ABSTRACT AND REFERENCES

MATERIALS SCIENCE

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A STUDY OF THE ELECTROLYTE COMPOSITION INFLUENCE ON THE STRUCTURE AND PROPERTIES OF MAO COATINGS FORMED ON AMG6 ALLOY
(p. 6–14)

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The influence of electrolysis conditions at different electrolyte compositions on the phase formation and properties of coatings obtained by microarc oxidation (MAO) on an aluminum alloy AMg6 was studied. For electrolysis, three types of electrolytes were used: alkaline electrolyte ((KOH) solution in distilled water), silicate electrolyte (with different percentages of Na_2SiO_3 component) and complex alkaline silicate electrolyte with liquid glass (1÷12 g/l Na_2SiO_3) and potassium hydroxide (1÷6 g/l KOH). An analysis of the results showed that the choice of electrolyte type and conditions of the microarc oxidation process allows a wide variation in the phase-structural state, thickness and properties of the AMg6 aluminum alloy. The criterion for the expected phase-structural state of the coatings as a result of microarc oxidation is the completeness of the γ–Al_2O_3→α–Al_2O_3 transformation process during coating formation. The use of an alkaline electrolyte does not allow achieving a high hardness of the coating due to the formation of the γ-Al_2O_3 phase and the absence of thermodynamic conditions for the γ–Al_2O_3→α–Al_2O_3 transition. When using a silicate electrolyte, it is possible to significantly increase the growth rate of the coating, but at the same time, the presence of a large specific Si concentration stimulates the formation of mullite and an amorphous-like phase. The use of a combined alkaline silicate electrolyte (with different percentages of KOH+Na_2SiO_3) with a low content (6 g/l) of Na_2SiO_3 in solution stimulates the formation of mullite. This is manifested to the greatest extent with the lowest content (1 g/l) of the KOH component. At a higher content (2 g/l) of the KOH component, the processes characteristic of an alkaline electrolyte become dominant. This leads to an incomplete transformation reaction and the formation of only the γ-Al_2O_3 phase. The achievement of the thermodynamic conditions of the γ–Al_2O_3→α–Al_2O_3 conversion became possible with an increase in the specific Na_2SiO_3 content in the electrolyte solution to 12 g/l. In this case, MAO coatings were formed on the AMg6 alloy with the highest hardness of 1500 kg/mm^2 and high electric strength of 12 V/μm.

Keywords: microarc oxidation, alkaline electrolyte, silicate electrolyte, complex electrolyte, phase composition, electric strength.

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STUDYING THE EFFECT OF ESTIMATED PARAMETERS ON THE DISTRIBUTION OF TEMPERATURE ZONES IN THE ELEMENTS OF A MOLD UNDER CONDITIONS OF ACTIVATED PROCESSING (p. 15–28)

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The reported estimation calculations have determined the kinetics of temperature changes in the model clamp–dielectric matrix–upper electrode–punch–sintered ring product–lower electrode–punch–stand. This has made it possible to determine the temperature of the control volumes of the product and tooling in a random period. The experiments have confirmed that the estimated values of temperature in the upper and lower layers of the sintered product are rather similar and differ little from actual ones. Specifically, it has been established that the sintered product concentrates 24 % of the thermal energy, which is released throughout the entire unit (press-tool–product). Under a conductive heating method, it is very important that the maximum temperature in the zone of the sintered product should be reached in the shortest period.

It has been shown that during exploitation the material of a mold under conditions of electric sintering is exposed to the thermocyclic and thermomechanical influence. The tooling components have different resistance to wear: a resource of the isolated insert is 20 cycles of sintering, of electrodes–punches – 50 cycles. This allows us to argue that it is necessary to choose a material for the components of a mold, which could meet the following requirements:

– the minimal heating of the tooling elements, thereby ensuring its structural reliability and operational adaptability (a holder, a matrix, a stand);

– the maximum heating of the chain: an upper electrode–punch–needle–the sintered product–a lower ring electrode-punch, thereby contributing to the accumulation of heat in the contact area between the components of the mold and a would-be product.

The above measures lead to the increased structural strength of sintered products, as well as to the optimization of control over would-be technological operations and prompt registration of important experimental data.

Thus, there are reasons to assert the possibility of the targeted adjustment of temperature fields through the preliminary calculation and selection of the tooling materials based on the thermal-physical characteristics. The application of a given mathematical model is an effective way to resolve the above issue.

Keywords: control volume method, press-tool, heat flow, electric sintering, joule heating.

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TARTRAZINE-INTERCALATED Zn–Al LAYERED DOUBLE HYDROXIDE AS A PIGMENT FOR GEL NAIL POLISH: SYNTHESIS AND CHARACTERISATION (p. 29–37)

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In the modern world, nail polish, gel polish, in particular, is one of the most commonly used cosmetics. The pigment is a component of gel polish, which determines the toxicity and color of the composition. Zn-Al layered double hydroxides intercalated with food dyes are promising pigments to be used for gel nail polish. Characteristics of Trartazine- intercalated Zn–Al (Zn:Al=4:1 and Zn:Al=4:1) hydroxide prepared at pH=8 and pH=11 have been studied. The crystal structure of the prepared samples has been studied by means of X-ray diffraction analysis and thermogravimetry, pigment properties – by measuring and calculating the color characteristics in CIELab and XYZ. The color characteristics of gel nail polish samples prepared with the synthesized pigments have been studied in the same way.

The results of XRD analysis and thermogravimetry revealed that Zn-Al-Tartrazine hydroxide synthesized at Zn:Al=4:1 is a layered double hydroxide with the α-$Zn(OH)_2$ structure. At pH=8, LDH with low crystallinity is formed, and at pH=11 crystallinity increases. It was discovered that Zn-Al LDH breaks down to ZnO during synthesis at pH=11. As a result, Zn–Al– Tartrazine hydroxide (Zn:Al=4:1), synthesized at pH=11, contains both LDH and

ZnO. For Zn–Al–Tartrazine hydroxide (Zn:Al=2:1), synthesized at pH=11, an almost complete breakdown of LDH was observed. It was found that the most promising for the preparation of gel nail polish are Zn-Al-Tartrazine hydroxide synthesized at pH=8. These pigments have an orange color (color tone 596–601 nm) with high monochromaticity (pigment color purity 60–65 %, color purity of gel nail polish 70–75 %). It is proposed that the breakdown of Zn-Al LDH to ZnO, discovered at higher pH can be exploited to prepare pigments with improved grindability.

Keywords: Zn–Al layered double hydroxide, pigment, gel nail polish, intercalation, Tartrazine.

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TEMPERATURE CYCLE ANALYSIS OF A6061-AISI304 DISSIMILAR METAL CONTINUOUS DRIVE FRICTION WELDING (p. 38–43)

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In the previous study, Continuous Drive Friction Welding (CDFW) had been investigated to determine the strength of joining, burn off, and temperature distribution. In this study, Dissimilar Metal CDFW was studied to assess temperature cycle analysis. Aluminum 6061 (A6061) workpiece was fixed, and an AISI 304 was rotated at 1,000 rpm. The temperature distribution was measured by using an OMEGA Thermocouple Data Logger. The thermocouple was installed near joining location 5 mm distance from the joint. In the computer simulation, the geometry of CDFW was designed using ANSYS Design Modeler. Computer simulation with transient thermal combined with static structural analysis was modeled by using ANSYS academic version Rel. 18.1. The boundary condition was set based on the experimental condition, where the Aluminum 6061 was fixed, and the AISI 304 was rotated at 1,000 rpm. Based on the experimental results, the temperature profile as the outer surface of the distance of the center of the joint location can be measured. From the simulation results, it can be seen that the temperature cycle profile is the same trend with experimental results. The mechanical properties provided that this phenomenon is shown in the characteristics of tensile strength, microstructure and hardness test as model analysis to denote the connection from temperature cycle profile with mechanical properties test results. Microstructure observation revealed that there is no significant difference in grain size and grain shape on the stainless steel side. Computer simulation results showed that the welded aluminum-stainless steel joint shows marks of heat affected zone near the weld interface only on the aluminum side, and this was confirmed by experimental results.

Keywords: continuous drive friction welding, aluminum, temperature cycle, dissimilar metal, mechanical properties test.

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ANALYSIS OF TECHNOLOGICAL APPROACHES TO ELECTROCHEMICAL SURFACE TREATMENT OF ALUMINUM ALLOYS (p. 44–55)

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Technological approaches to surface electrochemical treatment of aluminum alloys are analyzed. It is shown that directed modification of the carrier surface allows expanding the functional properties of the treated material. The mechanisms of treatment of aluminum alloys of different composition are investigated and technological models of processes using generalized phenomenological schemes are developed. Methods surface forming treatment of aluminum alloys by pulse current forming in chloride-containing electrolytes and plasma electrolytic oxidation in alkaline solutions of diphosphates are proposed. It is shown that the use of pulse electrolysis promotes the formation of a developed mesh and porous structure. Control methods and factors of the treatment process are generalized. The resulting systems can be used as carriers of catalytic material provided that a secondary catalytically active layer is applied. It is found that using plasma electrolytic oxidation, it is possible to change the shape and homogenize the surface layers of the carrier and apply a tightly adhered layer of catalytic material in one technological process. It is shown that the characteristic parameters of PEO depend on the composition of the treated material. It is revealed that the morphology and phase structure of surface oxide layers change during PEO. The formed oxide coatings consist of α-Al_2O_3 and have a high degree of surface development, which is a prerequisite for increasing their functional properties. The proposed approach can be used in surface engineering technology and for obtaining materials for environmentally friendly technologies.

Keywords: surface modification, surface forming, surface homogenization, process modeling, oxide coating.

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INVESTIGATING AN ALTERNATIVE ELECTRICITY SUPPLY SYSTEM FOR PREVENTING EMERGENCIES UNDER CONDITIONS OF limited capacity (p. 56–61)

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Film solar cells have been investigated to meet the need for an alternative system of electricity supply during the elimination and prevention of an emergency when an electricity supply system is damaged. Given the high degradation resistance of cadmium telluride, the study has examined the two-way sensitive solar cells based on CdS/CdTe with a super-thin base layer suitable for forming tandem structures. Creating the tandem structures makes it possible to improve the efficiency by placing another photoconverter at the front surface. We have measured the light volt-ampere characteristics of ITO/CdS/CdTe/Cu/ITO solar cells with a base layer thickness of 1 μm when simultaneously lighting the rear and frontal sides. It has been experimentally shown that two-way lighting makes it possible to increase the electrical power generated by the device structure by 30 %.

The study of the spectral dependences of transmittance has shown that the device structures ITO/CdS/CdTe/Cu/ITO with a thickness of the base layer of 1 μm demonstrate, in the spectral range (0.82–1.10) μm, average transmittance of 0.58. Examining the light volt-ampere characteristics of the solar cells Mo/CuInSe^2/CdS/ZnO/ZnO:Al/Ni: Al/Ni has shown that placing, at its frontal surface, the solar element ITO/CdS/CdTe/Cu/ITO leads to a decrease in efficiency from 11.2 % to 6.0 %. Such a decrease is primarily due to a decrease in the short-circuit current density from 25.9 mA/cm^2 to 13.8 mA/cm^2. However, as the efficiency of the ITO/CdS/CdTe/Cu/ITO solar element is 7.8 %, the tested tandem photovoltaic converters ITO/CdS/CdTe/Cu/ITO – Mo/CuInSe^2/CdS/ZnO/ZnO:Al/Ni demonstrated the efficiency 13.8 %.

Keywords: cadmium telluride, photoelectric converters, tandem and double-sided sensitive instrument structures.

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