Introduction for the Integrated Photonics: Challenges and Perspectives feature

Daoxin Dai,[1,4] Di Liang,[2,5] and Liu Liu[3,6]

[1]*Centre for Optical and Electromagnetic Research, State Key Laboratory for Modern Optical Instrumentation, Zhejiang University, Hangzhou 310058, China*
[2]*Systems Research Laboratory at Hewlett-Packard Laboratories, Palo Alto, California 94304, USA*
[3]*Centre for Optical and Electromagnetic Research, South China Academy of Advanced Optoelectronics, South China Normal University, Guangzhou 510006, China*
[4]*e-mail: dxdai@zju.edu.cn*
[5]*e-mail: di.liang@hp.com*
[6]*e-mail: liuliuliu@scnu.edu.cn*

Received September 16, 2015; accepted September 16, 2015;
posted September 16, 2015 (Doc. ID 250293); published October 1, 2015

We give an introduction for the background and motivation of the Integrated Photonics: Challenges and Perspectives feature. A very brief summary for the five invited review articles collected in this feature issue is also given.

OCIS codes: (130.0130) Integrated optics; (160.3130) Integrated optics materials; (250.0250) Optoelectronics.
http://dx.doi.org/10.1364/PRJ.3.000IP1

Integrated photonics has achieved great success since the idea was proposed by Dr. Stewart E. Miller in 1969. Various materials and technologies have been developed to realize photonic integrated devices for many applications, including next-generation optical networks, optical interconnects, wavelength division multiplexed (WDM) systems, coherent transceivers, and lab-on-a-chip. Large-scale photonic integrated circuits (LS-PICs) are now becoming very promising to achieve improved performance, reduced device footprints, low package costs, and low power consumption. However, the progress on LS-PICs is still quite limited. While fewer components are required to realize certain functionalities in photonics, compared to electronics, those components are based on different or even incompatible materials, e.g., silicon, silica, and compound semiconductors. Finding a better substrate to accommodate all required components with decent performance that can be fabricated in a low-cost, high-volume fashion is the key to building complex LS-PICs.

Currently the focus is on silicon and InP substrate technologies. InP is conventionally regarded as the platform for LS-PICs, since both passive and active components can be enabled on the same substrate. In recent years, silicon-based PICs have gained more popularity because of their compatibility with mature CMOS technologies with excellent processing control, low cost, and high-volume processing. Furthermore, ultracompact silicon photonic integrated devices can be realized due to the ultrahigh index contrast. However, the indirect bandgap nature of the silicon is still the biggest hurdle to integrating active PICs with lasers, as well as the photodetectors on it. Recent progress in heterogeneous integration by combining different materials provides a promising solution. Great results have been demonstrated, but challenges still exist. Therefore, it is interesting to have a discussion on the challenges and perspectives for integrated photonics by organizing this special issue. This special issue includes five invited review articles on the state of the art for integrated photonics.

The first invited review article is from Prof. John E. Bowers' group at the University of California, Santa Barbara, California. This paper gives a review of the recent advances in the field of heteroepitaxially grown quantum dot lasers on silicon. The device performance, reliability, and comparison with similar quantum-well lasers grown on silicon are discussed. The potential to build such a scalable, compact, and low-power consumption quantum dot nanolaser on silicon for future short-reach silicon photonics interconnects is also discussed.

The second invited review article is from Prof. Andrew W. Poon's group at the Hong Kong University of Science and Technology, China. This paper reviews the state of the art and the perspectives on silicon and hybrid silicon photonic devices for optical interconnects in datacenters. The recent developments, the remaining challenges, and key issues for on-chip hybrid silicon microlasers, WDM transmitters, and silicon photonic switch fabrics for intra-datacenters are described.

The third invited review article is from Prof. Zhiping Zhou's group at Peking University, China. This paper gives a review of silicon photonic devices and their performance in connection with energy consumption. Particularly, the authors have discussed the strategies to reduce the influence of the thermo-optic effect, increase the wall-plug efficiency of lasers on silicon, optimize energy performance of modulators, and enhance the sensitivity of photodetectors.

The fourth invited review article is from Prof. Roel Baets' group at Ghent University, Belgium. This paper gives a review for silicon and silicon nitride (Si_3N_4) integrated photonics for sensing applications, ranging from refractive index to spectroscopic sensing. Approaches such as waveguide-based absorption and Raman and surface-enhanced Raman spectroscopy

are discussed. The authors have also discussed on-chip spectrometers and on-chip broadband light sources covering from the very near-IR to the mid-IR spectrum to realize fully integrated spectroscopic systems on a chip.

The fifth invited review article is from Prof. M. K. Smit and Prof. K. A. Williams' group at Eindhoven University of Technology, The Netherlands. This article focuses on InP integrated photonics, which enables the monolithic integration of high-performance amplifiers, lasers, modulators, and detectors in combination with interferometers. The authors give a review of the current status in InP integrated photonics and the efforts to integrate the next generation of high-performance functionality on a common substrate using a generic methodology.

These collected invited review articles cover the topics of silicon photonics, III–V PICs, and hybrid silicon/III I–V photonic devices for the applications of optical communications/interconnects and optical sensing. The editors believe that these excellent articles will be very helpful for researchers working in this field, including young scientists and students.

Daoxin Dai, Guest Editor
Zhejiang University
Di Liang, Guest Editor
Hewlett-Packard Laboratories
Liu Liu, Guest Editor
South China Normal University.