Agarose optical fiber humidity sensor based on surface plasmon resonance in the infra-red region

M. Hernáez, C. R. Zamarreño, I. R. Matías, F. J. Arregui
Sensor Research Laboratory, Electrical and Electronic Engineering Department, Public University of Navarra (UPNA), Campus de Arrosadía, Pamplona, SPAIN.
miguel.hernaez@unavarra.es

Here, it is presented a novel optical fiber humidity sensor based on surface plasmon resonance (SPR) spectroscopy in the infra-red region. Most of SPR optical fiber sensors proposed in previous works have been based in the utilization of noble metals, e.g. gold or silver, to create the SPR supporting layer [1-2], which limited the detection range to the visible spectrum. In this work, a 200 µm optical fiber is coated with an indium tin oxide (ITO) layer in order to achieve SPR recognition in the infra-red region [3]. Then, ITO-coated fibers are used as substrates to deposit a hydrogel (agarose) whose thickness and refractive index variations are related to the external relative humidity (RH) changes [4]. These refractive index variations shift the SPR maximum absorption peak to higher wavelengths when RH rises and to lower wavelengths when RH falls.

The sensors fabrication involves the deposition of two different layers. Firstly, 200 µm optical fiber claddings and jackets were removed and an ITO coating was deposited over the optical fiber core using a sol-gel dip-coating method, as described by Ota et al. [5]. Then, the ITO-coated fibers were perpendicularly cleaved to obtain 7 cm pieces. Both sides of these fragments were spliced to 200 µm optical fiber pigtails. Finally, an agarose layer was created over the SPR supporting device using the boiling water bath method proposed by Arregui et al [4]. In Figure 1 are shown the different materials used in this work, all of them supplied by Sigma Aldrich.

The fabricated sensors were examined using the experimental setup shown in Figure 2, where the sensor structure is also schematically represented. In order to characterize the sensor to RH variations in the range from 20 to 80% it was placed into a climatic chamber (Angelantoni Inc.) meanwhile a spectrometer connected to a PC collected the spectra obtained at the end of the fiber. The absorbance spectra and maximum absorption wavelength (line) are represented in Figure 3, showing the variations with the RH. These variations are also represented in Figure 4, where the maxima absorption wavelength variation and the real RH obtained from the climatic chamber electronic sensor can be directly compared. In figure 4, it is observed the correspondence between the variations in RH and the SPR wavelength with a fast response of the sensor to small variations in RH. The sensor shows a dynamic range of 45 nm in this RH range.

References:

[1] D. Monzón-Hernández, J. Villatoro, D. Talavera, D. Luna-Moreno, Applied Optics, **46(3)** (2004) 1216-1220
[2] R. Slavík, J. Homola, J. Ctyroky, Eduard Brynda, Sens. & Actuators B, 74 (2001) 106-111.
[3] M Y. Xu et al, QELS Conference, San Jose California 4 May (2008)
[4] F. J. Arregui, Z. Ciaurriz, M. Oneca, I. R. Matías, Sens. & Actuators B, **96** (2003), 165-172.
[5] R. Ota et al., Thin Solid Films, **411** (2002) 42-45.

Figures:

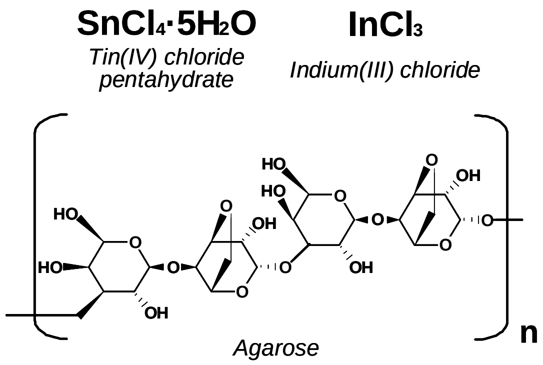

Figure 1. Molecules involved in the sensor fabrication process.

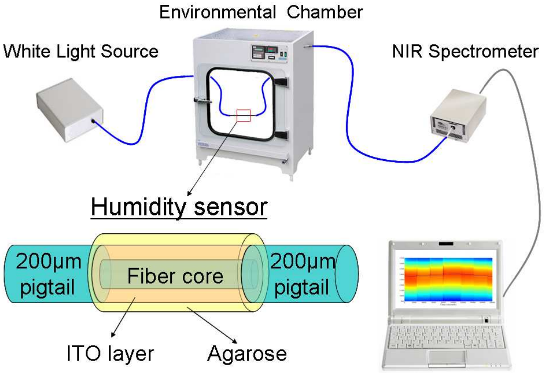

Figure 2. Experimental setup

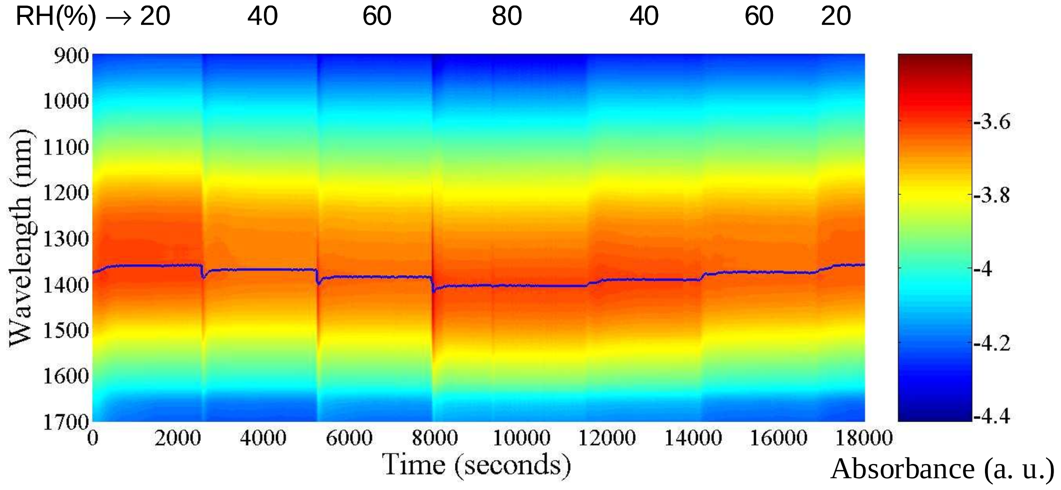

Figure 3. Spectral response and maxima absorption wavelength variations (line) at different RH values.

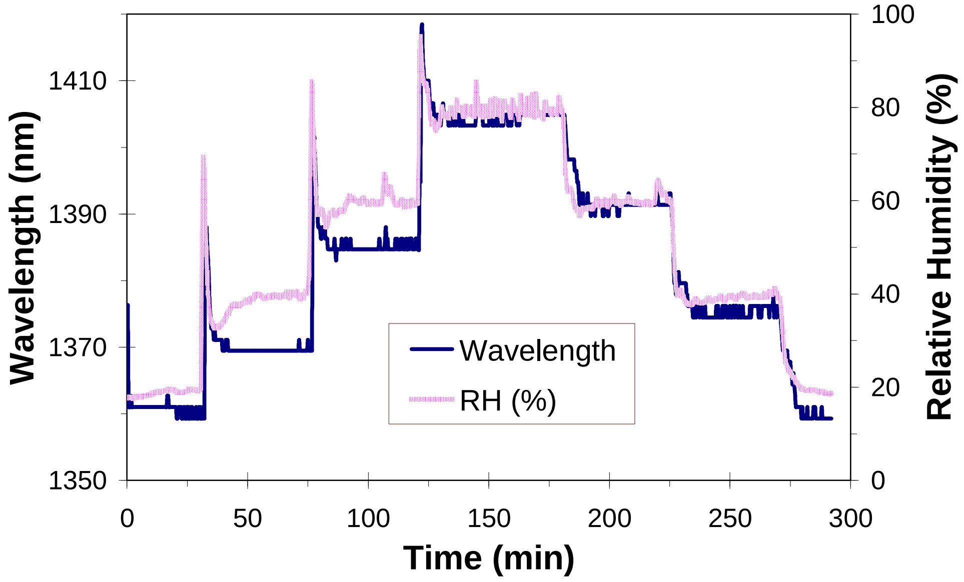

Figure 4. Wavelength variation at maximum absorbance when the sensor is subjected to RH changes.