A Novel Intensity-Based Sensor Platform for Refractive Index Sensing

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Abstract In the present investigation a new intensity-based sensor platform for refractive index sensing is presented. It is based on a special holder, a slab waveguide and two Plastic optical fibers (POFs). In particular, we present a comparison between two different configurations: the slab waveguide with and without a buffer layer. Advantages of this new approach are the possibility of sensing with a removable chip, the easy production of an engineered platform and the use of a special holder, which is also suitable for thermo-stabilized flow cells implementation.

Keywords Optical sensors · Plastic optical fibers · Slab waveguides

1 Introduction

Refractive index sensors based on optical fibers have more advantages than those based on different approaches, for example, the possibility of remote sensing. Optical fiber sensors are today widely proposed for applications in different areas of biochemical and chemical sensing [1–5]. Several optical sensors based on plastic optical fibers (POFs) have been recently proposed by the Authors [6–8]. For example, a plasmonic sensor based on a D-shaped POF is realized with a buffer layer between the exposed POF core and a thin gold film [6].

In this work, the POF is used only to launch the light into the slab waveguide and to collect the light emerging from the waveguide, conveying it to a spectrometer. The sensing region is realized on the PMMA slab waveguide inserted in a special holder. A photoresist (Microposit S1813) buffer layer is deposited over a PMMA chip (slab waveguide) by a spin coater. This photoresist buffer layer is required in order to increase the performances of the sensor. The experimental results indicated that the photoresist layer improves the performances and this configuration could be used for chemical sensing applications.

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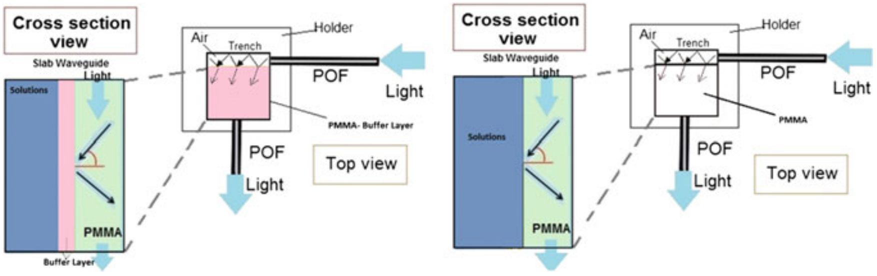

Fig. 1 Top and cross section view of two sensor configurations with and without the photoresist buffer layer

2 Optical Sensor System

Figure 1 shows two novel sensor configurations. They are based on a slab waveguide (a layer of PMMA 1 cm × 1 cm × 0.5 mm in size and with 1.49 RIU) with a photoresist buffer layer (Microposit S1813 Photoresist, 1.61 RIU, 1.5 μm thick deposited on its surface by spin coating) in the first one and without the buffer layer in the second one.

The slab waveguide (with or without the buffer layer) is inserted in a special holder. As indicated in Fig. 1, the exciting light (halogen lamp, HL–2000–LL, Ocean Optics) is introduced in the slab waveguide by a 10 mm long trench (size: 1 mm × 1 mm), realized in the holder, illuminated by a POF (1 mm in outer diameter). On the other hand, another PMMA POF, kept at the end of the slab waveguide at a 90° angle to the trench, is exploited to carry the output light to a spectrometer (FLAME-S-VIS-NIR-ES, Ocean Optics). The trench "air waveguide" has been designed because a large incident angle is required to improve the evanescent field excitation.

A similar approach has been already exploited to realize an innovative, low-cost and simple plasmonic sensor [7].

3 Experimental Results

Figure 2 reports the experimental transmission spectra (normalized to the spectrum recorded with air as the surrounding medium) referring to different water-glycerin solutions, with refractive index ranging from 1.332 to 1.401, for the sensor configuration without the buffer layer. Figure 2 clearly shows that the amplitude of the output decreases when the refractive index increases.

Figure 3 shows the output responses for the same refractive indices when on the PMMA waveguide is present the photoresist buffer layer.

Figure 4 shows the normalized output at 567.5 nm wavelength versus the refractive index for both the sensor configurations. In the same figure is also presented the

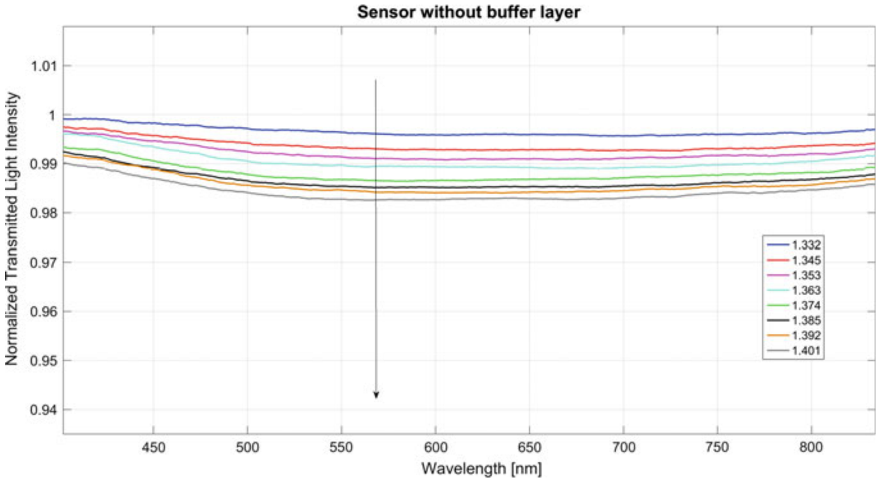

Fig. 2 Sensor configuration without buffer layer. Normalized output for different refractive indices of the aqueous medium

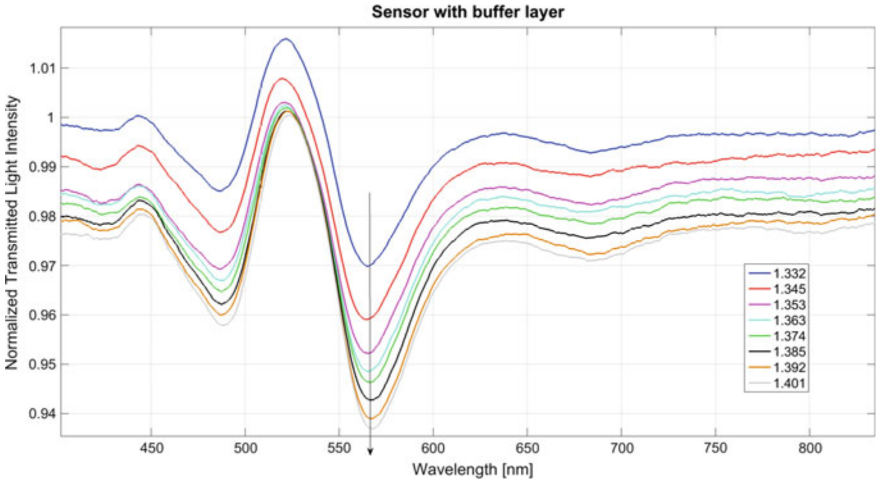

Fig. 3 Sensor configuration with buffer layer. Normalized output for different refractive indices of the aqueous medium

linear fitting to the experimental data. The sensitivity (the slope of the linear fitting) changes when the buffer layer is present. In particular, the buffer layer improves the performances of the sensor system, because the high value of the buffer's refractive index (larger than the PMMA one) improves the interaction between the evanescent field and the aqueous medium.

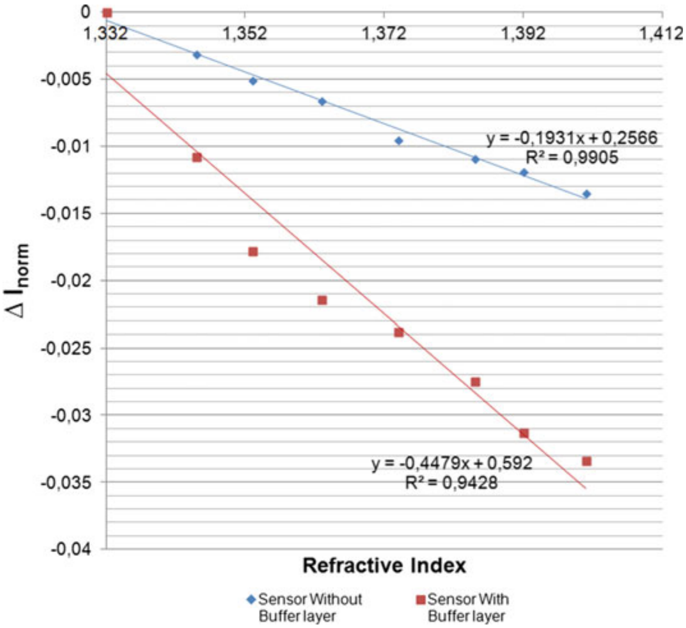

Fig. 4 Normalized output (at 567.5 nm wavelength) versus refractive index and linear fitting

4 Conclusions

The experimental results showed that the sensor's performances improve when the PMMA slab waveguide is coated with a high refractive index buffer layer. In the future, for selective detection of an analyte, we want to deposit by spin coating a chemical receptor layer (Molecularly imprinted polymer) on the slab waveguide. So, the selective detection of the analyte could be possible exploiting an MIP receptor combined with this new optical platform, through intensity-based configuration. In fact, this new sensing platform could be used with a very easy and low-cost experimental setup based on LEDs and photodetectors.

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