Western Nanofabrication Facility

Western Science

Improved nano-hole array structure in an opaque metal film for bulk-SPR sensing application

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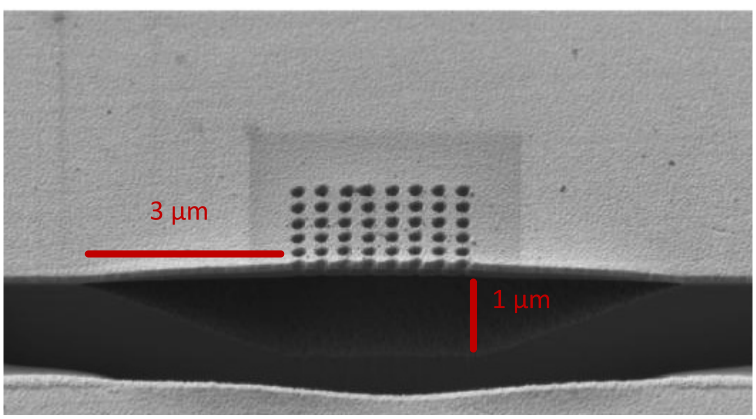
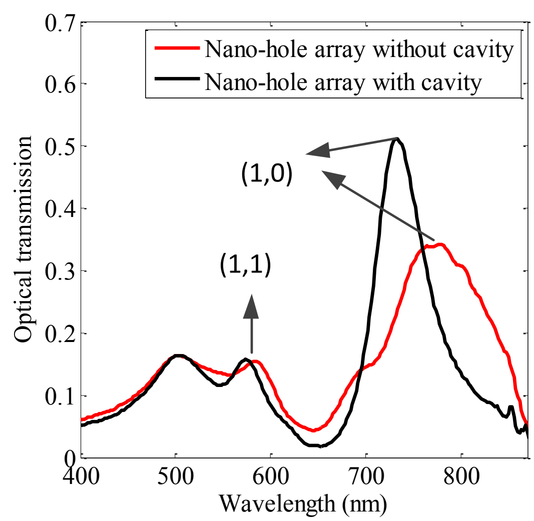
Sub-wavelength optics or photonics represents the interaction of light and matter at dimensions smaller than the wavelength of light. For example, an array of periodic sub-wavelength holes perforated in a metal film has demonstrated a unique optical property, the so-called extraordinary optical transmission (EOT) [1] [2]. The occurrence of unexpected optical properties of a sub-wavelength hole array structure in a metal film is associated with the interaction of light with Surface Plasmons (SP)s, where an oscillation of free electrons occurs at the interface between the metal and dielectric. The unique optical properties of metallic sub-wavelength hole structures have opened up new possibilities for creating and enhancing many photonic applications such as surface enhanced Raman spectroscopy (SERS) and surface plasmon resonance (SPR) sensing [3] [4].

In this context, our main objective is to fabricate a metallic nano-hole array (NHA) with a large cavity beneath its structure, which facilitates a dynamic SP energy matching between the top and bottom surfaces of the NHA structure and results in enhanced EOT properties of the NHA in SPR sensing applications. First, a NHA in a 100 nm gold film on Pyrex substrate was fabricated using electron beam lithography. Then, in order to create a cavity underneath the NHA structure, an isotropic wet-etching process was employed using a titanium etchant (TFT, Transene company, Inc.) to remove the titanium adhesion layers as well as isotropically etch the Pyrex substrate underneath the NHA. The NHA was exposed to the etchant for 4 minutes, resulting in a large cavity beneath NHA structure. An SEM image of the tilted sample (54°) with cross sectional visualization obtained after FIB cutting through the NHA structure is shown in Figure 1a. The image reveals a 1 µm deep cavity as well as a undercutting beneath the gold. The undercut region beyond the area of the NHA was on average 3 µm. We performed all the fabrication processes, FIB cutting and SEM imaging in the Western Nanofabrication facility.

The Figure 1b demonstrates optical transmission for the NHA without and with large a cavity. The (1, 0) resonance transmission and bandwidth was 1.5 times greater and 40 % narrower for the NHA with a cavity compared to the one lacking the cavity.



(a)



(b)

Figure 1. (a) SEM image of a NHA revealing the large cavity (FIB cutting performed in order to observe a large cavity beneath NHA). (b) Optical transmission spectra for NHA without and with a large cavity when a liquid of 1.39 refractive index were applied to the top surface.

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[4] D. Sinton, R. Gordon, and A. G. Brolo, "Nanohole arrays in metal films as optofluidic elements: progress and potential," Microfluidics and Nanofluidics 4, 107 (2008).

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