Study of optical transmittance through tack-typed and goblet-typed dielectric pillar arrays

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Dependence of optical transmittance on pillar shapes, such as tack-typed and goblet-typed dielectric pillar arrays has been investigated. These dielectric pillar-like arrays were fabricated on silicon nitride (SiN) membrane using electron-beam lithography with bi-layer photoresist, and the scanning electron microscope (SEM) micrographs of those structures are shown in Fig. 1. The whole fabrication process starts from a double-side polished and coated with low stressed SiN films of silicon wafer. First, the SiN hard etching masks with 400×400 μm^2 square windows were defined through a standard photolithography followed by a reactive ion etching (RIE) technique. Second, a 50×50 μm^2 square SiN free standing membrane was obtained after wet etching process using KOH solutions. Bilayer photoresists (PRs) containing a high sensitive bottom layer of LOR5B (1μm thick) and a relatively low sensitive layer of top PMMA (100 nm) were then spin-coated onto the top of SiN membrane. Sequentially, a hexagonal lattice of tack-typed PR array was obtained after delineating by using electron beam pattern generator, followed by a two-step development process to realize the pillar array. The raising angle of suspended PMMA disk with diameter of around 1.75μm for the goblet-typed PR structure can be manipulated through sputtering various thicknesses of metal film on the tack-typed PR structure after developing.

Prior to measurements, the optical transmittances through the tack-typed and goblet-typed dielectric pillar arrays have been simulated by a finite element method using a commercially available RF package. The cross-section and the meshed three-dimensional structure of the modeling unit cell on goblet-typed structure are schematically displayed in figure 2. The modeling unit cell is arranged in hexagonal lattice with period of 3μm which is referred to the real experimental structure. The thickness, diameter, and refractive-index of the LOR5B layer are 1μm, 0.5μm,, and 1.6, respectively, while the thickness, diameter, and refractive-index of the PMMA layer are 0.1μm, 2μm, and 1.4, respectively. The simulated transmittance spectra for tack-typed and goblet-typed dielectric pillar arrays are shown in figure 3. The simulated results reveal that the positions of the resonant dips are the same for two kinds of structures. However, the intensity of the goblet-typed dielectric pillar array is higher than the tack-typed one. In addition, the dependence of raising angle and the thickness of metal film on the transmittance shows asymmetrical transmittance behavior and effect of surface plasmons localized in the metal/PMMA-disk interface.

Details on the structure parameters and the subsequent experiments will be elaborated.

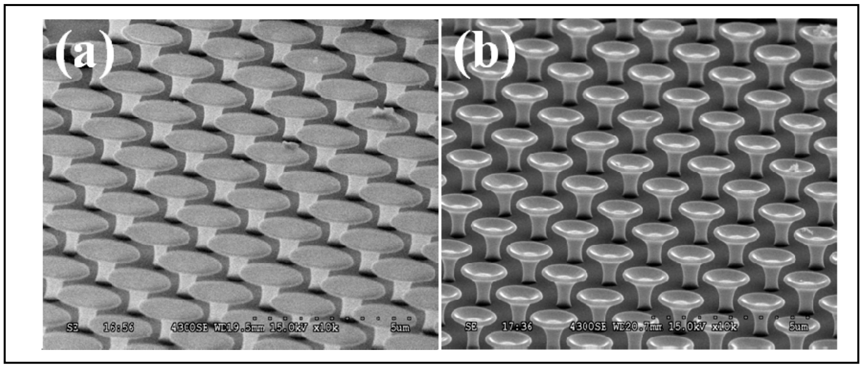

Figure 1: SEM micrographs of the (a) tack-typed array, and (b) goblet-typed array.

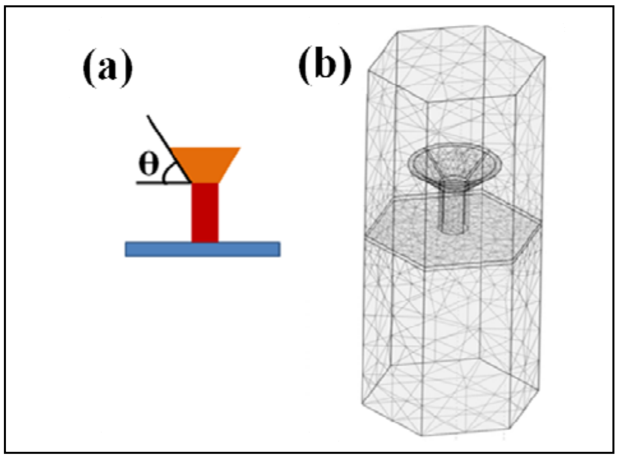

Figure 2: Schematic drawing of the goblet-typed structure：(a) and (b) show the cross-section and (b) the meshed 3-D diagram of the modeling unit cell, respectively.

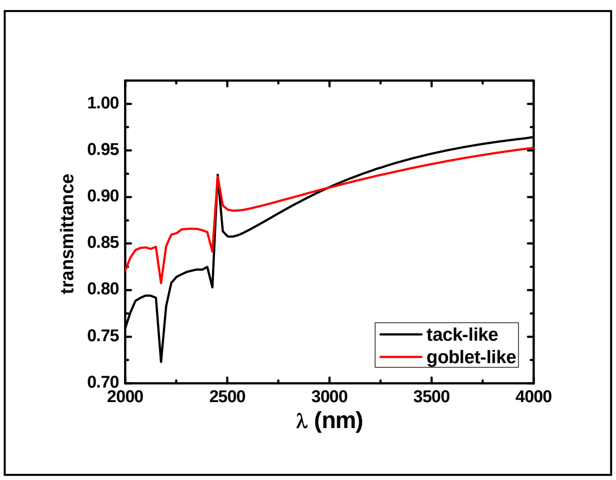

Figure 3: The simulated transmittance spectra for goblet-typed and tack-typed dielectric pillar array.