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Sharp resonances in waveguide-coupled surface plasmon sensors for super-resolution sensing

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1. Introduction

In conventional surface plasmon resonance (SPR) sensors, an Au single layer is commonly used, but the resolution is limited by the broad SPR for the Au layer. Attempts to get sharper resonances have been made using various structures including long range SPRs [1] and waveguide-coupled SPRs [2]. In waveguide-coupled SPR sensors, the waveguide structure is integrated in the SPR sensor. Sharp resonances have been achieved for both the p- and s-polarized incident light upon excitation of waveguide modes (WGM). However, coupling between SPP and WGM has not been achieved in the sensor structures proposed so far.

In this work, we propose a planar structure of waveguide-coupled SPR sensor that allows the coupling between SPP and WGM. Results of numerical calculations clearly exhibit sharp Fano- and EIT-type resonances. Our results also demonstrate that the sensor sensitivity can be enhanced by more than two orders of magnitudes compared to that of conventional SPR sensors.

2. Simulation Results and Discussion

The structure used for present simulations are schematically shown in Fig.1. This is a Kretchmann configuration consisting of a prism, metal film, and three dielectric layers. The metal-dielectric 1 interface supports SPP and the dielectric 2 supports WGM. Coupling between SPP and WGM can be achieved when the optical constants of the materials and the thicknesses of the layers are properly chosen.

Figure 2 shows typical results of reflectivity calculations based on a 2×2 transfer matrix method. The structure consisting of a SF11 prism, 50nm-thick Au film, 700 nm-thick Cytop film, 1400 nm-thick PMMA film and water was assumed. p- or s-polarized light with a wavelength of 632.8 nm was assumed to be incident on the structure. Figure 2 shows very sharp resonance features appearing for both the p- and s-polarization in addition to a broad reflection dip. The resonances for the p-polarization are due to the excitation of hybrid modes of SPP and WGM. Furthermore, the sharp resonances exhibit Fano-type line shapes. The resonances for the s-polarization are due to the excitation of WGM. The modification of the resonances caused by a change in the refractive index of water provides a sensor output. A rough estimate indicates that the sharp resonances lead to the enhancement in sensitivity by more than two orders of magnitude compared to conventional SPR sensors.

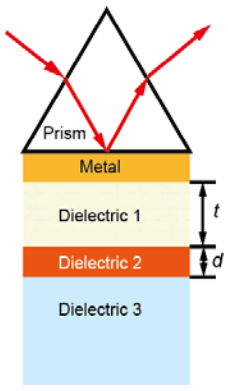

Fig.1　Structure proposed.

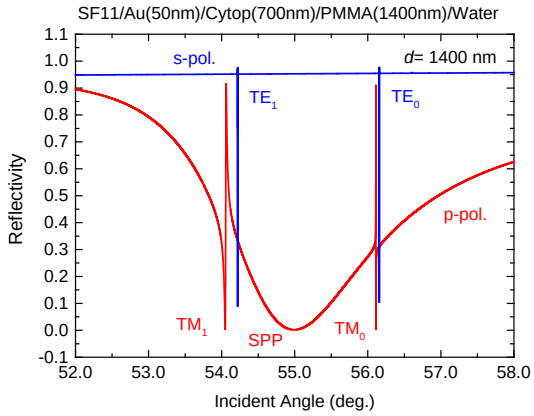

Fig.2　Reflectivity curves for p- and s-polarized incident light.

3. Conclusions

A planar multilayer structure that allows coupling between SPP and WGM is proposed. Results of reflectivity calculation exhibit very sharp resonances for both the p- and s-polarized incident light. The sharp resonances may find potential applications in super-resolution sensing.

References

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