# Integration of silicon nitride photonics with nanoscale materials: from passive to active photonics ICs

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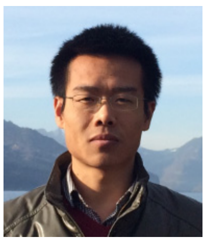
## Abstract

Silicon (Si) and silicon nitride (SiN) based photonic integrated circuits are emerging as efficient platforms for manipulating photons within structures with submicron dimensions. A large variety of such photonic integrated circuits (PICs), operating at both visible and infrared wavelengths, including low loss waveguides, high quality resonators and even full spectrometers have been demonstrated. Due to its compatibility with mature complementary metal-oxide-semiconductor (CMOS) manufacturing technology, integrated photonics has been considered a promising candidate for both fundamental optics research (e.g., cavity quantum electrodynamics and quantum optics) and cost-effective and high-volume applications such as information processing, quantum computing, and sensing technologies. Unfortunately, because of either its indirect bandgap (Si) or its dielectric nature (SiN), it is hard to realize optically active devices within these platforms, and therefore efforts to bring novel optoelectronic functionality onto these platforms are of high scientific and technological interest. Attempts to do exactly this have been undertaken, e.g. through the use of wafer bonding techniques or through direct growing III-V semiconductors (e.g., GaAs, InP, ...) on passive photonics have already been undertaken and laser devices operating at near infrared and telecom wavelengths have been demonstrated. Nevertheless, the integrated photonics community is in need of active devices with wide tunability of the working wavelength, high operating speed, low power consumption and low fabrication cost and the currently available III-V materials hybridly integrated on Si or SiN platforms cannot fulfill all these requirements. In particular expanding the operating wavelength from the infrared to the visible still remains a challenge. In fact, the hybrid integration concept however can also be applied to other materials and in particular to the rapidly developing nanoscale materials, possessing novel and tunable optical and electrical properties. Accordingly, an enabling integrating technique ensuring high performance in the final device is important but remains challenging. In the present talk, we will demonstrate a hybrid integration platform combining low-loss SiN photonics and semiconductor nanocrystals, also known as colloidal quantum dots (QDs). Based on this platform, we demonstrate on-chip integrated SiN-QD microdisk lasers with low threshold. This opens up a path towards realizing on-chip laser sources operating in a wide wavelength range, combining the advantages of gain-spectrum tunability in QDs and the spectrally broad operating range of low-loss SiN photonics. Moreover, the presently developed approach, together with our QD patterning technique, can be used for integrating a few QD emitters with SiN PICs for laser demonstration at a few or even single dot level and also for on-chip quantum emitters, as currently being investigated in our group. The demonstrated active SiN-QD building blocks will open up new opportunities for both fundamental studies and practical applications.

## Biography of Weiqiang Xie

Weiqiang Xie received his B.S. degree in applied physics from Xi'an Jiaotong University, China, and the M.S. degree in condensed matter physics from Shanghai Jiaotong University, China, in 2008 and 2011, respectively. He joined Photonics Research Group in Ghent University as a Ph.D. candidate in 2011. His research focuses on the development of passive silicon and silicon nitride photonics and their integration with nanoscale materials toward visible and infrared light sources on chip.

## Photo



# Conf. 11: Silicon-based Photonic Integration

(Room: 401)

***Conference Chairs:***

Dr. Jurgen Michel (Massachusetts Institute of Technology, USA)

Prof. Zhiping (James) Zhou Peking University, China

***Program Committee:***

Prof. Daoxin Dai(Zhejiang University, China), Prof. Jifeng Liu(Thayer school of engineering at Dartmouth, USA), Prof. Juejun Liu(Massachusetts Institute of Technology, USA), Prof. Minghao Qi(Purdue University, USA), Prof. Yikai Su(Shanghai Jiao Tong University, China), Prof. Xinliang Zhang(Huazhong University of Science and Technology, China)

| **Afternoon** | **10 May** |
|---|---|
| **Session 1** | **Chair:** Prof. Zhiping (James) Zhou (Peking University, China) |
| 14:00-14:30 | Integration of silicon nitride photonics with nanoscale materials: from passive to active photonics ICs, Dr. Weiqiang Xie (Ghent Univ Belgium) ***Invited*** |
| 14:30-14:45 | The True Time Delay Line for the Optical Beam Forming Network based on Silicon Photonics Technology(IPTA11-001), Jin Guo et al.(The China Electronics Technology Group Corporation No. 38 Institute,China) |
| 14:45-15:00 | Transfer Printing of Thin-Film Microscale GaAs Lasers on Silicon(IPTA11-003), Xing Sheng(Tsinghua University, China) |
| 15:00-15:30 | Silicon Colors: Ultrathin Silicon Films on Metals for Color Displays, Prof. Junpeng Guo(University of Alabama USA) ***Invited*** |
| **15:30-15:40** | **coffee/tea break** |
| **Session 2** | **Chair:** Dr. Jurgen Michel (Massachusetts Institute of Technology, USA) |
| 15:40-16:10 | On-chip power-efficient generation of broadband Kerr frequency combs in mid-infrared, Prof. Lin Zhang(Tianjin University, China) ***Invited*** |
| 16:10-16:25 | Robust dual-pump optical frequency comb generation in a high-Q micro-ring resonator (IPTA11-014), Weiqiang Wang et al.(Xi'an Institute of Optics and Precision Mechanics,CAS, China) |
| 16:25-16:40 | Study of plasma oscillations in photoelectric semiconductor detectors(IPTA11-004), Bing-feng Luo et al.(Sun Yat-Sen University,China) |
| 16:40-16:55 | Series-connected One-dimensional Photonic Crystal Nanobeam Bandstop Filter and Cavity Sensor for Accurate Refractive Index Sensing(IPTA11-005) Daquan Yang et al.(Beijing University of Posts |