Infrared nanophotonics based on ITO nanorod array

Shi-Qiang Li, Peijun Guo, Robert P. H. Chang[a)]
Materials Science and Engineering, Northwestern University, Evanston, IL 60208

Leonidas E. Ocola
Center for Nanoscale Materials, Argonne National Laboratory, Argonne, IL 60439
[a)]Electronic email: *r-chang@northwestern.edu*

To date, silver and gold are the two key materials for plasmonics research. However, the high dielectric loss due to the inter-band transitions or oxide formation in these materials prevents them from applications in such area as sensing and telecommunications.[1] Indium-tin-oxide (ITO), which is a highly-degenerated semiconducting oxide, offers numerous advantages for application in the near to mid infrared plasmonics and photonics. Firstly, ITO has inter-band transition lying in the UV region (3.8 eV) and phonon modes at far-infrared region (0.07 eV),[2] thus the dielectric loss near IR and IR region is negligible and the Drude model fits well. Secondly, both charge density and electron mobility of ITOs can be tuned by a factor of ten so that it can cover a broad range of spectrum with little modification in the fabrication process.

In this paper, we describe a nanofabrication technique developed to produce ITO nanorods with an integrated bottom-up and top-down approach, and how these strutures can be applied in photonic devices. The nanorods synthesized are single-crystalline, uniform in height and diameter. They can also be fabricated as arrays arranged into different lattice spacings and geometries. An SEM image of an ITO array with square lattice is shown in Figure 1. Together with discrete-dipole approximation and finite-element-methods, we have designed lattices of nanorods to study the mode coupling of plasmon waves and grating modes. Excellent agreement between the experiment and the simulation has been obtained. Two measured spectra showing the interference of two different modes from a fabricated sample are shown in Figure 2. Our work provides a versatile platform for designing novel nanophotonic devices of the future.

---

[1] A. Boltasseva and H. A. Atwater, Science **331**, 290 (2011).
[2] C. G. Granqvist and A. Hultaker, Thin Solid Films **411**, 1 (2002).

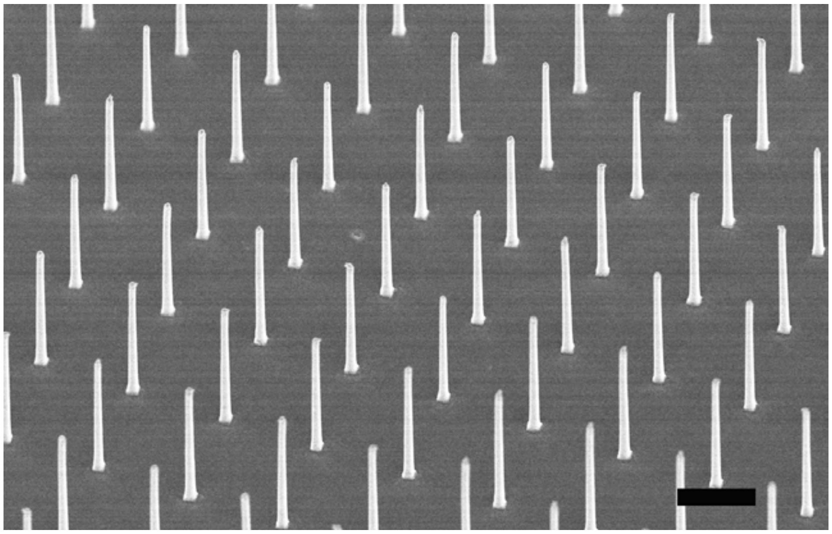

Figure 1: SEM image of a typical ITO nanorod array: This image was taken with 30° tilting to reveal the third dimension of the vertical aligned nanorods. The nanorods are 150 nm thick, 6 μm long. The lattice constant of this array is 3 μm.

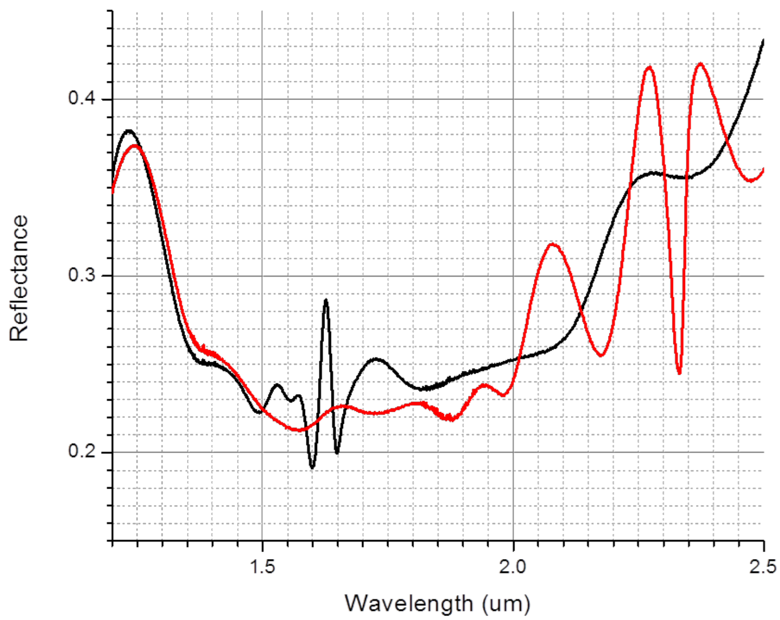

Figure 2: Reflectance curves from an ITO nanorod array measured with s-polarized light: The broad decrease of reflectance is a result of plasmon resonance and the rapid oscillation is the interference between the plasmon and geometric resonance. Red curve and black curve were measured from two different azimuthal angles of incidence (0˚ and 90˚).