Grand Ballroom A

8:30 AM–9:45 AM
Session MA1: Advanced OAM and SDM/WDM
Session Chair: Yoshinari Awaji, *NICT, Koganei, Tokyo, Japan*

MA1.1 8:30 AM–9:00 AM (Invited) Classical and Quantum Communications with OAM in Fibers
Siddharth Ramachandran, *Boston University, Boston, MA, USA*
We review advances in, and prospects of, multiplexing data in the classical domain, or achieving high-dimensional keys in the quantum domain, using optical fibers that support Orbital Angular Momentum (OAM) states for scaling mode count in fibers while minimizing intermodal cross-talk.

MA1.2 9:00 AM–9:15 AM Spatial Quadrature Amplitude Multiplexing Using Coherently Coupled Beams with Orbital Angular Momentum
Kaitlyn Morgan, Yuan Li, Wenzhe Li, J. Keith Miller, Richard J. Watkins, and Eric G. Johnson, *Clemson University, Anderson, SC, USA*
This paper demonstrates a system for spatial switching of two coherently coupled orbital angular momentum (OAM) modes for a free space optical link based on 32-QAM. In addition, coherent mode detection is accomplished using passive optics in a correlation receiver optical setup.

Grand Ballroom B

8:30 AM–10:00 AM
Session MB1: Avalanche Photodetectors
Session Chair: Dennis W. Prather, *University of Delaware, Newark, DE, USA*

MB1.1 8:30 AM–9:00 AM (Invited) AlGaAsSb Avalanche Photodiodes
Jo Shien Ng, and Chee Hing Tan, *University of Sheffield, Sheffield, UK*
The material AlGaAsSb (lattice-matched to InP substrates) has been studied experimentally in recent years as an alternative avalanche material for near infrared high-speed Avalanche Photodiodes. In this presentation, key characteristics of AlGaAsSb Avalanche Photodiodes, including gain-bandwidth product, excess noise, and temperature dependence, will be summarized.

MB1.2 9:00 AM–9:15 AM Comparison of Excess Noise in InAlAs and AlGaAs Digital and Random Alloy Avalanche Photodiodes
Yuan Yuan, Jiyuan Zheng, Yaohua Tan, Yiwei Peng, *University of Virginia, Charlottesville, VA, USA,* Ann-Kathryn Rockwell, Seth R. Bank, *University of Texas, Austin, Austin, TX, USA,* Avik W. Ghosh, and Joe C. Campbell, *University of Virginia, Charlottesville, VA, USA*
Digital alloy $In_{0.52}Al_{0.48}As$ avalanche photodiodes exhibit lower excess noise than those fabricated from random alloys. This paper compares the temperature dependence, from 203 K to 323 K, of the impact ionization characteristics of $In_{0.52}Al_{0.48}As$ and $Al_{0.74}Ga_{0.26}As$ digital and random alloys.

Grand Ballroom C

8:30 AM–10:00 AM
Session MC1: New Applications of Semiconductor Lasers
Session Chair: Luke J. Mawst, *University of Wisconsin-Madison, Madison, WI, USA*

MC1.1 8:30 AM–9:00 AM (Invited) Narrow Linewidth Stimulated Brillouin Scattering (SBS) Lasers
Daniel J. Blumenthal, Sarat Gundavarapu, Grant M. Brodnik, Debapam Bose, *University of California at Santa Barbara, Santa Barbara, CA, USA*, Ryan Behunin, *Northern Arizona University, Flagstaff, AZ, USA*, Peter Rakich, *Yale University, New Haven, CT, USA*, Karl D. Nelson, Matthew Puckett, and Jianfeng Wu, *Honeywell International USA*

MC1.2 9:00 AM–9:30 AM (Invited) Automotive LIDAR
Lute Maleki, *GM Cruise, USA*

Regency Ballroom A

8:30 AM–9:45 AM
Session MD1: Photonic Integration
Session Chair: Tolga Tekin, *Fraunhofer IZM Institute, Berlin, Germany*

MD1.1 8:30 AM–8:45 AM Local Quantum Well Intermixing for Fabricating High-Speed Electroabsorption Modulator
Chih-Hsien Chen, Po-Yun Wang, Rih-You Chen, Cong-Long Chen, Yang-Jeng Chen, and Yi-Jen Chiu, *National Sun Yat-sen University, Kaohsiung, Taiwan*
A new scheme waveguide fabrication for high-speed EAM using local quantum well intermixing (QWI) has been demonstrated. Large blue shift from narrow strip of QWI-induced blue shift forms an optical-index guiding structure, leading to low propagation loss of 0.7dB/100?m in waveguide and >25Gb/s high-speed modulation.

MD1.2 8:45 AM–9:00 AM Active-Passive Integration Using a-Si Waveguides for Substrate Removed Electro-Optic Modulators
Prashanth Bhasker, Selim Dogru, and Nadir Dagli, *University of California at Santa Barbara, Santa Barbara, CA, USA*
Amorphous silicon waveguides were integrated with substrate removed InAlGaAs/InAlAs multi quantum well waveguides in electro-optic modulators. Transitions efficiency between these waveguides is 95%. Modulation efficiency of MZMs is 0.165 V-cm.

Regency Ballroom B

8:30 AM–10:00 AM
Session ME1: Optical Coherence Tomography
Session Chair: Martin Villiger, *Massachusetts General Hospital, MA, USA*

ME1.1 8:30 AM–9:00 AM (Invited) Digital Aberration Correction for Optical Coherence Tomography
Rainer Leitgeb, *Medical University of Vienna, Vienna, Austria*
Cellular resolution retinal imaging requires correction of ocular aberrations. Coherent imaging techniques such as Optical Coherence Tomography record the complex sample field and allow reconstruction and digital manipulation of the sample wavefront. This enables digital aberration correction demonstrated across a 3D volume in the retina in-vivo.

ME1.2 9:00 AM–9:15 AM Imaging of Conjunctival Lymphatics Vessels Using Multi-Wavelength Optical Coherence Tomography
Ashley Francke, Morgan Heisler, *Simon Fraser University, Burnaby, British Columbia, Canada,* Peijun Gong, *University of Western Australia, Perth, Australia,* Paula Yu, Dong An, *Lions Eye Institute, Nedlands, Australia and University of Western Australia, Perth, Australia,* David D. Sampson, *University of Western Australia, Perth, Australia,* Dao-Yi Yu, Lions Eye Institute, *Nedlands, Australia and University of Western Australia, Perth, Australia,* and Marinko V. Sarunic, *Simon Fraser University, Burnaby, British Columbia, Canada*
The lymphatics system provides transport for excess fluids and proteins from the interstitial space to the blood circulation. In this report, imaging parameters of wavelength and numerical aperture are explored for the visualization of lymphatics with OCT using two systems: 1060 nm SSOCT, and 830 nm SDOCT.

Lake Anne A/B

8:30 AM–10:00 AM
Session MF1: Emerging Microresonator Devices
Session Chair: Frank Vollmer, *UK*

MF1.1 8:30 AM–9:30 AM (Tutorial)
Explore Whispering-Gallery Resonators for a Versatile Sensor Platform
Lan Yang
I will discuss the physics associated with whispering-gallery-mode resonators. Their sensing applications for a broad range of targets, e.g., nanoparticles, ultrasound and magnetic field, will be reviewed. I will discuss its potential as a new generation of sensing platform for the Internet of Things applications.

MF1.2 9:30 AM–9:45 AM
SNAP Resonators Introduced by Bending of Optical Fibers
D. Bochek, *Novosibirsk State University, Novosibirsk, Russia*, N. A. Toropov, *Aston University, Birmingham, UK*, I. Vatnik, *Novosibirsk State University, Novosibirsk, Russia*, and M. Sumetsky, *Aston University, Birmingham, UK*
We demonstrate a new method of fabrication of Surface Nanoscale Axial Photonics (SNAP) structures. We show experimentally that a SNAP microresonator with nanoscale effective radius variation can be introduced by bending of an optical fiber. Our results are in reasonable agreement with the developed theory.

Lake Audubon

8:30 AM–10:00 AM
Session MG1: Microwave Photonics Technologies for Defense
Session Chair: Thas Nirmalathas, *University of Melbourne, Melbourne, Austria*

MG1.1 8:30 AM–9:00 AM (Invited)
Microwave Photonics in the Industry
Edward I. Ackerman, *Photonic Systems, Inc., Billerica, MA, USA*
Since the late 1980s, when fiber-optic links were first shown to enable high-fidelity transport of analog signals between distant locations, additional capabilities enabled by microwave photonic technology have evolved. This paper provides an overview of the technology's contributions to the electronics industry as a whole.

MG1.2 9:00 AM–9:30 AM (Invited)
Trends in Defense System Architectures and the Impact of Photonics
Paul Matthews, *Northrop Grumman Corporation, Baltimore, MD, USA*
Recent technological innovations in electronic devices are resulting in dramatic changes in military sensor architectures and design. These trends and their impact on architectures and the system design process will be discussed in order highlight potential insertion opportunities for photonic techniques in future military systems.

Lake Thoreau

8:30 AM–10:15 AM
Session MH1: Attosecond Science
Session Chair: Eiji J. Takahashi, *RIKEN Center for Advanced Photonics, Saitama, Japan*

MH1.1 8:30 AM–9:00 AM (Invited)
Precision Measurements with Attosecond Pulse Trains
Cord L. Arnold, Marcus Isinger, *Lund University Lund, Sweden*, Richard Squibb, *University of Gothenburg Gothenburg, Sweden*, David Busto, Shiyang Zhong, *Lund University Lund, Sweden*, Anne Harth, *Max-Planck-Institut für Kernphysik Heidelberg Heidelberg, Germany*, David Kroon, *MAX-IV Laboratory, Skane Lan, Sweden*, Saikat Nandi, *Lund University Lund, Sweden*, Miguel Miranda, *Posto University, Porto, Portugal*, Marcus Dahlström, *Lund University, Lund, Sweden*, Eva Lindroth, *Stockholm University, Stockholm, Sweden*, Raimund Feifel, *University of Gothenburg, Gothenburg, Sweden*, Mathieu Gisselbrecht, and Anne L'Huillier, *Lund University Lund, Sweden*
We measure the relative ionization time delay between the 2s and 2p shells in neon using an interferometric technique. Combining high temporal and spectral resolution, we can disentangle direct ionization from shake-up and retrieve the ionization time delay in a 40 eV wide range. "

MH1.2 9:00 AM–9:30 AM (Invited)
Attosecond-Resolved Photoionization of Chiral Molecules
Antoine Comby, *Université de Bordeaux - CNRS - CEA, CELIA, France*

Reston A/B

9:00 AM–10:00 AM
Session MI1: Perils, Pitfalls and Pleasures: Turning Research Into a Real Product
Session Chair: Maura Raburn
***** Live Streamed*****

Grand Ballroom A	Grand Ballroom B	Grand Ballroom C	Regency Ballroom A	Regency Ballroom B
MA1.3 9:15 AM–9:45 AM (Invited) **Signal Processing for Ultra-dense WDM/SDM Transmission Systems** Koji Igarashi, *Osaka University, Osaka, Japan*	**MB1.3 9:15 AM–9:30 AM** **Modeling of High-Speed AlInAs Avalanche Photodiodes** Yegao Xiao, Zhiqiang Li, Zhanming S. Li, *Crosslight Software Inc., Vancouver, British Columbia, Canada* Modeling of high-speed AlInAs avalanche photodiodes is presented based on drift-diffusion model and frequency response theory. The simulation results show good agreement with multiplication gain and –3 dB bandwidth, with high ceiling bandwidth around 30 GHz for partially doped absorption region.	**MC1.3 9:30 AM–9:45 AM** **A TeraMAC Neuromorphic Photonic Processor** Mitchell A. Nahmias, Hsuan-Tung Peng, Thomas Ferreira de Lima, Chaoran Huang, Alexander N. Tait, Bhavin J. Shastri, Paul R. Prucnal, and Mitchell A. Nahmias, *Princeton University, Princeton, NJ, USA* We show that an integrated laser neuron can exhibit extraordinary low latency (<1 ns) and speed (10^{12} MACs/s per device) compared to state-of-the-art processors in digital electronics. We experimentally demonstrate positive (excitatory) and negative (inhibitory) inputs with 8× wavelength channels, and efficiency (<1 pJ/MAC) during closed-loop operation.	**MD1.3 9:00 AM–9:30 AM (Invited)** **Foundry for InP Based Photonic Integration** Luc Augustin, *SMART Photonics B.V., Eindhoven, The Netherlands* Photonic Integration is required to achieve cost, performance and scalability targets for data- and telecom. InP is the material of choice for full monolithic integration of lasers, amplifiers as well as modulators and passive circuitry. Progress in the technology opens the route to volume manufacturing.	**ME1.3 9:15 AM–9:30 AM** **Color OCT: Combined Optical Coherence Tomography and RGB Imaging through a Double-Clad Fiber Coupler** Xavier Attendu, Mathias Strupler, *École Polytechnique de Montreal, Montreal, Quebec, Canada,* Nicolas Godbout, and Caroline Boudoux, *École Polytechnique de Montreal & Castor Optics, Montreal, Quebec, Canada* We present a system combining optical coherence tomography and RGB imaging in a single double clad fiber. We demonstrate that it is possible to reproduce broadband white light imaging using only three or four narrowband laser sources
	MB1.4 9:30 AM–10:00 AM (Invited) **Digital Alloy-Based Avalanche Photodiodes** Jiyuan Zheng, Yuan Yuan, Yaohua Tan, Yiwei Peng, *University of Virginia, Charlottesville, VA, USA,* Ann-Kathryn Rockwell, Seth R. Bank, *University of Texas, Austin, Austin, TX, USA*, Avik W. Ghosh, and Joe C. Campbell, *University of Virginia, Charlottesville, VA, USA* Low noise avalanche photodiode has been realized by InAlAs digital alloy, wherein minigaps in band structure takes role of modulating the ionization coefficient ratio k to be as low as 0.01.	**MC1.4 9:45 AM–10:00 AM** **Temporal Dynamics of an Integrated Laser Neuron** Hsuan-Tung Peng, Mitchell A. Nahmias, Thomas Ferreira de Lima, Alexander N. Tait, Bhavin J. Shastri, and Paul R. Prucnal, *Princeton University, Princeton, NJ, USA* Temporal dynamics plays an important role in spike processing. We experimentally demonstrate various biologically-inspired processing tasks in a laser neuron in a photonic integrated circuit platform. Our system provides a platform for gigahertz signal processing and computing.	**MD1.4 9:30 AM–9:45 AM** **Method for Polarization-Resolved Measurement of Electroabsorption** Dzmitry Pustakhod, Kevin Williams, and Xaveer Leijtens, *Eindhoven University of Technology, Eindhoven, The Netherlands* We present a new method for measuring absorption spectra of integrated semiconductor devices. The main advantage of our method is that it allows polarization-resolved measurement of absorption without the need for polarization filtering in the setup, enabling automated testing of components.	**ME1.4 9:30 AM–9:45 AM** **Circular Ranging Optical Coherence Tomography Using a Fourier-Domain Mode-Locked Frequency Comb** Norman Lippok, Meena Siddiqui, *Harvard Medical School & Massachusetts General Hospital (MGH), Boston, MA, USA,* Benjamin J. Vakoc, and Brett E. Bouma, *Harvard Medical School & Massachusetts General Hospital (MGH), Boston, MA, USA and MIT, Cambridge, MA, USA* We present circular ranging based on a Fourier-domain mode-locked (FDML) frequency comb and an acousto-optic frequency shifter for delay discrimination. A FDML frequency comb offers an order of magnitude improved coherence length compared to traditional FDML laser and a 15-fold RF bandwidth reduction for imaging.
				ME1.5 9:45 AM–10:00 AM **Real-Time Delivery and Monitoring of Endoscopic Laser Therapy Using a Double Clad Fiber in an Optical Coherence Tomography System** Raphael Maltais-Tariant, Caroline Boudoux, *Polytechnique de Montreal, Montreal, Quebec, Canada*, and Néstor Uribe-Patarroyo, *Harvard Medical School and Massachusetts General Hospital, Boston, MA, USA* We present a system for real-time delivery and monitoring of laser therapy using an optical coherence tomography system with a double clad fiber. The therapy laser is guided through the outer cladding while the single-mode core is used to perform real-time monitoring of the therapy.

10:00 AM–10:30 AM – EXHIBITS / COFFEE BREAK – GRAND BALLROOM FOYER

Lake Anne A/B

MF1.3 9:45 AM–10:00 AM
Inelastic Resonant Transmission of a Single Photon through Optical Cavities with the Amplitude Approaching Unity
M. Sumetsky, *Aston University, Birmingham, UK*
We identify structures of optical cavities coupled to atoms and mechanical vibrations which enable the inelastic resonant transmission of a single photon approaching unity. These results suggest a way to maximize and control the inelastic transitions of photons in classical and quantum cavity electrodynamics.

Lake Audubon

MG1.3 9:30 AM–10:00 AM (Invited)
Efficient Antennas and Their Impact on Microwave Photonics Signal Processing
Rodney Waterhouse and Dalma Novak, *Pharad LLC, Hanover, MD, USA*
Efficient, integrated antenna/microwave/photonic modules are critical for communications, signal intelligence and radar signal processing applications. We present a model that enables the electromagnetic properties of the antenna (input impedance, antenna efficiency) to be readily incorporated into system simulation tools to enable full link optimization.

Lake Thoreau

MH1.3 9:30 AM–9:45 AM
Sub-μJ, 25 eV Bandwidth Continuum Soft X-Ray Harmonic Generated by a TW-Scale Three-Channel Waveform Synthesizer
Bing Xue, *RIKEN Center for Advanced Photonics, RIKEN, Saitama, Japan*, Yuuki Tamaru, *RIKEN Center for Advanced Photonics, RIKEN, Saitama, Japan and Tokyo University of Science, Noda-shi, Chiba, Japan*, Yuxi Fu, *RIKEN Center for Advanced Photonics, RIKEN, Saitama, Japan*, Oliver D. Mücke, *Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany and Universität Hamburg, Hamburg, Germany*, Akira Suda, *Tokyo University of Science, Noda-shi, Chiba, Japan*, Kastumi Midorikawa, and Eiji J. Takahashi, *RIKEN Center for Advanced Photonics, RIKEN, Saitama, Japan*
A 50-mJ three-channel waveform synthesizer is demonstrated for generating supercontinuum high-order harmonics in soft X-ray region. With the full stabilization of delay jitters, phase jitters, and CEPs, a stable intense continuum harmonic spectrum is obtained around 65 eV with the bandwidth up to 25 eV.

MH1.4 9:45 AM–10:15 AM (Invited)
Diffraction and Microscopy with Attosecond Electron Pulses
Yuya Morimoto and Peter Baum, *Ludwig-Maximilians-Universität München, Garching, Germany*
Attosecond imaging with sub-relativistic electron beams can access light-field-driven electronic dynamics in space and time. In this talk, we report first diffraction and microscopy experiments with attosecond electron pulses. We study attosecond-level timing of Bragg-spot emission and visualize propagating light-waves both in space and time.

Reston A/B

10:00 AM–10:30 AM – EXHIBITS / COFFEE BREAK – GRAND BALLROOM FOYER

Grand Ballroom A	Grand Ballroom B	Grand Ballroom C	Regency Ballroom A	Regency Ballroom B
10:30 AM–11:45 AM **Session MA2:** High Density SDM Transmission **Session Chair:** Tetsuya Hayashi, *Sumitomo Electric Industries, Ltd., Yokohama, Kanagawa, Japan*	**10:30 AM–12:00 PM** **Session MB2:** Novel Photodetectors **Session Chair:** Joe C. Campbell, *University of Virginia, Charlottesville, VA, USA*	**10:30 AM–12:00 PM** **Session MC2:** Nanowire Lasers and VCSELs & SL Tutorial **Session Chair:** Nelson Tansu, *Lehigh University, Bethlehem, PA, USA*		**10:30 AM–12:00 PM** **Session ME2:** Single Particle Optics and Optofluidics **Session Chair:** Rainer Leitgeb, *Medical University of Vienna, Vienna, Austria*
MA2.1 10:30 AM–11:00 AM (Invited) **Mode-Selective 45-Mode Spatial Multiplexer and Recent Applications of Multi-Plane Light Conversion** Satyanarayana Bade, Bertrand Denolle, Gauthier Trunet, Nicolas Riguet, David Allioux, Pu Jian, Olivier Pinel, and Guillaume Labroille, *CAILabs, Rennes, Bretagne, France* We report the fabrication and characterization of 45 mode space division multiplexers based on Multi-Plate Light Converter. The multiplexers show an average 4 dB insertion loss and -28 dB cross-talk across the C band. Present and future of industrial applications of this technology are exposed.	**MB2.1 10:30 AM–11:00 AM (Invited)** **III-V Photodiodes on Silicon for Analog Applications** Andreas Beling, *University of Virginia, Charlottesville, VA, USA* The talk reviews heterogeneously integrated InGaAs/InP photodiodes on silicon for analog photonics applications. Recent results from photodiodes based on molecular wafer bonding, adhesive die bonding, and direct III-V material growth on Si will be discussed and compared to their Ge-on-Si counterparts.	**MC2.1 10:30 AM–11:15 AM (Tutorial)** **Semiconductor Nanolasers** Cun-Zheng Ning, *Arizona State University, Tempe, AZ, USA* Recent progress in semiconductor nanolasers will be presented in a tutorial manner, including semiconductor nanolasers using plasmonic structures as light confinement mechanism and 2D monolayer transition metal dichalcogenides as gain media. The potential relevance of such nanolasers to energy efficient usage will be discussed.		**ME2.1 10:30 AM–11:00 AM (Invited)** **Laser-Tweezed Gold Nanorod Motors and Their Application for DNA Probing** Lei Shao, *Chinese University of Hong Kong, Shatin, Hong Kong* Gold nanorods support plasmonic resonances that greatly enhance optical forces and torques. They therefore are excellent light-driven motors. We here discuss the unprecedented rotation of laser-tweezed gold nanorods and demonstrate an ultrasensitive optomechanical method for probing and releasing DNA cargo from these individual nanomotors.
MA2.2 11:0 AM–11:30 AM (Invited) **10 Pbit/s SDM/WDM Transmission** Daiki Soma, Takehiro Tsuritani, and Itsuro Morita, *KDDI Research, Inc., Fujimino, Saitama, Japan* This paper reports our recent demonstrations of ultra-dense SDM transmission using C+L-band 739-WDM 12-Gbaud dual polarization – 64-quadrature amplitude modulation (QAM) / 16-QAM signals over 11.3-km 6-mode 19-core fiber. We achieve a record fiber capacity of 10.16 Pbit/s with an aggregate spectral efficiency of 1099.9 bit/s/Hz.	**MB2.2 11:00 AM–11:15 AM** **Internal Quantum Efficiency Dependence on Thickness of NiSi Schottky Barrier Photodetectors** Joshua Duran, *Air Force Research Laboratory – Sensors Directorate* and Andrew Sarangan, *University of Dayton, Dayton, OH, USA* We investigate the thickness dependence of internal quantum efficiency for NiSi/n-Si Schottky barrier photodetectors. We observe a 20-fold improvement between the thinnest and thickest films tested and find that internal quantum efficiency improves until the film becomes discontinuous, falling below its percolation thickness.	**MC2.2 11:15 AM–11:30 AM** **High Resolution Active Beam Scanner Based on VCSEL Amplifier** Zeuku Ho, Keisuke Shimura, Keisuke Kondo, Xiaodong Gu, Akihiro Matsutani, and Fumio Koyama, *Tokyo Institute of Technology, Yokohama, Japan* We demonstrate the high-resolution beam steering of 3 mm long VCSEL amplifier, exhibiting beam steering of 27°, narrow beam divergence below 0.04° and pulsed output power over 2.9 W.		**ME2.2 11:00 AM–11:15 AM** **2D Electro-Optical Trapping and Analysis of Single Particles on an Integrated Optofluidic Chip** M. Rahman, *University of California, Santa Cruz, Santa Cruz, CA, USA,* M. A. Stott, *Brigham Young University, Provo, UT, USA*, Y. Li, *University of California, Santa Cruz, Santa Cruz, CA, USA*, A. R. Hawkins, *Brigham Young University, Provo, UT, USA*, and H. Schmidt, *University of California, Santa Cruz, Santa Cruz, CA, USA* Two-dimensional electro-optical trapping of single particles is demonstrated by suppressing in-plane Brownian motion based on fluorescence tracking and electrokinetic feedback force. Trapping of single microbeads with significantly improved performance over 1D-trapping is demonstrated.
	MB2.3 11:15 AM–11:30 AM **Ge-on-Si Waveguide Photodiode Array for High-Power Applications** Keye Sun, Robert Costanzo, Ta-Ching Tzu, Qianhuan Yu, Steven M. Bowers, and Andreas Beling, *University of Virginia, Charlottesville, VA, USA* A Ge-on-Si photodiode array was demonstrated using the AIM Photonics platform. The PD array has a low dark current of 0.3 μA at –2 V, 0.58 A/W external responsivity, a 3-dB bandwidth of 15 GHz and an RF saturation power of 7 dBm.	**MC2.3 11:30 AM–11:45 AM** **Electrically-Controlled Spiking Regimes in Vertical-Cavity Surface Emitting Lasers** Joshua Robertson, Ewan Wade, and Antonio Hurtado, *University of Strathclyde, Glasgow, UK* Electrically-controlled, tuneable and repeatable neuron-like spiking regimes are generated in an optically-injected 1300 nm Vertical-Cavity Surface-Emitting Laser at sub-nanosecond speeds (>7 orders of magnitude faster than neurons). These results offer great prospects for compact and ultrafast photonic neuronal models for future neuromorphic computing platforms.		**ME2.3 11:15 AM–11:30 AM** **Multimode Interference Waveguide-Based 7X Multiplexed Detection of Nucleic Acids for Antibiotic-Resistant Bacterial Screening** G. G. Meena, *University of California, Santa Cruz, Santa Cruz, CA, USA*, M. A. Stott, O. Brown, R. Robison, A. R. Hawkins, *Brigham Young University, Provo, UT, USA*, and H. Schmidt, *University of California, Santa Cruz, Santa Cruz, CA, USA* A multimode interference (MMI) waveguide creates distinct spectral spot patterns at three wavelengths in a single liquid-core waveguide on an optofluidic chip. These patterns enable 7× multiplexed fluorescence detection of bacterial nucleic acids combinatorially labeled with these three colors.

Lake Anne A/B	Lake Audubon	Lake Thoreau	Reston A/B
10:30 AM–12:00 PM **Session MF2:** Microresonator and Photonic Crystal Devices **Session Chair:** Marko Loncar, *Harvard University, Cambridge, MA, USA*	**110:30 AM–12:00 PM** **Session MG2:** Microwave Photonics Technologies for Radar **Session Chair:** Christina Lim, *University of Melbourne, Melbourne, Australia*	**10:30 AM–12:00 PM** **Session MH2:** Laser-based Accelerators and Colliders **Session Chair:** Olive D. Mucke, *Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany*	**10:30 AM–12:00 PM** **Session MI2:** Realities of Photonics: From Design to Fabrication to Packaging **Session Chair:** Maura Raburn ***** Live Streamed*****
MF2.1 10:30 AM–11:00 AM (Invited) Low-Power High-Speed Resonance-Based Integrated Photonic Modulators Amir H. Hosseinnia, Tianren Fan, Hesam Moradinejad, Majid Sodagar, Seyediman Taghavi, Ali A. Eftekhar, and Ali Adibi, *Georgia Institute of Technology, Atlanta, GA, USA* A series of novel platforms for resonance-based integrated photonic modulators will be presented. It is shown that the use of high-quality hybrid materials along with new modulation schemes can significantly modify the conventional trade-offs between speed and power consumption to enable very low-power high-speed devices.	**MG2.1 10:30 AM–11:00 AM (Invited) Microwave Photonics in Radar** Antonella Bogoni, *Scuola Superiore Sant'Anna, Pisa, Italy and CNIT, Pisa, Italy*, Leonardo Lembo, *Scuola Superiore Sant'Anna, Pisa, Italy and Vallauri Institute, Livorno, Italy*, Giovanni Serafino, *Scuola Superiore Sant'Anna, Pisa, Italy*, Paolo Ghelfi and Filippo Scotti, *CNIT, Pisa, Italy* An overview on the trend and main issues of radars and the potential of introducing photonics will be presented. The advantages in terms of frequency-agility, multi-band operation and performance on a single radar apparatus and on multiple input-multiple output radar systems will be detailed. "	**MH2.1 10:30 AM–11:00 AM (Invited) Multi-GeV Electron Bunch Acceleration from Laser Plasma Acceleration at BELLA** Wim Leemans, *LBNL, Berkeley, CA, USA*	
MF2.2 11:00 AM–11:15 AM 40 Gb/s Carrier Depletion-Based Silicon Micro-Ring Modulators Yang-Jeng Chen, Rih-You Chen, Tzu-Hsiang Yen, Cong-Long Chen, Yung-Jr Hung, and Yi-Jen Chiu, *National Sun Yat-Sen University, Kaohsiung, Taiwan* A high-speed Si carrier-depleted ring modulator has been demonstrated. Small footprint of 7.5 μm radius with low doping in rib waveguide introduces both low capacitance and low optical loss of ring, leading to high Q of 7200, 4.5dB modulation depth, and 3.4Vpp driven 40Gb/s modulation.	**MG2.2 11:00 AM–11:30 AM (Invited) Millimeter-Wave Radars Using Radio-Over-Fibers** Tetsuya Kawanishi, *Waseda University, Tokyo, Japan and National Institute of Information and Communications Technology (NICT), Tokyo, Japan* This paper describes concept of sensor-over-fiber and its application to millimeter-wave radar systems with many antenna units connected through radio-over-fiber networks, where the radar range resolution can be a few centimeters.	**MH2.2 11:00 AM–11:15 AM Evaluation of Efficient Laser Plasma Acceleration Driven by a Relativistic Mid-Infrared Laser Field** Eiji J. Takahashi, *RIKEN Center for Advanced Photonics, RIKEN, Saitama, Japan*, Shin-ichi Masuda, *High Energy Accelerator Research Organization (KEK), Ibaraki, Japan*, and Eisuke Miura, *National Institute of Advanced Industrial Science and Technology (AIST), Ibaraki, Japan* We evaluate the feasibility of an efficient laser plasma acceleration driven by an mid-infrared pulse. The driving wavelength of 1.5 μm with a relativistic-laser-intensity can improve the number of accelerated electrons as an order of magnitude, compared with that driven by the same intensity of 0.8 μm.	
MF2.3 11:15 AM–11:30 AM FSR-Free Microring Coupling-Based Modulator Ajay Mistry, Mustafa Hammood, Lukas Chrostowski, and Nicolas A. F. Jaeger, *University of British Columbia, Vancouver, Canada* We propose a Mach-Zehnder interferometer-assisted coupling-based, microring modulator that achieves a free spectral range free response by integrating a bent, contra-directional-coupler into the ring cavity. This design enables high capacity microring-based dense wavelength division multiplexing transmitter systems.	**MG2.3 11:30 AM–12:00 PM (Invited) Universal MWP Signal Processors – Architectures and Technologies** Cun-Zheng Ning, *Arizona State University, Tempe, AZ, USA* and Jose Capmany, *Valencia University, Valencia, Spain*	**MH2.3 11:15 AM–11:45 AM (Invited) Extremely High-Order Multiphoton Thomson Scattering: Synchrotron Hard X-Rays from Ultra-Intense Laser Light** Donald Umstadter, *University of Nebraska-Lincoln, Lincoln, NE, USA* A multi-terawatt laser system generates two synchronized ultra-intense near-infrared light pulses. One pulse Thomson scatters from the relativistic electrons that are laser-wakefield accelerated by the other pulse. Single x-ray photons are created when greater than 500 laser photons are nonlinearly scattered by individual free electrons.	

Grand Ballroom A	Grand Ballroom B	Grand Ballroom C	Regency Ballroom A	Regency Ballroom B
	MB2.4 11:30 AM–11:45 AM **PbSe PhotoFETs: Levereging Bandstructure and Voltage Control for High Performance** Samiran Ganguly, *University of Virginia, Charlottesville, VA, USA*, Sung-Shik Yoo, *Northrop Grumman Corp., Rolling Meadows, IL, USA*, and Avik W. Ghosh, *University of Virginia, Charlottesville, VA, USA* In this work we describe the physics of PbSe detectors that accurately captures the carrier transport and long carrier-lifetimes arising from inverted channels due to the material bandstructure. We discuss performance improvement through voltage control of the bandstructure, opening pathways for high-performance low-cost IR photodetectors.	**MC2.4 11:45 AM–12:00 PM** **23 GHz Bandwidth and 25 mW Peak Optical Output Power with 980 nm Oxide Aperture VCSELs** Nasibeh Haghighi, Gunter Larisch, Ricardo Rosales, and James A. Lott, *Technische Universtität Berlin, Berlin, Germany* Conventional vertical-single-cavity surface-emitting lasers with oxide aperture diameters (phi) of ~16 micrometers exhibit record room temperature small-signal modulation bandwidths (f3dB) of 23 GHz in concert with optical output powers of 25 mW. The same wafer yields f3dB exceeding 30 GHz when phi ~2.5–4.0 micrometers.		**ME2.4 11:30 AM–11:45 AM** **Circular Nanoplasmonic Interferometer for Detection of Immune-Cell Secretion** Yifeng Qian, Xie Zeng, *Lehigh University, Bethlehem, PA, USA*, Yongkang Gao, *NeoPhotonics, San Jose, CA, USA*, Hang Li, Sushil Kumar, *Lehigh University, Bethlehem, PA, USA*, Qiaoqiang Gan, *State University of New York, Buffalo, Buffalo, NY, USA*, Xuanhong Cheng, and Filbert Bartoli, *Lehigh Univerisity, Bethlehem, PA, USA* We develop a nanoplasmonic interferometer imaging system based on intensity modulation to study dynamic response of immune cells. The biosensor reliably detected MMP-9 secretion from stimulated monocytic cells and demonstrated great potential for multiplexed sensing of multiple secretory molecules.
	MB2.5 11:45 AM–12:00 PM **Depletion Engineered Heterojunction p+-n HgCdTe Infrared Photodetector Structures** Can Livanelioğlu, Yigit Ozer, and Serdar Kocaman, *Middle East Technical University, Ankara, Turkey* Dark current suppression via depletion region engineering is performed to eliminate Shockley-Read-Hall, Radiative and Trap-Assisted-Tunnelling dark currents in various atmospheric transmission windows. Effectiveness of the suppression technique is compared for all types of detectors revealing the dominant mechanisms and the performance limitations.			**ME2.5 11:45 AM–12:00 PM** **Multi-Channel Velocity Multiplexing on a PDMS Based Optofluidic Chip** J. A. Black, V. Ganjalizadeh, J. W. Parks, and H. Schmidt, *University of California, Santa Cruz, Santa Cruz, CA, USA* Multi-channel velocimetry for multiplexed particle detection is demonstrated on-chip using a PDMS based optofluidic platform. One liquid-core multimode interference waveguide is used to excite two detection liquid-core channels. Three wavelengths are used with two speeds to demonstrate six-fold multiplexing of fluorescent microbeads.

12:00 PM–1:30 PM – LUNCH (ON OWN)

Lake Anne A/B	Lake Audubon	Lake Thoreau	Reston A/B

MF2.4 11:30 AM–11:45 AM
Band-to-Band Transition Based On-Chip Optical Modulator
Alperen Govdeli, Murat Can Sarihan, Utku Karaca, and Serdar Kocaman, *Middle East Technical University, Ankara, Turkey*
Photonic crystal slab phase shifter based, area efficient and low operation voltage optical modulator design is presented. Required index difference between the Mach-Zehnder interferometer arms of the proposed modulator comes from the photonic band transition.

MH2.4 11:45 AM–12:00 PM
A High Energy Photon Collider as a Next-to-Next New Physics Laboratory: Beyond the LHC and ILC Era. Prospective New Scenarios in Particles Physic
Huber Nieto-Chaupis, *Universidad de Ciencias y Humanidades, Lima, Peru*
We present a scheme to study New Physics inside the framework of Novel Colliders as the Photon Collider beyond the LHC era. Despite of the optical system and energy limitations our simulations sustains the prospective character of this machine entirely based in a Superintense Laser.

MF2.5 11:45 AM–12:00 PM
Integrated Optomechanical Resonators in Double-Layer Crystalline Silicon Platforms
Razi Dehghannasiri, Hesam Moradinejad, Tianren Fan, Amir H. Hosseinnia, Ali A. Eftekhar, and Ali Adibi, *Georgia Institute of Technology, Atlanta, GA, USA*
We report the fabrication of the integrated deformable resonators with strong optomechanical interactions in the double-layer crystalline silicon platforms along with the experimental observation of the sustainable optomechanical oscillations (up to 75 MHz). This enables novel on-chip RF-photonics applications and wideband high-speed integrated optical switches.

12:00 PM–1:30 PM – LUNCH (ON OWN)

Grand Ballroom A

1:30 PM–2:30 PM
Session MA3: OC Tutorial
Session Chair: Hussam Batshon, *TE Subcom*

MA3.1 1:30 PM–2:30 PM (Tutorial) Information-Theoretic Tools for Optical Communications Engineers
Erik Agrell, *Chalmers University of Technology, Gothenburg, Sweden* and Marco Secondini, *TeCIP Institute, Pisa, Italy*
Fundamental information-theoretic concepts are explained for nonspecialists, with emphasis on their practical usage. The notions of a "FEC threshold" and a "nonlinear Shannon limit" are critically reviewed, highlighting their limitations and possible alternatives. (joint work with Marco Secondini)

Grand Ballroom B

1:30 PM–3:00 PM
Session MB3: High Speed Photodetectors and Systems
Session Chair: Jo Shien Ng, *University of Sheffield, Sheffield, UK*

MB3.1 1:30 PM–2:00 PM (Invited) Performance and Applications of 25 G/50 G Ge/Si Avalanched Photodiodes
Dong Pan, *SiFotonics, Woburn, MA, USA*

MB3.2 2:00 PM–2:15 PM Zero-Bias GaAsSb/InP Photodiode with 40 GHz Bandwidth
Qianhuan Yu, Ze Wang, Keye Sun, Fengxin Yu, Jizhao Zang, Joe C. Campbell, and Andreas Beling, *University of Virginia, Charlottesville, VA, USA*
We demonstrate a back-illuminated modified uni- traveling carrier (MUTC) photodiode with 40 GHz bandwidth at zero bias. The photodiode has a responsivity of 0.2 A/W without anti-reflection (AR) coating and delivers -2.8 dBm RF output power.

MB3.3 2:15 PM–2:30 PM Optimum Design Criteria on Speed and Responsivity of InP/GaAsSb Electron-Injection Detector
Min-Su Park, Mohsen Razaei, *Northwestern University, Evanston, IL, USA*, Chee Leong Tan, *University of Malaya, Kuala Lumpur, Malaysia*, and Hooman Mohseni, *Northwestern University, Evanston, IL, USA*
Electron-injection detector has shown unprecedented performance for highly sensitive imaging and optical coherence tomography system. We present optimum design criteria for speed and responsivity of detectors, revealing that the smaller devices have the higher optical gain and the faster response owing to decreasing total capacitance.

Grand Ballroom C

1:30 PM–3:00 PM
Session MC3: Wide Bandgap Lasers
Session Chair: Jerry Meyer, *Naval Research Laboratory, CA, USA*

MC3.1 1:30 PM–2:00 PM (Invited) AlGaN-Based Deep UV Lasers: Challenges and Prospects
Michael Kneissl, Christian Kuhn, Martin Martens, Martin Guttmann, Anton Muhin, Bettina Neuschulz, *TU Berlin, Berlin, Germany*, Jörg Jeschke, *Ferdinand-Braun-Institut, Leibniz-Institut für Hoechstfrequenztechnik, Berlin, Germany*, Luca Sulmoni, Tim Wernicke, *TU Berlin, Berlin, Germany*, and Markus Weyers, *Ferdinand-Braun-Institut, Leibniz-Institut für Hoechstfrequenztechnik, Berlin, Germany*
We will review recent advances in the development of AlGaN-based deep ultraviolet lasers and discuss key challenges towards the realization of current-injection UV laser diodes including MOVPE growth on low defect density templates and the effects of AlGaN quantum well design on the gain characteristics.

MC3.2 2:00 PM–2:15 PM Gain Properties of InGaN Quantum Wells with AlGaInN Barriers
Hanlin Fu, Wei Sun, Onoriode Ogidi-Ekoko, and Nelson Tansu, *Lehigh University, Bethlehem, PA, USA*
The material gain properties of the InGaN quantum well (QW) with various AlInGaN barriers are studied through self-consistent k•p formalism. Our study shows that the InGaN QW with lattice-matched AlGaInN barriers achieves remarkable improvement over conventional InGaN QW.

MC3.3 2:15 PM–2:30 PM Dilute-As InGaNAs Quantum Wells for Red-Emitting Lasers
Damir Borovac, Wei Sun, *Lehigh University, Bethlehem, PA, USA*, Chee-Keong Tan, *Clarkson University, Potsdam, NY, USA*, and Nelson Tansu, *Lehigh University, Bethlehem, PA, USA*
Analysis on the electronic properties of dilute-As InGaNAs quantum well active region was carried out, and the finding showed excellent potential for implementation in red-light emitting lasers with high gain properties in the long wavelength spectral regime.

Regency Ballroom A

1:30 PM–2:45 PM
Session MD3: Award Winning Photonics Science and Technology I
Session Chair: C. Menoni, *Colorado State University, CO, USA*

MD3.1 1:30 PM–2:00 PM (Invited) *William Streifer Scientific Achievement Award* – What We Learned about Mutimode Fibers while Performing Communication Experiments
Roland Ryf, *Nokia Bell Labs, USA*
I will review scientifically interesting effects that we observed while working on mode-division multiplexed communication experiments in multimode fibers. In particular I will address linear mode coupling, four-wave mixing, stimulated Raman scattering, Brillouin scattering, and guided acoustic-waves Brillouin scattering, that are so much richer in mutlimode fibers compared to the single-mode fiber case.

MD3.2 2:00 PM–2:45 PM (Tutorial) *Quantum Electronics Award* – Fibre-Based Sources for Spectral and Temporal Versatility
James Roy *Taylor, Imperial College London, UK*
Master oscillator-power fibre amplifier configurations followed by nonlinear conversion both in fibre and crystalline materials has allowed extensive versatility, both spectrally and temporally, in compact, highly efficient geometries that are finding extensive application, as exemplified by the highly commercially successful, fibre-integrated supercontinuum source. However, the supercontinuum source does exhibit some limitations and alternative, more efficient approaches to provide wavelength and temporal selectivity from the uv to the mid IR will be described.

Regency Ballroom B

1:30 PM–3:00 PM
Session ME3: Computational Imaging and Image Computation
Session Chair: Giuliano Scarcelli, *University of Maryland, College Park, MD, USA*

ME3.1 1:30 PM–2:00 PM (Invited) Compressed Ultrafast Photography and Microscopy: Redefining the Limit of Passive Ultrafast Imaging
Liang Gao, *University of Illinois, IL, USA*
This (Invited) talk will give an overview of our recent effort to develop a second-generation compressed ultrafast photography (CUP) system and demonstrate its applications at scales from macroscopic to microscopic.

ME3.2 2:00 PM–2:15 PM Lensless Inline Holographic Microscope with Insufficient Spatial and Temporal Coherence
Jigang Wu and Shaodong Feng, *University of Michigan – Shanghai Jiao Tong University, Shanghai, China*
We propose a method to enhance the imaging resolution in lensless inline holographic microscope when a light source with insufficient spatial or temporal coherence is used. Our method models the imaging system as linear systems and the deconvolution technique can be applied for resolution enhancement.

ME3.3 2:15 PM–2:30 PM Automated Identification of Bacteria Using Three-Dimensional Holographic Imaging and Convolutional Neural Network
Geon Kim, YoungJu Jo, *KAIST, Daejeon, South Korea*, Hyungjoo Cho, *Seoul National University, Seoul, South Korea*, Gunho Choi, *Yonsei University, Seoul, South Korea*, Beom-Soo Kim, *Korea University, Seoul, South Korea*, Hyun-seok Min, and YongKeun Park, *KAIST, Daejeon, South Korea*
Rapid identification of microbial pathogens is crucial for treating infections. Here we present a rapid method for identification of bacteria. In our method, a trained convolutional neural network classifier can accurately determine the bacterial species from a given three-dimensional refractive index image.

Lake Anne A/B

1:30 PM–2:45 PM
Session MF3: Miroresonator Devices
Session Chair: Ali Adibi, *Georgia Institute of Technology, Atlanta, GA, USA*

MF3.1 1:30 PM–2:00 PM (Invited)
Integrated High-Q $LiNbO_3$ Resonators and Applications
Marko Loncar, *Harvard University, Cambridge, MA, USA*

MF3.2 2:00 PM–2:15 PM
Nanoscale Accurate Heterogeneous Integration of Waveguide Devices by Transfer Printing
B. Guilhabert, J. McPhillimy, *University of Strathclyde, Glasgow, UK*, C. Klitis, *University of Glasgow, Glasgow, UK*, M. D. Dawson, *University of Strathclyde, Glasgow, UK*, M. Sorel, *University of Glasgow, Glasgow, UK*, and M. J. Strain, *University of Strathclyde, Glasgow, UK*
The vertical micro-assembly of membrane photonic devices across a range of materials is presented, including polymers, silicon and III-V semiconductors. Fully-fabricated waveguide structures are integrated with sub-100nm absolute placement accuracy. Light-emitting diodes, silicon photonics and nanowire lasers are examples of the deployment of this technique.

MF3.3 2:15 PM–2:30 PM
Low-Loss Silicon-Photonic Devices for Mid-infrared Applications
A. Nitkowski, P. Bollond, M. Dinu, S. Cabot, J. Le Grange, J. Jaques, I. Kang, *LGS Innovations, Florham Park, NJ, USA*, Chia-Ming Chang, Po Dong, *Nokia Bell Labs, Holmdel, NJ, USA*, Xianshu Luo, and Guo-Qiang Lo, *Advanced Micro Foundry Pte, Singapore*
We demonstrate low-loss silicon-on-insulator devices for 2-μm or longer wavelengths. We achieve waveguide loss as low as ~0.18 dB/cm and further demonstrate high quality factor micro-ring resonator with intrinsic Q of ~0.56 million and free spectral range of 100 GHz.

Lake Audubon

Lake Thoreau

1:30 PM–3:00 PM
Session MH3: Silicon Photonics
Session Chair: Peter Schunemann, *BAE Systems, Inc., USA*

MH3.1 1:30 PM–2:00 PM (Invited)
Nonlinear Optics in Semiconductor Optical Fibers
Anna C. Peacock, *University of Southampton, Southampton, UK*
This paper will review progress in the development of nonlinear devices from the semiconductor optical fiber platform. The nonlinear performance will be benchmarked through demonstrations of high-speed all-optical wavelength conversion, modulation, and continuum generation across a broad wavelength range.

MH3.2 2:00 PM–2:15 PM
In Situ Fabrication of Far-Detuned Optical Fiber Wavelength Converters
Md Imtiaz Alamgir, Nurmemet Abudukelimu, and Martin Rochette, *McGill University, Montreal, Quebec, Canada*
We demonstrate the fabrication of wavelength converters with a far-detuned and precisely engineered wavelength offset enabled by an in situ approach. The technique enables the design and fabrication of precise wavelength converters with more than 44 THz of detuning.

MH3.3 2:15 PM–2:45 PM (Invited)
Ultra-Rich-Silicon...
Dawn Tan, Kelvin Ooi, *SUTD, Singapore*, Doris Ng, *A*STAR Data Storage Institute*, Ju Won Choi, Ezgi Sahin, Peng Xing, George Chen, and Byoung Uk Sohn, SUTD, Singapore
We present recent developments in nonlinear optics leveraging the ultra-silicon-rich nitride platform. Films with a high Kerr nonlinearity and negligible two photon absorption at the telecommunications wavelength are used to realize devices for high gain optical parametric amplifiers, wavelength conversion and slow-light enhancement.

Reston A/B

1:30 PM–3:00 PM
Session MI3: The Global Startup Scene
Session Chair: Dalma Novak, *Pharad, Hanover, MD, USA*
***** Live Streamed*****

Grand Ballroom A	Grand Ballroom B	Grand Ballroom C	Regency Ballroom A	Regency Ballroom B
	MB3.4 2:30 PM–3:00 PM (Invited) **45-Gbaud, 32-Pixel 2D-PDA for Multi-Core Fiber-Based Optical Wireless Communication** Toshimasa Umezawa, Takahide Sakamoto, Atsushi Kanno, Atsushi Matsumoto, Naokatsu Yamamoto, *National Institute of Information and Communications Technology (NICT), Tokyo, Japan*, and Tetsuya Kawanishi, *National Institute of Information and Communications Technology (NICT), Tokyo, Japan and Waseda University, Tokyo, Japan* We developed a 45-Gbaud, 32-pixel two-dimensional photodetector array (2D-PDA) device for multi-core based free-space optical (FSO) communication. In the demonstration using the multicore fiber (MCF) and 2D-PDA in free space, the simultaneous detection of four high-data-rate parallel beams was successfully achieved.			**ME3.4 2:30 PM–2:45 PM** **Accurate Representation of Microscopic Scatterers in Realistic Simulation of OCT Image Formation** Pawel Ossowski, *Nicolaus Copernicus University, Torun, Poland*, Andrea Curatolo, *Instituto de Optica "Daza de Valdes", Madrid, Spain and University of Western Australia, Perth, Australia*, David Sampson, *University of Surrey, Guildford, UK and University of Western Australia, Perth, Australia*, and Peter R. T. Munro, *University College London, London, UK and University of Western Australia, Perth, Australia* Realistic models of OCT image formation face a common challenge: how can microscopic scatterers be represented without limiting the overall size of the sample that can be modelled? We present a solution to this problem using the pseudospectral time domain method along with experimental validation.

3:00 PM–3:30 PM – EXHIBITS / COFFEE BREAK – GRAND BALLROOM FOYER

Lake Anne A/B	Lake Audubon	Lake Thoreau	Reston A/B
MF3.4 2:30 PM–2:45 PM **High-Q Microresonators at Near-Infrared/Near Visible Wavelengths on A 3C-SiC-on-Insulator (SiCOI) Platform** Tianren Fan, Ali A. Eftekhar, and Ali Adibi, *Georgia Institute of Technology, Atlanta, GA, USA* We demonstrate a 3C-SiC-on-insulator (SiCOI) platform through wafer bonding process. We fabricated fully-integrated microresonators at near-infrared/near-visible wavelengths (~770 nm) showing a Q of 5,000. Such high-Q resonators pave the way for realization of large-scale integrated spintronics/quantum devices based on carbon vacancies in SiC.		**MH3.4 2:45 PM–3:00 PM** **Crack-Free Silicon-Nitride-on-Insulator Nonlinear Circuits for Continuum Generation in the C-Band** Houssein El Dirani, Marco Casale, Sébastien Kerdiles, Carole Socquet-Clerc, *CEA-LETI, Grenoble, France*, Xavier Letartre, Christelle Monat, *Institut des Nanotechnologies de Lyon, Ecully, France*, and Corrado Sciancalepore, *CEA-LETI, Grenoble, France* We report on the fabrication and testing of silicon nitride- on-insulator nonlinear photonic circuits for complementary metal–oxide semiconductor (CMOS) compatible monolithic co-integration with silicon-based optoelectronics. This work paves the way to power-efficient Kerr-based broadband sources featuring compatibility with Si photonic integrated circuits on CMOS lines.	

3:00 PM–3:30 PM – EXHIBITS / COFFEE BREAK – GRAND BALLROOM FOYER

Grand Ballroom A

3:30 PM–4:45 PM
Session MA4: Steps Toward Practicality of SDM
Session Chair: Yoshinari Awaji, *NICT, Koganei, Tokyo, Japan*

MA4.1 3:30 PM–4:00 PM (Invited)
Toward the Practical Use of the Multi-Core Fiber in Optical Communications
Tetsuya Hayashi, *Sumitomo Electric Industries, Ltd., Yokohama, Japan*
The intensive research and development on multi-core and other types of optical fibers for space-division multiplexed transmission has continued already for nearly ten years. This talk will review and discuss recent research and development on the multi-core fiber toward the practical realization.

MA4.2 4:00 PM–4:15 PM
Suppression of Group-Delay Spread in Coupled Two-LP-Mode Four-Core Fiber
Takanori Sato, Kazuki Yoshida, Takeshi Fujisawa, *Hokkaido University, Hokkaido, Japan*, Taiji Sakamoto, Takashi Matsui, Kyozo Tsujikawa, Kazuhide Nakajima, *NTT Corporation, Ibaraki, Japan*, and Kunimasa Saitoh, *Hokkaido University, Hokkaido, Japan*
We newly develop the group-delay spread (GDS) analysis for a tight-bent coupled few-mode multicore fiber (FM-MCF) using pseudo guided modes and reveal that the GDS of coupled FM-MCF can be suppressed for the first time.

MA4.3 4:15 PM–4:45 PM (Invited)
Switching Paradigms for SDM-WDM Networks
Dan Marom, *Hebrew University of Jerusalem, Jerusalem, Israel*

Grand Ballroom B

3:30 PM–5:00 PM
Session MB4: High Power & UTC Detectors
Session Chair: Joshua Duran, *Air Force Research Laboratory – Sensors Directorate, Dayton, OH, USA*

MB4.1 3:30 PM–4:00 PM (Invited)
High-Power Photonic Phased Array Antennas
Matthew R. Konkol, *Phase Sensitive Innovations, Inc., Newark, DE, USA*, Victoria A. Carey, Shouyuan Shi, *University of Delaware, Newark, DE, USA*, Christopher A. Schuetz, *Phase Sensitive Innovations, Inc., Newark, DE, USA*, and Dennis W. Prather, *University of Delaware, Newark, DE, USA*
We review recent work on a new antenna concept—the high-power photonic phased array. By integrating high-power photodiodes proximal to the aperture's radiating elements, dense, lightweight, and broadband array designs are realized. Several manifestations of this basic idea are discussed, emphasizing different application specific design choices.

MB4.2 4:00 PM–4:15 PM
Phase Noise and Performance Optimization in MUTC Photodetectors Using the Drift-Diffusion Equations
Seyed Ehsan, Jamali Mahabadi, *University of Maryland, Baltimore, MD, USA*, Franklyn J. Quinlan, *National Institute of Standards and Technology, Boulder, CO, USA*, Thomas F. Carruthers, and Curtis R. Menyuk, *University of Maryland, Baltimore, MD, USA*
We calculate the phase noise in modified unitraveling carrier (MUTC) photodetectors using the drift-diffusion equations, avoiding computationally-expensive Monte Carlo simulations. We optimize the performance over a range of device currents and biases.

MB4.3 4:15 PM–4:30 PM
Large-Area High-Power Modified Uni-Traveling Carrier Photodiodes
Fengxin Yu, Keye Sun, and Andreas Beling, *University of Virginia, Charlottesville, VA, USA*
We report on 100-μm-diameter back-illuminated InGaAsP/InP modified uni-traveling carrier photodiodes with an RF output power of 23 dBm at 2 GHz. Very low dark current of 20 nA at –8 V, high responsivity of 0.63 A/W at 1.55 μm are demonstrated.

Grand Ballroom C

3:30 PM–5:00 PM
Session MC4: Quantum Cascade and High Power Lasers
Session Chair: Michael Kneissl, *TU Berlin, Berlin, Germany*

MC4.1 3:30 PM–4:00 PM (Invited)
Frequency Combs in Quantum-Cascade Lasers
Jérôme FAIST, *ETH Zurich, Zurich, Switzerland*

MC4.2 4:00 PM–4:30 PM
High-Power MOCVD-Grown Quantum Cascade Lasers
L. J. Mawst, C. Sigler, C. Boyle, J. D. Kirch, K. Oresick, H. Kim, *University of Wisconsin-Madison, Madison, WI, USA*, D. Lindberg III, T. Earles, *Intraband LLC, Madison, WI, USA*, and *D. Botez, University of Wisconsin-Madison, Madison, WI, USA*
MOCVD-grown step-taper active region – resonant-extraction (STA-RE) quantum cascade lasers (QCLs) demonstrate single-facet output powers of 2.6 W CW (@15 oC) with 12% CW power conversion efficiency. Five-element antiguided phase-locked arrays operate with in-phase-mode operation to 1.9 × threshold and 5.1 W front-facet emitted power.

MC4.3 4:30 PM–4:45 PM (Invited)
Influence of Lateral Refractive Index Profiles on the Divergence Angle of Gain-Guided Broad-Area Laser Diode Bars
Carlo Holly, Xiaohang Liu, Stefan Heinemann, Stewart McDougall, and Hagen Zimer, *TRUMPF Photonics, Inc., Cranbury, NJ, USA*
A numerical model for high-power diode lasers is employed to predict the lateral divergence angle over current for one emitter out of a laser array. The calculated values are compared to experimental data and comments are made regarding the guiding mechanisms in the device.

Regency Ballroom A

Regency Ballroom B

3:30 PM–5:00 PM
Session ME4: Advanced Microscopy
Session Chair: Norman Lippok, *Harvard Medical School, Boston, MA, USA*

ME4.1 3:30 PM–4:00 PM (Invited)
Mapping the Microbiome with Super Resolution Microscopy
Jochem Deen, *Swiss Federal Institute of Technology, Lausanne, Switzerland*
An immense number of microbial species live in a symbiotic relationship with their host (collectively called the microbiome). Current techniques limit identification of species within this microbiome. We propose a new method of identification based on super-resolution microscopy of sequence-specifically fluorescently labeled DNA.

ME4.2 4:00 PM–4:15 PM
Oblique-Sectional Single-Molecule Microscopy
Jeongmin Kim, Michal Wojcik, Yuan Wang, Ke Xu, and Xiang Zhang, *University of California, Berkeley, Berkeley, CA, USA*
We introduce oblique-sectional single-molecule microscopy (obSTORM) that images any oblique cross-sections of a biological sample into depth without lengthy z-stack acquisition. Combining oblique lightsheet illumination and direct oblique detection, obSTORM offers uniform super-resolution though imaging depth, thus well-suited for thick samples from cells to tissues.

ME4.3 4:15 PM–4:30 PM
A Handheld MEMS-Scanned In Vivo Optical-Sectioning Microscope for Early Detection and Surgical Guidance
Chengbo Yin, Linpeng Wei, *University of Washington, Seattle, WA, USA*, Sanjeewa Abeytunge, Gary Peterson, *Memorial Sloan Kettering Cancer Center, New York, NY, USA*, Adam K. Glaser, *University of Washington, Seattle, WA, USA*, Michael J. Mandella, *Michigan State University, East Lansing, MI, USA*, Milind Rajadhyaksha, *Memorial Sloan Kettering Cancer Center, New York, NY, USA*, and Jonathan T. C. Liu, *University of Washington, Seattle, WA, USA*
A miniature line-scanned (LS) dual-axis confocal (DAC) microscope, with a 12-mm diameter distal tip, has been developed for high-speed (>15 Hz) microscopic imaging of tissue surfaces up to a depth of ~150 μm.

Lake Anne A/B

3:30 PM–5:00 PM
Session MF4: Nonlinear Microresonators
Session Chair: Scott Papp, *National Institute of Standards and Technology, Gaithersburg, MD, USA*

MF4.1 3:30 PM–4:00 PM (Invited)
Microresonator Isolators Based on the Nonreciprocity of the Kerr Effect
Pascal Del'Haye, *National Physical Laboratory, England, UK*
This talk will focus on recent realizations of nonlinear interaction of counterpropagating light in ultra-high-Q microresonators that leads to spontaneous symmetry breaking. The resulting nonreciprocity of the light propagation can be used for integrated photonic isolators and circulators.

MF4.2 4:00 PM–4:30 PM (Invited)
Self-Injection Locking of Laser Diodes to Microresonators and Microcombs
Michael Gorodetsky, *USA*

MF4.3 4:30 PM–4:45 PM
Cavity Optomechanical Photothermal Sensors
Marcel W. Pruessner, Doewon Park, Todd H. Stievater, Dmitry A. Kozak, and William S. Rabinovich, *US Naval Research Laboratory, Washington, DC, USA*
We experimentally demonstrate a cavity optomechanical sensor that is actuated with gradient optical forces. The sensor can detect incident radiation via absorption and resulting photothermally-induced frequency shifts of the nanomechanical oscillator. Analysis suggests that nanostrain sensitivity and fJ-level energy detection are possible.

Lake Audubon

Lake Thoreau

3:30 PM–5:00 PM
Session MH4: High-Energy Sources and Applications
Session Chair: Cord L.Arnold, *Lund University, Lund, Sweden*

MH4.1 3:30 PM–4:00 PM (Invited)
High Energy THz Pulses for Electron Acceleration
Franz Kaertner, *CFEL, Hamburg, Germany*
Recent theoretical and experimental results on laser based high-energy single-cycle and multi-cycle terahertz pulse generation are discussed. The pulse formats are chosen to demonstrate various THz accelerating and beam manipulation devices. Results for a segmented terahertz electron manipulator and accelerator are presented.

MH4.2 4:00 PM–4:30 PM (Invited)
High Repetition Rate Petawatt Laser and High-Contrast Ultra-High Intensity Second Harmonic Beamline
Yong Wang, Shoujun Wang, Alex Rockwood, Bradley M. Luther, Reed Hollinge, Alden Curtis, Chase Calvi, Carmen S. Menoni, and Jorge J. Rocca, *Colorado State University, Fort Collins, CO, USA*
We demonstrate the generation of 0.85 PW, 30 fs pulses at a repetition rate of 3.3 Hz from a Ti:Sapphire laser system. Ultra-high contrast second harmonic fs pulses at 400 nm were generated with >40% efficiency and focused to an intensity of 6.5×10^{21} W/cm^2.

MH4.3 4:30 PM–4:45 PM
Development of High Energy, Picosecond Lasers with Kilowatt Average Power
Cory M. Baumgarten, Han Chi, *Colorado State University, Fort Collins, CO, USA*, Kristian Dehne, *XUV Lasers, Inc., Fort Collins, CO, USA*, Elzbieta Jankowska, *Colorado State University, Fort Collins, CO, USA*, Herman Bravo, *XUV Lasers Inc., Fort Collins, CO, USA*, Liang Yin, Hanchen Wang, Alex Meadows, Gabriel Murray, Carmen S. Menoni, *Colorado State University, Fort Collins, CO, USA*, Brendan A. Reagan, *XUV Lasers Inc., Fort Collins, CO, USA*, and Jorge J. Rocca, *Colorado State University, Fort Collins, CO, USA*
We report a chirped pulse amplification laser designed to produce Joule-level pulses of picosecond duration at 1 kHz repetition rate. This laser is based on cryogenically-cooled Yb:YAG active mirror amplifiers. A technique for mapping the temperature distribution within the active mirrors in 3D is discussed.

Reston A/B

3:30 PM–5:00 PM
Session MI4: Tech Titans: Words of Wisdom, War Stories and Crystal Balls
Session Chairs: Maura Raburn & Simon Poole
***** Live Streamed*****

Grand Ballroom A	Grand Ballroom B	Grand Ballroom C	Regency Ballroom A	Regency Ballroom B
	MB4.4 4:30 PM–5:00 PM (Invited) High Output Power Millimeter Wave GaAsSb-InP UTC Photoreceiver MMICs Christopher Coleman, Gregory Lee, Tom Low, Dieter Vook, Barry Wu, and Douglas M. Baney, *Keysight Technologies, Santa Rosa, CA, USA* We demonstrate a type-II GaAsSb/InP source-terminated MMIC UTC photoreceiver delivering 0.15 A/W responsivity with 5.1 dBm RF power measured at 170 GHz. The photodiode-based MMIC demonstrated a small-signal 3-dB bandwidth of 220 GHz. The photodiode MMICs were subsequently mounted on sapphire and packaged.	**MC4.4 4:45 PM–5:00 PM Modulation of Master Oscillator Power Amplifier for Free Space Optical Communications at 1.5 µm** Cécil Pham, Frédéric Van Dijk, Olivier Parillaud, Eric Vinet, Yannick Robert, Michel Garcia, Alexandre Larrue, *III-V Lab, Palaiseau, France*, Mickaël Faugeron, *Thales Alenia Space, Toulouse, France*, and Angélique Rissons, *ISAE Supaéro, Toulouse, France* A monolithic, three-section InP MOPA is presented. The device exhibits 380 mW of output power in continuous wave and a single mode optical spectrum with a 42 dB SMSR. Small-signal modulation is tested and a model is proposed to understand and predict its behaviour.		**ME4.4 4:30 PM–4:45 PM A Portable Quantitative Phase Microscope for Material Metrology and Biological Imaging** Mengxuan Niu, Gang Luo, and Renjie Zhou, *Chinese University of Hong Kong, Hong Kong, China* Quantitative phase microscopy (QPM) has enabled many important metrology and bioimaging applications. To increase its popularity, we have developed a low-cost portable common-path QPM system for both transmission and reflection measurements. Our system can be deployed for fabricated structure profiling and cell imaging applications.
				ME4.5 4:45 PM–5:00 PM Absolute Three-Dimensional Measurement of Refractive Index Via Photon-Phonon Phase Matching Antonio Fiore and Giuliano Scarcelli, *University of Maryland, College Park, MD, USA* We developed a microscopy technique that can map the refractive index of samples in an absolute manner and with three-dimensional resolution. To address this goal, we designed a dual geometry Brillouin spectroscopy configuration that sample the same phonon within a confocal voxel.

IEEE PHOTONICS SOCIETY WELCOME AND AWARDS BANQUET DINNER – 7:00 PM–9:00 PM – GRAND BALLROOM D/E/F/G
Session Chair: Amr Helmy, *University of Toronto, Ontario, Canada*

Lake Anne A/B

MF4.4 4:45 PM–5:00 PM
Influence of Nonlinear Losses on Spontaneous Four Wave Mixing in InP Membrane Micro-Ring Resonator
Rakesh Ranjan Kumar, *Chinese University of Hong Kong, Hong Kong, China*, Ming Feng, *Chinese University of Hong Kong, Hong Kong, China and Nankai University, Tianjin, China*, Marina Raevskaia, Vadim Pogoretskii, Yuqing Jiao, *Eindhoven University of Technology, Eindhoven, The Netherlands*, and Hon Ki Tsang, *Chinese University of Hong Kong, Hong Kong, China*
We experimentally study spontaneous four wave mixing in micro-ring resonator on an InP membrane in a continuous regime. The generation rate of single photons from spontaneous four wave mixing is limited by the reduction in loaded Q- factor of the micro-ring resonators at higher power.

Lake Audubon

Lake Thoreau

MH4.4 4:45 PM–5:00 PM
Bidirectional Mode-Locked Thulium-Doped Laser
Nurmemet Abudukelimu, M. Imrul Kayes, Alexandre Rekik, and Martin Rochette, *McGill University, Montreal, Quebec, Canada*
We demonstrate the first bidirectional mode-locked thulium-doped fiber laser. Mode locking is enabled thanks to a semiconductor saturable absorber mirror and nonlinear polarization rotation. Output wavelengths and repetition rate difference are both tunable.

Reston A/B

IEEE PHOTONICS SOCIETY WELCOME AND AWARDS BANQUET DINNER – 7:00 PM–9:00 PM – GRAND BALLROOM D/E/F/G
Session Chair: Amr Helmy, *University of Toronto, Ontario, Canada*

Grand Ballroom A

8:30 AM–10:00 AM
Session TuA1: Optical Transceivers
Session Chair: TBD

TuA1.1 8:30 AM–9:00 AM (Invited)
Scalable High-Performance Multi-Format Optical Transceivers
P. S. Bedrosian, J. P. Wang, and David Caplan, *MIT Lincoln Laboratory, Lexington, MA, USA*
The availability of flexible, scalable, and efficient optical transceivers can greatly influence the capabilities and cost of future free-space optical networks. We report on promising Agile Laser Transmitter and Receiver (ALTaR) technologies with performance suitable for next-generation systems.

TuA1.2 9:00 AM–9:15 AM
4 × 25 Gbit/s Silicon Photonics Tunable Receiver Using Transfer Printed III-V Photodiodes
Grigorij Muliuk, Kasper Van Gasse, Mahmoud Shahin, Jochem Verbist, *Ghent University - IMEC, Ghent, Belgium*, Antonio José Trindade, *X-Celeprint Limited, Cork, Ireland*, Brian Corbett, *Tyndall National Institute, Cork, Ireland*, Dries Van Thourhout, and Günther Roelkens, *Ghent University – IMEC, Ghent, Belgium*
We demonstrate a 4-channel silicon photonics thermally tunable microring receiver by transfer printing an array of commercial III-V C-band photodiodes. 25Gbit/s open eye diagrams were obtained for each receiver channel.

TuA1.3 9:15 AM–9:30 AM
Joint Tx and Rx Skew Calibration in Coherent Transceivers Based on Rx-Side DSP
Pavel Skvortcov, Christian Sanchez-Costa, Ian Phillips, and Wladek Forysiak, *Aston University, Birmingham, UK*
A calibration algorithm for both transmitter-side and receiver-side skews based on receiver-side DSP is proposed. Two conditions are required: presence of frequency offset between transmitter / receiver and SOP rotation. Sub-picosecond accuracy of the method is shown in numerical simulations.

Grand Ballroom B

8:30 AM–10:00 AM
Session TuB1: PSSI Tutorial
Session Chair: Andrew Sarangan, *University of Dayton, Dayton, OH, USA*

TuB1.1 8:30 AM–10:00 AM (Tutorial)
III-V Semiconductor Unipolar Barrier Infrared Detectors
David Z. Ting, *California Institute of Technology, Pasadena, CA, USA*
Rapid advances in III-V semiconductor bulk and type-II superlattice infrared material and the advent of the unipolar barrier infrared detector device architecture in the past decade have led to a new generation of high-performance infrared detectors and focal planes, providing a viable alternative to HgCdTe.

Grand Ballroom C

8:30 AM–10:00 AM
Session TuC1: Integration Technologies
Session Chair: Frédéric Grillot, *Universiteé Paris-Saclay, Paris, France*

TuC1.1 8:30 AM–9:00 AM (Invited)
Photonic Integration with Quantum Cascade Lasers
Mikhail Belkin, *University of Texas at Austin, Austin, TX, USA*

TuC1.2 9:00 AM–9:30 AM (Invited)
InAs Quantum Dot Lasers on Silicon Emitting at Telecom Wavelengths
Kei May Lau, *HKUST, Hong Kong, China*
The first 1.5 μm InP-based QD lasers directly grown on on-axis (001) Si by MOCVD, with multi-stack InAs/InAlGaAs/InP QDs on compliant III-V/Si substrates, as well as nano-ridge lasers with embedded quantum wells will be described. Growth and laser characteristics of nano-lasers, whispering-gallery-mode (WGM) micro-lasers, and Fabry Parot lasers will be discussed.

TuC1.3 9:30 AM–10:00 AM (Invited)
Photonics Silicon Foundry
Michael Liehr
AIM Photonics is a Manufacturing USA institute whose mission is to provide cost-effective and easy-to-use access to state-of-the-art silicon photonics processing. AIM Photonics is providing access to a Multi-Project-Wafer program enabled with a highly competitive component library and offers Assembly and Packaging services starting 2019.

Regency Ballroom A

8:30 AM–9:45 AM
Session TuD1: Silicon Photonics and Packaging
Session Chair: Luc M. Augustin, *SMART Photonics B.V., Eindhoven, The Netherlands*

TuD1.1 8:30 AM–9:00 AM (Invited)
Subwavelength Silicon Photonic Structures
Jens Schmid, *National Research Council Canada*

TuD1.2 9:00 AM–9:15 AM
Compliant Polymer Interface Demonstration with Standard Plug-In Connection to Fiber Cables
Tymon Barwicz, *IBM T.J. Watson Research Center, Yorktown Heights, NY, USA*, Kengo Watanabe, *Furukawa Electric Co., Chiba, Japan*, Richard Langlois, *IBM Bromont, Bromont, Quebec, Canada*, Katsuki Suematsu, *Furukawa Electric Co., Chiba, Japan*, Nathalie Normand, *IBM Bromont, Bromont, Quebec, Canada*, Shotaro Takenobu, *Asahi Glass Co., Kanagawa, Japan*, Alexander Janta-Polczynski, *IBM Bromont, Bromont, Quebec, Canada* Bo Peng, Yoichi Taira, *IBM T.J. Watson Research Center, Yorktown Heights, NY, USA*, Hidetoshi Numata, *IBM Research - Tokyo, Kanagawa, Japan*, Swetha Kamlapurkar, Sebastian Engelmann, *IBM T.J. Watson Research Center, Yorktown Heights, NY, USA*, and Nicolas Boyer, *IBM Bromont, Bromont, Quebec, Canada*
We demonstrate a mechanically-compliant polymer interface, between standard fiber cables and nano-photonic waveguides, with passive self-alignment at both the fiber and the chip connections. We show a peak transmission of –1.8dB with less than 0.7dB penalty over a 100nm bandwidth and all polarizations.

TuD1.3 9:15 AM–9:30 AM
A Thermally Tunable Superstructure Grating Filter in Silicon Photonics
Zifei Wang and Lawrence R. Chen *McGill University Montreal, Quebec, Canada*
We demonstrate a thermally tunable optical filter based on periodic heating of a uniform Bragg grating structure on silicon-on-insulator. Five metal heater blocks are used to heat the grating to introduce multiple phase shifts and realize tunability of the reflection spectra.

Regency Ballroom B

8:30 AM–10:00 AM
Session TuE1: Photothermal, Fluorescence Liftime, and Brillouin Imaging
Session Chair: Jigang Wu, *University of Michigan – Shanghai Jiao Tong University, Shanghai, China*

TuE1.1 8:30 AM–9:00 AM (Invited)
Dental Thermo-Photonic Imaging
Nima Tabatabaei, *York University Ontario, Canada*
Early detection of dental caries is key to the effectiveness of therapeutic and preventive approaches in Dentistry; yet, standard-of-care methodologies (e.g., x-ray) lack sensitivity to detect caries at early stages. Thermo-Photonic imaging allows for early caries detection by detecting the thermal-waves induced at carious lesions.

TuE1.2 9:00 AM–9:15 AM
Real-Time Time-Resolved Optical Measurements Using a Digital Adaptive Filter
Saurabh Gupta, Arya Chowdhury Mugdha, William Hudson, Victoria Palmer, Kevin L. Lear, and Jesse W. Wilson, *Colorado State University, Fort Collins, CO, USA*
We demonstrate a novel phosphorescence lifetime imaging microscopy technique using a pseudo-random modulated laser source for excitation, and an adaptive filter for resolving the detected emission. Our results show clear lifetime differences between the oxygenated and deoxygenated solutions of a ruthenium dye.

TuE1.3 9:15 AM–9:30 AM
Noncontact Characterization of Nuclear Mechanics within Intact Cells Using Brillouin Microscopy
Jitao Zhang, Miloš Nikolić, Xuefei A. Nou, *University of Maryland, College Park, MD, USA*, Hanyoup Kim, *Canon U.S. Life Sciences, Inc., Rockville, MD, USA*, and Giuliano Scarcelli, *University of Maryland, College Park, MD, USA*
Using all-optical Brillouin microscopy that probes light-matter interactions on the scale of ~200 nm in biological samples, we directly assessed nuclear modulus of intact cell with sub-micron resolution. We found that nuclear mechanics is affected by both nanoscale internal structures and extrinsic cytoskeletal modulations.

Lake Anne A/B

8:30 AM–10:00 AM
Session TuF1: Microresonator Sensors and Metrology
Session Chair: Pascal Del'Haye, *National Physical Laboratory, England, UK*

TuF1.1 8:30 AM–9:00 AM (Invited) Exploring the Nanoscale with Optoplasmonic Sensors
Frank Vollmer, *UK*

TuF1.2 9:00 AM–9:30 AM (Invited) Photonic-Chip Frequency Combs for Optical Synthesis and Metrology
Scott Papp, *National Institute of Standards and Technology, Gaithersburg, MD, USA*
Optical-frequency combs are versatile tools for measuring time, identifying chemicals, and generating quantum states. A new direction is to produce frequency combs through intriguing nonlinear behaviors of light in Kerr microresonators. I will discuss experiments that probe Kerr soliton comb formation and demonstrate ultra-precision measurements.

TuF1.3 9:30 AM–9:45 AM Noninvasive and Portable Diagnoses for Brain and Heart Disorder: Angle-Distinguishable Infrared Spectroscopy Based Upon a Three Dimensional Resonant Toroid Version of Whispering Gallery Modes
O'Dae Kwon, *POSTECH (Pohang Univ. of Sci. & Tech.), Seoul, South Korea*
Noninvasive and portable diagnoses in real time for brain and heart disorder are proposed. The answer is flowing in the wave of an angle-distinguishable near-infrared spectroscopy based upon a three dimensional quantized angle resonant toroid version of two dimensional whispering gallery modes, photonic quantum ring.

Lake Audubon

8:30 AM–10:00 AM
Session TuG1: Nanophotonic Light Emission
Session Chair: Alessandro Salandrino, *University of Kansas, Lawrence, KS, USA*

TuG1.1 8:30 AM–9:00 AM (Invited) The Next Generation of Colloidal Quantum Emitters for Nanophotonics
David J. Norris, *ETH Zurich, Zurich, Switzerland*
We will discuss recent work to develop new quantum emitters for nanphotonic devices. Examples include: lanthanide-doped nanocrystals that can provide both electric- and magnetic-dipole sources, semiconductor nanoplatelets that exhibit extremely narrow room-temperature linewidths, and perovskite nanocrystals that are significantly brighter than conventional semiconductor quantum dots.

TuG1.2 9:00 AM–9:15 AM Optical Antenna NanoLED Based Interconnect Design
Nicolas M. Andrade, Krishna T. Settaluri, Seth Fortuna, Sean Hooten, Kevin Han, Eli Yablonovitch, Vladimir Stojanovic, and Ming C. Wu, *University of California, Berkeley, Berkeley, CA, USA*
We performed an end-to-end link analysis for a directly modulated optical antenna nanoLED. Using a technology node extrinsic unity current-gain frequency of 260 GHz, we simulated an end-to-end energy consumption of under 1 fJ/bit up to 100 Gbps.

TuG1.3 9:15 AM–9:30 AM Electrical Tuning of Exciton-Polaritons in Monolayer WS_2
Biswanath Chakraborty, Jie Gu, *City University of New York, New York, NY, USA*, Zheng Sun, *University of Pittsburgh, Pittsburgh, PA, USA*, Mandeep Khatoniar, Rezlind Bushati, Alexandra Bohemke, Rian Koots, and Vinod M. Menon, *City University of New York, New York, NY, USA*
We present an approach to dynamically control the interaction between excitons in monolayer WS_2 and microcavity photons at room temperature. This is achieved by tuning the oscillator strength of the WS_2 excitons in the presence of charged carriers induced by electrostatic gating.

Lake Thoreau

8:30 AM–10:00 AM
Session TuH1: Solid-State & Fiber Lasers
Session Chair: Eric O. Potma, *University of California, Irvine, Irvine, CA, USA*

TuH1.1 8:30 AM–9:00 AM (Invited) Time and Frequency Measurement
Thomas Sudmeyer, *University of Nauchatel, Nauchatel, Switzerland*

TuH1.2 9:00 AM–9:15 AM Zirconium Boride as a High Fluence Saturable Absorber for Q-Switched Fiber Lasers
Haroldo T. Hattori, Ahasanul Haque, *University of New South Wales Canberra, Canberra, Australia*, Ziyuan Li, *Australian National University, Canberra, Australia*, and Benjamin Olbricht, *Coupled Optics LCC, Newark, DE, USA*
Zirconium boride (ZrB_{12}) is an ultra-high temperature material with measured laser damage threshold of 132 mJ/cm^2, higher than in many materials commonly used as saturable absorbers, making it suitable for work in high power laser systems.

TuH1.3 9:15 AM–9:30 AM Continuous Wave Operation of a Yb^{3+}-Ho^{3+} Co-Doped $LuVO_4$ Laser at 2076 nm
Xining Yang, Linjun Li, *Harbin University of Science and Technology, Harbin, China and Heilongjiang Institute of Technology, Harbin, China*, Yingjie Shen, *Yantai University, Yantai, China*, Long Zhou, Yuqiang Yang, Wei Wang, *Harbin University of Science and Technology, Harbin, China*, Yunfeng Bai, Wenqiang Xie, Guangchao Ye, *Heilongjiang Institute of Technology, Harbin, China*, and Xiaoyang Yu, *Harbin University of Science and Technology, Harbin, China*
We report a continuous wave Yb^{3+}-Ho^{3+} co-doped $LuVO_4$ laser dual-end-pumped by laser diodes. A c-cut Yb,Ho:$LuVO_4$ crystal is cooled at 77 K, and a 303-mW output power of the Yb,Ho:$LuVO_4$ laser is acquired at 2076 nm with a pump wavelength of 980.88 nm.

Grand Ballroom A	Grand Ballroom B	Grand Ballroom C	Regency Ballroom A	Regency Ballroom B
TuA1.4 9:30 AM–10:00 AM (Invited) **Flexible Transponder Based on Probabilistic Shaped QAM** Qian Hu, Fred Buchali, and Henning Buelow, *Nokia Bell Labs, Stuttgart, Germany* We study the flexibility of transponders supported by the combined adaptation of the symbol rate and the spectral efficiency. We review the recent progress on probabilistic shaping which allows a gridless adaptation to the transmission distance with flexible spectral efficiency.			**TuD1.4 9:30 AM–9:45 AM** **A Continuously Tunable SOI Microring Filter with Temperature Tracking** Yang Ren, David Perron, Fnu Aurangozeb, *University of Alberta, Edmonton, Alberta, Canada*, Zhiping Jiang, *Huawei Canada Research Centre, Ontario, Canada*, Masum Hossain, and Vien Van, *University of Alberta Edmonton, Alberta, Canada* We report a 2nd-order silicon microring filter that is continuously tunable over the full 7.8 nm free spectral range using the thermo-optic effect, achieving a tuning wavelength accuracy of ±27 pm. On-chip thermistors also allow for accurate tracking of the microring temperatures and thermal crosstalks.	**TuE1.4 9:30 AM–10:00 AM (Invited)** **Label-Free Photothermal Imaging for Tissue Studies** Michelle Y. Sander, *Boston University, Boston, MA, USA* Photothermal spectroscopy in the mid-infrared offers a label-free, non-destructive method for biochemical sample analysis based on inherent bond-specific vibrational fingerprints. The potential of mid-infrared photothermal imaging for label-free characterization of frozen tissue samples based on protein signatures will be discussed.

10:00 AM–10:30 AM – EXHIBITS / COFFEE BREAK – GRAND BALLROOM FOYER

Lake Anne A/B	Lake Audubon	Lake Thoreau
TuF1.4 9:45 AM–10:00 AM **Metal Organic Framework-Coated Optical VOC Gas Sensor** Yangyang Zhao, Mona Zaghloul, Yigal Lilach, *George Washington University, Washington, DC, USA*, Kurt Benkstein, and Steve Semancik, *National Institute of Standards and Technology, Gaithersburg, MD, USA* We report a metal organic framework (MOF)-coated nanohole array based plasmonic gas sensor. Arrays of 200 nm circular holes are fabricated with a period of 400 nm. MOF is coated on the sensor platform to provide high sensitivity and near real-time response to gases.	**TuG1.4 9:30 AM–9:45 AM** **AlGaN Nanowire Photonic Crystals: Design, Epitaxy, and High Efficiency Deep UV LEDs** Xianhe Liu, *University of Michigan, Ann Arbor, MI, USA and McGill University, Montreal, Quebec, Canada*, Binh H. Le, *McGill University, Montreal, Quebec, Canada*, Kishwar Mashooq, and Zetian Mi, *University of Michigan, Ann Arbor, MI, USA* We report on the design and epitaxy of AlGaN nanowire photonic crystal LEDs. The light extraction efficiency can, in principle, reach >90% for TM polarized emission. We have demonstrated AlGaN nanowire photonic crystal LEDs at 280 nm with output power ~0.9 W/cm^2 at 250 A/cm^2.	**TuH1.4 9:30 AM–9:45 AM** **Collisions of Moving Gap Solitons in Coupled Bragg Gratings with Cubic-Quintic Nonlinearity** Md. Jahedul Islam, *Khulna University of Engineering & Technology, Khulna, Bangladesh*, and Javid Atai, *University of Sydney, Sydney, Australia* The collision dynamics of moving gap solitons in coupled Bragg gratings with cubic-quintic nonlinearity are investigated. The effects and interplay of various parameters such as quintic nonlinearity, coupling coefficient, and velocity of solitons on the collision outcomes are discussed. “
	TuG1.5 9:45 AM–10:00 AM **Ultraviolet-A LED Based on Quantum-Disks-In-AlGaN-Nanowires—Optimization and Device Reliability** Bilal Janjua, Davide Priante, Aditya Prabaswara, *King Abdullah University of Science and Technology, Thuwal, Saudi Arabia*, Lafi Alanazi, *King Abdulaziz City for Science and Technology, Riyadh, Saudi Arabia*, Chao Zhao, *King Abdullah University of Science and Technology, Thuwal, Saudi Arabia*, Abdullah A. Alhamoud, *King Abdullah University of Science and Technology, Thuwal, Saudi Arabia and King Abdulaziz City for Science and Technology, Riyadh, Saudi Arabia*, Mohd Sharizal Alias, *King Abdullah University of Science and Technology, Thuwal, Saudi Arabia*, Abdulrahman M. Albadri, Ahmed Y. Alyamani, *King Abdulaziz City for Science and Technology, Riyadh, Saudi Arabia*, Tien Khee Ng, and Boon S. Ooi, *King Abdullah University of Science and Technology, Thuwal, Saudi Arabia* We investigated the structural optimization, simulation, and reliability of ultraviolet AlGaN/GaN nanowire-LEDs on low cost and scalable silicon substrate. We obtained 100× improvement in the direct recombination rate and 10× higher optical power for the sample with thicker active region and thinner top p-contact layer.	**TuH1.5 9:45 AM–10:00 AM** **Dynamics of Colliding Solitons in a Coupler with Separated Nonuniform Bragg Grating and Nonlinearity** Tanvir Ahmed, *Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh*, and Javid Atai, *University of Sydney, Sydney, Australia* The collision dynamics of moving gap solitons in coupled Bragg gratings with cubic-quintic nonlinearity are investigated. The effects and interplay of various parameters such as quintic nonlinearity, coupling coefficient, and velocity of solitons on the collision outcomes are discussed.

10:00 AM–10:30 AM – EXHIBITS / COFFEE BREAK – GRAND BALLROOM FOYER

Grand Ballroom A

10:30 AM–12:00 PM
Session TuA2: Modulation and Detection
Session Chair: Qian Hu, *Nokia Bell Labs, Stuttgart, Germany*

TuA2.1 10:30 AM–11:00 AM (Invited)
Stokes-Vector Receivers and Their Performance Analysis
Kazuro Kikuchi, *National Institution for Academic Degrees and Quality Enhancement of Higher Education, Tokyo, Japan*
Direct-detection-based Stokes-vector receivers can track polarization fluctuations using low-complexity digital-signal-processing circuits; then, spectrally efficient multilevel polarization-modulation formats can be introduced into the optical communication system with such receivers. This paper aims at analyzing their characteristics on the bit-error rate and spectral efficiency. “

TuA2.2 11:00 AM–11:15 AM
Frequency Comb Based Kramers-Kronig Detection
Qiulin Zhang and Chester Shu, *Chinese University of Hong Kong, Hong Kong*
Stimulated Brillouin scattering has been adopted to regenerate an optical carrier from a single sideband signal. The carrier is applied for locking two frequency combs at the transmitter and receiver in a multi-wavelength communication system. Kramers-Kronig detection of 5 × 10 Gbaud QPSK/16-QAM channels is successfully demonstrated.

TuA2.3 11:15 AM–11:30 AM
Bidirectional 4-PAM to Double Per-Fiber Capacity in 2-km Intra-Datacenter Links
Dario Pilori, Luca Bertignono, *Politecnico di Torino, Torino, Italy*, Antonino Nespola, *Istituto Superiore Mario Boella, Torino, Italy*, Fabrizio Forghieri, Marco Mazzini, *Cisco Photonics Italy S.r.l., Vimercate, Italy*, and Roberto Gaudino, *Politecnico di Torino, Torino, Italy*
We present a novel architecture for intra-datacenters (<2 km) PAM links which uses each fiber and each laser for simultaneous transmission in both directions, doubling per-fiber capacity. We show that the impact of back-reflections can be reduced with a small laser frequency detuning. “

Grand Ballroom B

10:30 AM–12:00 PM
Session TuB2: Imaging Sensors
Session Chair: Tobias Tiecke, Facebook

TuB2.1 10:30 AM–11:00 AM (Invited)
Computational-Pixel Image Sensors
Michael W. Kelly, Justin Baker, Curtis Colonero, and Christopher David, *Copious Imaging LLC, Lexington, MA, USA*
Copious Imaging is a small business that has spun off from the Massachusetts Institute of Technology Lincoln Laboratory to commercialize Computational Pixel Imager (CPI) technology. CPI sensors perform digitization and compute at the pixel-level to provide new sensing modalities and enable powerful system capability.

TuB2.2 11:00 AM–11:15 AM
Multiple Sampling Photodiode Readout that Overcomes ADC Resolution Limit
Lucas J. Koerner, Savannah M. Johnson, and Lucas S. Manke, *University of St. Thomas, St. Paul, MN, USA*
We present a light detection system (for point-of-care diagnostics) consisting of a multiple-sampling readout that forgoes the resolution limit set by a low-cost microcontroller ADC. Experimental measurements demonstrate a >5 ⋆ 10^6 input range and a noise floor of <210 fA.

TuB2.3 11:15 AM–11:30 AM
LED-Based Photometric Stereo-Imaging Employing Frequency-Division Multiple Access
Johannes Herrnsdorf, Jonathan McKendry, Mark Stonehouse, *University of Strathclyde, Glasgow, UK*, Laurence Broadbent, Glynn C. Wright, *Aralia Systems, Bristol, UK*, Martin D. Dawson, and Michael J. Strain, *University of Strathclyde, Glasgow, UK*
We present a photometric stereo-imaging approach based on illumination with light-emitting diodes (LEDs) from different angles where the LEDs are sinusoidally modulated and do not require synchronization with each other or with the camera.
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Grand Ballroom C

10:30 AM–12:00 PM
Session TuC2: Ultrafast Lasers
Session Chair: TBD

TuC2.1 10:30 AM–11:00 AM (Invited)
Utilizing the Complex Dynamics of InAs/GaAs Quantum Dot Lasers for Ultrafast Devices
F. Grillot, *Université Paris-Saclay, Paris, France and University of New Mexico, Albuquerque, NM, USA*, H. Huang, *Université Paris-Saclay, Paris, France*, L.-C. Lin, F.-Y. Lin, *National Tsing Hua University, Hsinchu, Taiwan*, D. Arsenijević, *TU Berlin, Germany*, and D. Bimberg, *TU Berlin, Germany and CIOMP, Changchun, China*
The nonlinear dynamics of InAs/GaAs quantum dot lasers emitting exclusively on single lasing states is investigated. While the ground state laser is of importance for the development of isolator-free transmitters, the excited state laser is essential for chaos-based applications, microwave photonics , and self-pulsating devices.

TuC2.2 11:00 AM–11:15 AM
Modulation Bandwidth Enhancement in Distributed Reflector Laser Based on Identical Active Layer Approach
Yuanfeng Mao, Zhengliang Ren, Lu Guo, Hao Wang, Ruikang Zhang, Yongguang Huang, Dan Lu, Qiang Kan, Chen Ji, and Wei Wang, *ISCAS, Beijing, China*
We demonstrate a distributed reflector laser with the distributed feedback section and the distributed Bragg reflector section sharing the same multiple-quantum-well structure. A direct modulation bandwidth of 27 GHz is obtained through the detuned-loading effect and photon-photon resonance effect.

TuC2.3 11:15 AM–11:45 AM (Invited)
Ultrafast Semiconductor Lasers: Pulse Generation and Stabilization
Paolo Bardella, Lorenzo L. Columbo, Mariangela Gioannini, *Politecnico di Torino, Torino, Italy*, Oleg Nikiforov, Thomas Walther, *Technische Universität Darmstadt, Darmstadt, Germany*, Andreas Klehr, Andrea Knigge, *Ferdinand-Braun-Institut, Berlin, Germany*, Stefan Meinecke, Lina Jaurigue, Kathy Lüdge, *Technische Universität Darmstadt, Darmstadt, Germany*, Julien Javaloyes, *Universitat de les Illes Balears, Palma de Mallorca, Spain*, Luke F. Lester, *Virginia Polytechnic Institute and State University, Blacksburg, VA, USA*, Christoph Weber, Dominik Auth, Sebastian Stutz, Martin Birkholz, Lukas Drzewietzki, and Stefan Breuer, *Technische Universität Darmstadt, Darmstadt, Germany*
Progress in the generation and stabilization of op-tical pulse trains of edge-emitting passively mode-locked (PML) quantum dot (QD) and quantum well (QW) lasers and self-mode locked (SML) QD lasers is addressed. The mechanism responsible for the timing phase noise (TPN) reduction and repetition rate (RR)...

Regency Ballroom A

10:30 AM–11:45 AM
Session TuD2: Optical Modulators
Session Chair: Jens Schmid, *National Research Council Canada, Canada*

TuD2.1 10:30 AM–10:45 AM
Monolithic Integration of Si/$BaTiO_3$ Electro-Optic Modulators on a Silicon Photonics Platform
Felix Eltes, Daniele Caimi, *IBM Reseach – Zurich, Rüschlikon, Switzerland*, Christian Mai, Georg Winzer, Despoina Petousi, Stefan Lischke, *IHP, Frankfurt (Oder), Germany*, Lukas Czornomaz, *IBM Reseach – Zurich, Rüschlikon, Switzerland*, Lars Zimmermann, *IHP, Frankfurt (Oder), Germany*, Jean Fompeyrine, and Stefan Abel, *IBM Reseach – Zurich, Rüschlikon, Switzerland*
We demonstrate an electro-optic modulator exploiting the Pockels effect, which we monolithically integrated on an advanced silicon photonics platform. We show integration through wafer bonding and discuss further integration paths. The devices, based on $BaTiO_3$ films, show excellent $V_\pi L$ (0.3 Vcm) and $V_\pi L\alpha$ (1.7 VdB).

TuD2.2 10:45 AM–11:00 AM
Impedance Matching for High-Speed InP Integrated Electro-Absorption Modulators
M. Trajkovic, *Eindhoven University of Technology, Eindhoven, The Netherlands*, F. Blache, K. Mekhazni, H. Debregeas, *III-V Lab, Palaiseau, France*, E. den Haan, L. M. Augustin, *SMART Photonics B.V., Eindhoven, The Netherlands*, K. A. Williams, and X. J. M. Leijtens, *Eindhoven University of Technology, Eindhoven, The Netherlands*
We study the influence of electrical connection methods on the high speed performance of electro-absorption modulators (EAMs). We report the reflection parameter S_{11} below –10 dB up to 22 GHz and 32 GHz bandwidth for a mounted EAM chip-on-carrier, with input alumina transmission line and output termination load.

TuD2.3 11:00 AM–11:15 AM
NASA Integrated Photonics
Michael Krainak, Mark Stephen, Jonathan Klamkin, *NASA Goddard Space Flight Center, Greenbelt, MD, USA*, Keren Bergman, Michal Lipson, *Columbia University, New York, NY, USA*, Shayan Mookherjea, *University of California, San Diego, San Diego, CA, USA*, Paul Leisher, *Lawrence Livermore National Laboratory, Livermore, CA, USA*, Seng-Tiong Ho, *Northwestern University, Evanston, IL, USA*, Behzad Moleshi, *IFOS Inc., Santa Clara, CA, USA*, James Harris, *Stanford University, Stanford, CA, USA*, Andrey Matsko, *Anatoly Savchenkov, OEwaves Inc., Pasadena, CA, USA*, S. J. B. Yoo, *University of California Davis, Davis, CA, USA*, Mark Lucente, *Nanohmics Inc., Austin, TX, USA*, George Nehmetallah, *Catholic University, Washington, DC, USA*, and Leif Johansson, *Freedom Photonics Inc., Santa Barbara, CA, USA*
Photonic integrated circuits permit size, weight, power and cost reductions. This is particularly critical for spacecraft platforms. We review recent progress on integrated photonic circuits NASA, industry and academia are developing for: (1) Sensors (2) Analog RF applications (3) Computing and free space communications.

Regency Ballroom B

10:30 AM–12:00 PM
Session TuE2: Imaging Through Scattering and Aberrating Tissues
Session Chair: Peter R. T. Munro, *University College London, England, UK*

TuE2.1 10:30 AM—11:15 AM (Tutorial)
Optical Imaging in Complex Biological Media: A Tutorial
Sylvain Gigan, *Laboratoire Kastler Brossel, France*
Biological tissues are heterogeneous at the wavelength scale and scatter light strongly. While conventional microscopy techniques are limited to the first few hundred microns, a new arsenal of techniques have been derived, allowing to control multiply-scattered light, and opening the possibility to achieve deeper imaging.

TuE2.2 11:15 AM–11:30 AM
Adaptive Optics for Brillouin Micro-Spectroscopy
Eitan Edrei and Giuliano Scarcelli, *University of Maryland, College Park, MD, USA*
Brillouin spectroscopy is a powerful optical technique for non-contact viscoelastic characterizations enabling three-dimensional mapping of biological samples. Here we present an adaptive-optics configuration for Brillouin spectroscopy providing 2.5-fold enhancement in Brillouin signal strength and 1.4-fold improvement in axial resolution by correcting for sample induced aberrations,

TuE2.3 11:30 AM–11:45 AM
4π Microscopy Immune to Sample-Induced Dephasing
Alejandro Diaz Tormo, Dmitry Khalenkow, Andre G. Skirtach, and Nicolas Le Thomas, *Ghent University, Ghent, Belgium*
In 4π microscopy it is commonly assumed that the point spread function is unaffected by the sample, a big assumption considering that cell studies have reported sample-induced phase changes of more than a wavelength. Here we describe a method that does away with that assumption.

Lake Anne A/B

10:30 AM—12:00 PM
Session TuF2: Modelling of Microresonator Structures
Session Chair: Misha Sumetsky, *Aston University, Birmingham, UK*

TuF2.1 10:30 AM–10:45 AM
Energy Transport in Lossy Resonators by Optical Admittance Methods
Pyry Kivisaari, Mikko Partanen, and Jani Oksanen, *Aalto University School of Science, Aalto, Finland*
We implement the quantized fluctuational electrodynamics in photonic resonators using optical admittance functions. The resulting wave-optical treatment of emission enhancement and photon recycling is coupled with drift-diffusion simulations to perform self-consistent modeling of optical and electrical energy transport in thin-film heterostructure devices.

TuF2.2 10:45 AM–11:00 AM
Digital Photonic Even Parity Bit Generator
F. K. Law, M. Rakib Uddin, Nur Musyiirah Masir, *University Teknologi Brunei (UTB), Gadong, Brunei Darussalam,* and Yong Hyub Won, *KAIST, Daejeon, South Korea*
This paper presents the novel design of a digital photonic even parity bit generator based on a single micro-ring resonator device. Time varying simulation at the data rate of 10 Gbps have been tested, resulting in clear output timing diagram of the parity bit.

TuF2.3 11:00 AM–11:15 AM
Broader Analysis of Scattering from a Subwavelength Dielectric Sphere
S. Jamilan and E. Semouchkina, *Michigan Technological University, Houghton, MI, USA*
Forward and backward scattering from subwavelength dielectric spheres is analyzed in a broad frequency range with the focus on the impact of phase changes of resonance oscillations at magnetic and electric Mie resonances. The effects of sphere permittivity on the specifics of scattering are discussed.

Lake Audubon

10:30 AM–12:00 PM
Session TuG2: Plasmonics
Session Chair: Thomas P. Purdy, *National Institute of Standards and Technology, Gaithersburg, MD, USA*

TuG2.1 10:30 AM–11:00 AM (Invited)
Plasmonic Parametric Resonance
Alessandro Salandrino, *University of Kansas, Lawrence, KS, USA*
Here we review the concept of Plasmonic Parametric Resonance (PPR): a novel way to amplify high-order plasmonic modes with a uniform optical pump. PPR originates from a temporal permittivity modulation. The threshold conditions for PPR and schemes of experimental realization and detection are also discussed.

TuG2.2 11:00 AM–11:15 AM
Plasmonic Nanoarcs — Tunable Plasmonic Elements for Non-Linear Optical Metamaterials
Kunyi Zhang and Oded Rabin, *University of Maryland, College Park, MD, USA*
Metallic nanoarcs (bent nanorods) fill the transition space between straight nanorod antenna and split-ring resonators. Their localized surface plasmon resonances were systematically investigated. The coupling between plasmon modes in nanoarcs was strategically used to enhance optical non-linearity and chiroptical effects.

TuG2.3 11:15 AM–11:30 AM
Surface Plasmon Polariton Modes on Coupled Square-Cylinder Silver Nanowires on Silica Substrate
Hsin-Mao Hsu and Hung-Chun Chang, *National Taiwan University, Taipei, Taiwan*
Waveguide modes on single and coupled square-cylinder silver nanowires placed on silica substrate are solved, including possible leaky modes, using an in-house developed imaginary-distance beam propagation method. The relation between the modes on the coupled structure and the two corresponding single nanowires is studied.

Lake Thoreau

10:30 AM–12:00 PM
Session TuH2: Combs & Nanophotonics
Session Chair: Thomas Sudmeyer, *University of Neuchâtel, Neuchâtel, Switzerland*

TuH2.1 10:30 AM–11:00 AM (Invited)
Chip-Based Frequency Combs
Alexander Gaeta, *Columbia University, New York, NY, USA*

TuH2.2 11:00 AM–11:15 AM
Ultra-Dense, CEO-Stabilized Optical Frequency Comb with Programmable FSR Using Spectral Self-Imaging
Mohamed Seghilani, Xiao-Zhou Li, Reza Maram, Luis Romero Cortés, and José Azaña, *INRS-EMT, University of Quebec, Montreal, Quebec, Canada*
We demonstrate a CEO-stabilized optical frequency comb with a programmable sub-MHz FSR through suitable temporal phase modulation of a 250-MHz OFC. The method preserves the energy and the bandwidth of the input OFC.

TuH2.3 11:15 AM–11:45 AM (Invited)
Vector-Field Nonlinear Microscopy of Nano-Objects
Martti Kauranen, Léo Turquet, and Godofredo Bautista, *Tampere University of Technology, Tampere, Finland*
We review our recent results on the use of cylindrical vector beams in nonlinear microscopy. Second-harmonic generation by focused radially and azimuthally-polarized beams is shown to have superior sensitivity to the morphology of nanoparticles and can enhance the coupling of light to complex nano-objects.

Grand Ballroom A	Grand Ballroom B	Grand Ballroom C	Regency Ballroom A	Regency Ballroom B
TuA2.4 11:30 AM–12:00 PM (Invited) 400 Gb/s Data Center Interconnects: Coherent Detection vs. Direct Detection David Plant, *McGill University / Ciena, Montreal, Quebec, Canada*	**TuB2.4 11:30 AM–12:00 PM (Invited) Photon-Counting CMOS Image Sensor** Eric R. Fossum, *Darmouth University, Hanover, NH, USA* Single-photoelectron detection at room temperature without the use of avalanche multiplication has been recently demonstrated by a 1M pixel Quanta Image Sensor operating at up to 1000 fps. The technology will be described and experimental results presented	**TuC2.4 11:45 AM–12:00 PM Low Linewidth Enhancement Factor and High Optical Feedback Resistance of p-Doped Silicon Based Quantum Dot Lasers** J. Duan, H. Huang, *Université Paris-Saclay, Paris, France*, D. Jung, J. Norman, J. E. Bowers, *University of California Santa Barbara, Santa Barbara, CA, USA*, and F. Grillot, *Université Paris-Saclay, Paris, France and University of New Mexico, Albuquerque, NM, USA* This work shows that p-doped quantum dot lasers grown on silicon exhibit a low linewidth enhancement factor and hence a high resistance against optical feedback which are promising for isolator-free transmissions in photonic integrated circuits.	**TuD2.4 11:15 AM–11:45 AM (Invited) 3D System-in-Package Technologies** Tekin Tolga, *Fraunhofer IZM Institute, Berlin, Germany*	**TuE2.4 11:45 AM–12:00 PM Reciprocity in Measuring Multimode Fiber Transmission** Szu-Yu Lee, Brett E. Bouma, *Harvard Medical School and Massachusetts General Hospital, Boston, MA, USA and Massachusetts Institute of Technology, Cambridge, MA, USA*, and Martin Villiger, *Harvard Medical School and Massachusetts General Hospital, Boston, MA, USA* Characterizing the transmission matrix through multimode fibers without access to their distal end would facilitate their use as miniature endoscopes. Here, we experimentally demonstrate that reciprocity causes the double-pass transmission matrix to be transpose symmetric and complicates the retrieval of the single-pass transmission.

12:00 PM–1:30 PM – LUNCH (ON OWN)

LAB AUTOMATION HACKATHON **REGISATION REQUIRED GRAND BALLROOM F/G**
Organizers: Nick Fontaine & Roland Ryf, *Nokia Bell Labs, USA*

Lake Anne A/B

TuF2.4 11:15 AM–11:30 AM
Dynamical FDTD Method for Coupled Integrated Resonators
Anil Aslan and Serdar Kocaman, *Middle East Technical University, Ankara, Turkey*
Finite Difference Time Domain Method (FDTD) has been extended to include the dynamical tuning of refractive index changes in order to demonstrate pulse trapping behavior with double micro-ring resonators. With this extension, various resonator structures can be numerically compared for performance characteristics.

Lake Audubon

TuG2.4 11:30 AM–11:45 AM
Titanium Nitride Surface Plasmon Coupling for Enhanced IQE in GaN:Eu Red Light Emitters
Ioannis E. Fragkos and Nelson Tansu, *Lehigh University, Bethlehem, PA, USA*
TiN is investigated as plasmonic material to enhance the IQE of a GaN:Eu red light-emitter. Our findings indicate that trough the tuning of the TiN layer thickness and its distance from the GaN:Eu active-region, strong coupling to the surface-plasmons with high Purcell factors is possible.

TuG2.5 11:45 AM–12:00 PM
Efficient Optical Trapping of Nanoparticle via Plasmonic Bowtie Notch
Yi-Chang Lin and Po-Tsung Lee, *National Chiao Tung University, Hsinchu, Taiwan*
We propose a metallic nanotweezer named plasmonic bowtie notch, which can provide much stronger trapping force on a nanoparticle than that of a bowtie aperture. The mechanism for boosting trapping force is thoroughly investigated and its capabilities for trapped target selecting and sensing are explored.

Lake Thoreau

TuH2.4 11:45 AM–12:00 PM
Tunable Quasi-Phase-Matching in Ion Implanted Silicon Waveguides
N. S. Balakleyskiy, *National Research University of Electronic Technology, Moscow, Russia,* and I. V. Mel'nikov, *Moscow Institute of Physics and Technology (State University), Dolgoprudnyi, Russia*
We suggest CMOS compatible integrated nonlinear device for widely tunable infrared generation as well as for effective phase modulation. Device exploits electric-field-induced quasi-phase-matching of ion implanted silicon waveguide in sum inducing up to 150 pm/V nonlinearity and phase modulation efficiency VnL of ~3 Vcm.

12:00 PM–1:30 PM – LUNCH (ON OWN)

LAB AUTOMATION HACKATHON **REGISATION REQUIRED GRAND BALLROOM F/G**
Organizers: Nick Fontaine & Roland Ryf, *Nokia Bell Labs, USA*

Grand Ballroom A

1:30 PM–3:00 PM
Session TuA3: Award Winning Photonics Science and Technology II
Session Chair: C. Menoni, *Colorado State University, CO, USA*

TuA3.1 1:30 PM–2:00 PM (Invited)
***Engineering Achievement Award* – Advances in Radio over Fiber Technologies**
Dalma Novak, *Pharad, USA*
It has been more than three decades since the first publications proposing the use of optical fiber feeder links to extend wireless coverage in radio systems. This talk describes some of the subsequent developments in radio-over-fiber technologies and their application in next generation wireless systems, such as 5G.

TuA3.2 2:00 PM–2:30 PM (Invited)
***Aron Kressel Award* – Interband Cascade Lasers: An Ongoing Journey**
Rui Q. Yang, *University of Oklahoma, USA*
Interband cascade (IC) lasers (ICLs) take advantage of the broken-gap band alignment in type-II InAs/Ga(In)Sb quantum wells to reuse injected electrons in cascade stages for photon generation with high quantum efficiency based on interband transitions. In the years since they were proposed in 1994, IC lasers have been developed into the most efficient semiconductor mid-infrared laser sources in terms of low power consumption and have been operated successfully in the Curiosity Rover for detection of CH4 on Mars. They are now commercially available for many applications such as chemical sensing and environmental monitoring. Yet, there are still many aspects that need to be explored and further developed. In this talk, I will review the basic features and current status of IC lasers, and discuss their future prospects with recent experimental results.

Grand Ballroom B

1:30 PM–3:00 PM
Session TuB3: Colloidal Detectors and Sensors
Session Chair: Ganesh Balakrishnan, *University of New Mexico, Albuquerque, NM, USA*

TuB3.1 1:30 PM–2:00 PM (Invited)
Colloidal Quantum Dots for Infrared Detection and Emission
Philippe Guyot-Sionnest, *University of Chicago, Chicago, IL, USA*
Colloidal quantum dots (CQDs) are cheaply synthesized as inks. Deposited as thin films, they are an alternative to single crystals for solar cells, photodetectors and transistors. Hg(Te,Se,S) CQDs allow thermal imaging in the mid-infrared with detectivity approaching single crystal InSb at the same operation temperature.

TuB3.2 2:00 PM–2:15 PM
Polarization Sensitive Plasmonic Photodetector Based on HgTe Quantum Dots
Bingqing Zhu, Mengyu Chen, *Chinese University of Hong Kong, Hong Kong, China*, Stephen V. Kershaw, Andrey L. Rogach, *City University of Hong Kong, Hong Kong, China*, Ni Zhao, and Hon Ki Tsang, *Chinese University of Hong Kong, Hong Kong, China*
A near-infrared plasmonic photodetector based on colloidal HgTe quantum dots is demonstrated. A metal nano-antenna is used to couple the off-chip light into plasmonic waveguide. The photoresponse is polarization dependent because surface plasmon polaritons are excited only by transverse electric light.

Grand Ballroom C

1:30 PM–3:15 PM
Session TuC3: Novel Lasers
Session Chair: Stefan Breuer, *Technische Universitat Darmstadt, Berlin, Germany*

TuC3.1 1:30 PM–2:00 PM (Invited)
Low Threshold Current and High-Speed Operation of Membrane Lasers
Shigehisa Arai, Nobuhiko Nishiyama, and Tomohiro Amemiya, *Tokyo Institute of Technology, Tokyo, Japan*
Membrane distributed reflector (DR) laser exhibited a low threshold current (0.21 mA) and high modulation current efficiency factor of 12 GHz/mA$^{1/2}$. A 20 Gbit/s direct modulation was obtained with the bias current of 1 mA, which corresponded to the energy cost of 93 fJ/bit.

TuC3.2 2:00 PM–2:15 PM
Selective Area Growth in Generic Integration for Extended Range Tunable Laser Source
F. Lemaître, Eindhoven, *The Netherlands & Palaiseau, France,* S. Latkowsky, *Eindhoven University of Technology, Eindhoven, The Netherlands,* C. Fortin, N. Lagay, *III-V Lab, Palaiseau, France,* R. Pajković, E. Smalbrugge, *Eindhoven University of Technology, Eindhoven, The Netherlands,* J. Decobert, *III-V Lab, Palaiseau, France,* H. Ambrosius, and K. Williams, *Eindhoven University of Technology, Eindhoven, The Netherlands*
Selective area growth is used for the first time in the TU/e generic integration platform to modify independently the bandgap of active sections. A chip combining 4 tunable lasers with shifted wavelength ranges has been fabricated. A 96\,nm wide tuning range is demonstrated.

Regency Ballroom A

1:30 PM–3:00 PM
Session TuD3: Chalcogenide and Microstructured Fibers
Session Chair: Wladek Forysiak

TuD3.1 1:30 PM–2:00 PM (Invited)
Tailoring the Nonlinear Gain of Chalcogenide Glass for Mid-infrared Applications
Martin Rochette, *McGill University, Montreal, Quebec, Canada*

TuD3.2 2:00 PM–2:15 PM
All-Chalcogenide Single-Mode Couplers
Mohsen Rezaei and Martin Rochette, *McGill University, Montreal, Quebec, Canada*
We demonstrate the fabrication of all-chalcogenide single-mode fiber couplers with a coupling extinction ratio of up to 35 dB. Couplers are made in two formats: wavelength-dependent and polarization beam-splitters with separation of the orthogonally polarized components up to 18 dB.

Regency Ballroom B

1:30 PM–3:00 PM
Session TuE3: Radio-over-Fiber for 5G and Novel Devices
Session Chair: Maurizio Burla, *ETH*

TuE3.1 1:30 PM–2:00 PM (Invited)
Low Latency PON and RoF for 5G Wireless Systems
Hwan Seok Chung, *Electronics and Telecommunications Research Institute (ETRI), Daejon, South Korea*
We review optical access technology candidates for 5G wireless systems requiring low latency as well as high transmission bandwidth. Recent feasibility studies with next generation PON prototype and analog transmission are discussed.

TuE3.2 2:00 PM–2:15 PM
Integrated Balanced Microwave Photonic Canceller
Eric C. Blow, Prannay Kaul, and Paul R. Prucnal, *Princeton University, Princeton, NJ, USA*
We demonstrate an integrated photonic circuit capable of simultaneous wideband self-interference cancellation and RIN suppression. This is the first integrated photonic canceller to use external modulation or balanced detection. Preliminary experimental results demonstrate 25 dB of cancellation over 20 MHz at various LTE frequencies.

Lake Anne A/B

1:30 PM–3:00 PM
Session TuF3: Nitride Materials and Devices
Session Chair: Zetian Mi

TuF3.1 1:30 PM–2:00 PM (Invited)
Nitride Single Photon Sources
T. Zhu, J. C. Jarmann, Christopher X. Ren, Fengzai Tang, *University of Cambridge, Cambridge, UK*, C. C. Kocher, T. J. Puchtler, Benjamin P. L. Reid, T. Wang, *University of Oxford, Oxford, UK*, Saroj K. Patra, Stefan Schulz, *University College Cork, Cork, Ireland*, Robert A. Taylor, *University of Oxford, Oxford, UK*, and R. A. Oliver, *University of Cambridge, Cambridge, UK*
Nitride single photon emitters present outstanding opportunities, such as operation at accessible temperatures. However, realizing quantum devices in these under-developed and highly defective materials is challenging. We have achieved a range of single photon emitting devices in non-polar nitrides which overcome some of these challenges.

TuF3.2 2:15 PM–2:30 PM
Electrical Control of Middle-Wavelength Infrared Thermal Emission Using GaN/AlGaN Photonic Crystals
Dongyeon Daniel Kang, Takuya Inoue, Takashi Asano, and Susumu Noda, *Kyoto University, Kyoto, Japan*
We experimentally demonstrate narrowband (Q ~ 40) thermal emission in the middle-wavelength infrared region and its electrical control at a temperature of 500°C using GaN/AlGaN multiple quantum wells and photonic crystals

Lake Audubon

1:30 PM–3:00 PM
Session TuG3: Silicon Photonics
Session Chair: Robinjeet Singh, *University of Maryland and National Institute of Standards and Technology, Gaithersburg, MD, USA*

TuG3.1 1:30 PM–1:45 PM
Improvement of Sidewall Roughness of Submicron SOI Waveguides by Hydrogen Plasma and Annealing
Cyril Bellegarde, Erwine Pargon, *University Grenoble Alpes, Grenoble, France and CEA, LETI, LTM, Grenoble, France,* Corrado Sciancalepore, *University Grenoble Alpes, Grenoble, France and LETI, Grenoble, France,* Camille Petit-Etienne, *University Grenoble Alpes, Grenoble, France and CEA, LETI, LTM, Grenoble, France,* Vincent Hugues, Daniel Robin-Brosse, Jean-Michel Hartmann, and Philippe Lyan, *University Grenoble Alpes, Grenoble, France and LETI, Grenoble, France*
We report the successful fabrication of ultra-low-loss submicrometric silicon-on-insulator strip waveguides for on-chiplinks. Postetching hydrogen annealing has been used to smoothen the waveguide sidewalls. Record-low propagation losses of less than 0.5 dB/cm are measured at 1310 nm for single-mode silicon strip waveguide

TuG3.2 1:45 PM–2:00 PM
Dual-Mode Silicon Photonic Crystal Nanocavity Modulator with Indium Oxide Gate
Erwen Li, Qian Gao, Spencer Liverman, and Alan X. Wang, *Oregon State University, Corvallis, OR, USA*
We report an ultra-efficient indium-oxide gated silicon photonic crystal nanocavity modulator, which is based on a dual-mode operation of resonance tuning and electro-absorption. With only 0.35 μm long electrode, we achieved a tuning efficiency of 250 pm/V and a modulation strength of 4 dB/V with 35% from electro-absorption.

Lake Thoreau

1:30 PM–3:00 PM
Session TuH3: Imaging & Microscopy
Session Chair: Martti Kauranen, *Tampere University of Technology, Tampere, Finland*

TuH3.1 1:30 PM–2:00 PM (Invited)
Mid-Infrared Upconversion – Trends and Applications
Christian Pedersen, *Denmark Technical University, Kongens Lyngby, Denmark*

TuH3.2 2:00 PM–2:15 PM
Ultrafast, High Power, High Repetition Rate, Simultaneous Generation of 1D and 2D Airy Beams and Their Frequency Doubling Characteristics
Raghwinder S. Grewal, Anirban Ghosh, and G. K. Samanta, *Physical Research Laboratory, Ahmedabad, India*
We report on simultaneous generation of high power, 1D and 2D Airy beam using a pair of concave and convex cylindrical lenses in a novel experimental scheme and studied their frequency doubling characteristics.

Grand Ballroom D

3:30 PM–5:00 PM
Session TuI4: Plenary I
Session Chair: Amr Helmy, University of Toronto, Toronto, Canada
***** Live Streamed*****

TuI4.1 3:30 PM–4:15 PM (Plenary)
Breaking Spectral and Performance Barriers for Diode Lasers with Material Innovation
Manijeh Razeghi, *Northwestern University, Evanston, IL, USA*
From humble beginnings, diode laser technology has evolved to become an invaluable tool for many aspects of our daily lives. Diode lasers exhibit a number of favorable properties which have led to their wide adoption, including compactness, robustness, and mass producibility.

TuI4.2 4:15 PM–5:00 PM (Plenary)
Implantable, Insertable and Wearable Micro-Optical Devices for Early Detection of Cancer
Christopher H. Contag, *Michigan State University, MI, USA*
Current technologies for the detection of cancer lack the sensitivity for early detection at times when therapy would be most effective, and cannot detect minimal residual disease that persists after conventional therapies. Therefore, it will be necessary to develop image-guided approaches for multiplexed molecular characterization of cancer and methods to visualize small numbers of cancer initiating cells.

Grand Ballroom A

TuA3.3 2:30 PM–3:00 PM (Invited)
Cells, Tissues, and Biomaterials: Seeing Them All
Yu Shrike Zhang, *Bringham & Women's Medical Center, Harvard Medical School, USA*
This talk will discuss some of our efforts in the past decade regarding development and optimization of various optical imaging strategies that have allowed us to visualize the structures and functions of engineered tissues and tissue models in a non-invasive manner at high precision.

Grand Ballroom B

TuB3.3 2:15 PM–2:30 PM
Detection of Copper & Mercury Ions Using LSPR Based U-Bent Fiber Optic Sensor
Anjali Khatri and Soumyo Mukherji, *Indian Institute of Technology Bombay, Mumbai, India*
Localized surface plasmon resonance (LSPR) based fiber optic sensor probe immobilized with chitosan was fabricated to detect metal ions. The preliminary studies show the limit of detection of 100nM for both, copper and mercury ions. Excellent sensor functionality was also obtained in lake water.

TuB3.4 2:30 PM–2:45 PM
Design of Resonant Optical Cavities for Ultrasound Detection Using Rigorous Electromagnetic Modelling
Dylan M. Marques, James A. Guggenheim, Rehman Ansari, Edward Zhang, Paul C. Beard, and Peter R. T. Munro, *University College London, London, UK*
Detection of very weak ultrasound waves with a Fabry-Perot interferometer has enabled a new range of biomedical applications such as photoacoustic imaging. We propose a realistic model of the optical readout of this device valid for arbitrary focussed readout beams and optical fibre based detection.

TuB3.5 2:45 PM–3:00 PM
Simultaneous Measurement of Multiple Fiber Bragg Grating Sensors Using Microwave Photonics
Maria I. Comanici, Parisa Moslemi, Lawrence R. Chen, *McGill University, Montreal, Quebec, Canada*, and Jingjing Hu, *Dalian University of Technology, Dalian City, China*
We demonstrate simultaneous interrogation of multiple fiber Bragg grating temperature sensors based on chirped microwave pulse generation using an arrayed waveguide grating Sagnac interferometer. Results show that the system provides a resolution of 16.3 ps/°C with an error of +/- 1 °C

Grand Ballroom C

TuC3.3 2:15 PM–2:45 PM (Invited)
Recent Progress on Interband Cascade Laser Research
Jerry Meyer, *Naval Research Laboratory, Washington, DC, USA*

TuC3.4 2:45 PM–3:00 PM
Design of Chirped Gratings Using Interferometric Lithography
Steve Benoit, *Colorado State University, Fort Collins, CO, USA,* and S. R. J. Brueck, *University of New Mexico, Albuquerque, NM, USA*
Interferometric lithography with curved wavefronts can produce grating with longitudinal or transverse chirp. The chirp is investigated for a range of interferometric configurations and experimental techniques for producing chirped gratings are presented. Applications discussed include design of widely tunable semiconductor lasers.

TuC3.5 3:00 PM–3:15 PM
Direct Measurement of Directional Emission from Monolayer WS_2 Laser with Heterostructure Photonic Crystal Cavities
Xiaochen Ge, *University of Texas at Arlington, Arlington, TX, USA,* Momchil Minkov, Shanhui Fan, *Stanford University, Stanford, CA, USA*, Xiuling Li, *University of Illinois Urbana-Champaign, Urbana, IL, USA*, and Weidong Zhou, *University of Texas at Arlington, Arlington, TX, USA*
Monolayer WS_2 shows highly directional emission when transferred onto heterostructure photonic crystal cavities based on the band edge mode above the light cone.

Regency Ballroom A

TuD3.3 2:15 PM–2:30 PM
Chalcogenide Fabry-Perot Fiber Tunable Filter
Kaixuan Zhang, *McGill University, Montreal, Quebec, Canada and Polytechnique Montréal, Montreal, Quebec, Canada*, Yves-Alain Peter, *Polytechnique Montréal, Montreal, Quebec, Canada*, and Martin Rochette, *McGill University, Montreal, Quebec, Canada*
We present an all-fiber Fabry-Perot filter that consists of chalcogenide fibers terminated with high reflectivity coatings. The tunable filter has large free spectrum range over 300 nm and a finesse of 15.

TuD3.4 2:30 PM–3:00 PM (Invited)
From Third Harmonic to Triplet Generation in Microstructured Fibers
N. Y. Joly, *University of Erlangen-Nuremberg, Erlangen, Germany and Max-Planck Institute for the Science of Light, Erlangen, Germany*, J. Hammer, *Max-Planck Institute for the Science of Light, Erlangen, Germany and University of Erlangen-Nuremberg, Erlangen, Germany*, *R. Pennetta, A. Cavanna, X. Jiang, M. H. Frosz*, *Max-Planck Institute for the Science of Light, Erlangen, Germany*, and M. V. Chekhova, *Max-Planck Institute for the Science of Light, Erlangen, Germany and University of Erlangen-Nurembergm Erlangen, Germany and Moscow State University, Moscow, Russia*
Direct observation of third-order spontaneous down conversion, where three low energy photons are generated from a single one, remains a challenging task. We report here on different strategies based on engineered optical fibers. These include gas-filled hollow-core photonic crystal fibers, hybrid- and tapered fibers.

Regency Ballroom B

TuE3.3 2:15 PM–2:30 PM
THz Photonic Transmitters with Type-II Hybrid Absorber UTC-PDs and Dual-Ridged Horn Antennas for High-Power and Extremely Wide Fractional Bandwidth Performances
Jhih-Min Wun, *National Central University Taoyuan, Taiwan*, Nan-Wei Chen, *Yuan Ze University, Taoyuan, Taiwan*, and Jin-Wei Shi, *National Central University, Taoyuan, Taiwan*
Waveguide-coupled THz photonic transmitters, which have novel design of dual-ridged horn antenna and ultra-fast photodiodes, demonstrate extremely wide 3-dB fractional O-E bandwidth (100%; 0.1-0.3 THz). A reasonable power (31.6 μW; 0.24 THz) can be detected in the receiving-end through wireless transmission.

TuE3.4 2:30 PM–3:00 PM (Invited)
Seamless Waveform Transport Technology in 5 G and IoT Era
Atsushi Kanno, *National Institute of Information and Communications Technology, Tokyo, Japan*
We introduce and demonstrate millimeter-wave radiocommunication technology based on radio over fiber network for automotive and train applications. High-capacity and low latency radio over fiber system will provide the millimeter-wave signal delivery to the remote site directly.

3:00 PM–3:30 PM – EXHIBITS & COFFEE BREAK – GRAND BALLROOM FOYER

Lake Anne A/B	Lake Audubon	Lake Thoreau	Grand Ballroom D
TuF3.3 2:30 PM–2:45 PM **Investigation of Band Anticrossing Parameters for Dilute-Anion III-Nitride Alloys** Justin C. Goodrich, Damir Borovac, *Lehigh University, Bethlehem, PA, USA*, Chee-Keong Tan, *Clarkson University, Potsdam, NY, USA,* and Nelson Tansu, *Lehigh University, Bethlehem, PA, USA* Band anticrossing parameters of dilute-anion III-nitride alloys are calculated for GaNAs and GaNP material systems. Incorporation of small amount of the dilute-anion in III-nitride allows for a wide tunability of the band gap and electronic properties of the resultant alloys.	**TuG3.3 2:00 PM–2:15 PM** **Coherent-Perfect-Absorption-Based DPSK Demodulator for Silicon Photonics** Asif Ahmed, Hao Yang, Jacob M. Rothenberg, *Columbia University, New York, NY, USA*, Brian Souhan, *United States Military Academy, West Point, NY, USA*, Zhao Wang, *McMaster University, Ontario, Canada*, Nathan C. Abrams, *Columbia University, New York, NY, USA,* Kirk A. Ingold, *United States Military Academy, West Point, NY, USA,* Christopher C. Evans, Joel M. Hensley, *Physical Sciences Inc., Andover, MA, USA*, Keren Bergman, *Columbia University, New York, NY, USA,* Richard R. Grote, *University of Pennsylvania, Philadelphia, PA, USA,* Andrew P. Knights, *McMaster University, Ontario, Canada*, Jerry I. Dadap, and Richard M. Osgood, Jr., *Columbia University, New York, NY, USA* We demonstrate a fully integrated 10 Gbps novel Si DPSK demodulator using coherent perfect absorption. Our device incorporates a silicon ring resonator, two bus waveguide inputs, monolithically integrated detectors, and operates passively at telecommunication wavelengths, and fits within a mm-scale footprint.	**TuH3.3 2:15 PM–2:45 PM (Invited)** **Coherent Vibrational Spectroscopy in the Single Molecule Limit** Eric O. Potma, *University of California, Irvine, Irvine, CA, USA* We discuss the latest developments in advancing the use of nonlinear optical spectroscopy for the purpose of studying vibrational dynamics of single molecules. In particular, we focus on surface-enhanced coherent Raman scattering measurements in the single molecule limit.	
TuF3.4 2:45 PM–3:00 PM **High Temperature Photoluminsence of InGaN-Based MQWs on Patterned Sapphire Substrates** Abbas Sabbar, Syam Madhusoodhanan, Sattar Al-Kabi, *University of Arkansas, Fayetteville, AR, USA,* Binzhong Dong, Jiangbo Wang, *HC SemiTek (Suzhou), Jiangsu, China,* Stanley Atcitty, Robert Kaplar, *Sandia National Laboratories, Albuquerque, NM, USA,* H. Alan Mantooth, Shui-Qing Yu, and Zhong Chen, *University of Arkansas, Fayetteville, AR, USA* Temperature and power dependent photoluminescence (PL) measurements from InGaN/GaN MQWs has been studied from 77 to 800 K to extract the PL efficiency. The laser powers at maximum quantum efficiency in a wide range of temperatures are calculated.	**TuG3.4 2:15 PM–2:30 PM** **Intensity and Spatial Dependence of Saturation Effects in Resonant Third Harmonic Generation from Amorphous Silicon Nanodisk Arrays** Keshav Kumar Jha, Rabindra Biswas, Lal Krishna A S, Jayanta Deka, Sruti Menon, and Varun Raghunathan, *Indian Institute of Science, Bangalore, India* Third harmonic generation microscopy of hexagonal arrays of amorphous silicon nanodisks with resonance at fundamental wavelength is presented. The onset and progression of intensity and spatially dependent saturation effects is clearly observed through the contrast reversal of third harmonic generation signal generated at the nanodisks.	**TuH3.4 2:45 PM–3:00 PM** **Generation of High Power, Ultrafast Asymmetric Vortices with Broad Orbital Angular Momentum Spectrum** A Srinivasa Rao, Sabir Ul Alam, Anirban Ghosh, Pravin Vaity, and G. K. Samanta, *Physical Research Laboratory, Ahmedabad, India* We report on controlled transition of pure to mixed orbital angular momentum (OAM) modes of different weightages by incorporating asymmetry in optical vortices. We also studied the effect of mixed OAM modes in nonlinear process.	
	TuG3.5 2:30 PM–2:45 PM **Hybrid Numerical-Analytical Effective Index Method for Designing Large Geometry Ridge Waveguides** Priyanka Roy, Pallabi Das, and Siddharth Tallur, *IIT Bombay, Mumbai, India* We present a design methodology for obtaining single-mode ridge waveguides with geometries larger than the wavelength of guided light. A hybrid numerical-analytical approach is proposed, that shows good agreement with FDTD simulations, as compared to more conventional effective index method based analyses.		
	TuG3.6 2:45 PM–3:00 PM **Modeling and Analysis of SOI Grating Coupler for Bio-Sensing Applications** *Venkatesha M, Vismaya K R, Prashanth A U, Meda Vyshnavi V,* and Narayan K, *Sai Vidya Institute of Technology, Bangalore, India* This work presents, analysis of SOI optical grating structure operating at 1310 nm wavelength. Power coupling analysis between optical source and grating structure is done. The maximum power coupling efficiency of 55.2% is achieved for 500 nm grating pitch having 50% duty cycly on 220 nm Si-layer.		

3:00 PM–3:30 PM – EXHIBITS & COFFEE BREAK – GRAND BALLROOM FOYER

Grand Ballroom A

8:30 AM–10:00 AM
Session WA1: Free-space Optical Communications
Session Chair: Ivan B. Djordjevic, *University of Arizona, Tucson, AZ, USA*

WA1.1 8:30 AM–8:45 AM
3-Gbps Free Space Optical Link Based on Integrated Indium Phosphide Transmitter
Hongwei Zhao, Sergio Pinna, Bowen Song, Ludovico Megalini, Simone Tommaso Šuran Brunelli, Larry Coldren, and Jonathan Klamkin, *University of California, Santa Barbara, Santa Barbara, CA, USA*
A free space optical link was demonstrated with an integrated indium phosphide transmitter, tunable from 1521 nm to 1565 nm. Error-free operation was achieved at 3 Gbps for an equivalent link length of 180 m (up to 300 m with forward error correction).

WA1.2 8:45 AM–9:00 AM
Dual-Color Micro-LED Transmitter for Visible Light Communication
J. F. C. Carreira, E. Xie, J. J. D. McKendry, B. J. E. Guilhabert, I. M. Watson, E. Gu, M. D. Dawson, *University of Strathclyde, Glasgow, UK*, R. Bian, and H. Haas, *University of Edinburgh, Edinburgh, UK*
We report the integration of blue micro-LED onto the substrate of green micro-LED, by transfer printing. This dual-color device fabrication and performance as a visible light communication transmitter is demonstrated.

WA1.3 9:00 AM–9:15 AM
Understanding LiFi Effect on LED Light Quality
Evangelos Pikasis and Wasiu O. Popoola, *University of Edinburgh, Edinburgh, UK*
A framework for investigating the effects of different LiFi modulation techniques on the emitted light quality of an LEDs is presented. It is a valuable tool for designing LiFi systems that are compliant with lighting and data communication requirements.

WA1.4 9:15 AM–9:30 AM
Experimental Demonstration of User Allocation in a Subcarrier Multiplexing-Based Multiuser LiFi System
Mounir Mohammedi Merah, Luc Chassagne, and Hongyu Guan, *University of Versailles Saint-Quentin, Velizy, France*
We want to allocate the users to the optimal subcarriers in visible light communication. Allocation algorithms adapted from fiber-optic and implemented in an experimental setup attain a deviation from the bit rate target inferior to 5 percent for 11 users.

Grand Ballroom B

8:30 AM–10:00 AM
Session WB1: Optical Transciever Technology
Session Chair: Judson Ryckman, *Clemson University, Clemson, SC, USA*

WB1.1 8:30 AM–9:00 AM (Invited)
Optical Integration: The Path to Terabit Transceivers
John E. Bowers, *University of California Santa Barbara, Santa Barbara, CA, USA*

WB1.2 9:00 AM–9:15 AM
Compact and High-Speed Ge Franz-Keldysh I/Q Modulator Used with Kramers-Kronig Receiver
Yeyu Tong, Qiulin Zhang, Xinru Wu, *Chinese University of Hong Kong, Hong Kong, China*, Chi-Wai Chow, *National Chiao Tung University, Hsinchu, Taiwan*, Chester Shu, and Hon Ki Tsang, *Chinese University of Hong Kong, Hong Kong, China*
We propose a compact and high-speed I/Q modulator based on two germanium-on-silicon Franz-Keldysh electro-absorption modulators. We demonstrate a 4-QAM signal transmission and reconstruct the complex signal in a Kramers- Kronig receiver for future datacenter interconnect applications.

WB1.3 9:15 AM–9:30 AM
40-Gbit/s 850-nm VCSEL-Based Full-CMOS Optical Link with Power-Data Rate Adaptivity
Mahdi Khafaji, Laszlo Szilagyi, Jan Pliva, Ronny Henker, and Frank Ellinger, *Technische Universität Dresden, Dresden, Germany*
An optical link with directly modulated VCSEL is reported operating at 40 Gbit/s with 3.4 pJ/bit. The frontends are implemented in highly-scaled CMOS technologies. Measured sensitivity is –1.9 dBm OMA. At lower data rates, the bandwidths of the circuits can be decreased adaptively resulting 2.7 pJ/bit at 20 Gbit/s.

WB1.4 9:30 AM–10:00 AM (Invited)
Monolithic Silicon Photonic Transceivers
Chi Xiong, *IBM, NY, USA*

Grand Ballroom C

8:30 AM–10:00 AM
Session WC1: Thermal Photonics and Optomechanics
Session Chair: Mo Li, *University of Minnestoa, Minneapolis, MN, USA*

WC1.1 8:30 AM–8:45 AM
Measuring Thermal Acoustic Radiation with an Optomechanical Antenna
Robinjeet Singh and Thomas P. Purdy, *National Institute of Standards and Technology, Gaithersburg, MD, USA*
We optically probe the silicon nitride membrane nanomechanical resonator modes that are strongly coupled to acoustic radiation in the substrate. We use this optomechanical system for temperature metrology by detecting the ballistic transport of thermal excitation from a remote bath.

WC1.2 8:45 AM–9:00 AM
Physical Stability Analysis for Optical MEMS Phase Shifters
Yiğit Özer and Serdar Kocaman, *Middle East Technical University, Ankara, Turkey*
Stability and switching performance of light force driven opto-mechanical phase shifters are examined and a formula determining the stability condition has been proposed for various structures. The analysis showed that cantilever beams are inadequate to generate 180° phase difference.

WC1.3 9:00 AM–9:30 AM (Invited)
Single Crystalline Aluminum Nitride for Visible Nonlinear Photonics
Hong Tang and Alexander Bruch, *Yale University, New Haven, CT, USA*
Aluminum Nitride (AlN) is a unique nonlinear photonic material, simultaneously possessing cubic and quadratic nonlinearities as well as a broad transparency window down to 200 nm. In this talk I will introduce nonlinear photonic circuits based on single crystalline AlN, highlighting devices that establish a new record in second harmonic generation and second-harmonic assisted visible frequency combs. Further, I will demonstrate the use of epitaxial AlN photonic waveguides for supercontinuum generation in the ultraviolet regime.

WC1.4 9:30 AM–10:00 AM (Invited)
Engineering Both Far-Field and Near-Field Thermal Radiation with Metamaterials
Liping Wang, *Arizona State University, USA*
Our recent work in tailoring thermal emission and absorption with selective metamterials for energy harvesting and radiative cooling will be presented. Besides, our recent progresses in near-field radiative heat transfer engineered with metamaterials across nanometer vacuum gaps will be outlined.

Regency Ballroom A

8:30 AM–10:00 AM
Session WD1: New Fiber Designs & OFT Tutorial
Session Chair: Michael Brodsky, *US Army Research Laboratory, MD, USA*

WD1.1 8:30 AM–9:30 AM (Tutorial)
Novel Material Approach to Advanced Optical Fibers and Fiber Lasers
John Ballato, *Clemson University, Clemson, SC, USA*
This tutorial provides a road-map for the development of simple core/clad optical fibers whose enhanced performance – in particular, marked reductions in optical nonlinearities – is achieved materially and not through the more conventional present routes of geometrically complex fiber design.

WD1.2 9:30 AM–10:00 AM (Invited)
Recent Advances in Antiresonant Fibre Technology
Francesco Poletti, *Southhampton University, Southampton, UK*

Regency Ballroom B

8:30 AM–10:00 AM
Session WE1: Microwave Photonics Devices and Comb Generations
Session Chair: William Loh, *Massachusetts Institute of Technology, Cambridge, MA, USA*

WE1.1 8:30 AM–9:00 AM (Invited)
On-Chip Optical Frequency Comb Generation for RF Photonic Applications
Xiaoxiao Xue, Xiaoping Zheng, *Tsinghua University, Beijing, China,* and Andrew M. Weiner, *Purdue University, West Lafayette, IN, USA*
We review several key problems in microresonator frequency comb generation for RF photonic applications, including comb intensity noise and power conversion efficiency, and show some preliminary demonstrations based on mode-locked and low-noise Kerr combs including programmable complex-tap signal processing and true-time-delay beamforming.

WE1.2 9:00 AM–9:15 AM
The Effects of Intracavity Phase Modulation and Extracavity Optical Filtering on Amplitude Noise of Mode-Locked Pulse Trains
Sarper Ozharar, *Bahçeşehir University, Istanbul, Turkey*, and Ibrahim Ozdur, *Abdullah Gul University, Kayseri, Turkey*
Intracavity active phase modulation at the cavity fundamental frequency was used to improve the stability of the mode-locked optical spectrum and to reduce the amplitude noise of the pulse train by 40% in an actively harmonically mode-locked semiconductor ring laser at 10 GHz.

WE1.3 9:15 AM–9:30 AM
Optically Controlled Microwave Attenuator Based on InP/InGaAs Photovaractor
Jizhao Zang, Jesse Morgan, Andreas Beling, and Joe C. Campbell, *University of Virginia, Charlottesville, VA, USA*
We report an optically controlled variable microwave attenuator based on zero-biased photovaractor. In the frequency range of 5 GHz to 55 GHz, an attenuation dynamic range up to 40 dB and phase variation <10 degree are achieved, respectively.

WE1.4 9:30 AM–9:45 AM
Kerr Combs for Single-Span Long-Haul Analog Optical Links
Mohammed S. Alshaykh, Yi Xuan, Daniel E. Leaird, *Purdue University, West Lafayette, IN, USA,* Jason D. McKinney, *U.S. Naval Research Laboratory, Washington, DC, USA,* Minghao Qi, and Andrew M. Weiner, *Purdue University, West Lafayette, IN, USA*
We utilize a single soliton generated in a SiN microring resonator for stimulated Brillouin scattering mitigation in a 50 km link. A 9.1 dB increase in threshold power relative to the CW case is obtained. Potential improvements of the results using dark pulses are discussed.

Lake Anne A/B

8:30 AM–10:00 AM
Session WF1: Next-Generation Data Centers
Session Chair: Ioannis Roudas, *Montana State University-Bozeman, Bozeman, MT, USA*

WF1.1 8:30 AM–9:00 AM (Invited)
Optical Interconnect Architectures for Data Centers
Pawel Wiatr, Di Yuan, *Uppsala University, Uppsala, Sweden*, Lena Wosinska, and Jiajia Chen, *KTH Royal Institute of Technology, Stockholm, Sweden*
The talk will highlight the challenges faced by the current datacenter networks, where using photonic technology offers a numbers of obvious advantages. Some existing optical intra-datacenter network architectures will be presented along with new ideas allowing for reduction of energy consumption and required spectrum resources.

WF1.2 9:00 AM–9:30 AM (Invited)
Novel Optical Fibers for Future Data Centers Optical Interconnects
Ming-Jun Li, *Corning Research and Development, Corning, NY, USA*
This paper presents novel optical fibers for data center optical interconnects, including wideband MMF for SWDM, long wavelength MMF for reducing chromatic dispersion, universal fiber for both single and multimode transmission, single mode fibers for short wavelength VCSELs, and multicore and few-mode fiber for SDM.

Lake Audubon

8:30 AM–10:00 AM
Session WG1: III-V Materials and Devices
Session Chair: Kei May Lau, *Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong*

WG1.1 8:30 AM–9:00 AM (Invited)
Monolithic Integration of III/V-Based Functionalities to CMOS-Based Si-micro- and nanoelectronics
Wolfgang Stolz, *Philipps University, Marburg, Germany and NAsP III/V GmbH, Marburg, Germany*
The monolithic integration of III/V-semiconductor materials and heterostructures on CMOS-compatible (001) Si-substrate is gaining increasing interest for the realization of integrated circuits with novel optoelectronic or photonic functionalities. The unique approach integrating the lattice-matched Ga(NAsP)-based laser stacks for Si-photonics applications will be presented and discussed.

WG1.2 9:00 AM–9:15 AM
Far-Infrared Emission from an Electrically-Injected Semiconductor Device
Junchi Lu, *Notre Dame University, Notre Dame, IN, USA*, Leland Nordin, *University of Texas at Austin, Austin, TX, USA*, Owen Dominguez, Lina Cao, Jingshan Wang, Patrick Fay, *University of Notre Dame, Notre Dame, IN, USA*, Daniel Wasserman, *University of Texas at Austin, Austin, TX, USA*, and Anthony Hoffman, *Notre Dame University, Notre Dame, IN, USA*
We demonstrate an electrically-injected device that emits in the Reststrahlen band of GaAs. The device comprises a superlattice designed to generate longitudinal optical (LO) phonons and a grating with a mode at the energy of the phonons. Emission, peaking at the LO phonon, is observed.

WG1.3 9:15 AM–9:30 AM
Advanced Light Management in Photovoltaics Using Dielectric Nano-Resonator Arrays
Dongheon Ha, *National Institute of Standards and Technology, Gaithersburg, MD, USA and University of Maryland, College Park, MD, USA,* and Nikolai B. Zhitenev, *National Institute of Standards and Technology, Gaithersburg, MD, USA*
We describe advanced light management technique using a variety of dielectric nano-resonator arrays. Substantial enhancement of opto-electronic properties with dielectric nano-resonator arrays is demonstrated for various photovoltaic materials including Si and GaAs, potentially surpassing a conventional thin-film-based antireflection technology based on complicated, costly fabrication processes.

WG1.4 9:30 AM–9:45 AM
Interplay of Strain Compensation and Relaxation in High-Performance InGaAs Quantum Well Lasers
Wei Sun, *Lehigh University, Bethlehem, PA, USA*, Honghyuk Kim, Luke J. Mawst, *University of Wisconsin-Madison, Madison, WI, USA,* and Nelson Tansu, *Lehigh University, Bethlehem, PA, USA*
The effect of GaAsP barriers on diminishing the strain relaxation is studied quantitatively via reciprocal space mapping and micro-photoluminescence for the InGaAs/GaAs MQWs at near-critical thickness. Our study provides insights into how to achieve better strain compensation effect in III-V based QWs lasers.

Lake Thoreau

8:30 AM–10:00 AM
Session WH1: Photonics in Space
Session Chair: Quinlin McCormick, *NASA, USA*

WH1.1 8:30 AM–9:00 AM (Invited)
Lasers as the Future Means of Free-Space Communications
Hossin Abdeldayem, *NASA Goddard Space Flight Center, Greenbelt, MD, USA*
The Lunar Laser Communication Demonstration (LLCD) in 2013 was NASA's first attempt to demonstrate Laser Communication from a lunar orbiting spacecraft to an Earth-based ground receiver. This paper presents an overview of the Laser communication as the future means of communication and possible future applications.

WH1.2 9:0 AM–9:30 AM (Invited)
Space Laser Instruments and Systems
Michael Krainak, *NASA Goddard Space Flight Center, Greenbelt, MD, USA*
NASA continues to develop space-based laser instruments and systems for science and exploration. We give a brief overview of laser technology on the Ice, Cloud & land Elevation Satellite-2 Advanced Topographic Laser Altimeter System (ICESat-2/ATLAS), the Laser Communication Relay Demonstration (LCRD) and the Global Ecosystem Dynamics Investigation (GEDI). We discuss laser technology for the upcoming Laser Interferometer Space Antenna (LISA) mission, a proposed Earth mesospheric temperature lidar, a robotic servicing laser imager, plans for space-based optical communications and more.

Grand Ballroom A	Grand Ballroom B	Grand Ballroom C	Regency Ballroom A	Regency Ballroom B
WA1.5 9:30 AM–9:45 AM **0.5-Gb/s OFDM-Based Laser Data and Power Transfer Using a GaAs Photovoltaic Cell** John Fakidis, Stefan Videv, *University of Edinburgh, Edinburgh, UK*, Henning Helmers, *Fraunhofer Institute for Solar Energy Systems, Freiburg, Germany*, and *Harald Haas, University of Edinburgh, Edinburgh, UK* In this work, laser-power converters are shown, for the first time, to be capable of high-speed data communication. Bit-and-power-loaded orthogonal frequency-division multiplexing is applied to ensure the optimal use of the communication bandwidth. Record data rates are reported for optical wireless information and power transfer.				.

10:00 AM–10:30 AM – EXHIBITS & COFFEE BREAK – GRAND BALLROOM FOYER

Lake Anne A/B	Lake Audubon	Lake Thoreau

WG1.5 9:45 AM–10:00 AM
APD Performance Enhancement: Minigap Engineering in Digital Alloys
Sheikh Z. Ahmed, *University of Virginia, Charlottesville, VA, USA*, Yaohua Tan, *University of Virginia, Charlottesville, VA, USA and Synopsys, CA, USA*, Jiyuan Zheng, Joe C. Campbell, and Avik W. Ghosh, *University of Virginia, Charlottesville, VA, USA*
Digital alloy APDs have recently demonstrated superiorperformance. This superiority is attributed to the presenceof minigaps in digital alloys. We study the minigaps in different digital alloys and their possible impact on APD performance.

10:00 AM–10:30 AM – EXHIBITS & COFFEE BREAK – GRAND BALLROOM FOYER

Grand Ballroom A

10:30 AM–12:00 PM
Session WA2: Optical Amplification and Processing
Session Chair: David Caplan, *MIT Lincoln Laboratory, Lexington, MA, USA*

WA2.1 10:30 AM–11:00 AM (Invited) Recent Technologies on Multicore EDFA
Ryuichi Sugizaki, Koichi Maeda, Shigehiro Takasaka, and Masayoshi Tsukamoto, *Furukawa Electric Co., Ltd., Chiba, Japan*
Multicore amplifier realizing ultra-high density transmission is summarized. Integration of components is the one of the key for increasing capacity of EDFA. Reduction of power consumption by cladding pumping scheme is introduced.

WA2.2 11:00 AM–11:15 AM Temporal Noise Mitigation in a Talbot Amplifier
Reza Maram, *INRS-EMT, University of Quebec, Montreal, Quebec, Canada and McGill University, Montreal, Quebec, Canada,* Mohamed Seghilani, Jinwoo Jeon, Xiao-Zhou Li, Luis Romero Cortés, *INRS-EMT, University of Quebec, Montreal, Quebec, Canada,* James Van Howe, *INRS-EMT, University of Quebec, Montreal, Quebec, Canada and Augustana College, Rock Island, IL, USA,* and José Azaña, *INRS-EMT, University of Quebec, Montreal, Quebec, Canada*
We analyze the temporal noise mitigation performance of a Talbot amplifier, employing an electro-optic phase modulator and a dispersive medium. In particular, we obtain transfer-functions of intensity-fluctuations and timing-jitter for the amplifier, showing a significant noise reduction above a cutoff-frequency and at periodic resonant frequencies.

WA2.3 11:15 AM–11:30 AM In-Band Non-Invasive Multiplexing of Data Signals through Reversible Linear Spectral Compression
Luis Romero Cortes, Reza Maram, and José Azaña, *INRS-EMT, University of Quebec, Montreal, Quebec, Canada*
We propose and experimentally demonstrate an in-band wavelength-division multiplexing strategy based on a linear method for reversible spectral compression of data signals, that liberates bandwidth (over 60% of the original signal bandwidth in the reported experiments) with no information loss.

Grand Ballroom B

10:30 AM–11:45 AM
Session WB2: Novel Packaging and Waveguide Technology
Session Chair: Jonathan Doylend, *Intel Corporation, Santa Clara, CA, USA*

WB2.1 10:30 AM–11:00 AM (Invited) Low Loss Fiber to Chip Packaging
Jaime Cardenas, *University of Rochester, Rochester, NY, USA*
We present a novel approach of fiber to chip packaging using fusion splicing. As proof-of-concept, we show 2.5dB loss for a permanently attached fiber to a silicon nitride photonic chip.

WB2.2 11:00 AM–11:15 AM Low-Loss Wafer-Scale Silicon Photonic Interposer Utilizing Inverse-Taper Coupler
Yichi Zhang, Kuanping Shang, Yu Zhang, and S. J. Ben Yoo, *University of California, Davis, Davis, CA, USA*
This paper experimentally demonstrates a low loss inter-chip coupler with coupling loss below 1dB utilizing inverse-taper coupling from a wafer scale silicon photonic interposer, designed to distribute laser emission to 100 photonic integrated circuit dies (PICs) with equal power and phase.

WB2.3 11:15 AM–11:45 AM (Invited) Group IV Compounds Modulators and Mid Index Waveguides for Enhanced CMOS Photonics
Frederic Gardes, Thalia D. Bucio, Lorenzo Mastronardi, Mehdi Banakar, Alexandre Bazin, Ali Khokhar, Cosimo Lacava, Periklis Petropoulos, *University of Southampton, Southampton, UK,* Callum Littlejohns, *Nanyang Technological University, Singapore,* and Kapil Debnath, *Indian Institute of Technology, Kharagpur, India*
We demonstrate CMOS compatible photonic components such as high speed Ge/SiGe electro-absorption modulators and a flexible BEOL SiN waveguide platform for applications such as temperature insensitive CWDM and all optical signal processing through enhanced non-linear characteristics.

Grand Ballroom C

Regency Ballroom A

10:30 AM–12:00 PM
Sessioln WD2: Novel Applications
Session Chair: Nicolas Y. Joly, *Max-Planck Institute for the Science of Light, Erlangen, Germany*

WD2.1 10:30 AM–11:00 AM (Invited) Electronically Controlled All-Fiber Graphene Devices
Dong-il Yeom, *Ajou University, Suwon, South Korea*
An electrically tunable highly efficient all-fiber graphene device was demonstrated based on strongly enhanced graphene-evanescent wave interaction. The device exhibits non-resonant large optical transition change of 20 dB through the Fermi-level control in a graphene layer by applied electrical signal of less than 3V.

WD2.2 11:00 AM–11:15 AM Near-Infrared Optical Image Transport through an All-Solid Tellurite Transversely Disordered Optical Fiber
Tong Hoang Tuan, Shunei Kuroyanagi, Takenobu Suzuki, and Yasutake Ohishi, *Toyota Technological Institute, Nagoya, Japan*
The transport of near-infrared optical images was demonstrated by using a 10-cm long all-solid tellurite transversely disordered optical fiber for the first time. The fiber was fabricated successfully using our developed tellurite glasses. It can be a promising candidate for biomedical IR imaging applications.

WD2.3 11:15 AM–11:30 AM Investigations on FM-to-AM Modulation Compensation Using All-Fibered Multi-Wavelength Tunable Filter
Mengqiu Fan, Xiaocheng Tian, Zhaoyu Zong, Dandan Zhou, Na Zhu, and Dangpeng Xu, *China Academy of Engineering Physic, Sichuan, China*
An all-fibered multi-wavelength tunable filter which is based on polarization interference technology to compensate the frequency modulation to amplitude modulation (FM-to-AM) conversion in laser driver facility is investigated and demonstrated. In the demonstrated compensation experiment, FM-to-AM index α is reduced from 16.78% to 3.12%.

Regency Ballroom B

10:30 AM–12:00 PM
Session WE2: Transmitter/Receiver for Microwave Photonics Applications
Session Chair: Meredith Hutchinson, *Naval Research Lab., Washington, DC, USA*

WE2.1 10:30 AM–11:00 AM (Invited) Microwave Photonics in the Industry
Edward I. Ackerman, *Photonic Systems, Inc., Billerica, MA, USA*

WE2.2 11:00 AM–11:15 AM High-Power Flip-Chip Bonded Modified Uni-Traveling Carrier Photodiodes with –2.6 dBm RF Output Power at 160 GHz
Jesse S. Morgan, Keye Sun, Qinglong Li, *University of Virginia, Charlottesville, VA, USA*, Steven Estrella, Maddy Woodson, Kenneth Hay, Milan Mashanovitch, *Freedom Photonics LLC, Santa Barbara, CA, USA,* and Andreas Beling, *University of Virginia, Charlottesville, VA, USA*
We report back-illuminated InGaAsP/InP charge-compensated modified uni-travelling carrier photodiodes with 0.2 A/W responsivity. RF output power performance of PDs ranging from 4 to 11-μm diameters is measured out to 165 GHz, achieving –2.6 dBm at 160 GHz (9-μm) and 3-dB bandwidth reaching 120 GHz (4-μm).

WE2.3 11:15 AM–11:30 AM Volterra Modeling of Wideband Behavior of MZM and Photodiode IMD2
Caitlin R. S. Williams, *Hastings College, Hastings, NE, USA,* Meredith N. Hutchinson, *Naval Research Lab, Washington, DC, USA*, Tegan E. Wilson, *Carleton College, Northfield, MN, USA,* and Jonathan M. Nichols, *Naval Research Lab, Washington, DC, USA*
A model that describes photodiode (PD) 2nd-order intermodulation distortion (IMD2) interaction with modulator IMD2 is expanded. We model the qualitative behavior of the PD phase/amplitude IMD2 via Volterra series and experimentally verify with wideband system analysis.

Lake Anne A/B

10:30 AM–11:30 AM
Session WF2: Probabilistic Shaping
Session Chair: I. Djordjevic

WF2.1 10:30 AM–11:30 AM (Tutorial)
Probabilistic Constellation Shaping: Key Enabler for Maximizing Transmission Capacity and Reach
Sethumadhavan Chandrasekhar, *Nokia Bell Labs*

Lake Audubon

10:30 AM–12:00 PM
Session WG2: Novel Photonic Materials and Metamaterials
Session Chair: Alexey Belyanin, *Texas A&M University, College Station, TX, USA*

WG2.1 10:30 AM–11:00 AM (Invited)
Optics of Materials with Dirac and Weyl Fermions
Alexey Belyanin, *Texas A&M University, College Station, TX, USA*
Materials with massless Dirac and Weyl fermions have fascinating optical properties which can be utilized in future optoelectronic devices. I will discuss several examples including plasmons and polaritons in Dirac/Weyl semimetals and nonlinear optical response of graphene and topological insulators.

WG2.2 11:00 AM–11:15 AM
Influence of Finite Grating Size on Guided Mode Resonance Transmission Filters
Martin Scherr, Michael Barrow, and Jamie Phillips, *University of Michigan, Ann Arbor, MI, USA*
Guided-mode resonance filters offer effective narrowband transmission filters. Finite gratings degrade the Bloch wave character of the guided mode and Fano resonance responsible for transmission. Asymmetric zero-contrast gratings are studied and two mitigation techniques are proposed: reflectors surrounding gratings, and geometries with increased guided-mode coupling.

WG2.3 11:15 AM–11:30 AM
Nonvolatile Tunable Integrated Mid-Infrared GST-SiC Metasurfaces
Xi Wu, Tianren Fan, Taylor G. Allen, Sajjad Abdollahramezani, Ali A. Eftekhar, *Georgia Institute of Technology, Atlanta, GA, USA*, Matteo Bosi, *IMEM-CNR Institute, Parma, Italy*, Joseph W. Perry, and Ali Adibi, *Georgia Institute of Technology, Atlanta, GA, USA*
We demonstrate an integrated mid-infrared 3C-SiC metasurface with relatively sharp transmission peaks associated with phonon-mediated magnetic polariton resonance. We further show the possibility of developing reconfigurable metasurfaces using such architectures by integrating a thin layer of phase-change material, $Ge_2Sb_2Te_5$, on top of the SiC layer.

Lake Thoreau

10:30 AM–12:00 PM
Session WH2: MicroLEDs and Display Technologies
Session Chair: Nicolas Laurand, *University of Strathclyde, Glasgow, Scotland, UK*

WH2.1 10:30 AM–11:00 AM (Invited)
High Brightness GaN Microdisplays for Augmented Reality Applications
François Templier, *CEA LETI, Rhone-Alpes, France*
Here we report high resolution, active-matrix, GaN-based LED microdisplays with a pixel pitch of 10 µm. Full video, high-resolution images have been obtained. These GaN-based microdisplays are suitable for a wide range of applications from augmented reality and head-up displays to pico- and compact projectors.

WH2.2 11:00 AM–11:15 AM
Integration of Micro-LED Array on CMOS by Transfer Printing
J. F. C. Carreira, B. J. E. Guilhabert, J. J. D. McKendry, E. Xie, K. Mathieson, I. M. Watson, E. Gu, M. D. Dawson, *University of Strathclyde, Glasgow, UK,* and R. K. Henderson, *University of Edinburgh, Edinburgh, UK*
Transfer printing of 450 nm-emitting micro-LED 8 × 8 arrays onto CMOS platform is reported. The pixels' average optical power density was measured at 4.4 W/cm^2 (50 A/cm^2). Sub-nanosecond pulses as well as MHz bandwidth modulation are other modes of operation of the hybrid device.

WH2.3 11:15 AM–11:45 AM (Invited)
Flexible Inorganic LEDs with Semiconductor Nanowires
Maria Tchernycheva, Nan Guan, Lorenzo Mancini, Nuno Amador, François Julien, *University Paris Sud., Orsay, France,* Akanksha Kapoor, Catherine Bougerol, Joël Eymery, and Christophe Durand, *Université Grenoble Alpes, Grenoble, France*
We will present our recent work on nanowire-based light emitting diodes (LEDs). We propose a method to combine high flexibility of passive transparent polymer films with high quantum efficiency and long lifetime of semiconductor nanowires to achieve flexible inorganic LEDs.

Grand Ballroom A	Grand Ballroom B	Grand Ballroom C	Regency Ballroom A	Regency Ballroom B
WA2.4 11:30 AM–11:45 AM **Polarization Multiplexing and Demultiplexing Technique for Large Capacity Small Optical Module by Using Optical Interleaver** Toshiya Matsuda, Toru Homemoto, and Kazuyuki Matsumura, *NTT Corporation, Musashino-shi, Japan* We propose a simple polarization multiplexing and demultiplexing technique to increase the transmission capacity of tunable small optical transceivers. We also experimentally demonstrate that a 25-Gbit/s dual polarization on-off keying signal is successfully transmitted over 50-km G.652 fiber without dispersion compensation technique.			**WD2.4 11:30 AM–12:00 PM (Invited)** **Optical Phased Array LiDAR** Chris Poulton, *Analog Photonics, USA* LiDAR with integrated optical phased arrays provides an attractive solution to commercial and defense industries by enabling solid-state, small-form-factor ranging systems fabricated on 300mm silicon wafers. We review this technology and present results with beam steering, real-time coherent LiDAR, and co-packaging with III/V lasers.	**WE2.4 11:30 AM–12:00 PM (Invited)** **Low-Noise Dual-Frequency VECSELs for Microwave Photonics and Metrology Applications** Isabelle Sagnes, *Centre de Nanosciences et de Nanotechnologies, Ile-de-France, France*, Fabien Bretenaker, Hui Liu, Gregory Gredat, *Laboratoire Aime Cotton, Orsay, France,* Syamsundar De, *Laboratoire Kastler-Brossel, Ile-de-France, France,* Fabienne Goldfarb, *Laboratoire Aime Cotton, Orsay, France,* Ghaya Baili, Francois Gutty, *Thales Research and Technology, Ile-de-France, France*, and Sophie Bouchoule, *Centre de Nanosciences et de Nanotechnologies, Ile-de-France, France* Dual-frequency VECSELs are interesting sources of single-side band optically carried microwave signals. We will describe how the intensity noise of the laser and the phase noise of the beatnote between the two modes can be controlled for applications to microwave photonics and atomic clocks.
WA2.5 11:45 AM–12:00 PM **Optical Comparator for 4-Bit and 6-Bit QPSK-Modulated Signals by Using Optical Delayed Interferometer** Yohei Aikawa, *Okinawa College, Okinawa, Japan* In this paper, a novel optical comparator for PSK-modulated signal has been proposed by using optical delayed interferometer. The feasibility of the comparators designed for 4-bit and 6-bit codewords, which comprise a successive two and three QPSK-modulated RZ-symbols at 10 Gbaud/s, was experimentally demonstrated.				

12:00 PM–1:30 PM – IEEE PHOTONICS FUND LUNCHEON **REGISTRATION REQUIRED LAKE FAIRFAX A/B**

Lake Anne A/B	Lake Audubon	Lake Thoreau
	WG2.4 11:30 AM–11:45 AM **Chromium for High Fluence Bowtie Nano-Antennas** Monir Morshed, *University of New South Wales, Canberra, Australia*, Ziyuan Li, *Australian National University, Canberra, Australia*, Benjamin C. Olbricht, *Coupled Optics LCC, Newark, DE, USA*, Lan Fu, *Australian National University, Canberra, Australia*, Ahasanul Haque, *University of New South Wales, Canberra, Australia,* Li Li, *Australian National University, Canberra, Australia,* and Haroldo T. Hattori, *University of New South Wales, Canberra, Australia* Nano-antennas cannot handle high energy density (fluences) due to their small footprint. In this paper, we propose chromium based nano-antenna and experimentally show that it can handle 110 times higher fluence than gold (Au) counterpart without a significant reduction in their electrical field enhancement capacities.	**WH2.4 11:45 AM–12:00 PM** **Holographic Display with an Enhanced Viewing Angle by Using a Non-Periodic Photon Sieve** Jongchan Park, KyeoReh Lee, *Korea Advanced Institute of Science and Technology, Daejeon, South Korea*, and YongKeun Park, *Korea Advanced Institute of Science and Technology, Daejeon, South Korea and Tomocube, Inc., Daejeon, South Korea* We present a flat-panel wavefront modulator capable of generating holographic images with a large viewing angle. Specifically, a non-periodic photon sieve, which diffracts light at a wide angle, is combined with a commercial LCD panel to generate dynamic holographic images.
	WG2.5 11:45 AM–12:00 PM **Hybrid Toroidal Modes in Planar Core-Shell Metamaterial Structures** Naznin Akter, Mustafa Karabiyik, and Nezih Pala, *Florida International University, Miami, FL, USA* Magnetic toroidal multipoles in 3D and planar resonators have been recently investigated for their unconventional characteristics and potential applications. We report on investigation of hybridized supertoroidal modes at terahertz frequencies in planar core shell structures along with their dependence on geometrical parameters.	

12:00 PM–1:30 PM – IEEE PHOTONICS FUND LUNCHEON **REGISTRATION REQUIRED LAKE FAIRFAX A/B**

Grand Ballroom A

1:30 PM–3:00 PM
Session WA3: DSP and Equalization
Session Chair: Gabriella Bosco, *Politecnico di Torino, Turin, Italy*

WA3.1 1:30 PM–2:00 PM (Invited)
Impact of Transceiver Subsystems on Digital Back Propagation Performance
Lidia Galdino, *University College London, London, UK*
The potential, limitations and practicalities of digital back propagation is investigated in the presence of noise arising from amplifier spontaneous emission noise a well as from a non-ideal transceiver subsystem.

WA3.2 2:00 PM–2:15 PM
10-Gb/s Transmission Over 10-m SI-POF with M-PAM and Multilayer Perceptron Equalizer
Isaac N. Osahon, Majid Safari, and Wasiu O. Popoola, *University of Edinburgh, Edinburgh, UK*
We demonstrate the gigabit-per-second transmission over a step-index plastic optical fiber (SI-POF) of 10-m length with a pulse-amplitude modulation (PAM). A multilayer perceptron-based equalizer is used to mitigate an intersymbol interference and non-linearity in the system.

WA3.3 2:15 PM–2:30 PM
Assessment of RB Noise in Bidirectional RoF Based on Different O-OFDM SSB Systems
Dhananjay Patel, Sardar Vallabhbhai *National Institute of Technology, Surat, India,* Siddharth Tallur, *Indian Institute of Technology, Bombay, Mumbai, India*, and Upena Dalal, *Sardar Vallabhbhai National Institute of Technology, Surat, India*
Novel bidirectional architecture on two optical OFDM SSB modulation techniques to mitigate Rayleigh backscattered and reflections interferences in RoF transmission is proposed. The interference effect is analyzed with mathematical model comparing conventional SSB and the modified SSB based on elimination of higher order RB-RE harmonics.

WA3.4 2:30 PM–3:00 PM (Invited)
Machine-Learning-Based Nonlinearity Equalization Techniques for Coherent Optical Communication Systems
Elias Giacoumidis, *Dublin City University, Dublin, Ireland*

Grand Ballroom B

1:30 PM–3:00 PM
Session WB3: Spin Photonics
Session Chair: Zhaowei Liu, *University of California, San Diego, San Diego, CA, USA*

WB3.1 1:30 PM–2:00 PM (Invited)
Chiral Interaction between Spin-Momentum Locked Photons and Surface Electrons in Topological Insulators
Li He and Mo Li, *University of Minnestoa, Minneapolis, MN, USA*
We demonstrate the integration a topological insulator (TI) Bi_2Se_3 with a chiral photonic waveguide. Because of optical spin-momentum locking, a directional, spin-polarized photocurrent that depends on the light propagation direction is generated on the TI surface.

WB3.2 2:00 PM–2:15 PM
Suppression of Rayleigh Backscattering in Resonators
Seunghwi Kim, *University of Illinois at Urbana-Champaign, Urbana, IL, USA,* Jacob M. Taylor, *University of Maryland, College Park, MD, USA and National Institute of Standards and Technology, Gaithersburg, MD, USA,* and Gaurav Bahl, *University of Illionis at Urbana-Champaign, Urbana, IL, USA*
We demonstrate dynamic suppression of Rayleigh backscattering in a whispering gallery mode resonator by locally breaking time-reversal symmetry through a Brillouin optomechanical interaction.

WB3.3 2:15 PM–2:30 PM
Silicon Nitride Echelle Grating Spectrometer for Operation Near 1.55 µm
Shengjie Xie, Yang Meng, *University of Maryalnd, College Park, MD, USA,* Joss Bland Hawthorn, *University of Sydney, Sydney, Australia,* Sylvain Veilleux, and Mario Dagenais, *University of Maryland, College Park, MD, USA*
We present an e-beam written Si_3N_4/SiO_2 Echelle Grating (EG) with a silver coated reflector. The EG exhibits a 2.7 dB on-chip loss and a spectral resolution power of ~1000. By minimizing stitching errors, more than 25 dB signal-to-noise ratio EG is obtained.

WB3.4 2:30 PM–3:00 PM (Invited)
Hot Atomic Vapor and Nanophotonics
Uriel Levy

Grand Ballroom C

1:30 PM–2:45 PM
Session WC3: SS Integrated Photonics & Information Security
Session Chair: Amy Foster, *Johns Hopkins University, Baltimore, MD, USA*

WC3.1 1:30 PM–2:00 PM (Invited)
Silicon-Based All-Optical Logic Gates and Memories for Low-Latency, High-Speed Cryptography
Imad Agha, *University of Dayton, Dayton, OH, USA*
While cryptographic protocols run efficiently on general computers, there has been a push towards deployment on smaller scales. Achieving high-throughput on devices with limited resources makes an all-optical approach an attractive prospect. All-optical logic gates and all-optical memories form the backbone of such a platform.

WC3.2 2:00 PM–2:15 PM
Silicon Photonic Cryptographic Engines
Bryan T. Bosworth, Brian C. Grubel, Michael R. Kossey, A. Brinton Cooper, Mark A. Foster, and Amy C. Foster, *Johns Hopkins University, Baltimore, MD, USA*
We present nonlinear chaotic silicon micro-cavities as unclonable physical keys to solve multiple problems in applied cryptography, particularly secure authentication and encryption.

WC3.3 2:15 PM–2:30 PM
Physical-Layer Security in Free-Space Optical Communications Using Bessel-Gaussian Beams
Tyan-Lin Wang and Ivan B. Djordjevic, *University of Arizona, Tucson, AZ, USA*
Physical-layer security in free-space optical communications channels is compromised when eavesdroppers perform optical beam-splitting attacks. Previous simulations showed that Laguerre-Gaussian beams carrying orbital angular momentum provide increased secrecy capacity compared to Gaussian beams. We extend those studies by simulating Bessel-Gaussian beams and obtain further improvement.

WC3.4 2:30 PM–2:45 PM
Photonic Physical Unclonable Functions Using Silicon Nitride Spiral Waveguides
Hongcheng Sun, Milad Alemohammad, Bryan T. Bosworth, Mark A. Foster, and Amy C. Foster, *Johns Hopkins University, Baltimore, MD, USA*
Silicon nitride spiral physical unclonable functions provide unique spectral fingerprints in a compact, integrated platform and have potential for use in IC authentication.

Regency Ballroom A

1:30 PM–3:00 PM
Session WD3: Modes and Propagation
Session Chair: Martin Rochette, *McGill University, Montreal, Quebec, Canada*

WD3.1 1:30 PM–2:00 PM (Invited)
Few-Mode Fibers for Mode Division Multiplexing
Ming-Jun Li, *Corning Research and Development, Corning, NY, USA*
We discuss few-mode fibers for mode division multiplexing applications. We present fiber designs for optimizing few-mode fibers with low differential mode group delays for MDM system using MIMO. We present also design approaches for reducing mode coupling for MIMO-less transmission systems.

WD3.2 2:00 PM–2:15 PM
Mode Selection for Measuring Modal Dispersion in Stokes Space
M. R. Dadras, I. Roudas, and J. Kwapisz, *Montana State University-Bozeman, Bozeman, MT, USA*
The appropriate choice of mode combinations is crucial to the accuracy of modal dispersion characterization techniques. We compute quasi-orthogonal launch modes that minimize the noise error in modal dispersion vector measurements using the mode-dependent signal delay method.

WD3.3 2:15 PM–2:30 PM
Passive Timing Stabilization over a 33-km Single Mode Fiber Link Using Temporal Imaging
Jasper R. Stroud, *Johns Hopkins University, Baltimore, MD, USA*, Olukayode Okusaga, Gregory Weaver, Nelli Mosavi, *Johns Hopkins University Applied Physics Lab, Laurel, MD, USA,* and Mark A. Foster, *Johns Hopkins University, Baltimore, MD, USA*
We demonstrate a temporal imaging system that uses parametric wavelength conversion and dispersion to distribute a stabilized clock and passively correct all-optically for environmental distortions. We demonstrate clock distribution with less than one picosecond drift over one thousand seconds through a 33-km single-mode fiber link.

WD3.4 2:30 PM–3:00 PM (Invited)
PDL-Induced Entanglement Degradation in Fibers with PMD
D. E. Jones, B. T. Kirby, and M. Brodsky, *U.S. Army Research Laboratory, Adelphi, MD, USA*
We experimentally investigate the entanglement quality of polarization-entangled photon pairs transmitted through two fibers with PDL. We compensate for entanglement loss due to PDL despite the presence of significant PMD. A theory supports our observations and provides insight into the conditions necessary for complete compensation.

Regency Ballroom B

1:30 PM–3:00 PM
Session WE3: THz Photonics & MWP Tutorial
Session Chair: Richard de Salvo, *Harris*

WE3.1 1:30 PM–3:00 PM (Tutorial)
THz Over Fiber for High Capacity Wireless Transmission
Alwyn Seeds, Katarzyna Balakier, Chris Graham, Xiaoli Lin, Cyril Renaud, Martyn Fice, and Haymen Shams, *University College London, London, UK*
The requirement for increased data transmission rates for new wireless systems such as 5G and above places heavy pressure on currently allocated wireless spectrum. THz over fibre offers a technology with the potential to meet future needs for short range high data rate communications.

3:00 PM–3:30 PM – EXHIBITS & COFFEE BREAK – GRAND BALLROOM FOYER

POSTER SESSION / STUDENT & YOUNG PROFESSIONALS POSTER COMPETITION AND JOB FAIR

6:00 PM–8:00 PM GRAND BALLROOM E/F/G
Session Chair: Carmen Menoni, *Colorado State University, USA*

Lake Anne A/B

1:30 PM–3:00 PM
Session WF3: Constelaltion Shaping
Session Chair: Ivan B. Djordjevic, *University of Arizona, Tucson, AZ, USA*

WF3.1 1:30 PM–2:00 PM (Invited) Low-Complexity Distribution Matcher Based on Hadamard Matrix Combined with Geometrical Shaping for PAM-4 IM-DD Transmission Systems
Nebojsa Stojanovic and Cristian Prodaniuc, *Huawei Technologies Duesseldorf GmbH, Munich, Germany*
We propose a simple algorithm for controlling PAM-4 level probabilities in IM-DD optical systems. Probabilistic shaping is combined with a level optimization procedure in systems dominated by optical noise. The OSNR gain of 1.5 dB is achieved in simulations by using an EML with ER = 8dB.

WF3.2 2:00 PM–2:30 PM (Invited) Hybrid Probabilistic-Geometric Shaping in Optical Communication Systems
Zhen Qu and Ivan B. Djordjevic, *University of Arizona, Tucson, AZ, USA*
We propose a universal distribution matcher applicable to any two-dimensional signal constellation. We experimentally demonstrate that the performance of the proposed 32-ary quadrature amplitude modulation (QAM), based on hybrid probabilistic-geometric shaping, is superior to probabilistically shaped (PS)-32QAM and regular 32QAM, and comparable to PS-64QAM.

WF3.3 2:30 PM–3:00 PM (Invited) Optimizing the Achievable Rates of Tricky Channels: A Probabilistic Shaping for OPC Channel Example
Metodi P. Yankov, *Fingerprint Cards A/S, Herlev, Denmark and Technical University of Denmark, Lyngby, Denmark,* Francesco Da Ros, Edson Porto da Silva, Søren Forchhammer, Michael Galili, and Leif K. Oxenløwe, *Technical University of Denmark, Lyngby, Denmark*
A method is presented for online probabilistic shaping parameter optimization for channels, which are non-trivial to model and are thus difficult to optimize offline. An example is provided for a mid-link optical phase conjugation based nonlinearity compensation channel with inline dispersion compensation.

Lake Audubon

1:30 PM–2:45 PM
Session WG3: Flexible Photonic Materials
Session Chair: Alexey Belyanin, *Texas A&M University, College Station, TX, USA*

WG3.1 1:30 PM–2:00 PM (Invited) Photonic Device Integration Using Elastomer Stamp Printing
Chris Bower, *X-Celeprint, Cork, Ireland*

WG3.2 2:00 PM–2:15 PM Valley Selective Optical Emission of 2D Excitons Using Chiral Metasurface
S. Guddala, R. Bushati, V. M. Menon, Mengyao Li, and A. B. Khanikaev, *City University of New York (CUNY), New York, NY, USA*
Optical control on specific valley polarization in transition metal dichalcogenide (TMD) monolayers is highly desirable for applications in Valleytronics. We demonstrate specific valley polarization aided through the integration of TMD 2D materials with chiral metasurface at room temperature.

WG3.3 2:15 PM–2:30 PM Electrical Tuning and Switching Effect in Graphene-Assisted Polarization-Insensitive Terahertz Metadevices
Riad Yahiaoui and Thomas A. Searles, *Howard University, Washington, DC, USA*
A tunable polarization-independent metadevice exhibiting a broadband cross-polarized transmission is investigated numerically in the terahertz (THz) regime. The spectral features of the device are dynamically modulated by varying the chemical potential of an overlaid monolayer of graphene without changing the geometrical dimensions of the resonators.

WG3.4 2:30 PM–2:45 PM A Patternable, Anti-Reflective Light Blocking Layer Using a Nano-Particle Suspension in Photoresist
Matthew Hamblin, Thane Downing, Sophia Anderson, Aaron Hawkins, *Brigham Young University, Provo, UT, USA*, and Holger Schmidt, *University of California, Santa Cruz, Santa Cruz, CA, USA*
This paper presents a method for fabricating a broadband anti-reflective light blocking layer patternable on a micron scale using standard photolithography using a combination of photoresist and Al_2O_3 nanoparticles over an aluminum layer.

Lake Thoreau

1:30 PM–3:00 PM
Session WH3: Phosphors and Long Wavelength GaN Materials
Session Chair: Yajie Dong, *University of Central Florida, Orlando, FL, USA*

WH3.1 1:30 PM–2:00 PM (Invited) Narrow Band Emitting LED Phosphors for Wide Color Gamut Displays & Energy Efficient SSL
James Murphy, *General Electric, USA*
Over 20 billion LEDs containing GE RadiantRed(tm) technology, specifically the narrow band red emission of $K_2SiF_6:Mn^{4+}$ phosphor, have been sold, making this phosphor the red emitting luminescent material of choice for wide color gamut displays. Improvements in absorption, efficiency and stability will be presented.

WH3.2 2:00 PM–2:15 PM InGaN-GaNAs Interface Quantum Well with AlGaN Interlayer for Amber-Red Emitters
Chee-Keong Tan, *Clarkson University, Potsdam, NY, USA,* Damir Borovac, Wei Sun, and Nelson Tansu, *Lehigh University, Bethlehem, PA, USA*
The spontaneous emission characteristics of InGaN / dilute-As GaNAs interface quantum well with AlGaN interlayer were calculated and analyzed, and the findings revealed the strong potential of implementing the active region for emission in amber and red spectral regime.

WH3.3 2:15 PM–2:30 PM Experimental Studies of Delta-InN Incorporation in InGaN Quantum Well for Long Wavelength Emission
Ioannis E. Fragkos, Damir Borovac, Wei Sun, Renbo Song, Jonathan J. Wierer, Jr., and Nelson Tansu, *Lehigh University, Bethlehem, PA, USA*
In this study we investigate the incorporation of a delta-InN layer into InGaN quantum wells. Our experimental results indicate that the insertion of this delta-InN layer maintains the crystal quality of the structure, while red-shifting the emitted wavelength towards the red wavelengths.

Grand Ballroom D

3:30 PM–5:00 PM
Session WI4: Plenary II
Session Chair: Amr Helmy, *University of Toronto, Toronto, Canada*
***** Live Streamed*****

WI4.1 3:30 PM–4:15 PM (Plenary) TBD
Ian Walmsley, *University of Oxford, Oxford, UK*

WI4.2 4:15 PM–5:00 PM (Plenary) Ultrafast Lasers for Multi-Photon Microscopy
Jim Kafka, *Spectra-Physics, CA, USA*
Combining femtosecond laser sources with microscopes has created the flourishing field of multi-photon microscopy and provided the ability to produce stunning 3 dimensional images in biological disciplines including neuroscience. Specialized ultrafast sources are required for successful 2-photon and 3-photon microscopy as well as CARS and optogenetics.

3:00 PM–3:30 PM – EXHIBITS & COFFEE BREAK – GRAND BALLROOM FOYER

POSTER SESSION / STUDENT & YOUNG PROFESSIONALS POSTER COMPETITION AND JOB FAIR

6:00 PM–8:00 PM GRAND BALLROOM E/F/G
Session Chair: Carmen Menoni, *Colorado State University, USA*

Grand Ballroom A	Grand Ballroom B	Grand Ballroom C	Regency Ballroom A	Regency Ballroom B
	8:30 AM–10:00 AM **Session ThB1:** Emerging Concepts in Optical Interconnects **Session Chair:** Amy Foster, *Johns Hopkins University, Baltimore, MD, USA*	**8:30 AM–10:00 AM** **Session ThC1:** Secure Communications **Session Chair:** Eduardo Temprana	**8:30 AM–10:00 AM** **Session ThD1:** Fiber Sensing **Session Chair:** Ming-Jun Li, *Corning Research and Development, Corning, NY, USA*	**8:30 AM–10:00 AM** **Session ThE1:** Microwave Photonics Subsystems **Session Chair:** Jean Kalkavage, *Johns Hopkins Applied Physics Lab*
	ThB1.1 8:30 AM–9:00 AM (Invited) **Optical Interconnects for Extreme Computing** Keren Bergman, *Columbia University, New York, NY, USA*	**ThC1.1 8:30 AM–9:00 AM (Invited)** **Integrated Quantum Cryptography: A New Tool in the Tool Chest** Chris Erven, *University of Bristol, UK*	**ThD1.1 8:30 AM–9:00 AM (Invited)** **Enabling Multicore and Single Core Fiber Sensing Using Enhanced Scatter Fibers** Paul Westbrook, *OFS, USA*	**ThE1.1 8:30 AM–8:45 AM** **Photonic-Assisted Multi-Frequency Phase-Coded Microwave Signal Generation** Yang Chen, *East China Normal University, Shanghai, China*, and Shilong Pan, *Nanjing University of Aeronautics and Astronautics, Nanjing, China* A novel photonic approach for multi-frequency phase-coded microwave signal generation is proposed using a dual-drive Mach-Zehnder modulator. The approach has good frequency tunability limited only by the bandwidth of the modulator. Simultaneous generation of phase-coded microwave signals at 5, 10 and 15 GHz are demonstrated.
	ThB1.2 9:00 AM–9:30 AM (Invited) **Data Center Interconnects** David Plant, *McGill University, Montreal, Quebec, Canada*	**ThC1.2 9:00 AM–9:15 AM** **Feasibility of Quantum Communications in Aquatic Scenario** Silvia Tarantino, Daniele Cozzolino, Karsten Rottwitt, and Davide Bacco, *Technical University of Denmark, Lyngby, Denmark* Security in underwater communications is a very sensitive topic due to its great interest in scientific, industrial and military applications. We present a feasibility analysis of different types of quantum communications protocols in aquatic scenario.	**ThD1.2 9:00 AM–9:15 AM** **Heat Transfer Rate Measurements with a Four-Core Fiber Optic Sensor** Sema Güvenç Kılıç and Mehmet Naci Inci, *Boğaziçi University, Istanbul, Turkey* A four-core optical fiber is used to investigate one-dimensional heat transfer measurements. Laser pulses are delivered onto one of the fiber cores, which results in a change in the refractive index and the physical length of the core, causing a phase shift in fringe pattern.	**ThE1.2 8:45 AM–9:00 AM** **GHz-Bandwidth Optical Isolation through Acoustic Pumping of a Nanophotonic Circuit** Donggyu B. Sohn, Seunghwi Kim, and Gaurav Bahl, *University of Illionis at Urbana Champaign, Urbana, IL, USA* We experimentally demonstrate GHz bandwidth non-reciprocal light transmission using acoustic pumping of a nanophotonic circuit. Non-reciprocity is achieved through an indirect interband optical transition as a result of photoelastic perturbation caused by an acoustic wave.
		ThC1.3 9:15 AM–9:30 AM **Toward the Integration of CV Quantum Key Distribution in Deployed Optical Networks** Fotini Karinou, Hans H. Brunner, Chi-Hang Fred Fung, Lucian C. Comandar, Stefano Bettelli, David Hillerkuss, Maxim Kuschnerov, Spiros Mikroulis, Dawei Wang, Changsong Xie, Momtchil Peev, and Andreas Poppe, *Huawei Technologies Duesseldorf GmbH, Munich, Germany* We report on the advances toward the integration of our developed CV-QKD system in existing optical infrastructure and WDM)networks. we demonstrate for first time the use of the aforementioned CV-QKD system to encrypt a 10GE client service over deployable OTN legacy equipment over 20-km.	**ThD1.3 9:15 AM–9:45 AM (Invited)** **Dynamic Range Limits of Fiber Laser Sensors** Brennan C. Pursley, *Sotera Defense Solutions, Herndon, VA, USA*, Peter W. Kampschroeder, Meredith Hutchinson, and Geoffrey A. Cranch, *Naval Research Laboratory, Washington, DC, USA* We demonstrate an upper bound on the dynamic range of fiber lasers sensors when strained sinusoidally at frequencies close to their relative intensity noise peak. Pulsing is observed for the laser with the weakest grating strength.	**ThE1.3 9:00 AM–9:30 AM (Invited)** **Integrated Photonics Optical Beam Forming Networks** Jonathan Klamkin and Yuan Liu, *University of California, Santa Barbara, Santa Barbara, CA, USA*

Lake Anne A/B

8:30 AM–10:00 AM
Session ThF1: High Capacity Flexible Optical Networks
Session Chair: Fatima Gunning, *Tyndall*

ThF1.1 8:30 AM–9:00 AM (Invited)
Migrating from Fixed Grid to Flexible Grid Optical Networks
Sifat Ferdousi, Tanjila Ahmed, Sabidur Rahman, *University of California, Davis, Davis, CA, USA,* Xiaosong Yu, *University of California, Davis, Davis, CA, USA and Beijing University of Posts & Telecom, China,* Massimo Tornatore, *University of California, Davis, Davis, CA, USA and Politecnico di Milano, Milano, Italy,* and Biswanath Mukherjee, *University of California, Davis, Davis, CA, USA*
The Internet backbone infrastructure has to regularly evolve to keep pace with the changing requirements of its users. Next-generation backbone networks will have to support reconfigurable optical channels working at multiple terabit per second to accommodate the growing number of users and their increasing bandwidth requests, as well as be able to adapt to support new and unanticipated services. For more than two decades, optical networks based on wavelength-division multiplexing (WDM) have met the bandwidth needs of the Internet, by scaling up their bandwidth by two to three orders of magnitude.

ThF1.2 9:00 AM–9:30 AM (Invited)
Knowledge-Based Service Provisioning in Multi-Domain Elastic Optical Networks
X. Chen, R. Proietti, M. Shamsabardeh, G. Liu, K. Zhang, and S. J. B. Yoo, *University of California, Davis, Davis, CA, USA*
This paper presents a knowledge-based service provisioning framework for building intelligent multi-domain elastic optical networks (EONs). The proposed framework enables multi-domain EONs operating cognitively according to an observe-analyze-act cycle. Case studies on quality-of-transmission aware light-path provisioning demonstrate the benefit of the proposed framework.

ThF1.3 9:30 AM–10:00 AM (Invited)
Modal Dispersion and Mode-Dependent Loss in Multi-Mode Fibers: Modeling, Measurement and Compensation
Joseph M. Kahn, Karthik Choutagunta, *Stanford University, Stanford, CA, USA,* Sercan O. Arik, *Baidu Research*, and Keang-Po Ho, *Apple*
We review linear propagation effects in strongly coupled mode-division-multiplexed (MDM) systems, including modal dispersion (MD) and mode-dependent loss (MDL). We discuss their impact on system performance and DSP complexity. We propose low-complexity MDL measurement techniques and schemes to compensate MD and MDL in MDM systems.

Lake Audubon

8:30 AM–9:45 AM
Session ThG1: Metamaterials and Imaging
Session Chair: TBD

ThG1.1 8:30 AM–9:00 AM (Invited)
Super-Resolution Imaging with Nanophotonic Structures
Zhaowei Liu, *University of California, San Diego, San Diego, CA, USA*

ThG1.2 9:00 AM–9:15 AM
Electrically Tunable MnO_2 Based Metasurface
Ahasanul Haque, Monir Morshed, *University of New South Wales Canberra, Canberra, Australia*, Ahmmed A. Rifat, Ziyuan Li, Li Li, *Australian National University, Canberra, Australia*, Andrey Miroshnichenko, and Haroldo T. Hattori, *University of New South Wales Canberra, Canberra, Australia*
We report the electrical control of the optical attenuation by a manganese dioxide (MnO_2) metasurface. The attenuation is varied by 25% with the change of current of 5.33 μA. The device shows the potential of this material in tunable devices.

ThG1.3 9:15 AM–9:30 AM
Propagation and Imaging Using Chiral Lenses Without and With Material Dispersion
Monish R. Chatterjee and Salaheddeen G. Bugoffa, *University of Dayton, Dayton, OH, USA*
Refraction across two non-chiral/chiral spherical boundaries is examined by using appropriate chiral Snell's laws via ray analysis assuming monochromatic propagation. The analysis includes transmitted left- and right-circular modes (LCP and RCP) leading equivalent ABCD matrices and 1-D and 2-D imaging analysis under variable chirality parameter.

Lake Thoreau

8:30 AM–10:00 AM
Session ThH1: Perovskites, QDs and Hybrid Devices
Session Chair: Handong Sun, *Nanyang Technological University, Singapore*

ThH1.1 8:30 AM–9:00 AM (Invited)
In-situ Fabricated Perovskite Quantum Dots for Display Technology
Haizheng Zhong, *Beijing Institute of Technology, Beijing, China*
Perovskite quantum dots are now emerging as low-cost alternatives for photonic and optoelectronics. I would like to present the development of in-situ fabricated hybrid perovskite quantum dots embedded composite films and single Cs_4PbBr_6 crystals embeded with $CsPbBr_3$ quantum dots for down-shifting LCD backlights.

ThH1.2 9:00 AM–9:15 AM
Luminescence Dynamics of $CsPbBr_3$ Quantum Dot-Based Color Converters
Miguel F. Leitao, Nicolas Laurand, and Martin D. Dawson, *University of Strathclyde, Glasgow, UK*
The excitation density dependent characteristics of a green-emitting $CsPbBr_3$ quantum dot color converter for GaN LEDs and lasers is reported. The bandwidth is found to increase with the excitation reaching up to 55 MHz at a 185 W/cm^2 pump density.

ThH1.3 9:15 AM–9:30 AM
Electrohydrodynamic-Jet Sprayed Quantum Dots for Solution-Processed QD Light-Emitting-Diodes
Tuan Canh Nguyen and Woon-Seop Choi, *Hoseo University, Asan, South Korea*
In this study, for the first time, quantum dot emitting layers were printed by EHD-Jet spray technology. The QD-LEDs had a structure of ITO/PEDOT:PSS/PVK/ EHD-sprayed QDs/ZnO/Al and showed a luminance of 3,433 cd/m^2, current efficiency of 1.36 cd/A, and EQE of 1.47 %.

Grand Ballroom A	Grand Ballroom B	Grand Ballroom C	Regency Ballroom A	Regency Ballroom B

ThC1.4 9:30 AM–9:45 AM
Polarization Entanglement Quantum Key Distribution with Covert Classical Communications
John Gariano and Ivan Djordjevic, *University of Arizona, Tucson, AZ, USA*
By using a covert classical communication channel for error reconciliation in QKD systems, higher SKRs are capable of being achieved. Assuming transmission over a 30km maritime channel, our previous results for the selection of optimum wavelength for use are re-examined.

ThC1.5 9:45 AM–10:00 AM
Slepian-FBGs-Based Optical Covert Communications
Ivan B. Djordjevic, *University of Arizona, Tucson, AZ, USA*
Various optical encryption/physical-layer security schemes are able to protect the content of the message, but are not able to protect user's privacy by preventing the detection of transmission attempt. To solve for this problem, we propose a Slepian-FBGs-based scheme enabling positive rate optical covert communications.

10:00 AM–10:30 AM – EXHIBITS & COFFEE BREAK – GRAND BALLROOM FOYER

IPC CLOSING CEREMONY – 10:30 AM–12:00 PM – GRAND BALLROOM D

THE IPC CLOSING CEREMONY WILL BE LIVE-STREAMED

Session Chair: Carmen Menoni, *Colorado State University, CO, USA*

BEST STUDENT PAPER AND POSTER AWARDS
POST-DEADLINE SESSION

Lake Anne A/B	Lake Audubon	Lake Thoreau

ThH1.4 9:30 AM–9:45 AM
Hybrid GaN LED/Elastomer Membrane for Uniform Area Illumination
F. Farrell, E. Xie, B. Guilhabert, *University of Strathclyde, Glasgow, UK,* A-M. Haughey, *Fraunhofer Centre for Applied Photonics, Glasgow, UK*, P. Connolly, M. D. Dawson, and N. Laurand, *University of Strathclyde, Glasgow, UK*
A mechanically-flexible device for uniform area illumination is presented. The device consists of a 1 mm-thick elastomeric membrane edge-lit by a GaN LED. Homogenous irradiance above 0.13 mW/cm^2 at 450 nm over 2.5 cm^2 is reported. Performance improvements, scalability and operation at other wavelengths are discussed.

ThH1.5 9:45 AM–10:00 AM
Improvement in the Radiative Efficiency of InGaN-Based Multiple Quantum Wells Using AlGaN Interlayers
Syed Ahmed Al Muyeed, Wei Sun, Xiongliang Wei, Renbo Song, *Lehigh University, Bethlehem, PA, USA,* Daniel Koleske, *Sandia National Laboratories, Albuquerque, NM, USA,* Nelson Tansu, and Jonathan J. Wierer, Jr., *Lehigh University, Bethlehem, PA, USA*
$Al_yGa_{1-y}N$ interlayers are used on top of $In_xGa_{1-x}N$ quantum wells as strain compensating layers to force pseudomorphic growth of the entire InGaN/AlGaN/GaN multiple quantum well stack. This leads to lower defect formation and higher radiative efficiency at green-gap (520–630 nm) wavelengths.

10:00 AM–10:30 AM – EXHIBITS & COFFEE BREAK – GRAND BALLROOM FOYER

IPC CLOSING CEREMONY – 10:30 AM–12:00 PM – GRAND BALLROOM D

THE IPC CLOSING CEREMONY WILL BE LIVE-STREAMED

Session Chair: Carmen Menoni, *Colorado State University, CO, USA*

BEST STUDENT PAPER AND POSTER AWARDS
POST-DEADLINE SESSION

Session WP: Poster Session / Student & Young Professionals Poster Competition and Job Fair
Wednesday, 3 October 2018
6:00 PM–8:00 PM
Room: Grand Ballroom E/F/G

Session Chair: Carmen Menoni, *Colorado State University, CO, USA*

WP1
All-In-One Optofluidic Platform for Differential Diagnostics of Multiple Biomarkers with Single Molecule Sensitivity, A. Jain, G. G. Meena, J. W. Parks, A. Stambaugh, *University of California Santa Cruz, Santa Cruz, CA, USA,* J. L. Patterson, *Texas Biomedical Research Institute, San Antonio, TX, USA,* A. R. Hawkins, *Brigham Young University, Provo, UT, USA,* and H. Schmidt, *University of California Santa Cruz, Santa Cruz, CA, USA*

Amplification-free and high throughput single nucleic acid detection, with minimal user input, is achieved by integrating optical waveguides with programmable valve array on a single microfluidic platform. Automated preparation and analysis of a dual protein-nucleic acid assay for Zika viral diagnostics is demonstrated.

WP2
Applying Voltage-Current-Converter Circuitry for Increasing Gray Levels in Dual-Panel Active-Matrix Organic Light-Emitting Display Architecture, Henglong Yang and Anne-Chin Lin, *Natioanl Taipei University of Technology (Taipei Tech), Taipei, Taiwan*

We investigated the feasibility of increasing effective gray levels of organic light-emitting diode (OLED) by applying voltage-current converter (VCC) circuitry for converting the driving voltage signals used in liquid-crystal display (LCD) to precise output driving current utilizing dual-panel (DP) active-matrix organic light-emitting display (AMOLED) architecture.

WP3
Fourier Transforms for Wavelength-Selective Optical Packet Switching with Wavelength Translation, Robert T. Weverka, *Fathom Computing, Palo Alto, CA, USA*

We show spatial switching and wavelength translation using an optical temporal Fourier transform to give wavelength-selective spatial switches where the number of spatial switches is reduced by 1/M for an M multiplexed wavelengths and the system uses order $\log_2(M)$ switches for wavelength translation.

WP4
Lighting as a Service that Provides Simultaneous 3D Imaging and Optical Wireless Connectivity, Johannes Herrnsdorf, Jonathan McKendry, Mark Stonehouse, *University of Strathclyde, Glasgow, UK*, Laurence Broadbent, Glynn C. Wright, *Aralia Systems, Bristol, UK*, Martin D. Dawson, and Michael J. Strain, *University of Strathclyde, Glasgow, UK*

Light-emitting diodes enable optical wireless datatransmission and advanced imaging methods such as photometricstereo-imaging. Both, wireless communications into a scene and3D imaging of that scene is enabled in parallel using the sameset of LEDs thus providing lighting-based infrastructure e.g. forautomated agents.

WP5
Synthesis, Microstructure and Quantum-Cutting Luminescence of Pr^{3+}/Yb^{3+}: $NaGdF_4$@ Yb^{3+}:$NaYF_4$ Core/Shell Nanocrystals, Yuansheng Wang, *Chinese Academy of Sciences, Fuzhou, China*

Pr^{3+}/Yb^{3+}:$NaGdF_4$@Yb^{3+}:$NaYF_4$ active-core/active-shell nanoparticles were fabricated, and their luminescent properties were studied. Rational distribution of active rare earth ions owing to the introduction of extra Yb^{3+} ions into the shells greatly suppresses the adverse concentration quenching effect, resulting in an efficient quantum-cutting luminescence for the nanostructures. “

WP6
Plasmonic Enhancement in Anisotropic Thin Films of Rhenium Disulphide (ReS_2), Bablu Mukherjee, Sandipta Roy, *Indian Institute of Technology Bombay, Mumbai, India*, Ergun Simsek, *Exponent, Inc., Bowie, MD, USA*, Sayantan Ghosh, *Indian Institute of Technology Bombay, Mumbai, India*, Venu G. Achanta, *Tata Institute of Fundamental Research, Mumbai, India*, and Saurabh Lodha, *Indian Institute of Technology Bombay, Mumbai, India*

Anisotropic optical constants of N-layer ReS_2 are determined by angle resolved reflection measurements. Optimum parameters for a metal nanoparticle array leading to maximum light-matter interaction are determined using numerical simulations. Plasmonic enhancement in absorptance of the ReS_2 layer and photocurrent are observed experimentally.

WP7

Design and Analysis of Graphene-Based Single Mode SOI Integrated Optical Sensor, Venkatesha M., Vaibhav L Shah, Sai Preethi Jatta, and Narayan K, *Sai Vidya Institute of Technology, Bangalore, India*

In this study, use of graphene in reduction of optical power loss occurring in SOI waveguides at red wavelength region has been presented. In comparison with SOI waveguide, 17.07% reduction in optical power loss is observed for graphene based SOI waveguide at 660 nm wavelength.

WP8

Thick Epsilon-Near-Zero ITO Metamaterial Films, Jimmy Ni, Wendy Sarney, *U.S. Army Research Laboratory, Adelphi, MD, USA*, Joe Bennett, *National Institute of Standards and Technology, Gaithersburg, MD, USA*, and Weimin Zhou, *U.S. Army Research Laboratory, Adelphi, MD, USA*

We explore the concept, material, and design of EMNZ material within the RF photonics regime. Thee wave-matter interaction has been studied on the ITO-based platforms and suggest feasible designs for implementation of environmental insensitive applications in the microwave regime.

WP9

Propagation across Chiral Interfaces and Tunable Slab Resonators Without and With Dispersion, Monish R. Chatterjee and Rajab Y. Ataai, *University of Dayton, Dayton, OH, USA*

Following up on analysis of Fresnel coefficients for a non-chiral/chiral interface, propagation and imaging characteristics are examined for materials with dispersion and chirality, including discrete chiral components such as lenses and chiral resonators. Properties such as anomalies, tunability, and possible new applications are also explored.

WP10

Laterally Coupled Nanowire Lasers: Bifurcations, Dynamics and High-Speed Potential, A. Hurtado, D. Jevtics, M. D. Dawson, *University of Strathclyde, Glasgow, UK*, M. J. Adams, and I. D. Henning, *University of Essex, Colchester, UK*

Regions of stability in two laterally-coupled InP nanowire lasers are analysed in terms of their separation, difference in resonant frequencies and pumping rate. The frequency of periodic oscillations for realistic laser separations and pumping is estimated to be of order 100–1000 GHz.

WP11

Biocompatible, Inkjet Printed Heterostructure Photodetector for Biosensing Applications, Ridwan F. Hossain and Anupama B. Kaul, *PACCAR Technology Institute and University of North Texas, Denton, TX, USA*

An inkjet printed, biocompatible photodetector to combat age-related-macular degeneration is described here that was constructed using inks of photo-active molybdenum disulfide and electrically conducting graphene which facilitated charge collection of the photocarriers. The flexible photodetector was tested as a function of photo intensity and strain.

WP12

Increasing Maximum Gain in InAs Quantum Dot Lasers on GaAs and Si, Samuel Shutts, *Cardiff University, Cardiff, UK,* Clemens Spinnler, *University of Basel, Basel, Switzerland*, Zhibo Li, Lydia Jarvis, Emmanuel Le Boulbar, David Hayes, *Cardiff University, Cardiff, UK*, Mingchu Tang, Huiyun Liu, *University College London, London, UK*, and Peter M. Smowton, *Cardiff University, Cardiff, UK*

InAs quantum-dot (QD) lasers emitting at 1300 nm with nominally undoped and modulated p-type doping are studied. Modal-gain measurements indicate a higher gain can be achieved from the ground-state for a given Fermi-level separation with p-doping and a reduced temperature-dependence of threshold current for short-cavity lasers.

WP13

Simulation of Integrated Transmitter with Enhanced Power for Analog RF Links, Varghese A. Thomas, Christian G. Bottenfield, Gareeyasee Saha, Siddharth J. Varughese, and Stephen E. Ralph, *Georgia Institute of Technology, Atlanta, GA, USA*

We present integrated transmitter architectures that overcome typical power limitations of silicon photonic modulators by relying on a silicon nitride bypass. Simulations demonstrate improvements in SFDR by ~10dB, NF by ~15 dB and Gain by ~25 dB.

WP14

Filtering, Unwrapping, and Denoising Sterategy for Quality Enhancement of the Noisy Wrapped Phase of the Neuronal Cells, Behnam Tayebi and Jae-Ho Han, *Korea University, Seoul, South Korea*

We present a novel technique to improve the quality of a noisy phase by reducing the residues using sin/cos averaging, unwrapping by the 2D minimum-network-flow, and denoising by the non-local filter. The feasibility of technique is demonstrated by improving the phase of neuronal cells.

WP15

Optomechanically Enhanced High-Q Slot Mode Photonic Crystal Nanobeam Cavity, Mertcan Erdil and Serdar Kocaman, *Middle East Technical University, Ankara, Turkey*

A high-Q slot mode photonic crystal nanobeam cavity based biosensor design with positive optomechanical feedback is presented. Detailed analysis of sensitivity enhancement due to feedback shows a fourfold improvement without any compromise in quality factor.

WP16

Optical Fiber Immunosensors Optimized with Cladding Etching and ITO Nanodeposition, Yamile Cardona-Maya, *Universidad Nacional de Colombia, Medellín, Colombia*, Ignacio Del Villar, Abian B. Socorro, Jesús M. Corres, *Public University of Navarra, Pamplona, Spain*, and Juan F. Botero-Cadavid, *Universidad Nacional de Colombia, Medellín, Colombia*

Etched optical fiber immunosensors, with and without nanodeposition, have been developed. The performance of these immunosensors has been assessed implementing an immunoassay. The sensitivity of the immnunosensor increased by a factor of 4 with the nanocoating.

WP17

Three-Dimensional Label-Free Characterization of Frog Erythrocytes Using Optical Diffraction Tomography, Geon Kim, Moosung Lee, *Korea Advanced Institute of Science and Technology, Daejeon, South Korea*, Daeheon Kwon, SeongYeon Youn, EuiTae Lee, Jonghun Shin, *Daejeon Science High School for the Gifted, Daejeon, South Korea*, SangYun Lee, *Korea Advanced Institute of Science and Technology, Daejeon, South Korea*, Youn Sil Lee, *Daejeon Science High School for the Gifted, Daejeon, South Korea*, and YongKeun Park, *Korea Advanced Institute of Science and Technology, Daejeon, South Korea*

Amphibian erythrocytes have cellular structures distinct from mammalian erythrocytes, yet have not been investigated in details. Here, we access the structures of live frog erythrocytes in three-dimension using optical diffraction tomography.

WP18

Controlled Synthesis of InGaN Quantum Dots for Efficient Light Emitters, Xiongliang Wei, Syed Ahmed Al Muyeed, Matthew Peart, Nelson Tansu, and Jonathan J. Wierer, Jr., *Lehigh University, Bethlehem, PA, USA*

InGaN quantum dots formed by quantum-size controlled photoelectrochemical etching are demonstrated. The QDs are capped with AlGaN/GaN passivation layers to reduce surface recombination. These QDs are small-sized, <10 nm in diameter, and emit at ~412 nm with a narrow FWHM of 8 nm at 77K.

WP19

Color Simulation and Demonstration of Perovskite Nanocrystal Filters for Wide Color Gamut Displays, Sinan Genc, Emre Beskazak, *Abdullah Gül University, Kayseri, Turkey*, Can Uran, *NANOME R&D, Erciyes Teknopark, Kayseri, Turkey*, and Evren Mutlugun, *Abdullah Gül University, Kayseri, Turkey*

In this study, we define spectral parameters of perovskite nanocrystals to improve LCD color gamut, replacing color filters (CFs) with perovskite based subpixels. The optimization of the CFs has been enhanced 15.8% (98.33% of Rec.2020) in simulation and 13.8% experimentally, with 97.23% color gamut coverage.

WP20

Tunable Microwave Photonic Filter for Millimeter-Wave Mobile Fronthaul Systems, Run Kai Shiu, *National Taipei University of Technology, Taipei, Taiwan*, Siming Liu, *Georgia Institute of Technology, Atlanta, GA, USA*, Peng-Chun Peng, Wei-Chieh Tang, *National Taipei University of Technology, Taipei, Taiwan*, Shuyi Shen, Qi Zhou, and Gee-Kung Chang, *Georgia Institute of Technology, Atlanta, GA, USA*

In this paper, a tunable microwave photonic filter for millimeter-wave mobile fronthaul systems is proposed and experimentally demonstrated. With the aid of the proposed filter, we can improve and centrally control the system transmission efficiency and decrease the complexity of the mobile fronthaul systems.

WP21

Latency and Reliability Measurements for a 3.5 GHz Optical-Wireless WDM-PON Network Using SDR, Mónica Rico-Martínez, Margarita Varón, *Universidad Nacional de Colombia, Bogotá, Columbia*, Jesús Álvarez Guerrero, Ferney Amaya, *Universidad Pontificia Bolivariana, Medellín, Colombia*, and Idelfonso Tafur Monroy, *Eindhoven University of Technology, Eindhoven, The Netherlands*

This article presents a 3.5 GHz Radio-over-Fiber experimental setup by combining WDM-PON and Software Defined Radio (SDR) for 5G networks applications. We performed a measurement of latency in the order of 1 ms with a Bit Error Rate (BER) lower than 10^{-9}.

WP22

Effect of Base Parameters on the Gain Performance of Multiple-Quantum Well Heterojunction Phototransistor, Rikmantra Basu and Ankit Kumar Pandey, *National Institute of Technology, Delhi, India*

A multiple quantum well heterojunction phototransitor with $Ge_{0.91}Sn_{0.09}$ well and Ge barrier is presented. The work is focussed on effect of base doping and base thickness on the gain performance of device. The optimised base thickness and doping are presented.

WP23

Carrier Lifetime in Mid-Infrared Type-II Superlattice Photodetectors, Wenxiang Huang, L. Li, L. Lei, J. A. Massengale, H. Ye, Rui Q. Yang, T. D. Mishima, and M. B. Santos, *University of Oklahoma, Norman, OK, USA*

A simple and effective electrical method is developed to extract the minority carrier lifetime in type-II InAs/GaSb/Al(In)Sb superlattices by taking advantage of the features of interband cascade infrared photodetectors. This method considers parasitic resistances and is more generally applicable with various transport mechanisms.

WP24

Hybrid Integration of Black Phosphorus-WSe_2 Heterojunction Photodetector on Silicon Waveguide, Yi Wang, Beilei Sun, *Chinese University of Hong Kong, Shatin, Hong Kong*, Ming Feng, *Chinese University of Hong Kong, Shatin, Hong Kong and Nankai University, Tianjin, China*, and Jianbin Xu, Hon Ki Tsang, *Chinese University of Hong Kong, Shatin, Hong Kong*

We design and fabricate a photodetector based on integrated black phosphorus–WSe_2 on silicon waveguide hybrid structure. The device has a photoresponsivity of 16 mA/W at 1560 nm.

WP25

Novel Concept for Heterogeneously Integrated High-Speed III-V Photodetector on Silicon Nitride Waveguide, Shahram Keyvaninia, Patrick Runge, Alexander Schindler, Tobias Beckerwerth, and Martin Schell, *Fraunhofer Heinrich Hertz Institute HHI, Berlin, Germany*

A novel design for heterogeneously integrated high-speed III-V photodetectors on the Si_3N_4 platform is proposed. This new approach offers a new platform to merge III-V and Si3N4 for 3D integration. The design is shown to have a high tolerance to bonding and lithography misalignment.

WP26

Characterization of Distributed Bragg Reflectors Using Optical Frequency Domain Reflectometry, Dan Zhao, Dzmitry Pustakhod, Kevin Williams, and Xaveer Leijtens, *Eindhoven University of Technology, Eindhoven, The Netherlands*

We present a novel and accurate method for characterizing the reflection spectra of distributed Bragg reflectors (DBRs) using the optical frequency domain reflectometry (OFDR) method. A compact test structure with integrated reference mirror and photodetector is designed to overcome the dependence on the fiber coupling.

WP27

Hybrid Integration of Broadband Silicon Modulators and InGaAs Photodetectors, Utku Karaca, Alperen Govdeli, and Serdar Kocaman, *Middle East Technical University, Ankara, Turkey*

We present on-chip integration of silicon modulators and InGaAs photodetectors via flip-chip bonding. Modulators fabricated on silicon-on-insulator (SOI) and photodetectors grown on InP wafers were fabricated independently and the hybrid integration was achieved by the deposition of indium (In) bumps on both sides.

WP28

Fabrication-Tolerant Efficient Dual-Etch Grating Couplers with Low Back Reflections, Andrew Michaels, *University of California, Berkeley, Berkeley, CA, USA and Hewlett Packard Labs, Palo Alto, CA, USA*, Thomas Van Vaerenbergh, Tho Tran, Marco Fiorentino, and Raymond G. Beausoleil, *Hewlett Packard Labs, Palo Alto, CA, USA*

Using inverse electromagnetic design, we optimize dual-etch grating couplers with a 100 nm minimum feature size compatible with DUV lithography that achieve a record peak coupling efficiency of –0.7 dB and unprecedented low back reflection of < –40 dB.

WP29

Effect of Surface Plasmons on the Insulator to Metal Transition in Thin Film Vanadium Dioxide, Scott Madaras, Jason Creeden, *College of William and Mary, Williamsburg, VA, USA*, Salinporn Kittiwatanakul, Jiwei Lu, *University of Virginia, Charlottesville, VA, USA*, Irina Novikova, and Ale Lukaszew, *College of William and Mary, Williamsburg, VA, USA*

We report on a new mechanism capable of inducing the insulator metallic transition (IMT) in VO_2 via surface plasmon polariton (SPP) excitation and the corresponding effect that the IMT will have on the surface plasmon resonance (SPR).

WP30

Asymmetric Band Gaps in Amorphous Photonic Materials, Murat Can Sarihan, *Middle East Technical University, Ankara, Turkey and University of California, Los Angeles, Los Angeles, CA, USA*, Alperen Govdeli, *Middle East Technical University, Ankara, Turkey*, Mehmet Sirin Aras, *University of California, Los Angeles, Los Angeles, CA, USA*, Cenk Yanik, *Sabanci University, Istanbul, Turkey*, Chee Wei Wong, *University of California, Los Angeles, Los Angeles, CA, USA*, and Serdar Kocaman, *Middle East Technical University, Ankara, Turkey*

A Monte Carlo method based design guideline for 2-D amorphous photonic materials are presented. The parameters affecting band gap are analyzed numerically and experimentally for telecommunication wavelengths. Asymmetric nature of band gap is explained in analogy with solid-state electronics.

WP31

Microstructural Engineering of the Near-UV Photocurrent Production in VO_2 Thin Film Based Detectors, J. A. Creeden, S. E. Madaras, D. B. Beringer, M. R. Beebe, I. Novikova, and R. A. Lukaszew, *College of William and Mary, Williamsburg, VA, USA*

Vanadium Dioxide is a strongly correlated material that can exhibit photoelectric properties via substrate-film hole transfer. We study these photoelectric properties in epitaxially grown VO_2 thin films under near UV-light on various substrates, namely TiO_2(001), and TiO_2:Nb in development of new, fast UV photodetectors.

WP32

Employing GRIN PC-Inspired Approach for Building Invisibility Cloak Media from Photonic Crystals, Saeid Jamilan and Elena Semouchkina, *Michigan Technological University, Houghton, MI, USA*

Employing photonic crystals in transformation media requires realizing prescribed anisotropic spatial dispersions of refractive index components. We show that in invisibility cloaks, anisotropy can be provided by using crystals with rectangular lattices, while inspired by GRIN PCs approach can be employed to decrease scattering cross-section.

WP33

Shallow Surface Reliefs on Zn-Diffusion VCSELs for High-Speed and High-Power Single-Mode Performances, Zuhaib Khan, Chen-Lung Cheng, Kai-Lun Chi, and Jin-Wei Shi, *National Central University, Taoyuan, Taiwan*

By creating shallow surface relief patterns above the Zn-diffusion apertures of VCSELs, a significant reduction in optical linewidth, enhancement in output power, and improvement in high-speed transmission performance over multi-mode fiber (MMF) have been first demonstrated.

WP34

Transfer-Matrix Investigation of High Sensitivity Hybrid Glass/Polymer Long Period Fiber Gratings, Bjorn Paulson, Hojoong Jung, Seongjin Hong, Kyunghwan Oh, *Yonsei University, Seoul, South Korea,* Sanghwa Lee, and Jun Ki Kim, *Univerity of Ulsan and Asan Medical Center, Seoul, South Korea*

Long-period fiber gratings (LPFGs) were fabricated by self-annealing of a polymer-filled silica hollow optical fiber without an amplitude mask, and show high temperature sensitivity. The spectral characteristics are modeled using the transfer matrix method, achieving good match with experimental results, and making possible further application.