Polarization independent 2×2 multimode interference coupler with bricked subwavelength metamaterial

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Abstract. The silicon-on-insulator (SOI) platform enables high integration density in photonic integrated circuits while maintaining compatibility with CMOS fabrication processes. Nevertheless, its inherently high modal birefringence hinders the development of polarization-insensitive devices. The dispersion and anisotropy engineering leveraging subwavelength grating (SWG) metamaterials makes possible the development of polarization agnostic waveguide components. In this work we build upon the bricked SWG metamaterial nanostructures to design a polarization independent 2×2 multimode interference (MMI) coupler for the 220 nm SOI platform, operating in the telecom O-band. The designed device exhibits a 160 nm bandwidth with excess loss, polarization dependent loss and imbalance below 1 dB and phase error lower than 5°.

Since their first demonstration in silicon photonics [1,2], SWG metamaterials [3,4] have been used as a powerful engineering tool for overcoming performance limitations of conventional silicon photonic devices [5]. However, achieving polarization-independent and broadband devices is still challenge [6]. In this work we leverage polarization independence provided by bricked SWG waveguides, a recently proposed new subwavelength nano-patterning topology [7,8], to design a polarization-insensitive 2×2 MMI coupler for the 220 nm SOI platform.

The general geometry of bricked SWG waveguide, as well as the MMI device that makes use of it, are shown in Fig. 1. Fig. 2 (solid lines) shows the beat length wavelength dependence of a conventional SWG waveguide for both TE and TM polarizations. By engineering the geometry of the bricked SWG waveguide, it is possible to equalize the beat length for TE and TM polarizations at a given wavelength, as shown in Fig. 2 (dashed lines). This multi-mode waveguide is subsequently implemented in the central region of the MMI coupler, yielding polarization-independent performance.

The performance of the MMI coupler was evaluated by 3D full-vectorial FDTD simulations. The simulated structure included the bricked SWG multimode waveguide and adiabatic tapers for widening the input mode profile and adapting silicon wires to the bricked SWG slab. The simulation results are shown in Fig. 3. Excess loss is below 1 dB in the wavelength range from

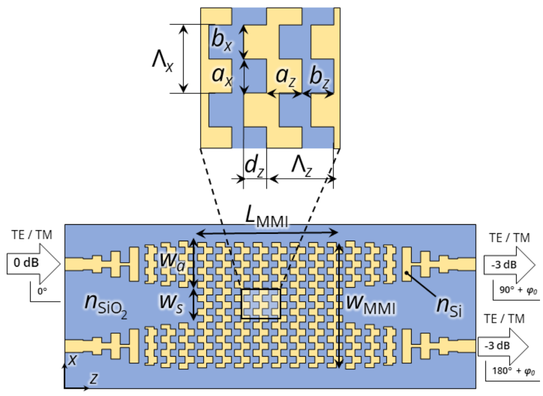

Fig. 1. Geometry of the bricked SWG waveguide and the designed multimode interference coupler.

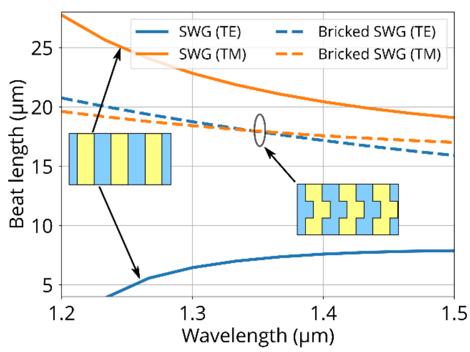

Fig. 2. Wavelength dependence of the beat length between the first two modes of the conventional and bricked SWG waveguides, for the TE and TM polarizations. In both cases, the width of the waveguide is 3 µm.

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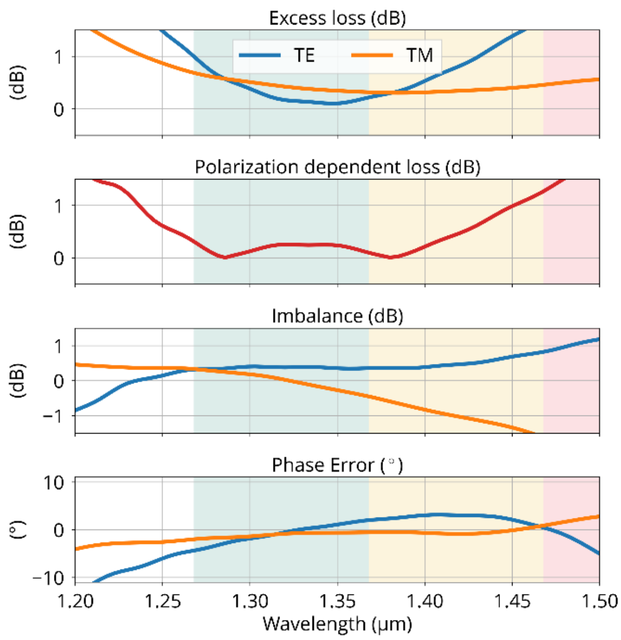

Fig. 3. Performance of the designed device calculated using 3D FDTD simulations.

1260 nm to 1420 nm for both TE and TM polarizations.

Polarization dependent loss is lower than 1 dB from 1240 nm to 1450 nm and power imbalance is less than 1 dB from 1190 nm to 1420 nm. Phase errors of <5º are predicted in the wavelength range 1260 nm – 1500 nm. This is, to the best of our knowledge, the first report of a polarization-insensitive 2×2 MMI for the 220 nm-thick silicon layer on the SOI platform. The results obtained in this work open prospects for the development of polarization-insensitive devices for silicon photonic integrated circuits.

We acknowledge funding from Ministerio de Economía y Competitividad (PID2019-106747RB-I00), Junta de Andalucía (P18-RT-1453, UMA20-FEDERJA-158), Ministerio de Ciencia Innovación y Universidades (FPU16/06762, FPU19/02408) and Universidad de Málaga, Campus de Excelencia Internacional Andalucía Tech.

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