Refractive Index Sensor based on Multilayered Au-SiO_2-Al Structure

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1. Introduction

The phenomenon of surface plasmon resonance (SPR) is used for detection of biomolecules, medical diagnostics and gas analysis [1]. SPR is an optical phenomenon in which TM polarized light beam excites the surface plasmon polaritons (SPP) at metal-dielectric interface. These polaritons could be excited by grating coupling. Generally, gold (Au), aluminum (Al), and silver (Ag) are used as SPR active material. For a good sensor, very narrow SPR reflection spectrum is required. Al grating offers narrower SPR spectrum but it is chemically less stable. While Au grating is chemically more stable but does not provide narrow SPR spectrum.

In this paper, we present a multilayered Au-SiO_2-Al structure to obtain better SPR response and chemical stability. Using proposed 'Au-SiO_2-Al' based structure, we could reduce the FWHM from 1.675° to 0.96° and hence could improve the resolution of the sensor.

2. Sensor Design and Simulations

We have analyzed the sensing performance of three different structures. Schematics of these structures are shown in Fig.1 (a-c). We have numerically simulated the specular reflection of the structures using rigorous coupled wave analysis (RCWA) [2] for grating period Λ = 350 nm, grating depth d = 10 nm at fixed incident wavelength λ = 900 nm. Specular reflections of various structures are shown in Fig. 1 (d). Structure - I (Fig. 1(a)) is a conventional sensor and consists of a grating engraved in gold film. From Fig. 1 (d), we observed that FWHM of the reflection curve of Structure - I is about 1.675°. To reduce the FWHM, we propose a bimetallic structure namely Structure - II as shown in Fig. 1 (b). In this sensor, Au grating is fabricated over Al film.

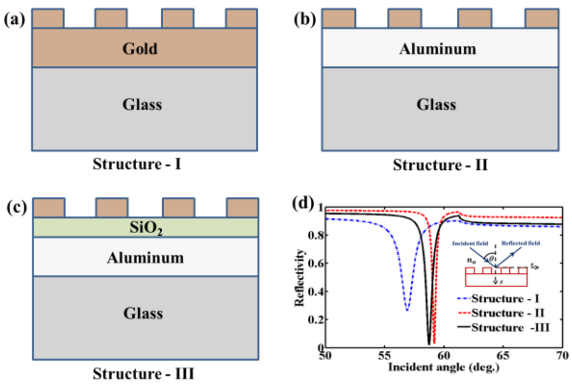

Fig. 1. Schematics of grating structure (a) I, (b) II, (c) III and (d) their specular reflection

Al undergoes oxidation if exposed to air and it may affect the performance of the sensor. To overcome this problem, we finally come up with a new configuration Structure - III that consists of an SiO_2 layer sandwiched between Au grating and Al film as shown in Fig. 1. (c). The resonance angle, at which dip occurs in the reflection curves, changes with refractive index of the analyte (n_a). Variation of resonance angle with n_a for three different structures is shown in Fig. 2 (a).

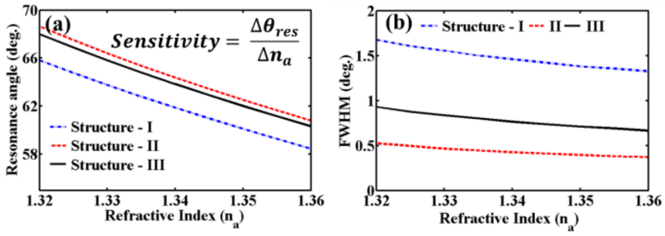

Fig. 2. Variation of (a) resonance angle and (b) FWHM with refractive index of analyte (n_a) for three different structures.

Here we observe that sensitivity (= $\Delta\theta_{res}/\Delta n_a$) of a conventional gold grating based sensor is 184°/RIU. To enhance the sensitivity we can use bimetallic structure. Structure - II offers the sensitivity of 196.5°/RIU. We noticed that use of Al underneath gold grating enhances the sensitivity. However, oxidation is always a problem with Al and to prevent this, we introduce SiO_2 layer between Au grating and Al film. Sensitivity of proposed Structure - III is obtain to be 191.9°/RIU.

In addition to high sensitivity, smaller FWHM is required for a good sensor. We have also plotted the variation of FWHM with n_a and shown in Fig. 2 (b) for all structures. Our numerical study shows that the FWHM for proposed Structure - III is better than that of conventional Structure - I.

3. Conclusions

We have analyzed the performance of gold grating based SPR sensor. We showed that introducing Al film underneath Au grating could reduce the FWHM. To prevent the oxidation of Al, we have proposed Au-SiO_2-Al based multilayered structure. Our proposed structure reduces the FWHM by 44%.

References

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