The Fabrication of Plasmonic Crystals by Electron Beam Lithography and Argon Ion Milling for Sensing Applications

B.G. Quan, W.J. Sun, Z. Liu, X.X. Xia, J.J. Li* and C.Z. Gu*
Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Science, Beijing 100080, China
jjli@aphy.iphy.ac.cn and czgu@aphy.iphy.ac.cn

Plasmonic crystals (PCs) with visible or infrared (IR) frequency response had attracted growing interests since the concept of PCs was arisen at the beginning of this century.[1] Due to the surface plasmon polariton (SPP) resonances of PCs, optical label-free chem-/biosensors can be realized by nanofabrication of noble metal thin films.[2] Nowadays, electron beam lithography and lift-off is one of the most widely used techniques for the fabrication of PCs. Unfortunately, the performance of sensors was influenced significantly by the defects of nanostructures, whereas side-wall is inevitable when lift-off is used. When it goes into optical frequency, the periodic of PCs is about one fifth of the wavelength of light and the feature size of the structure is about 30 nm in width, which makes the fabrication high quality samples more challenge. Etching is an alternative technique to fulfill the fabrication of optical PCs by using Argon ion milling to etch noble metal film.

The gold thin films with thickness varying from 30 nm to 50 nm were deposited on fused silica substrates by magnetron sputtering system with the grain size of gold being ca 30nm. Then the film was coated with a 50 nm PMMA (495K, Microchem) and underwent an electron beam lighography (Raith 150, Raith GmbH) process. After developing the samples were etched by an Argon ion milling system (LKJ-150, Beijing Institute of Advanced Ion Beam Technology). PMMA pattern was used as mask for Ar ion beam etching of gold film, with ion energy of 300 eV and ion current of 0.5 mA/cm^2. The etching rate of gold is faster than that of PMMA, so the residue of the PMMA was removed by oxygen plasma in a reactive ion etching system (Plasmalab 80 Plus, Oxford Instruments). Figure 1 shows the SEM images of PCs fabricated by electron beam lithography and Ar ion milling. The line width is about 30 nm.

Thiols and biotin were immobilized on to gold nanostructures by soaking the PCs samples into solutions of thiols and biotin solutions in sequence. Then the binding event of avidin and biotin was measurement using vis-IR spectrum. Finite-difference time-domain (FDTD) simulations (Figure2) were carried out for a deeper understanding of the mechanism of our experimental observations.

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[1] T Okamoto, J Feng, S. Kawata, NFO-8 conference, Korea, 2004.
[2] T. T. Troung, J. Maria, J. Yao, M. E. Stewart, T. W. Lee, S. K. Gray, R. G. Nuzzo and J. A. Rogers, Nanotechnology **20** (2009) 434011.

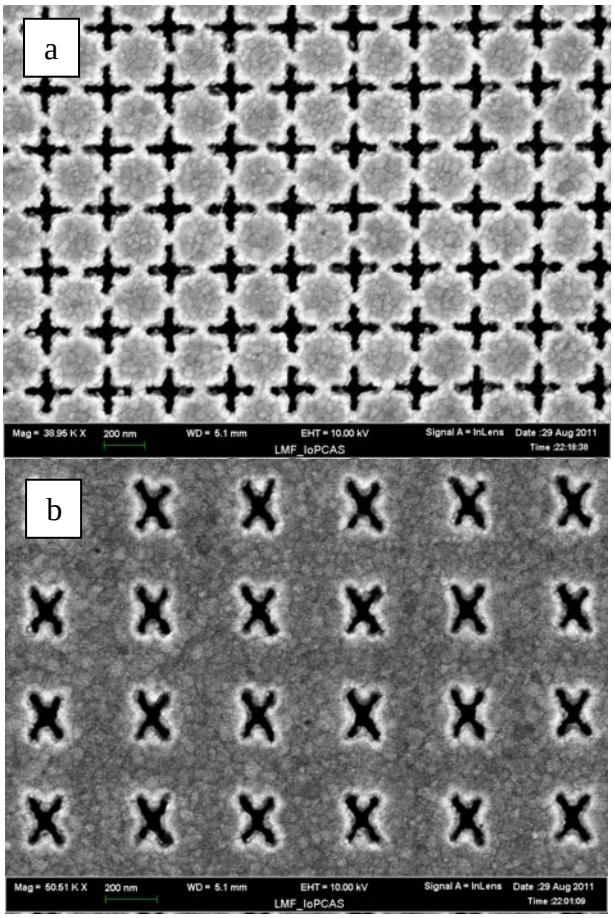

Figure1: the SEM images of plasmonic crystals. (a) cross-shaped PCs with period of 300 nm, and (b) X-shaped PCs with period of 400 nm.

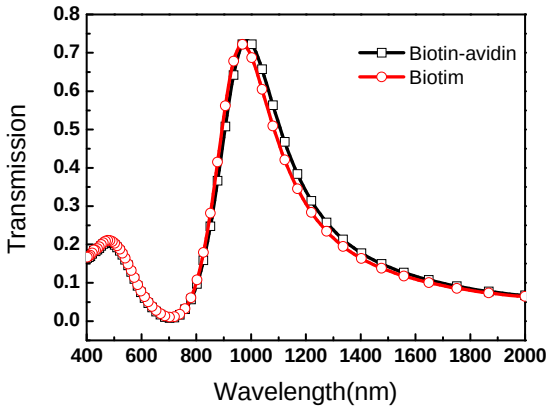

Figure2: FDTD simulation result of biotin-avidin binding event.