Integration of Curved D-Type Optical Fiber Sensor with Microfluidic Chip

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Abstract:

A curved D-type optical fiber sensor (OFS) combined with a microfluidic chip is proposed. This OFS, based on surface plasmon resonance (SPR) , is applied as a biosensor. This microfluidic chip-integrated OFS could be valuable for monitoring subtle changes in biological samples such as blood sugar, allergen, and biomolecular interactions.

Methods:

SPR Theory:

As shown in Figure 1a, the core of a D-type OFS is side-polished and coated with a thin gold film to achieve the SPR phenomenon. Figure 1b shows the three-layered Kretchmann's configuration, where an evanescent wave propagates along the metal-dielectric interface. This evanescent wave can interact with the plasma waves on the surface, excite the plasmons, and then cause resonance.

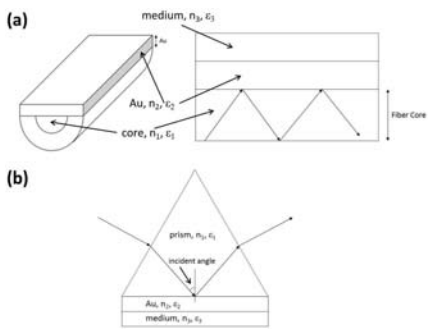

Figure1.The schemes of (a) the optical fiber sensor and (b) the Kretchmann's configuration.

Experimental processes:

(1).Fabrication
(2).Side-polishing the fiber core
(3).Gold film sputtering
(4).Measurement setup of OFS

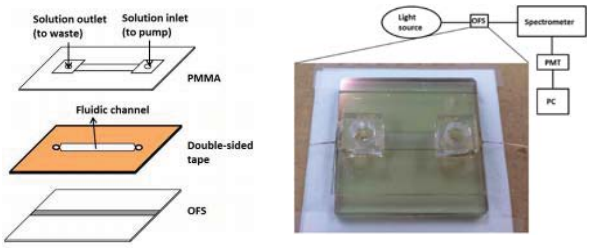

Figure 2 (left) The design of the microfluidic chip composed of PMMA and OFS(right) The experimental setup

Results:

The SPR Spectra:

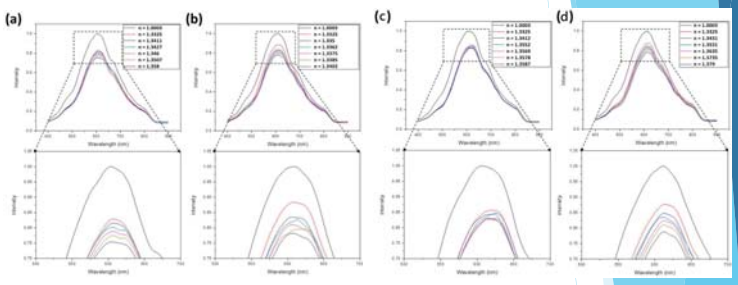

Figure 3 the normalized SPR spectra of (a)ethanol,(b) methanol,(c) ethanol-methanol and(d) glucose solutions with different refractive indices, which were measured by the Abbe refractometer. The enlarged figure indicates these peak values decreased with increasing refractive index

The Sensitivity:

The sensitivity S (in RIU) of the OFS can be defined as

$$S = \frac{\Delta T}{\left(\frac{\Delta A/N}{\Delta n}\right)}$$

ΔT is the resolution in the intensity of the light source
N is the normalization factor ΔA/Δn is the slope of the maximum intensity to the refractive index

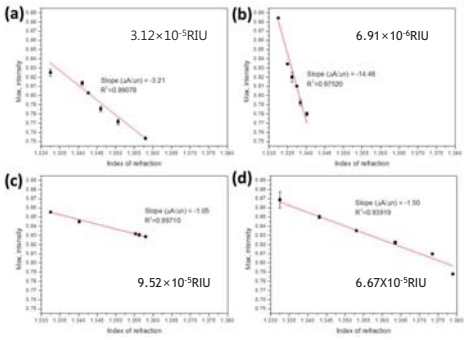

Figure 4 The maximum intensities as a function of the refractive index for (a) ethanol solutions; (b)methanol solutions; (c) ethanol-methanol solutions; and (d) glucose solutions. In each panel, the slope ΔA/Δn was derived by linearly fitting all points

Conclusions:

This OFS was used as a biosensor to measure the refractive indices of different bio-liquids. Its sensitivity was around 10^{-5}RIU. By advantages of this microfluidic chip-integrated OFS, e.g., small size, low cost, flexibility, easy fabrication, this device could have great applications as a biosensor for monitoring subtle changes in biological samples such as blood sugar, allergen, and biomolecular interactions.

References:

1.Hsu, J.C.; Jeng, S.W.; Sun, Y.S. Simulation and experiments for optimizing the sensitivity of curved D-type optical fiber sensor with a wide dynamic range. Opt. Commun. 2015, 341, 210–217.
2.Pilolli, R.; Visconti, A.; Monaci, L. Rapid and label-free detection of egg allergen traces in wines by surface plasmon resonance biosensor. Anal. Bioanal. Chem. 2015, 407, 3787–3797.