Surface plasmon resonance coupling assisted optical transmission through Ag/SiN /Ag photonic crystal slabs

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Manipulation of light passing through subwavelength holes has already been achieved by introducing many appropriate nanostructures. For example, the transmission light is modulated through a dielectric membrane embedded with a periodic hole array, which is called as a photonic crystal slab (PCS).[1] Furthermore, extraordinary optical transmission of a metal film perforated with a dielectric holes array may be tuned by controlling geometrical parameters, such as the period of the holes array, shape of holes, film thickness, and so forth.[2, 3] These are attributed to surface plasmon resonances (SPRs) through critical boundary conditions. When two thin metal films are placed closer than the attenuation length of surface plasmon waves, light transmission at characteristic resonant wavelength is assisted by coupling SPRs between two metal films.[4] Herein, we demonstrate a study combined the coupling SPRs with PCSs that is mainly focused on the enhancement of optical transmission through SiN-spaced double silver hole arrays and thus the controllability of transmission peaks is made possible by modulating the lattice constant. The studied sample consists of Ag/SiN/Ag trilayers that is perforated with a two dimensional holes array. The fabrication began with a 100 nm freestanding SiN-membrane. Pattern of holes array was achieved by using electron beam lithography in conjunction with a dry RIE etching. Sample was completed by thermally evaporating 20 nm silver films on each side, as shown in Fig. 1. Optical transmission measurements of SiN-PCS, Ag/SiN-PCS, and Ag/SiN-PCS /Ag were carried out, and figure 2(a) reveals a variety of resonances, such as guided mode resonances, SPRs, and coupled SPRs, respectively, from aforementioned PCSs. Clearly, the data indicate a strong enhancement of optical transmission through Ag/SiN-PCS /Ag. The efficiency is up to 30% that is higher than 17% of transmission through Ag/SiN-PCS, this may be attributed to an effect of surface plasmon resonance coupling through two patterned silver films. In addition, a series of samples, having various lattice constant, demonstrate an effect of lattice constant dependent tunable transmission peaks, as shown in figure 2(b). Details of the experimental results and simulation will be elaborated.

Reference

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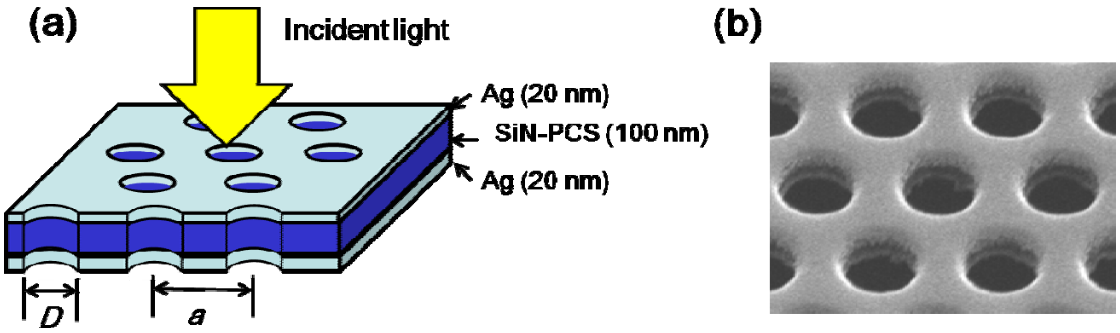

Figure 1. (a) Schematic view of the Ag/SiN-PCS /Ag. Note that the holes are arranged in hexagonal configuration with diameter ***D*** = 300 nm and lattice constant ***a*** = 552 nm. (b) SEM micrograph of the Ag/SiN-PCS/Ag, in which the silver films may be identified through the contrast of secondary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

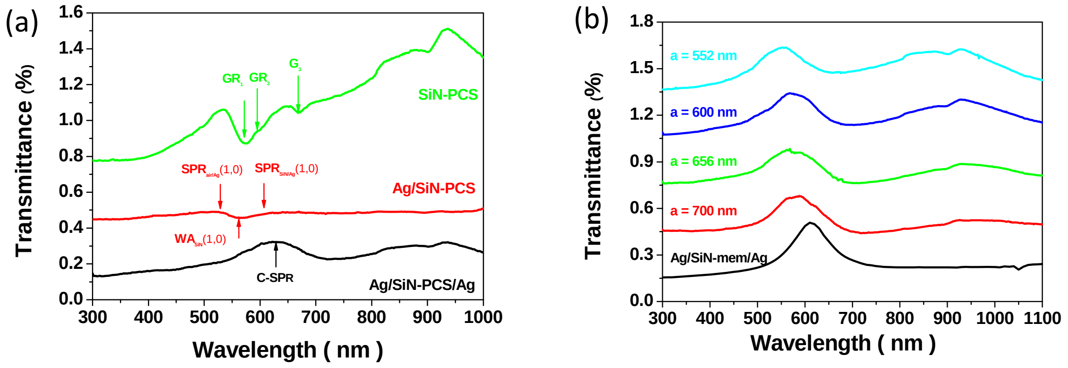

Figure 2. (a) Transmission spectra of SiN-PCS, Ag/SiN-PCS, and Ag/SiN-PCS /Ag, respectively, with a diameter of 300 nm, a lattice constant of 552 nm, and a SiN-thickness of 100 nm. Note that GR$_i$ is denoted as guided resonances; SPR is denoted as surface plasmon resonance; WA is denoted as Wood's anomaly; and C-SPR is denoted as coupled surface plasmon resonance. (b) Tunable transmission spectra of Ag/SiN/Ag-PCSs with various lattice constants, 552, 600, 656, and 700 nm, respectively, and with a hole-diameter of 300 nm and a SiN-thickness of 100 nm. Black plot indicates Ag/SiN-mem/Ag which is a multilayer without holes array.