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Experimental Characterization of a Fiber Based SPR Sensor in Terms of Stability and Limit of Detection

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Abstract: A multi-mode fiber surface plasmon resonance sensor to be used as refractometer for aqueous media is experimentally characterized. The sensor exhibits a standard deviation in the order 4×10^{-6} RIU for short term and a trend non bigger than $2 \times 10{-}6$ RIU per minute.

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The excitation of surface plasma waves (the so-called Surface Plasmon Resonance, SPR) is the elective approach exploited to detect changes in the concentration of liquid analytes, such as acqueous media. Particularly interesting for widespread long-term monitoring applications is the fiber-based configuration because of the portability and the low cost design, especially when multi-mode fibers are used to reduce the requirments of the optical source and of the connector tolerances. However, such fiber SPR sensors present some drawbacks in terms of stability and limit of detection [1]. The paper describes the fabrication of multi-mode fiber SPR sensors and presents its stability characterization results. The sensor is made with a MM (multi-mode) fiber 400 μm in core diameter, on the surface of which it is deposited 20 nm Titanium (Ti) adhesion layer followed by a 40 nm of Gold (Au) layer. A photo illustration of the sensor is shown in Fig. 1.

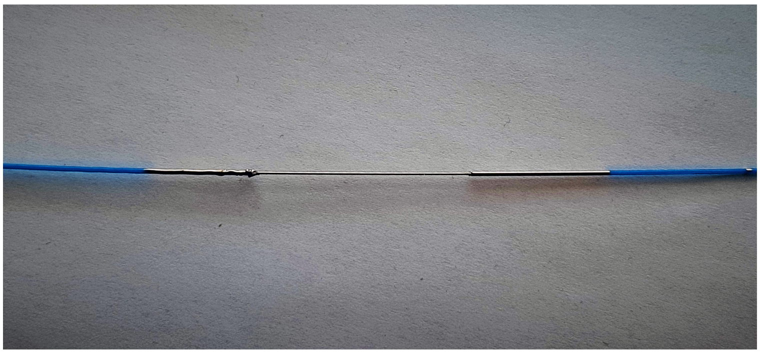

Fig. 1. Photo of the optical fiber based sensor with the sensitive part exposed to air. Length of the sensitive section is approxiamtely 2 cm.

The SPR occurs exactly on the interface of the Au layer with the external medium (water). The sensor has a sesnsitivity of 2500 nm/RIU for refractive indices close to 1.33 [2]. The characterization setup consists of a broadband white LED in the range 470-850 nm driven in constant current regime and coupled directly to the MM fiber. On the other side of the fiber the light is received and monitored via an Avantes (AvaSpec-3648) spectro-meter. Firstly, a reference spectrum is saved while the sensitive part is exposed to air, and later the sensor is submerged in a container full of distilled water. The ratio of the spectrum obtained while the sensor is immersed in liquid over the reference spectrum, shows what is considered to be the SPR spectrum (Eq.1), the dip of which shifts responding to changes in the refractive index of the medium.

$$S_{spr} = \frac{S_{water} - S_{dark}}{S_{air} - S_{dark}} \cdot 100\% \tag{1}$$

S_{dark} is the spectrum stored while the source is off. A spectrum is saved every 6 seconds and the experiment lasted for 96 hours. Each saved spectrum is imported to Matlab and is fitted with a second degree polynomial very close to the dip peak considering more data points than the spectrometer's resolution, in order to extract the

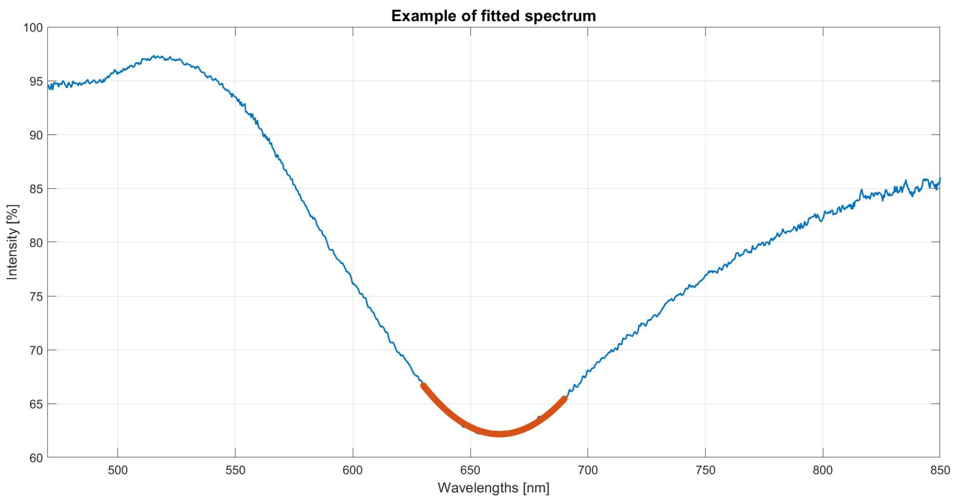

Fig. 2. SPR spectrum and its 2nd degree polynomial fit close to the dip of the curve.

wavelength of the dip rejecting the noise contributions. An example of a stored spectrum and its respective fit is shown in Fig. 2. The wavelength corresponding to the minimun of the fitted curves is extracted and plotted in Fig. 3 with respect to time (blue curve). In the same graph it is plotted the low-pass filtered data (red curve) in order to distinguish the long term trend from the short term fast oscillations.

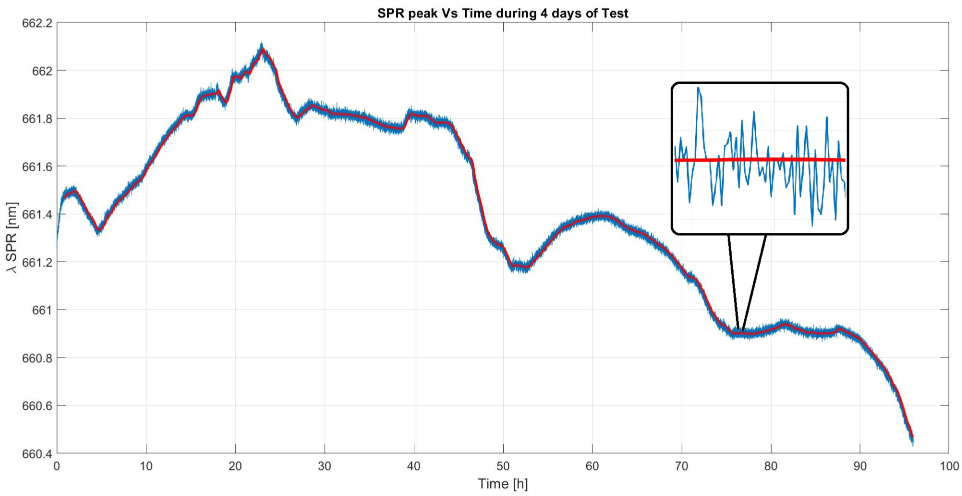

Fig. 3. SPR peak wavelengths with respect to time (blue). Low-pass filtered curve. (red)

The sensor performs with a short term noise contribution (standard deviation) of 10 pm which corresponds to a RI of 4×10^{-6}. In the long term the sensor performs with maximum trend of 5 pm per minute wich corresponds to 2×10^{-6} in terms of RI.

References

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