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Convergence of Electronics and Photonics in CMOS Integrated Systems for Classical and Quantum Optical Interconnects, Sensing and Scalable Integrated Photonic Apertures

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Abstract: The monolithic integration of electronics and photonics – and advanced CMOS platforms supporting it – have evolved over the past decade from a futuristic area of research to the state of the art for photonic systems-on-chip. I will start by briefly overviewing my and collaborators' work on advanced CMOS platforms, initial landmark demonstrations and commercial spinoff, and both the subsequent foundry development and new applications that has fueled. We started with limited photonic device performance, where the overall system provided a win, but today have record performance in a number of photonic components. The convergence of electronics and photonics has driven both foundry process developments trading and advancing photonics vs. electronics, and has called for foundry-process aware innovations in device design. In this talk, I will talk about two recent efforts as illustrations, and provide examples of other projects.

In the first part of my talk, I will describe the development of a highly robust integrated beam splitter, a basic component of complex photonic circuits. I will share with you a new electromagnetic concept, rapid adiabatic mode evolution, and its use to develop an integrated beam splitter of unsurpassed bandwidth, insertion loss, splitting ratio, and robustness against process uncertainty. The approach is a fundamental step beyond current state of the art adiabatic devices, the gold standard for insensitive design over the past 30 years. I'll also show an experimental demonstration of record performance (loss, split ratio), including wafer scale variation data, in a state of the art, soon to be public state CMOS photonics platform (GlobalFoundries 45CLO). I'll provide an overview of other high performance components, and share some examples of applications currently being pursued in quantum and cryogenic I/O.

In the second part of my talk, I will talk about scalable integrated photonic apertures for lidar, imaging, sensing and spectrometry. Even with complex integrated systems approaching reality, the complexity circuits needed for large area integrated optical apertures using conventional integrated optical phased arrays is excessive and doesn't scale well with area. I will talk about a new concept involving a tiled-array aperture and computationally-aided imaging to get around the inherent sensitivities of integrated photonics. The building block is the serpentine optical phased array (SOPA), a nominally passive tile allowing 2D wavelength steering. I will show the concept, experimental demonstrations, and initial demonstrations of Fourier basis imaging which allows imaging without beam forming, i.e. allows beam

forming in post processing. I'll also describe application of the SOPA to spectrometers, where the device has resolving power comparable to bulk grating spectrometers far outperforming integrated ones, with a footprint comparable to integrated spectrometers, far smaller than bulk. SOPAs may find utility not only in lidar but also spaceborne instruments and mobile devices.

Bio: Dr. Miloš Popović is an Associate Professor of Electrical and Computer Engineering at Boston University, and a Principal Investigator in the BU Photonics Center where he leads a research group in the area of integrated photonics. He is also a Co-Founder and Technical Advisor of Ayar Labs. Miloš earned his B.Sc. in Electrical Engineering from Queen's University, Canada in 1999, and his PhD from MIT in 2007. His interests are in the conception, theory, simulation and design of novel integrated photonic devices and systems, and in the monolithic integration of CMOS electronics and photonics in platforms allowing "vertically integrated", fast innovation from the device level through system and application. He is an author or co-author of over 40 patents and 240 journal and conference papers, and is a 2012 Fellow of the Packard Foundation.