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Obtaining Porous Structures in the Form of Parallel Plates on Aluminum Substrates

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ABSTRACT

We report how to obtain self-organized porous microstructures of Anodized Aluminum, using high purity Aluminum substrates of 1 cm^2 and 0.5 mm, 0.13 mm thick. Microstructures were obtained by electrochemical attack, using a solution of NaOH and $H_2C_2O_4$ at a temperature of 55 °C, 20V and attack times of 10, 20, 30, 60, 120, 180, 240 minutes. As a result, micrographs showed pores in the form of parallel sheets of aluminum oxides and hydroxides said according to the characterization tests.

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Introduction

Aluminum has a natural tendency to oxidize and to form a surface layer of aluminum oxide or alumina (Al_2O_3); this natural process can be carried out in a controlled way by a surface treatment called "anodized". This process uses aluminium as an anode and uses some chemically stable metal as a cathode, in the presence of an electrolyte. This process will modify its structural, physical, and chemical properties depending on the conditions of the system, like voltage, temperature, time of exposition, type of electrolyte, among others. There are two types of anodic films that can be formed, the barrier type and the porous type. The barrier type film is formed in insoluble electrolytes and the porous type of film are formed in slightly soluble electrolytes. The present work is developed in the latter line, using developing porous type films to obtain new materials and develop new technologies [1-10].

This type of porous structures with structural defects can be considered as non-ideal microcavities such that they can be used for the study of "slow light" to modulate the electromagnetic energy spectrum and therefore its optical properties. On the other hand. In the semiconductor industry, these porous structures can be used as photonic crystals, to which atoms can be selectively incorporated in these cavities or even to develop or improve acoustic devices since it is possible to control wave propagation, as you can see the applications are various and go hand in hand according to technological advances [11-13].

Methodology

Al sheets measuring 0.5 mm and 0.13 mm thick with areas around 1 cm^2 (99% Aldrich brand purity) were used and degreased with a 10% NaOH (Reactivos Quìmica Mayer-Reactive grade) solution for at least 30 seconds, were washed with deionised water and neutralized with a solution of HNO_3 (Sigma-Aldrich ACS reagent, 70%) 10% for several seconds in order to eliminate roughness on the surface. Subsequently, a chemical elerctro attack was carried out using a solution of NaOH/H_2O and (Sigma-Aldrich 98%) $H_2C_2O_4$/CH_3OH (Reactivos Mayer 99.8%) at 55ºC and different molar ratios ranging from 1 to 5 M. A titanium wire was used as a cathode and the Al foils previously treated at attack times as an anode of 10, 20, 30, 60, 120, 180, 240 minutes [9, 10].

Results

Most of the substrates attacked electrochemically showed luminescence with the naked eye. porous structures can be seen in the form of parallel plates that are characteristic by the SEM (JEOL model JSM-6810LV) that operated at the acceleration voltage of 20 kV (Figures 1 and 2).

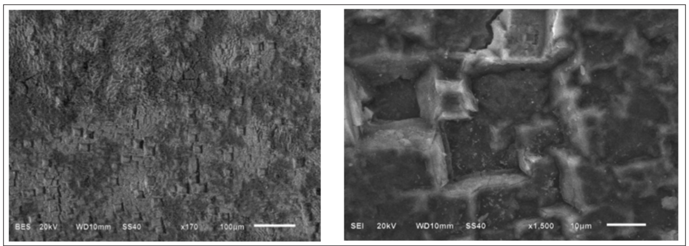

Figure 1 and 2: SEM image of an attacked Al lamina with a 4 M NaOH solucon and 1.5 $H_2C_2O_4$ at 30 min (Sample 1).

Table 1 EDS of Samples 1 and 2

	Al	C	O	Na
Sample 1	46 %	18 %	34 %	2 %

The materials were characterized by photoluminescence (He-Cd laser 50 mW) and showed signs with wide peaks at 445, 475, 495, 540, 590, 648, 650, 705 nm. That are typical signs Al_3, Al_2O_3, Al_xO_x.

In general, the materials showed pores in the form of two parallel sheets characteristic of aluminium hydroxides, it was observed that these structures can be accessed by applying a film of the solution in question without the need to apply electric current which leads to a surface wear. The formation of such structures can be explained according to the theory Frank - Van der Merwe which explains formation of epitaxial films of aluminum oxides and hydroxides. the results suggest that a mixture of porous aluminum oxides (Al_xO_x) and hydroxide was obtained in the form of two parallel plates, the presence of C and Na in the elemental analysis suggests the formation of other compounds in low concentration described in the following way:

$2\ Al + 2\ NaOH + 2\ H_2O \rightarrow 2\ NaAlO_2 + 3\ H_2$

$2NaAlO_2 + H_2O \rightarrow Al_2O_3 + 2NaOH$

$Al_2O_3 + 2\ NaOH + 3\ H_2O \rightarrow 2\ Na+ + 2\ [AI(OH)_4]^-$

$Al\ (OH)_3 + NaOH \rightarrow Na+\ [Al(OH)4]^-$

$NaAlO_2 + 3H_2C_2O_4 \rightarrow [Al\ (C_2O_4)\ 3H_2O]^{-3}\ Na^{+3}$

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