Formation of Coatings of Various Purposes by Microarc Oxidation

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Abstract – Influence of MAO-regimes on obtaining of the coatings with various properties was investigated. It was found, when MAO time is controlled the coatings of various purposes can be formed. The research results of MAO-coatings properties, such as insulating, wear resistance, heat resistance was proposed. The coatings were formed in the range from 2 to 10 min. The obtained results have found practical application at processing of the parts made of aluminum alloys and maintained in various conditions.

1. Introduction

Microarc oxidation (MAO) the increasing application finds as technology of the coating deposition of various purposes on the aluminum parts. However, most wide advance MAO-coatings have obtained which are used for hardening part surface, and for protection against corrosion. It is defined that is a few given attention to development of new electric circuits of power supplies and electrolytes of new compositions. We have developed the power supply which electric parameters allow obtaining the coatings of various purposes in electrolyte of the same composition at change of process time.

2. Experiment

Specimens from the 2024 aluminum alloy (4.4% Cu, 0.6% Mn, and 1.5% Mg) with a total area of 0.02 dm^2 served as anode. They were first etched in potassium hydroxide solution and then purified in the nitric acid solution. A plate from stainless steel 3 dm^2 in the area, served as a cathode. The treatment was carried out in the electrolyte based on phosphate and borate. The coating formation time took from 2 to 10 min, with an electrolyte temperature being 298–318 K. The potentiostatic processing regime with unipolar sinusoidal or pulse voltage 520 V was used.

The microphotograph and the element composition data on the coatings were obtained using a JSM 84 scanning electron microscope with the link adapter at the magnification of 1 000. Average concentrations of components were obtained from an area of 200×200 μm as an average of three measurements. The measurement of microhardness was carried out with use Nano Hardness Tester (NHT-S-AX-000X).

3. MAO-coatings as sublayer for the subsequent polymeric materials

Small process time of aluminum part surface – 3–8 min (Fig. 1), results to that we obtained the coating, which has the developed surface because of pores of the various size – 1–15 microns (Fig. 2, the 2nd minute) and good adhesion [1].

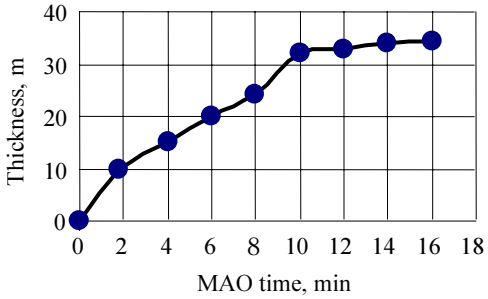
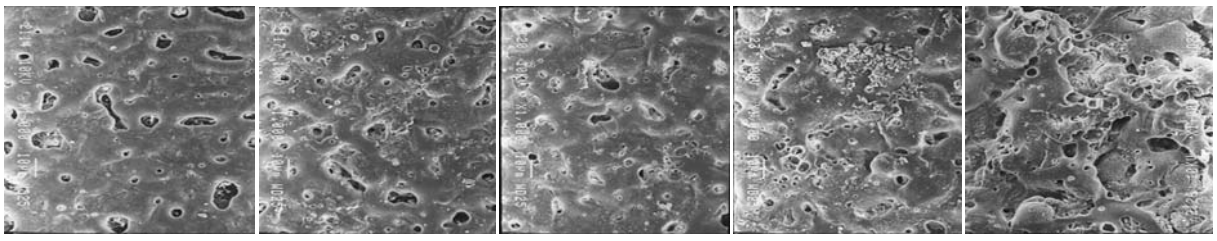


Fig. 1. Variation of MAO-coating thickness with process time

Presence of plenty of pores provides high electroconductivity of the coating that is the important characteristic when polymeric materials are coated on aluminum surface in electric field. The ceramic MAO sublayer enhances strength of the coating. Microhardness of the MAO sublayer in 1.7 times is more, than one of the coating obtained by anodizing and in 5.7 times more than a polymeric decorative coating (Table 2).



2nd min 4th min 6th min 8th min 10th min

Fig. 2. SEM images of MAO-coating surface formed in the range from 2 to 10 min

Table 1. Elemental composition of MAO-coatings

MAO time, min	Composition, %					
	2	4	6	8	10	12
Al	75.37	75.25	78.07	63.92	61.65	73.48
P	23.47	19.03	19.12	30.84	33.13	24.83
Fe	1.16	3.73	1.66	2.52	3.21	1.11
Mn	–	2.00	1.15	2.71	2.00	0.58

Table 2. Microhardness of different coating

Coating	Thickness, μm	Microhardness, H_V
Anodic coating	12	111
Polymeric coating	60	33
MAO-coating	10	190

The coating is applied substrate for increasing adhesion of polymeric materials, i.e., at coloring of parts, deposition of fluoroplastics or catalytically active materials. It was found in case of catalysis application the obtained MAO-coatings can be catalytic reactivity [2–4]. The coatings having such characteristics have thickness up to 10 microns, process time up to 2 min, treated surface in one loading – up to 600 dm^2.

4. Insulating and corrosion-resistant MAO-coatings

The increase of coating formation time results in reduction of the sizes and quantities of the sizes and quantities of pores (Fig. 2 the fourth minute) and to the further growth of coating thickness up to 10–15 microns (Fig. 1). Microhardness of the coating also is increased (Fig. 3). The coating contains up to 40% oxygen-containing compounds of aluminum and phosphorus.

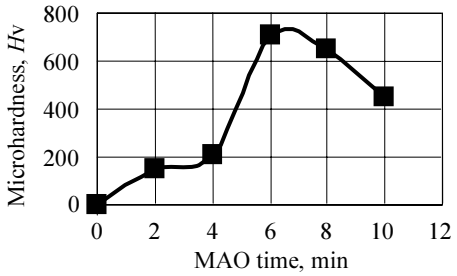


Fig. 3. Variation of MAO-coating microhardness with process time

All these parameters provide quite good insulating properties. The coatings maintain on breakdown up to 600 V. At additional treatment of the coating the breakdown voltage grows up to 1000–2500 V. Additional processing means closing pores through which breakdown occurs. The amount of pores is considerably reduced at increase of MAO process time. Also the pores can be closed by other materials, for example, polymers. Corrosion-resistant coatings are in the same range of thickness. High anticorrosive properties the gradient layer formed on metal – MAO-coating interface provides and in the way of penetration of corrosive medium through pores to the metal surface.

5. Wear-resistant and heat-resistant MAO-coatings

Since 10th min (Fig. 1), the coating formation rate is slowed down, however influence of microplasma discharges (MPD) on it proceeds. It is known in MPD-influence area high temperatures [5] and pressure [6] are evolved, because in the coating composition has aluminum oxygen-containing compounds. Among these compounds are big enough maintenance of various forms of aluminum oxide (basically α and γ) – 20–30% of total coating composition.

The analysis of element composition has shown that, maintenance of aluminum compounds maximum in coating which obtained on the sixth minute of MAO (Fig. 2, Table 1). The big maintenance of the compounds provides increase of strengthening properties of the coating.

In Figure 3 it is shown, that microhardness of the coating is maxim on the sixth minute of MAO. As shown in the same figure the increase of process time results in reduction of the coating microhardness. It is connected with increasing of coating thickness the contribution to coating formation of substrate oxidation process is reduced. At this stage formation of the coating occurs due to components of the electrolyte. In external part of the coating maintenance of phosphorus compounds is increased and one of aluminum compounds is reduced. It is confirmed by data of the analysis of element composition (Table 2).

6. Conclusion

When electric parameters and electrolyte composition are constant, the coatings of various purposes can be formed depending on duration of the MAO-process. With increase of process time and coating growth the character of influence of microplasma discharges on the coating changes. It leads to modification in structure and composition of the coating. Due to a variety of properties, such coatings have found application in electronics, medicine, petroleum industry, motor industry. The field of MAO-coatings application extends constantly.

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