Thermal dewetting of gold particles on a template surface

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Noble metallic nanoparticles have attracted intensive interest for promising applications in optics, optoelectronics, chemical and biological sensing. Here, a novel technique to arrange nanospheres induced by thermal dewetting process is introduced. Nanoparticles dispersed in a circular array on the top surface other than at the bottom of bowl template[1] can be well fabricated by introducing a pre-patterned anodic aluminum oxide template.

Figure 1 schematically represents a single cell of AAO template in the fabrication process. After the traditional two step anodization of pure aluminum foil in 0.3 M oxalic acid under 40 V into porous anodic aluminum oxide (AAO), as illustrated in the previous work[2], a thin film of 4 nm Au was deposited on the template by electron beam (E-beam) evaporation (Fig 1a) and subsequently heated in N_2 atmosphere at 800 ^oC for 40 s via rapid thermal processing (RTP). The flat thin film was ruptured into nanospheres by surface tension stresses at high temperature as shown in Fig 1b. The perimeter of the pores on AAO template rearranged the nanospheres around the pores other than random distribution.

Figure 2 displays the atomic force microscopy (AFM) images of heated particles under the same conditions dispersed on a flat alumina substrate (Fig 2a) and the ordered porous alumina template (Fig 2b). In comparison, the particles on AAO template are much more ordered than the ones on the flat substrate. Therefore, a substrate with pre-defined nanoscale patterns can well define the distribution of nanospheres ruptured from a flat thin film in high temperature, which makes AAO a promising candidate for further applications in nanofabrication, optics, biosensors. Figure 2c is a 3-D AFM image of the morphology in the area of 1×1 μm^2 after the thermal process.

Figure 3 clearly shows ordered nanoparticles around nanopores of AAO template. In comparison, the inset is the as-anodized AAO template with ordered and hexagonally arranged nanopores. The nanoparticles induced by thermal dewetting process are well arranged along the perimeter of the pores one by one, giving rise to circular arrays of nanoparticles around nanopores and two rows of spheres dispersed side by side on the rims between pores. It can be anticipated that the nanospheres on the rims can be re-arranged and coalesced into one row by widening the pore diameter, i.e. scaling down the neck width between pores.

In conclusion, the nanoparticles formed in the thermal dewetting process on an

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[1] S. Yang, F. Xu, S. Ostendorp, G. Wilde, H. Zhao, Y. Lei, *Adv. Funct. Mater.* **21**, 2446 (2011).
[2] Z. Q. Liu, G. S. Huang, M. L. Li, J. X. Li, Y. F. Chen, Y. F. Mei, R. Liu, *Microelectronic Engineering,* **97**, 147 (2012).

AAO template can be well arranged and modulated by controlling the parameters of nanopores and inter-pore distance. This novel structure can have potential applications in metal-enhanced fluorescence, surface plasmon based sensing, biosensors, etc.

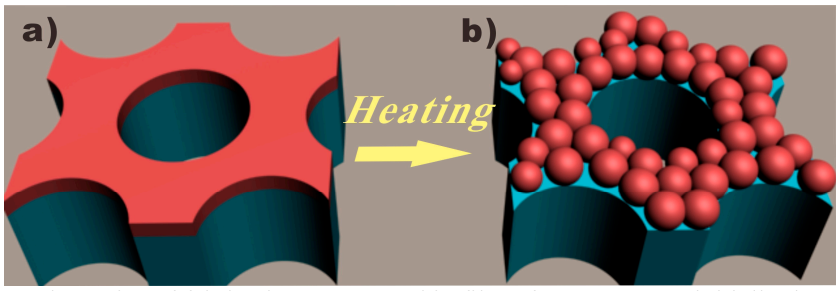

Figure 1. Schematics of fabrication process. Thin film of 4 nm Au was initially deposited on AAO template (a) and then was thermally dewetted into ordered gold particles distributed around pores of AAO template (b).

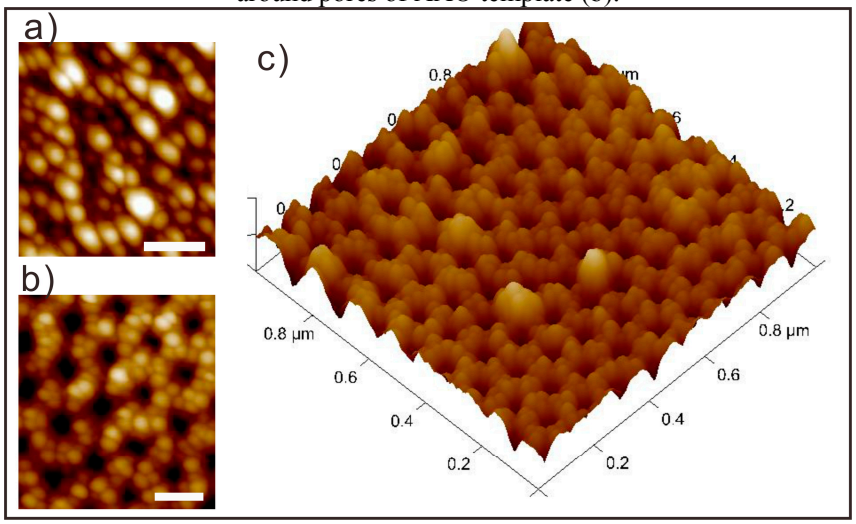

Figure 2. AFM images of dewetted particles on flat alumina substrate (a) and AAO template (b). (c) displays a 3D image of morphology of ordered particles. The scale bars are 100 nm.

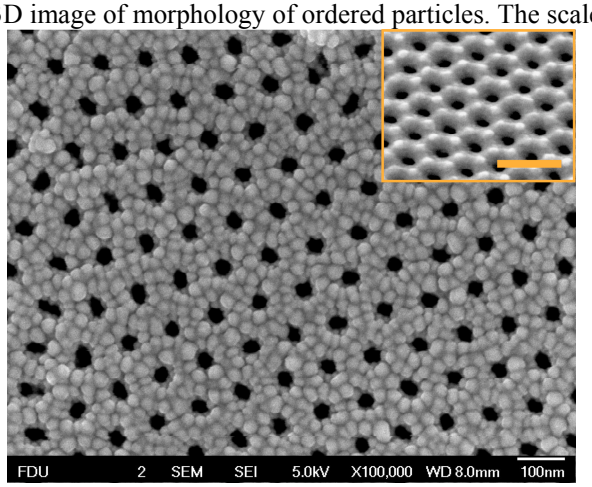

Figure 3. SEM images of morphology of particles distributed on the AAO template. The inset shows the as-anodized template (the scale bar is 200 nm).