Optical fiber biosensor based on Lossy Mode Resonances

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The detection of the specific binding between antigen and antibody is perhaps the most used technique for diagnosis in medicine and biology. More specifically, the utilization of optical devices, which enable the detection of specific antigen-antibody binding by means of the monitorisation of their spectral response, is extensively exploited in immunoassays. In this field, Surface Plasmon Resonance (SPR) sensing has been established as a leading technique capable of detecting low analyte concentrations [1]. SPR optical fiber devices are based on semiconductor or metallic coatings, commonly gold and silver, which enable to monitor outer refractive index changes [2]. Hence, biological sensors can be fabricated by synthesizing a thin film on the sensor probe, the refractive index of which is sensitive to a target analyte. This variation of the refractive index leads to a modification of the sensor spectral response [1]. Among many other thin-film fabrication techniques, layer-by-layer (LbL) electrostatic self assembly, owing to its precise thickness control, has been proposed as a promising fabrication method suitable for the immobilization of immunoglobulin G (IgG) and anti-IgG [3].

Recently, optical fiber devices based on Lossy Mode Resonances (LMR) have been presented in the literature [4]. LMR are obtained by the coupling of light from an optical waveguide to a supporting layer of an optical absorbing material. LMR-based devices produce a response to external refractive index variations similar to that based on SPR. The main difference is that LMRs are produced by both TE and TM polarized light and more than one LMR can be generated without modifying the waveguide morphology [4]. Moreover, many different materials apart from metals and semiconductors can be used to produce LMR, such as Indium Tin Oxide [4], TiO2/PSS [5] films or even polymers [6]. Thanks to the characteristics and advantages mentioned above LMR can be exploited for the fabrication of biological sensing devices.

In this work, a LMR-based optical fiber biosensor that consists of a 200 μm optical fiber core coated with titanium oxide nanoparticles and poly (sodium 4-styrenesulfonate) (PSS) is studied [5]. The experimental setup and details of the sensor head are depicted in Figure 1. The cladding of a fragment of a multimode optical fiber (FT200EMT, Thorlabs Inc.) was chemically removed and then the core was sonicated and cleaned in both detergent and acetone and then rinsed in ultrapure water. After that, a 4 cm fragment was perpendicularly cleaved. In order to form a mirror on the end surface of the fiber, one of the end tips was coated with a reflective film (Ag) and protected with a plastic cap. Then, the LMR supporting overlay composed of [TiO_2/PSS] bilayers was fabricated by using the LbL technique. In Figure 2 the spectral response as a function of the number of bilayers is represented, in this figures it can be easily observed the generated LMR. The $[TiO_2/PSS]_9$ structure was used as a precursor for the immunosensing layer and IgG molecules were adsorbed onto it by hydrophobic and electrostatic interactions [7]. In order to test the device, the sensor head was immersed in goat IgG solution (50μg/ml) for 90 min at room temperature and then in anti-goat IgG (50μg/ml). To reduce the non-specific binding, the sensor was rinsed with phosphate buffered saline (PBS) buffer solution. The results are plotted in Figure 3 showing the shift of the resonance between both cases. To our knowledge this is the first time that a biosensors based on LMR is presented in the literature.

References

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Figures

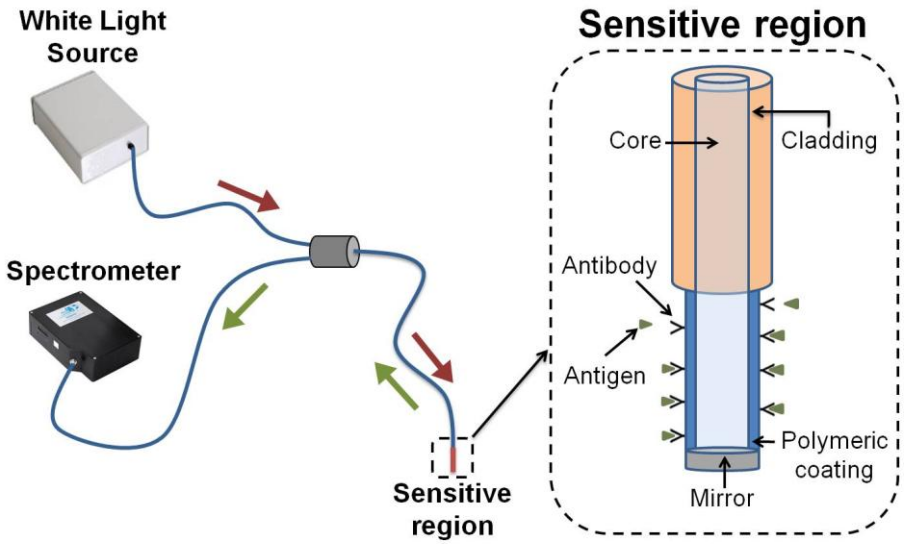

Figure 1. Experimental set-up

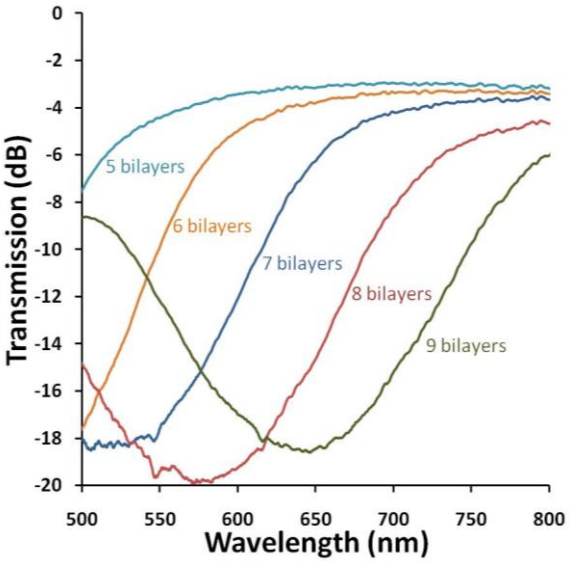

Figure 2. Spectral response of the LMR devices

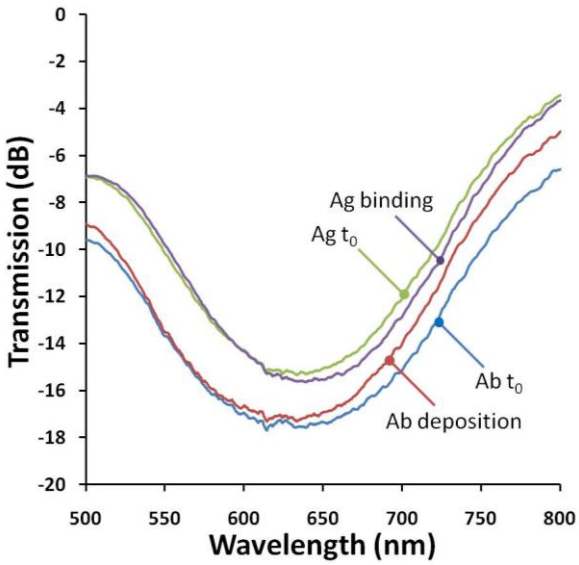

Figure 3. Spectral response before (Abt0) an after (Ab deposition) the deposition of antibodies and before (Agt0) and after (Ag binding) the attachment of antigens