Out-of-Plane Optical Interactions of Nanohole Trimers Milled in Stacked Gold Films

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Abstract- Optical interactions of symmetric nanohole trimers milled in stacked gold films are investigated. A dispersive finite-difference time-domain (D-FDTD) model is used to study the presented system through numerical simulations. The normalized scattering spectrum of the presented structure demonstrates two distinct resonant peaks. The scattering spectrum of the stacked structure is compared with the scattering spectrum of a symmetric nanohole trimer. It can be seen that for the stacked trimers the resonant peaks are blue shifted in comparison to a nanohole trimer milled in a single metallic film.

It has been shown theoretically and numerically [1], through the normalized electric and magnetic power amplitudes, and also experimentally [2], using SNOM measurements, that the output radiated power from a nanohole milled in a metallic film is dominated by magnetic power. Thus, each nanohole can be considered as a radiating magnetic dipole [3]. In other words, the nanoholes may radiate through surface plasmon polaritons (SPPs) at the dielectric-metal interface [4]. However, nanoholes may have in-plane or out-of-plane near-field interactions [5], which affect the scattering spectrum of the structure. Figure 1(a), and 1(b) demonstrate the schematic representation of the structure and scattering spectrum for symmetric nanoholes milled in a single (solid-line) and two stacked (dashed-line) gold films, achieved from D-FDTD numerical simulations, respectively. It is clear that two distinct resonant peaks are obvious according to Fig. 1(b). In addition, Figures 1(c), and 1(d) show the phase variations of the magnetic field component (i.e. $\angle H_y$) for the layered nanoholes at the first (short-wavelength), and second (long-wavelength) resonant peaks which correspond to $\lambda = 600$ nm, and $\lambda = 817$ nm, respectively. According to Figs. 1(c), and 1(d), it can be seen that at $\lambda = 600$ nm the out-of-plane nanoholes may interact out-of-phase (antibonding mode) and at $\lambda = 817$ nm the nanoholes can interact in-phase (bonding mode).

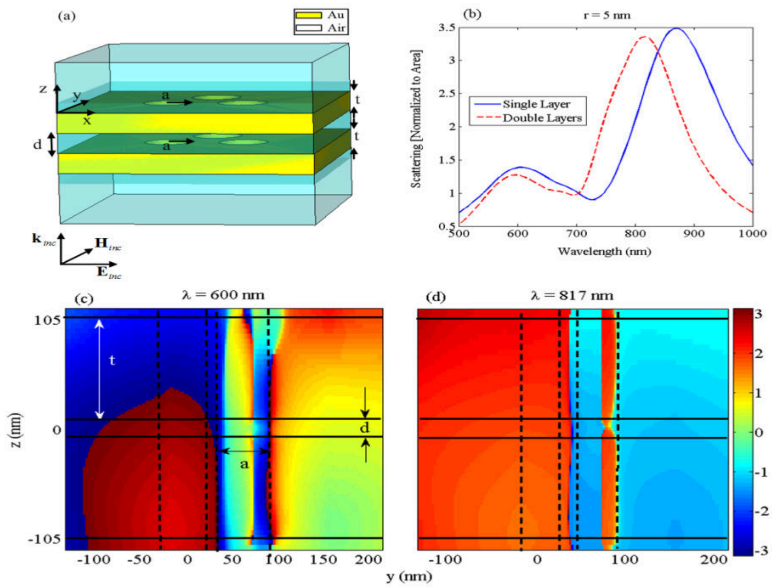

Figure 1 (a). The schematic representation of the stacked symmetric nanohole trimers. **(b)** The normalized scattering spectrum for the nanohole trimers milled in a single (solid-line), and double stacked (dashed-line) layers of gold film obtained by simulations. (c), and (d) phase variations of $\angle H_y$ component at $\lambda = 600$ nm, and $\lambda = 817$ nm, respectively.

Acknowledgements, Dr. Mohsen Janipour acknowledges the support of TUBITAK under the 2216- Research Fellowship Program.

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