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Silicon Photonics Packaging Technologies

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Abstract – Cost-efficient and scalable optical packaging is key to large-scale deployment of silicon photonics. A key enabler toward this goal is an efficient, large-mode, integrated fiber coupler and mode converter. In this talk, I will report the optical results from first integration of V-grooves with metamaterial converters to commercial structures fabricated in 300 mm CMOS production facilities. We demonstrate a peak transmission of −0.7 dB on the TE polarization and –1.4 dB on the TM polarization with a respective spectral roll-off of 0.3 and 0.4 dB over the 60 nm bandwidth measured [1]. In addition, we demonstrate, for the first time, a compliant polymer interface to silicon photonic circuits that includes plug-in connection to standard fiber patch cables in addition to self-aligned automated assembly to chip. We show a peak transmission of -1.8 dB with less than 0.7 dB penalty over a 100 nm bandwidth and all polarizations [2].

For the light source integration, we report a solder flip-chip integrated III-V/Si external cavity laser. Key innovations include lithographically-defined mechanical stand-offs to ensure alignment and solder reservoirs which are integrated on chip to self-balance the solder volume at the joining pads [3]. Using the hybrid laser, we further demonstrate a chip-scale spectroscopic methane sensor [4], incorporating a tunable laser, a sensor waveguide, and a methane reference cell, assembled as a compact silicon photonic integrated circuit. The sensor features a 20-cm-long TM-mode evanescent-field waveguide as the sensing element and is compatible with high-volume wafer-scale silicon photonics manufacturing and assembly processes. This sensor can be an enabling platform for economical methane and more general distributed environmental trace-gas monitoring.

[1] T. Barwicz et al. "Integrated metamaterial interfaces for self-aligned fiber-to-chip coupling in volume manufacturing." IEEE Journal of Selected Topics in Quantum Electronics 25(3), 1-13 (2019).
[2] T. Barwicz et al, “Compliant polymer interface demonstration with standard plug-in connection to fiber cables,” IEEE Photonics Conference, Reston, VA, 2018.
[3] T. Barwicz et al, “Automated, high-throughput photonic packaging,” Optical Fiber Technology 44, 24-35 (2018).
[4] C. Xiong, et al. "Silicon photonic integrated circuit for on-chip spectroscopic gas sensing." Silicon Photonics XIV. Vol. 10923. International Society for Optics and Photonics, 2019.

Bio – Dr. Chi Xiong is a Research Staff Member at IBM T. J. Watson Research Center. His current research activities are focused on quantum transducers, optical sensors, and high-speed optical modulators. His other research interests include integrated nonlinear optical waveguides and optomechanical resonators.

Dr. Xiong received a B.S. degree in Microelectronics from Peking University, Beijing, China in 2006 and a Ph.D. degree in Electrical Engineering from Yale University in 2012. Prior to joining IBM in 2013, he was a postdoctoral associate in the Department of Electrical Engineering at Yale University. At Yale, he demonstrated an integrated nonlinear optical and optomechanical platform based on AlN, which has since been widely used by the integrated photonics community. He receives the IBM Outstanding Technical Achievement Award in 2016 for his contribution to the commercialization of silicon photonics technology.