Optical Signal Processing Using Silicon Photonic Nanobeam Devices: Filtering and Switching

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Abstract— We discuss two optical signal processing functions in wavelength domain by using silicon photonic nanobeam devices. The first procession device is a wavelength tunable filter with a high tuning efficiency. We experimentally demonstrate an ultra-compact silicon photonic crystal nanobeam cavity with an energy-efficient graphene micro-heater. Due to the small mode volume of the nanobeam cavity, the light-matter interaction can be enhanced and the thermal-optic tuning efficiency is as high as 1.5 nm/mW. This provides a low power approach to tunable optical filtering. The rise and fall time constants are on the order of µs, as the graphene sheet is placed directly on the silicon waveguide Based on such silicon photonic crystal nanobeam cavity, we further demonstrate optical switching function using a 2×2 crossbar switch architecture employing the photonic crystal nanobeam cavity in a bus-nanobeam-busthree-waveguide (3 W) structure. Two cascaded 3 W switches are used to achieve high extinction ratios. By thermally tuning the silicon nanobeam cavities, the resonance wavelength of the 2×2 switch can be red-shifted. Owning to the ultra small mode volumes of the PCN cavities, only ~ 0.16 mW power is required to change the switching state from one to another. The crosstalk performance is better than -15 dB, and the insertion loss is lower than 1.5 dB. The thermal tuning efficiency is measured as 1.23 nm/mW. Finally, we demonstrate a 2×2 nanobeam switch in a Mach-Zehnder interferometer configuration, eliminating the need for phase control between the two cascaded 3 W structures as in the previous demonstration.