Fabrication of Periodic Al_2O_3 Nanohole Arrays with Conductive Support as a Nanostructured Template

Jie Gong[+,*], Bill Butler[*], Giovanni Zangari[*,Δ]
[+]Materials Science Program
[*]Center for Materials for Information Technology
University of Alabama
Tuscaloosa AL 35487-0209
[Δ]now at Dept. of Materials Science and CESE,
University of Virginia,
Charlottesville, VA 22904-4745

Nanochannel-array materials, which exhibit uniform channels of nanometer-scale dimension, have attracted considerable interests recently due to their possible utilization as a template structure for the fabrication of deep submicron structures, of interest in magnetic, electronic, and optoelectronic devices. Anodic porous alumina, a typical self-ordered nanochannel material formed by the anodization of Al in an appropriate acid solution, becomes a key material for these purposes.

In this work, anodic alumina with an ordered hole-array was first prepared using two-step anodization in an oxalic acid solution at a constant voltage of 40 V. Figure 1 (left) shows the textured pattern of concaves formed on the Al surface after stripping the oxide layer formed during the first anodization step. The textured Al specimen was anodized again, and a highly ordered alumina nanopore structure could be obtained (Figure 1, right).

After anodization, the Al substrate was removed by selective dissolution in saturated $HgCl_2$ solution. A periodic domed structure due to the wavy topography of the barrier layer is observed from the bottom side in Fig. 2.

Due to its unique geometric features, the U-shaped bottom cap of the alumina nanochannel can be opened by controlled grazing angle Ar^+ ion milling and thus smaller pore apertures can be engraved on the caps (Figure 3). The aperture dimension can be controlled by the grazing angle and milling time, and can be within a diameter of 10 nm.

It was also demonstrated that 200 nm thick copper, which was sputtered on the nanohole side, can provide a fully covered conductive support for further nanofabrications purposes (Figure 4).

The structure thus obtained, schematically depicted in cross section in Fig. 5, can be used to grow metallic, semiconductive and organic nanostructure by various techniques, as already demonstrated by several groups. In this talk we will show some of the structures we have been able to synthesize and their possible applications.

Figures:

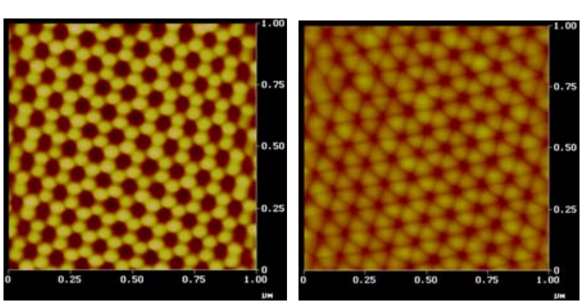

Figure 1 – AFM images of textured pattern on Al substrate after removing the anodic Al_2O_3 layer (left) and the highly ordered array of alumina nanopores after 2-step anodization (right).

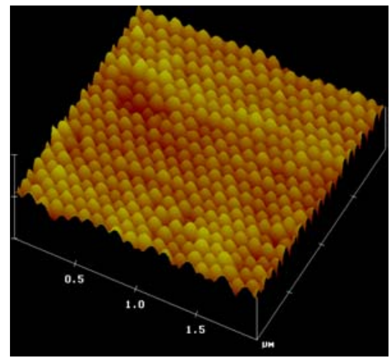

Figure 2 – AFM images of barrier layer (bottom view), after removal of Al.

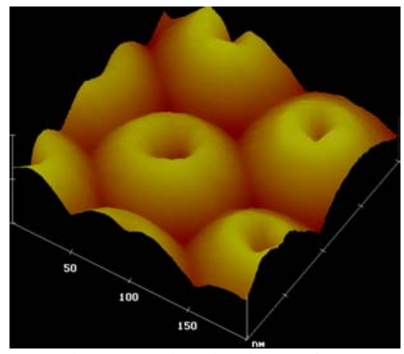

Figure 3 –AFM image of barrier layer (bottom view), after 4 minutes Ar^+ ion milling at an angle of 45°.

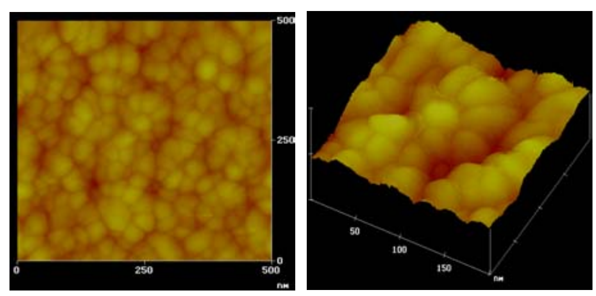

Figure 4 – AFM images of the nanohole side after sputtering 200 nm Cu. Note that the holes are fully covered by Cu.

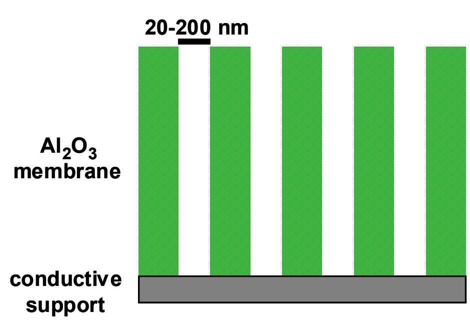

Figure 5 – Schematic drawing of the cross section of the nanostructured template thus obtained.