ICAM Workshop

on Emerging Topics of Silicon Photonics

The Garden Hotel, Guangzhou, China
7-10 November, 2012

Technical Program

In this workshop, we will bring together scientists in the areas of photonic integration, energy materials, and nanotechnology to discuss recent advances in the field of silicon photonics, especially about nano-waveguiding (optical interconnect) and harvesting (photovoltaic) of light. We will address the open and emerging technologies and ideas with which we can push forward the applications of silicon photonics in those fields. Topics such as hybrid integration, photonic-electronic integration, active and tunable mechanism, nano-fabrication, and solar light harvesting will be covered. This workshop will be collocated with Asia Communications and Photonics Conference (ACP) 2012.

Sponsored by:

ICAM-I2CAM **South China Normal University**

Organizers:

Sailing He, Zhejiang University, China, and Royal Institute of Technology, Sweden
John E. Bowers, University of California at Santa Barbara, USA
Roel Baets, Ghent University-IMEC, Belgium

IMPORTANT NOTE: If seats are available, ACP 2012 registrants are all welcome to this workshop.

Program at-a-glance:

7th Nov., 2012:

- **18:30-21:00** Welcome Reception (Pearl River Cruise. Meet in Lobby of Garden Hotel)

8th Nov., 2012:

- **08:00-10:00** Silicon Photonics I (ICAM virtual session in ACP 2012, Room Hydrangea, Garden Hotel)
- **10:00-10:30** Tea Break
- **10:30-12:15** Optoelectronic Integration, Devices, and Materials (ICAM virtual session in ACP 2012, Room Hydrangea, Garden Hotel)
- **13:45-15:30** Silicon Photonics II (ICAM virtual session in ACP 2012, Room Hydrangea, Garden Hotel)
- **15:30-16:00** Tea Break
- **16:00-18:00** Silicon Photonics III (ICAM virtual session in ACP 2012, Room Hydrangea, Garden Hotel)
- **19:30-21:45** Emerging Topics of Silicon Photonics I (Room Hydrangea, Garden Hotel)

9th Nov., 2012:

- **13:30-15:30** Silicon Photonics Sources (ICAM virtual session in ACP 2012, Room Hydrangea, Garden Hotel)
- **15:30-16:00** Tea Break
- **15:30-18:30** Poster Session (Lobby of Convention Hall, Garden Hotel)
- **19:00-21:00** Banquet (Convention Hall, Garden Hotel)

10th Nov., 2012:

- **13:30-15:30** Silicon Modulators (ICAM virtual session in ACP 2012, Room Hydrangea, Garden Hotel)
- **15:30-16:00** Tea Break
- **16:00-18:00** SC6-ICAM Joint Session on Plasmonics, LEDs, and Solar Cells (Room Marigold, Garden Hotel)
- **19:30-21:00** Emerging Topics of Silicon Photonics II (Room Hydrangea, Garden Hotel)

8th Nov., 2012

08:00-10:00

Room Hydrangea

Silicon Photonics I

(ICAM virtual session in ACP 2012)

Session Details: see ACP 2012 technical program

<u>8th Nov., 2012</u>

10:30-12:15

Room Hydrangea

Optoelectronic Integration, Devices, and Materials (ICAM virtual session in ACP 2012)

Session Details: see ACP 2012 technical program

<u>8th Nov., 2012</u>

13:45-15:30

Room Hydrangea

Silicon Photonics II

(ICAM virtual session in ACP 2012)

Session Details: see ACP 2012 technical program

8th Nov., 2012

16:00-18:00

Room Hydrangea

Silicon Photonics III

(ICAM virtual session in ACP 2012)

Session Details: see ACP 2012 technical program

8th Nov., 2012

19:30-21:45

Room Hydrangea

Emerging Topics of Silicon Photonics I

Session Details: see pages 8-10

8th Nov., 2012
19:30-20:15

VLSI Photonics: Issues and Challenges

El-Hang Lee

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This lecture presents an overview on the issues and challenges related to micro/nano-scale photonic integration for VLSI photonics and application. It discusses on the theory, design, fabrication, and integration of micro/nano-photonic devices, circuits, chips, and networks in the form of VLSI photonic integrated circuits and networks of generic and application-specific nature. This is done in two parts: Formation of optical printed circuit boards (O-PCBs) and VLSI photonic chips. These micro/nano-systems are designed to be compact, high-speed, light-weight, low-powered, and low-cost as applicable for broad applications and usages, including convergent IT/BT/NT micro/nano-devices, circuits, and chips. The new optical systems consist of 2-dimensional planar arrays of optical wires, circuits and devices of micro/nano-scale to perform the functions of sensing, storing, transporting, processing, switching, routing and distributing optical signals on flat modular boards or substrates. The integrated components include micro/nano-scale light sources, waveguides, detectors, switches, modulators, sensors, directional couplers, multi-mode interference devices, wavelength filters, micro-ring resonator devices, photonic crystal devices, and plasmonic devices made of polymer, silicon and other semiconductor materials. We discuss scientific and technological issues, challenges, and progresses regarding the miniaturization, interconnection and integration of micro/nano-scale photonic devices and circuits. The issues include the compatibility and interconnection mismatch issues between micro/nano-devices, in terms of materials, sizes, modes, and optical/mechanical/thermal mismatches. New physics and technological challenges related to these issues will be discussed along with the historical perspectives of the electrical technology. Recent progresses and examples will be presented along with the future outlook.

8th Nov., 2012
20:15-21:00

Heterogeneous Photonic-Electronic Integrated Circuits for Future Networking and Computing Systems

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The Future Internet critically relies on the scalability, performance, and energy-efficiency of computing and networking technologies. While the Moore's Law continues to pack more transitors in a die, the Dennard's Law has failed to keep pace with the Moore's law since 2004. As a result, the computing industry has introduced multi-core processors, and the power-efficiency and performance of computing systems depend strongly on networking and interconnection within and between multi-core processing units. In addition, rapidly emerging new services and data centers are driving the peak link capacity demands beyond 10 Tb/s, which are driving reconfigurable optical networking with high spectral efficiency beyond 1~10 b/s-Hz employing advanced modulation formats. Elastic optical networking has rapidly emerged as a viable technology for realizing software defined networks for the future Internet. Both trends in computing and networking are driving the need for photonic-electronic integrated circuits based on heterogeneous technology platforms which integrate the intelligence of electronics and high capacity of photonics. This paper will discuss heterogeneous photonic-electronic integrated circuits involving silicon and compound semiconductor platforms towards realizing future networking and computing systems with ultimate performance, scalability, and power-efficiency.

8th Nov., 2012
21:00-21:45

Silicon photonics at the wavelength and subwavelength scales

D.-X. Xu, P. Cheben, J.-H. Schmid, P. Bock and S. Janz

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Silicon photonic structures can be scaled down to submicron dimensions owing to its high refractive index contrast. This property allows the interaction between light and matter being manipulated at the wavelength and even the subwavelength scales, opening up new opportunities in realizing advanced photonic functions. Using simple lithographic processes, the effective refractive index of the guiding medium can be adjusted over a broad range, the polarization, dispersion, thermo-optic and electro-optic properties can all be manipulated. With these newly found design tools, devices including filters, fiber-to-waveguide couplers, demultiplexers and modulators with enhanced performance have been demonstrated. Highly sensitive and compact silicon photonic biosensors are also developed, leading to a serious contender for lab-on-a-chip technology by allowing the real-time monitoring of a large number of sensors for pathogen detection, genomics, disease diagnostics and drug discovery. For a broad range of applications, the pertinent silicon photonic components share the same material platform, dimensional range and fabrication technologies, thus driving the rapid growth in high quality material supply, knowledge in photonic design, photonic-specific CMOS-based fabrication technologies and facilities.

In this lecture we review recent advances in silicon and subwavelength optics for commu nications and biosensing applications.

<u>9th Nov., 2012</u>

13:30-15:30

Room Hydrangea

Silicon Photonics Sources
(ICAM virtual session in ACP 2012)

Session Details: see ACP 2012 technical program

9th Nov., 2012

15:30-18:30

Lobby of Convention Hall

Poster Session

Session Details: see page 13

ICAM.1

Photonic Crystal Spectroscopic Devices On Silicon Chips

Zhimin Shi, *The Institute of Optics, University of Rochester, USA*

We study the use of photonic crystal structures for on-chip spectroscopic applications. We show various optimized photonic crystal based spectrometers on silicon chips to meet different needs of spectral resolutions.

ICAM.2

A comparison of bulk and quantum dot GaAs solar cells

Tian Li, *Electrical and Computer Engineering, University of Maryland, USA*

We report on the realization of a GaAs type-I quantum dot solar cell with a record 29.9 mA/cm^2 short circuit current density and we compare it to a reference bulk GaAs solar cell.

ICAM.3

Remarkable Enhancement of the Photocurrent Response of Dye-Sensitized Solar Cells using CuInSe2 Nanocrystals

Ramy Said Nashed, *Chemistry Department, Georgia Tech, USA*

The Effect of introducing $CuInSe_2$ (CIS) Nanocrystals with the electrolyte on the photocurrent response of DSSCs was investigated. CIS Nanocrystals enhances the optical switching and increases the electrical stability of DSSCs since it improves the reduction rate of the electrolyte and provides a higher overall hole mobility. Short circuit photocurrent remained constant, even when applying several consecutive on-off photo-irradiations to the cell.

ICAM.4

Novel structure-assisted optical manipulation of high-index nanowires in liquid crystals

Michael Varney, *Department of Physics, University of Colorado, Boulder, USA*

We explore optical manipulation of high-index GaN nanowires infused in nematic and cholesteric LCs in the regime when optical gradient forces are much weaker than scattering forces. We show that stable non-contact optical manipulation of these particles is still possible because of structured LC self-organization and its response to laser beams.

<u>10th Nov., 2012</u>

13:30-15:30

Room Hydrangea

Silicon Modulators
(ICAM virtual session in ACP 2012)

Session Details: see ACP 2012 technical program

<u>10th Nov., 2012</u>

16:00-18:00

Room Marigold

SC6-ICAM Joint Session on Plasmonics, LEDs, and Solar Cells

Session Details: see ACP 2012 technical program

<u>10th Nov., 2012</u>

19:30-21:00

Room Hydrangea

Emerging Topics of Silicon Photonics II

Session Details: see pages 17-18

10th Nov., 2012
19:30-20:15

III-V/Silicon photonics for communication and sensing applications

Günther Roelkens

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Silicon-based photonic integrated circuits are gaining considerable importance for a variety of applications, from telecommunications to sensors. The interest in this technology stems mostly from the expectation that the maturity and low cost of CMOS-technology can be applied for advanced photonics products. Other driving forces for silicon photonics include the design richness associated with high refractive index contrast as well as the potential for integration of photonics with electronics. Building laser sources and other opto-electronic devices on integrated silicon circuits is a long sought goal, on one hand in order to complete the functionality of the integrated circuit but on the other hand also as a manufacturing approach for opto-electronic devices on large wafers in CMOS-fabs. In terms of device performance the most successful approach to date is definitely the hybrid (also called heterogeneous) III-V on silicon laser. In this device thin layers of III-V semiconductors are bonded to silicon. The laser cavity gets its gain from the III-V layers but couples its output light into a silicon waveguide. Often part of the cavity structure is implemented by means of patterning in silicon, thereby taking advantage of the resolution and accuracy of lithography tools in CMOS fabs. In that sense these hybrid III-V/silicon lasers take the best of two worlds.

In this presentation we will outline different types of integrated laser sources on a silicon platform, with a focus on emission at 1.3um and 1.55um. Besides communications, we will also elaborate on our first steps in the field of photonic integration for the short-wave and mid-infrared, for sensing applications.

10th Nov., 2012
20:15-21:00

Putting Silicon Photonics to Work in Canada – CMC's Perspective

Jessica Zhang

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The availability of Multi-Project Wafer (MPW) platforms of Silicon Photonics is changing the landscapes of photonics researches. The platforms allow university researchers and small companies to prove of concepts or to prototype devices with minimal costs accessing industrial standard foundries where cross-wafer uniformity and run-to-run repeatability is under control. The talk will introduce the purpose, the management model, and the performance of the Canada′s National Design Network and CMC Microsystems. CMC′s capability to bridge research to foundries will be demonstrated by its versatile products and services. The current offering in the field of photonics will be expanded using published design examples and successful stories. The talk will introduce accessible technologies worldwide on Silicon Photonics using published specifications. With the existing infrastructures such as CAD licensing and engineering support, CMC plays strong in providing MPW runs and technical training to researchers and firms who are engaged in both device level and system level functionalities in Silicon Photonics.