

# Pole-zero microring-resonator filters for dense wavelength-division multiplexed links in on-chip interconnects

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Silicon photonic on-chip interconnects may provide the energy efficiency and (areal) bandwidth density required to enable continued scaling of processor to memory interconnect performance. A key attribute enabling this energy efficiency is wavelength division multiplexing (WDM), and scaling to high (100 Tbps) aggregate data rates will require dense channel packing. While microring resonator based filters have been demonstrated to enable high-order all-pole filter responses, pole-zero response engineering, well known in circuit and microwave design, may enable high density channel packing with low order filters.

We present pole-zero based filter responses well suited for dense wavelength channel (de)multiplexers in WDM with a low order filter, and show microring-resonator-based photonic device geometries that implement such responses. We describe the general physical properties in coupled-microring-resonator structures that control the complex-plane position of poles and zeros, and the degree to which they can be manipulated via structure design. For a 20dB adjacent channel rejection and comparable passbands, the pole-zero filter can attain a channel density that is about 2.5 times greater than a typical Butterworth filter of the same order. As shown in the figure, this is accomplished by designing the pole-zero transmission response to have a zero at a finite detuning from the center frequency. We also discuss the electromagnetic device design and implementation challenges, address the design tradeoffs, and compare the proposed filters to current filter implementations. We also explore alternative geometries that implement pole-zero responses and address their sensitivities and constraints imposed by integration in advanced CMOS processes where photonics are to be integrated with microelectronics.

