Tunable Waveguide-Plasmon Coupling in Ag/SiN/Ag Photonic Crystal Slabs

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Over a decade ago, extraordinary optical transmission was observed on a perforated metallic film and the phenomenon has been attributed to surface-plasmon-resonance assisted transmission. This remarkable property has potential applications in photolithography, near-field microscopy, and photonic devices[1]. If the perforated metal film has symmetric interfaces, evanescent waves arisen from two surface plasmons will couple to each other resonantly, leading to an enhancement of optical transmission[2]. This surface plasmon resonance was also achieved in a dielectric space sandwiched between two metal films[3], which a waveguide coupling effect was accounted. However, the waveguide-plasmon coupling via guide resonances have not been clarified. In this report, we demonstrate the waveguide-plasmon coupling in the Ag/SiN/Ag photonic crystal slab and show a controllable coupling by modulating the lattice constant. A 100 nm-thick freestanding SiN-PCS was first fabricated by using a photolithography in combination with and RIE dry- and KOH wet-etching. A standard electron beam lithography and RIE etching technique were employed to fabricate a hexagonal air-hole array embedded in SiN membrane with the hole diameter $\boldsymbol{D}$ = 300 nm the lattice constant $\boldsymbol{a}$ = 552, 656 and 700 nm as shown in Fig. 1. The silver films were deposited on the both surfaces of the SiN-PCS with the thickness of 20 nm by using a thermal deposition. A halogen light source with wavelength ranging from 400 nm to 1000 nm was used for transmittance measurement. Figure 2 shows the transmittance spectra. Notice that guided mode resonances and Wood-Rayleigh's anomalies are present. Interestingly, a controllable waveguide-plasmon coupling by the modulation of the lattice constant is obtained. Details will be discussed.

1. W.-C. Tan, et al., Phys. Rev. B **59**, 12661 (1999).
2. S. A. Darmanyan and A. V. Zayats, Phys. Rev. B **67**, 035424 (2003).
3. R. -M. Bakker, et al., Opt. Express **12**, 3701 (2004).

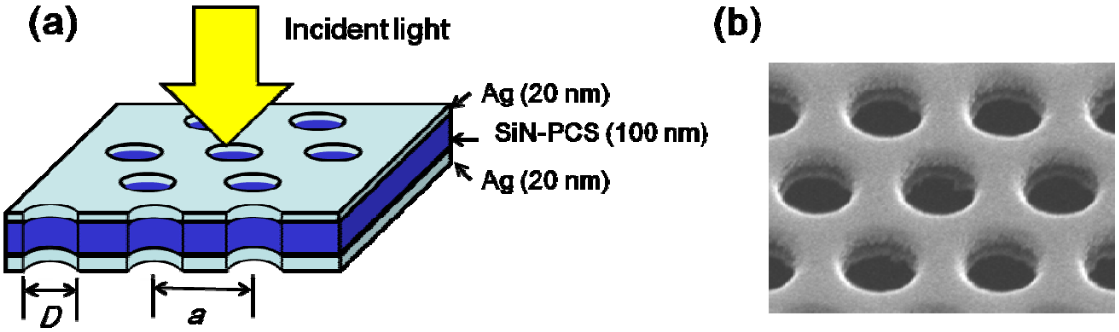

Figure 1. (a) Schematic view of the Ag/SiN/Ag PCS. Note that the holes are arranged in hexagonal configuration with diameter ***D*** = 300 nm and lattice constant ***a*** = 552 nm. (b) SEM micrograph of the PC, in which the silver films may be identified through the contrast of secondary electron image.

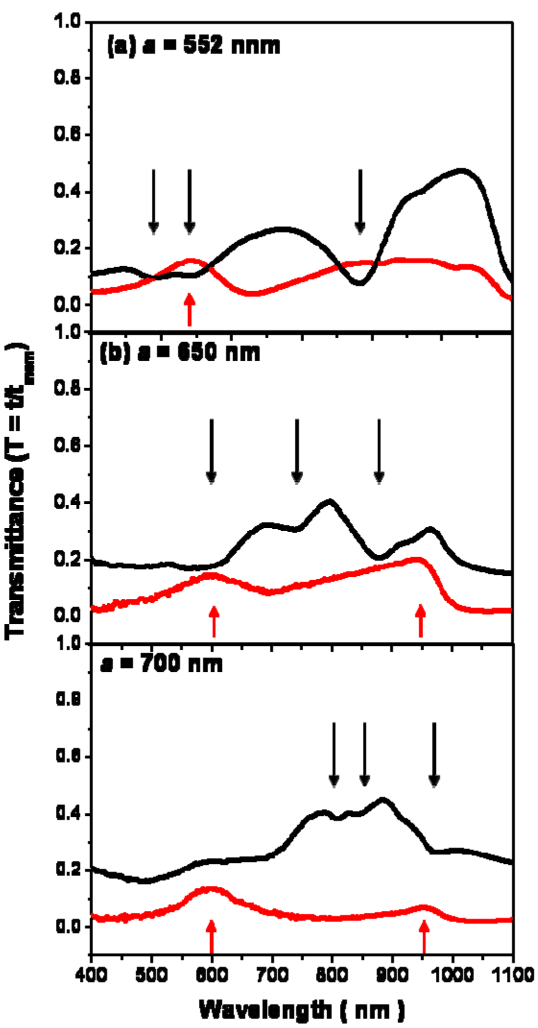

Figure 2. Transmittance spectra measured on PCSs with lattice constants *a* of 552 nm (a), 650 nm (b) and700 nm (c). Black curves are data measured from the Ag/SiN PCSs while the red curves are data measured from Ag/SiN/Ag PCSs. The Ag film was all deposited to be 20 nm thick. Note that the transmittance T is normalized to the transmission of a freestanding SiN membrane. Black arrows indicate guided resonances and red arrows indicate transmission peaks resulted in the waveguide-plasmon coupling of Ag/SiN/Ag PCSs.