Fabrication of Highly Ordered Alumina Template

Ryan D. Corpuz, Lyn Marie Z. De Juan

Abstract— Fabrication of ordered alumina template through soft and hard anodization processes using aluminum foil and thin aluminum sheet metal in 0.3M oxalic acid at constant voltage of 40 V for the former and 120 V for the latter and a current density of 5mA/cm2 was done. Morphology characterization through Scanning Electron Microscopy (SEM) showed that soft anodization using aluminum foil produced smaller pore diameter than hard anodization using aluminum thin sheet.

Index Terms— Anodization, AAO, hard anodized, SEM, soft anodized

1 INTRODUCTION

Anodization is more than a century old method of fabrication. It is commonly employed in metals as coatings for the protection of metallic surface from corrosion and environmental degradation, and at the same time enhances its aesthetic value. Anodization becomes an attractive method for commercialization not only for the quality of product, but most importantly, for its simplicity, inexpensiveness and fastness which is highly desirable for mass production.

Advancement in understanding, especially in the field of nanotechnology gives way for the rebirth of this old school method. Today, anodization becomes a popular process for fabricating highly ordered array for patterning of highly demand materials which has unique applications in semiconductor technology [1].

One of the favorite materials used as template for patterning is aluminum. It was observed that anodizing aluminum metal with the presence of acids such as sulfuric, oxalic and phosphoric produces self organized hexagonal oxide layer on the metallic surface which is highly ordered [2]. Most of the time, Sulfuric is used for creating ordered small pore sizes, oxalic for medium pore sizes and phosphoric for large pore sizes.

At first, it was observed that the ordered pattern is only short range, later on with continues research, long range order could now be fabricated given the proper control of initial surface roughness of metal [3], electrolyte concentration [4], temperature [5-6], voltage [6], electric field [7], and anodization time [8]. In addition, to achieve a good quality alumina template, multiple anodizing steps is recommended.

This study aimed to fabricate a highly ordered anodized aluminum oxide using two aluminum substrates: aluminum foil and aluminum thin sheet metal. The researchers utilized soft anodization for aluminum foil (anodization at medium voltage of 40V) and two step anodization procedure which includes the soft anodization as the first step and hard anodization at higher voltage of 120V as the second step for aluminum thin sheet.

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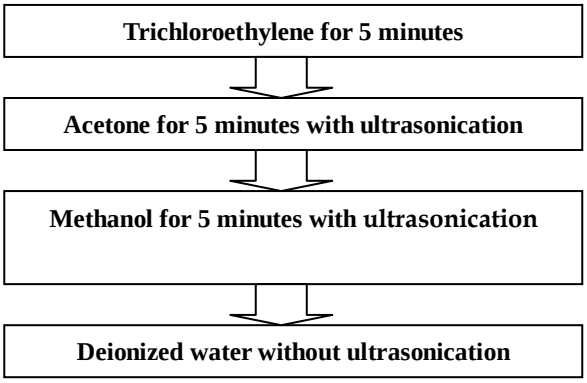
2 EXPERIMENTAL

2.1 Preparation of Aluminum foil and aluminum thin sheet metal substrate for Anodization

Preparation of aluminum foil and aluminum thin sheet metal substrate for anodization followed the step by step procedure outlined below.



These steps are necessary in order to prepare the surface of metal for a better quality anodized aluminum oxide.

2.2 AAO Template preparation procedure

2.2.1 Soft Anodization

After the preparation of aluminum foil substrates, it was then anodized in dilute 0.3 M oxalic acid solution at a DC voltage of 40 V and a current density of 5mA/cm2. This is done to transform the aluminum surface to aluminum oxide through anodic deposition. After anodization, the samples were then emerged in 5 wt % phosphoric acid for pore widening.

2.2.1 Hard Anodization

The first phase of hard anodization is similar to soft anodization except that the substrate is no longer aluminum foil but thin sheet aluminum metal. The second phase however was

done by gradually changing the voltage from 40V up to 120 V followed by pore widening in a 5 wt% phosphoric acid.

2.3 Characterization

Both aluminum foil and thin sheet metal samples were then characterized using Scanning Electron Microscope (SEM). This was done to view the pore size dimensions and visualize the degree of orderliness and regularity of pores on the aluminum substrate.

3 Results And Discussion

This study aimed to fabricate a highly ordered aluminum oxide by means of soft and hard anodization. Fabrication of these anodized aluminum oxides (AAO) was done by preparing first the surface of aluminum substrate followed by anodization in a 0.3 M oxalic acid under constant voltage and current density of 40V and 5mA/cm2 respectively. A second step anodization however is necessary for the preparation of hard anodized aluminum oxide. This step was done by gradually increasing the voltage up to 120 V and allowing the reaction to take place for 2 minutes upon reaching the desired voltage. For each anodization step, immersion into a 5 wt% phosphoric acid was done for pore widening.

Shown in the succeeding figures are the SEM micrographs of soft and hard anodized alumina.

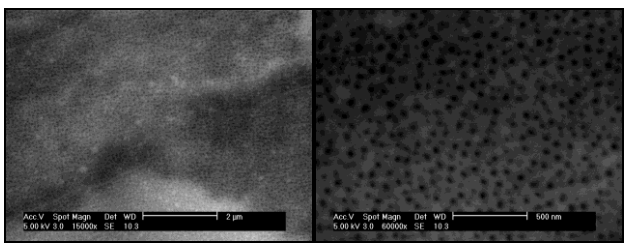


Fig. 1. Soft anodized aluminum oxide using aluminum foil

The SEM micrograph shown in Figure 1 is the surface of the substrate after soft anodization of aluminum foil. It is visible in here that the pores are regular and the diameters of these pores are about 40 to 60 nm.

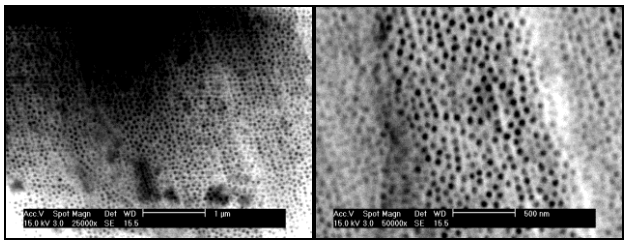


Fig. 2. Hard anodized aluminum oxide using thin aluminum sheet

Figure 2 shows the regular pattern after hard anodization of thin aluminum sheet. The pore diameter produced in this two step anodization process is around 50 to 70 nm. Evident from this micrograph is the uneven surface of the aluminum metal surface prior to anodization.

4 Conclusion

Fabrication of ordered soft and hard anodized aluminum oxide templates was successfully made using aluminum foil and thin aluminum sheet metal. Investigation of the substrate surfaces through Scanning Electron Microscopy (SEM) showed that soft anodized aluminum has smaller pore dimensions compared to two step hard anodization.

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