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Tunable Fano resonance in two-layer gold nanoslit array and its application for highly sensitive biosensors

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Abstract

Nanostructure-based sensors are capable of sensitive and label-free detection for biomedical applications. However, plasmonic sensors capable of highly sensitive detection with high-throughput and low-cost fabrication techniques are desirable. We utilized the thermal-embossing template-stripping method to fabricate large-area two-layered gold nanoslits on polymer films with low cost and ultrahigh SPR sensitivities. We found that a transverse magnetic-polarized wave in the nanoslits generated extremely sharp and asymmetric Fano resonances in transmission spectra. The full width at half-maximum bandwidth (FWHM) was only 3.88 nm (0.0063 eV) and the wavelength sensitivity was 644 nm/RIU (1.018 eV/RIU) for 650-nm-period nanoslits. In addition, the extremely sharp resonance leads to an ultrahigh intensity sensitivity up to 48117 %/RIU. Compared to previous single-layer SPR sensors, the proposed structure has a much narrower bandwidth as seen in Fig. 1(a) and Fig. 1(b). The figure of merit (FOM) of Fano mode reaches up to 166 (FOME=162). We attribute such high sensitivity to enhanced resonant effects by the second gold layer. It caps the gap plasmon in nanoslits, resulting an enhanced cavity mode. In addition, the outside surface plasmon wave between nanoslits is better confined, resulting an enhanced SPR mode. The strength of Fano coupling between both modes can be tuned by the thickness of gold film and slit width as seen in Fig. 1(c). The optimal Fano coupling is achieved when the gold layer thickness is close to the height of nanoslits. A protein-protein interaction experiment based on the interactions between bovine serum albumin (BSA) and anti-BSA were measured using two-layer gold nanoslits with a 600 nm period. Fig. 1(d) shows the normalized intensity change of as a function of the interaction time for protein-protein interactions. The measured intensity signal is at a wavelength of 810 nm. It is stable with time when the PBS buffer is injected into the microfluidic device. The BSA coated on the gold surface resulted in an intensity change of 13%. For the Anti-BSA, the 375 μg/mL concentration caused an intensity change up to 237%. Using the intensity measurement, the signal-to-noise ratio for Anti-BSA molecules is up to 1185 when the intensity stability is 0.2%.

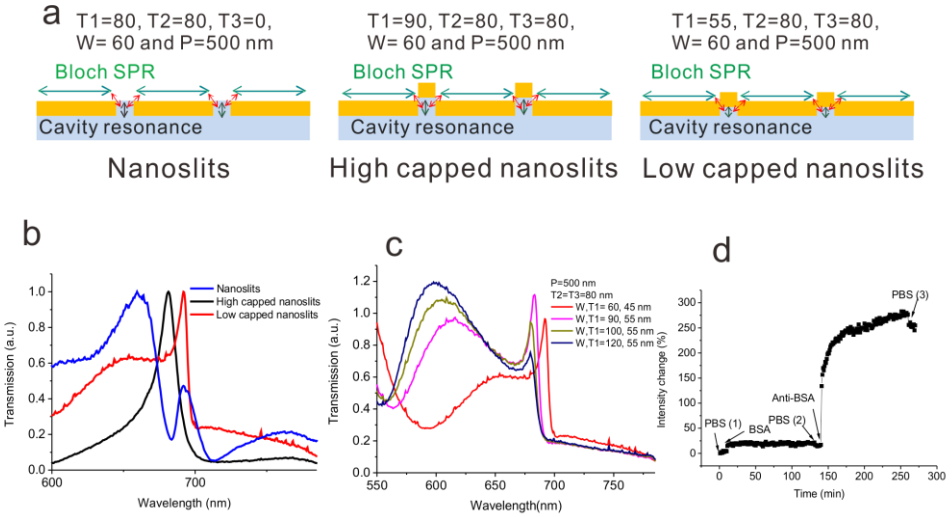

Figure 1. Schematic configuration and geometrical parameters of the single-layer and two-layer gold nanoslits, (b) The normalized transmission spectra of 500-nm-period gold nanostructures with different structure parameters in water, (c) Fano resonant modes for different slit widths, (d) the real-time measurement of antigen-antibody interactions using Fano resonant mode.

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References

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