Patterned Fabrication of ZnO Nanowire Arrays for Nanoplasmonic Waveguide Applications

Huizhong Xu, Thomas Lamson, and Sahar Khan
Department of Physics, College of Liberal Arts and Sciences, St. John's University, Jamaica, NY 11439
xuh@stjohns.edu

Dielectric nanowires of high refractive index have been increasingly used in the fabrication of nanoplasmonic devices for a variety of applications such as nanoscopic light-guiding and imaging, and high-resolution lithography.[1] For example, efficient guiding of visible light in ZnO nanowire waveguides of around 50 nm has been demonstrated.[2] These waveguides are based on randomly distributed ZnO nanowires synthesized using the hydrothermal process[3] on a glass substrate pre-seeded with ZnO nanoparticles.

In this study, we report the patterned fabrication of ZnO nanowire arrays of spacing ranging from 300 nm to 1200 nm and diameter between 50 nm and 140 nm. Electron beam lithography (EBL) is used to pattern hole arrays of varying diameter and spacing in a 100-nm-thick PMMA layer. ZnO nanowires are then synthesized in these patterned holes using the hydrothermal method, and the PMMA layer is subsequently removed. Some scanning electron microscopy images of the synthesized nanowires are shown in Figure 1. Each nanowire consists of two parts: a lower part which is confined inside the PMMA hole and an upper part which goes above the PMMA layer and has a larger diameter.

Zinc oxide nanowire waveguides are then formed by coating the nanowires with a 100-nm-thick silver film. Optical transmission through the ZnO nanowire waveguides are measured on an inverted microscope by collecting light transmitted through the ZnO nanowaveguides from the glass side of the sample. Strong resonant transmission of visible light through the nanowaveguides is observed. We have found that the resonance shifts to a longer wavelength with increasing nanowire diameter and is independent of the array period. These results strongly indicate that the observed resonance is due to the resonant excitation of surface plasmon polartion (SPP) mode of a single ZnO nanowire. The strong resonant transmission observed through these waveguides will enable new imaging techniques for applications where single-particle study of highly concentrated molecules is demanded.

---

[1]H. Wei and H. Xu, Nanophoton. **1**, 155 (2012).
[2]V. L. Garcia, M. G. Velasco, S. B. Mamer, K. R. Singh, N. K. Hossain, G. He, M. Sadoqi, and H. Xu, Appl. Phys. Lett. **101**, 081113 (2012).
[3]L. E. Greene, M. Law, D. H. Tan, M. Montano, J. Goldberger, G. Somorjai, and P. Yang, Nano Lett. **5**, 1231 (2005).

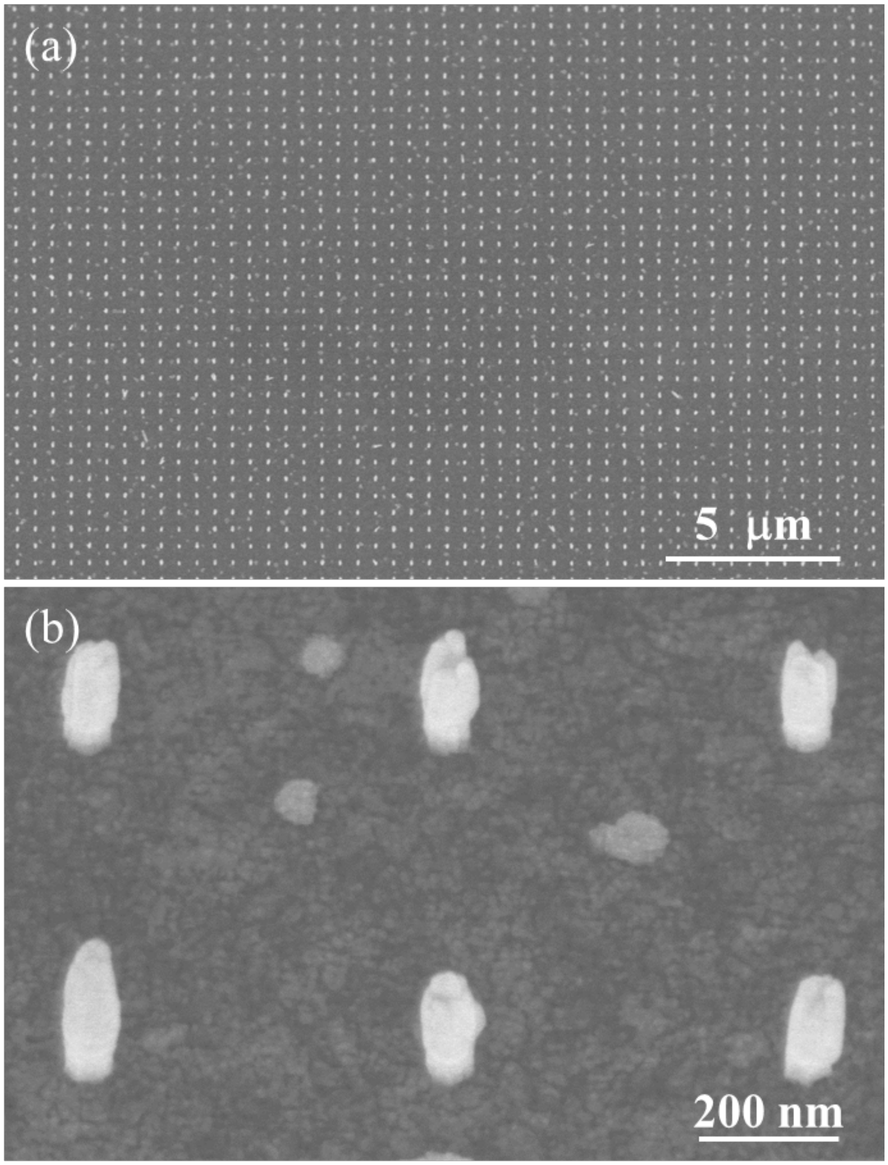

Figure 1: SEM images of ZnO nanowire arrays synthesized inside PMMA holes patterned with EBL. Both images are viewed with a 20° tilt angle. The array has a period of 500 nm and the average diameter of the nanowires is 69 nm for the lower part. EBL was conducted at the Center for Functional Nanomaterials of the Brookhaven National Laboratory.