Diameter-dependent extraordinary optical transmission of dielectric hole-array membrane

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Dielectric nano-hole arrays made of silicon nitride membrane have been fabricated and the extraordinary optical transmission (EOT) was observed in the optical measurements. Besides the mechanism accounted for this phenomenon, the influence of the hole-diameter on the transmission spectrum will be reported in this presentation. So far, the EOT has been investigated in both theory and experiment for nearly a decade that it is often interpreted by the surface plasmon coupled from the metal surface with periodic structure and the light re-radiated from the other surface of the perforated metal film [1-3]. This report is for the first time that a dielectric hole-array membrane is used for this study. First of all, a double side polished and 100nm-thick low-stressed silicon nitride coated Si-wafer was prepared. A 800μm×800μm square pattern was exposed to a photoresist coated on one side of the sample, followed by a RIE dry etching to remove silicon nitride and a KOH wet etching to etch out Si-substrate, leaving a free standing silicon nitride membrane with total area of 40μm×40μm. Sub-wavelength hole-array was then patterned on the other side of the whole membrane using a standard electron beam lithography in combination with RIE etching process. The hole-diameters were designed in 385nm and 410nm, respectively, and the arrays were arranged in hexagonal lattice with a fixed period of 656nm, as shown in Figure 1. The optical transmission measurement was carried out with a normal incident halogen light source. As a result, the EOT was observed in both samples, in which a transmission enhancement occurs, in addition to many absorption dips, at the wavelength between 600nm and 700nm. Moreover, the transmission intensity increases and the characters of the spectrum shift to shorter wavelength with increasing the hole-diameter, as shown in Figure 2. The details of this study will be elaborated.

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[2] D. E. Grupp, H. J. Lezec, T. W. Ebbesen, K. M. Pellerin and Tineke Thio, Appl. Phys. Lett. **77**, 1569 (2000)

[3] K. L. van der Molen, F. B. Segerink, N. F. van Hulst and L. Kuipers, Appl. Phys. Lett. **85**, 4316 (2004)

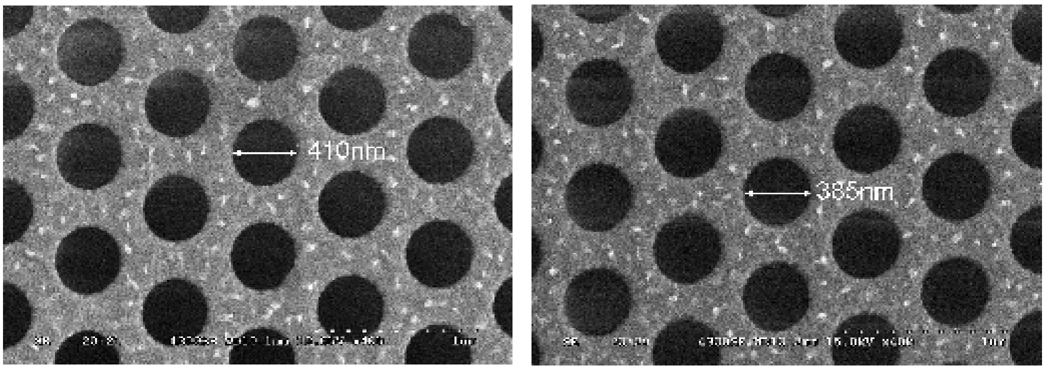

Fig 1: SEM micrographs of the dielectric hole-array membranes. The hexagonal hole lattice has a fixed period of 656nm and the hole diameters are 410 nm and 385 nm, respectively.

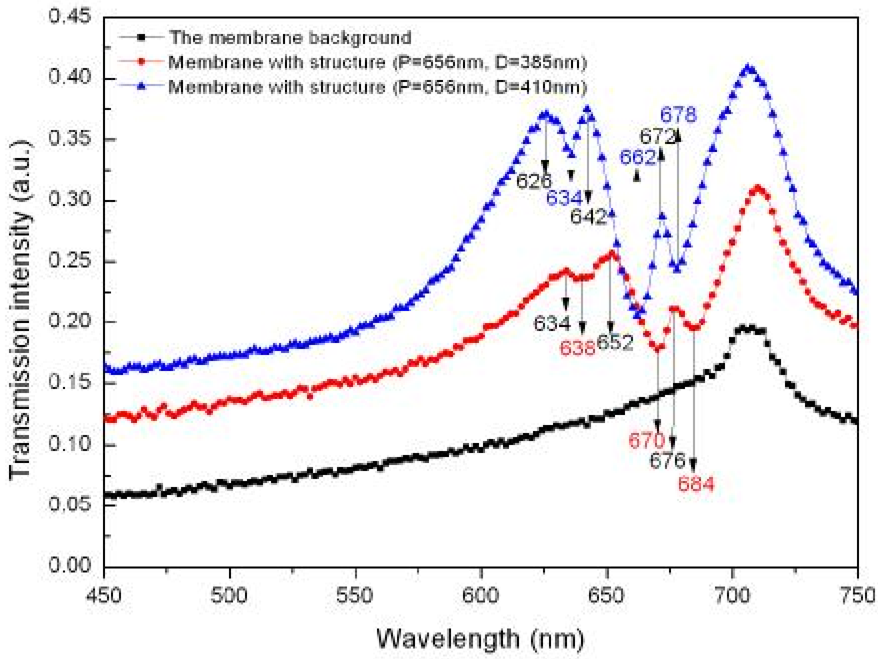

Fig 2: Optical transmission measurements taken on dielectric membranes without hole-array, with 385 nm diameter hole-array, and with 410 nm diameter hole-array, respectively.