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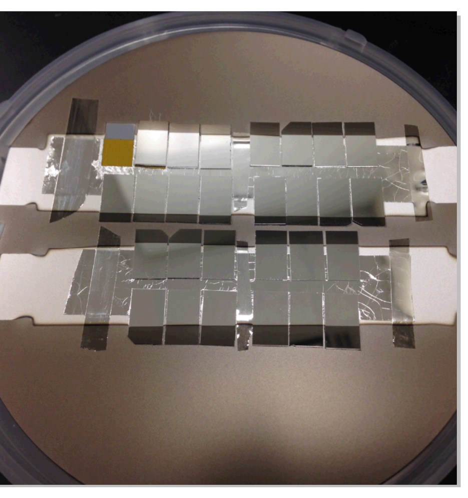

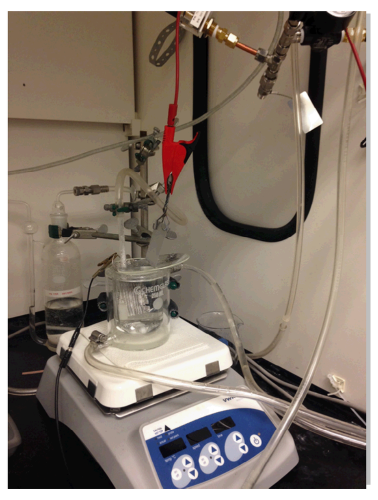

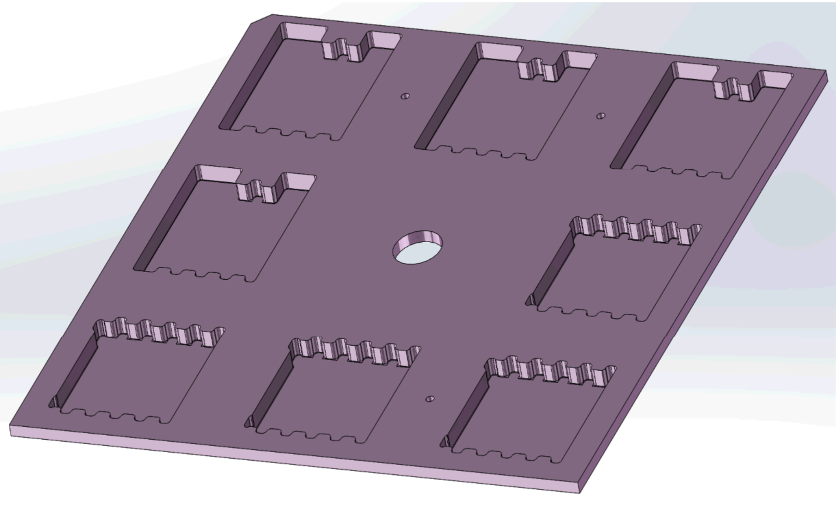

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Anodization As A Low Cost, Scalable, and Tunable Nanoscale Manufacturing Technique

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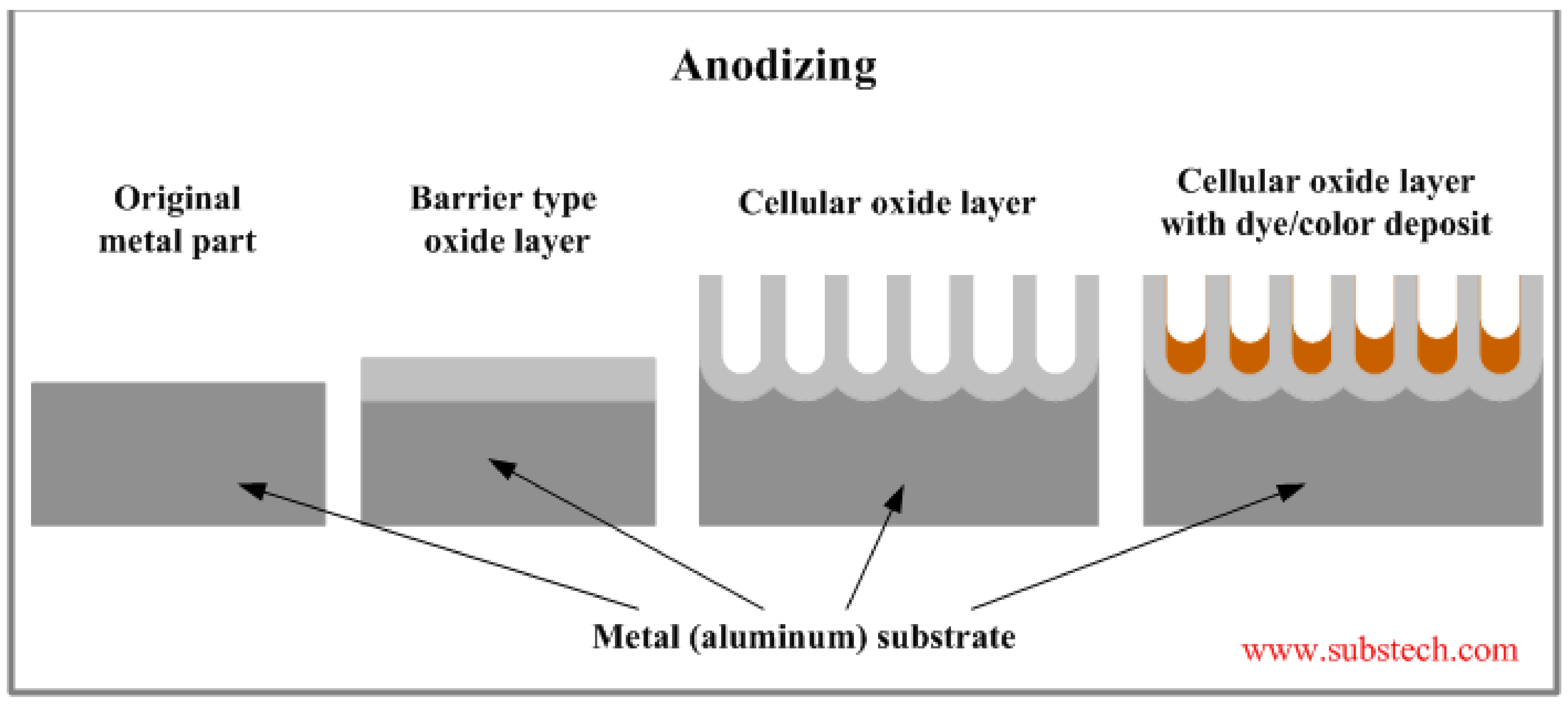
Abstract

We explore the application of anodization of aluminum as a low cost, efficient, and highly scalable technique useful not only for manipulation of macroscopic properties of materials, but also as a starting point for the creation of nanoscale metallic structures. Using simple chemical setups and software controls, we have been able to selectively anodize aluminum, without affecting underlying substrate. This process has yielded alumina samples suitable for further development.

Introduction

Anodization is a method of modifying metals that has been used since 1923, when it was particularly useful as a corrosion barrier. The process is an electrochemically accelerated form of oxidation, which occurs naturally; however, the oxide layer formed by anodization is as much as 3 orders of magnitude thicker than the layers found naturally. In addition, due to the acidic conditions of most anodization baths, micropores are formed from the dissolution of the aluminum oxide at surface defects, such as grain boundaries. Using this, one application of anodization explored thus far has been the creation of porous templates as templates for catalysis of carbon nanotube growth. The second has been the anodization of aluminum to produce components used in thermoelectric stacks. These stacks rely on specifically controlled electrical contacts between opposing semiconductor filaments; the alumina is therefore useful as an insulating support structure for the stacks.



Various results of anodization

Images in side panel, clockwise from top: A single cell in the stack array; setup for anodization of stack array; CAD model of stack array

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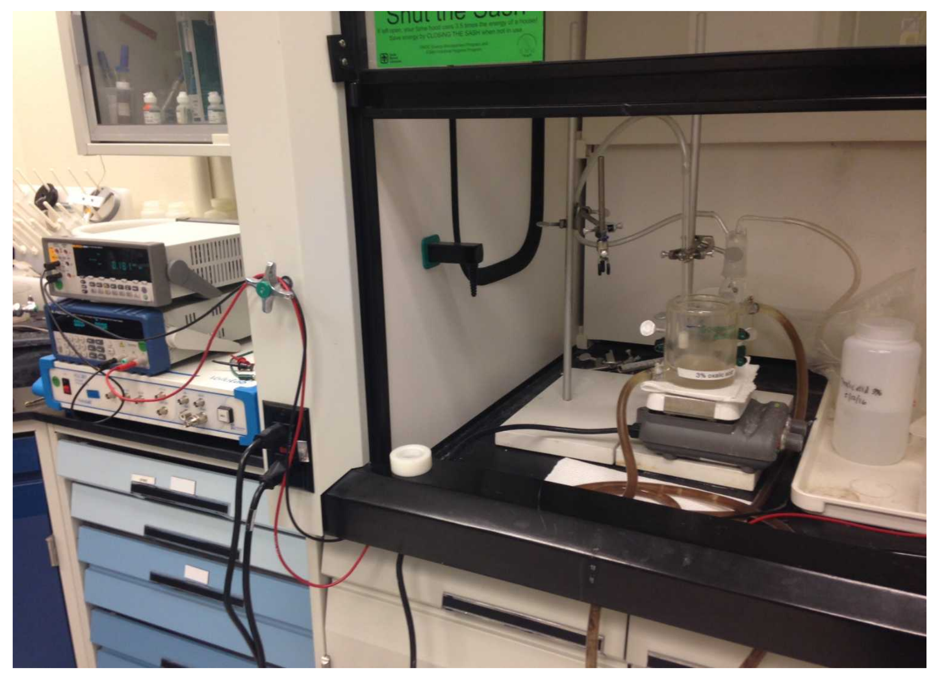
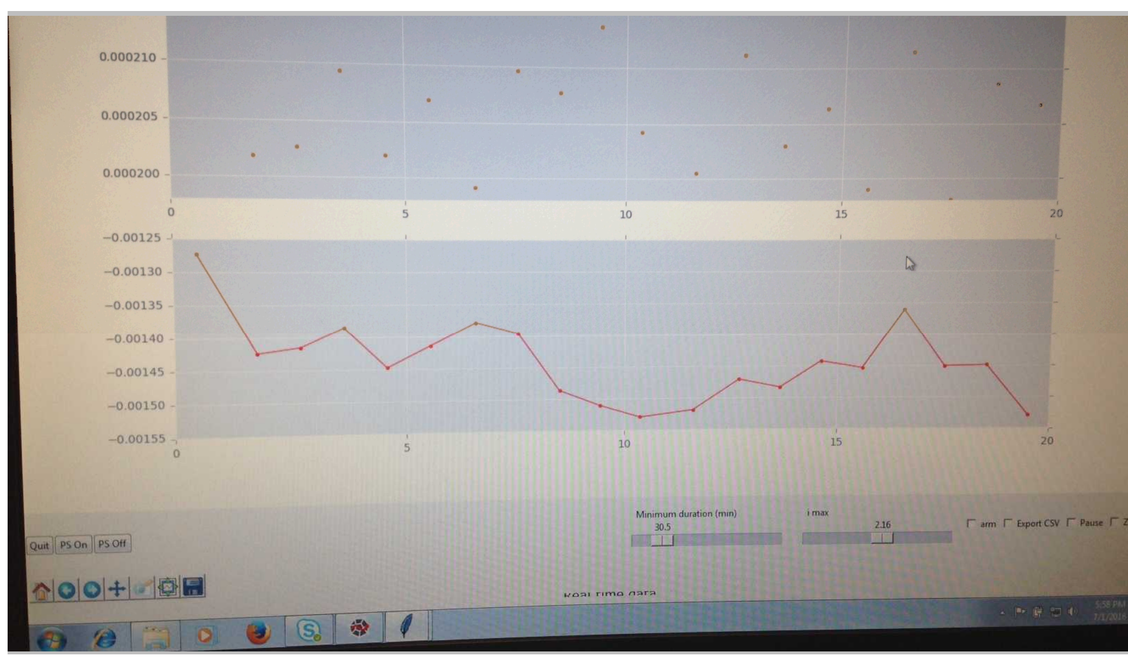
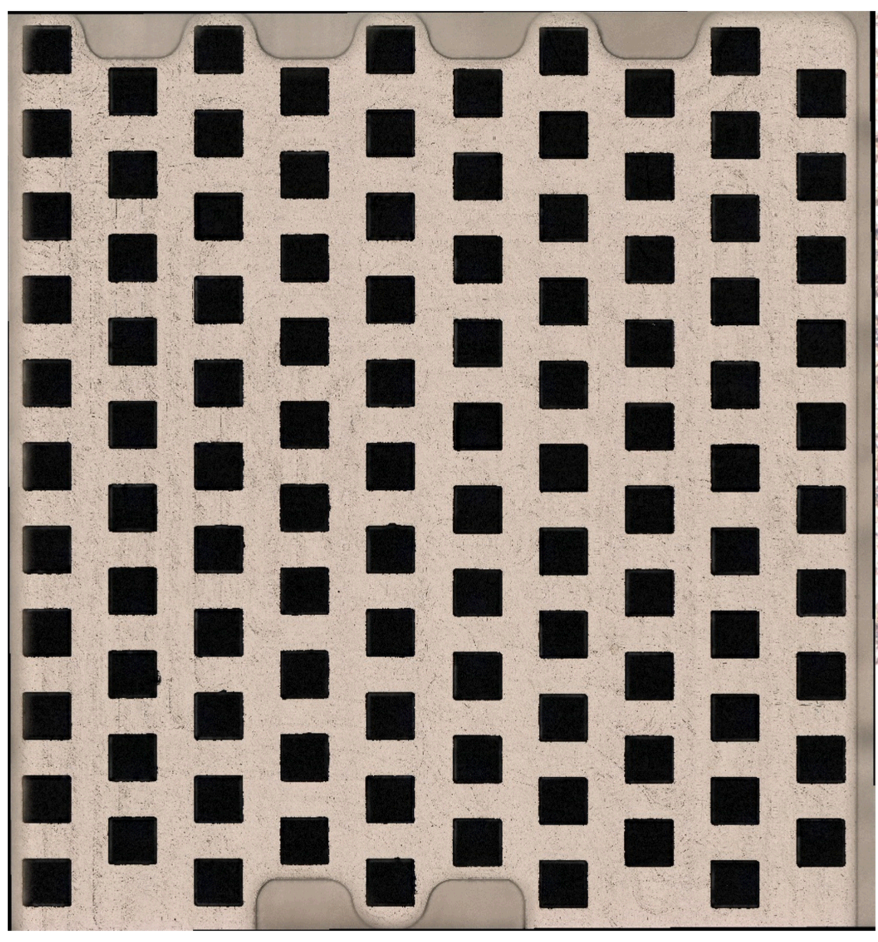
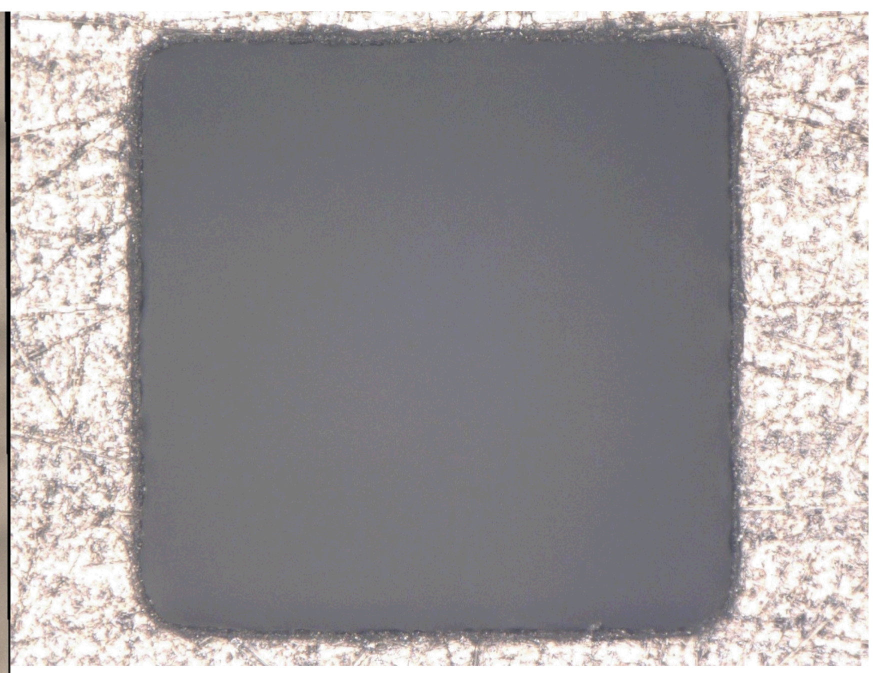




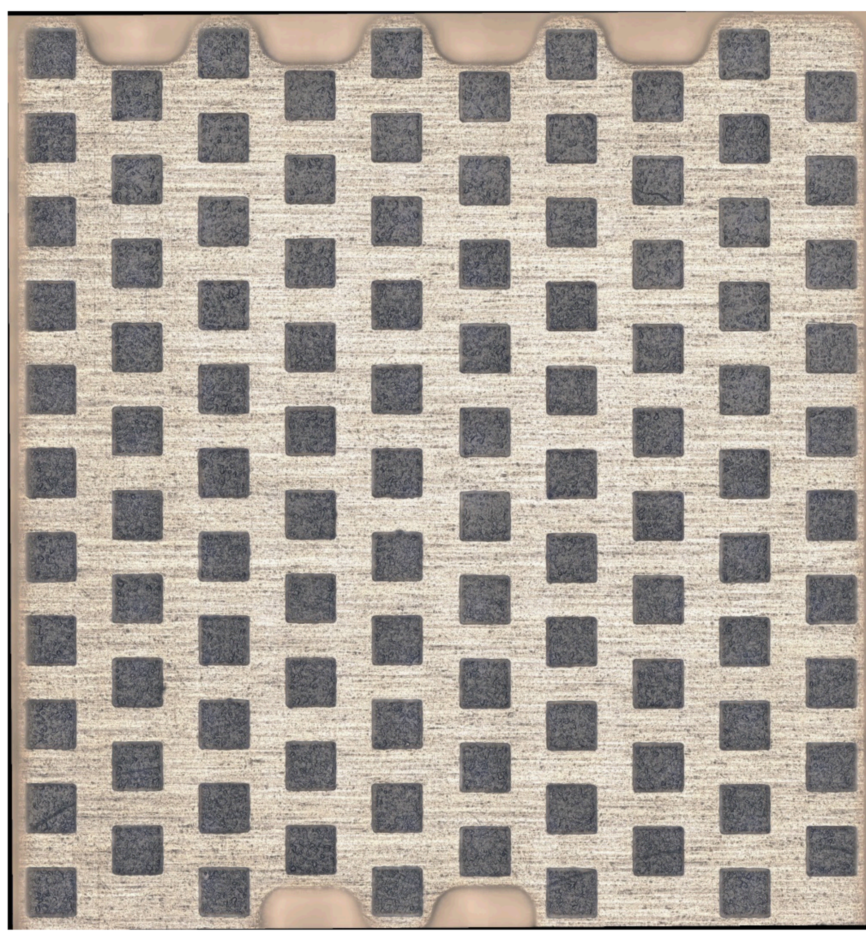
Methods

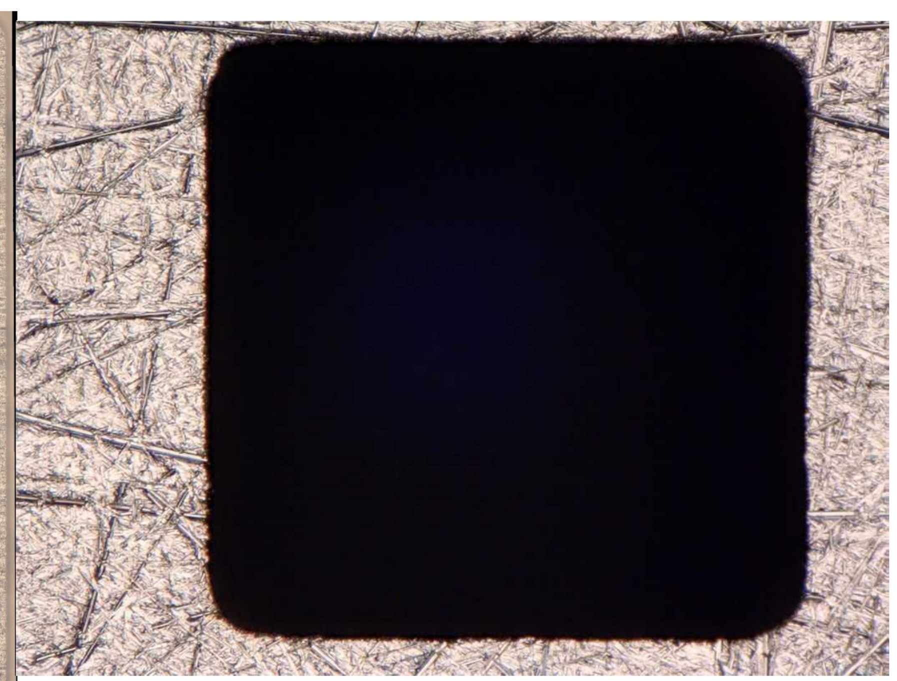
The process begins with unanodized aluminum. For the CNT templates, the aluminum is atop a stack of tungsten, titanium, and sapphire; for the thermoelectric stack, it is a standalone machined piece. The metal is then introduced to an acid bath, along with a counterelectrode. The anodization then proceeds, controlled by custom Python software that controls the length of anodization based on the appropriate parameter for each process.





Full array and single cell: pre-anodization





Full array and single cell: post-anodization

Results/Discussion

We have been successful in anodizing aluminum in a highly controlled manner, to the point where human monitoring is no longer required to get consistently good results. In the stack arrays, we've seen appropriate amounts of material growth, as well as loss of conductivity. The CNT templates could only be studied based upon conductivity, due to the nanoscopic nature of the structures being formed. Unfortunately, we discovered that there was an issue in these samples, stemming from the sputtering process that deposited the aluminum. We anticipate moving forward with this project once that issue is resolved. The anodization, however, seems to be successful for both applications at this time.

Images in panel, left to right: Example data readout from CNT anodization process; CNT anodization setup; interface for Python script

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