Technologies for large-scale programmable photonic circuits

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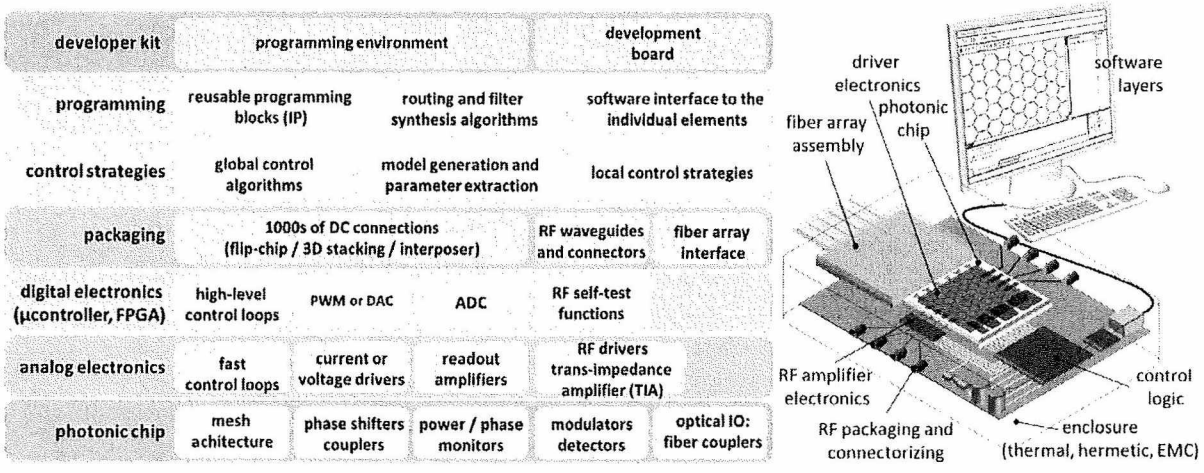
Photonic chips have now become a key technology in telecom and datacom applications. The growing maturity of silicon photonics enables the creation of more complex photonic circuits that can now be fabricated in industrial CMOS fabs. However, the threshold for building new photonic chips is quite high, especially when compared to electronics. The cycle of design-fabrication-test of a photonic chips can easily take up one year, and the design processes today have not yet advanced to 'first-time-right', especially for complex circuits that also need electronic control. This long development cycle is a major obstacle to the widespread adoption of photonic circuits, especially beyond the traditional markets of fiber-optic communication.

The proposed solution to resolve this barrier is the introduction of general-purpose programmable photonic chips. Instead of a photonic chip where the parts of light are fixed at the design stage, we introduce a mesh of optical waveguides where the connectivity can be controlled electronically, so it can be adjusted on the chip at run time. Such a chip can then be reconfigured into new functions by means of a software layer, which explains why they are called 'programmable'. This enables a use model similar to that of programmable electronics (e.g. a field-programmable gate array or FPGA), that can be used for fast prototyping of new applications, and even find its way into products.

The technological requirements to realize programmable photonic chips go somewhat beyond those of traditional, application-specific photonic circuits. Programmable photonics requires a large number of electrically actuated phase shifters and tunable waveguide couplers to control the flow of light, and obviously these have to perform very well if they are cascaded in large numbers: optical losses, optical path length and electrical power consumption need to be very low, and this means that traditional technologies such as heaters are not very attractive. Alternative techniques based on electro-optic effects (e.g. Pockels) or micro-electromechanical systems (MEMS) are being explored. And these many actuators need to be interfaced with their specialized driver electronics, which creates additional packaging challenges.

To make it useful, a programmable photonic chip needs a software layer that allows users to configure the functionality. Routing light between the functional building blocks, and configuring the waveguide mesh to perform interferometric filtering operations, require new design routines that are different from traditional photonic circuit design. In addition, the photonic chip now requires control layers to govern its behavior, read out built-in monitor detectors to stabilize the many actuators, and provide failover and redundancy routines in case one or more elements on the chip fail.



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SC3: Programmable Optical Devices and Circuits by Dr. Yewei Xie, Prof. Rajesh Kumar

Session 2P1b
SC2&SC3: Ultrafast Laser-matter Interactions and Nanofabrications 2

Tuesday PM, April 26, 2022

Room 1 - Midtown Hall

Organized by Xuewen Wang, Yanlei Hu

Chaired by Xuewen Wang, Yanlei Hu

16:25 Invited — Characterization of Acoustic Deformation Potential of Mg_3Sb_2 via Coherent Acoustic Phonon Dynamics
Liang Guo (*Southern University of Science and Technology*);

16:40 — A New Method to Pattern Liquid Metal Based on Femtosecond Laser for Flexible Electronic Devices
Hao Wu (*University of Science and Technology of China*);

16:50 — High-performance and Multifunctional Magnetically Responsive Liquid Manipulator
Shaojun Jiang (*University of Science and Technology of China*);

17:00 — Smart Microactuator Fabricated by Asymmetric Femtosecond Bessel Beam for Microparticles/Cells Manipulation
Rui Li (*University of Science and Technology of China*); *Jiawen Li* (*University of Science and Technology of China*); *Dong Wu* (*University of Science and Technology of China*);

Session 2P1c
SC3: Optical Fiber Based Lasers: Dynamics and Applications

Tuesday PM, April 26, 2022

Room 1 - Midtown Hall

Organized by Chengbo Mou, Hongyan Fu

Chaired by Chengbo Mou

17:10 Invited — Random Fiber Grating Based Lasers
Xuewen Shu (*Huazhong University of Science and Technology*);

17:30 Invited — Ultrashort Pulse Generation from a Tm-doped Fiber Laser
Jin Zhang Wang (*Shenzhen University*);

17:45 — Diverse Pulsating Solitons in Spatiotemporal Mode-locked Fiber Laser
Guang-Xin Liu (*South China Normal University*); *Jin-Gan Long* (*South China Normal University*); *Jia-Wen Wu* (*South China Normal University*); *Zhi-Chao Luo* (*South China Normal University*); *Wen-Cheng Xu* (*South China Normal University*); *Aiping Luo* (*South China Normal University*);

17:50 — Wavelength-tunable Q-switched Mode-locked Multimode Fiber Laser
Jia-Wen Wu (*South China Normal University*); *Guang-Xin Liu* (*South China Normal University*); *Zhi-Chao Luo* (*South China Normal University*); *Wen-Cheng Xu* (*South China Normal University*); *Aiping Luo* (*South China Normal University*);

18:05 — A Multi-wavelength Fiber Ring Laser Based on Hybrid Gain Medium and Sagnac Interferometer Used for Temperature Sensing
Xun Cai (*Xiamen University*); *Haoran Wang* (*Xiamen University*); *Jian Luo* (*Xiamen University*); *Hongyan Fu* (*Xiamen University*);

Session 2P2a
SC3: Programmable Optical Devices and Circuits 2

Tuesday PM, April 26, 2022

Room 2 - Shixin Hall 1

Organized by Yiwei Xie, Rajesh Kumar

Chaired by Yiwei Xie, Rajesh Kumar

13:00 Invited — Towards Non-volatile Programmable Photonics
Oded Raz (*Eindhoven University of Technology*); *Jimmy Melskens* (*Eindhoven University of Technology*); *Ripalta Stabile* (*Eindhoven University of Technology*); *Francesco Pagliano* (*Eindhoven University of Technology*); *Chenhui Li* (*Eindhoven University of Technology*); *Christian C. M. Sproncken* (*TU/E*); *Berta Gumí-Audenis* (*TU/E*); *Emilija Lazdanaité* (*Eindhoven University of Technology*); *Wilhelmus M. M. Kessels* (*Eindhoven University of Technology*); *Ilja K. Voets* (*TU/E*); *Mahir Asif Mohammed* (*Eindhoven University of Technology*);

13:15 Invited — Technologies for Large-scale Programmable Photonic Circuits
Wim Bogaerts (*Ghent University — IMEC*); *Lukas Van Iseghem* (*Ghent University — IMEC*); *Xiangfeng Chen* (*Ghent University — IMEC*); *Iman Zand* (*Ghent University — IMEC*); *Hong Deng* (*Ghent University — IMEC*); *Mi Wang* (*Ghent University — IMEC*); *Katta Pradeep Nagarjun* (*Ghent University — IMEC*); *Muhammad Umar Khan* (*Ghent University — IMEC*);

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