Di-block Copolymer Directed Anodization of Hexagonally Ordered Nanoporous Aluminum Oxide

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Abstract

Porous anodized aluminum oxide (AAO) nanostructures have been extensively investigated as versatile templates for nanodots and nanowires for many applications. Such self-ordered AAO structures are often achieved by so-called two-step anodization. Ordered pore arrangements can be obtained in the second step after removing AAO layer formed in the first anodizing step during which hexagonally ordered, concave-pored Al surface is formed so as to serve as vertical pore nucleation sites for the subsequent anodization step. While such a two-step anodization process has proven useful for bulk Al surface, the relatively large amount of Al material that needs to be used up to obtain well ordered AAO template is an issue when the starting material is a controllably deposited thin film layer of Al rather than a bulk Al foil. For example, for the case of Al films on Si substrate, unless pre-texturing techniques such as focused ion beam, electron beam and nanoimprinting are utilized, sub-50nm scale, well structured nano pattern vertical pore arrays are not always easy to obtain.

In this report, we demonstrate successful fabrications of ordered and vertically aligned AAO nanopore patterns directed by hexagonally patterned PS-b-P4VP di-block copolymer layer placed on the Al film surface. Di-block copolymers have been extensively studied in recent years for guided nano island formation for high-density information storage in magnetic recording media. Al film was sputter-deposited on Si substrate at low temperature to improve surface smoothness.[1] Prior to Al film deposition, Au film was deposited to serve as electrode during electrodeposition after anodization process. A solution containing PS-b-P4VP di-block copolymer was spin coated on Al film on Si substrate. The sample was then solvent annealed to induce mobility and allow a nanoscale phase separation to occur. The di-block copolymer surface nanopattern so achieved was then transferred by reactive ion etch (RIE) process to create nucleation site nanopits on the Al film surface. Subsequent anodization of the Al film in a sulfuric acid containing solution led to the formation of self-ordered AAO pores with improved and nanoscale dimensions. Various metal nanowires can be obtained using the AAO pore array template structure utilizing electrodeposition method. Here, we have demonstrated a successful deposition of magnetic nanowires such as Ni into the AAO nanopores and studied their magnetization properties.

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[1] K. Noh, C. Choi, J.Y Kim, Y. Oh, K. S. Brammer, M. C. Loya, and S. Jin, *J Vac. Sci, Technol. B,*. 28(6), C6M88 (2010).

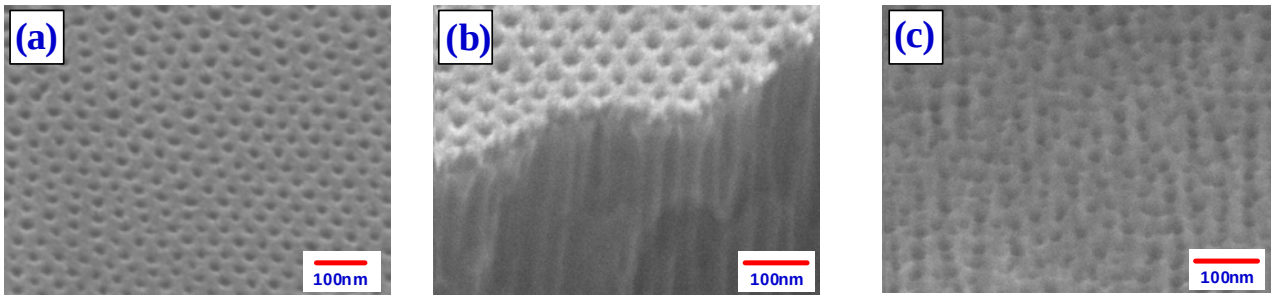

Fig. 1 SEM micrographs of (a) solvent annealed PS-b-P4VP film on Al thin film (before anodization), (b) AAO templates directed by PS-b-P4VP film and (c) control AAO templates anodized under identical conditions but without being guided by the PS-b-P4VP nanopattern.