Optical Fiber pH Sensor based on Surface Plasmon Resonance in the Infra-red Region

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In this work, we present the fabrication of novel optical fiber pH sensors based on surface plasmon spectroscopy detection technique in the infra-red region. Surface plasmon resonance (SPR) spectroscopy has originated numerous works in the area of chemical, biochemical and biological sensors within the last decades [1]. However, the utilization of noble metals, such as gold and silver, as the SPR supporting layer has often limited the development of further applications. Here, we propose the utilization of indium tin oxide (ITO) coated optical fibers as the SPR supporting devices [2], which shift the SPR wavelength to the infra-red region [3]. Then, these new optical fiber SPR supporting devices are used as substrates to deposit a polymeric pH sensitive coating, which varies its thickness with the pH of the surrounding medium.

The fabrication of these devices was structured in two differentiated parts. Firstly, ITO was deposited over a 200 μm diameter fused silica fiber using a sol-gel dip coating process as previously described by R. Ota et al. [4]. Then, Layer-by-Layer deposition technique was used to fabricate a thin homogeneous polymeric coating onto the ITO coated optical fiber formed by the sequentially adsorption of the poly-acrylic acid (PAA) and poly-allyllamin hydrochloride (PAH) films up to 50 bilayers [5]. In Figure 1 it is shown a scanning electron microscope image of a transversal section of the pH sensitive device where it can be appreciated the ITO film and the polymeric coating of approximately 300 nm and 150 nm respectively.

The deposited $[PAH/PAA]_{50}$ coating has been already proven to be sensitive to variations in the pH of the surrounding media, which originates variations in the thickness of the coating, known as the swelling/deswelling phenomenon. Hence, these variations can be detected by monitoring the shifts in the surface plasmon resonance wavelength using a typical optical transmission setup as it is represented in Figure 2. The sensor response was characterized when the sensitive region was immersed in different pH buffer solutions. In Figure 3 are shown the absorbance spectra obtained when the sensor was immersed alternately in pH 5, pH 6 and pH 7, where it can be clearly appreciated the variation in absorbance for the different pH values. Finally, the maximum absorbance wavelengths were obtained by using a peak detection algorithm and are represented in Figure 4 showing fast response time and high repeatability with a maximum variation of 35 nm in the studied range.

References:

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[5] J. Goicoechea, C.R. Zamarreño, I.R. Matias, F.J. Arregui, *Sens. & Actuators B*, **138** (2009) 613-618.

Figures:

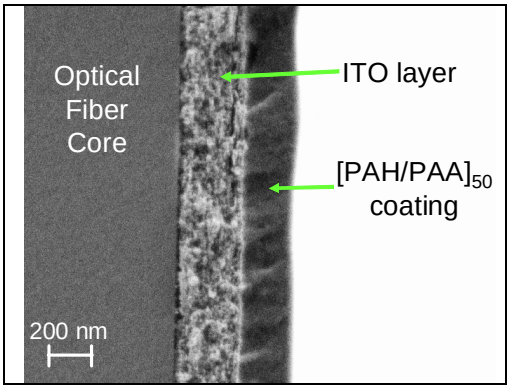

Figure 1. SEM image of the structure formed onto the optical fiber.

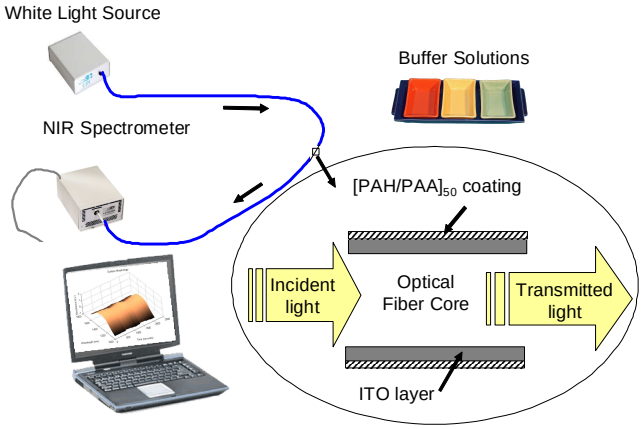

Figure 2. Experimental transmission setup

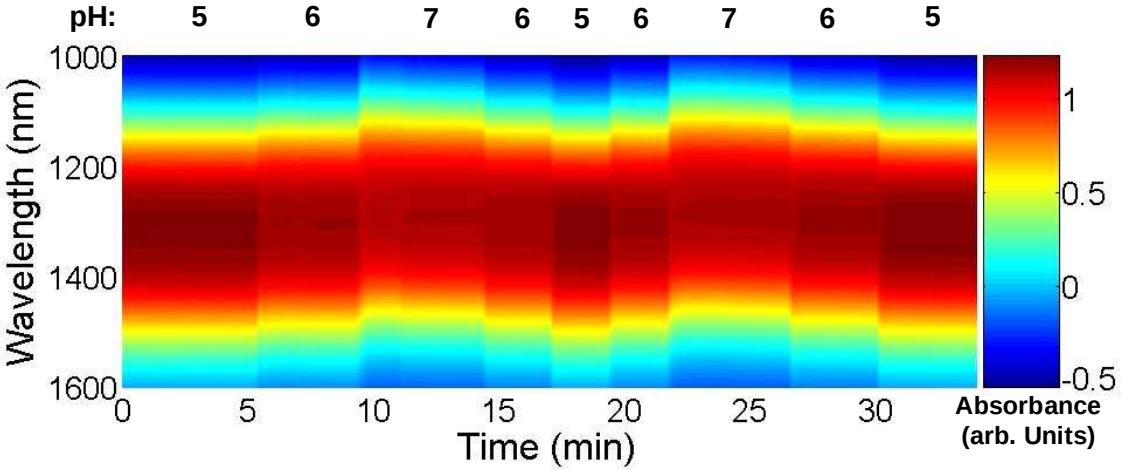

Figure 3. Dynamical response in absorbance when the sensitive region is immersed in different pH buffer solutions.

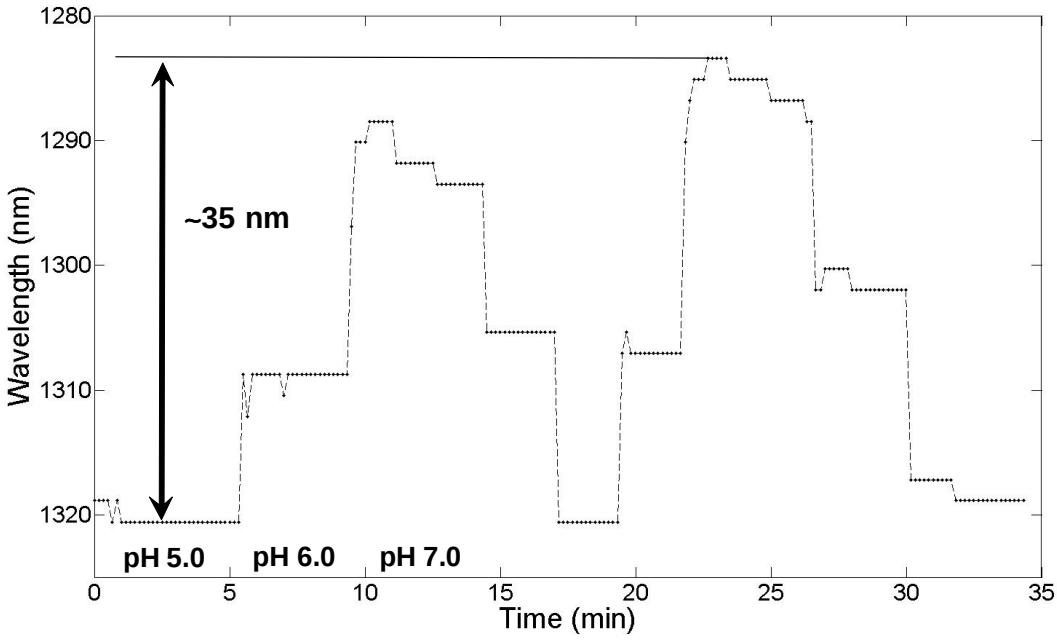

Figure 4. Variation of the wavelength at maximum absorbance when the sensor is immersed in different pH buffer solutions.