

Anomalous transmission through metal-VO₂ hole arrays

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Collaborator: J. Y. Suh, Eugene Donev, Rene Lopez, Leonard C. Feldman, Richard F. Haglund Jr.

Dielectric or metallic surfaces are able to support various kinds of electromagnetic wave modes, *e.g.* surface plasmon, determined by the dielectric constants of the media.¹ The impact of the studies about light transmission through sub-wavelength holes (smaller than the wavelength of light) has been significant for its spectral selection ability and the anomalously large transmittance greater than the estimate of the standard diffraction theory.^{2 3 4} We are focusing on the manipulation of the transmission characteristics controlled by switching of a thin vanadium dioxide (VO₂) film between the metallic and semiconducting phases. The periodic array of subwavelength apertures implemented in a bilayer film (metal and VO₂) provides a possibility of realizing a practical photonic device since the metal-insulator transition can be induced either thermally or by laser irradiation, thus modulating the dielectric function without changing the physical structure.

For the sample fabrication and characterization, a variety of techniques are applied: Thermal evaporation for metal deposition; Pulsed laser deposition (PLD) and annealing for VO₂ synthesis; Direct focused ion beam (FIB) milling for 2-D subwavelength

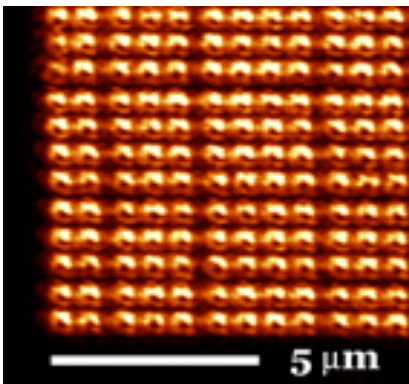


Figure 2 Near-field scanning optical microscope image for the Au-VO₂ hole array

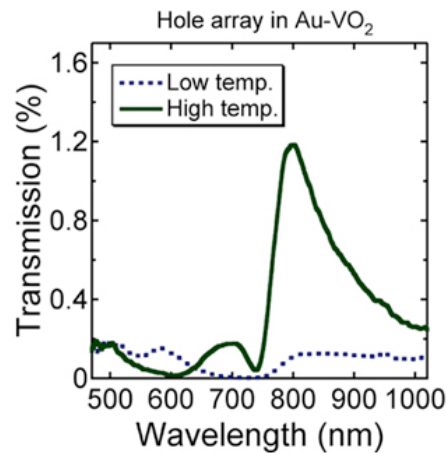


Figure 1 Transmission intensity as a function of wavelength for the Au-VO₂ double layered hole array.

hole array; Rutherford backscattering spectrometry (RBS) and optical transmission spectroscopy for the oxide stoichiometry, film thickness and visible/near-IR transmission measurement; etc.

We have demonstrated that the light transmission through a subwavelength hole array in the metal-VO₂ bilayer structure can be controlled by means of VO₂ phase transition. Interestingly, it has turned out that the transmission amplitude increases in the metallic VO₂ (Figure 1). As shown in the near-field scanning optical microscope (Figure 2), the transmitted light is localized at the holes. In turn, our simulation results mimic well

this transmission amplitude changes in the two different phases of the underlying VO₂ layer.

- ¹ H. Raether, *Surface Plasmon*. (Springer-Verlag, Berlin, 1988).
- ² T. W. Ebbesen, H. J. Lezec, H. F. Ghaemi et al., "Extraordinary optical transmission through sub-wavelength hole arrays," *Nature* **391**, 667 (1998).
- ³ H. Bethe, "Theory of diffraction by small holes," *Phys. Rev.* **66**, 163 (1944).
- ⁴ William L. Barnes, Alain Dereux, and Thomas W. Ebbesen, "Surface plasmon subwavelength optics," *Nature* **424**, 824-830 (2003).