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Ultra-compact Polarization Splitter Based on a Multimode Interference Coupler with a Silicon Hybrid Plasmonic Waveguide

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1. Introduction

Polarization handing devices including polarization beam splitters (PBSs) are playing a pivotal role in polarization-involved applications [1]. Many waveguide PBSs have been demonstrated with various structures. Regarding the design simplicity and fabrication tolerance, the multimode interference (MMI) structure is a good choice to realize PBSs. However, the conventional MMI-based PBS are quite long (10~10^3 μm) since the polarization dependence of the beat-length of an MMI section is not strong [2].

In this paper, we propose a novel ultra-compact PBS using a multimode interference coupler with a silicon hybrid plasmonic waveguide [3]. The silicon hybrid plasmonic waveguide, with strong polarization dependence, has been used to realize asymmetrical evanescent coupling systems for PBSs, whose total length is 5~10 μm when the gap width is chosen as small as 100 nm [4, 5]. Here our novel PBS has no any nano-slot and the footprint is only 1.8 × 2.5 μm^2, which is the smallest reported to date. The present PBS has a large fabrication tolerance and the extinction ratio (ER) is >10 dB over a broad band (>80 nm).

2. The device structure, design and fabrication

Fig. 1(a) shows the structure of our proposed PBS based on an MMI structure covered by a metal stripe partially. When operating with TE-polarization, the metal layer on the top hardly influences the light propagation so that a mirror image is formed at the cross port due to the self-image effect in the MMI section. For TM polarization, the fundamental mode (TM_0) in the MMI section is very similar to that in the input hybrid plasmonic waveguide because of the plasmonic effect. Thus, light will be "bounded" to propagate along the metal strip and finally output from the thru port. In order to enhance the ER, a subwavelength bending section is connected at the thru port, as shown in Fig. 1(a). Fig. 1(b) shows our fabricated device with silver on the top and the measurement is being done.

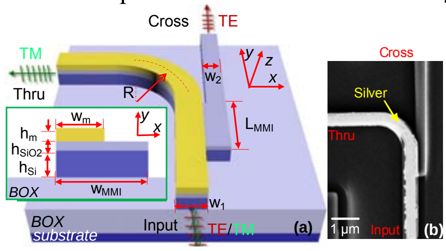

Fig. 1. (a) The schematic configuration of the proposed PBS; (b) The SEM picture of the fabricated PBS.

Fig. 2 shows the simulated light propagation in our novel PBS with the following optimal parameters: w_{MMI} = 0.8 μm, w_m = w_1 = 420 nm, R = 1.2 μm, the MMI length L_{MMI} = 1.1 μm. It can be seen that TE and TM polarizations are separated very well as expected.

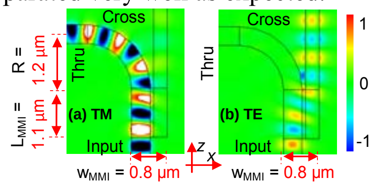

Fig. 2. Light propagation in the designed PBS.

We also give an analysis for the wavelength dependence of the proposed PBS, as shown in Fig. 3(a). It can be seen that the ER is >10 dB over a broad band of >80 nm. Fig. 3(b) shows the ERs and the excess losses of the PBS when assuming there is a width difference Δw (= w_1-w_m) between the metal strip and the Si nanowire. One sees the PBS still works well even when the variation Δw is as large as 200 nm, which indicates the fabrication is very tolerant.

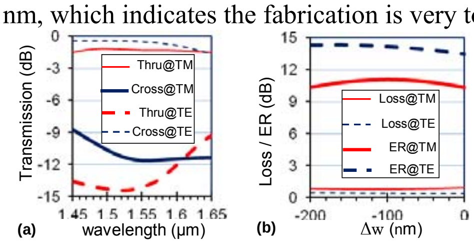

Fig. 3 (a) The wavelength dependence of the PBS; (b) The excess losses and ERs as Δw varies; Δw = w_m–w_1 and w_1 = 420 nm.

3. Conclusions

An ultra-compact PBS (only 1.8 × 2.5 μm^2) has been proposed by utilizing a MMI coupler with a silicon hybrid plasmonic waveguide, which has a broad band (>80 nm for 10 dB ER) and large fabrication tolerance.

Acknowledgements

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