

Fabrication of Periodic Hollow-Shell Nano-Volcano Arrays for Particle Trapping

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Colloidal lithography, based on the self-assembly of monodispersed nanospheres, is a simple, low-cost, and high-throughput technique for patterning nanostructures [1]. This approach has the capability to fabricate high-quality nanostructures, such as nanopores, hemispherical metal caps, and sculptured colloids [2-4]. Recently, fabrication of complex periodic 3D structures by combining this technique with phase lithography has been reported [5]. That work harnesses the Talbot effect, and demonstrates the versatility of combining colloidal self-assembly with lithography. In previous work [6], we have demonstrated the fabrication of hollow-shell nano-volcanoes using light scattering from colloidal nanospheres. In this work, we investigate further the fabrication of such structures with periodic order and their applications in particle trapping.

The fabrication process of periodic nano-volcano arrays is shown in Figure 1, where a close-packed monolayer of nanospheres is self-assembled on the surface of a photoresist stack. The whole stack is then subjected to isotropic oxygen plasma etching to reduce the particle size without losing the spherical shape and periodic order. Subsequent UV light exposure and development process produce the periodic nano-volcano arrays. Figure 2(a) and (b) illustrate preliminary fabrication results of 1 μm -tall nano-volcano arrays patterned using 1 μm and 2 μm -diameter particles prior to particle size reduction. Each individual nano-volcano has hollow-shell geometry with wall thickness less than 100 nm. Figure 2(c) depicts a 500 nm-tall nano-volcano array with period of 2 μm , which has improved structural quality owing to less light interference between the scattered light orders from neighboring particles in the photoresist region.

Hollow nanostructures have drawn particular interests in the area of drug delivery and particle/bio trapping. Researchers have successfully demonstrated the drug loading and release mechanisms via a phase change material using gold nanocages [7]. The hollow-shell nano-volcano structure fabricated in this work can serve as a particle/drug storage surface with a confined volume. Using the fabricated nano-volcanoes, we have investigated the loading mechanism of 50 nm silica particles using vacuum. Preliminary results using single nano-volcano are shown in Figure 3, where (a) and (b) present the fabricated nano-volcano before and after particle loading, respectively. We will discuss the loading and release mechanisms of the nanoparticles, and their potential applications in drug delivery.

In this work, periodic nano-volcano arrays will be fabricated and tested for loading and release of nanoparticles. The effect of etched particle size and structural quality control will be further studied and quantitatively described. More precise particle trapping and drug delivery can be expected using an array of nano-volcanoes. The loading and release mechanisms in these hollow-shell structures will be explored, and a more comprehensive characterization will be conducted.

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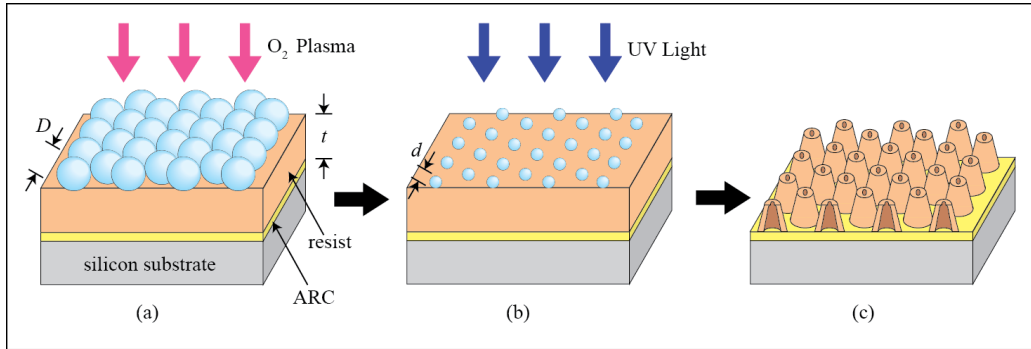


Figure 1 Fabrication process of periodic nano-volcano arrays. (a) Large nanospheres are self-assembled on resist and then subjected to isotropic oxygen plasma etching. (b) The whole stack is exposed with UV light after size of nanospheres is reduced. (c) Resultant periodic hollow-shell nano-volcano arrays with cross sections of individual structures in the first row.

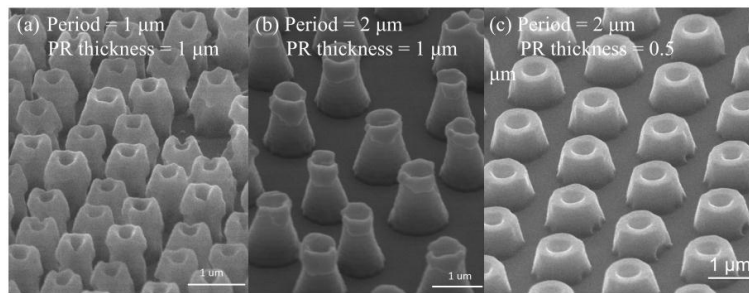


Figure 2 SEM images of periodic nano-volcano arrays. (a) 1 μm period and 1 μm high, (b) 2 μm period and 1 μm high, and (c) 2 μm period and 500 nm high.

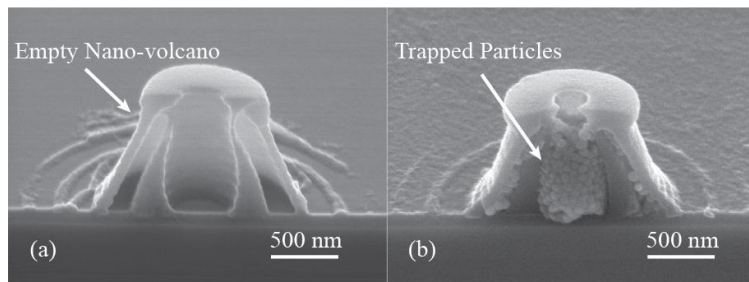


Figure 3 SEM images of a single nano-volcano (a) before and (b) after being loaded with 50 nm-diameter silica nanospheres

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