Thermally-Tunable Notch Filter Based on a Mach-Zehnder Coupled Microring Resonator

Jingya Xie, Linjie Zhou*, Xiaomeng Sun, Zhi Zou, Liangjun Lu, and Jianping Chen
State Key Laboratory of Advanced Optical Communication Systems and Networks
Department of Electronic Engineering, Shanghai Jiao Tong University, Shanghai 200240, P. R. China
**ljzhou@sjtu.edu.cn*

Abstract: A microring notch filter with a thermally-tunable Mach-Zehnder coupler is demonstrated. The thermal tuning is enabled via an intrinsic thermal resistor based on a lateral p-i-p junction across a silicon waveguide. Experimental results show that the extinction ratio of the notch filter can be increased by >10 dB with a current of 0.4 mA.
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1. Introduction

Microring notch filters are one of the building blocks in optical signal processing. They have the merits of compact size, simple structure, and narrow bandwidth etc [1]. However, in order to get a high extinction ratio or critical coupling, the coupling between the bus waveguide and microring should be well-controlled, which imposes a great challenge on device fabrication. One of the feasible ways to control the resonance extinction ratio is to use a tunable coupler [2, 3]. Here we experimentally demonstrate a microring notch filter with its coupling controllable by a thermal Mach-Zehnder coupler.

2. Device structure and experimental results

Fig. 1(a) shows the schematic drawing of the device, which is composed by a 2×2 Mach-Zehnder interferometer (MZI) with one input and one output ports connected to form a ring resonator. The 3-dB multimode interference (MMI) couplers in the MZI are 5-μm-wide and 31.5-μm-long. The active tuning arm is 250 μm long. The lateral p-i-p thermal resistor is schematically shown in Fig. 1(b). It should be noted that the thermal resistor is composed by the waveguide (so called 'intrinsic' thermal resistor), and thereby the power efficiency and switch speed can potentially be improved since the generated heat directly interacts with the optical mode.

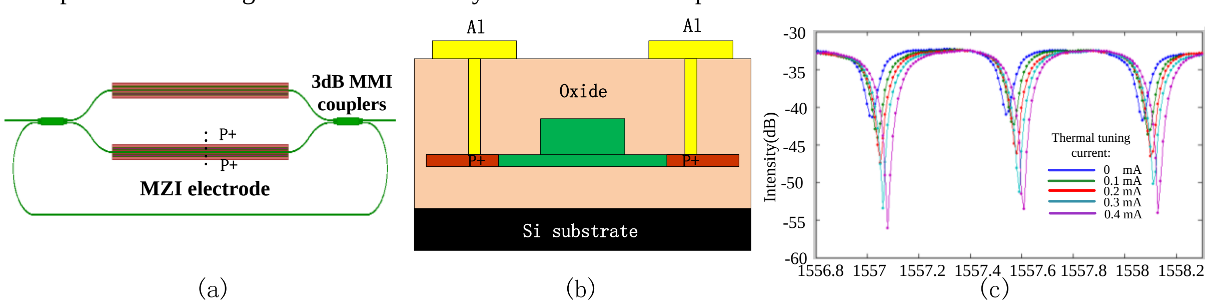

Fig. 1. (a) Schematic of the Mach-Zehnder coupled microring notch filter. The p-i-p thermal resistor is embedded in the arms of the Mach-Zehnder coupler. (b) Cross-sectional schematic of the thermal resistor. (c) Measured transmission spectra under various thermal tuning currents.

Active tuning of the filter is achieved by injection of current into one of the MZI arms. Fig. 1(c) illustrates the measured transmission spectra under various injection currents. The optical field is transverse electric (TE)-polarized. Originally, the resonance extinction ratio is only 8 dB, because the coupling and the cavity loss are not balanced. With the increment in tuning current, the resonance extinction ratio is gradually enhanced, together with a resonance redshift. In particular, at 0.4 mA, the extinction ratio reaches 20 dB, close to critical coupling. The resonance redshift is 0.6 nm. It should be noted that the resonance wavelength can be tuned across one free-spectral range (FSR) while maintaining a high extinction ratio if the two thermal electrodes are both tuned.

3. References

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