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A High-resolution Integrated Spectrometer based on cascaded a ring resonator and an AWG

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Abstract: A high-resolution integrated spectrometer consists of a cascaded microring resonator and an AWG is demonstrated and achieved a high resolution of 0.42 nm and bandwidth of 90 nm. It has high potential in biochemical sensing applications.

OCIS codes: (300.6190) Spectrometers; (130.3120) Integrated optics devices; (130.6010) Sensors.

Introduction

One of the most significant current researches in spectrometer is about spectrometers based on planar integrated optical waveguide technology with various structures, such as arrayed waveguide gratings (AWGs) [1], echelle gratings [2], microring resonators (MRR) [3] and waveguide Fourier-transform (FT) spectrometers [4-5]. Among them, the traditional spectrometers with splitting light such as AWG and EDG have been researched for a long time. In our previous work, we proposed and demonstrated an integrated spectrometer with high resolution and wide bandwidth based on the cascaded AWG and tunable microring resonator array [4]. However, the microring from each channel need to be tuning, which is very time-consuming. In this paper, we proposed a structure of cascading a heat-tuning MRR with an AWG to produce a high-resolution spectrometer, which reduces time spending caused by microring array tuning.

Design and theoretical analysis

The image of the chip packaged to a control PCB and an optical microscopic picture of the tunable MRR are presented in Fig.1. The spectrometer comprised of two main components: an MRR and an AWG. The chip was fabricated on a silicon on insulator (SOI) platform with a 220 nm silicon layer on a 2 μm silica insulator layer. For the MRR, the widths of all the straight waveguides are 0.45 μm with a ridge height of 0.22 μm and the ring diameter of 7.5 μm . For the AWG, it consists of 10 output channels with FSR 9 nm. To measure the spectral response of the spectrometer, a tunable laser source (Santec TSL-510) was used as the light source. A polarization controller was used to rotate the polarization of the input light for maximum coupling to the TE mode. The light is coupled into the input port of MRR by the edge coupling and transmitted into the AWG and detected from 10 channels.

Fig.1. (a) Image of the chip packaged to a control PCB; (b) Schematic image of a ring resonator and an AWG structure.

Results and Discussions

In Fig. 2 (a), different colors denote different modulated states of the MRR. The output from drop port of the MRR transmit to the AWG and final signal is received by PD from each channel. In Fig. 2 (b), different colors show the spectrum from each channel of AWG cascaded with microring. The total spectrum can retrieve the spectrum of AWG correctly. In other words, after we normalize spectrum of AWG, we can retrieve the original input spectrum with a high resolution.

Fig. 2. (a): MRR transmission from drop port when input spectrum is Gaussian distribution; (b): Retrieved spectrum of AWG.

To characterization the spectrometer, a tunable laser source (Santec TSL-510) was used as the light source. The normalized retrieved spectra from channel 5-10 are shown in Figure 3. The wavelength increment is achieved by heating-tuning of microring and the smallest wavelength interval can reach 0.42 nm. The working spectral ranges of the 10 channels can obtain 90 nm.

Fig. 3. Normalized retrieved spectra from the channel 5-10 with heater tuning wavelength.

Conclusions

In conclusion, we have proposed a novel on-chip spectrometer structure with small footprint, which is composed by cascading an MRR and an AWG. The high resolution of the spectrometer has been demonstrated experimentally. The measured resolution is as high as 0.42 nm and the bandwidth are 90 nm. It has further applications in the biochemical sensing field.

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