheng Kung University), Taiwan.* High Near-IR response photo-diode (0.1A/W@800nm) and high efficiency a-Si/a-SiGe tandem solar cell (8.38%) were demonstrated using high-density plasma-fabricated a-SiGe:H technology . The 140oC a-SiGe:H technology are suitable for flexible solar self-powered multi-functional panel.

ATh4N.4 • 17:30 Invited
InGaN-Based Solar Cells and High-Performance Broadband Optical Coatings for Ultrahigh Efficiency Hybrid Multijunction Device Designs, Robert M. Farrell[1], Daniel J. Friedman[2], Nathan Young[1], Emmett Perl[3], Nihal Singh[1], Jordan Lang[1], Carl Neufeld[3], Michael Iza[1], Samantha Cruz[1], Stacia Keller[3], William E. McMahon[2], Shuji Nakamura[1,3], Steven P. DenBaars[1,3], Umesh K. Mishra[3], John E. Bowers[1,3], James S. Speck[1]; [1]*Materials Department, University of California, USA;* [2]*National Renewable Energy Laboratory, USA;* [3]*Department of Electrical and Computer Engineering, University of California, USA.* Efficiencies exceeding 40% have already been achieved with GaAs-based multijunction (MJ) solar cells. In this talk, we will discuss the unique advantages and challenges of fabricating hybrid InGaN-GaAs MJ cells for ultrahigh efficiency device designs.

ATh4O • Symposium on The Path to Sustainable Energy: Laser Driven Inertial Fusion Energy – Future Perspective of ICF as Sustainable Energy Source—Continued

ATh4O.3 • 17:30 Invited
Laser Fusion Experimental Reactor LIFT Based on Fast Ignition and the Issue, Takayoshi Norimatsu[1], Yasuji Kozaki[1], Hiroshi Shiraga[1], Hisatori Fujita[1], Kunihiko Okano[1], Hiroshi Azechi[1], members of Design Committee for Laser Fusion Experimental Reactor[1], [1]*Institute of Laser Engineering, Osaka University, Japan.* We organized a design committee for the laser fusion experimental reactor to show the feasibility to construct it with existing materials and improved technologies. The issue includes the coupling efficiency and target injection.

CLEO: QELS-Fundamental Science

QTh4A • Engineering Light-Matter Interactions—Continued

QTh4A.6 • 18:00
Transformed Cladding Waveguides: Confining Light with All-Dielectric Metamaterials, Saman Jahani[1], Zubin Jacob[1]; *[1]University of Alberta, USA.* Contrary to popular assumption, we show that all-dielectric metamaterials ε>1 μ=1 can be used to strongly confine light. This leads to a new class of lossless waveguides capable of dense photonic integration.

QTh4A.7 • 18:15
Trapping light by mimicking gravitational lensing, Hui Liu[1], Chong Sheng[1], Yi Wang[1], Shining Zhu[1], Genov A. Dentcho[2]; *[1]Nanjing University, China; [2]College of Engineering and Science, Louisiana Tech University, USA.* We propose a distorted optical waveguide around a microsphere to mimic curved spacetimes caused by the "gravitational fields". Gravitational lensing effects analogues are experimentally demonstrated and this can be used to prospective light harvesting.

QTh4B • Nanoemitters & Lasers and Spasers—Continued

QTh4B.7 • 18:00
SPASER versus SPED, Jacob Khurgin[1], Gregory Sun[2]; *[1]Johns Hopkins Univ., USA; [2]University of Massachusetts Boston, USA.* We develop a theoretical model to obtain the input-output characteristics of the single mode coherent emitter of surface plasmons (SPASER) and compare it to the prospect of surface plasmon emitting diodes (SPEDs).

QTh4B.8 • 18:15
Investigation of surface plasmon amplification in finite-width gold stripline based on Nd:YVO4 crystal, Thanh Phong Vo[1,2], Alizera Maleki[1,2], James E. Downes[2], David W. Coutts[1,2], Judith M. Dawes[1,2]; *[1]Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS), Macquarie University, Australia; [2]MQ Photonics, Department of Physics and Astronomy, Macquarie University, Australia.* We report the strong surface plasmon amplification of the finite-width gold micro-stripline on Nd:YVO4 crystal substrate at 1064nm. The low-loss plasmonic 2D waveguide may be advantageous for potential applications in standard optoelectronics devices.

QTh4C • Quantum Optics with Atoms and Molecules—Continued

QTh4C.6 • 18:00
Trapped Atoms in One-Dimensional Photonic Crystals, Sean Meenehan[1], Chen-Lung Hung[1], Justin D. Cohen[1], Richard Norte[1], Akihisa Goban[1], Su-Peng Yu[1], Jonathan Hood[1], Darrick E. Chang[2], Oskar Painter[1], Jeff Kimble[1]; *[1]California Instititue of Technology, USA; [2]Institut de Ciencies Fotoniques, Spain.* We present one-dimensional photonic crystal waveguides which can stably trap neutral atoms and achieve single-atom reflectivities of more than 0.9, as well as experimental progress towards fabrication and optical testing of such structures.

QTh4C.7 • 18:15
A multi-state interferometer on an atom chip, Jovana Petrovic[1,2], Ivan Herrera[1], Pietro Lombardi[1,3], Florian Schaefer[1], Francesco S. Cataliotti[1,3]; *[1]Vinca Institute of Nuclear Sciences, Serbia; [2]Laboratory for Nonlinear Spectroscopy - LENS, Italy; [3]Dipartimento di Fisica e Astronomia, Universita di Firenze, Italy.* We introduce a multi-state interferometer on an atom chip with an enhanced resolution and nearly perfect fringe visibility. We demonstrate its application as a sensor of the state-dependent interaction of atoms with circularly polarized light.

QTh4D • High Field Effects and X-rays Probes—Continued

QTh4D.6 • 18:00
Reconstructing ultrafast acoustic pulses using time-resolved x-ray diffraction, Yuan Gao[1], Aaron Loether[1], Barry C. Walker[1], Zhiyuan Chen[1], Zachary Bond[1], Matthew F. DeCamp[1]; *[1]University of Delaware, USA.* Time-resolved x-ray diffraction is utilized to visualize laser generated transient strain formation from nanometer-scaled laser-excited gold films into crystalline substrates. We directly invert the time-domain signals to reconstruct the spatio-temporal shape of the transient strain.

QTh4D.7 • 18:15
Sub-picosecond, table-top x-ray absorption spectroscopy using superconducting microcalorimeters, Luis Miaja Avila[1], Kevin Silverman[1], Doug Bennett[1], Chris Cromer[1], Marla Dowell[1], Joe Fowler[1], William Doriese[1], Galen o'Neil[1], Dan Swetz[1], Jens Uhlig[1], Joel Ullom[1], Zin Yoon[2], Ralph Jimenez[2], Robert E. Marvel[3], Richard F. Haglund[3], Villy Sundstrom[4]; *[1]NIST, USA; [2]JILA, USA; [3]Vanderbilt University, USA; [4]Lund University, Sweden.* We present time-resolved X-ray absorption measurements of vanadium dioxide using ionizations radiation generated by a femtosecond pulsed laser source in combination with superconducting microcalorimeters capable of measuring energies of individual radiation quanta.

18:30–20:00 Dinner Break *(on your own)*

20:00–22:00 Postdeadline Paper Sessions, *Marriott San Jose Salons I & II, III, IV, V & VI*

NOTES

Executive Ballroom 210H	Executive Ballroom 210G	Executive Ballroom 210F	Executive Ballroom 210E
CLEO: QELS-Fundamental Science	**CLEO: Science & Innovations**		
QTh4E • Integrated Nonlinear Photonics—Continued	**CTh4F • Waveguides and Passive Components—Continued**	**CTh4G • Defect & Quantum Dot Emitters—Continued**	**CTh4H • Fiber Devices & Sensors—Continued**
QTh4E.7 • 18:00 **Formation and control of Turing patterns from interacting polaritons in coupled semiconductor microcavities,** Vincenzo Ardizzone[1], P. Lewandowski[2], Yuen Chi Tse[3], Nai-Hang Kwong[4,5], Samuel Luk[3], Andreas Lucke[2], Marco Abbarchi[1,5], Jacqueline Bloch[6], Aristide Lemaitre[6], P.T. Leung[3,4], Philippe Roussignol[1], Rolf Binder[5,7], Jérôme Tignon[1], Stefan Schumacher[2,5]; *[1]Laboratoire Pierre Aigrain, Ecole Normale Supérieure, France; [2]Physics Department, Center for Optoelectronics and Photonics Paderborn, Germany; [3]Department of Physics, The Chinese University of Hong Kong, China; [4]Center of Optical Sciences, The Chinese University of Hong Kong, China; [5]College of Optical Sciences, University of Arizona, USA; [6]Laboratoire de Photonique et de Nanostructures, CNRS, France; [7]Department of Physics, University of Arizona, USA.* We report on the formation of hexagonal polariton patterns in double semiconductor microcavities operating in the OPO regime. We experimentally and theoretically demonstrate both the formation and the optical control of these patterns.	**CTh4F.7 • 18:00** **Colorless Grating Couplers Realized by Interleaving Dispersion Engineered Subwavelength Structures,** Xiaochuan Xu[1], Harish Subbaraman[2], David Kwong[1], John L. Covey[1], Amir Hosseini[2], Ray T. Chen[1]; *[1]University of Texas at Austin, USA; [2]Omega Optics, Inc., USA.* A wideband grating coupler based on interleaving dispersion engineered subwavelength structures has been proposed and experimentally demonstrated. The fabricated device shows a coupling efficiency of 5.1dB and a 1dB bandwidth of 70 nm.	**CTh4G.6 • 18:00** **Extremely wide lasing bandwidth from InAs/InP quantum-dash ridge-waveguide laser near 1.6 µm,** Mohammed Zahed M. Khan[1], Tien K. Ng[1], Chi-Sen Lee[2], Pallab K. Bhattacharya[2], Boon S. Ooi[1]; *[1]Photonics Laboratory, King Abdullah University of Science and Technology (KAUST), Saudi Arabia; [2]Electrical Engineering and Computer Science, University of Michigan, USA.* We demonstrate an ultra-broad lasing bandwidth (-3dB) of > 50 nm utilizing InAs/InGaAlAs/InP quantum-dash ridge-waveguide laser using chirped AlGaInAs barrier layer thickness. Our device exhibits a recorded bandwidth and significant improvement of laser characteristics	**CTh4H.6 • 18:00** **Dynamic Wavelength Switching in a Fiber Grating Cavity,** Zhangwei Yu[1,2], Patrik Rugeland[1,2], Irina V. Kabakova[3], Pierre-Yves Fonjallaz[2], Oleksandr Tarasenko[2], Martijn De Sterke[3], Walter Margulis[1,2]; *[1]Applied Physics, Royal Institute of Technology, Sweden; [2]FIber Optics, Acreo Swedish ICT AB, Sweden; [3]University of Sydney, Australia.* Dynamic wavelength switching of a phase-shifted fiber grating cavity with electrical pulses is studied experimentally and numerically. Simulations accurately describe observations. The effect of acoustic oscillations and fiber Bragg grating cavity refilling explains the results.
QTh4E.8 • 18:15 **Freestanding lithium niobate photonic crystal cavities for nonlinear optics applications,** Séverine Diziain[1], Reinhard Geiss[1], Matthias Zilk[1], Frank Schrempel[1], Ernst-Bernhard Kley[1], Andreas Tünnermann[1], Thomas Pertsch[1]; *[1]Institute of Applied Physics, Friedrich-Schiller-Universität Jena, Germany.* We demonstrate second harmonic generation with a continuous wave source in L3 photonic crystal cavities drilled in self-suspended lithium niobate membranes. The fabricated structures exhibit quality factors of around 500.	**CTh4F.8 • 18:15** **Integrated Bragg Gratings in Spiral Waveguides,** Xu Wang[1], Han Yun[1], Lukas Chrostowski[1]; *[1]Electrical and Computer Engineering, University of British Columbia, Canada.* We demonstrate a compact Bragg grating in a silicon-on-insulator spiral waveguide. A 3.12 mm long grating with a bandwidth of 0.27 nm has been experimentally realized within an area of 141 µm×146 µm.	**CTh4G.7 • 18:15** **High Performance, Spatially Coherent, Multi-color Distributed Feedback Lasers in Optically Pumped Colloidal Quantum Dots,** Kwangdong Roh[1], Cuong H. Dang[1], Joonhee Lee[1], Sungmo Ahn[2], Heonsu Jeon[2], Craig Breen[3], Jonathan S. Steckel[3], Seth Coe-Sullivan[3], Arto Nurmikko[1]; *[1]Brown University, USA; [2]Seoul National University, Republic of Korea; [3]QD Vision Inc., USA.* Novel distributed feedback lasers were created in densely packed colloidal quantum dot single exciton gain media. The optically pumped lasers demonstrated internal efficiency of 28%, spatially coherent beams, average power of 400 µW	**CTh4H.7 • 18:15** **High Speed Wavelength Switching Using Saw-Tooth Pulse Generated by Optical Pulse Synthesizer,** Ken Kashiwagi[1], Azusa Hasegawa[1], Takashi Kurokawa[1]; *[1]Tokyo Univ of Agriculture and Technology, Japan.* Bit-by-bit wavelength switching for 10 Gbps signal based on a cross phase modulation in a fiber was successfully demonstrated by using 10-ps-wide saw-tooth control pulse generated from an optical pulse synthesizer.

18:30–20:00 Dinner Break *(on your own)*

20:00–22:00 Postdeadline Paper Sessions, *Marriott San Jose Salons I & II, III, IV, V & VI*

NOTES

CLEO: Science & Innovations

CTh4I • Thermal Challenges for High Average Power Lasers II—Continued

CTh4I.7 • 18:00
0.5W single-longitudinal mode, monolithic Nd:YVO4 microchip laser, Jaroslaw Z. Sotor[1], Grzegorz Dudzik[1], Grzegorz J. Sobon[1], Karol Krzempek[1], Krzysztof M. Abramski[1]; [1]*Wroclaw University of Technology, Poland.* We present a single frequency Nd:YVO4 microchip laser operating at 1064 nm with monolithic laser resonator containing of birefringent filter as a single mode selector. It supports stable operation with 0.5W output power with 42% efficiency.

CTh4I.8 • 18:15
Stable single-axial-mode operation of injection-seeded Q-switched Nd: YAG laser by real-time resonance tracking method, Xiaozhen Xu[1], Jean-Claude M. Diels[1]; [1]*University of New Mexico, USA.* A real-time resonance tracking method is described and experimentally demonstrated in controlling an injection-seeded Q-switched Nd:YAG laser for stable single- axial-mode operation. Noise insensitive single axial mode with 100% recurrence is achieved with mW seeding power.

CTh4J • Photodetectors II—Continued

CTh4J.7 • 18:00
Broadband Responsivity of a Graphene Photodetector, Xinghan Cai[1,2], Ryan J. Suess[3,4], Andrei B. Sushkov[1,2], Thomas E. Murphy[3,4], Michael S. Fuhrer[1,2], H. Dennis Drew[1,2]; [1]*Physics, University of Maryland, USA;* [2]*Center for Nanophysics & Advanced Materials, University of Maryland, USA;* [3]*Electrical & Computer Engineering, University of Maryland, USA;* [4]*Institute for Research in Electronics & Applied Physics, University of Maryland, USA.* The responsivity of a monolayer graphene photodetector based on the photo-thermoelectric effect was measured at room temperature for dc, terahertz, and optical frequencies and found to be approximately 81, 188, and 18 V/W respectively.

CTh4J.8 • 18:15
Characterization of APD- PIN photodiodes using InAs/InAlGaAs quantum-dot absorption layer, Toshimasa Umezawa[1], Koichi Akahane[1], Atsushi Kanno[1], Tetsuya Kawanishi[1]; [1]*National Institute of Information and Co, Japan.* We found avalanche multiplications in InAs/InAlGaAs quantum-dot PIN photodiodes, and characterized the temperature dependence of I-V curves, the multiplication factors and the RF responses.

CLEO: Applications & Technology

ATh4K • Advanced Sensing & Metrology—Continued

ATh4K.6 • 18:00
Microfabricated Hollow core fibres for Gas Sensing using Wavelength Modulation Spectroscopy, Mohammad amanzadeh[1,2], Eoin Sheridan[2], Saïed M. Aminossadati[1], Mehmet S. Kizil[1], Warwick P. Bowen[2]; [1]*School of mechanical and mining engineering, The University of Queensland, Australia;* [2]*School of mathematics and physics, The University of Queensland, Australia.* Micro-drilled hollow fibres as gas sensors are developed and calibrated using wavelength modulation spectroscopy technique. This method has shown acceptable accuracy and sensitivity to be used in underground coal mine methane gas detection.

ATh4K.7 • 18:15
Sulfur Dioxide Detection Using CW-DFB-QCL Based Quartz-Enhanced Photoacoustic Spectroscopy, Johannes P. Waclawek[1], Rafal Lewicki[2], Harald Moser[1], Markus Brandstetter[1], Frank K. Tittel[2], Bernhard Lendl[1]; [1]*Institute of Chemical Technologies and Analytics, Vienna University of Technology, Austria;* [2]*Electrical & Computer Engineering Department, Rice University, USA.* The development of a sensitive SO_2 QEPAS based sensor platform employing a 140 mW CW-DFB-QCL will be reported. A detection limit of 75 ppbv (3σ) was achieved with a 1-sec averaging time for the 1380.94 cm^{-1} SO_2 absorption line.

CLEO: Science & Innovations

CTh4L • Novel Components and Applications—Continued

CTh4L.7 • 18:00
Ultra-compact Optical Switch Using High Contrast Grating Hollow-core Waveguide, Weijian Yang[1], Connie Chang-Hasnain[1]; [1]*University of California Berkeley, USA.* An ultra-compact 2x2 optical switch based on high contrast grating (HCG) hollow-core waveguide (HCW) is proposed. Simulation results show that the switching length is ~25x smaller than the conventional 2x2 multimode interference coupler.

CTh4L.8 • 18:15
Quadratic Compressed Sensing in a Waveguide Array, Yoav Shechtman[1], Eran Small[2], Yoav Lahini[2], Mor Verbin[2], Yonina C. Eldar[3], Yaron Silberberg[2], Mordechai Segev[1]; [1]*Physics, Technion Israel Institute of Technology, Israel;* [2]*Physics, Weizmann Institute of Science, Israel;* [3]*Electrical Engineering, Technion Israel Institute of Technology, Israel.* We present a scheme for recovering the input signal launched into a waveguide array from partial measurements of its output intensity, given that the input is sparse. Possible applications include optical interconnects, and quantum tomography.

18:30–20:00 Dinner Break *(on your own)*

20:00–22:00 Postdeadline Paper Sessions, *Marriott San Jose Salons I & II, III, IV, V & VI*

NOTES

CLEO: Science & Innovations

CLEO: Applications & Technology

CTh4M • Attoseconds and CEP Control—Continued

CTh4M.4 • 18:00
Reduction of Timing Jitter to the Sub-20-Attosecond Regime in Free-Running Femtosecond Mode-Locked Fiber Lasers, Hyoji Kim[1], Peng Qin[1,2], Junho Shin[1], Youjian Song[1,2], Chur Kim[1], Kwangyun Jung[1], Chingyue Wang[2], Jungwon Kim[1]; [1]*Korea Advanced Inst of Science & Tech, Republic of Korea;* [2]*Tianjin Univ, China.* We demonstrate 18-attosecond timing jitter [10 kHz - 94 MHz] pulse trains from 188-MHz mode-locked Yb-fiber lasers. This is the lowest timing jitter from free-running fiber lasers, comparable to the performance of lowest-jitter Ti:sapphire lasers.

CTh4M.5 • 18:15
Towards Optical Attosecond Pulses: Broadband Phase Coherence between an Ultrafast Laser and an OPO via Lock-to-zero CEO Stabilization, Richard McCracken[1], Jinghua Sun[1,2], Christopher Leburn[1], Derryck Reid[1]; [1]*Institute of Photonics & Quantum Sciences, Heriot Watt University, United Kingdom;* [2]*School of Physics, Huazhong University of Science and Technology, China.* The carrier-envelope-offset frequencies of the pump, signal, idler and related sum-frequency mixing pulses have been locked to 0 Hz in a 20-fs-Ti:sapphire-pumped optical parametric oscillator, satisfying a critical prerequisite for broadband optical pulse synthesis.

ATh4N • Energy from the Sun—Continued

ATh4N.5 • 18:00
Solar-thermally driven PCR for power-free diagnostics, Li Jiang[1], Zhengda Liu[1], Matthew Mancuso[1], David Erickson[1]; [1]*Cornell University, USA.* We introduce a solar-thermally powered polymerase chain reaction (PCR) technique to circumvent traditional electricity requirements, potentially making PCR technology broadly accessible in the developing world.

ATh4N.6 • 18:15
Au-Ag alloy popcorn nanoparticles enhanced dye-sensitized solar cells, Qi Xu[1], Fang Liu[1], Yuxiang Liu[1], Yidong Huang[1]; [1]*Electronic Engineering, Tsinghua University, China.* The Au-Ag alloy popcorn-shaped nanoparticles enhanced dye-sensitized solar cells (DSCs) are proposed and investigated. It is demonstrated that the efficiency of DSCs are increased by 32% from 5.94% to 7.85% with broadband excitation of localized-surface-plasmons.

ATh4O • Symposium on The Path to Sustainable Energy: Laser Driven Inertial Fusion Energy – Future Perspective of ICF as Sustainable Energy Source—Continued

ATh4O.4 • 18:00 Invited
Concept for a kJ amplifier using cryogenic gas cooled multi-slab Yb:YAG medium, Paul J. Phillips[1], Klaus Ertel[1], Paul D. Mason[1], Andrew Lintern[1], Justin Greenhalgh[1], Saumyabrata Banerjee[1], C. Hernandez-Gomez2[1], John Collier[1]; [1]*Science and Technology Facilities Council, United Kingdom.* kJ-class DPSSL systems with multi-Hz repetition rate for IFE and other laser-plasma based applications require an amplifier architecture with high efficiency and high gain. We present a concept based on cryogenically cooled ceramic Yb:YAG.

18:30–20:00 Dinner Break *(on your own)*

20:00–22:00 Postdeadline Paper Sessions, *Marriott San Jose Salons I & II, III, IV, V & VI*

NOTES