High-density Sub-20 nm Plasmonic Nanostructures Fabricated by Nanoimprint Lithography using a Block Copolymer Template

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Plasmonic nanostructures have been exploited in many photonic applications such as photovoltaics and biosensors due to their unique capabilities of localizing light at nanoscopic dimensions.[1] Though reproducible metallic nanoparticle arrays have been demonstrated by using the Nanoimprint lithography,[2] creating dense and much smaller particle sizes is very challenging using this approach.

In this work, sub-20 nm plasmonic nanostructure was successfully developed using nanoimprint molds fabricated from a self-assembled block copolymer template. The self-organization property of block copolymer to obtain well-ordered nanostructures has been widely used due to ease of accessing complex nanostructures.[3] The density and the dimension of such self-organized nanostructure are usually beyond the reach of typical conventional top-down nanofabrication techniques. However, the long processing time needed to develop the self-assembled structures has drastically reduced the potential impact of this versatile nanopatterning technique. To overcome this limitation, we fabricated nanoimprint molds by using the block copolymer template, and used nanoimprint lithography for high speed nanopatterning.

In our process, sub-20 nm polystyrene hole arrays were first fabricated by plasma-etching of self-assembled PS-PMMA diblock copolymer hexagonal patterns developed on top of a neutral layer.[4] These patterns were then used as a template to create nanoimprint mold with both nanohole and nanopillar array structures (Fig. 1). Using Nanoimprint and metal deposition, we have successfully fabricated high-density sub-20nm metal particle and mesh structures. These structures exhibit strong and tunable localized surface Plasmon resonances (Fig. 3). The strong enhancement of light absorption at the resonance wavelength is currently being evaluated in organic solar cells to improve the power efficiency.

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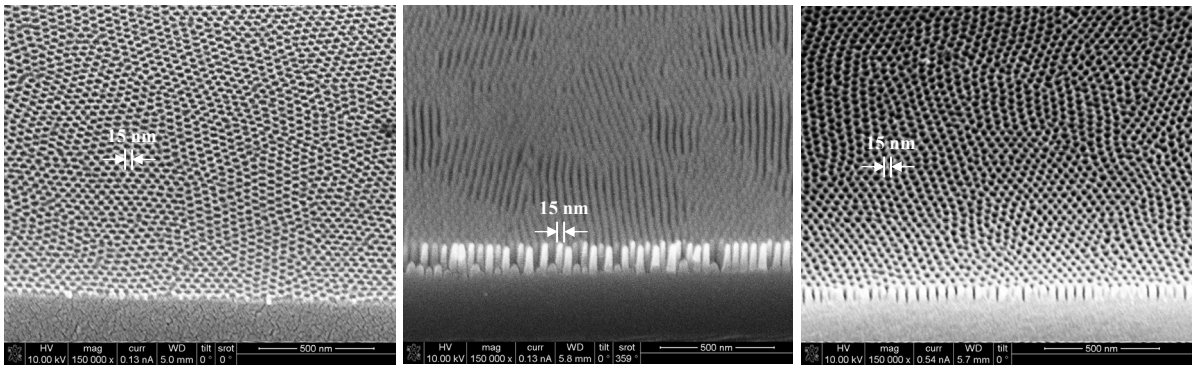

(a) (b) (c)

Figure 1. (a) PS template fabricated by etching PMMA domain of self-assembled PS-PMMA hexagonal patterns. Nanoimprint molds of both pattern polarities made in SiO_2 fabricated using the PS template: (b) pillar arrays and (c) holes arrays.

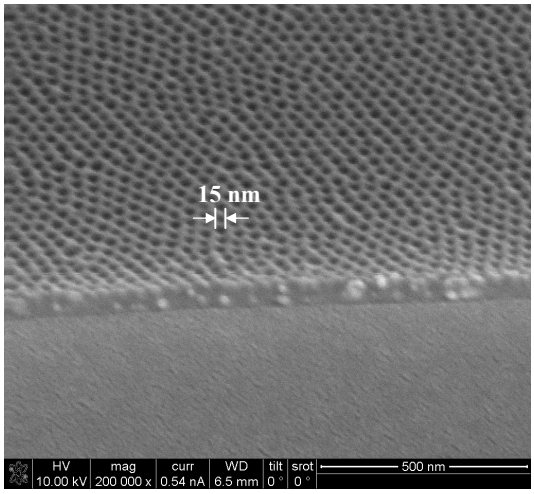

Figure 2. PMMA hole array patterns fabricated by nanoimprint lithography using the SiO_2 pillar array mold.

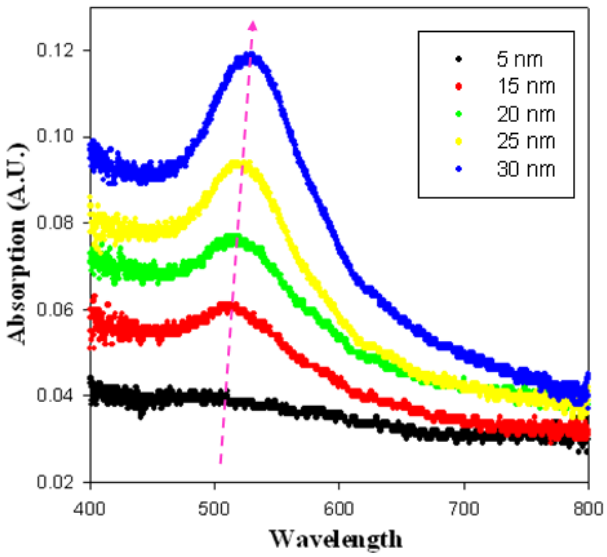

Figure 3. Absorption spectra of sub-20 nm size plasmonic Au particle arrays with different Au thickness.