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Optimized Silicon Photonic Components for High-Performance Interconnect Systems

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Abstract:

Silicon photonics offers great opportunities to replace the bulky free-space systems with compact, highly integrated ones. However, dedicated optimization work is required to realize high performance systems for practical applications. This talk presents a library of optimized photonic components and a high-performance system as example.

Silicon photonics offers great opportunities to replace the free-space optical systems, i.e., bulky systems with discrete components, with compact and highly integrated ones. While crucial active components such as modulators [1] and detectors [2] have received tremendous attentions, small passive components that seem trivial are actually also vital in high complex and high-density system level integration since a small performance improvement in each passive component may aggregate quickly and make huge advantage for active components. Meanwhile, well-performed passive devices may save a significant amount of extra controlling effort on the chip to improve energy efficiency and reduce cost off the chip. This work shows a library of optimized fundamental passive components ranging from signal crossing, wavelength routing to polarization transform. A polarization insensitive WDM receiver system is demonstrated at the end.

Waveguide crossing is one of the most fundamental building blocks in photonics integrated circuits, especially for switch applications. Fig. 1(a) shows the schematic of a single layer waveguide crossing. The crossing is divided into 12 segments, with 13 independent variables that act as optimization variables. [3] Particle swarm optimization (PSO) is integrated with finite-difference time-domain (FDTD) method to achieve the final geometry. The simulated E-field is depicted in Fig. 1(b). By cascading the crossings (Fig. 1(c)) with a grating coupler loop, the insertion loss can be accurately extracted (Fig. 1(d)) in wafer scale. The measured insertion loss is 0.0278 ± 0.0092 dB across a 30-die wafer, which is extremely low and highly uniform.

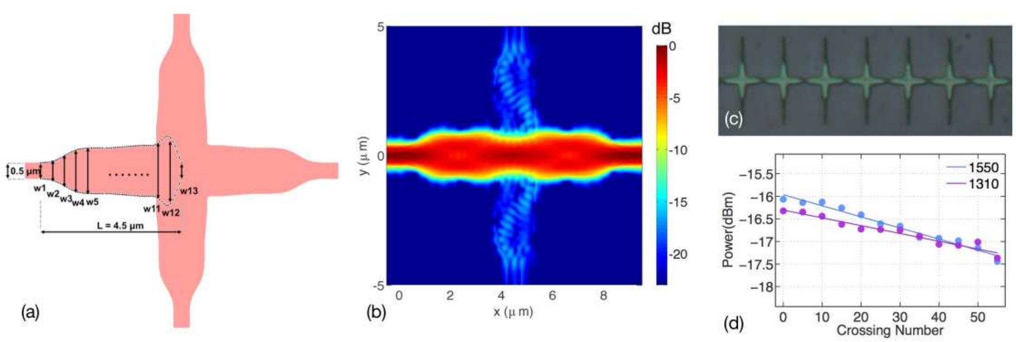

Fig. 1 (a). Schematic of optimized waveguide crossing. (b). Simulated E-field of the crossing in dB scale. (c). A micrograph of cascaded crossings to extract insertion loss. (d). Measured insertion loss.

Wavelength routing components is another important type of devices for WDM (wavelength division multiplexing) and PON (passive optical network) applications. We show here a wavelength diplexer that multiplexes/de-multiplexes O-band (centered around 1310 nm) and C-band (centered around 1550 nm) signals. [4] Instead of using conventional MMIs (top of Fig. 2(a)), we convert a portion of the MMI into a bent taper (bottom of Fig. 2(a)) that transits from single mode region to multimode. The footprint of the device can

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be dramatically decreased from this conversion. Similar to the optimization method on waveguide crossing, the bent taper as well as the right portion of the MMI can be further optimized. Fig. 2(b) shows the de-multiplexing behavior of the device at 1550 nm and 1310 nm. The simulated insertion loss is 0.25 dB with a 1dB bandwidth of ~ 100 nm. Crosstalk is below 20dB at center wavelengths. For the most common use of a diplexer (in PONs) this crosstalk is not pertinent as the light for the two bands is traveling in opposite directions. The bent taper can also be tuned to perform as a part of TM0-TE0 polarization rotator, as demonstrated in [5].

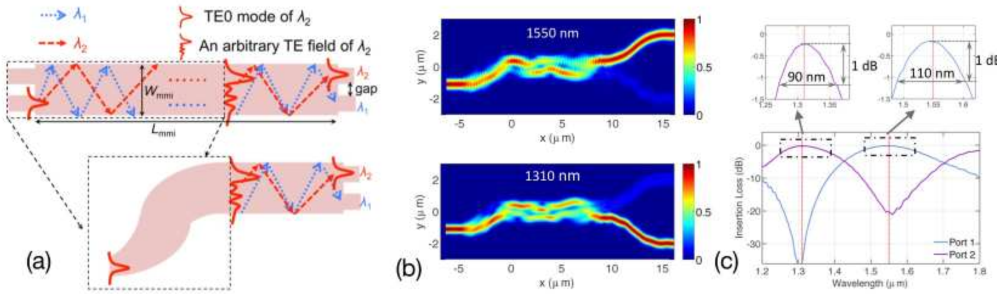

Fig. 2 (a). Schematic of a wavelength diplexer. (b). Simulated E-field of the diplexer at 1550 nm (top) and 1310 nm (bottom). (c). Simulated performance showing insertion loss, bandwidth and crosstalk.

Polarization handling (rotation, conversion, multiplexing) devices has been greatly studied recently. But to our knowledge the design goal of a polarization splitter/rotator (PSR) has been separating the TE0 and TM0 modes in a waveguide (i.e., taking TE0 and TM0 as orthogonal bases), here we introduce a novel PSR that rotates the orthogonal polarization bases for 45-degrees (Fig. 3(a)). [6] A 4-channel polarization insensitive WDM receiver system (Fig. 3(b) and Fig. 3(c)) is demonstrated, showing 40Gb/s (Fig. 3(d)) data transmission with 0.7+/-0.2 dB polarization dependent loss (PDL) and 6.2 dB total loss.

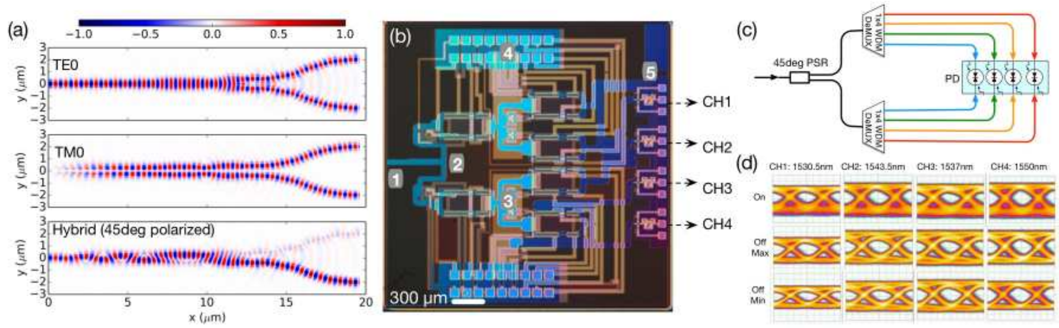

Fig. 3 (a). Simulated E-field showing the principle of an integrated 45-degree PSR. (b). Micrograph of a 4-channel polarization insensitive WDM receiver. (c). Schematic of the receiver. (d). 40Gb/s data transmission at different polarizations and wavelengths.

References:

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