These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

07:00–18:00 Registration, Grand Peninsula Foyer

08:00–10:00 JM1A • Introductory Remarks and Plenary Session, Grand Peninsula EF

10:00–10:30 Networking Coffee Break with Exhibitors, Grand Peninsula D

10:30–12:30 NeM2D • Free-space Optical and Satellite Communications
Presider: David Geisler; Massachusetts Inst. of Tech Lincoln Lab, USA

NeM2D.1 • 10:30
NASA Optical Communication Strategy and Technology, Michael A. Kranak, Donald M. Cornell; NASA, USA. We discuss NASA’s next decade program for deployment of space-flight optical communication satellites and ground stations. Key technology includes integrated photonics, optical phased arrays, pointing-tracking systems, and photon-counting detectors.

NeM2D.2 • 11:00 Top Selected
Narrowband Optical Filtering with Wide Angular Acceptance for Free-space Optical Communications, Katia Shyrykova, Igor Gaschits, David O. Caplan, MIT Lincoln Laboratory, USA. We demonstrate improved angular acceptance for low-loss narrowband optical filtering for high-sensitivity photon-counting free-space applications. Using a silicon etalon, a GHz-class passband with 230% greater low-loss angular acceptance is achieved.

NeM2D.3 • 11:30
Liquid Crystal Tunable Beam Steering for Free-space Optical Communications, Francisco Algorri1, Noureldine Berna1, Dimitris Zografopoulos1, Virginia Uruch1, Przemyslaw Mostwaci2, Lezrek Jaroszewicz2, Jose Manuel Sanchez-Pera2,1; UC3M, Spain; 2Instituto per la Microelettronica e Microsistemi (CNR-IMM), Italy. In this work it is proposed a LC beam steering that overpass the typical LC phase modulators, it has a very simple voltage control is lighter and smaller than previous proposals.

NeM2D.4 • 11:45
Free-space Optical Communication for Spacecraft and Satellites, including CubeSats in Low Earth Orbit (LEO), Peter M. Goorjian, NASA Ames Research Center, USA. A static system is described, and computed results for it are shown for laser beam transmissions from a Cubsat in low Earth orbit. This system can replace current architectures which use dynamical systems (moving parts).

12:30–14:00 Lunch (on own)

14:00–16:00 Lunch (on own)

16:30–18:00 Lunch (on own)

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These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

**14:00–16:00**

**IM3A • Integrated Devices and Circuits**

**Presider:** Meer Nazmus Sakib; Intel Labs-Photonics Research, USA

- **IM3A.1 • 14:00**  
  System-on-a-Chip Photonic Integrated Circuits Enabling C+L Band 57.6 Tbps Capacity Long Haul Links, Thomas Frost, Gloria Hoefler, Payam Abolghasem, Lee Dardis, Abdou Diba, Bryan Ellis, Ryan Goings, Xian Xu, Alex Kumpara, Scott Corzine, Sajeev Murthy, Matthias Kuntz, Jianping Zhang, Parmjit Samra, Vikrant Lal, Don Pavinski, Tim Butrie, Jeffrey Rahn, Steve Sanders, Vince Dominic, Peter Evans, Mehrdad Zarif, Fred Kish; Infineon Corporation, USA. We present multi-channel monolithically integrated InP-based photonic integrated circuits emitting in both the C and L bands with 200 Gbps transmission per wavelength, enabling long haul links with up to 57.6 Tbps capacity.

- **IM3A.2 • 14:30**  
  Parameter Extraction, Variability Analysis and Yield Prediction of the Photonic Integrated Circuits, Umar Khan, Yule Xing, Wim Bogerts, Photons Research Group, Ghent Univ.-IMEC, Belgium; Center of Nano and Biophotonics, Belgium. We discuss the complete workflow from the extraction of behavioral and fabricated geometry parameters using optical measurements to a decomposition of spatial variability and ultimately to the layout-aware yield prediction of PICs.

- **IM3A.3 • 15:00**  
  Electronic/Photonic Design Automation (EPDA) for InP-Photonic Integrated Circuit Process Design Kit, Yuchun Zhou, Ashish Bhardwaj, John Mason, Wai Leong; Shun Li, Stefan Wolf; Thomas Ballaart; Adam James, Pablo Menas, Enrico Ghillino, Rob Scarmozzino, Gloria Hoefler, Fred Kish; Infineon Corporation, USA; Synopsys Inc., USA. A state-of-the-art process design kit for an InP photonic integrated circuit foundry using electronic/photonic design automation environment is discussed. Automated design tools are used to design PICs using data-driven models.

- **IM3A.4 • 15:15**  
  Improved Power-handling of OEO Conversion on a Generic Photonic Integration Platform, Peter L. Tanning, Martin J. Heck; Aarhus Univ. Dept. of Engineering, Denmark. Improved power-handling of optical-electrical-optical conversion structures purely by circuit design within a commercially available photonic integration platform. This conversion is achieved with no electrical RF-input.

- **IM3A.5 • 15:30**  
  Improved Power-handling of OEO Conversion on a Generic IM3A.4 • 15:15

**Presider:** Mikhail Kats; Univ. of Wisconsin-Madison, USA

- **NoM3B.1 • 15:00**  
  Measuring Everything You’ve Always Wanted to Know about a Light Pulse, Rick Trebino; Georgia Inst. of Technology, USA. I will review techniques (and their issues) for measuring ultrashort laser pulses in time and space, including simple methods for measuring the complete spatio-temporal electric field of an arbitrary, potentially complex light pulse.

- **NoM3B.2 • 15:00**  
  Graphene Oxide for Enhanced Nonlinear Optics in Integrated Waveguides, Jayang Wu, Yunyf Yang, Xingyan Xu, Yang Gu; Linnan Jia, Yuning Zhang, Yoa Liang, Sai T. Chu; Brent Little, Roberto Morandotti, Baohua Jia; David J. Moss; Swinburne Univ. of Technology, Australia; Chinese Academy of Science, China; City Univ. of Hong Kong, China; INRS, Canada. We experimentally demonstrate enhanced Kerr optical nonlinearities of waveguides integrated with layered graphene oxide (GO) films. Up to > 9.5 dB enhancement of four-wave mixing conversion efficiency is achieved for a waveguide with 2 layers of GO.

- **NoM3B.3 • 15:15**  
  Measurement of Wavelength and Temperature Dependent Refractive Index of GaSb, Jean Wei, Joel Murray, Charles Reiney, Shekhar Guha; US Air Force Research Laboratory, USA. Temperature-dependent refractive index values of GaSb were measured at wavelengths between 1.7 and 9.8 micrometers, over a temperature range of 81 to 400 K. A temperature dependent Sellmeier equation was obtained.

**14:00–16:00**

**PM3C • LED 1**

**Presider:** Seunghyup Yoo; Korea Advanced Inst of Science & Tech, Korea (the Republic of)

- **PM3C.1 • 14:00**  
  Efficient Perovskite Optoelectronic Devices: Carrier Kinetics and Efficiency Modelling, Dawei Di; Zhejiang Univ., China; Univ. of Cambridge, UK. We demonstrate perovskite-polymer bulk heterostructure LEDs exhibiting external quantum efficiencies of up to 20.1%. The kinetics of excited-state carriers is studied. Besides, we present our progress in the modelling of new solar cell structures.

- **PM3C.2 • 14:30**  
  In silico Discovery of Emitters and Charge Transporters for Organic Light-Emitting Diodes, Hironori Kaji; Kyoto Univ., Japan. Recently, remarkable progress has been made in the development of organic LEDs. Here, we show our recent results on thermally activated delayed fluorescence, multiscale charge transport simulation, and dynamic nuclear polarization-NMR.

- **PM3C.3 • 14:45**  
  Realization of Stretchable OLEDs through the Stacked Structure of Stress Relief Layer and Stretchable Platform, Taehyun Kim, Hyeonwoo Lee, Seunghiee Lee, Seunghyup Yoo; Korea Advanced Inst. of Science and, Korea (the Republic of). The stress relief layer is an effective method to fabricate stretchable OLEDs with minimal compromise in performance. Stretchable OLEDs fabricated by this method have very little change in efficiency even when interconnectors are stretched 140%.

- **PM3C.4 • 15:00**  
  Efficient Light-emitting Diodes Based on Colloidal Metal-halide Perovskite Nanoparticles, Tae-Woo Lee; Seoul National Univ., Korea (the Republic of). We report ligand-engineered perovskite nanoparticles (NPs) based on methylammonium (MA) and formamidinium (FA) cations beyond quantum size and highly efficient perovskite NP light-emitting diodes (LEDs).
14:00–16:00
**NeM3D • Devices and Transmission 1**
Presider: Wolfgang Freude; Karlsruhe Inst. of Technology, Germany

**NeM3D.1 • 14:00**
Invited
Single Wavelength Intensity-modulation and Direct Detection at 500 Gb/s, Xi Chen; Nokia Bell Labs, USA. Single Wavelength Intensity-modulation and Direct Detection at 500 Gb/s.

**NeM3D.2 • 14:30**
Invited

**NeM3D.3 • 15:00**
10 Gb/s Data Transmission over 30 km Using a 1.5 µm Widely Tunable Directly Modulated InGaAsP DBR Laser, Daibing Zhou, Song Liang, Guangzian Chen, Wu Zhao, Dan Lu, Lingjuan Zhao, Wei Wang; Inst Semiconductors, CAS, China. We report 10 Gb/s data transmission over 30 km using a packaged two-section InGaAsP distributed Bragg reflector (DBR) laser. The tunable DBR laser has a wavelength tuning range over 12 nm.

**NeM3D.4 • 15:15**
Nanophotonics Based Residue Number System, Shuai Sun, Jiaxin Peng, Tarek El-Ghazawi, Volker J. Sorgel; George Washington Univ., USA. We design a nanophotonic RNS arithmetic by spatially shifting the input relative to the outputs, where the moduli are represented by the number of waveguides, which can be used for functional analysis of convolutional neural networks.

14:00–15:45
**SpM3E • Optical Signal Processing**
Presider: Koji Igarashi; Osaka Univ., Japan

**SpM3E.1 • 14:00**
GHz-speed Tracking of the Frequency Spectrum of Complex Continuous Waveforms through Photonic Analog Processing, Saikrishna Reddy Konatham, Reza Maram, José Azaña, INRS-EMT, Canada. We demonstrate real-time dynamic Fourier analysis of complex GHz-bandwidth microwave waveforms, including multiple evolving frequency bands, by mapping the full spectrogram along the time domain using a simple photonic sampling and dispersion scheme.

**SpM3E.2 • 14:30**
Noise-tolerance Evaluation for Optical 8QAM Coded Label Recognition Circuit, Tumendemberel Surenkhoroil, Hiroki Kishikawa, Nobuo Goto, Tokushima Univ., Japan. A waveguide-type label recognition circuit is proposed for optical 8QAM coded signal. The proposed method is operable for both of the maximum and minimum output detection cases for which the noise tolerance evaluation is investigated.

**SpM3E.3 • 14:45**
Dual Channel Wideband Microwave Photonic Switch Exploiting Single Mode Fiber Based Fano Resonance, Siva Shakthi A, Ravi Pant; IISER Thiruvananthapuram, India. We report the first demonstration of high resolution dual-channel wideband microwave photonic switch from 1-11GHz with extinction >30dB exploiting Fano resonance based on stimulated Brillouin scattering in single-mode fibre.

**SpM3E.4 • 15:00**
Invited
Optical Signal Processing and Sensing in Parametric Devices, Ana Pejkic, Stojan Radic; Univ. of California San Diego, USA. Optical signal processing and sensing at a few photon level is now possible in parametric devices due to progress in longitudinal dispersion engineering. Amplifier design and performance is reviewed and results are summarized.
IM3A • Integrated Devices and Circuits—Continued

IM3A.5 • 15:30
Electro-optically Tunable Modified Racetrack Resonator in Hybrid Si₃N₄-LiNbO₃, Abu Naim Rakib Ahmed¹, Shouyuan Shi¹, Jack Manely¹, Peng Yao¹, Dennis Prather¹; Univ. of Delaware, USA. We experimentally demonstrate the first Si₃N₄-LiNbO₃ hybrid electro-optic tunable racetrack resonator with the modified electrode to enhance the modulation efficiency. The measured tunability and the intrinsic Q are 2.8 pm/V and 8 × 10⁶ respectively.

IM3A.6 • 15:45
Shallow-angle Grating Coupler for Vertical Emission from Indium Phosphide Devices, Keisuke Kajima¹,², Toshiaki Koike-Akino¹, Mohammad Tahersima¹, Kieran Parsons¹, Thomas Messers², Bowen Song², Jonathan Klamkin²; Mitsubishi Electric Research Labs, USA;¹ Electrical and Computer Engineering Dept, University of California Santa Barbara, USA. We propose a long period grating in an indium phosphide waveguide for redirecting the guided mode to a downward angle targeting hybrid integration with silicon waveguides. A simulated end-to-end coupling efficiency of 58% is obtained.

NoM3B • Nonlinear Materials and Devices—Continued

NoM3B.4 • 15:30
Broad Band Ultrafast Response Vertical Phototransistors Based on Perovskite / Quantum Dot Hybrid, Yating Zhang, TengTeng Li, Yifen Li, Hongliang Zhao, Qingyan Li, Zhiyang Chen, Tu Yu, Lufan Jin, Jianquan Yao; Tianjin Univ., China. Vertical field effect phototransistors (VFEpTs) based on methylammonium lead halide perovskite / PbS quantum dot (QD) hybrid were design and fabricated. VFEpTs exhibit an broadband and ultrafast photoresponse, as well as a high photosresponsivity.

NoM3B.5 • 15:45
Cavity Mode between Two Dielectric Bragg Reflectors for Refractive Index Sensing, Samir Kumar¹,²;¹ Department of Physics, Hotilal Ramnath College Amnour, India;² Department of Physics, Jai Prakash Univ. Chapra, India. A simple method of refractive index sensor is proposed using dielectric Bragg reflectors. The refractive index sensor is based on the cavity modes formed in an analyte (cavity) region sandwiched between dual dielectric Bragg reflectors.

PM3C • LED 1—Continued

PM3C.5 • 15:30
Efficient, Color Tunable, and Flexible Thin Film Perovskite Light Emitting Devices, Lianfeng Zhao, Barry P. Rand; Princeton Univ., USA. We discuss metal halide perovskite LEDs exceeding 17% EQE, with improved stability and flexible as organic electronic thin films. We also show stabilized mixed halide (I and Br) and mixed Pb-Sn films to tune emission from the green to near infrared.

16:00–16:30 Networking Coffee Break with Exhibitors, Grand Peninsula D
NeM3D • Devices and Transmission 1—Continued

NeM3D.5 • 15:30  Invited
Membrane-based DMLs-on-Si for Energy-efficient 400GbE SDM Transmission, Nikolaos Panteleimon Diamantopoulos1, Kota Shikama1, Hidetaka Nishi1, Takuro Fuji1, Takashi Matsui1, Takaaki Kakitsuka1, Hiroshi Fukuda1, Kazuhide Nakajima1, Shinji Matsuo1; 1 NTT Device Technology Labs, NTT, Japan; 2 NTT Access Networks Service Systems Labs, NTT, Japan. We present our recent achievements regarding short-reach 400-Gb/s links and optical data-center interconnections using our energy-efficient membrane-based III/V-on-Si directly-modulated lasers and space-division multiplexing over multi-core fiber.

SpM3E • Optical Signal Processing—Continued

SpM3E.5 • 15:30
High-speed Electro-optic Equalizer for Data Center Interconnects, Rishab Maheshwari, Rakesh Ashok, Shivangi Chugh, Shalabh Gupta; IIT Bombay, India. We propose a PIC based equalizer for intra-data center interconnects that uses a modified sign-sign LMS algorithm. Simulation results for a 2 km SSMF 50 Gbps IM/DD link have been presented.

16:00–16:30 Networking Coffee Break with Exhibitors, Grand Peninsula D
Integrated Optical Phased Array Butterfly Architecture for a scalable two-dimensional integrated optical phased array architecture with cascaded butterfly-shaped pixels is introduced. This novel architecture enables compact, in-line independent amplitude and phase control with power recycling.

Sulfur- and Selenium-based Polymers for Infrared Optics and Photonics, Robert A. Nonwood, Univ. of Arizona, USA. Ultra-high refractive index polymers based on elemental sulfur and selenium have been developed. The high refractive indices (1.7-2.1) and transparency in the MWIR provide the opportunity for advances in low-cost bulk optics and integrated photonics.

Calibration-free Si-SiN Optical Phased Arrays, Milan L. Mashanovitch, Freedom Photonics, USA. Abstract not available.


We describe the development of novel perovskite active layers and sputter-buffer layers for perovskite-silicon tandem efficiencies surpassing 25% that pass a variety of IEC standard stability tests.

We present a calibration-free OPA leveraging low phase error in a SiN feeding network to feed a transparency in the MWIR provide the opportunity for advances in low-cost bulk optics and integrated photonics.

Invited talks on Nanophotonic Perovskite Thin-film Solar Cells by Thermal Nano-imprint Lithography, Raphael Schmager, Ilteaz M. Hossain, Yidenekachew J. Dine, Fabian Schackmar, Guillaume Gomard, Bryce S. Richards, Ulrich W. Paetzold, Karlsruhe Inst. of Technology, Germany. Direct texturing of the perovskite absorber layer with a facile thermal nano-imprint lithography process, enables the great opportunity to tune and enhance the absorbance of perovskite solar cells by coupling incident light to the quasi-guided modes.

Nanophotonic Perovskite Thin-film Solar Cells by Thermal Nano-imprint Lithography, Raphael Schmager, Ilteaz M. Hossain, Yidenekachew J. Dine, Fabian Schackmar, Guillaume Gomard, Bryce S. Richards, Ulrich W. Paetzold, Karlsruhe Inst. of Technology, Germany. Direct texturing of the perovskite absorber layer with a facile thermal nano-imprint lithography process, enables the great opportunity to tune and enhance the absorbance of perovskite solar cells by coupling incident light to the quasi-guided modes.
These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

16:30–18:00
NeM4D • Devices and Transmission
Presider: Marco Fiorentino; Hewlett Packard Enterprise, USA

NeM4D.1 • 16:30 Invited
Ultra-stable Integrated Lasers and Low-cost, Low-energy Coherent Data Center Interconnects, Daniel J. Blumenthal; Univ. of California Santa Barbara, USA. In this talk, we describe FRESCO, an approach to bring highly coherent WDM Terabit links inside the data center without the need for DSPs and other power consuming technologies.

NeM4D.2 • 17:00
Power Optimization for Datacenter Optical Transmitters, Sergio Pinna, Sarvagya Dwivedi, Larry A. Coldren, Clint Schow, Jonathan Klamkin; Univ. of California Santa Barbara, USA. Power allocation is investigated for a non-repeated/non-amplified datacenter network. A mathematical model is constructed for the optical eye amplitude in a power constrained case, and the effectiveness of the model is demonstrated experimentally.

NeM4D.3 • 17:15 Invited
Subwavelength Metamaterial Nanophotonic Waveguide Devices, Pavel Cheben; National Research Council, Canada. Subwavelength grating metamaterial structures are becoming established as fundamental building blocks for the silicon photonics integrated devices. In this invited talk we will present an overview of our recent advances in this surging field.

16:30–18:00
SpM4E • Networks and Transceiver Technology
Presider: David Hillerkuss; Huawei Technologies, Germany

SpM4E.1 • 16:30 Invited
White Boxes in Optical Networks: An Operator’s Viewpoint, Andrew Lord; Applied Research, BT, UK. Where and what kind of whitebox technology will appear in telecom operator networks and what benefits will it bring?

SpM4E.2 • 17:00 Invited
InP Transceivers for Terabit Coherent Optical Communications Systems, Daniel Tauber, Robert Griffin; Lumentum, Inc, USA. We review high performance, highly integrated InP coherent optics that have enabled bandwidth growth from 100 to 600 Gigabits per second (Gbps) per wavelength when incorporated with CMOS DSP chips.

SpM4E.3 • 17:30 Invited
InP-based Coherent PICs for 100 Gbaud Operation, Ryan Going, Stefan Wolf, Robert Maher, Pavel Studenkov, Vikrant Lal, Huan-Shang Tsai, Scott Corzine, Jiaming Zhang, Babak Behnia, Carlo Di Giovanni, Thomas Vallatix, Jeannie Yan, John Osenbach, Matthias Kunts, Thomas Frost, Hossein Mousavi, Stefano Porto, Sanketh Buggaveeti, Hossein Hodaei, Zhenxing Wang, Xian Xu, Peter Evans, Jeffrey Rahn, Tim Butrie, Mehrdad Ziar, David Welch, Fred Kish; Infinera Corporation, USA. We present our progress in developing InP-based coherent Transmitter (Tx) and Receiver (Rx) Photonic Integrated Circuits (PIC) for 100 Gbaud transmission, enabling future multi-Tb/s optical engines.

18:30–20:00 Congress Reception, Grand Peninsula D
08:00–10:00  
IT1A • Frequency Combs 1  
Presider: Shamsul Arafin; ECE, Ohio State Univ., USA

IT1A.1 • 08:00  Invited  
Infrared Optical Frequency Comb Generation with Nonlinear Ultrafast Photonics, Scott Diddams, NIST, USA. We report the generation and spectroscopic application of optical frequency combs spanning 2–27 mm using ultrafast nonlinear optics in quasi-phase-matched LiNbO₃ and GeP waveguides and crystals, as well as dispersion-engineered suspended Si waveguides.

IT1A.2 • 08:30  Invited  
Sub-harmonic and Harmonic Synchronization of Kerr Frequency Combs, Jae K. Jang¹, Alexander Kleiner¹, Xinghen Shi², Chaitanya Joshi³, Yoshitomo Okawachi¹, Michal Lipson¹, Alexander L. Gaeta¹. Columbia Univ., USA; Cornell Univ., USA. We describe our recent work on the synchronization of microresonator-based Kerr frequency combs. By utilizing microresonators of various sizes, we can extend our synchronization technique to the sub-harmonic and harmonic regimes.

IT1A.3 • 09:00  
Dual-pumped Kerr Cavity Soliton Based Synchronous All-optical Buffer: Raman Resilience, Akadev Roy¹, Rakini Halder¹, Shailendra K Varshney¹, EBECE Department, IIT Kharagpur, India; Electrical Engineering, California Inst. of Technology, USA. In this work, we numerically show that dual-pumped Kerr microresonator exhibits resilience against the stimulated Raman scattering and self-steepening phenomena that creates a favorable condition for effectively realizing Raman free optical systems.

IT1A.4 • 09:15  
Millimeter-wave Synthesizer Based on Microresonator Soliton Dual-comb Photomixing, Jiahao Zang¹, Travis C. Bries¹, Jesse Morgan¹, Su-perg Yu¹, Andreas Beling¹, Scott Papp¹; Univ. of Colorado Boulder/NIST, USA; Univ. of Virginia, USA. We propose a tunable millimeter-wave synthesizer design based on microresonator soliton dual-comb photomixing. The generated 50–550 GHz signal is expected to reproduce the stability of a microwave reference clock.

08:00–10:00  
NoT1B • Materials for Solar/LED Applications  
Presider: Jason Myers; US Naval Research Laboratory, USA

NoT1B.1 • 08:00  Invited  
The Pursuit of Novel Phosphors for the Next Generation of LED Lighting, Jakoosh Brigo¹, Ya Zhao¹, Univ. of Houston, USA. The development of phosphors for next-generation high power LED lighting requires a unique approach for materials discovery. Our research employs machine learning and computation to identify new luminescent materials guiding our synthetic efforts.

NoT1B.2 • 08:30  Invited  
Understanding the Origin of Green Photoluminescence in Low-dimensional Lead Halide Perovskites, Jinglin Bao¹, Zhaojun Qin¹, Shenyu Dai¹, Chang Wang¹, Xinhua Su¹,Guoying Feng¹, Ziming Wang¹, Viktor Hadži¹, Yinan Wang¹, Univ. of Houston, USA; Xunnan Univ., China; Chang’an Univ., China; Schuan Univ., China; Univ. of Electronic Science and Technology of China, China. We discuss the controversy and challenges of the origin of green luminescence centers in 2D CsPb₂Br₅ and OD Cs₄PbBr₆ and suggest several new experimental techniques to resolve the controversy and identify their underlying nature.

NoT1B.3 • 09:00  Invited  
Investigating the Optical and Electrical Properties of Two-dimensional Organic-inorganic Hybrid Perovskite Multiple Quantum Wells via Electrosorption Spectroscopy Studies, Eric Ameringer¹, Luisa Whittaker-Brooks¹, Univ. of Utah, USA. Two-dimensional (2D) organic-inorganic hybrid perovskites have strong spin-orbit coupling (SOC) leading to the Rashba splitting effect. In this talk, we will explain how doping affects exciton and free-carriers in 2D perovskite thin films.

08:45–10:00  
PT1C • Emerging 1  
Presider: Giulia Tagliaabue; Swiss Federal Inst. of Technology, USA

PT1C.1 • 08:45  Invited  
Atomically-thin Photovoltaics: Progress and Prospects, Deep Janiwala, Electrical and Systems Engineering, Univ. of Pennsylvania, USA. I will present demonstration of unity light absorption in sub-15 nm thick semiconductors and photovoltaic devices with record quantum efficiencies. Ongoing work on application of two-dimensional materials in photovoltaics will be presented.

PT1C.2 • 09:15  Invited  
Upconversion Performance Enhancement in Real 1D Photonic Crystals: Simulation, Experiment and Perspectives for Photovoltaics, Clarissa L. Hofmann¹,², Emil H. Erisken¹, Deniz U. Yazioglu¹, Stefan Fischer³, Benedikt Bläsi³, Christian Reitz³, Bryce S. Richards¹,², Jan-Christoph Goldschmidt¹, Fraunhofer Inst. for Solar Energy Systems ISE, Germany;¹ Inst. of Microstructure Technology (IMIT), Karlsruhe Inst. of Technology KIT, Germany;° Department of Physics and Astronomy, Aarhus Univ., Denmark;° Department of Materials Science and Engineering, Stanford Univ., USA;° Karlsruhe Nano Micro Facility, Karlsruhe Inst. of Technology KIT, Germany;°Light Technology Inst. (LTI), Karlsruhe Inst. of Technology KIT, Germany. We investigate photonic effects of optimized 1D photonic structures on embedded upconverting core-shell nanoparticle layers in a thorough comparison of simulation and experiment regarding parameters relevant for photovoltaic applications.
08:00–10:00
NeT1D • Network Management and Operation
Presider: Marija Furdek; Chalmers Tekniska Hogskola, Sweden

09:00–10:00
SpT1E • Access Networks
Presider: Naoki Suzuki; Mitsubishi Electric Corporation, Japan

NeT1D.1 • 08:00 • Invited
Path Computation and Topology Description Scheme for Consistently Supporting Heterogeneous Optical Node Structures, Kyo Ishii1, Atsuko Takefusa2, Shu Namiki1, Tomohiro Kudoh1;1 National Inst. of Advanced Industrial Science and Technology, Japan; 2 National Inst. of Informatics, Japan; 3 The Univ. of Tokyo, Japan. A physical network topology description scheme where individual optical switching functionalities are specified in a mathematically exact manner is presented. The applicability of the proposed scheme is evaluated through path computations.

NeT1D.2 • 08:30 • Invited
Configuration and Monitoring of the Optical Physical Layer Using Software-defined Tools, Yuliya Verbishchuk1,2, Cormac J. Sreenan1, Fatima C. Garcia Gunning1,2; 1 Tyndall National Inst., Ireland; 2 Physics, Univ. College Cork, Ireland. In this paper we discuss the need for implementation of SDN-based elements and tools towards disaggregated physical layer devices for optimum management of resources.

NeT1D.3 • 09:00 • Invited
End-to-end Network Slicing and Orchestration in 5G Infrastructures with SDM-based Fronthaul, Giacomo Bernini, Marco Capitani, Giada Landi, Gino Carrozzo; Nextworks, Italy. 5G services drive an evolution of network infrastructures towards optical technologies for more capacity, flexibility, and agile network slicing. The paper proposes a slicing and orchestration framework operating 5G infrastructures with SDM fronthaul.

SpT1E.1 • 09:00 • Invited
Digital Signal Processing in Optical Access Systems, Dora van Veen, Vincent Houtsma; Nokia Bell Labs, USA. We analyze the introduction of DSP in optical access. We review the specific requirements of PON and compare performance and feasibility of solutions with and without DSP for cost-effectively increasing the bit-rate in PON.
IT1A • Frequency Combs 1—Continued

IT1A.5 • 09:30
Self-healing Micro-combs, Hualong Bao¹, Juan S. Totero-Gongora², Maxwell Rowley³, Luana Olivieri⁴, Sai T. Chu⁵, Brent E. Little⁶, Roberto Morandotti⁷, David J. Moss⁸, Marco Pecchiari⁹, Alessia Pasquaï¹⁰; ¹Univ. of Sussex, UK; ⁵City Univ. of Hong Kong, China; ⁷Xian Inst. of Optics and Precision Mechanics, Chinese Academy of Science, China; ⁸NRS-EMT, Canada; ⁹Inst. of Fundamental and Frontier Sciences, Univ. of Electronic Science and Technology of China, China; ¹⁰Centre for Microphotonics, Swinburne Univ. of Technology, Australia. We demonstrate a scheme for generating micro-combs by embedding a micro-cavity in a fibre-laser cavity. The addition of an all-pass, fibre-based filter produces a periodic spectral-phase modulation which stabilises the comb for long fibre amplifiers.

IT1A.6 • 09:45
Microwave and RF Applications Based on Kerr Micro-combs, Jayang Wu¹, Xingyuan Xu¹, Mengxi Tan¹, Thach Nguyen², Yang Qu³, Linnan Jia¹, Yuning Zhang¹, Sai T. Chu³, Brent Little⁶, Roberto Morandotti⁷, Aman Mitchell⁸, David J. Moss⁹; ¹Swinburne Univ. of Technology, Australia; ²RMIT Univ., Australia; ³City Univ. of Hong Kong, China; ⁴Chinese Academy of Science, China; ⁵INRS, Canada. We present our recent progress on microwave and RF applications based on integrated Kerr micro-combs, including adaptive photonic RF filters with 80 taps, photonic RF filters via bandwidth scaling, and broadband photonic microwave mixer.

NoT1B • Materials for Solar/LED Applications—Continued

NoT1B.4 • 09:30
Invited
In Situ Measurement of the Excited State Dynamics of Evolving Materials Systems, Kelly S. Wilson, Morgan L. Sosa, Madelyn N. Scott, Cathy Y. Wong; Univ. of Oregon, USA. Single-shot transient absorption and linear absorption measure excited state dynamics and electronic structure in situ during the formation of a pseudo-isocyanine film. A model used to fit the absorption spectra reveals evolving aggregate structure.

PT1C • Emerging 1—Continued

PT1C.3 • 09:45
Optimizing Tm²⁺-doped Dihalide Thin Film Luminescent Solar Concentrators, Evert P. Merkx, Erik van der Kolk; Technische Universiteit Delft, Netherlands. Local property-mapping of gradient thin films of Mₓ₀·₇₆₃Tm²⁺ (M=Ca,Sr), where x and film thickness vary, is used to optimize for LSC use. Tm²⁺ absorbs the entire visible spectrum and emits at 1140 nm.

10:00–10:30 Networking Coffee Break with Exhibitors, Grand Peninsula D
NeT1D • Network Management and Operation—Continued

NeT1D.4 • 09:30  
**Invited**  

SpT1E • Access Networks—Continued

SpT1E.2 • 09:30  
Dynamic Bandwidth Allocation Algorithms for NG-PON2 to Support 5G Fronthaul Services, Azza Zaouga1,2, Amaro de Sousa2, Monia Najjar1, Paulo P. Monteiro2; 1 Communication Systems Laboratory (SysCom), Communication Systems Laboratory (SysCom), National Engineering School of Tunis (ENIT), Univ. of Tunis El Manar (UTM), Tunisia; 2 Instituto de Telecomunicações, Universidade de Aveiro, Portugal. In this work, we propose DBA algorithms for NG-PON2 access networks to support both 5G fronthaul services and data services guaranteeing the 5G fronthaul latency requirements and maximizing data service throughput.

SpT1E.3 • 09:45  
DAC-friendly Staggered CAP Modulation, Grzegorz Stepniak; Politechnika Warszawska, Poland. In the paper, it is shown that the recently proposed staggered CAP (sCAP) modulation not only can achieve 100% spectrum efficiency but also can fully exploit the digital to analog converter sampling rate.

10:00–10:30  
Networking Coffee Break with Exhibitors, Grand Peninsula D
Tuesday, 30 July

Grand Peninsula G

Integrated Photonics Research, Silicon and Nano Photonics

Sandpebble Room AB

Novel Optical Materials and Applications

Sandpebble Room CD

Optical Devices and Materials for Solar Energy and Solid-state Lighting

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

10:30–12:30
IT2A • Frequency Combs 2 and Resonators
Presider: Judith Su; Univ. of Arizona, USA

IT2A.1 • 10:30
Nanophotonic Supercontinuum Based Mid-infrared Dual-comb Spectroscopy, Haining Guo1, Wenle Wang1, Junqiu Liu2, Fan Yang1, Wolfgang Hänse1, Camille-Sophie Brès3, Luc Thévenaz1, Ronald Holzworth1, Tobias Kippenberg1; LPQM, Swiss Federal Inst. of Technology Lausanne (EPFL), Switzerland; 2GFO, Swiss Federal Inst. of Technology Lausanne (EPFL), Switzerland; 3Menlo Systems GmbH, Germany; 4PHOSL, Swiss Federal Inst. of Technology Lausanne (EPFL), Switzerland; 5Key Laboratory of Specialty Fiber Optics and Optical Access Networks, Shanghai Univ., China. We demonstrate an approach to dual-comb spectroscopy, based on dispersion engineered and broadband supercontinuum generation in photonic integrated noninfrared waveguides, and driven by low-noise fiber-laser combs, which covers the range 2800-3650nm.

IT2A.2 • 11:00
Laser Cavity-solitons in Micro-resonators, Alessia Pasquazi1, Haiqiong Bao2, Andrew Cooper1, Luigi Di Lauro1, Marco Peccani2, Sai T. Chu3, Brett Little4, Gian-Luca Oppo4, Roberto Morandotti4; University of Arizona, USA; 2Karlsruhe Institute of Technology, Germany; 3South China Univ. of Technology, China; 4The University of Sydney, Australia. We report the observation of temporal laser cavity-solitons in a system comprising an optical micro-cavity nested in a fibre laser.

IT2A.3 • 11:30
Kerr-microresonator Frequency Combs with Tantalum-pentoxide Nanophotonics, Scott Papp; National Inst of Standards & Technology, USA. Abstract not available.

10:30–12:30
NoT2B • Biomimetic and Biocompatible Optical Materials
Presider: Woei Ming Lee; Australian National Univ., Australia

NoT2B.1 • 10:30
Dynamic Materials Inspired by Cephalopods, Alon Gorodetsky; Univ of California Irvine, USA. Cephalopods have capitvated the imagination of both the general public and scientists alike, emerging as exciting models for novel materials and systems. In this regard, we have developed cephalopod-inspired materials with unique functionalities.

NoT2B.2 • 11:00
Optical Light Actuators for Non-genetic Optical Stimulation, Giugliermo Lanzani, Giuseppe M. Paternò; Center for Nano Science and Technology, Istituto Italiano di Tecnologia, Italy. Although optogenetics is a great tool to induce light sensitivity to living organism, its invasiveness limits real applications. Here, I describe alternative approaches aimed at NON-genetically inducing sensivity in cells and organism.

NoT2B.3 • 11:30
Soft Matter and Biological Lasers, Matjaž Humar1, 2; Faculty of Mathematics and Physics, Univ. of Ljubljana, Slovenia; 2Karlsruhe Institute of Technology, Germany. We discuss the use of GaN high-power laser diode in general lighting applications. After reviewing the laser diode achievements; the phosphors materials, the optical design and the possible performances of these devices are discussed.

10:30–12:30
PT2C • LED 2
Presider: Clarissa Hofmann; Fraunhofer Inst Solare Energie Systeme, Germany

PT2C.1 • 10:30
GaN High-power Lasers for Solid-state Lighting, Guillaume Lheureux, Shlomo Mehari, Daniel Cohen, Philip Chan, Haqun Zhang, Kareem Hamdy, Caroline Reilly, Ryan Anderson, Emer Zeitz, Ram Seshadri, Tal Margalith, Claude Wesbuch, James S. Speck, Steven P. DenBaars, Shuji Nakamura; Materials, Univ. of California Santa Barbara, USA. We discuss the use of GaN high-power laser diode in general lighting applications. After reviewing the laser diode achievements, the phosphors materials, the optical design and the possible performances of these devices are discussed.

PT2C.2 • 11:00
Stationary Adjustable Luminaires via Optical Beam Steering, John Lloyd, Peter Kozadoy, Christopher Gladden, Andrew Kim, Glint Photonics Inc., USA. Adjustable luminaires deliver targeted light in countless illumination scenarios. The high brightness and surface emission characteristic of LED light sources enable new optical design of adjustable luminaires to include beam steering.

PT2C.3 • 11:30
Transparent Nanophosphor Films for Efficient White-light Generation, Gabriela Lozano-Barbero, Elena Cabello- Olmo, Dongling Geng, Hernán Míguez; Instituto de Ciencia de Materiales de Sevilla, Consejo Superior de Investigaciones Científicas, Spain. Here, we demonstrate highly transparent white-light-emitting coatings of tunable shade with photoluminescence quantum yields above 35% by a sequential stacking of optically quench layers made of Eu2+ and Dy3+ doped rare-earth nanocrystals.

PT2C.4 • 11:45
Foamed Polymer/Quantum Dots Composite Films with Enhanced Photoluminescence Efficiency, Shudong Yu1, 2, Benjamin Fritz1, Dominik Theobald1, Siegbert Johnsen1, Dmitry Busko2, Bryce S. Richards3, Marc Hippler4, Gabriele Wiegand4, Yong Tang4, Zengtao Li4, Ulli Lemmer1, Hendrik Hälscher1, Guillaume Gomard4, 1South China Univ. of Technology, China; 2Karlsruhe Inst. of Technology, Germany. We use the CO2 foaming method to control the introduction of pores in polymer/quantum dots light converting films, whose photoluminescence efficiency is improved owing to an efficient light management scheme.

PT2C.5 • 12:00
Impact of Surface Reflectance on Spectral Optimization for Melanopic Illuminance and Energy Efficiency, Dorukalp Durmus, Pacific Northwest National Laboratory, USA. Although surfaces impact melanopic response, they are not considered in optimization studies. Calculations with iteratively-generated narrowband LED combinations show that reflectance in short wavelengths has a large impact on melanopic illuminance.

PT2C.6 • 12:15
How Useful is Photochemical Upconversion for Lighting Applications?, Laszlo Frazer; ARC Centre of Excellence in Exciton Science, School of Chemistry, Monash Univ., Australia. Triplet-triplet annihilation photochemical upconversion is a method of converting light to a higher frequency. We show theoretically that photochemical upconversion can be applied to Watt-scale lighting.

12:00–14:00
Lunch break

14:00–18:00
(No concurrent sessions listed)
10:30–12:30  
NeT2D • Access, Metro and Transport Network Evolution  
Presider: Fatima Garcia Gunning; Tyndall National Institute, Ireland

NeT2D.1 • 10:30  
Scaling the Next Generation Broadband Access Networks with Super-PON, Cedric F. Lam; Google, USA. We present the design, deployment and the standardization of a TWDM Super-PON fiber access network with 50km transmission distance and 768 users on a single fiber strand from the central office (CO).

NeT2D.2 • 11:00  
Full PON Virtualisation Supporting Multi-tenancy beyond 5G, Nima Afraz, Frank Syke, Marco Ruffini; CONNECT, Univ. of Dublin Trinity College, Ireland. In this paper, we introduce a virtualization technique to enable fully customizable resource sharing for Passive Optical Networks. We provide a summary of the concept, economic challenges and implementation.

NeT2D.3 • 11:30  
How the Metro Network Evolves in the MEC Era, Qinqing Shi, Qing Zhang; Fujitsu Laboratories of America Inc., USA; Fujitsu Network Communications, USA. As multi-access edge computing (MEC) is emerging in telecom metro networks, we analyze its impact on IP over WDM metro network architectures, as well as central office nodal architectures, based on future metro traffic patterns.

NeT2D.4 • 12:00  
Designing Ultra-reliable 5G-ready Transport Networks, Bodhisattwa Gangopadhyay, João Pedro, Nuno Borges; Infineon, Portugal. Exponential traffic growth with stringent SLA built upon heavily interconnected backbone and heterogeneous infrastructure is 5G reality. A hybrid control plane policy providing augmented resiliency for such networks is the focus of this paper.

12:30–14:00  Lunch (on own)

12:30–14:00  Student and Early Career Professional Development & Networking Lunch and Learn, Sandpebble Room E

10:30–12:30  
SpT2E • Digital Signal Processing 1  
Presider: Hany Elgala; State Univ. of New York at Albany, USA

SpT2E.1 • 10:30  
Digital Predistortion Techniques for Ultra-high Symbol Rates, Ginni Khanna, Bernhard Spinnler, Erik De Mier, Norbert Hanik; Technische Universität München, Germany; Infineon, Germany. An adaptive digital pre-compensation scheme to jointly compensate for the linear and non-linear effects for high baud rate and higher order modulation formats optical transmitters is discussed.

SpT2E.2 • 11:00  
Nonlinearity Compensation Techniques Using Machine Learning, Stylianos Sygletos; Aston Univ., UK. We discuss the potential of dynamic neural networks to provide mitigation of nonlinear impairments in long haul transmission systems and we compare their performance and computational efficiency against conventional digital back propagation methods.

SpT2E.3 • 11:30  
Autoencoder Model for OFDM-based Optical Wireless Communication, Priti Pachpande, Monette Khadr, Hesham Hussien, Hany Elgala, Dola Saha; Univ. at Albany, USA. An orthogonal frequency division multiplexing based Autoencoder model for optical wireless communication is implemented. Symbol-error performance demonstrates the viability of using neural networks and deep learning techniques in OWC systems.

SpT2E.4 • 11:45  
Detecting Underwater Laguerre Gaussian Modes Using a Convolutional Neural Network, Abderrahmen Trichili, Chaouki Ben Issaid, Yujian Guo, Tien Khee Ng, Boon S. Ooi, Mohamed-Slim Alouini; King Abdullah Univ of Sci & Technology, Saudi Arabia. We propose the use of a convolutional neural network (CNN) to detect single and superpositions of Laguerre Gaussian modes in an underwater environment which will open the doors towards fast and reliable underwater optical wireless communications.

SpT2E.5 • 12:00  
Emission Spectrum Denoising Algorithm for Microlasers-based Neurotransducers, Maurizio Manzo, Ibrahim L. Ibrahim, Volker J. Sorger; George Washington Univ., USA. Emission spectra from microlasers are noisy due to the presence of higher order optical modes and first order missing modes. Here, the proposed algorithm eliminates the noise and reconstructs the missing peaks.

SpT2E.6 • 12:15  
Free Space Optical Coprocessor for Image Processing and Convolution Neural Network, Mario Miscuglio, Zibo Hu, Jonathan George, Zhizhen Ma, Volker J. Sorger, George Washington Univ., USA. Convolution Neural Networks are artificial networks able to extract features from large dataset by spatial filtering. Here we propose an optical coprocessor able to perform large image filtering and convolutions, outperforming current architectures.
**Grand Peninsula G**

Integrated Photonics Research, Silicon and Nano Photonics

**Sandpebble Room AB**

Novel Optical Materials and Applications

**Sandpebble Room CD**

Optical Devices and Materials for Solar Energy and Solid-state Lighting

*These concurrent sessions are grouped across two pages. Please review both pages for complete session information.*

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**14:00–16:00**

**IT3A • Photodetectors and Sensing**

Presider: Heayoung Yoon; Univ. of Utah, USA

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**14:00–16:00**

**NoTB • Metamaterials and Metasurfaces 1**

President: Mikhail Kats; Univ. of Wisconsin-Madison, USA

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**14:00–16:00**

**PT3C • Emerging 2**

Title not available, Ana Arias; Univ. of California Berkeley, USA

Abstract not available.

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**14:00–16:00**

**IT3A.1 • 14:00**

Invited

1310 nm High-speed All-silicon Waveguide Photodetectors for Low-cost Photonic Integration, Meer Nazmus Sakib1, Hao Li2, Ranjeet Kumar1, Hasitha Jayathilake2, Ganesh Balumurugan2, James Jau1, Hasheng Rong1, Bryan Casper3; Intel Labs- Photonics Research, USA; 4Intel Labs, USA. We present an all-silicon waveguide photodetector co-packaged with a 28-nm CMOS TIA. At 1310nm datacom wavelength, we demonstrate an optical signal detection at 40 Gb/s with an open eye diagram and SNR of 10.

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**14:00–16:00**

**NoTB.1 • 14:00**

High-Q Metasurfaces for Nonlinear Free-space Optics, Jennifer Dione1, James Jaussi2, Haisheng Rong1, Bryan Casper2; 1Intel Labs-Photonics Research; 2Dept. of Physics and Astronomy “E. Majorana”, Univ. of Catania, Italy; 3CNR-IPP, Italy; 4CNR IMM, Italy. Si nanowires are promising building blocks for future nanoscale devices. The combination of their high aspect-ratio and quantum effects allows the realization of ultrasensitive of label-free optical biosensors with novel perspectives in photonics.

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**14:00–16:00**

**IT3A.2 • 14:30**

Invited

Silicon Nanowires for Photonics, Photovoltaics and Sensing, Maria J. Lo Faro1,2, Prolo Francesco1,3, Dario Morganti1,4, Antonino A. Leonardo1,2, Paolo Musumeci1, Barbara Faiz1, Alessia Inerra1,1, ‘Dept. of Physics and Astronomy “E. Majorana”, Univ. of Catania, Italy; 2CNR-IPP, Italy; 3CNR IMM, Italy. Si nanowires are promising building blocks for future nanoscale devices. The combination of their high aspect-ratio and quantum effects allows the realization of ultrasensitive of label-free optical biosensors with novel perspectives in photonics.

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**14:00–16:00**

**IT3A.3 • 15:00**

Up to 1700nm Broadband High-efficiency Surface-illuminated Ge/Si Photodiode with Microhole Array, Soroush Ghandi9n1, Aly F. Etefai2,1, Ahmed S. Mayet1, Cesar Bartolo-Perez1, Hilal Cansizoglu1, Yang Gao1, Ekaterina P. Devine2, Taha Landolsi3, M. S. Islam4; 1Univ. of California Davis, USA; 2W & W sens, USA; 3Department of Computer Science and Engineering, American Univ. of Sharjah, United Arab Emirates; 4Electrical Engineering, Baskin School of Engineering, Univ. of California Santa Cruz, USA. We demonstrate a 10 Gb/s CMOS-compatible surface-illuminated Ge/Si Photodiode integrated with photon-trapping microhole arrays with broadband high efficiency up to 1700nm. The Ge/Si photodiode has >80% and >73% EQE at 1310nm and 1550nm, respectively.

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**14:00–16:00**

**IT3A.4 • 15:15**

A Single Photon Detector with an Amorphous/Crystalline Silicon Heterointerface, Lujiang Yan, Mohammad Abu Raihan Miah, Jayun Zhou, Yang Zhang, Yuhwa Lo; University of California San Diego, USA. We demonstrate a single photon detector of dual gain sections design with internal control. At 100MHz, it shows over 11% single photon detection efficiency, sub-nano-second self-recovery time, low excess noise with only 8.5V bias.

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**14:00–16:00**

**NoTB.2 • 14:30**

Manipulating and Imaging Quantum Light with Dielectric Metasurfaces, Andrey A. Sukhorukov1, Nonlinear Physics Centre, Research School of Physics and Engineering, Australian National Univ., Australia. We present theoretical and experimental results demonstrating non-classical multi-photon interferences at the subwavelength scale in dielectric metasurfaces, enabling tailored manipulation and measurement of multi-photon quantum states.

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**14:00–16:00**

**NoTB.3 • 15:00**

Enhanced Optical Nonlinearities in All-dielectric Metasurfaces, Polina Vabishchevich1,2, Aleksandr Yakulin3, Sadyrkas Adduman1, Nicholas Kari2, Sheng Lu1,2, Andrei Shamas1, Ganesh Balumurugan2, John L. Reno2,1, Gordon A. Keeler1, Michael Sinclair1, Isabelle Staudte1, Igi Brener1,2, 1Sandia National Laboratories, USA; 2Center for Integrated Nanotechnologies, Sandia National Laboratories, USA; 3Inst. of Applied Physics, Abbe Center of Photonics, Friedrich Schiller Univ., Germany; 4Center for High Technology Materials (CHTM), Univ. of New Mexico, USA. We demonstrate high-Q modes can be generated within dielectric metasurfaces, opening new possibilities for nonlinear free-space nanophotonics. We utilize these nonlinear metasurfaces for nanoscale nonreciprocity and neuromorphic nanophotonic networks.

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**14:00–16:00**

**PT3C.2 • 14:30**

Plasmonic Hot Holes: Fundamentals and Devices, Giulia Tagliabue1, Joseph DuChene1, Harry Atwater1, EPFL, Switzerland; 2Applied Physics and Material Science, Caltech, USA. Photoelectrochemical, photoelectrical and ultra-fast pump-probe studies elucidate the generation and dynamics of plasmonic hot-holes and suggest new opportunities for hot-carrier optoelectronic devices.

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**14:00–16:00**

**PT3C.3 • 15:00**

Strengthened Enhancement of Thin Film Bismuth Vanadate through 3D Mothe-Eye Structured Triple-deck Photoanode: AuNPs/BiVO4/SnO2/Au Nanocomposites, Junho Jun, Sucheol Ju, Heon Lee; Korea Univ., Korea (the Republic of). Absorption of thin film bismuth vanadate was enhanced by introduction of hierarchical moth-eye structured Au/SnO2 mirror layer and AuNP decoration. Owing to structural effects, current density of 3D photoanode has 3-4-fold higher than reference.

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**14:00–16:00**

**PT3C.4 • 15:15**

Simultaneous Improvement of Absorption and Separation Efficiencies of MoBiVO4 Photoanodes via Nanopatterned SnO2/Au Hybrid Layers, Sucheol Ju, Junho Jun, Daehong Huh, Soomin Son, Heon Lee; Korea Univ., Korea (the Republic of). Nanopatterned photoanodes have increased light absorption efficiency and carrier separation efficiency simultaneously. As a result, the total efficiency increases by 3.5 and 3.08 times than that of flat electrode respectively.
14:00–16:00
NeT3D • High-performance Networks
Presider: Marco Ruffini; Univ. of Dublin Trinity College, Ireland

NeT3D.1 • 14:00 • Invited
Candidate Technologies for High-capacity Optical Communication Systems, Lidia Galdino, Daniel Semrau, Polina Bayvel; Univ. College London, UK. The practicalities in designing high-capacity optical communication systems are described. With a given perspective on the present and future technologies, we cover the transceiver design and optical amplifier technologies to maximize fiber capacity.

NeT3D.2 • 14:30 • Invited
Spatial Channel Cross-connect (SXC) Architectures and Their Enabling Technologies for Future Spatial Channel Networks (SCNs), Masahiko Jinno; Kagawa Univ., Japan. We discuss two types of spatial channel cross-connect architectures based on sub-matrix-switches, core selective switches, and their enabling technologies for spatial channel networks in the forthcoming spatial division multiplexing abundant era.

NeT3D.3 • 15:00 • Invited
Optical Multi-band Networks: Maximizing Lifetime of Deployed Fiber Infrastructure, Johannes Fischer1, Pablo Wilke Benignou2, Behnam Shariati3, Antonio Napoli4, Ewan Pincemin2, Alessio Ferrari5, Vittorio Cumm6, Nelson Costa7, João Pedro8; Infineon, Germany; 2Orange Labs, France; 3Infineon Unipessoal Lda, Portugal; 4Fraunhofer Inst. for Telecommunications Heinrich-Hertz-Inst., Germany; 5Politecnico di Torino, Italy. Optical multi-band networks provide an option for scaling the capacity of single-mode fiber with the continuously increasing demand. Achievable capacities are reviewed and challenges to realize them in deployed systems are highlighted.

14:00–16:00
SpT3E • Digital Signal Processing 2
Presider: Koji Igarashi; Osaka Univ., Japan

SpT3E.1 • 14:00 • Invited
ADC and DAC: State of the Art and Technology Trends, Tomislav Drenski; Socionext Europe GmbH, UK. Technology trends for high speed ADC & DAC and their ASIC implementation in optical transport/access, starting from Ultra Long Haul to Short Reach transmissions are shown. New requirement for 5G applications are reviewed and possible solutions given.

SpT3E.2 • 14:30 • Invited
Flexible and Low-power Probabilistic Shaping for Fiber-optic Communications, Tsuyoshi Yoshida1,2, Naoki Suzuki1; 1Mitsubishi Electric Corporation, Japan; 2Graduate School of Engineering, Osaka Univ., Japan. Deep probabilistic shaping with coarse base constellation leads to significant increase of power consumption and fiber nonlinear degradation. We show potentials of flexible probabilistic shaping with multiple and granular base constellations.

SpT3E.3 • 15:00 • Invited
Dimensions Grading Optimization of Orthogonal Volterra DPD Based on Signal-projection, Hananel Faig, Eyal Wohlgemuth, Yaron Yoffe, Dan Sadot; Ben-Gurion Univ. of the Negev, Israel. An efficient grading method for dimensions-reduced digital pre-distorter based on orthogonal Volterra series for band-limited nonlinear components is proposed. The method is based on a combination of dimension variance and signal projection.
IT3A • Photodetectors and Sensing—Continued

IT3A.5 • 15:30
Integrated Graphene Plasmonic Slot Photodetector with High Responsivity, Zhizhen Ma, Kazuya Kikunaga, Shuai Sun, Rubab Amin, Mario Miscuglio, George Washington University, USA. We demonstrated an ultra-narrow (15 nm) plasmonic slot photodetector using graphene demonstrating an external responsivity of 0.67 A/W. Tuning the gating for graphene a strong short-channel was found to increase the photo-to-dark current ratio.

IT3A.6 • 15:45
Ultra-low Capacitance, High-speed Integrated Waveguide Photodiodes on InP, Bassem Tossoun, Jesse Morgan, Andreas Beling, University of Virginia, USA. We demonstrate integrated waveguide modified uni-traveling carrier (MUTC) photodiodes with dark currents as low as 5 nA at -1 V, capacitance of 1.8 fF, 0.26 A/W external responsivity, and a 3-dB bandwidth of 85 GHz.

NoT3B • Metamaterials and Metasurfaces 1—Continued

NoT3B.4 • 15:30
Realization of Topology-optimized Multilayer Metasurfaces, Evan W. Wang, Thaibao Phan, David Self, Jonathan A. Fan; Department of Electrical Engineering, Stanford University, USA; Department of Applied Physics, Stanford University, USA. Multilayer metasurfaces promise extraordinary electromagnetic control beyond those achievable with single layer devices. We discuss methods for the practical design and fabrication of multilayer metasurfaces.

NoT3B.5 • 15:45
Optical Properties of Hybrid Carbon Flakes and their Dependence on Fabrication Parameters, Muhammad Abdullah T. Butt, Martin Neugebauer, Antonino Cala Lesina, Lora Ramunno, Pierre Berini, Thomas Bauer, Daria Mamonova, Alina Manshina, Peter Banzer, Gerd Leuchs; Max Planck Institute for the Science of Light, Germany; School of Electrical Engineering and Computer Science, University of Ottawa, Canada; Department of Quantum Nanoscience, Delft University of Technology, Netherlands; Institute of Chemistry, St. Petersburg State University, Russia; University of Ottawa Centre for Extreme and Quantum Photonics, Max Planck Center, Canada; Optical Materials and Systems, School of Advance Optical Technologies, Germany. We investigate the effects of fabrication parameters on optical properties of carbon flakes. We use microscopic Müller matrix measurement technique to experimentally investigate different samples of carbon flakes.

PT3C • Emerging 2—Continued

PT3C.5 • 15:30
Plasmon-enhanced Photoelectrochemical Water Splitting Using Three-dimensional Gold Nanotube Electrode, Daehong Hu, Kwan Kim, Soomin Son, Junho Jun, Sucheol Ju, Heon Lee; Korea University, Korea (the Republic of). Visible light-induced AuNT/TiO2/AuNPs photoanode system for water splitting was fabricated using three-dimensional gold nanotube electrode. It works in visible range due to the plasmon effect and the efficiency of photoanode was increased.
NeT3D • High-performance Networks—Continued

NeT3D.4 • 15:30  
Launched by Nihel D. Benzaoui, NOKIA, France. We present Deterministic Dynamic Network as a solution for 5G Edge Cloud and show how we control latency to ensure end-to-end deterministic performance of only tens of microseconds latency and tens of nanoseconds jitter per-application.

SpT3E • Digital Signal Processing 2—Continued

SpT3E.4 • 15:30  
Modulation Format Independent Joint Polarization Demultiplexing and IQ Imbalance Compensation, Marwa Kazdoghli Lagha, Pascal Scalart, Christophe Peucheret, Robin Gerzaguet, Laurent Bramerie; 1 Univ Rennes, CNRS, IRISA, France; 3 Univ Rennes, CNRS, FOTON-UMR 6082, France. We propose a new joint Tx-IQ imbalance compensation and polarization demultiplexing algorithm for arbitrary $M$-QAM coherent systems. Evaluated metrics demonstrate its effectiveness as a blind approach compared to cascaded CMA and BASS algorithms.
Birefringent Laser Pulse Shaper Generating Arbitrarily Optimal Temporal Output Pulse Profiles, Abde Rezaq Halass, Rachid Hamdi, Bad-Eddine Berkellati, Laboratoire des Télécommunications, Algérie; SAMVAR, Télécom SudParis, CNRS, Institut Polytechnique de Paris, France. We demonstrate a birefringent pulse shaper generating arbitrarily optimal temporal pulse profiles. The opto-geometrical shaper parameters are obtained by a resolution of generalized nonlinear equation system based on a time-domain Jones matrix formalism.

Frequency Offset Stabilization for Frequency Combs Using Electro-optic Modulators, Daniel Bodenmüller, Jose C. Boggs, Martin M. Roth, Leibniz-Institut für Astrophysik Potsdam, Germany. Frequency offset locking of two lasers by means of a digital controller was performed using two different methods. The frequency instability at an average time of 1 s was below 1 kHz.

On Performing Complete Stokes Polarimetry Using Only One Liquid Crystal, Muhammad Abdullah T. Butt, NanoOptics group, Schoenenburg, Germany. We analyze the implementation of complete stokes polarimetry, exploiting the beam movement during stokes analysis.

Robust Couplers Designed by Fast Quasiadiabatic Elimination, Hung-Ching Chung, Jheng-Yi Sie, Shuo-Yen Tseng, National Chung Hsing Univ., Taiwan. We propose robust waveguide couplers by combining adiabatic elimination and the fast quasiadiabatic method ensures no rotation of liquid crystal retarder, to avoid any beam movement during stokes analysis.

Infrared Emission from ZnO-doped Er:ZrO2 Thin Films, José L. Caballé, Gaston Lozano Calderón, Víctor García, Eulayed Marega, Instituto de Física de São Carlos - Universidade de São Paulo (IFSC-USP), Brazil; Departamento de Física - Universidade Nacional Mayor de San Marcos (DF-UNMSM), Peru. We investigated the energy of ZnO concentration on structural and optical properties of Er:ZrO2 thin films grown using electron beam vapor deposition. The photoluminescence and lifetime was measured with 980 nm excitation.

SDN for Passive Optical Networks and Passive Optical Ethernet, Yuxin (Eugene) Dai, Wei Dai, Senior Consultant, USA; Appolito, USA. This paper first introduces the concept of Passive Optical Ethernet. Then constructs a foundation for developing a unified SDN model for Passive Optical Network and Passive Optical Ethernet.

Infrared Mirror Coating to Improve Efficiency in Solar Thermal Energy Applications, Daniela De Luca, Carmine D’Alessandro, Davide De Maio, Emiliano Di Gennaro, Marilena Musto, Giuseppe Rotondo, Roberto Russo, Univ. of Naples “Federico II”, Italy; CNR, Italy. High vacuum solar flat thermal panel, the heat losses are mainly due to emitted radiation. Photon recycling, obtained through optimized infrared mirror coating on glass, can improve thermal efficiency and increase operating temperatures.

Theoretical Analysis and Design of a High Bandwidth SiNx on SOI Grating Coupler for Communications Applications, Albert Djekeng, Univ. of Texas at San Antonio, USA. Asymmetric grating trenches and optimization of grating dimensions of a SiNx on silicon-on-insulator (SOI) grating coupler are examined with results of 28.57 nm 1dB bandwidth and a maximum coupling efficiency of 49.77%.

Near-field Scanning Optical Microscopy of Luminescent Nanostructured Semiconductors, Laszlo Fraizer, Heyou Zheng, Chun Kui Ng, Pegah Maasoumi, Jacek Jasieniak, Paul Mulvaney, Alison Furstner, ARC Centre of Excellence in Exciton Science, School of Chemistry, Monash Univ., Australia; ARC Centre of Excellence in Exciton Science, School of Chemistry, The Univ. of Melbourne, School of Materials Science and Engineering, Monash Univ., Australia. The ability to image nanostructures with near-field visible light optics is limited by diffraction. We use Near-field broaden Optical Microscopy (NISOM/SNOM) to increase resolution of luminescence imaging, while avoiding radiation damage.

Synthesis, Crystal Growth and Optical Spectroscopy of Pr4+ Doped CaPcICl, Perovskite Crystals for Photonic Applications, Uwe H. Hombichr, Lanjiah Flagg, Aliamin Kabir, Aiheba Bluet, Sudhir Trivedi, Hampton Univ., USA; Dept. of Chemistry, Geology, Physics, Elisabeth City State Univ., USA; Brimrose Technology Corporation, USA. We report on the purification, synthesis, crystal growth and spectroscopy Pr4+ doped CaPcICl, perovskite bulk crystals for photonic applications. The Pr:CaPcICl exhibited infrared emission at 1625nm, 2450nm and 4450 nm under pumping at ~1500nm.

Theoretical Analysis of Waveguide Mode Profiles Obtained by the Source-added Transfer Matrix Method in Organic Light-emitting Diodes, Jiyoung Kim, Kyoung-Youm Kim, Jungho Kim, Dept. of Information Display, Kyung Hee Univ, Korea (the Republic of); Dept. of Electrical Engineering, Sejong Univ., Korea (the Republic of). We calculate the spatial profile of optical waveguide modes based on the source-added transfer matrix method inside organic light-emitting diodes. The effect of the dipole source on waveguide mode profiles is investigated.

Enhanced Magnetic Circular Dichroism in Graphene Oligomers at Low Static Magnetic Fields, Jian Q. Liu, Jiujian Liu, University of Science and Technology, China. Giant magnetic circular dichroism (MCD) is promising for nanophotonic devices. We numerically demonstrate that MCD is enhanced three times larger than reported method based on the resonance of electric dipole plasmonic mode.

Broadband TiO2 Dielectric Metamaterial Absorber, Tian Lan, Pinwei Liu, Xiaomei Chen, School of Optics and Photonics, Beijing Inst. of Technology, China. In this paper, we demonstrate a broadband, polarization-insensitive, and omnidirectional metamaterial absorber which is relatively easy to fabricate. This device exhibits absorption above 90% in the wavelength range from 639 nm to 1339 nm.

Recognizing Network Activity Based on Hierarchical Clusterization in Optical Networks, Anurag Prakash, Subrat Kar, IIT Delhi, India. We review the hierarchical clustering method to provide low-rank parametric embeddings of network activity patterns. Since optical parameters exhibit spatial and temporal locality, we create dendrogram clustering representation for such an embedding.

SHG of Quasistatic Origin from Extreme Nano-scaled Heterodiodes, Maya H. Shoh, Avi Niv, Ben-Gurion Univ. of the Negev, Israel; Solar Energy and Environmental Physics, Ben-Gurion Univ. of the Negev, Israel. We show experimentally that SHG from gold-silver nanodimers is qualitatively different from the prediction of known theory. Consequently, we propose a quasi-static interaction model that is relevant to extreme nano-sized objects at hand.
JT4A.22 Investigation of 1-D Quasi-periodic Photonic Crystal Based Sensor for Detection of Hemoglobin, Bipin K. Singh¹, Vipul Rastogi¹, Praveen C. Pandey¹; Department of Physics, Indian Inst. of Technology Roorkee, India; Department of Physics, Indian Inst. of Technology (BHU) Varanasi, India. We investigate the detection of different concentrations of Hemoglobin in 1-D quasi-periodic photonic crystals by infiltrating samples in defect layer. The significant shift in sensing dips is analyzed for different concentrations and parameters.

JT4A.23 Enhanced Optical Absorption in Thin Film GaAs Solar Cells with Double Al Nanoparticle System, Gurjit Singh, S. S. Verma; Sant longowal Inst. of engg. & tech, India. The effect of single and double Al nanoparticle array on absorption of thin film GaAs solar cells is investigated by FDTD method. Plasmonic action of double array yields a maximum absorption enhancement factor of 1.74.

JT4A.24 Analysis of the Surface Recombination Influence on Organic Solar Cell J-V Curve, Ali R. Khaif, Jovana P. Gojanovic, Natasa A. Cirovic, Monirul Islam, Sandra Zivanovic, Petar Matavulj; School of Electrical Engineering, Serbia; Louisiana Tech Univ., USA. We suggest the SML (Small Medium Large) surface recombination velocity approach to systemize the analysis of its influence on organic solar cell J-V curve. The ITO/PEDOT/P3HT:ICBA device was analyzed and its J-V curve was reproduced.

JT4A.25 Light-slice: Evaluation of Slice-ability-based RMCSA Algorithms in SDM-EON, Yue Wang, Vinod Vokkarane; ECE Department, Univ. of Massachusetts Lowell, USA. We investigate the potential of using SDM-EON to handle exhaustion of current network resources. We propose to utilize the combination of Slice-ability and Best-Fit RMCSA algorithm to decrease spectrum fragmentation due to contiguity constraint.

JT4A.26 Withdrawn
08:00–10:00
IW1A • Optomechanics and Nanophotonics
Presider: Lucia Caspani; Univ. of Strathclyde, UK

IW1A.1 • 08:00
Electromechanical Brillouin Scattering in Integrated Optomechanical Waveguides, Mo Li, Qiu Li, Song Bi, Huan Li; Univ. of Washington, USA. We demonstrate electromechanically excited Brillouin scattering in integrated, piezoelectric optomechanical waveguides. Acoustic phonons of 16 GHz are excited with transducers to scatter counter-propagating photons into the anti-Stokes sideband.

IW1A.2 • 08:30
Synthetic Magnetic Fields for Phonons and Photons through Optomechanical Interactions, Javier Del Fino1, Ewald Verhagen1, John P. Mathew1, Robert Duggan2, Andrea AUI2, ‘FOM Inst. for Atomic and Molecular Physics (AMOLF), Netherlands; 2Department of Electrical and Computer Engineering, The Univ. of Texas at Austin, USA, ‘Photons Initiative, Advanced Science Research Center, USA. We demonstrate synthetic magnetic fields for both light and sound via radiation pressure. We show how optomechanical interactions and suitable symmetry breaking enable non-reciprocal phononic transport and polarization control for photons on a chip.

IW1A.3 • 09:00
Towards Optical Manipulation on a Chip, John Canning; Univ. of Technology Sydney, Australia. Hovering of optical water using an optical tractor on an SPR excited sputtered gold (Au) surface is demonstrated. Direct visual observation shows accumulation of water towards optical light passing through a gold layered metal film.

IW1A.4 • 09:15
Simulating Travelling Waves in Large 3D Whispering Gallery Mode Resonators Decorated with Plasmonic Nanoparticles, Lei Chen1,2, Cheng Li1, Yu-min Liu1, Judith Su1, Euan McLeod1; ‘Univ. of Arizona, USA, ‘Beijing Univ. of Posts and Telecommunication, China. Nanostructures can improve the performance of high-Q whispering gallery mode (WGM) resonators. Here we use a new simulation method capable of handling travelling waves in large 3D WGM systems to design a free space coupler.

IW1A.5 • 09:30
High Efficiency Metasurface Design Based on Deep Generative Models, Jiaqiang Jiang1, David Sell2, Jonathan A. Fan1; 1Department of Electrical Engineering, Stanford Univ., USA; 2Department of Applied Physics, Stanford Univ., USA. We show that generative neural networks can train from images of periodic topology-optimized metasurfaces to produce high-efficiency, topologically complex devices, served as a new design tool to facilitate metasurface design.

IW1A.6 • 09:45
Multi-spectral SWIR PbS Quantum Dot Pixels Realized Using Transfer Printing, Nayyera Mahmood1, Willem Wairvrens1, Robin Petit2, Michael Van Daele2, Christophe Deetemier1, Zeger Hens1, Gunther Roelkens1; 1Information Technology, Photonics Research Group, Ghent Univ.-IMEC, Belgium; 2Center for Nano and Biophotonics, Ghent Univ.-imec, Belgium. We report on the transfer-printing-based integration of PbS QD pixels for multi-spectral imaging in the short-wave infrared. A proof-of-concept, 8 multi-spectral pixels each consisting of 4 QD photodetectors operating in the SWIR are demonstrated.

08:00–10:00
NoW1B • Metamaterials and Metasurfaces 2
Presider: Mikhail Kats; Univ. of Wisconsin-Madison, USA

NoW1B.1 • 08:00
Tutorial
Emerging Material Platforms: Design Approaches for Nanophotonic Devices, Alexandra Boltasseva; Purdue Univ., USA. Emerging nanophotonic materials will be discussed including transparent conducting oxides, semimetals, 2-D and trans-dimensional materials such as graphene and MXenes. Topology optimization and machine learning for photonic design will be mentioned.

NoW1B.2 • 09:00
Integrated Dichroic Filtering for Octave-spanning Silicon Photonics, Emir Salih Magden; Electrical and Electronics Engineering, Koc Univ., Turkey. Broadband filters with sharp roll-offs are essential for flexibly handling optical signals in integrated photonic platforms. Here, recent developments on novel silicon photonic structures with octave-wide multiplexing capabilities will be reviewed.

NoW1B.3 • 09:30
Mid-infrared Hyperbolic Plasmons in Aligned Carbon Nanotube Metamaterials, Shangjie Yu1, John A. Roberts1, Po-Hsun Ho2, Stefan Schoeche3, Abram L. Falk4, Jonathan A. Fan1; 1Electrical Engineering, Stanford Univ., USA; 2Applied Physics, Stanford Univ., USA; 3IBM T.J. Watson Research Center, USA; 4J.A. Woollam Co., Inc., USA. A tunable mid-infrared hyperbolic metamaterial is demonstrated based on aligned carbon nanotube films. The hyperbolic dispersion of the plasmon modes is clearly shown through the experimental and theoretical studies of various nanopatterned films.

NoW1B.4 • 09:45
Manipulating Fano Coupling in All-dielectric Meta-molecules, Linghan Lin, Xiao-Ping Peng, Yuebing Zheng, Univ. of Texas at Austin, USA. We demonstrate the all-optical assembly of dielectric Fano metamolecules in the opto-thermoelectric trap with both reconfigurability and tunability.
These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

07:30–17:30 Registration, Grand Peninsula Foyer

08:30–10:00 PW1C • LED 3
Presider: Guillaume Lheureux; University of California Santa Barbara, USA

08:00–10:00 QtW1E • Quantum Technologies Part 1
Presider: David Hillerkuss; Huawei Technologies, Germany

09:00–10:00 QtW1E.2 • Invited
Quantum Key Distribution, Qiang Zhang; Univ. of Science and Technology of China, China. Abstract not available.

10:00–10:30 Networking Coffee Break with Exhibitors, Grand Peninsula D
**Grand Peninsula G**

Integrated Photonics Research, Silicon and Nano Photonics

**Sandpebble Room AB**

Novel Optical Materials and Applications

**Sandpebble Room CD**

Optical Devices and Materials for Solar Energy and Solid-state Lighting

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*These concurrent sessions are grouped across two pages. Please review both pages for complete session information.*

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10:30–13:00

**IW2A** • Photonic Computing and Emerging Technologies

**Presider:** Luca Dal Negro; Boston Univ., USA and Anna Tauke-Pedretti; Sandia National Laboratories Albuquerque, USA

**IW2A.1 • 10:30**

Invited

Accelerating the Development of Emerging Photonics Technologies through Microsystem Applications, Gordon A. Keeler, DARPA, USA. Photonics investments at DARPA/MTO seek revolutionary microsystem solutions to communications, sensing, and metrology challenges through innovation in materials, components, and integration. This talk highlights results from recent program efforts.

**IW2A.2 • 11:00**

Invited

Machine-learning-assisted Topology Optimization for Refractory Photonics, Alexandre Boitessa, Zhanylik Kudyshev, Alexander Kidishev, Vladimir Shalaev; Purdue Univ., USA. We expand metamaterial design methodology to a global optimization space by advancing topology optimization via artificial-intelligence-assisted algorithms and design efficient refractory photonics for thermophotovoltaics.

**IW2A.3 • 11:30**

Invited

InP Photonic Circuit for Deep Neural Networks, Bin Shi, Nicola Calabretta, Ripalda Stabile; Technische Universiteit Eindhoven, Netherlands. We perform weight addition of four 10 Gbit’s channels employing a photonic integrated indium phosphide chip based on semiconductor optical amplifier technology. We demonstrate classification of classes of iris flowers with an accuracy of 91.6%.

**IW2A.4 • 12:00**

Ultra-high Resolution and Broadband Chip-scale Speckle Enhanced Fourier-transform Spectrometer, Uttam Paudel; The Aerospace Corporation, USA. We report on a chip-scale silicon-on-insulator (SOI) hybrid optical spectrometer that combines speckles and discrete Fourier transform technology to achieve an ultra-high resolution spectral resolution (<150 MHz) across 10 nm bandwidth.

**NoW2B • Two-dimensional Materials**

**Presider:** Woei Ming Lee; Australian National Univ., Australia

**NoW2B.1 • 10:30**

Invited

Two-dimensional Semiconductors for Atomically-thin Optoelectronics, Deep Janjua; Univ. of Pennsylvania, USA. I will present recent computational and experimental advancements in enhancing light-matter interactions in two-dimensional materials and their heterostructures for making opto-electronic devices and present strategies for exploiting their tunability.

**NoW2B.2 • 11:00**

Second Harmonic Generation and Electroluminescence in 2D Semiconductors, Thomas Mueller, Lukas Menzel, Matthias Paur, Aday Molina-Mendoza; Vienna Univ. of Technology, Austria. Optical second harmonic-generation in strained two-dimensional semiconductors and electroluminescence from multi-particle exciton complexes in these materials will be discussed.

**NoW2B.3 • 11:30**

Invited

Ge2Sb2Te5 Integrated Silicon Photonics, Arka Majumdar, Jaiju Peng, Peipeng Xu, Jonathan Doylend; Univ. of Washington, USA; Ningbo Univ., China; intel, USA. Based on the non-volatile GST-on-silicon photonics platform, we demonstrate compact (~30 µm), low-loss (~1dB), and broadband (over 30 nm with crosstalk < -10 dB) 1 × 2 and 2 × 2 photonic directional coupler switches.

**NoW2B.4 • 12:00**

Silicon Microring Resonator Integrated MoTe, Photodetector, Rohi Madi, Chandramani Patil, Rohit Hemmadi, Volker J. Sorger, George Washington Univ., USA. Here we demonstrate a TMD-based photodetector heterogeneously integrated into a silicon photonics microcavity. The photodetector shows high responsivity (~0.1 A/W) with a low dark current at 1550 nm.

10:30–12:30

**PW2C • Modeling, Bifacial, Solar Resource, BIPV**

**Presider:** Klaus Jaeger; Helmholtz-Zentrum Berlin, Germany

**PW2C.1 • 10:30**

Invited

Ray Tracing of Complete Solar Cell Modules, Matthias Ruben Vogt, Robert Witteck, Timo Gehlert, Henning Schulte-Huxel, Carsten Schinke, Kansten Bothe, Rolf Brendel; Institute for Solar Energy Research in Hamelin (ISFH), Germany; Leibniz Universität Hannover, Germany. We use the Daidalos-Cloud module ray tracer to quantify optical losses in a PERC+ cell module in three different spectrally resolved irradiance conditions. In mean annual irradiation conditions 8.6 mA/cm² are lost, in contrast to 7.6 mA/cm² in STC.

**PW2C.2 • 11:00**

Comparison of FMM, FEM and FDTD for Absorption Modeling of Nanostructured Solar Cells and Photodetectors, Nicklas Anttu, Henrik Martyninen, Toulki Sadi, Antti Matikainen; Jan Turunen; Harri Lipsanen; ’Aalto Yliopisto, Finland; ’Univ. of Eastern Finland, Finland. We compare FMM, FEM and FDTD for absorption modeling. We discuss optimum choice of modeling method for varying nanostructures, enabling solar cell and photodetector design optimization that would be impossible with a suboptimal method choice.

**PW2C.3 • 11:15**

Module to Array Design for Bifacial Photovoltaics, Peter Bermel, Yuba Sun; Purdue Univ., USA. Here, I discuss the potential for designing bifacial photovoltaic modules to balance electrical and optical losses using interdigitated back contacts, and then extend this concept to the bifacial panel arrays.

**PW2C.4 • 11:30**

Experiments of the Spectral and Angular Solar Irradiance, Shevata Paal, Rebecca Saven; Univ. of Twente, Netherlands; California Inst. of Technology, USA. We propose an experimental procedure to measure spectro-angular solar irradiance for optimization of bifacial solar power plants. Our data shows strong spectro-angular irradiance variations dependent on location, surroundings and cloud coverage.

**PW2C.5 • 11:45**

Performance of Solar Cells under Spectro-angular Solar Irradiance, Shevata Paal, Roland Adelbreth, Rebecca Saven; University Twente, Netherlands. Performance of solar cells is usually determined under AM 1.5 conditions rarely existing at power plant sites. We present the dependence of solar cell output on the spectro-angular solar irradiance.

**PW2C.6 • 12:00**

Planar Light Guide Concentrators for Building Integrated Photovoltaics, Eryna Fennig, Greg Schmidt, Duncan T. Moore; Univ. of Rochester, USA. A light guide alternative to Fresnel lenses for building integrated photovoltaics is discussed. The design studies resulting in the final manufactured prototypes are reviewed and prototype testing results are reported.
These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

10:30–12:15
NoW2D • Glass Materials and Applications
Presider: Brandon Shaw; US Naval Research Laboratory, USA

NoW2D.1 • 10:30
Invited
Designing Dispersion in Infrared-transparent Glasses, J. David Musgraves, Rochester Precision Optics, USA. This presentation will discuss methods for intelligent design of glasses with desired dispersion profiles for use in infrared optical systems.

NoW2D.2 • 11:00
Invited
Chalcogenide Glasses and Fibers for Infrared Applications, Catherine Boussard-Pledel; Université de Rennes I, France. Abstract not available.

NoW2D.3 • 11:30
Fabrication of Broadband Anti-reflective Surface on Fused Silica from Visible to SWIR Spectral Band, Rajendra Joshi, Greg J. Gbur, Menelaos K. Poutous; Univ of North Carolina at Charlotte, USA. A reactive-ion etching process, can be optimized to fabricate an angle of incidence independent, anti-reflective, random-structured novel material; and can be tailored to shift the nearly perfect transmissive waveband through it from Visible to SWIR.

NoW2D.4 • 11:45
Ultra-sharp Single-crystalline Nano Probes for Near-field Applications, Duc Huy Nguyen¹, Yu-Wei Liu¹, Jung-Tse Huang¹, Jian-Zhi Huang¹, Chi-Whi Lin²; ¹Physics, National Dong Hwa Univ., Taiwan; ²Opto-Electronic Engineering, National Dong Hwa Univ., Taiwan. We present how an effective fiber drawing process followed by low-cost and controllable etching enables atomically smooth YAG crystal fiber, producing high-crystallinity, defect-free, and ultra-sharp tapered probes with apexes down to 1.5 nm.

NoW2D.5 • 12:00
Optimisation of Design Parameters Using Soft Computing Techniques for High Transmission Optical Filter Design, Sunita Parmam¹, Shashi Poddar¹, Mukesh Kumar¹, Neelam Kumar¹, Vinod Karan¹, Amit L. Sharma²; ¹CSIR-CSIO, India; ²Academy of Scientific and Innovative Research, India. High transmission optical filter with desired specifications is designed in visible region by optimising the layer thickness values. Genetic and particle swarm optimisation algorithms are used and compared for transmission performance and CPU time.

10:30–12:30
QtW2E • Quantum Technologies Part 2
Presider: David Hillerkuss; Huawei Technologies, Germany

QtW2E.1 • 10:30
Invited
Optimized Quantum Photonics, Jelena Vuckovic; Stanford Univ., USA. We present our recent progress on developing high quality qubits based on color centers in diamond and silicon carbide, combined with powerful optimized photonic structures providing efficient optical interfaces and interconnects.

QtW2E.2 • 10:50
Invited
Ultra-low Loss Waveguide Platforms for Integration of Quantum Circuits, Daviel J. Blumenthal; Univ. of California Santa Barbara, USA. In this talk we review work in ultra-low loss silicon nitride and related waveguide technology and the prospects and challenges to integrate sources, detectors, switches and other functions that can operate in the quantum regime.

QtW2E.3 • 11:10
Invited
Commercialization of QKD, Imran Khan; InfiniQuant, Germany. Abstract not available.

QtW2E.4 • 11:30
Invited
SKR Improvement for an Entanglement Assisted BB84 System Using Adaptive Optics on an FSO Link, John Ganano, Ivan B. Djordjevic; Univ of Arizona, USA. Implementing QKD systems over FSO channels can suffer due to time-varying channel degradations. To reduce the channel degradations use of adaptive optics to compensate for atmospheric turbulence is studied in a 30 km maritime channel.

QtW2E.5 • 11:50
Invited
High-dimensional Quantum Communication in Optical Fibres Using Spatial States, Leif Katsuo Oxenløwe; Technical Univ. of Denmark, Denmark. Abstract not available.
IW2A • Photonic Computing and Emerging Technologies—Continued

IW2A.5 • 12:15
Quantum Coherence Enhanced Graphene Spaser, Lakshitha Kumarapperuma, Malin Premaratne; Monash Univ., Australia. We demonstrate the possibility of significantly enhancing the output characteristics of a plasmonic nano-laser (spaser) made of a graphene plasmonic resonator and 3-level gain chromophores by using a coherent electric field to control the dynamics.

IW2A.6 • 12:30
Materials Aspects of Disordered Self-assembled Structures, Cefe Lopez; Consejo Superior de Inv Cientificas, Spain. Self-assembled structures are intrinsically disordered. Therefore it no surprise that supressing disorder to improve performance will encounter many difficulties. Where surprise lurks is in the difficulty to produce disorder entirely averting order.

NoW2B • Two-dimensional Materials—Continued

NoW2B.5 • 12:15
Optical Characteristics of Hybrid-nanostructures Using 2D Semiconductors and Applications to Photo-triggered Field-effect-transistors and Sensitive Photodetectors, Jinsoo Joo’, Cheol-Joon Park1, Hyeon Jung Park1, Taeho Noh1, Jeongyong Kim1; Korea Univ., Korea (the Republic of); 1Hannam Univ., Korea (the Republic of). Optical properties for 2D MoS2 hybridized with organic semiconductors or perovskite CsPbBr3 are studied. Photo-triggered MoS2/rubrene transistors are controlled by gate-bias. Photoresponsivity of MoS2 device is enhanced by hybridization with CsPbBr3.

PW2C • Modeling, Bifacial, Solar Resource, BIPV—Continued

PW2C.7 • 12:15
Enhanced Multi-layer Lens-let Array for Extreme Angle Solar Collection, Rakan E. Alsaigh1, Ralf Bauer1, Martin P. Lavery1; 1Univ. of Glasgow, UK; 2Univ. of Strathclyde, UK. Deployment of solar panels on the side of buildings leads to very-low collection-efficiency. We present an enhanced multi-layer lens-let array that increases the daily generated power at near vertical deployment by a factor of 4.783.

12:30–14:00 Lunch (on own)

12:30–14:00 Workshop: Hands-on Introduction to Data Analytics and Machine Learning in Optical Networks, Sandpebble Room E
12:30–14:00 Workshop: Hands-on Introduction to Data Analytics and Machine Learning in Optical Networks, Sandpebble Room E
Our work demonstrates the first III-V avalanche photodiodes grown directly on silicon by heteroepitaxy.

The InGaAs/InAlAs APD exhibits gain > 20, low dark current, quantum efficiency > 40%, and low excess noise (k value ~0.2).

The InGaAs/InAlAs APD exhibits gain > 20, low dark current, quantum efficiency > 40%, and low excess noise (k value ~0.2).

We demonstrate photodiodes on Si_3 N_4 waveguides with record-high external (internal) responsivities of 0.68A/W (0.8A/W) and 0.24A/W (0.6A/W) at 1550nm and 1064nm. Balanced photodiodes have low dark current of 10nA, 7GHz bandwidth, and over 40 dB CMRR.
Zehnder optical couplers in the multistage delayed interferometers operating 1×8 (de)multiplexer by adopting point-symmetric Mach-Zehnder interferometers, Wideband 1×8 Silicon Optical Demultiplexer Based on Point-symmetric Cascade Mach-Zehnder Interferometers, Novel Optical Materials and Applications, Optical Devices and Materials for Solar Energy and Solid-state Lighting.

These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

08:00–10:00
ITh1A • Silicon Photonic Integrated Circuits (Si PICs)
Presider: Benjamin Yang; Georgia Tech Research Inst., USA

ITh1A.1 • 08:00
Invited Laser Integration Technologies for Silicon Photonics, Jonathan Klamin, Lei Wang, Bei Shi, Simone Tommaso Sun Brunielli, Hong-gzhi Zhao, Bowen Song, Univ. of California Santa Barbara, USA. Heteroepitaxy of III-V materials on silicon for laser integration is reported. State-of-the-art templates and indium arsenide quantum dots are realized by metalorganic chemical vapor deposition, demonstrating potential for large-scale integration.

ITh1A.2 • 08:30
Classical and Quantum Integrated Silicon Photonics, Lorenzo Pavese, Universita degli Studi di Trento, Italy. Silicon Photonics is a platform to integrate classical as well as quantum photonics. Here we discuss an optical switches for telecom, a compact biosensor for screening toxins, a quantum random number generator and a source of heralded single photons.

ITh1A.3 • 09:00
Invited Overview of Silicon Photonics Components for Commercial DWDM Applications, M. Abshak Seyedi, Jared Hulme, Peng Sun, Thomas Van Vaerenbergh, Xiaogao Zheng, Geza Kurczveil, Zhichang Huang, Di Liang, Marco Fiorentino, Ray Beausoleil, Hewlett Packard Enterprise, USA. This paper presents an overview of the work done by Hewlett Packard Labs on high bandwidth, scalable and cost-effective interconnect solution. We outline the proposed link architecture, review components and discuss co-packaged form factors.

ITh1A.4 • 09:30
Wideband 1×8 Silicon Optical Demultiplexer Based on Point-symmetric Cascade Mach-Zehnder Interferometers, Seok-Hwan Jeong, PETRA, Japan. We propose and demonstrate wideband operating 1×8(8)demultiplexer by adopting point-symmetric Mach-Zehnder optical couplers in the multistage delayed interferometers over >100-nm range in O-band regime.

ITh1A.5 • 09:45
Refractive Index Engineering Inside Silicon by Infrared Laser Pulses of Different Pulse Durations in the Picosecond Regime, Andong Wang, Amlan Das, Olivier Utzra, David Grijo, CNRS, France. We report on the refractive index engineering inside silicon bulk by picosecond infrared lasers. Different responses are observed depending on the pulse durations. This represents a critical step for prototyping 3D silicon photonics microdevices.

10:00–10:30 Networking Coffee Break with Exhibitors, Grand Peninsula D
These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

08:00–10:00  NeTh1D • Network Telemetry, Data Analytics and Visualization  
Presider: Nihel Benzaoui; Nokia Corporation, France

NeTh1D.1 • 08:00  Invited  
Analytics-driven Network Management, Mohit Chamania1, Xiaomin Chen2; 1ADVA Optical Networking, Germany; 2Nantong Univ., China. This paper presents a network management architecture that can effectively integrate inputs from various analytics frameworks to manage network and service lifecycles, along with some open research challenges for autonomous network management.

NeTh1D.2 • 08:30  Invited  
Physical-layer Visualization and Analysis toward Efficient Network Operation by Deep Neural Networks, Takahito Tanimura, Yuichi Akiyama, Takeshi Hoshida; Fujitsu Limited, Japan. We discuss digital coherent receiver-based physical layer information visualization, which utilizes machine learning techniques such as neural networks to provide useful information to network operators for the better operational decision.

NeTh1D.3 • 09:00  Invited  
Data Analytics for Re-dimensioning of SDM Links in Spectrally-spatially Flexible Optical Networks, Krzysztof Wałkowik1, Raza Goscier2, Adam Włodarczyk, Patry Lechowicz1, Miroslaw Klinkowski2; 1Warsaw Univ. of Science and Technology, Poland; 2National Inst. of Telecommunications, Poland. We focus on spectrally-spatially flexible optical networks and analyze benefits of adjusting the number of active spatial modes in network links using various metrics based on data analytics with the goal to maximize the served traffic.

NeTh1D.4 • 09:30  Invited  
Achieving Low-latency H2M Communications through Predicting Bandwidth Demand: A Comparative Study of Statistical Prediction and Machine Learning Techniques, Elaine Wong, Lihua Ruan; Electrical and Electronic Engineering, Univ. of Melbourne, Australia. Bandwidth demand prediction is crucial in reducing uplink latency of human-to-machine traffic in future converged networks. A comprehensive review of existing statistical prediction and state-of-the-art machine learning techniques is presented.

08:30–10:00  SpTh1E • Transmission 1  
Presider: Maria Vasilica Ionescu; Nokia Bell Labs France, France

SpTh1E.1 • 08:30  Invited  
Frequency Comb Based High-spectral Efficiency Transmission, Mikael Mazur1, Jochen B. Schröder2, Abel L. Riesgo1, Magnus Karlsson1, Peter A. Andrekson1; 1Chalmers Tekniska Hogskola, Sweden; 2Instituto de Telecomunicaciones (IT), Portugal. We review our work on high spectral efficiency frequency comb-based superchannels using shared optical pilot tones combined with digital signal processing. The coherence of frequency combs is exploited to minimize the pilot tone overhead.

SpTh1E.2 • 09:00  Invited  
Overlapping Estimation Based on DBSCAN Algorithm in Nyquist-WDM Systems, Jhon J. Granada Torres1, Neil G. Gonzalez2; 1Universidad de Antioquia, Colombia; 2Universidad Nacional de Colombia, Colombia. We propose a method to estimate the percentage of overlapping between optical channels based on DBSCAN algorithm applied to received symbols. We experimentally verified this method in a 3×16-Gbaud 16QAM Nyquist-WDM system.

SpTh1E.3 • 09:15  Invited  
KNN-based Demodulation in Gridless Nyquist-WDM Systems Affected by Interchannel Interference, Alejandro Escobar Pérez1, Jhon J. Granada Torres1, Neil G. Gonzalez2; 1Universidad de Antioquia, Colombia; 2Universidad Nacional de Colombia, Colombia. We propose a digital demodulation technique based on KNN algorithm for 16-QAM signals affected by interchannel interference in gridless scenarios. We experimentally verified this technique in a 3×16-Gbaud 16QAM Nyquist-WDM system.

SpTh1E.4 • 09:30  Invited  
Towards FPGA Emulation of Fiber-optic Channels for Deep-BER Evaluation of DSP Implementations, Erik Börjeson, Christoffer Fougstedt, Per Larsson-Edefors; Chalmers Univ. of Technology, Sweden. We introduce an FPGA-based fiber-optic channel emulator, including both AWGN and carrier phase noise, which can be used to perform deep-BER simulations of DSP implementations and accurately evaluate DSP implementation penalties.

10:00–10:30  Networking Coffee Break with Exhibitors, Grand Peninsula D
On-chip Frequency Combs, Michael Kues, Christian Reimer, D-dimensional Frequency-time Entangled Cluster States with IT 2A.4 • 11:45 Ruocco, Michael Watts; Research Laboratory of Electronics, Massachusetts Institute of Technology, USA. We enable a new class of electro-optic components based on a strong Pockels effect (>900 pm/V) in photonic integrated circuits. Integration concepts and examples of high-speed electro-optic modulators and ultra-low power tuning elements are discussed.

Highly Entangled Photon Pairs from Semiconductor Quantum Dots, Armando Rastelli, Johannes Kepler Universität Linz, Germany. We report here on semiconductor quantum dot pairs capable of emitting highly entangled photon pairs, on the conditions required to achieve high degree of indistinguishability, and on the implementation of photonic quantum teleportation.

Efficient Parametric Source of Non Classical Light Based on a Photonic Crystal Cavity, Gabriel Marty, Sylvain Combrèl, Antoine Raineri, Alfredo De Rossi, Thales Research and Technology, France; Centre de Nanosciences et de Nanotechnologies, CNRS, Université Paris Saclay, Palaiseau, France, France; Université Paris Diderot, Sorbonne Paris Cit, 75205 Paris, France, France. Efficient (<6 dB) parametric conversion is achieved in Photonic Crystal Cavities by compensating disorder-induced spectral misalignment. Spontaneous Four Wave Mixing up to 20 pW is detected with pump power about 0.1 mW.

Broadband Electric-field-induced Second Harmonic Generation in a Silicon Waveguide, Manan Raval, Neetesh Singh, Alfonso Broadband Electric-field-induced Second Harmonic Generation, IT 2A.3 • 11:30 Raman Kashyap, Alfonso Cino, Sai T. Chu, Brent E. Little, David Spence, Stefan Abel, Felix Eltse, Jean Fompeyrine, Stefan Abel, IBM Research – Zurich, Switzerland. We enable a new class of electro-optic components based on a strong Pockels effect (>900 pm/V) in photonic integrated circuits. Integration concepts and examples of high-speed electro-optic modulators and ultra-low power tuning elements are discussed.

Bandgap and Interface Engineering of Two-dimensional Layered Semiconductors, Arvind Pan, Hunan Univ., China. In this talk, we report our recent progress on the band gap and interface engineering of 2D atomically thin layered semiconductors, and demonstrate some interesting optical properties and device applications of these novel 2D nanostructures.

Excitons in Atomically Thin 2D Materials and Heterostructures, Tony Heinz, Stanford Univ., USA. Abstract not available.

Compact Double Graphene Layer Modulators in Dielectric Waveguides, Arif Gungor, Nadir Dagli, Univ. of California Santa Barbara, USA. Simple and low-cost electro absorption modulators in low loss Si,N,SO platform containing two graphene layers are fabricated. 100 micron long devices demonstrate about 3 dB absorption change, which agrees well with the calculations.

Mach-Zehnder ITO Modulator on SOI, Rubab Amin, Rishi Maiti, Carlin Cafemo, Zhihui Ma, Mohammad Tahemsi, Ygal Liach, Dilan Ratnayake, Hamed Dalir, Valer J. Sorger, George Washington Univ., USA; Nanofabrication and Imaging Center, George Washington Univ., USA; Omega Optics Inc., USA. We demonstrate a monolithically integrated compact ITO electro-optic modulator in silicon on insulator photonics based on a Mach-Zehnder interferometer featuring a high-performance half-wave voltage and active device length product of 1 V μm.

High noise tolerance. We developed a d-level cluster witness and showed a d-dimensional entanglement of time-frequency hyper-entangled states, and converted them via a deterministic controlled gate into d-level cluster states. For detection, we developed a d-level cluster witness and showed a high noise tolerance.
10:30–12:30
NeTh2D • Heterogeneous and Distributed Photonic Networks
Presider: David Caplan; MIT Lincoln Lab, USA

NeTh2D.1 • 10:30  Invited
Optical Solutions for Next-generation Wireless Networks, Benjamin Imanilov, Michael Sauer, Andrey Kobyakov, Corning Inc., USA. We review evolution of in-building radio access networks (RAN) from early distributed antenna systems to 5G RAN and analyze the role of optical solutions in realistic system deployments.

NeTh2D.2 • 11:00  Invited
Microwave Photonics for a Radar Network, Leonardo Lembo1, Salvatore Marescal, Giovanni Serafinno1, Filippo Scotti1, Antonio Malacarne1, Paolo Ghelfi1. The benefits of photonics-based fully coherent radar networks are analyzed. The first photonics-based coherent 2x2 MIMO radar network has been implemented and tested in real environments confirming the potential of photonics in overcoming RF issues.

NeTh2D.3 • 11:30  Invited
5G Transport Networks: Capacity, Latency and Cost, Jiajia Chen1,2; KTH Royal Inst. of Technology, Sweden; 2Chalmers Univ. of Technology, Sweden. We summarize recent research on 5G transport networks addressing challenges on capacity, service migration and techno-economics brought by cloud radio access networks, diverse usage scenarios and heterogeneous deployments, respectively.

10:30–12:15
SpTh2E • Transmission 2
Presider: Mikael Mazur; Chalmers Tekniska Hogskola, Sweden

SpTh2E.1 • 10:30  Invited
Challenges in Subsea Transmission Systems, Maria Vaslica Ionescu, Nokia Bell Labs, France. This paper examines the capacity evolution in subsea optical transmission systems and presents the specific challenges faced in sustaining growth in future systems, particularly under cost and electrical power constraints.

SpTh2E.2 • 11:00  Invited
Substantial Capacity Increase via Optimized Power/Bit Allocation in Spatially Multiplexed Power-limited Submarine Systems, Jose Krause Peiri1, Joseph M. Kahn1, John Downie2, Jason Hurley1, Kevin Bennett1; 1Stanford Univ., USA; 2Corning, Inc., USA. We show how to optimize the channel bit/power allocation in submarine systems under an electrical power constraint. Our design strategy increases the theoretical link capacity by up to 70% compared to a recently proposed system.

SpTh2E.3 • 11:30  Invited
Low-complexity PDL-resilient Signaling Design, Arnaud Dumenil, Ele Awwad, Cyril Measson, Nokia Bell Labs, France. Building on recent works on PDL-resilience, we show how to derive optimal and practically-efficient low-complexity multidimensional signaling. Analytic arguments provide optimized unitary transforms of multiplexed square QAM as a function of the PDL.
These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

**ITh2A • Quantum and Nonlinear Photonics—Continued**

**ITh2A.5 • 12:00**
Generation and Detection of Photon Pairs at 2.080 μm by Spontaneous Parametric Down Conversion in a PPLN Crystal, Shashi Prabhakar1, Taylor Shields1, Damjan Powell1, Gregor Taylor1, Dmitry Morozov2, Mehdi Ebrahimi3, Michael Kues1,2, Luca Caspani2, Carin Gawith3, Robert Hadfield1, Matteo Clerici1; 1Univ. of Glasgow, UK; 2Hannover Center for Optical Technologies, Leibniz Univ. Hannover, Germany; 3Inst. of Photonics, Department of Physics, Univ. of Strathclyde, UK; 4Coversion Ltd. & Optoelectronics Research Centre, Univ. of Southampton, UK. We report the generation and detection of photon pairs at 2.080 μm. We characterized the coincidence to accidental ratio for a source with potential applications in integrated quantum optics, away from the Silicon two-photon absorption.

**ITh2A.6 • 12:15**
Time-resolved Nonlinear Ghost Imaging, Luana Olivieri, Juan Sebastian Toto Gonora, Vittorio Cecconi, Robyn Tucker, Luke Peters, Alessia Pasquazi, Marco Peccianti; Univ. of Sussex, UK. We propose a new type of THz Ghost-Imaging technique combining nonlinear pattern generation and time-resolved single-pixel measurements. Our approach allows to reconstruct the morphology and spectrum of the sample with deep subwavelength resolution.

**NoTh2B • Two-dimensional Materials and Nanomaterials—Continued**

**NoTh2B.4 • 12:00**
Indium Tin Oxide Metatronic Circuit Board for Analog Computing, Mario Miscuglio, Joseph Crandall, Shuai Sun, Yaliang Gui, Volker J. Sorge, George Washington Univ., USA. Analog processors provide an equivalent model for complex problems. Here, we propose a nano-optics metatronic approach based on EpsilonNearZero circuit, which provides accurate solution for Laplace differential equation similarly to a resistive mesh.

**NoTh2B.5 • 12:15**
Numerical Calculations of Band Shifting and Permittivity of Silver-based Bi-metallic Alloys, Min-Hsueh Chiu1, Jia-Han Li; National Taiwan Univ., Taiwan. The operating frequency of the plasmonic devices can be tuned by the materials. In this work, we simulate the silver-based bi-metallic alloys and discuss the effects of band shifting on permittivity.

**ITh2C • Modulators—Continued**

**ITh2C.5 • 12:00**
From the Backscattering to the Reactive Coupling, Stefano Biasci1, Fernando Ramiro-Manzano2, Mher Ghulinyan3, Iacopo Carusotto1, Lorenzo Pavel1; Univ. of Trento, Italy; 3Instuto de Tecnología Química, Spain; 1Centre for Materials and Microsystems, Fondazione Bruno Kessler, Italy; 2Physics, INO-CNR BEC Center and Department of Physics, Univ. of Trento, Italy. We use the knowledge of the complex field to study experimentally the inter-mode coupling. Reducing the mutual dependence of the parameters we confirm the key-role of a reactive inter-mode coupling reported in [Phys. Rev. 90.053811, J Phys. B 42,215401]

**ITh2C.6 • 12:15**
Integrated Visible-light Liquid-crystal Variable-tap Amplitude Modulator, Milica Notaros, Jelena Notaros, Manan Raval, Michael Watts, Massachusetts Inst. of Technology, USA. An integrated visible-light liquid-crystal variable-tap amplitude modulator is proposed and experimentally shown. The device leverages liquid-crystal birefringence to vary the coupling between two waveguides and enable compact, low-power modulation.

**12:30–14:00**  Lunch (on own)
NeTh2D • Heterogeneous and Distributed Photonic Networks—Continued

SpTh2E • Transmission 2—Continued

SpTh2E.4 • 12:00
Zero Forcing Pre-compensation Technique for Multi-core Fiber Transmission System, Akram A. Abouseif, Ghaya Rekaya-Ben Othman, Yves Jaouen; LTCI, Telecom ParisTech, France. We propose pre-compensation to enhance the multi-core fiber performance. The proposed solution avoids the feedback estimation of the channel by applying mathematical channel model. The pre-compensation offers close performance to the Gaussian channel.

12:30–14:00  Lunch (on own)
**ITh3A • Biophotonics and Sensing**

**President:** Noelia Vico Triviño; IBM, Switzerland

**ITh3A.1 • 14:00**

**Invited**

*Terahertz Spectrometry through Photomixing, Mona Jamahi; UCLA, USA.* We present a heterodyne terahertz spectrometer that utilizes plasmonic photomixing to offer quantum-level sensitivities at room temperature, for the first time, through a flexible platform capable of operating over 0.1-5 THz frequency band.

**ITh3A.2 • 14:30**

**Invited**

*Photonic Integrated Inertial Sensors, Sunaj Bramhavar, Dave Khara, Paul Juodawlkis; MIT Lincoln Laboratory, USA.* We demonstrate a chip-scale photonic platform that integrates photonic circuits with large mechanical structures at the wafer-scale. The platform can be used to realize chip-scale inertial sensors with performance exceeding traditional MEMS devices.

**ITh3A.3 • 15:00**

**Invited**

*Imaging Flow Cytometer and Image-guided Cell Sorter, Yuhwa Lo; Univ. of California San Diego, USA.* We discuss techniques that integrate microscopy and flow cytometry and flow cytometer cell sorter into a single device. We report on the InP-based coupled ridge-waveguide laser arrays emitting at 2.1μm with high output power of 521mW and a far-field distribution with a dominant central lobe were achieved.

**NoTh3B • Active Materials and Metamaterials**

**President:** Woel Ming Lee; Australian National Univ., Australia

**NoTh3B.1 • 14:00**

**Invited**

*Engineering III-V Nanowires for Optoelectronics: From Visible to Terahertz, Hannah Joyce1, Chawit Usawach1, Stephanie Adeyemo1, Srabani Kar1, Djamaad Damry2, Kun Peng3, Michael Johnston4, Jennifer Wong-Leung5, Hee Tan6, Chennaipti Jagadish1; 1Univ. of Cambridge, UK; 2Univ. of Oxford, UK; 3Australian National Univ., Australia.* We describe how optimized growth processes and contact-free electrical characterization techniques are accelerating the development of III-V nanowire-based optoelectronic devices with new and enhanced performance.

**NoTh3B.2 • 14:30**

**Invited**

*Control Architectures for Coherent Phase Photonics, Artur Davoyan; Univ. of California Los Angeles, USA.* As the complexity of optical systems grows novel system level functions emerge. In this talk I will discuss our recent work on understanding and controlling emergent phenomena in coherent phase optical systems and meta-structures.

**NoTh3B.3 • 15:00**

*Terahertz Time-dependent Random Metamaterials, Jacob D. Tunesi1, Luke Peters1, Juan Sebastian Totero Gongora2, Alessia Pasquazi3, Andrea Fratalocchi1, Marco Pecchiari2; 1Univ. of Sussex, UK; 2 King Abdullah Univ. of Science and Technology, Saudi Arabia.* Plasmonic metamaterials enable access to extremely nonlinear regimes with remarkable full-field control. We theoretically and experimentally demonstrate a novel form of photo-induced semiconductor optical processes, which is enabled by the tight confinement of optical fields and optical scattering forces.

**NoTh3B.4 • 15:15**

*Nanomanipulation of Colloidal Particles via Optothermally-gated Photon Nudging, Jingang Li, Yaoran Liu, Yuebing Zheng; The Univ. of Texas at Austin, USA.* We report an all-optical technique for versatile nanomanipulation and assembly of various colloidal particles on a solid substrate by harnessing both photothermal effects and optical scattering forces.
These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

Thursday, 1 August

14:00–16:00
NeTh3D • Devices and Transmission 3
Presider: Nick Parsons; HUBER+SUHNER Polatis, Inc, UK

14:00–16:00
SpTh3E • Freespace Optics and Visible Light Communication
Presider: Hany Elgala; State Univ. of New York at Albany, USA

NeTh3D.1 • 14:00
The Scalability of Silicon Photonics for Optical Networks, Po Dong; Nokia Bell Labs, USA. Abstract not available.

SpTh3E.1 • 14:00
Impact of Variable Field of View in Indoor Visible Light Communications Networks, Thomas Little1, Iman Abdalla1, Michael B. Rahaim1,2; Boston Univ., USA; 1Engineering, Univ. of Massachusetts at Boston, USA. We describe and evaluate a dynamic field of view receiver for increasing coverage and SNR in medium access for a dense network of overhead optical access points.

NeTh3D.2 • 14:30
Polarization Independent and Ultra-broadband Silicon Photonics for Future Networks, Timo Aalto; VTT Technical Research Center of Finland, Finland. Abstract not available.

SpTh3E.2 • 14:30
Deep Learning Based Optical Camera Communications, Ian Walter, Monette H. Khadr, Hany Elgala; Electrical and Computer Engineering, Univ. at Albany, USA. A deep convolutional autoencoder (C-AE) for end-to-end adoption of orthogonal frequency division multiplexing (OFDM) based optical camera communications (OCC) is proposed and the feasibility of the neural network (NN) is verified by simulations.

NeTh3D.3 • 15:00
Polarization-shift Keying Using Low-coherence Sources, Mark D. Feuer, Mario V. Bnyamin, Xin Jiang; College of Staten Island, USA. Polarization-shift keying offers multi-dimensional signaling for systems using low-coherence sources. Non-Gaussian noise distributions are found to enable low bit-error rates up to at least 10 Gsym/s when broad source bandwidths are used.

SpTh3E.3 • 14:45
Open Source Visible-light Communication (VLC) System for Ultra-low Latency Optical Wireless Links in ITS, Marco Seminara1, Tassadaq Nawaz2, Stefano Caputo3, Francesco S. Cataliotti4, Lorenzo Mucchi5, Jacopo Catanii6,1; CNR-INO National Inst. of Optics of CNR, Italy; 2LENS, Italy; 3Univ. of Firenze, DINFO - Information Engineering Dept., Italy; 4Univ. of Firenze, Physics and Astronomy Dept., Italy; 5Univ. of Firenze, DINFO - Information Engineering Dept., Italy; 6Univ. of Firenze, Physics and Astronomy Dept., Italy. We developed an open-source VLC decode-and-relay transceiver with sub-ms latency for intelligent transportation systems. Range and speed performances are tested in a realistic setting, using a regulated LED traffic-light as optical information source.

NeTh3D.4 • 15:15
Optimization of Modulation Formats for Improved Quality of Transmission, Olga Vassilieva, Inwoong Kim, Tadashi Ikeuchi; Fujitsu Laboratories of America Inc., USA. We review the different candidates of modulation formats (from fixed to tunable) for improved network resource utilization and discuss how they can assist in achieving high capacity gains with precise knowledge of quality of transmission.

SpTh3E.4 • 15:00
Advanced Physical Layer Design for Li-Fi in the Industrial Internet of Things, Malte Hinrichs, Pablo Wilke Berenguer, Ronald Freund, Volker Jungnickel; Fraunhofer HHI, Germany. An energy efficient physical layer (PHY) employing pulsed modulation and simultaneous transmission enabling reliable Li-Fi networks for industrial applications. Essential PHY components are laid out and tested in a simulated manufacturing cell.
These concurrent sessions are grouped across two pages. Please review both pages for complete session information.

**ITh3A • Biophotonics and Sensing—Continued**

**ITh3A.4 • 15:30**

Ultra-sensitive and Selective Biomolecular Detection Using Frequency-locked Microtoroid Optical Resonators, Judith Su; Univ. of Arizona, USA. We used frequency locked microtoroid optical resonators to detect attomolar concentrations of Alzheimer’s biomarkers. In addition, we present methods to improve the sensitivity and selectivity these sensors.

**ITh3A.5 • 15:45**

Subwavelength Grating Bimodal Waveguide for Refractive Index Sensing, Luis Torrijos Morán, Jaime García-Rupérez; Biophotonics, Nanophotonics Technology Center - UPV, Spain. Periodic subwavelength structures supporting two TE modes are presented as high performance sensors with bulk and surface sensitivities of 1375.5nm/RIU and 6.138nm/mm, respectively. A complete theoretical study is provided by numerical simulations.

**NoTh3B • Active Materials and Metamaterials—Continued**

**NoTh3B.5 • 15:30**

Surface Terahertz Emission from 2D-flakes Micro-junctions, Luke Peters, Jacob D. Tunesi, Sean Ogilvie, Juan Sebastian Totero Gongora, Matthew Large, Alessia Pasquaiz, Alan Dalton, Marco Peccianti; Univ. of Sussex, UK. We consider the passive modulation of the surface field at a junction between semiconductors and 2D-materials. We experimentally demonstrate that this boosts the optical-to-terahertz conversion efficiency beyond that of benchmark surface emitters.

**NoTh3B.6 • 15:45**

Tunable Metasurface Based on Silicon Doped Indium Oxide, Hongwei Zhao, Ran Zhang, Hamid Chorsi, Wesley Britton, Yuyao Chen; Prasad P. Iyer, Jon Schuller, Luca Dal Negro, Jonathan Kamilik; Univ. of California Santa Barbara, USA; Boston Univ., USA. A tunable metasurface based on silicon doped indium oxide has been investigated. The amplitude of reflected light was actively tuned with a gate bias, demonstrating 57% reflectance change and 366 nm of resonance wavelength shift.

**ITh3C • Photonic Technologies—Continued**

**ITh3A.6 • 15:45**

Subwavelength Grating Bimodal Waveguide for Refractive Index Sensing, Luis Torrijos Morán, Jaime García-Rupérez; Biophotonics, Nanophotonics Technology Center - UPV, Spain. Periodic subwavelength structures supporting two TE modes are presented as high performance sensors with bulk and surface sensitivities of 1375.5nm/RIU and 6.138nm/mm, respectively. A complete theoretical study is provided by numerical simulations.
NeTh3D • Devices and Transmission - 3—Continued

SpTh3E • Freespace Optics and Visible Light Communication—Continued

SpTh3E.5 • 15:30
Influence of Angular Deflection on Mode Sorting with Adaptive Compensation for Beams Carrying Orbital Angular Momentum, Hiroki Kishikawa, Noriyuki Sakashita, Nobuo Goto; Tokushima Univ., Japan. We propose a method of adaptive compensation for angular deflection of orbital angular momentum beam on high resolution mode sorting. The sorting performance measured by crosstalk is effectively reduced for lateral angular deflection.

SpTh3E.6 • 15:45
8-ary OAM Shift Keying for FSO Link with Atmospheric Turbulence, Munkhbayar Adiya, Hiroki Kishikawa, Nobuo Goto; Tokushima Univ., Japan. We propose an 8-ary orbital angular momentum shift keying technique for free-space optical communication with atmospheric turbulence to improve tolerance to noise and phase distortion by atmospheric turbulence.

NeTh3D.5 • 15:45
Mitigation of Spectral Slicing Penalty Using Binary Polarization-shift Keying, Mark D. Feuer, Mario V. Bryamin, Xin Jiang; College of Staten Island, USA. Polarization-shift keying (PolSK) is shown theoretically and experimentally to improve performance of optical links based on spectrally-sliced sources. BER floors observed with on-off keying (OOK) at 5 Gba/s are eliminated when 2-PolSK is used.

Mitigation of Spectral Slicing Penalty Using Binary Polarization-shift Keying, Mark D. Feuer, Mario V. Bryamin, Xin Jiang; College of Staten Island, USA. Polarization-shift keying (PolSK) is shown theoretically and experimentally to improve performance of optical links based on spectrally-sliced sources. BER floors observed with on-off keying (OOK) at 5 Gba/s are eliminated when 2-PolSK is used.