Flexible anodic alumina nanomembranes

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Traditional technique of alumina membranes production, based on two-step anodizing, was studied. Besides, some disadvantages, such as fragility, time-consuming technique of obtaining membranes and necessity of using a special holder, were also stated. Since their main disadvantage is high fragility, it is necessary, firstly, to create more flexible flat membranes, and, secondly, to form cylindrical nanomembranes, called “tubular”.

Samples were made of 50 and 100 μm thick aluminium foil, both flat and in the form of a tube with a diameter of 6-7 mm. Before anodization samples were annealed at 450°C for 30 minutes and chemically cleaned in diluted NaOH. Studying of samples’ structure was carried out by Atomic Force Microscopy in tapping mode on Scanning Probe Microscope “Solver-Next” NT-MDT. To obtain images, both standard (NSG01) and high-resolution diamond-like cantilevers (NSG10 DLC) were used.

We implemented two-step anodizing technique. For anodizing we used water solution of oxalic acid as an electrolyte at the 1st stage; and a special multicomponent (mixture of oxalic, citric, and boric acid as well as isopropyl alcohol) electrolyte for the 2nd stage to prepare flexible films.

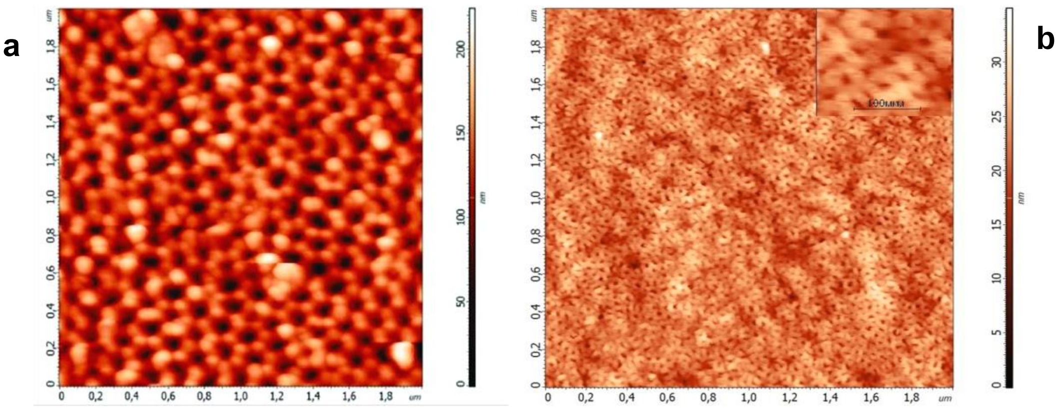

Figure 1. AFM images of: (a) porous layer surface of porous anodic alumina films, (b) barrier layer after their thinning.

From AFM images we got an approximate size of cells (250 nm) and pores (80 nm). It is found that the resulting anodic oxide film had increased elasticity and ability to withstand bending angle of 120°. For removal of films’ barrier layer we used a method of barrier layer thinning “from above”. For that, sequential decrease in voltage was carried out, which led to stepwise reduction of the current. Reaching the zero (or close to zero) value meant appearing of barrier layer permeability.

The next stage in fabrication of nanomembrane was removal of metal in a solution based on $CuCl_2$. After that we got partly permeable membranes, as it is shown in Figure 1a,b. It is seen that this procedure leads to generation of holes of about 20 nm from the side of the barrier layer.

Thus it has been shown that the developed two-step anodizing technique using special multicomponent electrolyte at the 2nd stage allows forming nanoporous alumina films of high flexibility. We found that a method of barrier layer thinning “from above” in combination with chemical removal of metal enables permeable alumina membranes fabrication.