ABSTRACT AND REFERENCES

APPLIED PHYSICS. MATERIALS SCIENCE

ANALYSIS OF ENERGY EFFICIENCY OF A SUPERCONDUCTING SHORT CIRCUIT CURRENT LIMITER (p. 4-12)

Vladimir Dan'ko, Eugene Goncharov, Igor Polyakov

The work deals with theoretical and experimental studies, aimed at increasing operational indicators of high-temperature superconducting short circuit current limiter of inductive type.

We designed a high-temperature superconducting current limiter of inductive type with a superconductive screen, a superconductive winding and a core, which are placed in a general cryostat, which ensures an improvement in energy efficiency. The inductances of magnetic system of a current limiter were determined for the nominal and emergency operating modes.

A special feature of the proposed procedure for the calculation of power losses in a current limiter, as well as the magnitude of heat flows to a cryostat, is the fact that the developed procedure considers design parameters of magnetic system with complete cryogenic cooling.

Based on the developed procedure, we carried out analysis of the power losses of a superconducting current limiter of inductive type and heat tides to the cryostat for the nominal regime, which demonstrated that the effect of cryogenic cooling of magnetic circuit on the power of heat release of a current limiter is insignificant and amounts to less than one percent.

We simulated the work of experimental model of the magnetic system of a current limiter of inductive type during cryogenic cooling with liquid nitrogen. The calculation procedure proposed makes it possible to analyze energy efficiency while determining necessary critical parameters of a superconducting current limiter. It was experimentally explored that the power losses under the nominal mode in the magnetic circuit of a superconductive current limiter of inductive type are insignificant, which corresponds to the previous theoretical calculations. The conducted experimental research confirmed theoretical positions and developed mathematical models.

Keywords: current limiter, high-temperature superconductor, magnetic circuit, short circuit.

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INCREASING THE EFFICIENCY OF FILM SOLAR CELLS BASED ON CADMIUM TELLURIDE (p. 12-18)

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We conducted analysis of losses in the output parameters of solar cells based on CdTe/CdS, which are caused by the design features of instrument structure and by the photoelectric processes that occur in its volume when absorbing light. Based on the carried out analysis, the ways for the improvement of SC are determined for the purpose of increasing the efficiency of a photo element. The approaches to increasing the efficiency of a photo element are examined, which were previously realized by scientists. It was established that, despite the implemented technologies, efficiency of the obtained samples does not reach theoretical maximum (η_{theor}≈29 %). A basic technological approach, which was realized by many authors, when creating the low ohmic contacts to SC based on CdS/CdTe is the formation of tunnel contacts, using in this case thin films that contain copper or copper chalcogenide. However, the diffusion of copper into the base layer leads to the degradation of output parameters of the film SC based on CdS/CdTe. That is why we carried out comprehensive studies, aimed at designing back contacts to the CdTe base layers for the creation of highly effective, degradation-resistant solar cells.

It is experimentally established that in the absence of the copper layer at the back surface or in the absence of the annealing process after the formation of a back contact, efficiency of the film ITO/CdS/CdTe/Cu/Au SC is limited at the level of 3–4 % due to the work of instrument structure in the regime of "open diode". In the course of formation of quality Cu/Au tunnel contact, the SC efficiency increases to 10,4 %.

Keywords: film solar element, heterostructure, cadmium telluride, output parameters, back contact.

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NUMERICAL ANALYSIS OF THE PHYSICAL FIELDS IN THE PROCESS OF ELECTRODE BLANKS GRAPHITIZATION IN THE CASTNER FURNACE (p. 19-25)

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In the study, a numerical model is developed on the basis of the suggested physical and mathematical models to research the thermoelectric power state of the Castner furnace in the process of graphitizing electrode blanks. A distinctive feature of this study is an opportunity to take into account the impact of factors such as thermal effects of the chemical reactions of gasification, evaporation, condensation, sublimation of graphite, and thermoelectric power contact interaction between the elements of the furnace design. The verification of the numerical model of graphitizing electrode blanks has showed that the relative deviation between the calculated values of the average temperature of the candle blank after the start of the carbonaceous material gasification process is about 4 % in the temperature range of 600-1,600 °C in comparison with the physical experiment. The analysis of the numerical simulation results has revealed overstated average temperature values of candle blanks in the case of excluding the impact of thermal effects of chemical gasification reactions, heat and mass transfer of moisture, and conversion of the carbon monoxide and the hydrogen in the insulating charge of the furnace. Under the circumstances, the relative deviation in the average temperature of the candle workpieces in the examined points exceeds 10 % in comparison with the experimental data.

Keywords: graphitization, electrode blanks, gasification, thermoelectric power state, direct heating furnace.

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PROVISION OF ENVIRONMENTAL SAFETY THROUGH THE USE OF POROUS SEMICONDUCTORS FOR SOLAR ENERGY SECTOR (p. 26-33)

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The paper considers the ways of provision of environmental safety. A scheme of multilevel decomposition of the problems of provision of environmental safety through the use of innovative technologies for solar energy sector is presented. It is demonstrated that it is possible to increase efficiency of photoelectric modifiers of energy through the use of nanostructured semiconductors. The possibilities of minimizing the reflection ability (due to catching light in pores), an increase in the width of the restricted band of porous layer (due to quantum retaining of charges in microcrystallites) due to changing the porosity allow the use of layers of porous semiconductor both as anti-reflecting coating and as a broadband photosensitive layer. Under condition of using nanostructured semiconductors, the sensitivity of solar panels to the surface contamination decreases greatly. The economic benefits of using porous silicon in solar power include low cost of an area unit of a solar battery, which is provided for by the cost parameters of basic technology for manufacturing porous material. The method of electrochemical etching of nanostructures was used to obtain nanostructures. Basic regularities of the formation of porous layer at the surface of semiconductors of the A3V5 group and silicon were established. Technological conditions are selected individually for each semiconductor. The establishment of these regularities allows the optimization of the etching process and the fabrication of porous layers with the assigned parameters.

Keywords: nanostructured semiconductors, photoelectric modifiers of energy, ecological safety, electrochemical etching, multilevel decomposition, porous layers.

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A MODIFIED METHOD OF APPLYING DETONATION-SPRAYED COMPOSITE COATINGS BY A MAGNETIC FIELD (p. 33-38)

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The article deals with the problem of improving the wear resistance and corrosion resistance of machine parts, which is essential for

the equipment operation at high speeds and loads. The main purpose of the research was to study ceramic composite materials, which are highly resistant to the intensive wear and adverse environment. It has been established that these requirements are met by ceramic composites based on silicon carbide and aluminum oxide, which have high levels of physical and mechanical properties while being inexpensive and common materials. The selected component of the composite wear-resistant coating for detonation-sprayed coatings was the SiC-Al_2O_3 ceramic structure, previously tested as a compact ceramic material with a high level of tribotechnical characteristics. It is definite that the strengthening carbide phase of an active interaction with single-component melts takes place with silicide formation under hot pressing. During the charge agglomeration to apply the coating, the SiC-Al_2O_3 ceramic phase becomes ground as being more friable, but the artificially introduced metal component is plastically deformed without changing the size. The study has revealed a positive effect on the process of applying and the structure of composite detonation-sprayed coatings of the system (SiC-Al_2O_3)-Fe produced by an external constant magnetic field, which improves the coating porosity 1.5 times and enhances the coating adhesion 5 times. Moreover, a constant magnetic field in the process of applying the coating significantly decreases the coating porosity. The research results can be applied by experts in the fields of tribology, materials specialists, and experts in the field of operating and maintaining technical systems.

Keywords: coating, composite material, detonation spraying, magnetic field, adhesion, refractory component, metal bond.

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DEVELOPMENT AND APPLICATION OF THE DISCRETE MODEL OF MULTI-LAYERED TEXTILE MATERIALS (p. 39-45)

Ganna Shchutska

The discrete method of modeling the fluid passage through the textile material was developed, which makes it possible to define the boundary of the wetted section of material both at the surface and in the depth for materials with an arbitrary number of layers.

The essence of the proposed method lies in modeling the material with a system of cells and passages for spreading the fluid with the assigned characteristics.

Preliminary studies substantiated the relevance of this method, which was applied for studying a specific material. Such studies are necessary for the correct prediction of the processes that occur in therapeutic textile materials. They also create prerequisites for designing materials with the required properties.

We revealed the effect of additional concentrations inside the material, the consideration of which makes it possible to correctly predict the dynamics of fluid passage through textile material.

An analysis of functional dependences of the boundary of the wetted zone for two-layered fabrics, which are used for therapeutic purposes, allowed us to recommend it in the form of the sum of exponential function and exponential function with the maximum. Each two-layered material in this case is characterized by four constants in the course of the fluid passage.

The actual characteristics of two-layer textile material were defined. They are used for determining the fluid concentration in the lower layer of material. This makes it possible to predict the period of using material as a therapeutic textile system.

The use of the proposed method for multi–layer materials makes it possible to select the most rational characteristics of separate components for a specific case.

Keywords: textile materials, spread of fluid, structure, multilayered, discrete, continual, inhibition, cotton.

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EXPLORING THE PROPERTIES OF ULTRAFILTRATION MEMBRANES WITH A DYNAMIC LAYER AND BACTERICIDAL INOCULATION FOR THE PURIFICATION OF NATURAL WATERS (p. 46-53)

Nikolay Nechitaylo, Elena Nagornaya, Elena Nesterova

The authors established that with the creation at the surface and in the pore space of membrane of a dynamic layer, there occurs a sharp reduction in the performance efficiency of membranes due to the biological fouling. Biofilms block the outflow thus decreasing the productivity of membranes. In order to eliminate the blocking, it is proposed to introduce biocidal additives to the dynamic layer, which made it possible to decrease the influence of biofouling. The formation of a dynamic layer in the pore space and at the surface of membrane is substantiated with the help of simulation using the filtration equation of Poiseuille. To confirm theoretical positions under laboratory conditions, we developed a procedure for the modification of a flat filter. Next, at a semi-industrial installation we conducted a comparison of operation of membranes with a biocidal additive, without it and with a periodic washing by sodium hypochlorite. The membrane with a biocidal inoculation at the surface demonstrated a stable work at the highest efficiency.

Testing at flat membranes may be used as an express method for evaluating the modifying properties of different compositions of additives. This makes it possible to rapidly estimate effectiveness of different compositions of reagents for the surface modification of any type of filters.

Specific productivity of the membrane with a modified layer without a biocide treatment reached 58 $l \times m^2/h$, of the membrane with a periodic treatment – 97,5 $l \times m^2/h$, while the membrane with a modified layer and a bactericidal inoculation demonstrated a more stable performance and its productivity in seven days amounted to 89 $l \times m^2/h$.

The proposed technology enables obtaining water with the required quality via one-stage treatment, which considerably simplifies the process of water preparation.

Keywords: ultrafiltration, biocidal inoculation, purification of natural waters, biofilm, permeability of membranes.

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