Polarization splitters based on form birefringence for micron-scale silicon photonics

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Introduction

The polarization handling has significant benefits for photonic integrated systems targeting coherent receivers, polarization multiplexed transmission systems, and sensing applications. For polarization handling, on-chip polarization management which includes polarization splitters and rotators is important. Indeed, VTT silicon photonics platform has low polarization dependency, which is an advantage when both polarization should be handled the same way. The polarization splitters along with rotators can be used to develop on-chip polarization manipulation devices including all-silicon optical isolators and circulators. In this work we investigated how to achieve on-chip polarization splitters based on interferometer design, utilizing the tunable birefringence of our waveguides.

Mach-Zehnder Interferometric (MZI) polarization splitters

In the polarization splitter based on interferometric design shown in Fig.1, polarization-dependent phase shifts are achieved by introducing birefringence in the waveguide arms of a MZI, by varying the waveguide dimensions, which in practice means width variations. An analytical model is developed for these MZI based polarization splitters, which takes in account waveguide width variation and physical path length change.

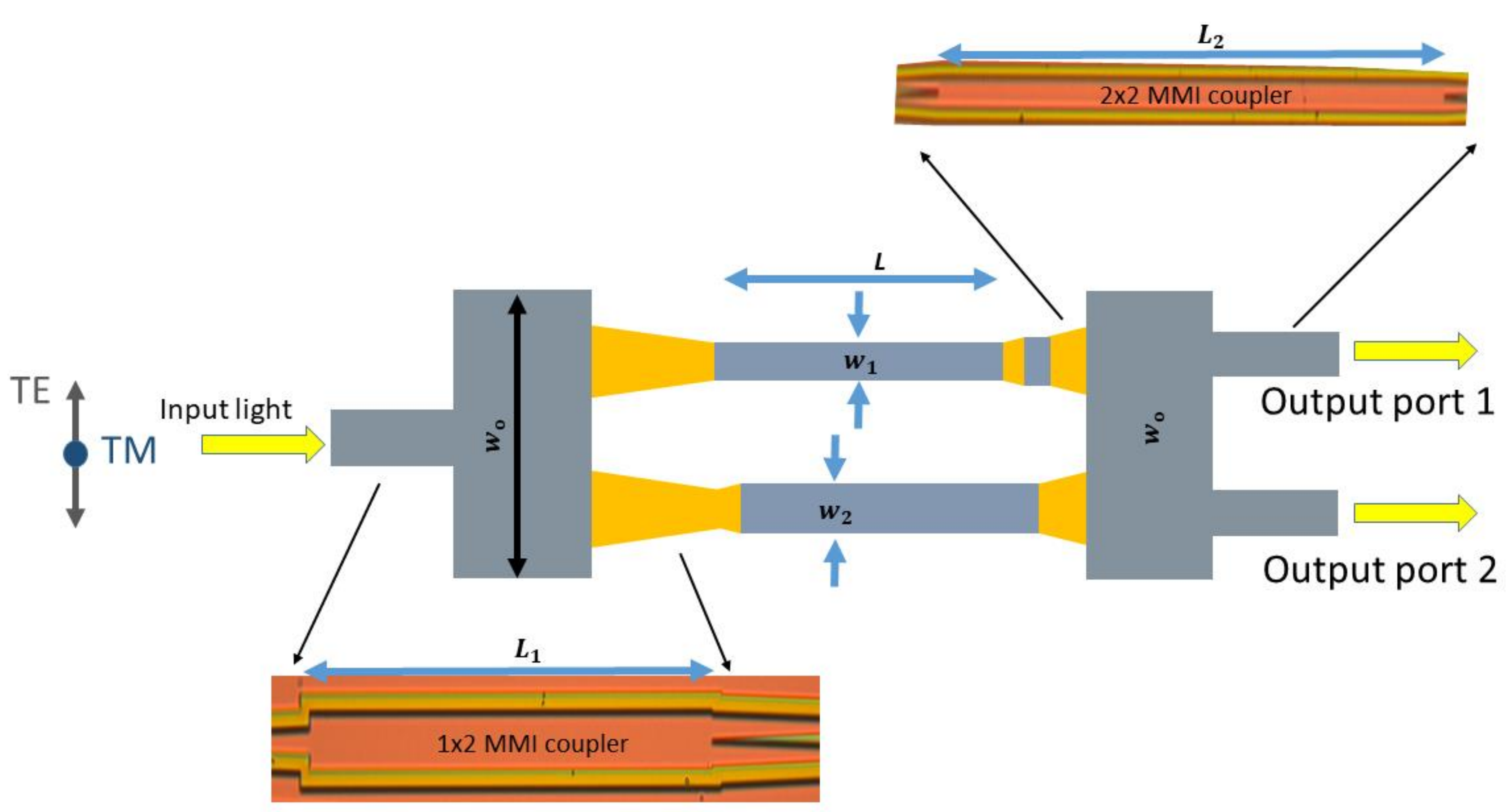

Figure 1. Schematic and microscopic pictures of polarization splitter based on Mach-Zehnder interferometer design.

The length and the width of the 1×2 MMI is L_1 and w_o, respectively, the width of the upper arm waveguide is w_1 whereas the width of lower arm waveguide is w_2. The length of the 2×2 MMI is L_2 and width is w_o. L presents the length of birefringent section.

Simulation results for an ideal polarization splitter

Simulation results for ideal device are presented in Fig.2. Extinction ratio (ER) >20 dB is achieved for both polarizations in the wavelength range 1511-1551 nm, and ER >40 dB is observed around 1540 nm wavelength.

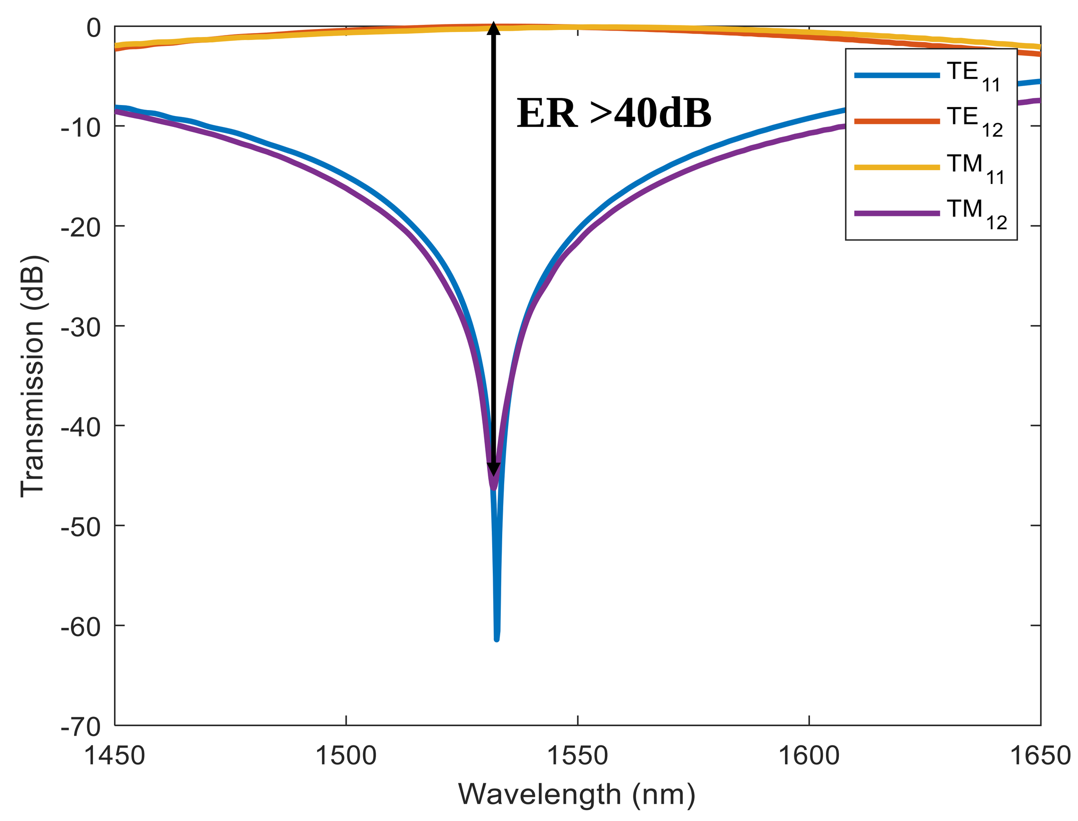

Figure 2. Simulation of ideal polarization splitter. $w_1 = 1.58\ \mu m$, $w_2 = 2.5\ \mu m$, $L_1 = 236.5\ \mu m$, L_2 = 793.6 μm, w_o = 13.5 μm, and L = 216 μm is used for simulation.

Experimental results

Measurement results from passive wafer are presented in Fig.3 with solid lines. Dotted lines show the simulation results which are in good agreement with measurement. The measured insertion losses are less than 1 dB. When input light is TE-polarized, ER >20 dB is achieved in the wavelength range of 1550 - 1580 nm, and >14 dB ER is observed on 40 nm bandwidth. In case of TM-polarized light, ER is approximately 14 dB in the wavelength range of 1475 - 1515 nm.

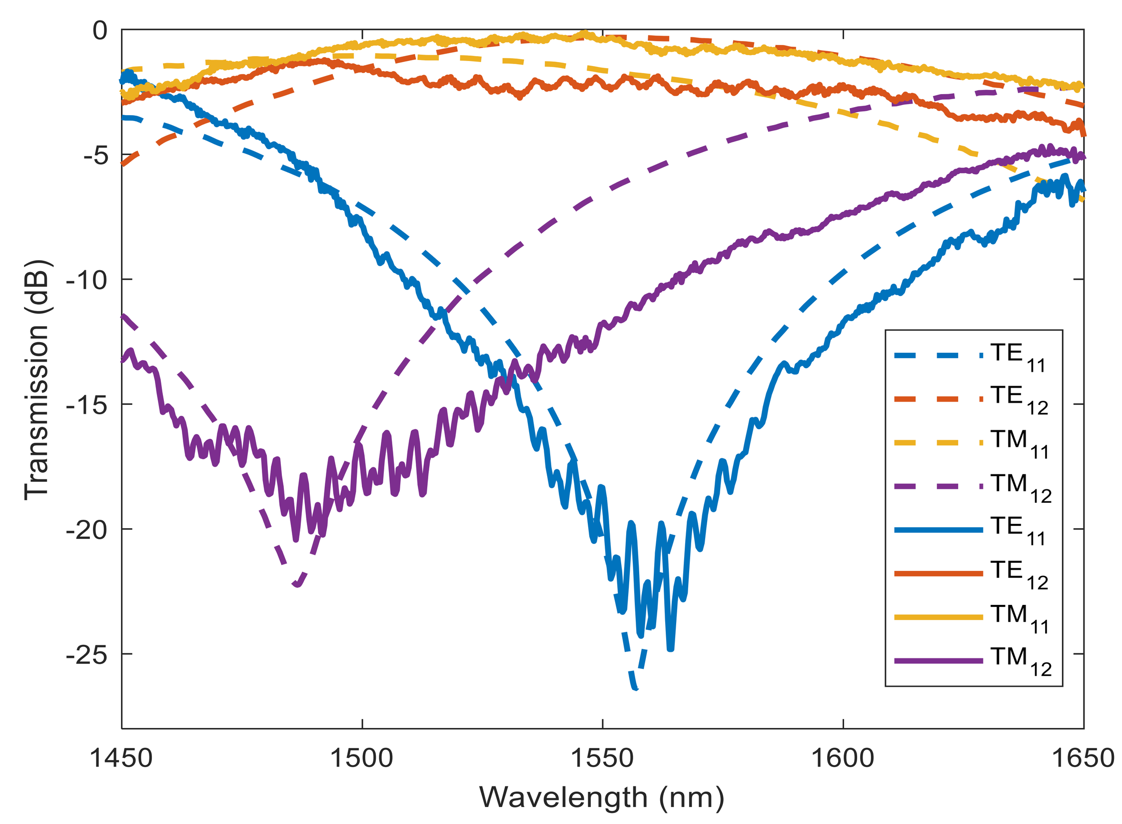

Figure 3. Analytical model results compared with measurement results.

Conclusion and future outlook

Up to 14 dB ER has been achieved for both polarizations on a bandwidth of 40 nm. The device can be optimized with active tuning and we can expect upto 20 dB ER on same wavelength range.

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