T-shape Suspended Silicon Nitride Microring Resonator Sensor

Jijun Feng and Ryoichi Akimoto

Electronics and Photonics Research Institute, National Institute of Advanced Industrial Science and Technology, Tsukuba 305-8568, Japan
E-mail: jijun-feng@aist.go.jp; r-akimoto@aist.go.jp

1. Introduction

Label-free photonic biological sensors and environmental monitors can perform sensitive and quantitative multi-parameter measurements, where a crucial component is a transducer that can transform an environmental refractive index variation to a measurable optical transmission change. By using optical whispering gallery mode (WGM) resonators with high quality factor that have narrow resonance valleys, the smallest detectable spectra shift can be minimized, which are beneficial for the improvement of the detection limit. In order to increase the device sensitivity, suspended structures are developed. To the best of our knowledge, a T-shape suspended racetrack ring resonator has not been demonstrated.

Silicon nitride (Si_3N_4) is a promising waveguide material for optical sensing due to its wide transparency bandwidth and medium refractive index. Si_3N_4-based devices also offer a large fabrication tolerance and superior performance in the coupling and propagation loss [1-3]. With careful control of the wet etching process to form a SiO_2 pedestal for supporting the Si_3N_4 core, a mechanical stable T-shape suspended racetrack ring resonator integrated with an access waveguide is presented here, which has an enhanced sensitivity and high quality factor [4].

2. Device Fabrication and Performance

The microscope image of the fabricated T-shape suspended racetrack resonator is shown in Fig. 1(a), which consists of a directional coupler and a 20-μm-radius curve structure. Inset shows the cross-sectional scanning electron microscopy (SEM) image of a suspended straight waveguide (bottom) and a directional coupler (top). Here, the Si_3N_4 thickness is about 310 nm with a straight waveguide width of 1.3 μm.

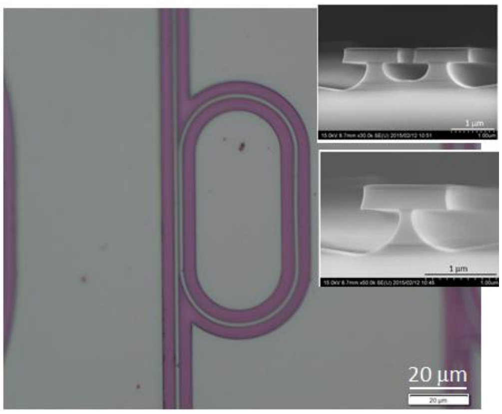

Fig. 1. Microscope and SEM image of a suspended resonator.

The suspended device can work for TE polarization. The device sensitivity was measured by dropping different organic liquids on the top surface of the suspended resonator, including deionized water, methanol, ethanol, and isopropyl alcohol (IPA). The corresponding resonant wavelength varies with the liquid refractive index, as shown in Fig. 2, with the inset for the measured transmission spectrum response around 1550-nm wavelength without liquid, which shows a quality factor of about 1.6×10^4. It can be fitted that the sensitivity of the suspended resonator is about 247 nm/RIU. Actually, the sensitivity can be influenced much by the long coupling region, where the suspended waveguide is a little asymmetric with a wider SiO_2 pedestal caused by the reduced wet-etching rate in the gap area. Nonetheless, the present device could realize a better performance with an enhanced sensitivity.

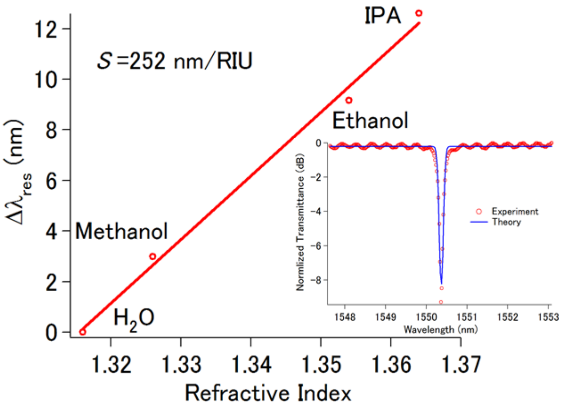

Fig. 2. Resonant wavelength shift varying with the liquid refractive index. Inset: Normalized transmission spectrum.

3. Conclusions

A mechanical stable T-shape suspended Si_3N_4 racetrack ring resonator on a SiO_2 pedestal has been demonstrated. The developed device can work with a high quality factor and extinction ratio. It can have a wide optical sensor application prospect due to its enhanced sensitivity.

Acknowledgements

Jijun Feng acknowledges support from the Japan Society for the Promotion of Science.

References

[1] J. Feng, R. Akimoto, IEEE Photonics Technol. Lett. **26**, 706 (2014).
[2] J. Feng, R. Akimoto, IEEE Photonics Technol. Lett. **26**, 2391 (2014).
[3] J. Feng, R. Akimoto, Jpn. J. Appl. Phys. **54**, 04DG08 (2015).
[4] J. Feng, R. Akimoto, IEEE Photonics Technol. Lett. **27**, DOI: 10.1109/LPT.2015.2432124 (2015).