Long-Range Ordered Aluminum Oxide Nanotubes by Nanoimprint-Assisted Aluminum Film Surface Engineering

Kunbae Noh, Chulmin Choi, Karla Brammer, Jin-Yeol Kim, Young Oh, Mariana Loya, and Sungho Jin
Materials Science and Engineering, University of California, San Diego, La Jolla, CA 92093

Abstract

Porous anodized aluminum oxide (AAO) structures, self-ordered as vertically aligned configurations, have been extensively investigated as versatile templates for nanodots and nanowires for many applications. However, the self assmbled regions are often micrometer sized with undesirably altered pattern orientations at domain boundaries, and there have been few reports on the creation of ideally arranged single domain AAO arrays. Such perfectly position-aligned structures over large areas without domain boundaries are required for major modern technical applications such as ultra-high-density magnetic recording media application. With the soaring demand for cost-effective and long-range ordered nanotemplates and nano-stamps for technical applications, nanoimprint-assisted guided anodization technique has been pursued to achieve such a viable structure.

In this report, we present on successful fabrications of hexagonally ordered and vertically aligned AAO nanotube array patterns over a large area (at least ~ 6mm x 6mm) by utilizing nanoimprint-guided anodization on sputter deposited Al thin films. Perfectly periodic nanotube arrays with no domain boundaries are obtained. Nano-indented patterns comprised of hexagonal pillar arrays having a periodically absent pillar in the center of each hexagon were pattern transferred onto PMMA coated Al film surface via reactive ion etch (RIE) followed by the subsequent guided anodization to produce a long-range ordered vertical pore arrays. Upon further anodization, a self-assembled extra pore was formed in the center of each hexagon in addition to the regular pores formed at the impressions location, thus leading to a pattern increase by 50%. Interestingly, it is seen that the resultant AAO structure can be altered via RIE process time duration, i.e. Al surface topographic modification prior to anodization. Similarly, pattern-doubling phenomenon was observed when a triangular-patterned nanoimprint stamp was used, by producing self-assembled central pores in the center of all triangles as well as guided pores at the impressed location, thus increasing the total number of pores by a factor of two.

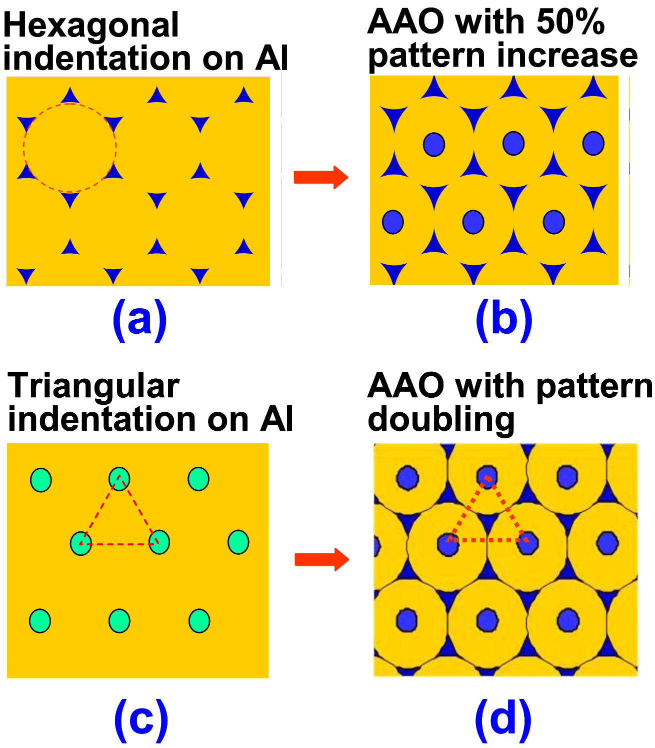

Fig.1 Schematic illustration of guided anodization process: (a,b) Hexagonal indentation followed by anodization and (c,d) triangular indentation followed by anodization

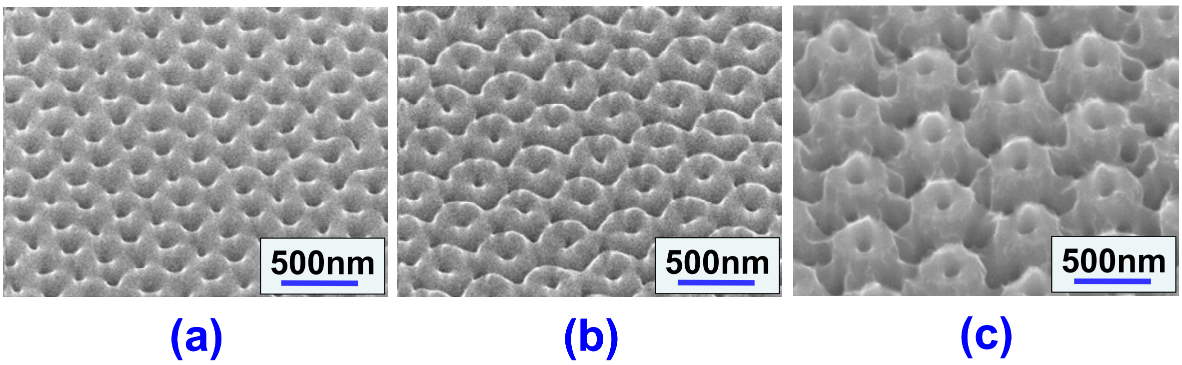

Fig.2 SEM micrograph representing the resultant AAO morphology via Al film surface engineering prior to anodization. (a) nanoporous, (b) nanodonut-like, and (c) nanotubular AAO