Numerical study on plasmonic sensor based on double-side metal-coated dielectric nanoslit array

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1. Introduction

Surface plasmon resonance (SPR) has been widely used in sensors because of its high sensitivity to refractive index change of the surrounding materials. Recently, much attention has been placed on metallic nanoslit array sensors by using various mechanisms such as Fano-resonance and extraordinary optical transmission because they allow SPR at normal incidence which can be used for miniaturization of plasmonic sensors [1]. The sensing performance of nanoslit-array-based SPR sensors are often quantified by the sensitivity (S) and the figure of merit (FOM). These parameters are highly dependent on the dielectric constant of slab material ($\varepsilon_m = \varepsilon_r + i\varepsilon_i$). When $|\varepsilon_r|$ and $|\varepsilon_i|$ decrease, sensitivity and FOM increase respectively [2]. Such reduction of effective dielectric constant of the slab can be achieved by replacing the conventional metal nanoslit array into the proposed double-side metal-coated dielectric nanoslit array.

2. Sensitivity characteristics of the proposed structure

Figure 1(a) shows the schematic of the proposed structure, which consists of silicon dioxide (SiO_2) nanoslit array coated by thin gold (Au) layers. The period of array is set to 900 nm which determines the resonance wavelength. The background medium is assumed to water (n = 1.333) and the TM-polarized light is normally incident. The transmission spectrum is calculated by finite element method as shown in Fig. 1(b).

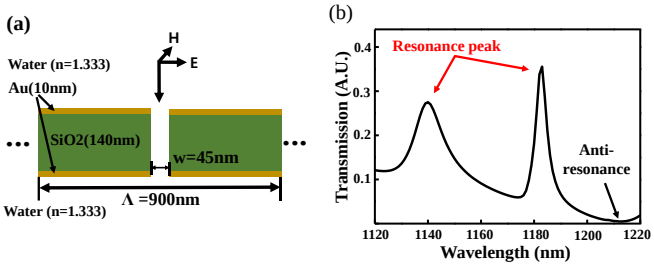

Fig. 1. (a) The schematic of the proposed structure and (b) its transmission spectrum.

The nanoslit array has anti-resonance peak at λ = 1214 nm resulting from Fano-resonance and resonance peaks at λ = 1140 nm and λ = 1183 nm adjacent to anti-resonance wavelength. As the position of the resonance peak is closer to the anti-resonance wavelength, the width of resonance peak becomes narrower. Next, we calculate the transmission by varying refractive index of background medium from 1.333 to 1.423. The shift of transmission peak is shown in Fig. 2(a). Also, the full width half maximum (FWHM) of resonance peak is shown in Fig. 2(b) when the surrounding medium is water.

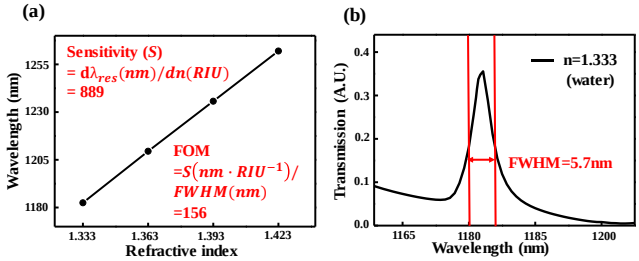

Fig. 2. (a) The wavelength of resonance peak as a function of refractive index of background medium. (b) Full width half maximum (FWHM) of the resonance peak.

As the refractive index of background medium changes, the wavelength of resonance peak shifts from 1182 nm to 1262 nm, thereby the sensitivity and FOM of the structure are 889 nm/RIU and 156 respectively. The obtained values are higher than those of the previously reported gold nanoslit array (S = 726 nm/RIU, FOM = 19) [3].

3. Conclusions

In this research, we proposed a refractive index sensor based on double-side metal-coated dielectric nanoslit array. The structure shows extremely sharp resonance peak adjacent to anti-resonance peak and the FOM is 156. Also, we can obtain ultra-high sensitivity of 889 nm/RIU over wavelength ranging from 1182 nm to 1262 nm.

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References

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