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Ultra-high-speed Optical Signal Processing Using Silicon Photonics

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Abstract— In supercomputers, the optical inter-connects are getting closer and closer to the processing cores. Today, a single supercomputer system has as many optical links as the whole worldwide web together, and it is envisaged that future computing chips will contain multiple electronic processor cores with a photonic layer on top to interconnect them. For such systems, silicon is an attractive candidate enabling both electronic and photonic control. For some network scenarios, it may be beneficial to use optical on-chip packet switching, and for high data-density environments one may take advantage of the ultra-fast nonlinear response of silicon photonic waveguides. These chips offer ultra-broadband wavelength operation, ultra-high timing resolution and ultra-fast response, and when used appropriately offer energy-efficient switching.

In this presentation we review some all-optical functionalities based on silicon photonics. In particular we use nano-engineered silicon waveguides (*nanowires*) [1] enabling efficient phase-matched four-wave mixing (FWM), cross-phase modulation (XPM) or self-phase modulation (SPM) for ultra-high-speed optical signal processing of ultra-high bit rate serial data signals. We show that silicon can indeed be used to control Tbit/s serial data signals [2], perform 640 Gbit/s wavelength conversion [3] 640 Gbit/s serial-to-parallel conversion [4], 160 Gbit/s packet switching as well as all-optical regeneration [5]. We will also discuss the performance limitations of crystalline silicon and discuss emerging materials such as amorphous silicon [6].

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