Athermal Silicon Mach-Zehnder Lattice Filters

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Abstract: We present a CMOS compatible temperature-independent silicon lattice filter made of 10 cascaded 2×2 asymmetric Mach-Zehnder interferometers. Simulation and preliminary experimental results are given.
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1. Introduction

Silicon waveguide devices and circuits are promising for optical communication and interconnect applications, because of their compact size and easy integration with electronic circuits. However, high temperature sensitivity is one of the fundamental limitations of silicon photonic devices because silicon has a large thermo-optic coefficient of $1.86\times10^{-4}\,K^{-1}$. Several approaches have been proposed to reduce the temperature sensitivity; however, most of the approaches are either not compatible with CMOS process [1] or power hungry [2, 3]. One choice is to use an asymmetric Mach-Zehnder interferometer (MZI) structure, which has been proposed and demonstrated to have athermal optical properties [4, 5]. In this paper, we present a CMOS compatible temperature-independent silicon lattice filter based on the athermal MZI.

2. Device structure and experimental results

Fig.1 (a) shows the schematic view of the device comprising 10 cascaded 2×2 MZIs. Fig.1 (b) shows one stage of the asymmetric MZI structure with the waveguide width and length labeled in the figure. The device is fabricated on a SOI wafer with a top silicon layer thickness of 220 nm and a buried oxide layer thickness of 2 μm. The waveguide was patterned with 248-nm deep ultra-violet (DUV) photolithography and then plasma dry etched. Finally, it was deposited by a 1-μm-thick silicon dioxide layer using plasma-enhanced chemical vapor deposition (PECVD). Fig.1 (c) shows the simulated transmission spectra of the bar and cross ports of the lattice filter. The filter extinction ratio, defined as the intensity difference between the main peak and the first sidelobe of the cross port, is ~7 dB. When temperature changes, the spectra do not shift as the temperature induced phase shifts in the MZI arms are exactly canceled. It should be noted that the filtering performance can be improved if more stages of MZIs are used or the lattice filter is properly apodized. Fig.1 (d) shows the preliminary experimental results. The filter central wavelength is found to be at 1509 nm and the extinction ratio is ~6 dB. The filtering bandwidth is ~8 nm, narrower than the designed one, probably due to the weakened coupling in the MZIs.

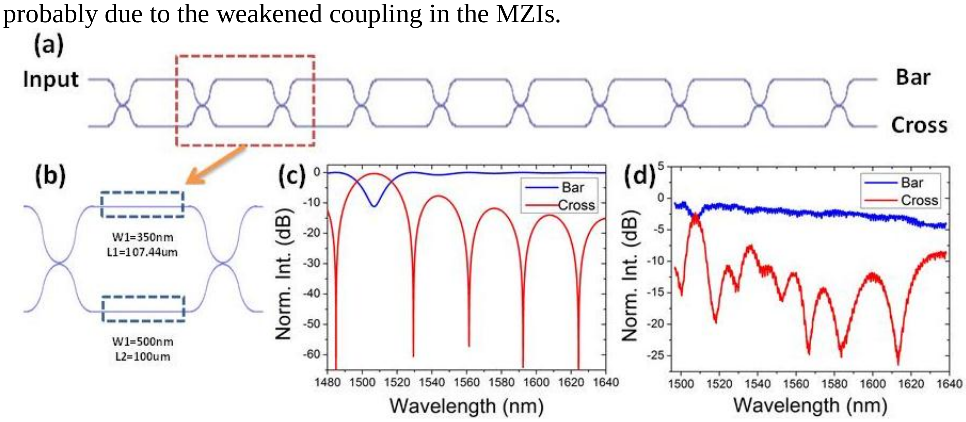

Fig. 1. (a) Schematic of the lattice filter. (b) Zoom-in of one MZI stage. (c) Simulated and (d) measured transmission spectra of the lattice filter.

3. References

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