Strong-Confinement Silicon Photonics from First-Principles Explorations to VLSI Interconnects

Silicon microphotonic circuits based on strong confinement enable dense photonic integration on a chip and raise the prospect of highly energy efficient on-chip communication links. They also make available new degrees of freedom in design enabling device innovation based on unique device physics and topologies that become practical in this regime, including novel types of coupling, optical nonlinear effects and optical forces. In this talk, I will describe recent work to demonstrate energy efficient integrated photonic communication links in unmodified, state-of-the-art microprocessor and DRAM CMOS processes, as a path to addressing the CPU-memory communication bottleneck to enable continued scaling of computational power in the world of multicore CPUs. I will show results of the first successful efforts to demonstrate photonic devices in advanced CMOS, including 65nm and 32nm bulk silicon CMOS, and 45nm SOI CMOS, with no process changes. I will also describe the first successful co-integration with electronics in these advanced nodes, including a transmitter based on a modulator in 45nm SOI CMOS driven by adjacent driver circuits in the same device layer. These results show promise to enable highly energy efficient CPU to memory photonic links.

In the second part of my talk, I will describe some results of research on first-principles opportunities for device innovation, including optimal filters and dispersionless delay lines based on quasi-magnetic and complex coupling, breaking the linewidth-sensitivity tradeoff in resonant modulators, and novel structures based on imaginary coupling. The latter give rise to device concepts based on localized destructive mode interference and a new, unidirectional guided Bloch wave, that enables efficient waveguide crossings, modulators, and other optically efficient contacted structures, as well as a new family of “dark state” laser. The theme in general is synthesis from first principles of device level solutions to current problems in the field.

Last, I will describe initial work on synthesis of photonic circuits for nonlinear and quantum photonics applications, and how these developments are driving our research into other directions such as photonic circuits based on optical forces.

<u>Biography:</u>

Miloš Popović is an Assistant Professor and Donnelly/GE Faculty Fellow in the Department of Electrical, Computer and Energy Engineering, University of Colorado Boulder. He received his B.Sc.E. degree in Electrical Engineering from Queen’s University, Canada in 1999, and his M.S. and Ph.D. degrees at Massachusetts Institute of Technology in 2002 and 2007. His research interests include theory and design of integrated photonic devices for telecom and on-chip interconnect applications, CMOS photonics integration, nanooptomechanical devices based on light forces, and nonlinear and quantum integrated photonics. He is author or coauthor of 16 patents and 90 journal and conference papers. In 2012, he was named a Fellow of the David and Lucile Packard Foundation to pursue research in optical forces and nonlinear effects on the nanoscale.