Morphology Control of Anodic Porous Alumina Using Nanoimprinting

S. Iwasaki[1]*, K. Nagato[1,2], L. Wang[1], Y. Li[3], J. J. Delaunay[1], M. Nakao[1],
[1]*Department of Mechanical Engineering, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan,*
[2]*Research Fellow of Precursory Research for Embryonic Science and Technology (PRESTO), Japan Science and Technology Agency (JST)*
[3]*Department of Chemical System Engineering, The University of Tokyo*
**iwasaki@hnl.t.u-tokyo.ac.jp*

Porous alumina is an electrochemically fabricated oxide film on an aluminum surface, in which pores are arrays of parallel cylinders organized by anodization.[1] The ordered porous array can be applied into a variety of devices such as a template for nanostructures of patterned media, electrodes of capacitors or Li batteries, and photonic crystals. Features of self-organized pore array are determined by the anodization condition. Both pitch and diameter of the pores are dependent mainly on the voltage. Self-organized pores which are fabricated with a constant voltage anodization form triangular lattice array. It is already known that the pitch is estimated when the voltage is less than 160 V.[2] However, the pores can not be fully ordered because alumina pores extend from random dents on the Al surface. Pore diameter is a half or less of a pitch and can not be determined independently from the pitch.

In this work, we control pitch of alumina pores by nanoimprinting, and diameter by dissolution after anodization. Figure 1 shows the process for fabricating controlled porous alumina. The Al surface is nanoimprinted and textured with dents before anodization, in order to induce pores into artificial ordered dents on the surface. The samples are imprinted with triangular lattice dots. The experimental samples were 99.999 % Al, and the anodization was carried out in 0.5 wt% citric or 0.2 vol% phosphoric acid, with various voltages from 140 V to 350 V, which was expected to form porous array with pitches from 350 nm to 875 nm.

The anodized samples with imprinting were observed to form highly ordered porous alumina. On the other hand, samples without imprinting formed alumina with smaller pitches than expected, and pores were randomly arranged on the surface of the samples with different sizes [Figure 2, 3]. Pores extended only from imprinted dents, and not from native ones. It was shown that self-organization is completed if the sample is appropriately imprinted. Pore expansion was observed from 220 nm to 430 nm [Figures 4]. It was achieved to independently control the pitch and diameter of anodic porous alumina.

---

[1] H. Masuda and K. Fukuda, *Science* 268 (1995) 1466.
[2] A. P. Li, F. Müller, A. Birner, K. Nielsch, and U. Gösele, *J. Appl. Phys.* 84 (1998) 6023.

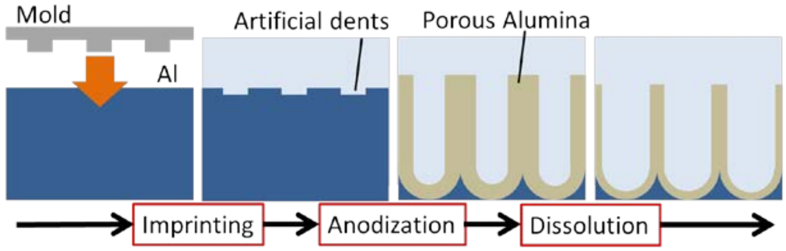

Figure 1: Process for fabricating controlled porous alumina.

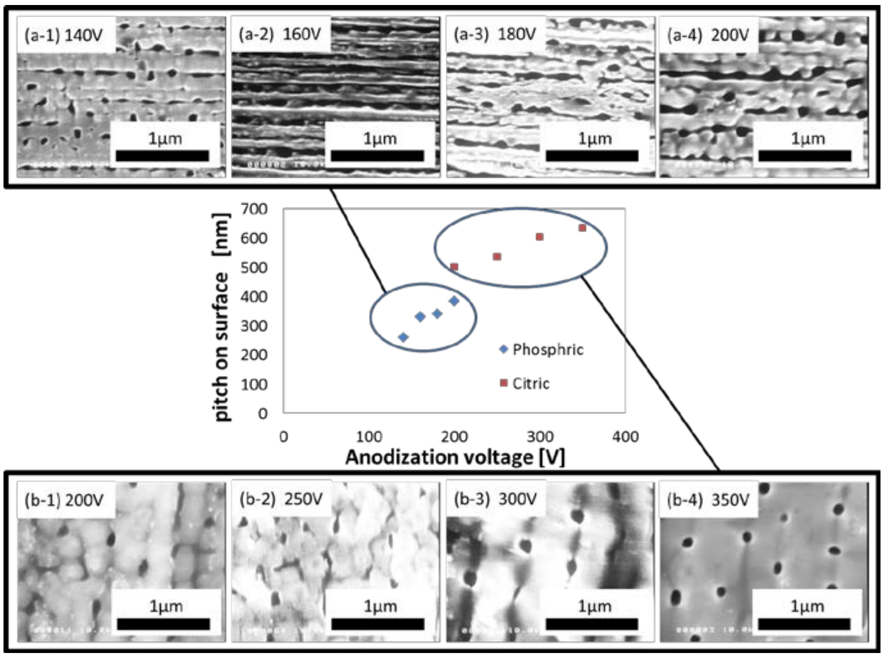

Figure 2: SEM images of anodized samples without imprinting.
(a):in 0.2 vol% phosphoric acid for 10 min
(b):in 0.5 wt% citric acid for 120 min

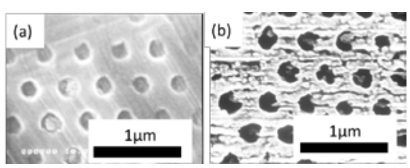

Figure 3: SEM images of imprinted samples before/after anodization
(a):before anodization
(b):after anodized in 0.2 vol% phosphoric acid for 10 min

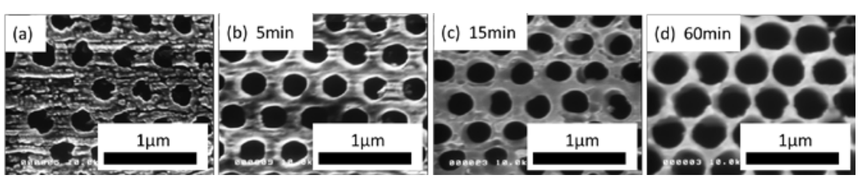

Figure 4: SEM images of expanded 440 nm pitch porous alumina dissolved in 5 wt% NaOH. (a):0min, (b):5 min, (c):15 min, (d):60 min