Freestanding Alumina Membrane by Double-Layer Anodization

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Principal Investigators: Michael G. Spencer, James N. Turner
Users: Xingqun Jiang, Nirankar Mishra

Affiliations: School of Electrical and Computer Engineering, Cornell University; Wadsworth Research Center, Albany, NY
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Contact: spencer@ece.cornell.edu, turner@wadsworth.org, xj22@cornell.edu, nirankar.mishra@gmail.com

Abstract

Anodic alumina membrane has been of great interest because of its unique nano-porous structure. Here a double-layer anodization (DLA) [1] has been developed for fabricating full or partial freestanding anodic alumina based on a silicon substrate. A microfluidic channel formed by alumina membrane is also demonstrated. For its simplicity and flexibility, DLA is expected to be a useful approach in anodic aluminum oxide (AAO)-related applications.

Experimental Research

In our DLA method, a sacrificial metal layer (Cu or Ag, 50 nm thick) is introduced between an Al film (200 nm thick) and an Si$_3$N$_4$ substrate by evaporation. A freestanding alumina film at wafer scale is successfully achieved by anodizing the double metal layer at 20 V dc in 0.3M H$_2$SO$_4$ at room temperature, during which the alumina is spontaneously stripped off the Si$_3$N$_4$ substrate due to the anodic oxidation of the sacrificial layer (Figure 1). The barrier oxide at the bottom of the alumina film is effectively removed either by H$_3$PO$_4$ dissolution or by CF$_4$ reactive ion etching, making the alumina film a through-hole membrane (Figure 2). The freestanding alumina film is utilized as a contact mask to transfer its nanoporous pattern to a Si substrate. By patterning the sacrificial metal layer with contact lithography, a partial freestanding alumina film is successfully achieved on the silicon chip, producing a...
unique micro/nanofluidic channel (Figures 3-4). Compared with previous techniques, the method reported here is advantageous for its simplicity and flexibility.

**Summary of Research**

The difficulty of fabricating freestanding AAO films is essentially the stripping of the AAO from the substrate. DLA makes this stripping process simple by adding an extra metal layer for lift-off purpose. The Al anodization and the AAO stripping are simply merged as a one-step fabrication, requiring no additional process. Another unique feature of DLA is its capability to produce partial freestanding AAOs, which would be interesting to the fields such as nanofluidics.

**References**


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*Figure 3, top: A microfluidic channel by a partial freestanding alumina film.*

*Figure 4, bottom: High magnification view of Figure 3.*