Dual-band optical filter based on a microracetrack resonator embedded with Bragg gratings

Zhang Zecen* Geok Ing Ng, Haodong Qiu, Xin Guo, Wanjun Wang
Mohamed Saïd Rouifed, Chongyang Liu, and Hong Wang
Nanyang Technological University, Singapore

* Email: ZZHANG023@e.ntu.edu.sg; Tel.: +65-8351-5512

In the last decades, dual-band optical filters (DBOFs) have attracted great attentions as they play important roles in various optical applications, such as optical modulation [1], sensing [2], fast/slow light [3], etc. Multiple microring resonators have been utilizing in various methods to realize the dual-band filtering spectrum [4-6]. However, the multiple-microring-resonators structure is not suitable for high volume integration due to its large form factor. In this work, we firstly developed a novel design based on single-microracetrack-resonator structure embedded with Bragg gratings, which is more compact and feasible for large-scale integration. Besides, through changing the dimensional sizes of the Bragg gratings, the reflectivity of the Bragg grating can be tuned and the transmission spectrum can be engineered as well.

The schematic of the microracetrack resonator embedded with Bragg gratings is shown in Fig. 1. Two embedded Bragg gratings act as partial reflective elements to form a Fabry-Perot resonator with a part of the microracetrack. The coupling between the F-P resonator and the microracetrack gives rise to the dual-band filtering transmission spectrum. In the simulation, we regard the Bragg grating as a periodic structure consisting of wide waveguide segments, narrow segments and reflective interfaces [7]. As shown in Fig. 2, the transmission spectrum is calculated with a specially designed numerical model based on the transfer matrix method. In this simulation, the parameters are chosen as: width of the waveguides = 500 nm, dw = 20 nm, pitch = 324 nm, the number of pitches = 20, radius of the microracetrack = 10.2 μm. The effective indices of the waveguides under different wavelengths around 1.55 μm are calculated with the BeamPROP module of Rsoft software by taking the dispersion into account.

As shown in Fig. 3, the microracetrack resonator embedded with Bragg is fabricated on a SOI platform with a 220-nm top silicon slayer and a 2um buried oxide (BOX) layer. The grating layer and the waveguide layer both are patterned with electron beam lithography. The grating layer is etched with RIE to the depth of 70 nm. The waveguide layer is etched down to the BOX layer. Then the sample is coated with a 1 um SiO_2 cladding layer. The characterizations are carried out at room temperature. The experimental results are plotted in Fig. 4. As it can be seen, the extinction ratios (ERs) of the dual-band filtering spectrum are ~ 4.5 dB. The separation between two notches is ~ 0.5 nm. The full-width-at-half-maximums (FWHMs) are 0.05 nm and 0.045 nm, which corresponds to the Q factors of 30900 and 34400. The insertion loss is < 0.5 dB. The uneven transmission may be caused by the F-P resonator formed by the two end facets of the bus waveguide. By reducing the roughness of the waveguide sidewalls, the ER can be further increased.

This compact dual-band filter is expected to have good potential for applications in optical modulation, optical signal processing, and biological/chemical sensing.

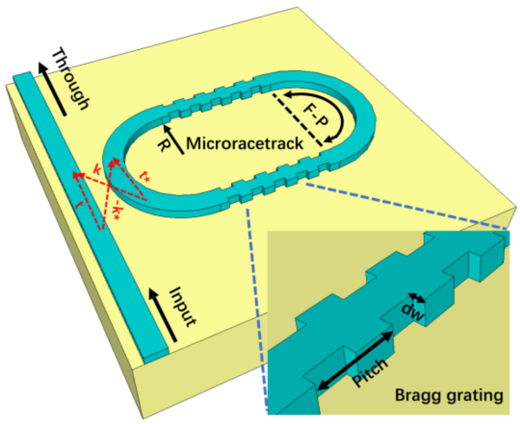

Figure 1. The schematic of the microracetrack resonator embedded with Bragg gratings.

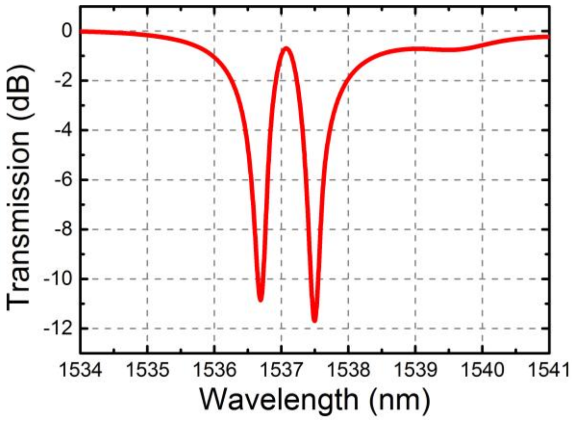

Figure 2. The simulated transmission spectrum of the microracetrack resonator embedded with Bragg gratings.

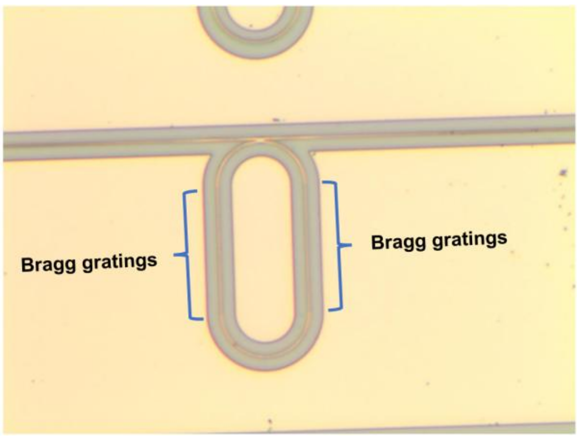

Figure 3. The fabricated microracetrack resonator embedded with Bragg gratings.

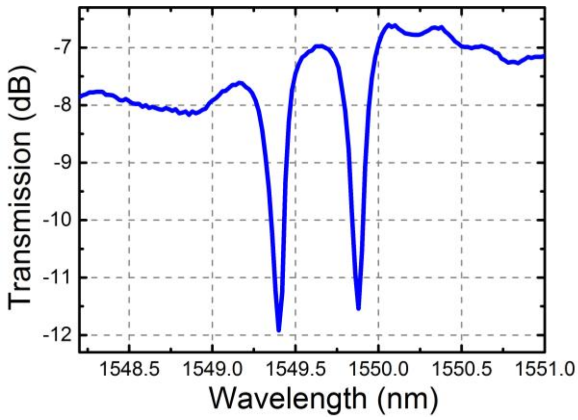

Figure 4. The experimental transmission spectrum of the microracetrack resonator embedded with Bragg gratings.

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