

Patterning of Nanoporous Anodic Aluminum Oxide Arrays by Using Sol-gel Processing, Optical Photolithography and Plasma Etching

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Anodic aluminum oxide (AAO) membranes, self-ordered nanoporous arrays, are attractive for many technical applications in the rapidly growing nanotechnology field.¹⁻⁴ AAO membranes have been shown to serve as templates for fabrication of diverse nanostructures and membranes from other materials (e.g. polymers and metals).^{1,2} The modification of the AAO membrane pores with metals or semiconductor materials will be useful for the fabrication of novel materials and devices with new properties and functions. In addition, AAO membranes can be fabricated with a very high aspect ratio of pores. All of these properties make these nanoporous arrays very promising for application in design of new nanotechnology products, such as sensing devices, adsorbers, pre-concentrators, gas and liquid transport fields or membranes in microreactors or micro-power sources.

Despite many attractive features, freestanding AAO membranes have drawbacks that may limit their facile integration into micro- and nano- devices. They lack electrical conductivity and have low mechanical strength. One possible approach to address these issues is to fabricate the patterned AAO arrays in which regions composed of nanoporous aluminum oxide alternate with regions composed of aluminum. In this report, we show the application of a sol-gel procedure, optical photolithographic patterning with plasma etching and a two-step anodization procedure⁵ to fabricate the patterned AAO arrays. The fabrication process includes the following main steps. Initially, a layer of aluminum is thermally evaporated onto silicon wafers. A silica layer is then deposited by spin coating a sol solution. Next, standard optical photolithography methods are employed to create a patterned layer of a photoresist. Subsequently, the pattern of photoresist is

transferred to the underlying layer of silica by fluorocarbon plasma etching. Finally, a two-step anodization procedure is applied to fabricate nanoporous AAO arrays only in the areas that do not contain silica.

Deposition and etching of the silica layer were monitored by spectroscopic ellipsometry. Electrical measurements were performed to investigate the ability of the silica layer to act as a barrier that prevents anodization of aluminum. The structure of patterned AAO arrays was studied by scanning electron microscopy. A clear boundary was observed between two regions: one with pores arranged in an approximately hexagonal order and the other with no pores. The patterned AAO arrays have two key advantages over other AAO arrays. These arrays exhibit high mechanical strength and possess electrical conductivity, due to a rigid support made of aluminum. These properties will facilitate the incorporation of patterned AAO arrays into micro- and nano-devices. In addition, all the fabrication steps were carried out using standard microfabrication tools and can be integrated into a suitable fabrication line.

References.

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