#groupivphotonics2018

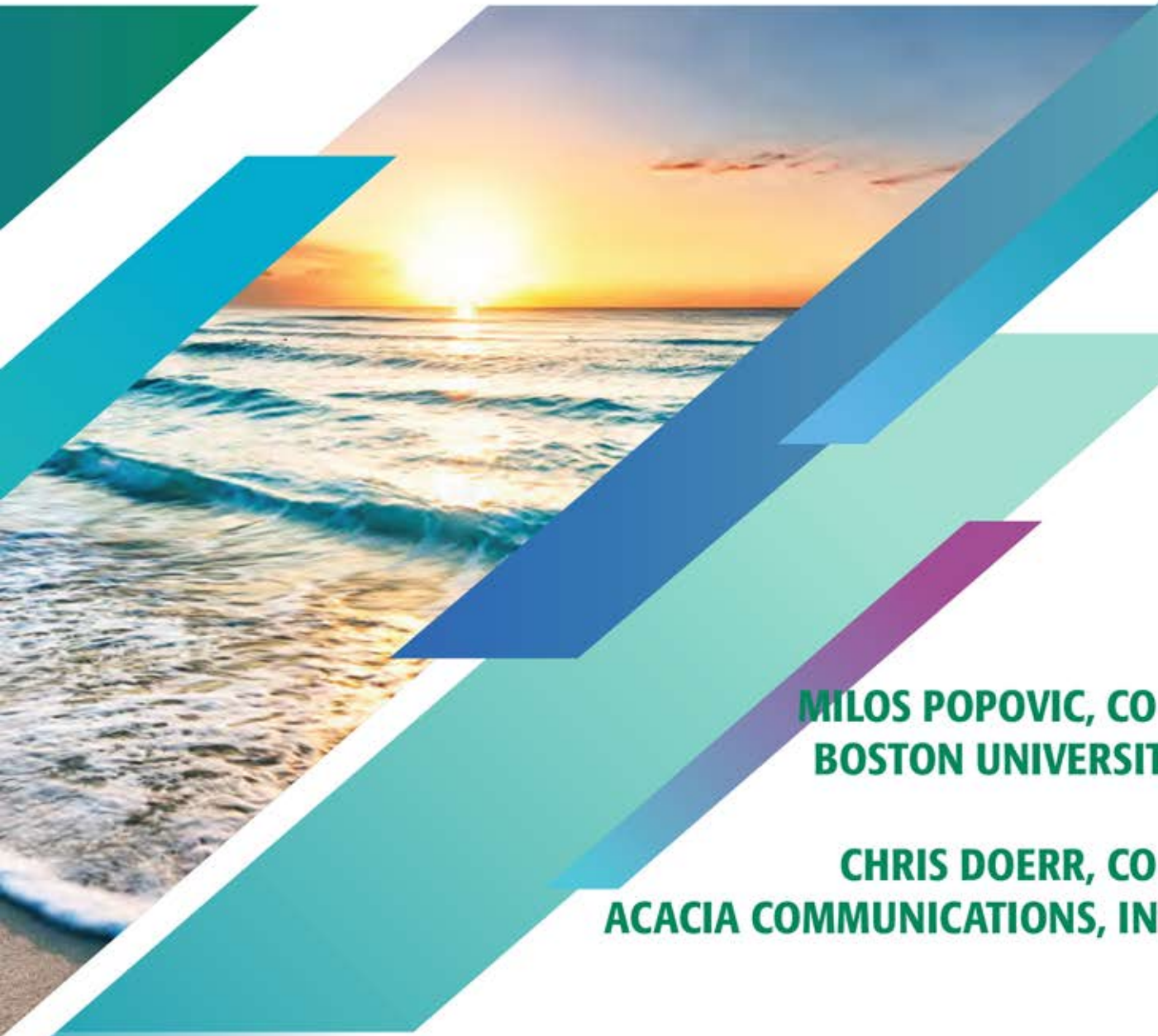
15th INTERNATIONAL CONFERENCE ON

GFP2018

GROUP IV PHOTONICS

29-31 AUGUST 2018

CANCUN, MEXICO



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GROUP IV PHOTONICS CONFERENCE 2018 Program-at-a-Glance

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Welcome Reception</td><td colspan="2">ALL GENERAL SESSIONS TO BE HELD IN TULUM A, B & C
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Welcome to the 15th International Conference on Group IV Photonics in Cancun, Mexico at the InterContinental Presidente Cancun Resort.

The Group IV Photonics Conference (GFP 2018), now in its 15th year, delivers insights on current and future innovations in Group IV element-based photonic materials and devices, including silicon photonics, as well as other integration and fabrication technologies. Scheduled as a single-track conference, GFP 2018 facilitates personal interaction between colleagues, including oral and poster sessions of contributed and invited papers, as well as a plenary session with overviews of important Group IV element photonics topics.

Christopher Doerr, Conference Co-Chairs

Milos Popovic, Conference Co-Chairs

Group IV Photonics Conference 2018 Chair & Committee List

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Milos Popovic**,** Boston University, USA

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Committee Members:
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Dan Mihai Buca, Forschungszentrum Jülich, Germany
Li Yang, Futurewei USA
Haisheng Rong, Intel Corp., USA
Andrew Knights, McMaster University, Canada

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Topic Chair:
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Committee Members:
Patrick Dumais, Huawei Canada, Canada
Xinliang Zhang, HUST, China
Joyce Poon, Univ. Toronto, Canada
Ying Huang, Rain Tree Photonics, Singapore
Kazuhiro Goi, Fujikura, Japan

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Group IV Photonics 2018 Exhibitors

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SYNOPSYS OPTICAL SOLUTIONS GROUP
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Umicore Electro-Optic Materials (EOM) supplies germanium-based solutions to customers around the world. Our main markets are thermal imaging and opto-electronic applications, for which we supply germanium wafers, infrared lenses and optics, and germanium-based chemicals such as germanium tetrachloride (GeCl4). We also supply high-purity germanium crystals to the scientific community. We guarantee our customers a secured germanium supply. In addition, we provide unique solutions to treat a wide variety of germanium-containing recycling streams.

Final Program

WEDNESDAY, 29 AUGUST 2018

8:00 am–10:00 am **Tulum A, B & C**
Session WA Lasers

8:00 am–8:30 am ***(Invited)***

WA1 **Investigation of GeSn Lasers towards Group IV Photonics Applications,** Shui-Qing Yu, *University of Arkansas, Fayetteville, AR, USA*, Wei Du, *Wilkes University, Wilkes-Barre, PA, USA,* Joe Margetis, John Tolle, *ASM, AZ, USA,* Seyed Ghetmiri, Aboozer Mosleh, *University of Arkansas at Pine Bluff, AR, USA*, Jifeng Liu, *Dartmouth College, Hanover, NH, USA*, Greg Sun, Richard Soref, *University of Massachusetts Boston, Boston, MA, USA*, Baohua Li, *Arktonics, LLC, AR, USA*, and Wei Du, Wilkes *University, Wilkes-Barre, PA, USA*

GeSn technique has attracted increasing interests due to the unique optical and electrical properties. The optically pumped GeSn edge-emitting lasers based on direct bandgap all group-IV materials have been systemically investigated. The laser operation wavelengths cover broad shortwave- and mid-infrared ranges.

8:30 am–8:45 am

WA2 **Low Pumping Threshold GeSn/SiGeSn Multiple Quatum Well Lasers,** Detlev Grützmacher, Nils von den Driesch, Daniela Stange, Denis Rainko, *Forschungszentrum Jülich, Jülich, Germany*, Zoran Ikonic, *University of Leeds, England, UK,* Jean-Michel Hartmann, *CEA-LETI, Grenoble, France, and* Dan Buca, *Forschungszentrum Jülich, Jülich, Germany*

GeSn/SiGeSn multiple quantum well structures have been grown by means of low temperature reactive gas source epitaxy on Ge pseudosubstrates. The MQW structures exhibit type I band alignment. Optically pumped μ-disc laser exhibit a threshold of 40kW/cm^2 to obtain optically pumped lasing.

8:45 am–9:00 am

WA3 **Microscopic Gain Analysis of Modulation-Doped GeSn Quantum Well: Epitaxial Design toward High-Temperature Lasing,** Takeshi Fujisawa, *Hokkairo University, Hokkaido, Japan,* Masakazu Arai, *University of Miyazaki, Miyazaki, Japan, and* Kunimasa Saitoh, *Hokkaido University, Hokkaido, Japan*

Material gain of modulation-doped GeSn quantum well is analyzed based on many-body theory. Significant gain increase can be expected for n-type modulation doping. The doping condition for elevated temperature lasing is discussed through the comparison of threshold carrier density of GeSn and conventional III-V lasers.

9:00 am–9:30 am ***(Invited)***

WA4 **InAs Quantum Dot Lasers Grown on Si,** Justin Norman, Yating Wan, *University of California Santa Barbara, Santa Barbara, CA, USA,* Robert Herrick, *Intel Corporation, CA, USA,* Arthur Gossard, John E. Bowers, and Daehwan Jung, *University of California Santa Barbara, Santa Barbara, CA, USA*

We present recent progress in performance and reliability of InAs quantum dot lasers epitaxially grown on (001) on-axis silicon. Fabry-Perot lasers show low threshold current densities (<150 A/cm^2), high output power (>185 mW) and extrapolated lifetimes more than 10 million hours.

9:30 am–9:45 am

WA5 **Ultra-Low Threshold InAs QD Microcavity Laser on U-shape Si (100) and SOI Platform by Epitaxial Growth,** Ting Wang, *Chinese Acadamy of Sciences, Beijing, Beijing, China,* Wen-Qi Wei, *Chinese Acadamy of Sciences, Beijing, China and Wuhan University, Wuhan, China,* Bin Zhang, Qi Feng, Hui Cong, and Jian-Jun Zhang, *Chinese Acadamy of Sciences, Beijing, China*

Recent years, the growing demand for silicon based light sources has boosted the research field of III-V/IV hybrid lasers. Here, the ultra-low threshold lasing of InAs quantum dot microcavity laser epitaxially grown on U-shape patterned Si (100) and SOI substrates is reported.

9:45 am–10:00 am

WA6 **Demonstration of an On-Chip III-V/Si Hybrid Semiconductor Optical Amplifier for Photonics Integration,** Ranjeet Kumar, Jonathan Doylend, Meer Sakib, Jie Sun, and Haisheng Rong, *Intel Corporation, Santa Clara, CA, USA*

We demonstrate a III-V/Si hybrid semiconductor optical amplifier at 1284 nm with on-chip gain >20 dB, output power >50 mW, internal noise-figure <7 dB, 3 dB bandwidth >40 nm, and amplification of 25 Gbps NRZ data with <1 dB power penalty at 1E-12 BER.

10:00 am–10:30 am **Tulum Foyer**

Exhibits / Coffee Break

10:30 am–12:00 pm **Tulum A, B & C**

Session WB Optical Modulators & Applications

10:30 am–10:45 am

WB1 **20-Gb/s Silicon Optical Modulators for the 2 µm Wavelength Band,** Wei Cao, David J. Thomson, Milos Nedeljkovic, Shaif-Ul Alam, Junjia Wang, Frederic Gardes, Graham T. Reed, Goran Z. Mashanovich, *University of Southampton, Southampton, UK,* Callum G. Littlejohns, and Mohamed Said, *Rouifed, Nanyang Technological University, Singapore*

We demonstrate silicon-on-insulator based high speed modulators working at a wavelength of 1950 nm. The carrier-depletion Mach-Zehnder interferometer modulator operates at a data rate of 20 Gbit/s with an extinction ratio of 5.8 dB and modulation efficiency ($V_\pi \cdot L_\pi$) of 2.68 V·cm at 4V reverse bias.

10:45 am–11:00 am

WB2 **Estimation of Optical Modulator Efficiency from Electrical Characteristics,** Hiroshi Fukuda, Yoshiho Maeda, Toru Miura, Tatsuou Hiraki, and Shinji Matsuo, *NTT Corporation, Atsugi, Japan*

We propose a new testing method to estimate the efficiency of Mach-Zehnder modulators by using only electrical characteristics, which is suitable for wafer-level testing. The breakdown voltage of the phase modulator shows a clear relationship with modulator efficiency.

11:00 am–11:30 am ***(Invited)***

WB3 **Silicon Based High-Speed Micro-Ring Modulators and Detectors for Low-Cost Photonic Integration,** Haisheng Rong, Ranjeet Kumar, Haisheng Rong, Jie Sun, Meer Sakib, Jeffrey Driscoll, and Hasitha Jayatilleka, *Intel Corporation, Santa Clara, CA, USA*

With commercialization of the silicon photonics technology in the recent years, research and development have been focusing on higher density integration to further reduce the fabrication cost. Here we present a compact micro-ring resonator based photonic chip capable of data transmission up to 128 Gb/s.

11:30 am–11:45 am

WB4 **3D Fin Waveguide on 10 nm Gate Oxide Bonded Double-SOI for Low VπL Accumulation Modulator,** J. Byers, *University of Southampton, Southampton, UK,* K. Debnath, *University of Southampton, Southampton, UK and Indian Institute of Technology, Kharagpur, India,* H. Arimoto, M. K. Husain, M. Sotto, Z. Li, F. Liu, A. Khokhar, K. Kiang, S. A. Boden, D. J. Thomson, G. T. Reed, and S. Saito, *University of Southampton, Southampton, UK*

We propose a new design for a low VpL accumulation optical modulator using 3-Dimensional (3D) Fin-waveguides on double Silicon-On-Insulator (SOI). We have introduced and demonstrated a novel, self-aligned patterning process to pattern the bottom SOI layer using anisotropic wet etching.

11:45 am–12:00 pm

WB5 **320 Gbps Physical Random Bit Generation from a Chaotic Oscillator with Silicon Microring Resonator Modulator,** Wenjing Tian, Lei Zhang, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China,* Jianfeng Ding, Xin Fu, *Chinese Academy of Sciences, Beijing, China*, and Lin Yang, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China*

We demonstrate physical random bit generation from a chaotic optoelectronic oscillator with silicon microring resonator modulator. The chaotic signal digitalized at 40 GS/s with 8 bit resolution result in a 320 Gbps bit stream, which passes all the NIST statistical tests after a self-delay XOR operation.

12:00 pm–1:30 pm

Lunch Break (On Own)

1:30 pm–3:30 pm **Tulum Foyer**
Session WP **Poster Session**

1:30 pm–3:30 pm

WP1 **Four-Port Mode-Selective Optical Router for Optical Interconnect,** Hao Jia, Ting Zhou, Xin Fu, Lei Zhang, and Lin Yang, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China*

We propose and demonstrate a four-port optical router using mode-selective property. The router uses modes as labels to direct signals between different ports. The insertion loss and the crosstalk of the device which fabricated on silicon-on-insulator is lower than 8.0 dB and –22.0 dB.

WP2 **Realizing Room Temperature Single-Photon Sources with Integrated Nanoplasmonic Quantum Interfaces,** Frédéric Peyskens, *Massachusetts Institute of Technology, Cambridge, MA, USA,* Darrick Chang, *Barcelona Institute of Science and Technology, Barcelona, Spain,* and Dirk Englund, *Massachusetts Institute of Technology, Cambridge, MA, USA*

We derive optimal operating conditions for single photon extraction and indistinguishability into the guided mode of a hybrid nanoplasmonic cavity-emitter system, evanescently coupled to a waveguide, and explicitly take into account emitter quenching and dephasing.

WP3 **A Time-Division Demultiplexer Using Differential Microring Samplers,** Ming Gong and Hui Wu, *University of Rochester, Rochester, NY, USA*

This paper presents a new electronic-photonic integrated circuit design of a time-division demultiplexers using microring couplers as samplers and employing a time-interleaved architecture. The differential circuit design overcomes limitation in microring extinction ratio, improves output signal amplitude, and reduces glitches due to sampling.

WP4 **Accelerating Passive and Active Silicon Photonics Design Using Multiple Numerical Techniques,** Mayank Bahl, Ying Zhou, Robert Scarmozzino, Evan Heller, Chenglin Xu, Daniel Herrmann, *Synopsys, Inc., Ossining, NY, USA,* and Gergoe Letay, *Synopsys, LCC, Zurich, Switzerland*

This work compares three numerical techniques for modeling the optics of passive and active silicon photonic devices. A comparison of computation time revealed that a judicious choice of technique can lead to the reduction of design cycle time by orders of magnitude.

WP5 **Cascaded Mach-Zehnder Wavelength (De-)Multiplexer for Low-Loss Flat-Top DWDM Applications,** Xin Fu, Hao Jia, Xiongfeng Fang, Jianfeng Ding, Lei Zhang, and Lin Yang, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China*

We demonstrate a four-channel cascaded Mach-Zehnder wavelength (de-)multiplexer with a small channel spacing of 0.5 nm on SOI platform. The device has flat pass-bands and shows insertion loss lower than 0.5 dB and crosstalk below –18 dB.

WP6 **Enhanced Tensile Strain in Ge Epitaxitial Layers Grown on Si-on-Quartz Wafers,** Michiharu Nishimura, *University of Tokyo, Tokyo, Japan,* Yoshiyuki Tsusaka, Junji Matsui, *University of Hyogo, Hyogo, Japan,* and Yasuhiko Ishikawa, *Toyohashi University of Technology, Toyohashi, Japan*

Ge epitaxial layers grown on Si-on-"quartz" wafers reveal an enhanced in-plane tensile strain of $0.36 \pm 0.03\%$, which is 2–3 times larger than those grown on ordinary Si-on-insulator wafers. The enhancement is derived from an increased thermal expansion mismatch.

WP7 **Lasing Effect in GeSn Photonic Crystal,** Q. M. Thai, N. Pauc, J. Aubin, M. Bertrand, J. Chrétien, R. Khazaka, A. Chelnokov, J. M. Hartmann, V. Reboud, and V. Calvo, *University Grenoble Alpes, Grenoble, France*

A photonic crystal membrane was fabricated on a GeSn 16% layer, grown on a step-graded buffer structure. The single mode lasing observed at low temperature under optical pumping was attributed to a guided band edge mode of the photonic crystal.

WP8 **$LiNbO_3$/Si-Hybrid Slot-Waveguide Electro-Optic Modulators,** I. Tomita, *University of Southampton, Southampton, UK and Gifu College, Gifu, Japan,* K. Debnath, *University of Southampton, Southampton, UK and Indian Institute of Technology, Kharagpur, India,* K. Ibukuro, M. K. Husain, J. Byers, Z. Zhang, and S. Saito, *University of Southampton, Southampton, UK*

A new $LiNbO_3$/Si-hybrid electro-optic modulator that utilizes a doped-Si slot waveguide is proposed. An excellent performance, i.e., an improvement of two orders of magnitude in $V\pi$ L, is demonstrated via simulations when compared with the performance of the conventional $LiNbO_3$ modulators.

WP9 **Noise Modeling of GeSn Heterojunction Phototransistors: Group IV Material based Alternative Photodetector,** Harshvardhan Kumar and Rikmantra Basu, *National Institute of Technology Delhi, New Delhi, India*

This work focuses on analytical based study of noise behaviour and gain of $Ge_{1-x}Sn_x$-based Heterojunction Photo-Transistor (HPT), as an alternative of III-V based exisiting photodetectors. Analysis ensures high gain and good SNR in comparison with group III-V compound based HPTs.

WP10 **Silicon Nitride Photonic Platform for LIDAR Applications,** S. Malhouitre, D. J. Fowler, S. Garcia, O. Lemonnier, N. Tyler, and W. Rabaud, *University Grenoble Alpes, Grenoble, France*

LIDAR in automotive systems typically uses 905 nm or 940 nm wavelength light for short to medium range mapping. The fabrication of an Optical Phase Array (OPA) for LIDAR applications at 905 nm wavelength on a silicon nitride platform using metal heaters for beam steering is reported here.

WP11 **Design of Efficient Phase Shifter Using InGaAs-InAs/Ge SIS Capacitor for Mid-IR Photonics Application,** Jae-Hoon Han, *Korea Institute of Science and Technology (KIST), Seoul, South Korea,* Hyung-jun Kim, *Korea Institute of Science and Technology (KIST) and University of Science and Technology, Seoul, South Korea,* Won Jun Choi, *Korea Institute of Science and Technology (KIST), Seoul, South Korea,* Jindong Song, and SangHyeon Kim, *Korea Institute of Science and Technology (KIST) & University of Science and Technology, Seoul, South Korea*

We investigate a hybrid SIS phase modulator for mid-IR application. Owing to its large free-carrier effect, InGaAs-InAs/Ge SIS capacitor can provide efficient phase modulation scheme. For achieving a high-performance device, structure design is carried out.

WP12 **Feasibility Study on Negative Capacitance SIS Phase Shifter for Low-Power Optical Phase Modulation,** Jae-Hoon Han, *Korea Institute of Science and Technology (KIST), Seoul, South Korea,* Pavlo Bidenko, Jindong Song, and SangHyeon Kim, *Korea Institute of Science and Technology (KIST) and University of Science and Technology, Seoul, South Korea*

We investigate a negative capacitance SIS phase shifter with ferroelectric materials for low-power optical switching. Negative capacitance can realize comparable charge with lower voltage owing to the charge polarization of ferroelectric materials. We discuss the charge enhancement, modulation efficiency and switching characteristic of this device.

WP13 **Comparison Among the Methods to Generate the PAM-4 Optical Signal with the Silicon Mach-Zehnder Optical Modulator,** Sizhu Shao, Jianfeng Ding, Lingchen Zheng, Lei Zhang, Xin Fu, and Lin Yang, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China*

We compare the three methods to generate the PAM-4 optical signal with the silicon Mach-Zehnder optical modulator. To achieve a uniform optical PAM-4 signal, the operating point for the single-arm-driving configuration is farther away from the quadrature point compared with the other driving configurations.

WP14 **Tunable Optical Filter with Variable Bandwidth Based on Vernier-Cascade Second-Order Microring Resonators,** Haoyan Wang, Lei Zhang, Xin Fu, Hao Jia, and Lin Yang, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China*

We report an optical bandpass filter with the bandwidth varying from 37.5 to 100 GHz and the wavelength tuning from 1460 to 1550 nm. The insertion loss is ~ –6dB, including the fiber-chip coupling losses.

WP15 **Optoelectrical Characterizations of GeSn Heterojunction Photodiodes with 6% to 16% of Sn,** M. Bertrand, Q. M. Thai, J. Chrétien, N. Pauc, R. Khazaka, J. Aubin, O. Lemonnier, A. Chelnokov, J. M. Hartmann, V. Calvo, and V. Reboud, *University Grenoble Alpes, Grenoble, France*

We study vertical GeSn p-i-n heterostructures on GeSn step-graded buffers with Sn content ranging from 6% to 16%. The performed spectrally-resolved photocurrent measurements allowed us to determine the directness bandgap behaviour of our devices. We report on the electrical and optical behavior of fabricated photodiodes.

WP16 **Tunable Silicon Photonic Grating Couplers with Low Power Consumption,** Shengqian Gao and Xinlun Cai, *Sun Yat-Sen University, Guangdong, China*

We demonstrate a thermally tunable grating coupler with low power consumption. The grating coupler is suspended by removing underlying Si, which effectively avoid heat leakage. We achieve central wavelength shift of 45 nm, and a record tuning efficiency of 2.56 nm/mW.

WP17 **Phase-Shifted Multimode Bragg Gratings in Silicon-on-Insulator for Sensing Applications,** Manuel Mendez-Astudillo, *Waseda University, Japan,* Hideaki Okayama, *Oki Electric Industry Co., Ltd., Japan,* Tomohiro Kita, *Waseda University and Tohoku University, Japan, and* Hirochika Nakajima, *Waseda University, Japan*

In this paper, we experimentally characterize the sensitivity of different types of multimode Bragg gratings in Silicon-On-Insulator and demonstrate a high sensitivity of 120 nm per refractive index unit using Bragg gratings for TM polarized light.

WP18 **2×8 Silicon Multicast Switch for On-Chip Optical Interconnect,** Shanglin Yang, Ting Zhou, Shanglin Yang, Hao Jia, and Lin Yang, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China*

We demonstrate a 2×8 silicon optical switch for multicast and broadcast functionalities. It is composed of six 3-dB multimode interference splitters and four Mach-Zehner optical switching units. The insertion loss is 7.6 dB and the crosstalk is below – 29.0 dB at 1550 nm.

WP19 **Germanium Photodetector with Enhanced Photo-Response at the L-Band and Beyond for Integrated Photonic Applications,** Yiding Lin, *Nanyang Technological University, Singapore and Singapore-MIT Alliance for Research and Technology, Singapore,* Danhao Ma, *Massachusetts Institute of Technology, Cambridge, MA, USA,* Kwang Hong Lee, *Singapore-MIT Alliance for Research and Technology, Singapore,* Jin Zhou, Xin Guo, Hong Wang, *Nanyang Technological University, Singapore*, Chuan Seng Tan, *Nanyang Technological University and Singapore-MIT Alliance for Research and Technology, Singapore*, and Jurgen Michel, *Singapore-MIT Alliance for Research and Technology, Singapore and Massachusetts Institute of Technology, Cambridge, MA, USA*

A germanium (Ge) MSM photodetector is demonstrated with significantly-enhanced photo-response at the L-band and beyond, using SiN_x stressor at the waveguide sidewalls created by a self-aligned dry etching method. This provides a CMOS-compatible solution for Ge detectors for broadband high-speed integrated photonic applications.

WP20 **Enhanced Self-Phase Modulation in Graphene-Integrated Silicon Waveguides,** Qi Feng, Hui Cong, *Chinese Academy of Sciences, Beijing, China,* Wenqi Wei, *Chinese Academy of Sciences, Beijing, China and Wuhan University, Wuhan, China*, Bin Zhang, Jianhuan Wang, Jieyin Zhang, Ting Wang, and Jianjun Zhang, *Chinese Academy of Sciences, Beijing, China*

Silicon-on-insulator waveguides covered with graphene in different lengths have been fabricated. We report self phase modulation in hybrid structures, and enhanced nonlinear phase shift and Kerr nonlinearity has been confirmed by experiments and simulations.

WP21 **Silicon Broadband Thermo-Optic 2 × 2 Four-Mode Optical Switch for On-Chip Optical Space and Local Mode Switching,** Ting Zhou, Hao Jia, Jianfeng Ding, Lei Zhang, Xin Fu, and Lin Yang, *Chinese Academy of Sciences, Beijing, China and University of Chinese Academy of Sciences, Beijing, China*

We present a silicon broadband thermo-optic 2 × 2 four-mode optical switch optimized for optical space switching plus local optical mode switching. The insertion losses are 8.0~12.2 dB and the optical signal-to-noise ratios are larger than 11.2 dB in 1525~1565 nm. 40 Gbps data transmission is implemented.

WP22 **Direct Frequency Modulated Photonic Crystal Laser,** P. K. J. Singaravelu, Sharon M. Butler, Andrei P. Bakoz, *Cork Institute of Technology, Cork, Ireland and Tyndall National Institute, Cork, Ireland,* Alexandros A. Liles, *School of Physics and Astronomy, St. Andrews, UK,* Stephen P. Hegarty, *Cork Institute of Technology, Cork, Ireland and Tyndall National Institute, Cork, Ireland,* and Liam O'Faolain, *Cork Institute of Technology, Cork, Ireland and Tyndall National Institute, Cork, Ireland and School of Physics and Astronomy, St. Andrews, UK*

We demonstrate the direct frequency modulation of Si Photonic crystal laser based on a high-speed electro-optic modulator. By modulating the resonant reflector frequency, the external cavity (EC) laser itself modulated at a few MHz with modulation depth of 2.5 GHz.

WP23 **The Research of InSb on Si Avalanche Photodiode,** Ling Hong Peng, Qiang Ying Xu, and Hua Wan Zheng, *Chinese Academy of Sciences , Beijing, China*

We demonstrate a bonding InSb/Si wafer and its application in APD. The InSb/Si APD with high gain and high bandwidth is discussed.

WP24 **Low Loss and Compact Silicon TE-Pass Waveguide Polarizer,** J. Jiang, D. J. Goodwill, C. Zhang, P. Dumais, D. Celo, *Huawei Technologies Canada Co., Ltd., Ottawa, Canada,* M. Li, F. Zhao, X. Tu, D. Geng, *Huawei Technologies Co., Ltd., Wuhan, China,* and E. Bernier, *Huawei Technologies Canada Co., Ltd., Ottawa, Canada*

A silicon photonic TE-pass polarizer is demonstrated using serpentine 180° adiabatic bends, in an MPW foundry process. By choosing the number of bends, we can trade TM extinction versus TE loss. 16 dB extinction had 0.37 dB loss. 26 dB extinction had 0.78 dB loss.

WP25 **Photonic Phased Array Design by Synthesis,** Francis Smith and Hui Wu, *University of Rochester, Rochester, NY, USA*

We present a scalable photonic phased array design methodology based on synthesis of the array from a single element, decoupling simulation accuracy and time tradeoffs and enabling robust modeling of arbitrary array geometries and sizes.

WP26 **Distributed Feedback Lasers Operating at 780 nm Wavelength Integrated on Si Substrates for Chip-Scale Atomic Systems,** Kevin Gallacher, Ross W. Millar, Douglas J. Paul, *University of Glasgow, Glasgow, UK,* Francesco Mirando, Gary Ternent, Gordon Mills, and Brendan Casey, *Kelvin Nanotechnology, Glasgow, UK*

There has been recent interest in developing chip-scale cold atom systems for a range of timing and sensing applications. Here we present DFB lasers at 780 nm flip-chip bonded onto a Si substrate with the light coupled into Si3N4 waveguides and a micro-ring locking cavity.

WP27 **Ultra Low Loss Asymmetric Multimode Interference Power Splitters,** Ruixuan Chen, Qingzhong Deng, and Zhiping Zhou, *Peking University, Beijing, China*

Ultra low loss arbitrary-ratio multimode interference (MMI) splitters are realized by utilizing tilted tapers with minimum excess loss predicted to be 0.05 dB and the maximum no more than 0.215 dB.

WP28 **Automating Photonic Design with Machine Learning,** Dusan Gostimirovic and Winnie N. Ye, *Carleton University, Ottawa, Ontario, Canada*

We propose and demonstrate the first end-to-end artificial neural network modeler for the automated design of photonic devices. Trained models are used to predict the output of different device variations for orders-of-magnitude faster optimization or system-level simulations, with comparable accuracy to numerical simulations.

WP29 **FSR-Free Microring-Based Modulator,** Ajay Mistry, Mustafa Hammood, Hossam Shoman, Lukas Chrostowski, and Nicolas A. F. Jaeger, *University of British Columbia, Vancouver, Canada*

We propose a microring modulator in which the free spectral range is eliminated by using a bent, contra-directional-coupler to couple light into and out of the ring and in which the extinction ratio and bandwidth are tuned using a secondary, two-point coupler.

WP30 **Optimization of a Polarization Beam Splitter for Broadband Operation Using a Genetic Algorithm,** Po-Han Fu and Ding-Wei Huang, *National Taiwan University, Taipei, Taiwan*

We present a design method for a polarization beam splitter for broadband operation based on a genetic algorithm (GA). The devices are segmented into short sections, where the geometric parameters for each device are determined using a GA.

WP31 **Demonstration of >48 GHz Single-Drive Push-Pull Silicon Mach-Zehnder Modulator with Low $V_\pi L$,** Giovanni B. de Farias, Yesica R. Bustamante, Hening A. de Andrade, Uiara C. Moura, *CPqD Foundation, Campinas, Brazil,* Alexandre P. Freitas, and Diogo de A. Motta, *University of Campinas, Campinas, Brazil*

In this work, we experimentally demonstrate a single-drive push-pull Silicon Mach-Zehnder modulator with more than 48 GHz modulation bandwidth and $V_\pi L \approx 2.3$ V.cm, compatible with standard Silicon-on-Insulator (SOI) process. The modulator also presents $S_{11} < -15$ dB up to 50 GHz.

WP32 **Silicon Photonic Modulator Using Mode Conversion with Asymmetric Sidewall Bragg Gratings,** Omid Jafari, Wei Shi, and Sophie LaRochelle, *Université Laval, Quebec, Canada*

An asymmetric sidewall grating allows to operate a Bragg modulator in reflection without circulator and with less than 1.5 dB on-chip loss. An asymmetric Y-branch directs the incident TE0 mode to the grating, while the reflected TE1 mode is guided to the drop port.

3:30 pm–4:00 pm **Tulum Foyer**

Exhibits / Coffee Break

4:00 pm–5:00 pm **Tulum A, B & C**
Session WC Optical Sensors

4:00 pm–4:15 pm

WC1 Novel Fiber Alignment Method for On-Wafer Testing of Silicon Photonic Devices with PN Junction Embedded Grating Couplers, Yoshiho Maeda, Toru Miura, Hiroshi Fukuda, and Shinji Matsuo, *NTT Corporation, Atsugi, Japan*

We propose a new fiber alignment method using a PN junction embedded grating coupler (GC). It enables us to quickly and easily search the optimum position for optical coupling between the GC and an optical fiber, enabling efficient on-wafer testing.

4:15 pm–4:30 pm

WC2 System-Level Integrated Active Silicon Photonic Biosensor for Detecting Small Molecule Interactions, Enxiao Luan, Loic Laplatine, *University of British Columbia, Vancouver, Canada*, Jonas Flueckiger, *SiDx, Inc., Seattle, WA, USA,* Osama Al'Mrayat, *University of British Columbia, Vancouver, Canada,* Daniel M. Ratner, *University of Washington, Seattle, WA, USA,* Karen Cheung, and Lukas Chrostowski, *University of British Columbia, Vancouver, Canada*

We present a system-level integration of active silicon photonic biosensors. With on-chip photodetectors, sensors are characterized in the photovoltaic mode. A biotin-avidin affinity assay is employed to exemplify the detection of small molecule interactions, showing a detection limit in the order of 10 uM.

4:30 pm–5:00 pm ***(Invited)***

WC3 Optical Phased Arrays for Integrated Beam Steering, Christopher V. Poulton, *Analog Photonics, Boston, MA, USA*

The development of on-chip beamsteerers such as optical phased arrays has expanded the application space of silicon photonics, and offers a unique solution for low-form-factor solid-state systems. Here, we present recent results on high-performance optical phased arrays in applications such as LiDAR and free-space communication.

5:00 pm–6:30 pm **Tulum A, B & C**

Session WD Components and Electronic-Photonic Design Automation

5:00 pm–5:15 pm

WD1 Widely Tunable Ce:YIG on Si Microring Isolators for TE Mode Operation, Duanni Huang, Paolo Pintus, Jonathan Peters, *University of California Santa Barbara, Santa Barbara, CA, USA,* Paul A. Morton, *Morton Photonics, West Friendship, MD, USA*, Yuya Shoji, Tetsuya Mizumoto, *Tokyo Institute of Technology, Tokyo, Japan,* and John E. Bowers, *University of California Santa Barbara, Santa Barbara, CA, USA*

We demonstrate fully integrated optical isolators using bonded Ce:YIG on silicon microrings with an integrated electromagnet. The isolator operates for TE mode input light and can be tuned between 1540 to 1580 nm with >20 dB isolation.

5:15 pm–5:30 pm

WD2 Broadband Polarization Splitter-Rotator Using Sub-Wavelength Grating Assisted Adiabatic Waveguides, Minglei Ma, *University of British Columbia, Vancouver, Canada,* Yun Wang, *McGill University, Montreal, Quebec, Canada,* Anthony Park, Han Yun, Nicolas A. F. Jaeger, and Lukas Chrostowski, *University of British Columbia, Vancouver, Canada*

We demonstrate a broadband polarization splitter-rotator (PSR) based on sub-wavelength grating (SWG) assisted adiabatic waveguides. The SWG-based adiabatic PSR is more compact than previously reported adiabatic PSRs. Less than –19 dB polarization crosstalk was measured over a broad wavelength range from 1545 to 1615 nm.

5:30 pm–5:45 pm

WD3 Electric Field Tuning of BaTiO3-on-Silicon Multi-Ring Resonators via the Pockels Effect, J. Elliott Ortmann, *University of Texas, Austin, TX, USA,* Felix Eltes, Daniele Caimi, and Stefan Abel, *IBM Research – Zurich, Rüschlikon, Switzerland*

We demonstrate optical tuning in hybrid barium titanate-silicon photonic structures. Individual resonances of a multi-ring resonator are coalesced into a single resonance. Critically, device operation is stable in time. Our devices enable adjustable wavelength filters and offer a low power solution to compensate fabrication imperfections.

5:45 pm–6:00 pm

WD4 Hierarchical Model for Spatial Variations of Integrated Photonics, Yufei Xing, Jiaxing Dong, Umar Khan, Wim Bogaerts, *Ghent University – IMEC, Gent, Belgium and Center of Nano and Biophotonics, Gent, Belgium*

The paper presents a hierarchical model that decomposes the spatial process variations of integrated photonics into different levels. We performed an analysis of automated wafer measurements and derived systematic intra-wafer variation and systematic intra-die variation of the wafer.

6:00 pm–6:15 pm

WD5 **Layout-Aware Yield Prediction of Photonic Circuits,** Wim Bogaerts, Umar Khan, and Yufei Xing, *Ghent University, Gent, Belgium*

We demonstrate yield prediction of silicon wavelength filters using layout-aware Monte-Carlo circuit simulations. Maps of wafer and die-level variability of width and thickness are projected onto circuit layout and translated into circuit model parameters. We apply this onto Mach-Zehnder lattice filters with different filter orders.

6:15 pm–6:30 pm

WD6 **Novel Quick and Precise Method for Evaluating Optical Characteristics,** Toru Miura**,** Yoshiho Maeda, Hiroshi Fukuda, and Shinji Matsuo, *NTT Corporation, Kanagawa, Japan*

We describe a new test element and method for evaluating optical characteristics such as a propagation loss. The propagation loss is accurately derived by a few elements. This method has potential for drastically reducing measurement time in wafer-level inspection.

6:30 pm–7:30 pm **Tulum Foyer**

Welcome Reception

THURSDAY, 30 AUGUST 2018

8:00 am–9:30 am **Tulum A, B & C**
Session ThA Plenary

8:00 am–8:45 am ***(Plenary)***

ThA1 Electronics-Photonics Integration, Vladimir Stojanovic, *University of California, Berkeley, Berkeley, CA, USA*

8:45 am–9:30 am ***(Plenary)***

ThA2 On Neurophotonics – A Report From a Journey of a Photonics Engineer into Neuromorphic Computing and Neurobiology, Yurii Vlasov, *Urbana, IL, USA*

I will review emerging applications of integrated optics to neuromorphic computing as well as to experimental neuroscience. Experience in developing commercial photonics technology, together with more recent transition to neurobiology provide an unusual perspective for reevaluating goals and metrics for these fields.

9:30 am–10:00 am **Tulum Foyer**

Exhibits / Coffee Break

10:00 am–12:00 pm **Tulum A, B & C**
Session ThB Integrated Components and Subsystems

10:00 am–10:30 am ***(Invited)***

ThB1 First 400G 8-Channel CWDM Silicon Photonic Integrated Transmitter, Jeffrey Driscoll, Pierre Doussiere, Syed Islam, Raghuram Narayan, Wenhua Lin, Hari Mahalingam, Jung Park, Yiching Lin, Kimchau Nguyen, Katherine Roelofs, Avsar Dahal, Ranju Venables, Ling Liao, Richard Jones, Daniel Zhu, Sunil Priyadarshi, Bharadwaj Parthasarathy, and Yuliya Akulova, *Intel Corporation , CA, USA*

We demonstrate an 8-channel 400G CWDM silicon photonics transmitter leveraging Intel's highly integrated wafer-scale photonics manufacturing platform. The transmitter consists of integrated lasers, high-bandwidth carrier-depletion modulators, an integrated silicon wavelength multiplexer, compact passive components, and efficient output optical couplers on a single silicon chip.

10:30 am–10:45 am

ThB2 **Subwavelength-Grating-Based 4-Channel Add-Drop Multiplexers in Silicon Photonics,** Behnam Naghdi and Lawrence R. Chen, *McGill University, Montreal, Quebec, Canada*

We demonstrate a compact silicon photonic 4-channel optical add-drop wavelength multiplexer enabled by subwavelength-grating-based contra-directional couplers. Pass-bands of the device show on-chip insertion losses below 1.3 dB with wide 3dB bandwidth of 6.7 nm suitable for coarse wavelength division multiplexing in short-reach optical interconnect applications.

10:45 am–11:00 am

ThB3 **Silicon Photonics Wavelength Converter Based on Inter-Modal Four Wave Mixing Bragg Scattering,** C. Lacava, M. A. Ettabib, *University of Southampton, Southampton, UK,* G. Sharp, *University of Glasgow, Glasgow, UK,* Y. Jung, P. Petropoulos, D. J. Richardson, *University of Southampton, Southampton, UK,* M. Sorel, *University of Glasgow, Glasgow, UK, and* F. Parmigiani, *University of Southampton, Southampton, UK*

We present the first ever inter-modal silicon photonic wavelength converter operated with a telecom-compatible dual pump CW scheme. We achieve phase matched inter-modal four wave mixing, allowing for wavelength conversion with a pumps to signal wavelength detuning of 70 nm.

11:00 am–11:30 am ***(Invited)***

ThB4 **High Performance, Low Noise-Figure Brillouin-Based Integrated Microwave Photonic Filters,** Benjamin J. Eggleton, *University of Sydney, New South Wales, Australia*

We present compact, high-performance, low-noise, microwave photonic filters based on stimulated Brillouin scattering (SBS) in photonic circuits. The performance includes a record low noise figure of average 10 dB with a bandpass tunability and frequency reconfigurability. Progress towards full integration is discussed.

11:30 am–11:45 am

ThB5 **A Packaged Silicon Photonic Circuit Integrating a Hybrid Tunable Laser, a Modulator and an Amplifier,** Alexandre Shen, *Thales & CEA, Palaiseau, France,* Guy Aubin, *Univ. Paris-Saclay, Marcoussis, France,* Antonin Gallet, Théo Verolet, *Thales & CEA, Palaiseau, France,* Xavier Pommarède, *Antony, France,* Dalila Make, *Thales & CEA, Palaiseau, France,* Stéphane Malhouitre, Ségolène Olivier, *CEA LETI, Grenoble, France,* Peter O'Brien, *Tyndall National Institute, Cork, Ireland, and* Guanghua Duan, *3SP Technologies, Nozay, France*

A Silicon Photonic hybrid Transmitter Integrated Circuit containing a tunable laser, an electro-absorption-switched modulator and a semiconductor optical amplifier is designed, fabricated, tested and packaged for both NRZ and BPSK operations. Error-free transmission up to 50 km is validated for the NRZ format at 11 Gbit/s.

11:45 am–12:00 pm

ThB6 **On the Transfer of Quantum-Optic Pair Sources Realized on SOI Photonics to Electronic Wafers,** Bernhard Schrenk, Fabian Laudenbach, Paul Müllner, *AIT Austrian Institute of Technology, Vienna, Austria,* Stefan Jessenig, Jochen Kraft, *ams AG, Premstaetten, Austria,* Moritz Eggeling, *AIT Austrian Institute of Technology, Vienna, Austria,* Daivid Fowler, *CEA LETI, Grenoble, France,* Rainer Hainberger, and Hannes Hübel, *AIT Austrian Institute of Technology, Vienna, Austria*

A micro-ring assisted photon-pair engine for CWDM and DWDM emission in the 1550-nm region is implemented on silicon-on-insulator technology. Coincidences in pair emission show a 95% visibility for the photonic die. Just a small degradation is observed after wafer-level transfer to a BiCMOS electronics wafer.

12:00 pm–1:30 pm

Lunch Break (On Own)

1:30 pm–3:30 pm **Tulum A, B & C**

Session ThC Electronics-Photonics Integration

1:30 pm–2:00 pm ***(Invited)***

ThC1 **Short Reach Optical Transceiver (PIC/EIC Integration),** Stefan Meister, *Sicoya, Berlin, Germany*

In this talk we are presenting monolithically integrated Silicon Photonics engines for 100 G and 400 G optical transceivers. The engines integrate all electrical and optical functions in one chip and it will be demonstrated how monolithic integration improves the key business metrics cost, quality and performance.

2:00 pm–2:30 pm ***(Invited)***

ThC2 **Electronic ICs for Silicon Photonic Transceivers,** P. Ossieur, H. Ramon, J. Lambrecht, M. Vanhoecke, L. Breyne, *Ghent University - IMEC, Ghent, Belgium,* S. Zhou, *Tyndall National Institute, Cork, Ireland and University College Cork, Cork, Ireland and S3 Group, Cork, Ireland*, S. Facchin, P. D. Townsend, *Tyndall National Institute, Cork, Ireland and University College Cork, Cork, Ireland,* G. Torfs, X. Yin, and J. Bauwelinck, *Ghent University - IMEC, Ghent, Belgium*

We present progress on high-speed electronic ICs for Silicon Photonic Transceivers. The freedom offered by Silicon Photonics is exploited to generate multilevel modulation formats, reduce power consumption and physical footprints or increase speed. We show drivers and receivers integrated in CMOS and SiGe BiCMOS nodes.

2:30 pm–3:00 pm ***(Invited)***

ThC3 **Electronic-Photonic Systems for Multi-TBPS Optical I/O,** Mark Wade, *Ayar Labs, Inc., CA, USA*

3:00 pm–3:15 pm

ThC4 **A High Performance Ge PIN Photodiode Compatible with High Volume Silicon Photonics Production Processes,** Difeng Zhu, Jie Zheng, Yasir Qamar, Oleg Martynov, and Edward Preisler, *Towerjazz Semiconductor Ltd., Newport Beach, CA, USA*

A High Performance Ge PIN Photodiode has been demonstrated, integrated into a high volume-capable foundry Silicon Photonics Production Process. It features 0.9 A/W responsivity, 67 GHz optical bandwidth, and dark current density of 90 mA/cm^2 @-1V.

3:15 pm–3:30 pm

ThC5 **A Compact Model for Si–Ge Avalanche Photodiodes,** Binhao Wang, Zhihong Huang, Xiaoge Zeng, Rui Wu, Wayne V. Sorin, Di Liang, and Raymond G. Beausoleil, *Hewlett Packard Enterprise, Palo Alto, CA, USA*

A compact Si-Ge avalanche photodiode (APD) circuit model, including carrier transit time and electrical parasitics, is demonstrated and accurately captures electrical and optical dynamics in a wide range of multiplication gain. Excellent matching between simulated and measured 30 Gb/s eye diagrams is presented.

3:30 pm–4:00 pm **Tulum Foyer**

Exhibits / Coffee Break

4:00 pm–5:30 pm **Tulum A, B & C**

Session ThD **Panel Discussion: Electronics–Photonics Integration I**

FRIDAY, 31 AUGUST 2018

8:15 am–10:00 am **Tulum A, B & C**
Session FA Neuromorphic Photonics and Components

8:15 am–8:45 am ***(Invited)***

FA1 **Programmable Nanophotonics for Computation,** Darius Bunandar, Tomo Lazovich, Michael Gould, Ryan Braid, Carl Ramey, and Nicholas C. Harris, *Lightmatter, Inc., Boston, MA, USA*

As Moore's law and Dennard scaling end, new devices and computing architectures are being explored. The rise of machine learning has prompted explorations into both. While silicon photonics is typically viewed as a communications platform, it is an attractive computing platform for specific problems.

8:45 am–9:15 am ***(Invited)***

FA2 **Multiplanar Dielectric Waveguides for Neural Communication,** Jeffrey Chiles, Sonia M. Buckley, Sae Woo Nam, Richard P. Mirin, and Jeffrey M. Shainline, *National Institute of Standards and Technology, Boulder, CO, USA*

Neural computing requires dense, local communication and system-wide information integration. Light can achieve massive fanout at the chip and wafer scale and long-range communication with minimal delay. We present 3D integrated photonic routing networks based on amorphous silicon and silicon nitride which facilitate such communication.

9:15 am–9:30 am

FA3 **Method to Generate Sigmoid-Like Function in Silicon Photonic Devices towards Applications in Photonic Neutral Network,** Guangwei Cong, Makoto Okano, Yuriko Maegami, Morifumi Ohno, Noritsugu Yamamoto, and Koji Yamada, *National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan*

We propose a silicon photonic passive device and a method to generate sigmoid-like functions which could be applied as nonlinear neurons for photonic neutral network. This device can convert the phase input to the sigmoid-like power output, which was confirmed by simulation and experiment.

9:30 am–10:00 am ***(Invited)***

FA4 **Ferroelectric Barium Titanate Embedded in Silicon Photonics – New Opportunities for Photonic Circuits,** Stefan Abel, *IBM Research - ZURICH, Zurich, Switzerland*

We demonstrate hybrid barium titanate/silicon photonic structures with large Pockels coefficients for a novel class of optical building blocks. The usage of our platform for CMOS compatible high-speed communication links and for realizing optical neural networks will be discussed.

10:00 am–10:30 am **Tulum Foyer**

Exhibits / Coffee Break

10:30 am–12:00 pm **Tulum A, B & C**
Session FB Panel Discussion: Neuromorphic Computing & Photonics K

12:00 pm–1:30 pm

Lunch Break (On Own)

1:30 pm–2:30 pm **Tulum A, B & C**
Session FC Silicon Nitride Devices

1:30 pm–1:45 pm

FC1 **Si-SiN Photonic Platform for CWDM Applications,** Q. Wilmart, C. Sciancalepore, D. Fowler, H. El Dirani, K. Hassan, S. Garcia, S. Malhouitre, and S. Olivier, *Université Grenoble Alpes, Grenoble, France*

We introduce our 200 mm Si-SiN photonic platform targeting energy-efficient optical transceivers. We present the fabrication process and wafer level characterizations in the O-band of a temperature quasi-insensitive SiN multiplexer as well as hybrid Si-SiN grating fiber coupler and Si-SiN interlayer transition.

1:45 pm–2:00 pm

FC2 **Low-Temperature NH3-Free Silicon Nitride Platforms for Integrated Photonics,** T. Dominguez Bucio, S. L. Scholl, S. T. Ilie, C. Lacava, *University of Southampton, Southampton, UK,* K. Debnath, *Indian Institute of Technology, Kharagpur, India,* A. Z. Khokhar, M. Banakar, M. Sotto, K. M. Grabska, *University of Southampton, Southampton, UK,* M. Clementi, D. Bajoni, M. Galli, *Universita di Pavia, Pavia, Italy,* S. Saito, P. Petropoulos, and F. Y. Gardes, *University of Southampton, Southampton, UK*

We demonstrate 3 platforms based on silicon nitride layers processed at 350°C and tailored to have different refractive indices. With these platforms, we have successfully fabricated low loss waveguides at telecom wavelengths, temperature tolerant (de)multiplexing devices, nonlinear waveguides, photonic crystal cavities and waveguides.

2:00 pm–2:15 pm

FC3 **Influence of UV Light on PECVD Silicon Nitride Waveguide Propagation Loss,** Pieter Neutens, Monika Rutowska, Willem Van Roy, Roelof Jansen, Federico Buja, *IMEC, Leuven, Belgium,* and Pol Van Dorpe, *IMEC, Leuven, Belgium and KU Leuven, Leuven, Belgium*

Exposure of silicon nitride waveguides to UV light is found to have a large influence on the waveguide propagation loss. We experimentally demonstrate that the origin of this effect is the population and depopulation of optically active defect states in silicon nitride.

2:15 pm–2:30 pm

FC4 **Widely Tunable Si_3N_4 Triple-Ring and Quad-Ring Resonator Laser Reflectors and Filters,** Chao Xiang, *University of California, Santa Barbara, CA, USA,* Paul A. Morton, *Morton Photonics, West Friendship, MD, USA,* Jacob Khurgin, *Johns Hopkins University, Baltimore, MD, USA*, Christopher Morton, *Morton Photonics, West Friendship, MD, USA*, and John E. Bowers, *University of California, Santa Barbara, CA, USA*

We demonstrate widely tunable triple/quad ring-resonator reflectors using ultra-low loss Si_3N_4 waveguides. A single reflection peak with 2.6 pm bandwidth, >15 dB SMSR across >45 nm tuning range is demonstrated. This tunable reflector enables integrated narrow linewidth lasers and high-performance filters.

2:30 pm–3:30 pm **Tulum A, B & C**

Session FD **Switches, Resonators and Waveguides**

2:30 pm–2:45 pm

FD1 **Liquid Crystal Loaded Silicon Mach-Zehnder Optical Switch Incorporating Groove Array Based Initial Alignement Technique,** Yuki Atsumi, *National Instutute of Advanced Industrial Science and Technology (AIST), Ibaraki, Japan,* Kazuhiro Watabe, Narutaka Uda, *National Instutute of Advanced Industrial Science and Technology (AIST), Ibaraki, Japan and Meiji University, Kanagawa, Japan,* Noboru Miura, *Meiji University, Kanagawa, Japan,* and Youichi Sakakibara, *National Instutute of Advanced Industrial Science and Technology (AIST), Ibaraki, Japan and Meiji University Kanagawa, Japan*

We developed a liquid-crystal-loaded Si Mach-Zehnder optical switch incorporating a locally controllable LC initial alignment technology using grooved array. The fabricated device driven by a vertically applied electric field showed a $V_\pi L$ of 1.1 V · mm and response time of 1.4 and 1.1 msec.

2:45 pm–3:00 pm

FD2 **Real-Time Phase Trimming of Mach-Zehnder Interferometers by Femtosecond Laser Annealing of Germanium Implanted Waveguides,** X. Yu, B. Chen, X. Chen, M. M. Milosevic, S. Saito, G. T. Reed, and O. L. Muskens, *University of Southampton, Southampton, UK*

We demonstrate a real-time trimming technique, enabling accurate and permanent correction of typical fabrication based phase errors of integrated Mach-Zehnder Interferometers (MZIs). The output signal can be monitored during entire annealing process.

3:00 pm–3:15 pm

FD3 **Compact Contra-Directional-Coupler-Based Filters for CWDM Applications,** Mustafa Hammood, Ajay Mistry, Minglei Ma, Lukas Chrostowski, and Nicolas A. F. Jaeger, *University of British Columbia, Vancouver, Canada*

We experimentally demonstrate and compare contra-directional-coupler-based filters in a compact series cascaded configuration and an ultra-compact, fabrication variation tolerant, parallel stacked configuration. Both filters are shown to be similar in performance as regards their sidelobe suppression ratios and bandwidths.

3:15 pm–3:30 pm

FD4 **Photonic Bonding Modes with Circular Polarization at Zero-Group-Velocity Points,** Moïse Sotto, *University of Southampton, Southampton, UK,* Kapil Debnath, *University of Southampton, Southampton, UK and Indian Institute of Technology Kharagpur, Kharagpur, India,* Ali Z. Khokhar, *University of Southampton, Southampton, UK,* Isao Tomita, *Gifu College, Gifu, Japan,* David Thomson, and Shinichi Saito, *University of Southampton, Southampton, UK*

Breaking the parity symmetry of a photonic crystal waveguides can lead to the bonding of guided modes with orthogonal dominant polarizations. Here we present how this coupling allows anomalous zero-group-velocity and prominent circular polarization to emerge, which can be used to enhance uni-directional photon emission.

3:30 pm–4:00 pm **Tulum Foyer**

Exhibits / Coffee Break

4:00 pm–5:30 pm **Tulum A, B & C**

Session FE **Mid-IR Integrated Photonics**

4:00 pm–4:30 pm ***(Invited)***

FE1 **III-V/Si Photonic Integrated Circuits for the Mid-Infrared,** Gunther Roelkens, Ruijun Wang, Anton Vasiliev, Sanja Radosavljevic, Xiaoning Jia, Nuria Teigell Beneitez, Bahawal Haq, Fabio Pavanello, Muhammad Muneeb, *Ghent University - IMEC, Ghent, Belgium,* Guy Lepage, Peter Verheyen, Joris Van Campenhout, Stephan Sprengel, Gerhard Boehm, Markus-Christian Amann, *IMEC, Leuven, Belgium and Technische Universität München, Garching, Germany,* Ieva Šimonytė, Kristijonas Vizbaras, Augustinas Vizbaras, *Brolis Semiconductors UAB, Vilnius, Lithuania,* and Roel Baets, *Ghent University - IMEC, Ghent, Belgium*

We review our work on SOI and Ge-on-SOI PICs for the mid-infrared. We demonstrate the integration of III-V semiconductors on the SOI platform for 2–4 μm wavelength range integrated lasers and spectrometers, as well as tunable filters implemented on the Ge-on-SOI platform beyond 4 μm.

4:30 pm–4:45 pm

FE2 **Mid-Infrared Platforms for Chemical Sensing,** J-M. Fedeli, P. Labeye, A. Marchant, O. Lartigue, M. Fournier, and J-M. Hartmann, *CEA-LETI, Grenoble, France*

For gas systems using arrays of QCL sources, we developed two technology platforms for the fabrication of AWG, with more than 35 inputs in (i) the 3 μm–8 μm band for $SiGe_{40}$ cores cladded with Si and (ii) the 8–12 μm band for Ge cores cladded with $SiGe_{20}$.

4:45 pm–5:00 pm

FE3 **Ge-on-Si Mid-Infrared Waveguides Operating Up to 11 µm Wavelength,** R. W. Millar, K. Gallacher, U. Griskeviciute, D. J. Paul, *University of Glasgow, Glasgow, UK*, L. Baldassarre, and M. Ortolani, *Università di Roma "La Sapienza", Roma, Italy*

Germanium-on-silicon, mid-infrared waveguides operating up to 11 micron wavelength are demonstrated for the first time, with propagation losses below 5.5 dB/cm. The results indicate that the platform could be suitable for sensing applications in the 8–13 micron atmospheric window of the molecular fingerprint region.

5:00 pm–5:15 pm

FE4 **$Ge_{0.9}Sn_{0.1}$ p-i-n Photodiode with Record-High Responsivity at Two-Micron-Wavelength,** Shengqiang Xu, *National University of Singapore, Singapore,* Yi-Chiau Huang, *Applied Materials Inc., Sunnyvale, CA, USA,* Wei Wang, Yuan Dong, Saeid Masudy-Panah, *National University of Singapore, Singapore,* Xin Guo, Hong Wang, *Nanyang Technological University, Singapore,* Xiao Gong, and Yee-Chia Yeo, *National University of Singapore, Singapore*

We demonstrate a $Ge_{0.9}Sn_{0.1}$ photodiode on Si substrate with record-high responsivity R_{op} of 0.17 A/W at wavelength λ of 2 µm. Fourier-transform infrared spectroscopy (FTIR) reveals that the detector has a cutoff wavelength λc at ~2.6 µm.

5:15 pm–5:30 pm

FE5 **On-Chip 2 µm Wavelength Silicon-on-Insulator Optical Interconnect,** David E. Hagan and Andrew P. Knights, *McMaster University, Hamilton, Canada*

We demonstrate the operation of a monolithic, mid-IR (~2 µm) optical interconnect featuring a micro-ring resonator modulator and a defect-mediated silicon detector. Preliminary measurements show excellent DC modulator performance and a maximum detector responsivity of ~0.045 A/W.

END OF PROGRAM

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