ABSTRACT AND REFERENCES

APPLIED PHYSICS

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REFINED CALCULATION OF INDUCTION MOTOR EQUIVALENT CIRCUIT NONLINEAR PARAMETERS BY AN ENERGY METHOD (p. 4-10)

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The topicality of the research aim is caused by the analysis of the processes of energy conversion taking into account the induction motor particular nonlinearities that reveal the physical properties and phenomena in structural materials under the action of electrical and electromagnetic impacts. Taking into consideration the nonlinearities of the induction motor equivalent circuit influences the accuracy of determination of the electric machine operating characteristics. Most conventional methods for parameter identification do not enable assessment of the induction motor nonlinear characteristics and properties.

It is proposed to use resistive impedance and inductance dependences on the rotor current to take into account the rotor nonlinear parameters. To form identification equations, the instantaneous power components for the rotor nonlinear resistive impedance and nonlinear inductance have been obtained. The solution of the identification equations resulted in determination of the equivalent circuit electromagnetic parameters taking into account the rotor nonlinear parameters and the amplitudes of the harmonics of the current cosine and sine components of the rotor and magnetization circuit. The results of identification of the induction motor equivalent circuit parameters taking into account the rotor nonlinear parameters have been obtained with sufficient accuracy. This is confirmed by a low error of determination of the electromagnetic parameters. The adequacy of the identified parameters is determined by comparison of the stator current experimental and calculated curves.

Keywords: induction motor, energy method, equivalent circuit, nonlinear electromagnetic parameters.

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METHOD FOR THE EROSION RATE MEASUREMENTS OF STATIONARY PLASMA THRUSTER INSULATORS (p. 11-17)

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Despite the fact that for many years the stationary plasma thruster (SPT) has been used in space, this technology has not yet been fully studied. One of the research directions to improve SPT characteristics is the increase of thruster lifetime. This can be achieved with the research of the discharge chamber (DCh) walls erosion rate as a function of different thruster operational modes.

The analysis of the SPT DCh wear rate diagnostics methods was carried out. It is shown that the considered methods cannot provide measurements of the insulators erosion rate separately during the experiment.

The method of optical emission spectroscopy with plasma scanning through collimator (OESSC) was developed. The method allows registration of radiation separately for each of SPT DCh walls directly during the experiment. According to this, the experimental time of different SPT operational regimes research was reduced by 98 %.

Experimental equipment of the OESSC method was developed, produced and tested. It consists of the high-resolution spectral block with the range of 240...820 nm and the optical detector positioning system.

A set of experiments were provided with the OESSC method. As a result, the inner and outer insulators erosion rates are researched as functions of thruster operational regimes. It is shown that for the outer and inner coils currents of 5 and 6 A, respectively, there is a uniform wear of DCh walls. For such SPT operational regime, the difference in the insulators specific relative erosion rates is 2 %.

The results of the OESSC method measurements allowed increasing the anode block lifetime significantly.

Keywords: stationary plasma thruster, optical emission spectroscopy, discharge chamber, relative erosion rate.

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RESEARCH INTO RESOURCE-SAVING MOLYBDENUM-CONTAINING ALLOYING ADDITIVE, OBTAINED BY THE METALLIZATION OF OXIDE CONCENTRATE (p. 18-23)

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We established that the phase composition of oxide molybdenum concentrate is re presented mainly by MoO_3, as well as MoO_2, WO_3, Mo_2C and associated ore impurities of Al_2O_3, CaO, SiO_2 and MgO. We found non-uniform microstructure in the form of plates, granules of round shape, and thread-like formations. It was determined that phase composition of metallized molybdenum concentrate, obtained by carbon-thermal technique, is mostly composed of metal Mo with the presence of MoC and Mo_2C. Unrestored component is represented by the oxy-carbide compound (Mo, O, C) and the lower molybdenum oxide MoO_2. We noted fragmented presence of Mo_8O_{23}. Spongy microstructure revealed areas where the molybdenum oxide restoration products dominate. The presence of residual oxygen confirms the existence, along with metal Mo, of unrestored oxide or oxy-carbide compounds. The residual oxygen could also be contained in the oxide compounds of Si, Al, Ca, Mg, K, Na as associated ore impurities. This is confirmed by discovery of the specified elements in the examined areas. The detected phases and compounds do not display significant susceptibility to sublimation. High restorative ability, due to the excess of carbon in the form of carbides, provides the post-restoration of oxide component in the liquid metal in the process of alloying, as well as protection against secondary oxidation.

Keywords: molybdenum concentrate, carbon-thermal restoration, metallization, sublimation, phase analysis, microstructure, resource saving.

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INVESTIGATION OF PROPERTIES OF ELECTROCONDUCTING NANOZONES IN MATERIALS OF VARIOUS NATURE BY THE ELECTRON PARAMAGNETIC RESONANCE METHOD (p. 24-30)

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This work studied properties of conductive nanozones in dependence on the material nature by the method of electron paramagnetic resonance. Delocalization of charge carriers and strong exchange interactions between paramagnetic centers take place in annealed biominerals, like in polyaniline in a form of emeraldine salt. Since biominerals, unlike polyaniline, can be subjected to a high-temperature anneal, this extends potentials of the EPR method in solving issues associated with the properties of conductive zones in nanosized polyaniline. It was shown that the EPR signals in the materials under consideration are conditioned by the electrical charge carriers and variations of electrical properties result in variation of the EPR signal characteristics. Consequently, information on the mechanisms of the EPR signal induction in one group of specimens can be used

for interpretation of the signal nature and elucidation of properties of local conductive zones in other materials.

It was ascertained that the characteristics of electron paramagnetic resonance of conductive nanozones in biominerals and the textile materials containing nanoparticles of polyaniline are similar. This feature is due to the similarity of paramagnetic charge carriers localized in nano-sized conductive zones of biominerals and organic polymers. Interconnected electron paramagnetic resonance studies of conductive zones in various materials can promote a more successful application of electron paramagnetic resonance in developing nanotechnologies for creation of conductive textile materials containing nanoparticles, especially nanoparticles of polyaniline with a high level of oxidation.

Keywords: nanoparticles, polyaniline, biomineral, enamel, bones, textile material, electron paramagnetic resonance, conductive nanozones.

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RESULTS OF APPROBATION OF THE INNOVATIVE METHOD OF ION NITRIDING FOR STEELS WITH LOW TEMPERATURES OF TEMPERING (p. 31-36)

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The innovation technique of complex treatment for steels with the low temperature of tempering is proposed and tested in the course of present study. It includes nitriding in the vacuum gas discharge before hardening and tempering. In this case, during nitriding, the heating temperature influences little the process of high-temperature treatment. In this case, the process of diffusion of nitrogen atoms is accelerated considerably (since nitrogen atoms penetrate untempered steel more easily), which leads to an increase to 2000 μm in the depth of penetration of nitrogen atoms and in

the thickness of the formed region with changed structure and hardness. It was established that, according to the properties, the region of exposure is divided into a surface layer (with a thickness of about 200 μm) with lowered hardness and the deeper operating layer with enhanced hardness. Layer with the greatest hardness is at depth of 400–800 μm. In this case, enhanced hardness, in comparison with the base, is maintained at depth that exceeds 2000 μm. The surface layer with low hardness makes it possible to implement the allowance for finishing, in order to obtain the required accuracy of dimensions and surface finish. Hardness of the surface of articles after this sequence of operations for the steels with low temperature of tempering is at the level of 8–10 GPa. The phase composition of the nitrided layer with high hardness, detected by the X-ray diffraction method, is the lowest nitride Fe4N and the solution of nitrogen in α-Fe.

Keywords: ionic nitriding, complex treatment, diffusion, depth of impact, diffraction spectra.

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RESEARCH INTO REGULARITIES OF PORE FORMATION ON THE SURFACE OF SEMICONDUCTORS (p. 37-44)

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A general procedure is devised to control the process of formation of porous layers on semiconductor surfaces by the method of electrochemical etching. When controlling the process of pore formation on the surface of crystal, it is necessary to consider: conditions of pore formation, requirements that are put forward to quality of the obtained nanostructures, and mechanisms that underlie the process of pore formation. It is shown that the built scheme could be used for different cases of the synthesis of nanostructured semiconductors. We investigated the processes that underlie pore formation and define morphological properties of nanostructures. A thermodynamic analysis of processes at the boundary of contact «semiconductor – electrolyte» was performed. We examined a relative drop in potential in the Helmholtz layer, which is an important characteristic of the process of pore formation on the surface of crystal. Main morphological criteria are selected of quality of porous nanostructures for their application in solar batteries. These include diameter and depth of the pore, a degree of porosity of the surface of a nanostructured crystal. Taking into account these criteria, we received porous spaces on the surface of semiconductors A3V5 that could be used for solar cells. We determined the value of boundary voltage of the early pore formation for semiconductors of group A3V5 during etching in the electrolyte HF:C2H5OH:H2O=1:2:1 for 15 min. It was established that at chosen conditions of etching. the largest capacity to pore formation is displayed by crystals of indium phosphide. The results obtained demonstrate that at the same conditions of etching semiconductors possess different ability to form pores.

Keywords: quality of nanostructures, electrochemical etching, porous semiconductors, Helmholtz layer, morphology, semiconductors.

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RESEARCH INTO THE PROCESS OF PREPARATION OF UKRAINIAN COAL BY THE OIL AGGREGATION METHOD (p. 45-53)

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We conducted a study into concentration of Donetsk coal with varying degrees of coalification – anthracite and grade G – by the method of oil aggregation. We determined the character of impact of the following factors on the results of oil aggregation of coal: the ash content of original coal, pulp agitation duration, pulp density, consumption and type of reagent-binder.

The research demonstrated a possibility of effective preparation of finely- and thinly dispersed Donetsk coal the size of 0–0.1; 0–1 (2) mm and ash content from 10–15 % to 65–70 % by the method of oil aggregation.

In this case, it was established that with an increase in the ash content of original coal, the process of oil aggregation displays a capacity of self-leveling. By reducing the speed of aggregation, it is possible to attain practically stable technological results over the entire examined range of ash content of original coal – from 10–15 % to 65–70 %.

Obtained results substantiate the possibility of employing the process of oil aggregation for the re-preparation of waste, in particular, waste of flotation and gravitation separation of coal preparation.

Keywords: oil aggregation, coal preparation, ash content of coal, aggregation, self-leveling of oil aggregation.

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RESEARCH INTO CONSTRUCTIVE AND TECHNOLOGICAL FEATURES OF EPITAXIAL GALLIUM-ARSENIDE STRUCTURES FORMATION ON SILICON SUBSTRATES (p. 54-61)

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The technology of formation of LSI structures on GaAs epitaxial layers, formed on Si-substrates of large diameter, is developed, which makes it possible at least by an order of magnitude to reduce the production cost of crystals due to epitaxial growth of GaAs layers and the use of technological equipment of silicon technology. This technology also enables the useof heterostructures to increase the speed of the LSI.

An analysis of complex structures of different architecture of IC/LSI on GaAs epitaxial layers, formed on Si-substrates, is carried out. The influence of the scattering processes of charge carriers on the potential fluctuations on the magnitude and profile of the mobility of electrons along the thickness of the epitaxial structure is investigated. When using epitaxial technology in structures, there are no isoconcentric impurities of oxygen and carbon, which are the factors of scattering of charge carriers, which makes it possible to achieve high values of mobility of charge carriers.

It is shown that the use of epitaxial layers of gallium arsenide eliminates the effects of isoconcentration impurities of oxygen and carbon in gallium arsenide layers that increases their purity.

A test element was implemented that allows non-destructive measurement of the mobility of charge carriers in the technological cycle of the formation of LSI structures. This allows us to realise the electrophysical diagnosis of the reliability of the LSI at the stage of crystal manufacturing.

Keywords: complementary structures, semiconductors, epitaxy, integrated circuits, technological features.

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