Template-Based Nanowire Fabrication

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Abstract

Nanoscale structures often bring about distinct and fascinating properties for many materials. By applying multiple steps of electrochemical procedures, a thin layer of porous alumina can be obtained. The porous alumina layer is, then, used as a template to grow metal nanowires. We explored various experimental procedures and optimized several parameters to form porous structure with lengths of 100 - 900 nm (nanometer) and diameters of 50 - 90 nm. The results are verified by the images taken from JEOL JSM-6700F Field Emission SEM and Veeco DimensionTM 3100 AFM. The precise control of nanowire growth has important applications in many fields of bioresearch. The current investigation of the interaction between uniform nanowire structures and cell growth aims to elucidate how live cells interact with nanoscale morphology, with potential applications in single-cell interrogation and nanomedicine.

Introduction

What makes this material so interesting?

- Unique shape of uniform hexagonal porous structure
- Can be potentially employed as templates to grow nanowires on large scale

Objective

The most critical:

- To understand, control and optimize experimental parameters which allow the growth of porous alumina with desirable length and size
- To study and optimize the method which allows the growth of porous alumina all the way down to the coated metal layer

Method

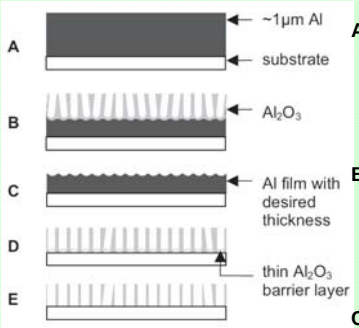


Figure 1. Adapted from:
Melissa S. Sander and Le-Shon Tan,
Advanced Functional Materials **13** (5), 393 (2003).

A) About 1um aluminum film is evaporated onto the silicon (Si) substrate with 35 nm gold (Au), 5 nm titanium (Ti) and 100 nm silicon dioxide (SiO2) coating on the top.

B) The aluminum film is partially anodized, and this process is named first anodization. The anodization is carried out in the sulfuric acid at 0-3º Celsius by applying ~23-25 v DC.

C) The first alumina film is removed using a chemical etch. The purpose of this step is to set up better uniformity on the remaining film surface. This allows better vertical growth of porous alumina in the subsequent step.

D) All of the remaining aluminum is anodized, leaving only a thin aluminum barrier at the pore bottom.

E) The barrier is thinned by etching the sample using phosphorus acid. Pores further reach down by employing a decreasing voltage anodization step which forms size-shrinking alumina while rapidly approaching the bottom of aluminum film. The starting voltage is set to be 23 v, and is decreased at rate of -0.7 v/min, -0.5 v/min, and -0.3 v/min, sequentially, until the threshold voltage of 4 v is reached.

Conclusion

- Large area of uniform porous alumina is obtainable using the electrochemical deposition method.
- Pores with different length can be made without sacrificing structural properties.
- Variable voltage method can be adapted to lower the residual aluminum.
- A direct contact between porous alumina and beneath surface can be achieved.

Future Work

- A variety of nanowires can be grown by adapting this template-based fabrication method.
- The interaction between uniform nanowire structure and cell growth can be studied.

Results

1. Layer of uniform porous alumina has been obtained.

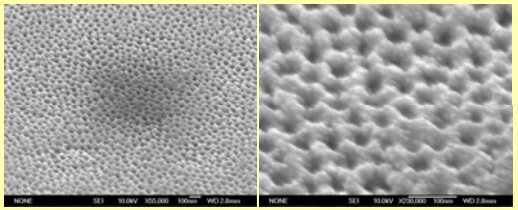
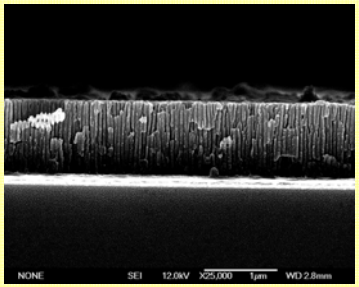


Figure 2 & 3. Top down view of the porous alumina

2. Pores with different length have been grown.



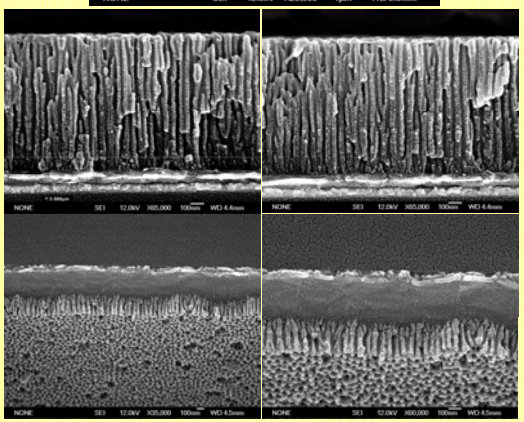


Figure 4, 5, 6, 7, 8. Cross-sectional View of the porous alumina.
Figure 4-6 features pore length of ~850 nm
Figure 7-8 features pore length of ~150 nm

Acknowledgement

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