Track 5: Microwave Photonics and Optical Signal Processing

Suzhou Room, 3F

October 25

13:30–15:15

M4E • Photonic AI I

Presider: Shui Xiang, Xidian University, China

M4E.1 • 13:30 Tutorial

Silicon Photonics for Neuromorphic Computing and Artificial Intelligence, Bhavin J. Shastri[1,2], Chaoran Huang[3], Alexander Tait[1,3], Paul Pruc- nal[3]; *[1]Queen's Univ., Canada; [2]The Vector Inst., Canada; [3]Princeton Univ., USA.* Neuromorphic photonics exploit optical device physics for neuron models, and optical interconnects for distributed, parallel, and analog processing for high-bandwidth, low-latency and low switching energy applications in artificial intelligence and neuromorphic computing.

M4E.2 • 14:15 Invited

Scalability of Photonic Deep Neural Networks Based on on-Chip Integrated Matrices of SOAs, Ripalta Stabile[1], Nicola calabretta[1], Bin Shi; *[1]Eindhoven Univ. of Technology, Netherlands.* We demonstrate an all-optical neural network based on SOA-based cross-connect architecture with WDM inputs. We analyze its use as deep neural network, finding that it can scale to perform MNIST classification with 10 GS/s inputs.

M4E.3 • 14:45

Back-Propagation Neural Network Assisted Photonic Real-Time Fourier Transformation System, Zihao Wang[1], Dan Zhu[1], Xiaopeng Hu[1], Shilong Pan[1]; *[1]Nanjing Univ Aeronautics & Astronautics, China.* A photonic real-time Fourier transformation system assisted by back-propaga- tion neural network is proposed. The frequency measurement over 2 to 11 GHz is experimentally achieved. The absolute measurement error is im- proved from 47.9 to 4.3 MHz. The generalization performance is also proved.

M4E.4 • 15:00

FPGA Implementation of Time-Interleaved Pruning Neural Network Equalizer for Short Reach Optical Interconnects, Mingyuan Li[1], Wenjia Zhang[1], Zuyuan He[1]; *[1]State Key Laboratory of Advanced Optical, China.* A time-interleaved parallel pruning neural-network equalizer is pro- posed and implemented on FPGA for 100-Gbps PAM-4 optical interconnects, demonstrating over 55% and 40% hardware resource reduction for single and 8-channel equalization.

16:00–18:00

M5E • Terahertz Photonics

Presider: Xianbin Yu, Zhejiang University, China

M5E.1 • 16:00 Invited

Passive Optical to Terahertz Conversion Through Plasmonic Nanoantennas Arrays, Mona Jarrahi[1]; *[1]Univ. of California Los Angeles, USA.* We utilize the functionalities of plasmon-coupled surface states to demonstrate passive wavelength conversion of nanojoule optical pulses at a 1550 nm center wavelength to terahertz regime with efficiencies that exceed nonlinear optical methods by 4-orders of magnitude.

M5E.2 • 16:30 Invited

Title to be Announced, Xianbin Yu[1]; [1]*Zhejiang Univ., China.* Abstract not available.

M5E.3 • 17:00 Invited

Photonic Integrated Chips for THz Beam Steering, Peng Lu[1], Thomas Haddad[1], Jonas Tebart[1], Andreas Stöhr[1]; [1]*Univ. of Duisburg-Essen, Germany.* For future mobile THz applications, steerable high gain antennas are required to compensate for the high free-space path-loss and to support mobility. This invited talk will discuss THz beam steering technologies using photonic integrated chips.

M5E.4 • 17:30

Anti-Dispersion Distributed Multi-Output Mi- crowave Photonic Phase Shifter, Hanxiao Xue[1], Jiasi Yang[1], Yunping Bai[1], Zhonghan Su[1], Zhennan Zheng[1], Xinlu Gao[1], Shanguo Huang[1]; [1]*Beijing Univ. of Posts & Telecommun., China.* We pro- pose an anti-dispersion distributed multi-output microwave photonic phase shifter for application in large-scale microwave photonic network sce- narios. In the experiment, the signals at remote outputs have good coherence.

M5E.5 • 17:45

30 GHz Lithium Niobate Integrated Optoelec- tronic Oscillator, Rui Ma[1], Ying Pan[1], Xinlun Cai[1]; [1]*State Key Laboratory of Optoelectronic Materi- als and Technologies and School of Electronics and Information Technology, Sun Yat-sen Univ., China.* An optoelectronic oscillator (OEO) for 30 GHz with discrete components is experimentally demonstrated, and its phase noise is -103 dBc/ Hz@10KHz. The phase noise of Lithium Niobate integrated OEO is simulated, which is –115 dBc/ Hz@1MHz.

08:30–10:00

T1E • Photonic AI II

Presider: Weiwen Zou, Shanghai Jiao Tong University, China

T1E.1 • 08:30 Invited

Intelligent Optical Signal Processing for Opti- cal Communications, Chaoran Huang[1], Thomas Ferreira de Lima[2], Hsuan-Tung Peng[2], Alexander Tait[2], Simon Bilodeau[2], Bhavin Shastri[3], Paul Pruc- nal[2]; [1]*Chinese Univ. of Hong Kong, Hong Kong;* [2]*Princeton Univ., USA;* [3]*Queens Univ., Canada.* Machine learning can solve many applications in optical communications, but its benefits are largely validated offline using conventional com- puters. We will introduce a radically new hardware platform, neuromorphic photonics, for machine learning, and review its applications in different optical communication systems.

T1E.2 • 09:00 Invited

Photonics Spiking Neural Network: Theory, Device and Algorithm, Shui Y. Xiang[1], Yue Hao[2]; [1]*State Key Laboratory of Integrated Services Network,Xidian Univ., China;* [2]*School of Micro- electronics, Xidian Univ., China.* Photonics neu- romorphic computing is a promising candidate for the next generation of intelligence comput- ing. The optical devices that can emulate the neuron-like and synapse like-dynamics, and the hardware-friendly supervised learning algorithm will be introduced.

T1E.3 • 09:30

OAM Mode Division Multiplexing Based IM/ DD Transmission With CNN Equalizer, Fei Wang[1], Ran Gao[1], Huan

Chang[1], Yi Cui[2], Zhipei Li[1], Sitong Zhou[1], Qi Zhang[2], Feng Tian[2], Qinghua Tian[2], Yongjun Wang[2], Leijing Yang[2], Xiangjun Xin[1]; *[1]Beijing Inst. of Technology, China; [2]Beijing Univ. of Posts and Telecommunications, China.* We propose a Convolutional Neural Network as the nonlinear equalizer in the orbital-angular- momentum transmission system with intensity modulation and direct detection. 3dB and 1.5dB benefits in two-mode groups are achieved com- pared with the Volterra equalizer .

T1E.4 • 09:45

Noise and Scalability Investigation of SOA- Based All-Optical Photonic Deep Neural Network, Bin Shi[1], Bitao Pan[1], Nicola calabretta[1], Ripalta Stabile[1]; *[1]Technische Universiteit Eind- hoven, Netherlands.* We emulate and experimen- tally validate the scaling of SOA-based all-optical deep neural networks by accurately modeling the OSNR degradation in a chain of SOAs: The photonic neural network can scale up to 16 layers when using only 4 neurons/layer without notable accuracy degradation.

10:30–12:00

T2E • Integrated Photonics

Presider: Jiejun Zhang, Jinan Universality, China

T2E.1 • 10:30 Invited

Silicon-Based on-Chip Bragg Gratings and its Applications in Microwave Photonics, Weifeng Zhang[1]; *[1]Beijing Inst. of Technology, China.* Fiber Bragg gratings, as a versatile optical filter, is widely used in optical communication and sensor systems. With the rapid development of silicon photonics technology, waveguide Bragg gratings has become a hot research topic. In this talk, different silicon-based on-chip waveguide Bragg grating will be reviewed with an emphasis on reconfigurable gratings, and their applications in microwave photonics will be discussed.

T2E.2 • 11:00 Invited

Large-Scale Quantum Photonic Processors, Jelmer Renema[1,2]; *[1]QuiX B.V., Netherlands; [2]Univ. of Twente, Netherlands.* Recently, Quix Quantum realized the largest quantum photonic processor (tunable multimode interferometer) to date. In this talk, I will discuss the operation and characterization of this processor. I will discuss the demonstration of high fidelity optical transforma- tions and quantum interferene, and present our roadmap for the future.

T2E.3 • 11:30

Simultaneous All-Optical XOR and XNOR Logic Gates in Highly Nonlinear Organic-Silicon Hy- brid Slot Waveguide, Piaopiao Ye[1]; *[1]Shenzhen Univ., China.* We have experimentally demonstrat- ed all-optical XOR and XNOR gates at 40 Gb/s based on the non-degenerate four-wave mixing in a 3 mm long highly nonlinear organic-silicon hybrid slot waveguide, providing great potential for future applications in all-optical networks.

T2E.4 • 11:45

Neuromorphic Binary Convolution and Pyra- midal Neuron-Like Dynamics Dominated by Dendritic Action Potentials Based on a VCSEL, Yahui Zhang[1], Shuiying Xiang[1,2], Xingxing Guo[1], Aijun Wen[1], Yue Hao[2]; *[1]State Key Laboratory of Integrated Service Networks, Xidian Univ., China; [2]State Key Discipline Laboratory of Wide Bandgap Semiconductor Technology, Xidian Univ., China.* Neuromorphic binary convolution and pyramidal neuron-like dynamics dominated by dendritic ac- tion potentials based on a VCSEL are proposed and demonstrated experimentally. This work shows potentials for image gradient magnitudes calculation and exclusive OR operation

08:30–10:00

W1D • Microwave Photonic Measurement

Presider: Peixuan Li, Southwest University of Science & Technology, China

W1D.1 • 08:30 Invited

Microwave Photonic Cognitive Radar System, Dan Zhu[1], Shilong Pan[1]; [1]*Nanjing Univ Aeronautics & Astronautics, China.* Micro- wave photonic cognitive radar system can realize high resolution detection and good environment adaptiveness simultaneously. The developments of microwave photonic cognitive radar system and the key photonic techniques are presented and discussed.

W1D.2 • 09:00

High-Accuracy Small Target Recognition With Photonics-Based Radar HRRP, Jinhu Li[1], Fangzheng Zhang[1], Shilong Pan[1], Bindong Gao[1], Guanqun Sun[1]; [1]*Nanjing Univ Aeronautics & Astronautics, China.* Small target recognition using high resolution range profiles (HRRP) of an 8-GHz bandwidth photonics-based radar is demonstrated. Applying convolutional neural networks for feature extraction and classification, the recognition accuracy reaches as high as 97.16%

W1D.3 • 09:15

Reconfigurable Photonic Channelized Receiver Based on Polarization Multiplexing and Coherent Detection, Huan Huang[1], Xiaowen Wang[1], Chongfu Zhang[1], Sinian Liu[1], Kun Qiu[1]; [1]*Univ. Electron. Sci. & Technol. China, China.* Based on polarization multiplexing and coherent detection, a reconfigurable and efficient photonic channelized receiver is proposed. To show the reconfigurability, two broadband signals with different center frequencies and bandwidths are channelized into different-size sub-channels respectively.

W1D.4 • 09:30

Simultaneous Target Positioning and Velocity Measurement Using a DP-BPSK Modulator With VLFM Waveform Modula- tion, Yan Li[1], Muguang Wang[1]; [1]*Beijing Jiaotong Univ., China.* A photonics-assisted system based on a dual-polarization binary phase shift keying modulator and auxiliary receiving antenna that can simultaneously implement target positioning and velocity measurement is proposed using V-shaped linear frequency modulated waveforms.

W1D.5 • 09:45

Speed-Enhanced Optical Fiber Transfer Delay Measurement Based on Digital Phase Detecting, Lihan Wang[1], Xi Liu[1], Xufeng Chen[1], Shupeng Li[1], Xiaohu Tang[1], Xiangchuan Wang[1], Shilong Pan[1]; [1]*Nanjing Univ Aeronautics & Astronautics, China.* A speed- enhanced optical fiber transfer delay measurement system is proposed based on digital phase detecting. The measurement speed reaches as high as 6.7 kHz, which is improved by 320 times compared to the previous work.

10:30–12:00

W2E • Frequency Comb

Presider: Yihan Li, Beihuang University, China

W2E.1 • 10:30 Invited

Integrated Frequency Combs for Microwave Photonics, Jijun He[1], Junqiu Liu[1]; [1]*Swiss Federal Inst. of*

Technology Lausanne, Switzerland. We review recent achieve- ment of the integrated Si_3N_4 circuits and the demonstration of chip-scale frequency combs (microcombs), and discuss the microwave applications of microcombs, such as low noise microwave signal generation and microwave filter.

W2E.2 • 11:00 Invited

Artificial Intelligence Powered Microwave Photonic Signal Processing, Weiwen Zou[1], Shaofu Xu[1]; [1]*Shanghai Jiao Tong Univ., China.* We propose an architecture of artificial intelligence (AI) powered microwave photonic signal processing, which suc- cessfully implements various applications such as high-quality signal recovery, high accuracy target recognition and wideband signal separation.

W2E.3 • 11:30

Self-Oscillating Broadband Optical Frequency Comb Generation Using an EML- Based Optoelectronic Oscillator and a Recirculating Frequency Shifter, Quanjing Zhao[1], Juanjuan Yan[1]; [1]*Beihang Univ., China.* A self-oscillating optical frequency comb generator is designed and demonstrated using an electroabsorption modulated laser based optoelectronic oscillator and a recirculating frequency shifter. A 10GHz 38-tone OFC is generated with a 1.2dB flatness.

W2E.4 • 11:45

Octave-Spanning Frequency Comb Generation Based on a Dual-Mode Square Microlaser and a Brillouin Fiber Loop, ting wang[1], Ji-Liang Wu[1], Xu-Cheng Zhang[2], Yue-De Yang[1], Jin-Long Xiao[1], Guan-Shi Qin[2], Yong-Zhen Huang[1]; [1]*Inst. of semiconductors, CAS, China;* [2]*State Key Laboratory of Integrated Optoelectronics, College of Electronic Science and Engineering, Jilin Univ., China.* A 38-GHz spaced optical frequency comb spanning from 1100 nm to 2200 nm is generated by the nonlinear spectral broadening of a Brillouin optical comb seeded by a dual-mode square microlaser.

13:30–15:30

W3E • Microwave Photonic Signal Generation

Presider: Weifeng Zhang, Beijing Institute of Technology, China

W3E.1 • 13:30 Invited

Optoelectronic Oscillator for High-Quality Microwave Signal Generation, Jiejun Zhang[1]; [1]*Jinan Univeristy, China.* Optoelectronic oscillators (OEOs) with novel mode control and selection techniques will be discussed, including parity-time symmetry, Fourier domain mode locking and optical synthetic dimension, which enable OEOs with unprecedented performance and functionalities.

W3E.2 • 14:00 Invited

Photonics-Enabled Microwave Frequency Synthesis, Yihan Li[1]; [1]*Beihang Univ., China.* This talk discusses the advantages and limitations of several representative approaches based on photonic techniques for the generation of high-quality RF waveforms in the microwave, millimeter-wave and terahertz spectral regions.

W3E.3 • 14:30

Photonics-Based Reconfigurable Chirp Signal Generation With Controllable Amplitude, Phase, and Frequency, Wenhao Du[1], Dan Zhu[1], Shilong Pan[1]; [1]*Nanjing Univ Aeronautics & Astronautics, China.* A photonics-based reconfigurable chirp signal generation scheme using optical frequency combs (OFCs) with controllable amplitude, phase, and frequency is proposed. The center frequency, bandwidth, and the time duration can also be adjusted flexibly.

W3E.4 • 14:45

Simultaneous Low-Correlation Multi-Channel Chaos Generation Based on Asymmetrically-Coupled Semiconductor Lasers Networks, Shiqin Liu[1], Ning Jiang[1], Yiqun Zhang[1], Jiafa Peng[1], Anke Zhao[1], Kun Qiu[1]; [1]*Univ of Electronic Science & Tech China, China.* We propose a novel low-correlation multi-channel chaos generation scheme by utilizing asymmetrically-coupled semi- conductor laser networks. It is demonstrated that effective bandwidths around 20 GHz, pairwise cross correlation below 0.1, and time-delay-signature suppression are simultaneously achieved.

W3E.5 • 15:00

Computational Model of an Active Mode Locking Optoelectronic Oscillator, Yilin Wu[1], Zhen Zeng[1], Lingjie Zhang[1], Zhiyao Zhang[1], Shangjian Zhang[1], Heping Li[1], Yong Liu[1]; [1]*Univ. of Electron. Sci&Tech of China, China.* A computational model is proposed for an active mode locking optoelectronic oscillator based on electric amplitude modulation. In the simulation, the building-up process and the phase noise of the generated microwave pulse train are obtained.

W3E.6 • 15:15

Frequency Synthesis of High Power Microwaves Exceeding 20 GHz With Uniform Phase Noise Enabled by a Dual-Wavelength Brillouin Laser and a High Saturation Power UTC-PD, hao -. guo[1], Zixuan Li[1], Yihan Li[1], Yuxin Tian[2], Enfei Chao[2], Bing Xiong[2], Yanjun Han[2], Jian Wang[2], Hongtao Li[2], Zheng Zheng[1]; [1]*Beihang Univ., China;* [2]*Tsinghua Univ., China.* Based on a dual-wavelength Brillouin laser and a packaged high-saturation uni-travelling-carrier photodiode, frequency synthesis exceeding 20 GHz with frequency-independent phase noise and ~0.74 Watts power is experimentally demonstrated.