ABSTRACT AND REFERENCES

MATERIALS SCIENCE

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THE STUDY OF PHYSICALCHEMICAL PATTERNS OF RESOURCESAVING RECYCLING OF TUNGSTEN-CONTAINING ORE RAW MATERIALS BY SOLID-PHASE REDUCTION (p. 4-9)

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It was determined that the oxidic tungsten concentrate is represented basically by $CaWO_4$. Other phases have a fragmentary manifestation with a low intensity of the corresponding diffraction peaks. Microstructure is heterogeneous, disordered. Particles with presence of the accompanying ore impurities (molybdenum, calcium, silicon, iron, aluminum, fluorine and carbon) were found. The metallized tungsten concentrate after heat treatment at 1,250 K had a reduction degree of 21 % with a prevalence of $CaWO_4$ in the phase composition. An increase in temperature to 1,350 K and 1,450 K provided a reduction degree of 69 % and 87 %, respectively. Under these conditions, a significant predominance of WC and W_2C carbides was found in the phase composition. The presence of $CaWO_4$ was of a residual nature with a relatively low intensity of manifestation. The microstructure of metallized tungsten concentrate was inhomogeneous with the presence of particles of various sizes and chemical compositions. As the reduction temperature increased, manifestation of the processes of sintering of particles was observed, especially clearly after treatment at 1,350 K and 1,450 K.

Keywords: tungsten concentrate, carbothermic reduction, metallization, sublimation, phase analysis, microstructure, resource saving.

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STUDY OF THE FREE SURFACE ENERGY OF EPOXY COMPOSITES USING AN AUTOMATED MEASUREMENT SYSTEM (p. 9-17)

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Results of development of the automated measurement system (AMS) for determining contact wetting angles and calculations of components of free surface energy (FSE) of solid surfaces by the Van Oss-Chaudhury-Good method were presented. It was shown that AMS allows for calculations based on experimental measurement of geometrical parameters of a lying drop on the surface and energy characteristics of test fluids. It was found that the measured contact wetting angles and calculated values of FSE components of surfaces of epoxy polymer composites, steel and glass are adequate and reliable.

Based on the conducted measurements and calculations, relationship between FSE, the structure and properties of epoxy polymer composites, filled with rutile, was established. In the course of research that was conducted using AMS, it was found that at an increase of the content of rutile, total FSE (γ_s), dispersive (γ^d) and acidic-basic (γ^{ab}) components of composites increase. Dependences γ_s and γ^d on the filler's content are extreme in character, and γ^{ab} increases and does not change at a subsequent increase in the amount of rutile. The influence of rutile is represented most vividly by dependences of the acidic (γ^a) and basic (γ^b) components, into which the polar (acidic-basic) FSE component γ^{ab} is disintegrated. It was found that structural transformations are associated with the acidic-basic mechanism of intermolecular and inter-phase interactions in epoxy compositions.

Keywords: free surface energy, automated measurement system, epoxy composite, rutile.

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INVESTIGATION OF THE COMBINATION OF ITO/CDS/CDTE/CU/AU SOLAR CELLS IN MICROASSEMBLY FOR ELECTRICAL SUPPLY OF FIELD CABLES (p. 18-23)

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Studies aimed at optimizing the design of micromodules based on ITO/CdS/CdTe/Cu/Au photoelectric converters, which are used in autonomous power plants for field camps, have been carried out. To use photoelectric converters as power sources, they are combined into micromodules and modules. The nature of commutation of single solar cells in the microassembly significantly affects the output characteristics of the micromodule and, consequently, the efficiency of the photoelectric converter as a whole.

It is found that the series connection of the ITO/CdS/CdTe/Cu/Au PEC in the micromodule ensures its stability even if the output parameters of one or more single solar cells fail or deteriorate. If the composition of the micromodule includes a solar cell with significantly worse output characteristics, or there are several such elements, then when they are connected in series, the efficiency of the micromodule is several times higher than for a parallel cell. With the series connection of the ITO/CdS/CdTe/Cu/Au PEC in the micromodule composition, experimental samples of the micromodule with an efficiency of 5.3 % are obtained, which is almost 2 times higher than for parallel connection of the same PEC.

Keywords: film photocell, micromodule, electrical commutation, solar cell, cadmium telluride, current-voltage characteristic.

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DEVELOPMENT OF LEAN TITANIUMALLOYED ALUMINIUM ALLOY FOR ELECTROTECHNICAL PURPOSES (p. 23-29)

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The influence of titanium amount and pouring temperature on the structure and properties of lean-alloyed alloy was explored. It was determined that lean titanium-alloyed aluminum alloys have better mechanical and electrical properties, which is explained by formation of heat-resistant dispersoids in solid solution. It was found that an increase in the amount of titanium by more than 0.5–0.6 % has a negative influence on electrical properties of the aluminium-based alloy. It was revealed that formation of four types of phases in complex-alloyed Fe and Si alloys contribute to preservation of tensile strength.

The results of comparative studies of ingots and wires from experimental and mass-produced alloys were given. Results of experimental research on determining the modes and parameters of deformation and thermal treatment and their influence on mechanical and electrical properties of aluminum alloys were presented. They made it possible to develop the technology of production of lean titanium-alloyed aluminium-based alloy and rolling electrical products from it. During its implementation it was found that aluminum ingots, cold-treated sheets and wires, retain the necessary strength and minimal specific electrical resistance at high enough temperatures. A positive effect of cold deformation and intermediate annealing on formation of the rational structure and a good combination of electrical and mechanical properties of the products was revealed.

Keywords: aluminum alloys, alloying, titanium, strength, heat resistance, products for electro-technical purposes.

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A STUDY OF MULTILAYERED ELECTROCHROMIC PLATINGS BASED ON NICKEL AND COBALT HYDROXIDES (p. 29-35)

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The multilayered electrochromic films based on $Ni(OH)_2$ and $Co(OH)_2$ have been prepared using sequential cathodic template deposition for solutions containing polyvinyl alcohol, nickel nitrate and cobalt nitrate at a current density of 0.625 mA/cm^2. The prepared films have demonstrated electrochemical activity and high electrochromic properties – coloration degree 25–80 %, high reversibility during cycling. The prepared films had a large number of structural defects and, possibly, large amounts of structural water, determined from them being X-ray amorphous. All the films had demonstrated similar electrochemical characteristics, except for the film composed of three layers of $Ni(OH)_2$, $Co(OH)_2$ and $Ni(OH)_2$. The best electrochromic characteristics had been demonstrated by the film prepared by consecutive deposition from solutions with polyvinyl alcohol containing nickel nitrate and cobalt nitrate for 2 and 78 minutes, respectively: coloration degree of 80 %, rectangular shape of the coloration-bleaching curve. A simple mechanism has been proposed, which describes better electrochromic characteristics of this film. It consists in the oxidation of cobalt hydroxide to CoOOH, which can act as an electrically conductive bridge between the substrate and the $Ni(OH)_2$ layer.

Keywords: $Ni(OH)_2$, $Co(OH)_2$, electrochromism, electrochromic materials, CoOOH, polyvinyl alcohol, multilayered films.

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SURFACE HARDENING AND FINISHING OF METALLIC PRODUCTS BY HYBRID LASER-ULTRASONIC TREATMENT (p. 35-42)

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Theoretical and experimental study of the possibilities of using laser heat treatment (LHT) combined with ultrasonic impact treatment (UIT) for surface hardening and finishing of metallic products was carried out. The austenization temperature range (1,050...1,350 °C) at different speeds (50...150 mm/min) of LHT without surface melting by the scanning laser beam, as well as the beginning (~360 °C) and end (~245 °C) temperatures of the martensitic transformation during the specimen cooling were determined. As a result, it allows narrowing the range of optimum LHT regimes, providing the surface hardness of 800...1,000 HV and the hardening depth of 200...400 μm of the surface layer. Experimental studies have confirmed that the determined magnitude of temperature on the specimen surface of AISI 1045 steel correlates well with the heating temperature measured by the laser pyrometer. As a consequence, this provides the ability to determine the application distance of the ultrasonic tool during cooling in the laser surface hardening of metallic surfaces.

The comparative analysis of the microhardness of the surface layer and the surface roughness of the samples treated by LHT, UIT, combined and hybrid laser-ultrasonic treatment was carried out. It was found that the hybrid laser-ultrasonic treatment allowed increasing the microhardness of surface layers more than 3 times and reducing the roughness parameter Ra approximately 3 times compared to the initial state, provided favorable conditions to trap oil on the product surface. Thus, there are reasons to assert the possibility of using the hybrid LHT+UIT for surface hardening and finishing of the large-sized products that work in extreme conditions.

Keywords: laser-ultrasonic hardening, AISI 1045 steel, thermo-kinetic model, thermo-physical model, hardness, roughness.

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EFFECT OF ELECTROLYSIS REGIMES ON THE STRUCTURE AND PROPERTIES OF COATINGS ON ALUMINUM ALLOYS FORMED BY ANODE-CATHODE MICRO ARC OXIDATION (P. 43-47)

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The study provides research findings on the effect of current regimes in microplasma oxidation on the phase composition and the properties of oxide coatings on an aluminum alloy. To obtain oxide coatings, micro arc (microplasma) oxidation is carried out in an alkaline-silicate electrolyte with an alternating sinusoidal current and in a pulsed current mode. It has been shown that an increased density of microdischarges in the case of the pulse technology increases the total energy released in them. This produces an increase in the growth rate of the oxide coating and the probability of formation of the α-Al_2O_3 phase. A linear dependence of the thickness of the coating on the duration of the process time and, accordingly, on the amount of transmitted electricity has been established. It has been found that for a small thickness of the oxide layer, the high rate of heat transfer both to the metal and to the electrolyte promotes the formation of aluminum oxide in the form of the γ-Al_2O_3 phase. The energy concentration in a thick oxide layer causes the formation of a high-temperature modification of α-Al_2O_3. It has been shown that the mechanism for the formation of α-Al_2O_3 is determined by the action of two facts: the difference in the energies of the γ-Al_2O_3 and α-Al_2O_3 phases as well as the polymorphic high-temperature transformation of γ-Al_2O_3→α-Al_2O_3 in the high-temperature region of a micro arc discharge.

The coatings obtained by microplasma oxidation in the pulsed current mode have high hardness (23 GPa) and electrical strength (20 V/μm).

Keywords: structural engineering, anode-cathode regime, coating thickness, phase composition, corundum, properties.

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