**Department of Electrical and Computer Engineering**

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# High Performance Electronic-Photonic Integrated Circuits for Optical Interconnects Applications

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Silicon photonics promise low cost and high volume production of highly integrated electronic-photonic systems by taking advantage of the well characterized and maintained complementary metal-oxide semiconductor (CMOS) manufacturing infrastructures in the microelectronic industry. It is considered as a promising solution to meet the future demand for high speed optical interconnect which continue replacing its electrical counterpart. High performance silicon photonic devices fabricated on standard CMOS or CMOS compatible processes have been studied intensively. The convergence of photonics and electronics into a single platform catalyzes the development of electronic-photonic integrate circuits (EPIC). Complete electro-optical systems including both the electronic and photonic circuits have been demonstrated through either monolithic or multi-chip integration with good performance. However, challenges still remain in photonic device performance and electronic-photonic system co-design and integration. First of all, silicon does not have a strong electro-optical effect. It is challenging to make a modulator that can operate at high speed and at the same time has large modulation efficiency. Further, the electronic-photonic interface becomes the bottleneck of the whole system as data rate increases. Last but not least, the wide adoption of the silicon photonic technology also requires the exploration of new functional blocks to enrich the component library of silicon photonics.

To address these challenges, we firstly proposed an integrated, multi-physics design flow for EPIC design to seamlessly interfacing electronics and photonics. The design flow is exemplified through the design of a traveling wave Mach-Zehnder modulator (TWMZM). Use the EPIC design flow as the design methodology, we then proposed a multi-function EPIC design based on a single Mach-Zehnder modulator (MZM). A single MZM is capable of performing optical pulse shaping in addition to EO conversion, or pulse generation with tunable pulse width at double clock rate when biased properly. Furthermore, as an example of electronic-photonic co-design, a novel high speed TWMZM with built-in feedback equalization is designed using the same EPIC design methodology. Simulation results show that the equalized TWE increases the 3-dB bandwidth by 1.4 times and the 6-dB bandwidth is improved by 57\%.