ABSTRACT AND REFERENCES

APPLIED PHYSICS AND MATERIALS SCIENCE

METHOD OF CYLINDRICAL HARMONIC ANALYSIS OF MAGNETIC FIELD OF OBJECTS WITH INDUCTIVE MAGNETIZATION (p. 3-8)

Andrey Getman, Alexander Konstantinov

At present, there are a large number of theoretical and empirical methods of development of electrical devices. In addition, a large number of technical objects is characterized by a cylindrical shape of their magnetoactive part. In particular, the electromagnets of control system of spacecraft orientation have the shape of cylinders. These electromagnets are made in the form of multi-layer solenoids with soft magnetic core inside.

Despite a great number of numerical methods for calculation of the magnetic characteristics of technical objects, in practice, it is important to obtain the accurate analytical models that permit to analyze the model according to a set of parameters. The complexity of the relationship between the parameters of a technical object and its magnetic field makes it difficult, and sometimes makes it impossible to conduct a comprehensive analysis of structural, energetic and magnetic parameters of the technical object solely on the basis of the results of the numerical calculations.

The article proposes an analytical method for calculating the magnetic moment of the cylindrical electromagnet and the efforts at the interaction of a cylindrical electromagnet with a magnetic plate, built on the basis of the mathematical apparatus of cylindrical harmonics.

Keywords: cylindrical harmonic, magnetic moment, electromagnet

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OPTICAL PROPERTIES OF LITHIUM NANOPARTICLES (p. 8-18)

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The modern physics of solids emphasis the physical properties of alkali-halide crystals and their practical application. For practical application of physics and chemistry of alkali-halide crystals, it is important to study the formation and properties of the point defects. The article presents the calculations of the spectra of light attenuation by spherical and ellipsoidal lithium nanoparticles in various environments. It also presents the measured spectra of light absorption and compares them with the calculated ones. This comparison allows the identification of colloidal bands of absorption of lithium in crystals. In addition, it provides an opportunity to assess the correctness of the spectral dependence and the values of the optical constants of the massive metal. The results obtained in the article, make it possible to evaluate the properties of nanoparticles of metals, which have unique properties, useful in modern technologies.

Keywords: color centers, colloidal particle, cluster, spectra of light absorption, attenuation coefficient

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FORMING TREATMENT OF METAL PLATES AND DISKS BY LOCAL LASER HEATING (p. 19-22)

Olexiy Kaglyak

The article is devoted to the study of thermal methods of forming. Namely, the laser forming, as the laser as a thermal source is stable, well defined, bases easily, and provides a locality heating. The mechanisms of laser forming were analyzed. The results of experimental studies were presented. It was found that the amount of deformation is proportional to the number of irradiation cycles for both carbon and austenitic stainless steels. When processing carbon steels the "post-deformation" occurs. It may or may not be coincident with the direction of the main deformation. The resistance of the laser formed constructions was studied. It was shown that the resistance of the constructions formed with the laser to force and thermal load is higher than of the constructions formed by the pressure treatment.

This is explained by the fact that the pressure treatment in the processing zone causes wall thinning of an item, in turn, the laser forming causes the reverse process - thickening. Technological recommendations on the treatment of metal plates were worked out. The results of the forming of items of complex spatial configuration with the irradiation by the parallel and cross laser passages were presented.

It was found that during the irradiation along the curvilinear trajectories it is appropriate to use a uniform heating, which can be achieved by rotating a workpiece with a frequency of 11000 rotations in a minute. The uniform heating of the workpiece in a closed curvilinear contour allows a uniform distribution of stresses and strains.

Keywords: laser forming, plate materials, deformation, thermal method of forming, heat-affected zone

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MODELING THE BEHAVIOR OF AIR BUBBLES IN THE FIELD OF STATIONARY ARC DISCHARGE (p. 23-29)

Stanislav Petrov, Sergey Bondarenko, Denis Rubets, Alexandr Savanchuk, Veronika Yanyuk

The article discusses the processes occurring at the electric arc discharge in the pore (bubble) liquid. The results of modeling of the dynamics of the behavior of a single bubble in the field of the stationary arc discharge were presented. To describe such a discharge a homogeneous model of a short cylinder was used. The model was supplemented by the equations that permit to determine the plasma density and its pressure in the discharge channel. The change of the size of the gas bubble was determined during its breakdown, taking into account the evaporation and condensation of steam and for the account of the radial motion of the bubble. The equations of the critical pressure inside the gas bubble were obtained, and on the basis of the first law of thermodynamics the temperature inside it was determined. The equations of the intensity of heat and mass transfer through the surface of the gas bubble were obtained on the basis of the molecular kinetic theory.

To solve the equations of the mathematical model an algorithm, implemented in the environment Mathcad was developed. The kinetic, dynamic and energetic characteristics of the behavior of the gas bubble in the field of the arc discharge were obtained.

Keywords: arc discharge, breakdown, plasma, gas bubble, mathematical modeling, heat transfer, mass transfer, algorithm, water, plasma-chemical cleaning.

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SIMULATION HIGH-VOLTAGE TRIPLE-JUNCTION PHOTOVOLTAIC CONVERTERS BASED ON AMORPHOUS AND MICROCRYSTALLINE SILICON (p. 29-34)

Sergei Chebotarev, Alexander Pashchenko, Marina Lunina, Vladimir Irkha

The design of triple-junction thin-film solar cells with hydrogen and oxygen microcrystalline and amorphous silicon layers α-Si:H(n-i-p)/μc-Si:O(n-i-p)/μc-Si:H(n-i-p) is suggested. The physical model and the software for simulation performances of these solar cells are developed. The numerical simulation results demonstrate that efficiency of the proposed thin-film solar cells can be increased to 16 %, open-circuit voltage U_{OC}=1.957 V, fill factor ff=78%. Improving the performance ensures by increasing absorptance in the visible region (λ=500-800 nm) to 40-60 % and in the near-infrared region (λ=800-1100 nm) to 75-80 %. The analyses of the triple-junction structure's external quantum efficiency spectral dependences shows that combining α-Si:H and μc-Si:H n-i-p junction can be possible using different solar irradiation regions to expand spectral sensitivity of silicon photovoltaic converter in HF and near-IR regions.

Keywords: triple-junction thin-film photovoltaic converter, amorphous and microcrystalline silicon, numerical simulation.

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RECYCLING OF PRECIOUS METALS (p. 35-38)

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The article presents the analysis of the recycling of electronic equipment and drawing of precious metals. The alternative recycling methods, such as acid leaching and waste melting in the molten copper were considered. The acid leaching of the concentrate was conducted with aqua regis (HNO_3 + HCl, in a ratio of 1:3). The dissolution of gold, silver and platinum was carried out in an aqueous acid solution. The thermodynamic analysis of the reactions showed that the acid leaching is most favorable for metals such as platinum and silver. As an alternative, the concentrate after the concentration was melted in the crucible. Copper was used as a basis. The melting was carried out in an induction furnace at 1250 ... 1450 °C. The process of refinement of the copper melt was performed by air blowing. At temperatures above 1030 °C the reaction of Cu2O formation and oxidation of the impurities dissolved in the copper proceed. This forms the oxide of impurities that float on the surface of the bath in the form of slag. Thus refined copper containing dissolved precious metals is sent to electrolysis to produce the electrolytic copper and electrolysis slime concentrated by gold, platinum and silver. The resulting slime is sent further to the hydrometallurgical recycling in order to separate precious metals.

Keywords: radio-electronic scrap, grinding, separation, acid leaching, melting, electrolysis.

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SCATTERING OF PLANE ELECTROMAGNETIC WAVES ON CARBON NANOTUBE (p. 38-46)

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The article presents an overview of the methods of production the tensor of dielectric permeability of multi-walled carbon nanotube (MWCNT) and the use of finite-element approach for calculating the scattering of a plane electromagnetic wave on the MWCNT in the optical range. The approach used was tested by calculation of the differential cross-sections of scattering of a metal rod in the far field and the distribution of electrical, magnetic fields, Poynting vector and conduction currents on the surface of the rod in the near field. The article presents the results of calculations of the scattering of plane electromagnetic waves on a MWCNT for parallel and normal polarized electric field vectors of the incident wave with respect to its axis. It was shown that in the far field the increase in length of MWCNT leads to the formation of the anisotropic angular distribution of the differential scattering cross sections, and the presence of anisotropic dielectric loss causes both quantitative and qualitative changes in the nature of the angular distribution of the differential cross sections: the losses not only scale the scattering cross-section, but also change their shape. Changing the direction of the electric component of the incident field from parallel to perpendicular (relative to the axis of the MWCNT) change the distribution of the differential cross sections: "petals" of the radiation pattern form in the direction perpendicular to the direction of incidence. The study of the distribution of electromagnetic fields within a solid dielectric cylinder showed that the dielectric losses do not prevent the permeability of the fields inside the cylinder, and this means that to describe the scattering on MWCNT it is necessary to consider the thickness of its wall.

Keywords: cross section, carbon nanotubes, dielectric tensor, optical range

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THE SYNTHESIS OF THERMITE HEAT AND HEAT-RESISTANT STEELS (p. 46-50)

Yuri Zhiguts

The present paper the basic solutions to the problem of obtaining heat-resistant steels examined the use of thermite steels, the benefits of combining thermite steels with metallotermic methods of getting is showed. The advantages of metallotermic synthesis methods include: autonomy of processes, independence of energy sources, simplicity of equipment, high-performance process and easy transition from experimental research to industrial production. The need to developed the technology of synthesis thermite heat-resistant steels, as a result of aluminothermic reactions and establishment of technological features' of synthesis it all led. At the first phase of the study of chemical composition of the synthesized heat-resistant steels is determined. In continuation of studies microstructure, mechanical and technological tests were performed. Technological features of the synthesis process and the impact of components exothermic reaction were revealed. The result of comprehensive research was the development of fusion technology thermite heat-resistant steel "12ХМФ", "15ХМФ", "12Х2МФБ", "25Х2МФ", setting of the charge for the synthesis of the specified steel, revealing the microstructure and mechanical properties of thermite steels, the research of technological properties of steel, namely the casting of properties and effects on the structure of individual alloying elements. In addition, the author has set the limits and boundaries of creep for thermite steel and their dependence on temperature.

Keywords: metallothermy, mechanical properties, heat-resistant steel

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THERMAL MODES OF SILICON PHOTOTRANSDUCER WITH FOCLINE CONCENTRATORS (p. 50-53)

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At present solar energy having certain advantages for provision of ecologically clean and wasteless production and having inexhaustible natural resources becomes leading industry in the world energy. The main problem on the way of its implementation is low efficiency of solar irradiation phototransduction by modern solar cells that can be solved by using concentrating elements, among which foclines – concentrators with flat reflective surfaces – are the easiest in realization.

This paper is devoted to the research of silicon photoconverter crystal temperature depending on change of concentration factor multiplicity and ambient temperature. At that the values of light flux concentration and heat-sink regime of focline concentrator construction were taken into account. Calculations of the temperature distribution over the crystal and side surfaces of focline concentrator are made, temperature distribution in the concentrator cross-section for various thickness of the heat sink radiator is represented.

The calculated dependences allow estimating the maximum permissible value of concentration factor and necessary conditions for heat sink without disturbance of the crystal allowed thermal conditions.

Keywords: concentrator, photoconverter, solar cell, concentration factor, luminous density

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