Nanomatrixes on the Base of Anodic Alumina

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ABSTRACT

Anodic alumina is a convenient material for the reception of nanodimensional templates because of its secondary porosity, which is formed by the transformation of anodic alumina in a polycrystalline form. Luminescence of pure and modified anodic alumina was investigated. It is shown that anodic alumina membranes can be used as a host for nanodimensional particles investigations.

INTRODUCTION

The properties of single particles (metal, oxide and others) differ from properties of same bulk material. Investigations of such miniaturized materials are very interest and actual for nanoelectronics but they are possible if one is able to organize them into three-, two- or one-dimensional arrays. Additionally the reproducibility and controllability of particle sizes are necessary. Because of the unique structure porous anodic amorphous alumina films (membranes) are applied as a host for various microparticles [1-4]. The size of introduced inclusions is defined by the through pores size, the diameter of which is possible to vary controllably from 13 up to 300 nm.

It is known that initial anodic alumina films have natural regular cellular-porous structure [5, 6]. Anodic aluminium oxide consists of a compact barrier layer directly attaching metal and located over it thick porous layer. The porous layer consists of regular hexagonal cells, which are parallel to each other and create normal to normal to the initial surface. Each individual cell has a central axial pore reaching up to barrier layer. A schematic illustration of the porous film structure is shown in figure1. It has been established that the steady-state barrier layer thickness, cell diameter (D), which is equal to the "width" of the hexagon, and pore diameter (d) are directly proportional to the formation voltage [5]. Porous anodic alumina has high thermal and chemical resistance. The thickness of anodic alumina films depends on the anodization time. Films thicker than 10 micrometers have high mechanical strength, but thinner films request a

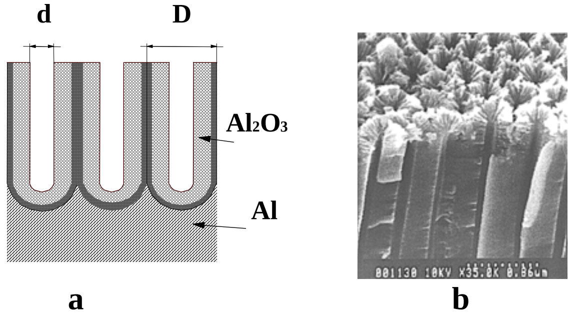


Figure 1. Structure of anodic alumina:
a – scheme (d – pore diameter, D – cell diameter); b – the scanning electron microscopic image of anodic alumina film cross section.

support. It is not problematic, as one can leave aluminium after anodization and keep it on the steps required high hardness. Anodic alumina is transparent in the visible range of the spectrum up to the near infrared region [3].

Our investigations show that after the transformation of anodic alumina in a polycrystalline form its primary porosity is kept and secondary porosity occur by the size up to 4 nm, and their volume makes up to 50 % of general oxide matrix porosity. Such films of polycrystalline anodic alumina are unique matrixes for creation and investigations of whole class of nanodimentional media.

EXPERIMENT

The process of the samples obtaining consists of the following steps. High purity (99.99 %) aluminium plates with size of 20 mm×20 mm×0.2 mm were chemical and electrochemical polished. Aluminium plates were anodized in a 3-wt % solution of oxalic acid ($(COOH)_2$). The applied voltage was 70 V and the solution temperature was kept at 10 °C. After reaching of the assigned oxide thickness an unoxidized aluminium was moved out chemically. Anodic alumina plates were annealed at the different temperatures in order to transform anodic alumina in a polycrystalline form.

The idea consists in following: to receive nanodimentional inclusions of various substances by their introduction mainly in nanopores of anodic alumina matrix. As basic material for the nanoporous carrier was applied a polycrystalline film of anodic alumina with thickness up to 100 microns and general porosity ~ 17-30 %.

There are many methods of the materials introducing in to host. We used the simplest one: a salt or a complex of the correspondent metal is dissolved in an appropriate solvent and after the impregnation is decomposed thermally to request compound (oxide).

RESULT AND DISCUSSION

The amorphous alumina does not show any photoluminescence, but after annealing photoluminescence was found. Figure 2 illustrates the photoluminescence spectra of an unfilled aluminium oxide film. After heating up to 800 °C two photoluminescence peaks were observed: the main peak at 564 nm and a second peak at 544 nm. Both peaks disappeared after annealing at the temperature of 900 °C. Anodic alumina membranes heated at the temperature of 900 °C do not distort the experimental results, therefore they can be used as a passive host under nanodispersed media investigations.

It was shown by us, that after the introduction of 10 and 25 mass %, for example, indium oxide, the distinction in a position of a fundamental band of absorption is observed: the edge of a fundamental band of absorption of templates with 10 % of introduced substance is moved to short-wave area approximately on ~80 nm in comparison with sample which has the contents of introduced substance 17 and more % (figure 3). At the same time, light emission with a maximum 740 nm is observed in a spectrum of luminescence at greater concentration of introduced substance, corresponding, probably, to excitation of dopant levels of polycrystals, introduced in basic porous of anodic alumina, while for a sample with smaller concentration of introduced substance luminescence in this region is not observed (figure 4). These phenomena are connected to primary formation of nanodimensional particles at low concentration of introduced substance. There is the filling of nanoporous originally, bringing to formation of a nanodimensional forms in anodic alumina matrix.

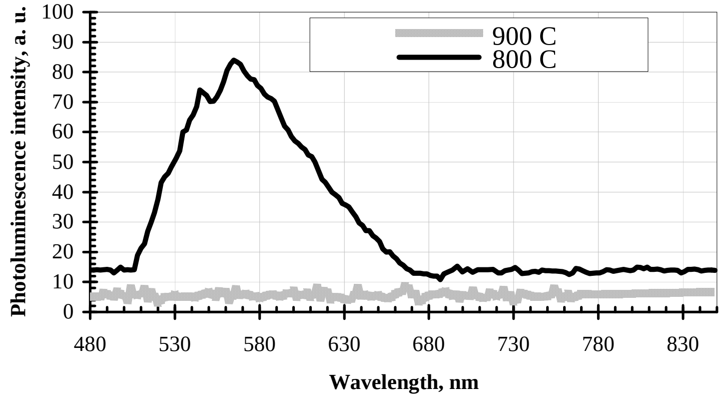


Figure 2. Photoluminescence spectra of unfilled anodic alumina membranes after heating at the temperatures of 800 and 900 °C.

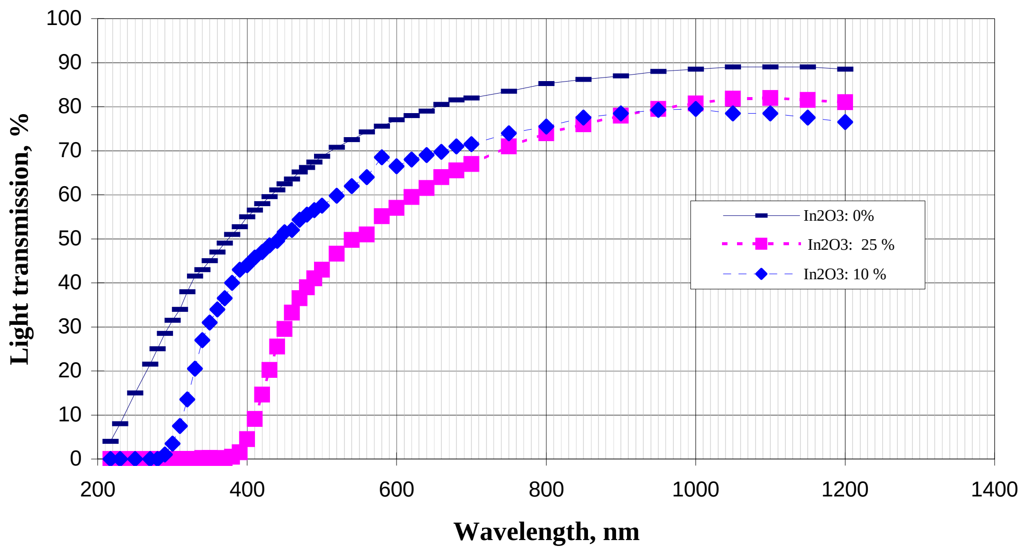
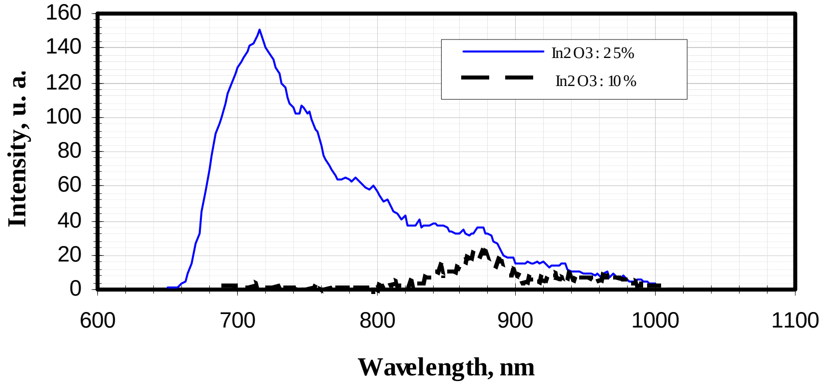
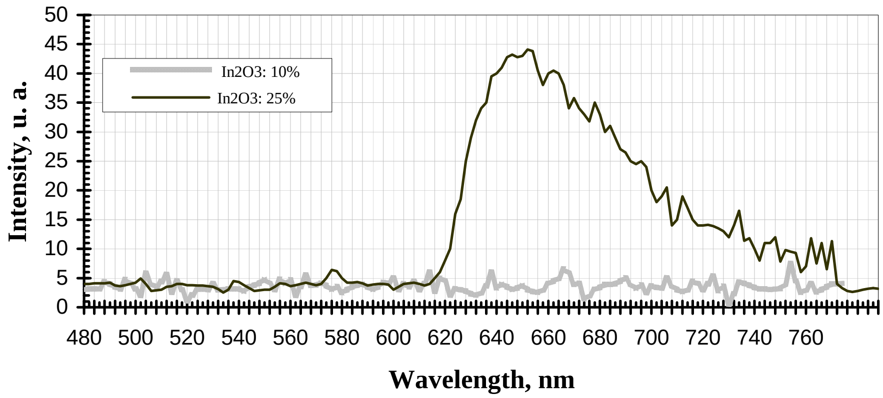


Figure 3. Transmission spectra of anodic alumina with different concentrations of indium oxide.



a



b

Figure 4.. Laser stimulated luminescence of modified anodic alumina : **a** - 632.8 nm laser and **b** - 440 nm laser.

CONCLUSION

Possibility of anodic alumina matrix application as passive host for fixed nanodimensional crystals of introduced substance was investigated. Hence, polycrystalline anodic alumina is a convenient material for the reception of nanodimensional templates. The peculiarities of free anodic alumina plates photoluminescence and modified by In_2O_3 nanotemplates luminescence at excitation by radiation of various wave are discussed in this work. It is demonstrated that the filling of nanoporous is original and brings to formation of a nanodimensional forms in anodic alumina matrix.

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