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SPR fiber tip sensor for the simultaneous measurement of refractive index, temperature, and level of a liquid

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Abstract

We proposed and demonstrated a novel, compact and simple-to-construct optical fiber tip sensor capable of simultaneously measuring of the refractive index (RI), temperature (T) and level (L) of liquid samples by means of the Surface Plasmon Resonance (SPR) phenomenon.

1.- Introduction

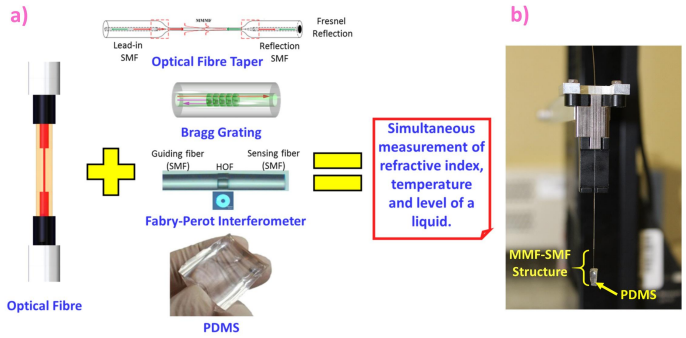

Fig. 1. Multiparameter Sensors: **a)** A single fiber sensor can become a multiparameter sensor by adding an extra fiber device [1-5], **b)** Dual-channel SPR based on a hetero-core fiber in reflection.

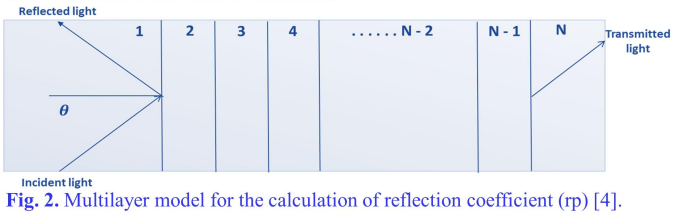

Fig. 2. Multilayer model for the calculation of reflection coefficient (rp) [4].

Transmitted power $$P = \frac{\int_{\theta_c}^{\frac{\pi}{2}} R_p^{N_{ref}(\theta)} \left(\frac{n_1^2 \sin\theta \cos\theta}{(1 - n_1^2 \cos^2\theta)^2} \right) d\theta}{\int_{\theta_c}^{\frac{\pi}{2}} \left(\frac{n_1^2 \sin\theta \cos\theta}{(1 - n_1^2 \cos^2\vartheta)^2} \right) d\theta}$$

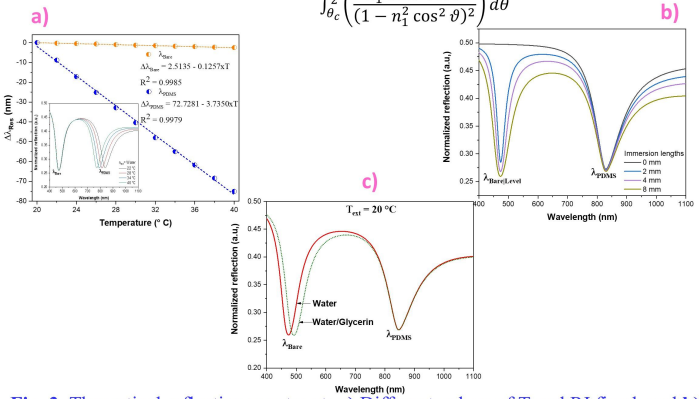

Fig. 3. Theoretical reflection spectra at: **a)** Different values of T and RI fixed, and **b)** Different immersion lengths at RI and T fixed, **c)**.Different values of RI and T fixed.

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[4] Sharma, A.K., and Gupta, B.D., Nanotechnology, 2006, 17, (1), pp. 124-131.
[5] J.S. Velázquez-González, D. Monzón-Hernández, F. Martínez-Piñón, D.A. May-Arrioja, I. Hernández-Romano, IEEE J Sel Top Quantum Electron (2017) 23 (2).

2.- Fabrication Process and Experimental Setup

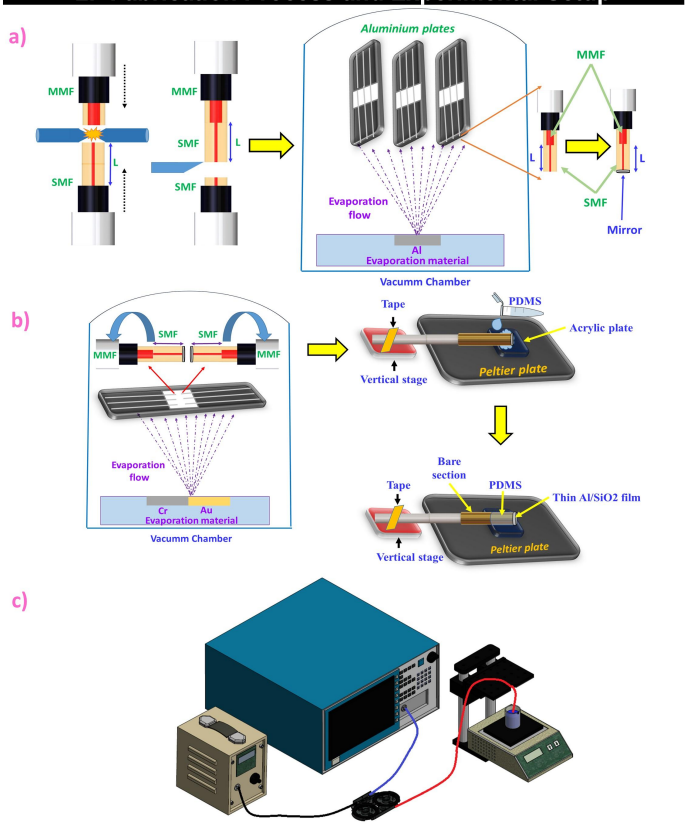

Fig. 4. Fabrication process: **a)** MMF-SMF-MMF structure and mirror deposition, **b)** Metal layer deposition, and PDMS coating, and **c)** experimental setup.

3.- Experimental Results

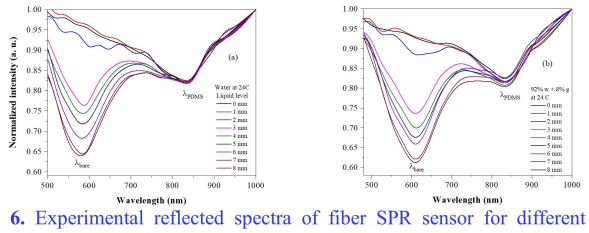

Fig. 6. Experimental reflected spectra of fiber SPR sensor for different fiber immersion lengths in (a) water and (b) water/glycerol solution at 24 °C.

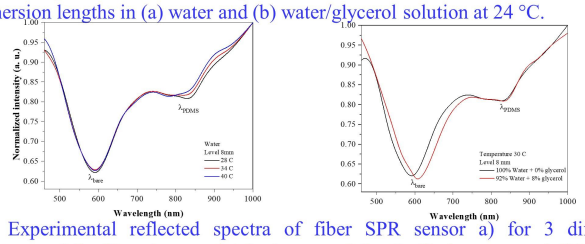

Fig. 7. Experimental reflected spectra of fiber SPR sensor a) for 3 different temperatures while fiber is completely immersed in distilled water, and (b) for 2 different RI, while the temperature was kept constant.

Conclusions

A novel, compact and simple-to-construct optical fiber tip sensor for simultaneous measurement of RI, T and L of liquid samples was proposed and experimentally demonstrated. Changes in the RI and L of the liquid affect the position and the deepness of the metal-bare dip, while the T variations affects RI of liquid and PDMS, the position of both dips are dependent of T (metal-bare and metal-bare embedded in a polymer). Although the polymer was in contact with the liquid sample, the polymer resonance dip was independent on the changes of the sample RI and L. This device could be easily integrated in a microfluidic chip for biological applications.

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