Optimization and Experimental Demonstration of Compact and High-Sensitive Multi-Slotted Bragg grating Waveguide Sensor on SOI Platform

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1. Introduction

With the need of more efficient and smaller photonics devices one of the most common platforms for fabrication is silicon on insulator (SOI). To make the whole device smaller one would need to use firstly more compact elements. For example change mach-zehnder interferometers with micro ring resonators (MRRs). To make the element more sensitive to surrounding media influences one needs to modify the waveguide shape. Which is why sub-wavelength grating (SWG) receive much attention lately [1]. To further improve it was combined with multiple slots [2]. However at small radiuses MRRs will have high bend losses so using Bragg gratings (BG) is setup is more suitable. Most recent result on this topic with BGs used phase shift exhibited a high sensitivity of 579 nm/RIU and a length of 67.2 µm [3]. In our research we aimed for more compact BG sensor by adopting a small period count and by using a steep first side lobe of the stop-band for higher sensitivity. The optimal device structures were designed by rigorous 3D FDTD simulation and actual devices were fabricated to demonstrate a record-high sensitivity with compact size.

2. Operation principle

The studied structure was composed of silicon waveguides formed on a SOI wafer with multi-slotted SWG structures that satisfy Bragg condition with a diffraction order of one for the largest diffraction efficiency, and hereafter we call it as multi-slotted Bragg grating (MSBG) waveguide structure sensor. Input and output of the device were connected through grating couplers for TE mode, and the sensor grating itself was surrounded with liquids of which the refractive indices were measured.

3. Experimental results

A SEM view of the fabricated device is shown in Fig. 1 with symmetric slot sizes of 60 nm, a total waveguide width of 1145 nm, a BG duty ratio of 70 %, a BG period count of 20 and a total BG length of 9.5 µm. Transmission spectral shifts by changing surrounding liquids from pure water to sugar-dissolved waters of 5%, 10% and 15% concentrations, acetone and isoproanol are shown in Fig. 2. Small ripples appeared in the whole data are due to spurious FP resonance between the grating couplers of 550 µm distance [4]. The average sensitivity was a record-high value of 831 nm/RIU. To improve the obtained ERs of 9 dB we adopted a larger period count of 50 obtaining an ER of 15 dB but with a lower average sensitivity of 706 nm/ RIU, which may be due fabrication defects.

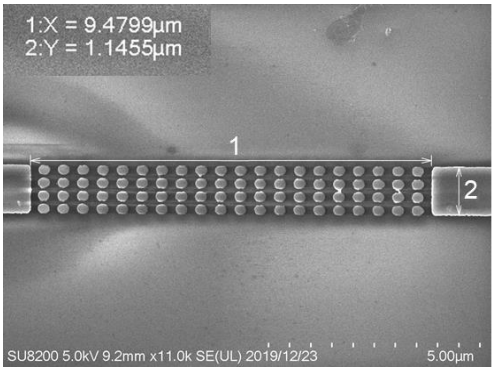

Fig. 1. SEM view of the fabricated MSBG sensor

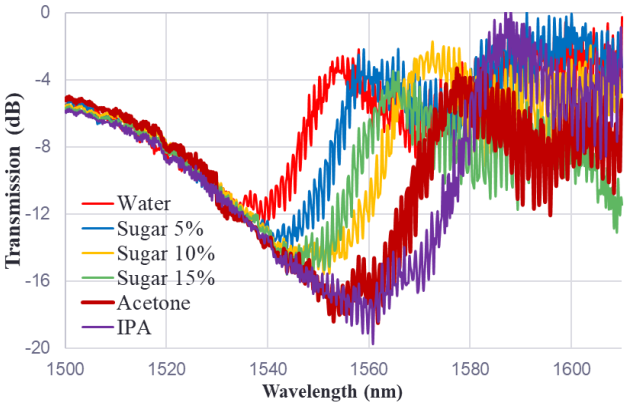

Fig. 2. Transmission spectra for various liquids

4. Refrerences

[1] Jonas Flueckiger et. al., Opt. Express, Vol. 24, Issue 14, pp. 15672-86, 2016.
[2] E. Luan et al, IEEE J. Sel. Top. in Quantum Electron., Vol. 25, Issue 3, pp. 1-11, 2018.
[3] E. Luan et al., Biomed. Opt. Express, Vol. 10, Issue 9, pp. 4825-4838, 2019.
[4] Q. Zhong et al, Opt. Express, Vol. 22, Issue 10, ppt. 18224-31, 2014.