EFFECTS OF TECHNOLOGICAL REGIMES AND SURFACE MORPHOLOGY ON WETTABILITY PROPERTIES OF POROUS Al_2O_3 COATINGS

D. Shimanovich[1], D. Tishkevich[2], A. Vorobjova[1], A. Trukhanov[2]
1 Belarusian State University of Informatics and Radioelectronics, Minsk, Belarus
2 Scientific-Practical Materials Research Centre of National Academy of Sciences of Belarus, Minsk, Belarus

I. INTRODUCTION

In recent years coatings with special wettability such as hydrophobic (superhydrophobic) or hydrophilic (superhydrophilic) have attracted considerable interest due to their practical application – from self-cleaning surfaces to microfluidic and drip technologies.

Electrochemical anodizaion is one of the most effective methods of surface treatment and the formation of a nanostructured Al_2O_3 surface matrix. Structural and topological parameters of Al_2O_3 matrix significantly affect the functional characteristics and quality of coatings. Materials with low or high surface energy are usually combined with surface structuring with hierarchical topography on the nano- or micrometer scale for the hydrophobic or hydrophilic coatings synthesis. Therefore, due to the possibility of controlling the pore size and regulating the chemical composition of the surface the porous anodic alumina structures represent a great potential for obtaining surfaces with special wettability [1]. Alumina itself has a certain tendency to be wetted with water and therefore is a moderately hydrophilic with a contact angle in the tage of 45-60°. However, in combination with its specific surface structure and surface chemistry high hydrophilicity or hydrophobicity can be achieved.

II. RESULTS AND DISCUSSION

Based on experimental data the effect of technological regimes of an aluminum electrochemical anodizing and pores chemical modification on morphological parameters of nanoporous Al_2O_3 and on the contact angle of alumina structures in order to increase the hydrophilic properties of the final modified coatings was studied. Two- and three-step anodization methods were carried out in a 4% H_3PO_4 at 18-20 °C under various galvanostatic modes at each stage (current densities of 15, 20 and 25 mA/cm^2) during 60-240 min for the synthesis of various types of Al_2O_3 structures. The methods based on increasing the electrolyte temperature to 30-35 °C at the final anodization stage or post-anodizing chemical etching of Al_2O_3 in a 5% H_3PO_4 solution at 40 °C for various times from 7 to 25 min were used for the chemical modification of the alumina porous

structure combined with pore expansion. It was shown that it is possible to obtain high hydrophilic parameters with a contact angle value up to 17-20° using high values of current density, anodizing time, and electrolyte temperature by adjusting the electrochemical conditions. It was found that the obtained Al_2O_3 coatings with a thickness of 5-12 μm have a disordered branched porous structure with a pore diameter from 120 to 180 nm. The average pores diameter increased up to 210 nm with significant thinning and destruction of the pore walls after expansion of the pores using chemical etching (Figure 1).

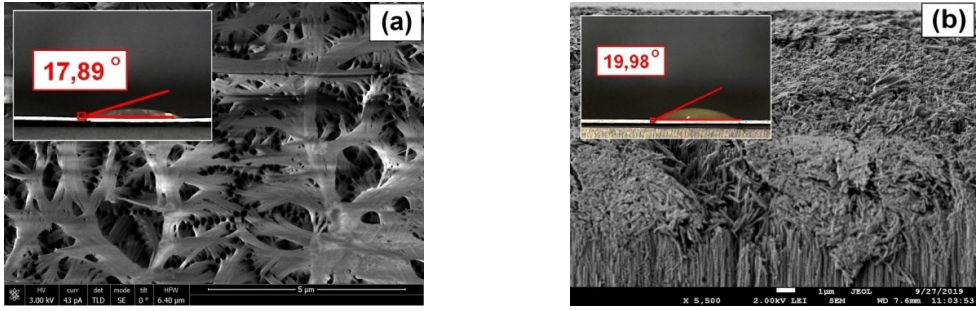

Figure 1. SEM images of modified porous alumina coatings and associated low contact angles: (a) - three-step anodization (15-20-25 mA/cm^2), 7 μm Al_2O_3; (b) - two-step anodization (15-20 mA/cm^2), 5 μm Al_2O_3

III. CONCLUSIONS

The comparative analysis of Al_2O_3 coatings and effect of surface morphology on the wettability properties were discussed. It was seen that this type of modified Al_2O_3 structures provides direct experimental evidence for the theory of three-dimensional capillaries regarding superhydrophilicity.

REFERENCES

[1] D.L. Shimanovich [et al], "Preparation and Morphology-Dependent Wettability of Porous Alumina Membranes", Beilstein J. of Nanotechnology, Vol. 9. pp. 1423-1436, 2018.