TOWARDS POLARIZATION INDEPENDENT HIGH-INDEX CONTRAST MICROPHOTONICS

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ABSTRACT

High-index-contrast (HIC) dielectric waveguides exhibit highly confined optical modes. The tight confinement allows for waveguides to be spaced closely together without inducing cross-talk and the propagating field to be guided around sharp bends with minimal radiative loss. However, as the index contrast is increased, the differences between the lateral boundary conditions for TE and TM modes become more pronounced, causing critical device parameters such as the propagation rate and coupling strength to be polarization dependent. And, while the geometry of the waveguides may be designed to compensate for one or the other of these effects for a particular device, it becomes difficult to compensate both simultaneously in a manner that applies to all devices on a HIC chip. To enable polarization independent performance, a necessary feature for a standard single mode fiber based communications link, we propose circumventing the polarization sensitivity by implementing an integrated polarization diversity scheme (Fig. 1a) whereby the random polarization emanating from the fiber is split into orthogonal components. By further rotating one of the components to obtain like-polarized states, the components may be acted on in parallel with identical structures. The reverse process may then be employed to recombine the outputs.

Here, in the context of a micro-ring resonator based optical add-drop multiplexer (OADM) application, we consider the use of an integrated polarization diversity scheme (Fig. 1a) to circumvent the polarization dependence of the devices on the chip to enable chip level polarization independence. Allowing the devices to be polarization dependent enables the use of high-index-contrast waveguides to form coupled microring-resonator-based filters with large free spectral ranges, flat passbands, and sharp roll-offs. We use rigorous electromagnetic simulations to design coupled microring-resonator based filters (Fig. 1c) and the integrated polarization splitters (Fig. 1b) and rotators (Fig. 1d) needed to implement the polarization diversity scheme. All structures were fabricated using direct e-beam write processes and the fabricated devices demonstrate performance that closely matches the theoretical predictions. The filters demonstrate flat passbands along with the largest FSRs and best through-port extinctions of any reported microring-resonator-based filters while the integrated polarization splitters and rotators demonstrate broadband low cross-talk performance and, to our knowledge, represent the first demonstration of an integrated optic polarization splitter-rotator. The actual integration of coupled microring-resonator filters with polarization splitters and rotators is all that remains to implement a polarization independent optical add-drop multiplexer formed from polarization dependent coupled micro-ring resonators.

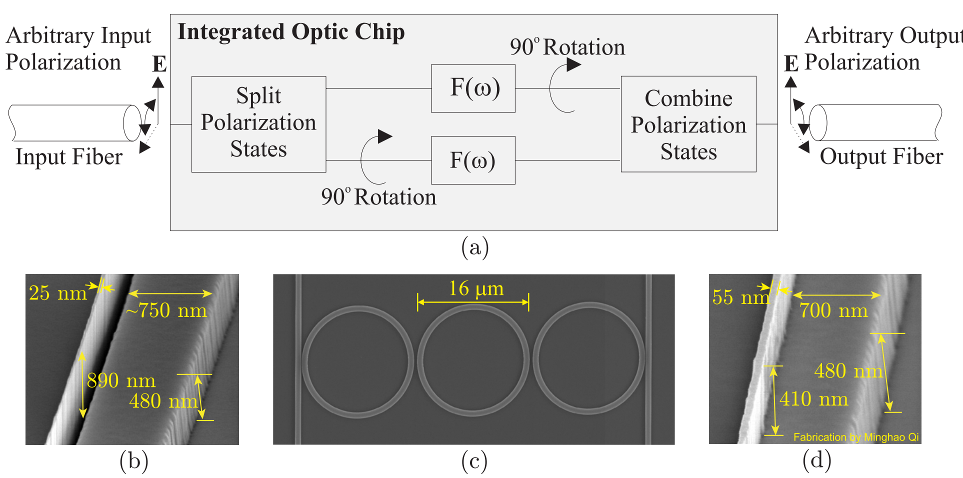

Fig. 1 (a) Diagram of an integrated polarization diversity scheme along with scanning electron micrographs of (b) an integrated optic polarization splitter, (c) micro-ring resonator, and (d) an integrated optic polarization rotator.