Tutorial title:

Siliconized photonics-electronics as an emerging technology

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Abstract:

Silicon photonics is an emerging technology offering novel solutions in different areas such as optical communications, optical computer interconnects, sensing, bio-applications, all requiring highly integrated novel photonics-electronics. Silicon photonics-based communication has many advantages over electric wires for multiprocessor and multicore macro-chip architectures including high bandwidth data transmission, high speed and low power consumption, not possible with all electronics solutions at the required high transmission rates. Following the INTEL's concept to "siliconize" photonics, silicon device technologies should be able to meet the requirements for six main building blocks for realization of the emerging optical interconnects technology: light generation, guiding of light including electronically controllable wavelength selectivity, light modulation for signal encoding, detection, low cost assembly including optical connecting of the devices to the real world and finally the electronic control systems.

The silicon-based materials, mainly alloying Si with other elements in the group IV, in form of quantum well or dot structures demonstrate new photonic properties as well as carrier transport, paving the path for a paradigm shift which is along with the semiconductor industry's needs in the near future. For example, novel Sn-GeSi materials have shown the possibility of having direct bandgap property. Epitaxial growth of strained (or relaxed) Sn-GeSi materials on Si for lasing and detection of telecommunication wavelengths is an on-going development.

This tutorial includes the all important issue of light generation and detection in group IV materials, an overview of waveguide silicon photonics devices, including the possibility of employing the silicon compatible electro-optic polymers for high speed, low power phase modulation, especially important in view of the quest for advanced modulation formats and then presents how this photonics technology can be developed into a monolithically integrated photonics-electronics technology on silicon, which can be obtained when Sn-GeSi alloys are integrated in the chip. The tutorial will also present briefly the CMOS part of the chip in the *More than Moore* approach of the roadmap. The difficulties to achieve the next technology node (16 nm node by 2014 timeframe) will be shortly overviewed. The future down-scaling of transistors is discussed, when the *quantum tunneling* will occur and limits the functioning of devices (no matter of the applied material). This tutorial will provide insights into a potential Si electronics-photonics roadmap scenario when new material systems and concepts are introduced.

Proposed schedule

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1. **Building lasers and detectors from group IV materials (Henry Radamson)**
2. **Modulators , switches and WDM devices: Plasmonics and electrooptic polymers for Si based low power nanophotonics integrated photonics fabrics for communications and interconnect (Lars Thylen)**
3. **Merging the best of two worlds: Issues in monolithic nanoscale photonics-electronics integration (Henry Radamson)**

Presenter short CV

Lars Thylén received the M.Sc. degree in electrical engineering and the Ph.D. degree in applied physics in 1972 and 1982, respectively, both from the Royal Institute of Technology (KTH), Stockholm, Sweden. From 1973 to 1982, he was with SRA Communications, working in the areas of digital electronics, digital image processing, diffraction optics, and optical signal processing. From 1976 to 1982, he was with the Institute of Optical Research, Stockholm, engaged in research in integrated and guided wave optics. In 1982, he joined Ericsson, heading a group doing research in the area of integrated photonics for optical communications and switching. In 1987, he was appointed Adjoint Professor at the Department of Microwave Engineering, KTH. Since 1992, he is Professor and heading the Laboratory of Photonics and Microwave Engineering at KTH. From 2003 to 2007, he was Director of the Strategic Research Center in Photonics at KTH, funded by the Swedish Foundation for Strategic Research. He is one of two Chief Scientists of the Joint Research Center of Photonics of the Royal Institute of Technology and Zhejiang University (PR China). He was a co-founder of Optillion AB. He is since 2008, in addition to his position at KTH, employed by Hewlett Packard, HP Laboratories in Palo Alto, US. Current research interests include nano-photonics, high-density integrated photonics, devices for photonic switching and high-speed modulations well as electronic and photonic switching. He has authored or coauthored more than 200 journal papers and conference contributions, and several book chapters. He was general cochair and technical program committee chair of ECOC 2004 in Stockholm and general chair for the 2008 Asia Pacific Optical Communications Conference in China. He is a member of the Optical Society of America and of the IEEE, as well as of the Royal Swedish Academy of Engineering Sciences.

Henry H. Radamson received the M.Sc. degree in physics and the Ph.D. degree in semiconductor materials from Linköping University in Sweden, in 1989 and 1996, respectively. In 1997, he joined the Royal Institute of Technology in Stockholm as a senior scientist, where he has been an Associate Professor since 2001. He has participated in many national and international projects as well as industrial projects. His current research interests include GeSnSi electronic and photonic devices. He is the author or co-author of more than 150 scientific papers published in international journals, conferences and chapter books. He is co-founder and technical manager of *Nocilis Materials* in Kista, Stockholm in Sweden.