Anodized aluminum oxide as a template for fabrication of nano-structures: metal / metal oxide / pores

Dmitri A. Brevnov,[§] Tim S. Olson,[§] Marcos J. Barela,[§] Todd M. Bauer,[†] Gabriel P. López,[§] Plamen B. Atanassov[§]

Email: dbrevnov@unm.edu, Phone: (505) 277-2563, Fax: (505) 277-5433

§ Department of Chemical and Nuclear Engineering, Center for Micro-Engineered Materials, University of New Mexico, Albuquerque NM 87131, USA and † Sandia National Laboratories, Albuquerque, NM 87185, USA.

Anodic aluminum oxide (AAO) arrays are self-ordered porous structures, which are suitable for many technical applications. These arrays are attractive for design of nanotechnology devices because of the hexagonal pore arrangement, a very high aspect ratio of 1000 (pore length to pore diameter) and a high pore density of 10^{11} pores/cm^2.

In this presentation, we describe a novel procedure (Figure 1) for the fabrication of patterned AAO arrays by using a dense barrier aluminum oxide layer as the anodization mask. This fabrication procedure includes the following steps. The aluminum is patterned with a photoresist and then briefly anodized at a high voltage, which produces a dense layer of barrier aluminum oxide. The photoresist is then removed and the aluminum film is again anodized at a low voltage to grow porous aluminum oxide. The dense barrier aluminum oxide acts as an anodization barrier thus leaving the underlying aluminum intact. As a result, fabricated AAO arrays (Figure 2) consist of alternating regions of porous aluminum oxide and aluminum metal perpendicular to the silicon substrate.

AAO arrays are suitable templates for non-lithographic fabrication of an array of nanoelectrodes. The electrodes can be made, for example, by electrodeposition of gold inside the pores of AAO arrays. For the functional array of nanoelectrodes, it is important to deposit continuous columns of gold. Electrodeposition of continuous columns of gold is facilitated by decreasing the thickness of the barrier oxide layer formed during porous-type anodization of aluminum. The thinning of the barrier oxide layer can be accomplished by the voltage reduction method originally implemented for detachment of the AAO membrane from the underlying aluminum support. As a result of this method, the thickness of the barrier oxide layer decreases, because it is linearly proportional to the applied voltage. In the second part of this presentation, we report a procedure aimed at (1) fabrication of AAO arrays with hexagonally arranged pores, (2) thinning of the barrier oxide layer and (3) electrodeposition of gold into the pores of AAO arrays. The continuous columns of gold are expected to function as an array of nanoelectrodes (Figure 3), which can be utilized for a diverse number of applications in analytical chemistry.

Topic: Nanomaterial

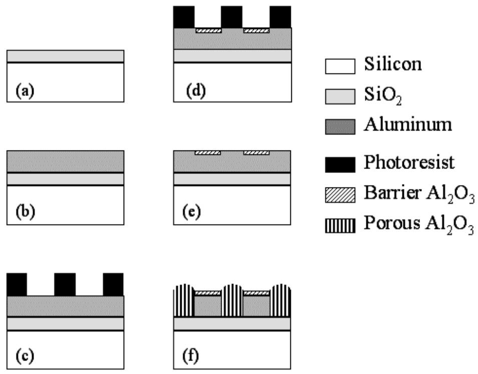

Figure 1. Schematic of the fabrication method

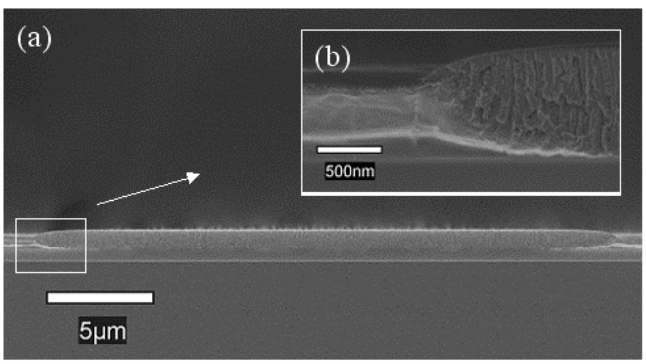

Figure 2. (a) SEM micrograph of a patterned feature, showing both porous aluminum oxide (middle) and aluminum covered by dense barrier aluminum oxide (left and right). (b) SEM micrograph: the cross sectional view of the interface between the porous anodic aluminum oxide and aluminum.

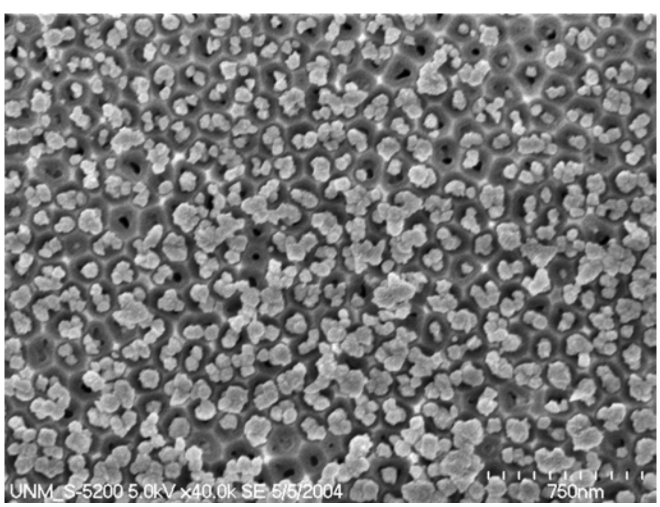

Figure 3. SEM micrograph of an AAO template with embedded gold nano-rodes.