Design and Fabrication of Plasmonic Notch Color Filters

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Metallic nanostructures are effective scatterers of light, and can support plasmon resonances to produce colors in the visible range. However, these resonances are broad and are not suitable for certain spectroscopic applications, such as notch filters with high transmittance at other non-target wavelengths. Here, we propose to use surface lattice resonances, instead of local plasmon resonances, to create notch filters. Plasmonic color filters have been of great recent interest as they can be actively controlled and have tunable optical properties[1]. Figure 1 shows that a periodic array of aluminium discs on a glass substrate acts as a notch filter, by scattering light in a narrow wavelength range and transmitting light with greater than 95% efficiency at other wavelengths. The resonance wavelength can be tuned from the UV to the visible spectrum by changing the period of the discs.

Laser interference lithography is a simple and low-cost technique for patterning large areas of nanostructures, thus it is suitable for patterning centimeter-scale samples for rapid inspection. By combining an incident laser beam and a laser beam reflected off a mirror (Lloyd mirror set-up)[2], we create an interference pattern in a layer of photoresist, which produces periodic one-dimensional or two-dimensional structures, such as gratings, discs and holes. The size of the structures is controlled by the dose of the laser beam, while the periodicity of the structures is controlled by the angle between the sample and the laser.

Using a 405nm diode laser and carefully aligning the beam to the sample, we are able to produce ~60nm tall aluminum discs with a minimum period of <300nm with suitable etching of the AZ Mir 701 resist. A 20nm thick layer of AZ Barli-II was used as the adhesion layer. Atomic force microscopy measurements (Figure 2) showed that a large uniform area of discs was achieved (~ 1 cm by 1cm). Inverted patterns may also be formed by adjusting the dose of the laser beam, which is proportional to the product of the exposure time and the laser current.

[1] T. Ellenbogen, K. Seo, and K. B. Crozier, Nano Lett. 12, 2 (2012).
[2] C. P. Fucetola, H. Korre, and K. K. Berggren, J. Vac. Sci. Technol. B 28 (2009).

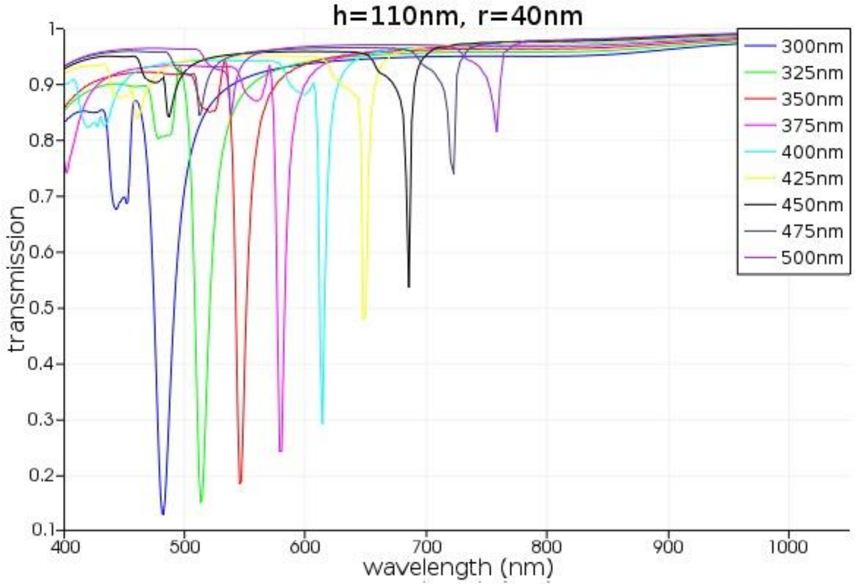

Figure 1: Plot of simulated transmission spectra: The plot shows the transmission spectra for periodic arrays of 80nm wide posts with periodicities between 300nm and 500nm. The transmission dip wavelength is tunable from 480nm to 760nm.

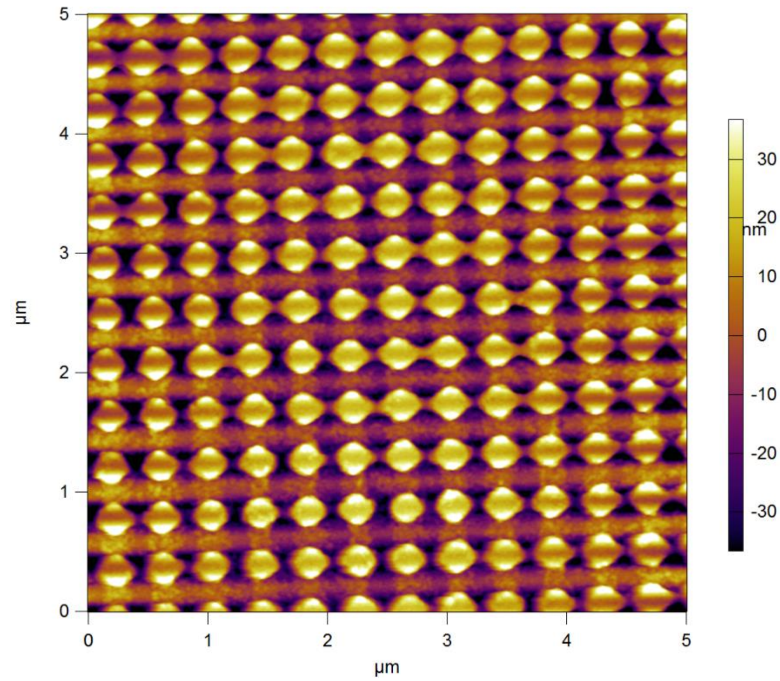

Figure 2: Atomic Force Microscopy Scan: The image shows an array of 60nm tall and 250 nm wide posts with a periodicity of 400 nm. The posts consist of PMMA on top of an antireflection coating, while the substrate consists of bulk silicon.