The dispersion of localized surface plasmons in the gold-capped silicon nitride rods photonic crystal slab

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Photonic crystal slabs (PCSs) consisted of two dimensional dielectric rods array have been extensively studied. Most of the systems studied provide a vertical out-of-plane confinement, giving rise to a guided mode in the slab. The obvious feature of the rod-type PCS is the photonic band gap that is interpreted as frequency gaps forbidding the propagation of the electromagnetic waves. For the enhancement of the photonic band gap many studies have been carried out by coating various metallic films on the dielectric rods, in which a strong surface plasmon induced on the metallic claddings is the origin of physics involved. However, the details of the coupling between surface plasomons and the PCS itself are not clarified. In this letter, we demonstrate a gold-capped silicon nitride rods array and show a controllable coupling by modulating the rods height. The samples fabrication starts with a preparation of a free standing silicon nitride membrane with a total area of 40μm×40μm by using optical lithography in combination with a wet etching process. Gold nanodots array is then fabricated onto the membrane, in which the gold thickness is fixed to be 50 nm and the diameters are varied to be 200 nm, 300 nm and 400 nm, respectively. The fabrication is done by an electron beam lithography through a lift-off process. The gold film is thermally evaporated and a crystal monitor is used for thickness control. Furthermore, gold nanodots are used as an etching mask for the following RIE dry etching. As a result, gold-capped silicon nitride rods array is achieved, as shown in figure 1. The rods height is varied from 15 nm to 50 nm by controlling the RIE etching time. The optical transmission measurement was carried out with a normal incident halogen light source. Guided resonances of silicon nitride rods photonic crystal slabs have been observed as shown in figure 2(a). In figure 2(b), optical transmission shows constructive grating peaks through the gold nanodots array before etching into silicon nitride membrane, but reveals absorption dips after etching into silicon nitride membrane with the silicon nitride rods height of 15 nm and 50 nm, respectively. The data illustrate clearly that the existence of silicon nitride rods array provide guided modes for coupling to surface plasmons, leading to optical absorptions.

Reference:

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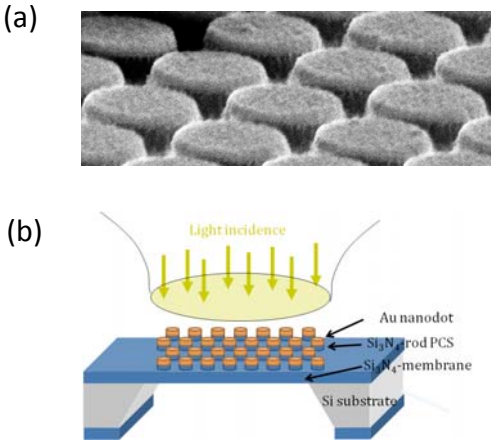

Figure 1. (a) SEM micrograph of gold-capped silicon nitride rods array. Notice that the hexagonal rods lattice constant is 552 nm, the diameter is 400 nm and the height is 50 nm. (b) Schematics of the optical measurement set up.

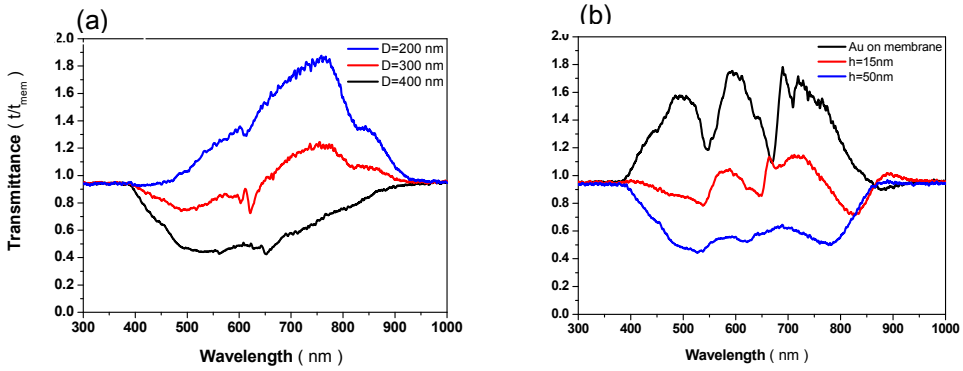

Figure 2. (a) Optical transmission spectra of gold-nanodots array with diameters of 200 nm, 300 nm and 400 nm, respectively. (b) Optical transmission spectra of gold-nanodots array sitting on SiN membrane and gold-capped silicon nitride rods array with the gold diameter of 200 nm under two rods heights of 15 nm and 50 nm, respectively.