ABSTRACT AND REFERENCES

APPLIED PHYSICS

SINGLE-PHOTON EMISSION TOMOGRAPY METHODS (p. 3-7)

Oleg Malahov, Sergey Schelkanov

The research topic is a part of the project for developing a tomographic gamma-monitor for controlling nuclear technical objects. The device must provide localization, quantitative assessment, identification and visualization of radionuclide distribution by the volume of the object under investigation.

A comparative analysis of options, algorithms and methods of a single-photon emission computer tomography is given in the paper. An overview of the main tomography objectives is given, and the methods for their solution are briefly considered. In particular, design features of the devices, general issues of the data processing methods, several methods of original structure reconstruction are considered. The classes of tomography problems with a limited amount of data: a few projection and a small-angle tomography are considered. In conclusion, an overview of the properties of tomography systems with coded apertures is given.

As a result of studying the tomography methods the conclusion on the most promising implementation of data processing algorithm for the designed device was made.

Keywords: single-photon emission computed tomography, gamma-rays, gamma-camera, coded aperture, Radon transform.

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ANALYTICAL SYSTEM FOR 3,4-BENZOPYRENE DETECTION BASED ON NANOPHOTONIC SENSOR (p. 8-15)

Olga Sushko

Anthropogenic pollution of environmental water is a huge problem for humanity today as it leads to an increase of incurable diseases. For example, the penetration into the organism of organic carcinogens such as polycyclic aromatic hydrocarbons (PAHs) can lead to the development of cancer tumors. The most dangerous among PAHs is 3,4-benzopyrene (BP). Therefore, the article is devoted to the development of nanophotonic sensor device construction and analytical system based on this device working on the flow injection analysis principle for the PAH in particular BP detection in environment water. Detector elements of nanophotonic sensor device are spherical quantum dots (QDs) fixed on the working electrode. Optimal choice of QDs energy parameters and its diameters were obtained using quantum-chemical calculation. Those data allowed us to prove probability of energy-transfer reactions between charged forms of QD's and BP and to obtain sensor with low detection limit and high selectivity of BP definition. Due to the fixed quantum dots monolayer on the working electrode using Langmuir-Blodgett technology nanophotonic sensor possesses reproducibility and can operate as multiple use device. The nanophotonic sensor can be used in the framework of the developed analytical system or independently as an integral part of similar systems. As a result of this work electrochemical and spectroscopic studies of BP in water samples were carried out. A number of model water samples with known BP concentrations were investigated and statistical processing of this results calibration graph for BP detection using nanophotonic sensor was accomplished and treated by regression analysis.

Keywords: 3,4-benzopyrene, analytical system, quantum dots, quantum-chemical calculations, nanophotonic sensor.

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CREATING A MIXTURE OF GASES FOR ION-PLASMA TECHNOLOGIES (p. 15-19)

Yuri Sysoiev, Vitaliy Rudenko, Andrey Dolomanov

A method for creating gas mixtures, intended for producing complex composition coatings in ion-plasma installations is proposed. The method is based on creating in a mixing chamber predetermined values of partial pressures of gas components. A peculiar feature of the method is a cyclic purging of the mixing chamber to create therein an atmosphere, consisting of no less than 99.9 % of one mixture component. Hereafter, according to the given percentage of gases in the mixture gas components are consistently supplied to the respective partial pressures.

The method is characterized by simplicity of implementation. An industrially applicable gas mixture generator (for case of three gases) was designed on its basis. The hardware and software of generator management system are developed. The gas mixture generator is characterized by high productivity of creating gas mixtures and the exact ratio of component in a mixture (the error of each component does not exceed 0.1 %). The application of the designed gas mixture generator in the processes of ion-plasma processing will provide obtaining the coatings with optimal properties.

Keywords: gas mixtures, ion-plasma technology, partial gas pressure, gas mixture generator.

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FEATURES OF HEATING HARDENING REINFORCED CONCRETE PROCESS DESIGN AND CONTROL BY THE INTERNAL HEAT SOURCES (p. 20-24)

Julia Shichireva, Gennadiy Oborsky, Oksana Saveleva

Thermal processes, occurring during heating the concrete, hardening in the cold are analyzed. The features of hardening concrete heating process design and control are analyzed. The objective of the work, which lies in lowering energy consumption through optimal design and control of technological processes, which use intense heating of concrete products in construction, is formulated. Basic problems such as analyzing the causes of energy loss during electrical heating of concrete by internal heat sources, constructing a mathematical model of heat transfer processes at such heating method and experimental verification of the developed model are stated and solved.

The mathematical model, used in the design and control to optimize electricity expenditure for heating is built.

Accuracy of the proposed model is confirmed experimentally by comparing the calculation results with the data, obtained by direct and indirect measurement of temperature fields.

The problem of optimizing heat transfer in hardening concrete, based on the proposed heating model is considered. The objective optimization function – total electricity consumption in heaters is outlined. Optimizing arguments - the distance between heaters and their diameters, as well as current in heaters, are formulated. Limitations - the range of variation in average temperature on the concrete part surface and the maximum permissible value of the surface temperature spread are highlighted. The conditions and assumptions, made when stating and solving optimization problems are formulated.

Keywords: concrete, hardening in the cold, internal heat sources, temperature fields modeling.

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THE ANALYSIS OF THE ELECTRONIC DEVICES SUBSTRATES ROUGHNESS TESTING METHODS (p. 25-30)

Igor Nevliudov, Irina Zharikova, Ivan Perepelitsa, Alexey Reznichenko

Reliability and stability of the finished product depend largely on the electronic component substrate surface quality. The thickness of the layers, deposited on the substrate should not exceed tens or hundreds of angstroms, and the roughness of such surfaces - units of angstroms.

The analysis of the basic testing methods of the substrate surface roughness for electronic products, during which the main features, advantages and disadvantages of these methods are identified, is performed in the paper. The conclusion on the need to improve the considered control methods is drawn.

Roughness control automation, which will allow promptly obtain information about the control object and effectively manage the technological process of manufacturing substrates for electronic devices, is defined as the urgent task.

Also, following the analysis results, further research direction for solving the tasks on developing technology for automated roughness control, based on the interference method is selected.

Thus, the authors performed systematization of provisions that may be useful to specialists-technologists in creating non-destructive testing methods, ensuring high accuracy and reliability of the obtained results.

Keywords: substrate, surface quality, roughness, testing methods, profilometer, interferometer, technological process.

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MONOSILANE PLASMA PYROLYSIS REACTOR (p. 31-38)

Stanislav Petrov

The technology for continuous production of silicon granules from monosilane through the liquid phase in an apparatus is based on a great variety of interrelated physical processes. A complex mathematical and full-scale modeling of equipment and processes of production and condensation of silicon vapors on a hot wall from various materials with the skull formation, liquid silicon flow, obtaining silicon droplets, their cooling, was made. As a result of the conducted studies, it was shown that any scientific technical constraints on the practical implementation of the technology of continuous granular silicon production in a plasma pyrolysis apparatus are absent. The adequate mathematical description of the process and equipment with different degrees of accuracy that allows implementing the engineering development of the pilot plant productivity of 100 kg/h was obtained. The discovered phenomenon of rapid collapse of the liquid silicon film into droplets allows creating a granulator on this basis. Thus, the conditions actually in one process operation of combining two processes – condensation of silicon vapor to liquid and production of granules are provided.

Keywords: plasma pyrolysis, reactor, silicon, plasmotron, skull, monosilane, cyclone, condensation.

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METHODOLOGICAL FEATURES IN RESEARCH OF POOL BOILING PROCESSES OF NANOFLUID ISOPROPANOL/Al_2O_3 (p. 39-45)

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Promising direction of heat-transfer intensification is modification of the liquids used as coolants or working bodies for various kinds of equipment. Within this framework the usage of nanofluids (suspensions of nano-size particles (up to 100 nm) in a base fluid) is proposed.

The results obtained have shown that the additive of Al_2O_3 nanoparticles to isopropanol increases the heat transfer coefficient during pool boiling up to 10–26 %. However, such effect was found only at the low heat flux densities. At the high heat flux densities the presence of the nanoparticles in isopropanol leads to decreasing the heat-transfer coefficient. According to the authors, this is the result of nanofluid destabilization.

It is shown that the complex nature of nanoparticles Al_2O_3 effect on the changes in heat-transfer coefficient is related to a combined contribution of different factors: interaction of nanoparticles with heating surfaces, changing in thermal properties of nanofluids compared to the base fluid, hydrodynamic radius of nanoparticles and their concentration in isopropanol.

According to the authors, the possible reason of nanofluid destabilization during pool boiling may be the destruction of heterogeneous micelles on the heater surface. Therefore, the study of nanofluids pool boiling and correct interpretation of the collected data should consider the stability, concentration changes of nanofluid and heating surface properties.

The study on hydrodynamic radius of nanoparticles was carried out using experimental setup wherein DLS method has been realized. The results has shown increasing in hydrodynamic radius from 53 to 86 nm with an increasing in the mass fraction of nanoparticles from 0.036 to 4.2 wt. %. The experiments to determine the stability of nanofluid has shown that the system remains stable throughout the period of the experiment (100 hours), temperatures interval (20–70 °C) and the mass fraction of nanoparticles (0.036–4.2 wt.%). In addition, in this paper, the dependence of the mass fraction of Al_2O_3 nanoparticles in isopropanol on the value of the transmitted light through the nanofluid was obtained. The magnitude of the transmitted through the nanofluid light is proportional to the mass fraction of nanoparticles.

Keywords: boiling, heat-transfer coefficient, nanofluid, stability, hydrodynamic radius, concentration.

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HEAT TRANSFER INTENSITY IN THE EVAPORATION ZONE OF TWO-PHASE THERMOSYPHONS (p. 45-50)

Volodymyr Kravets, Valeriy Konshin, Nataly Vaneeva

Decrease in the weight and size of electronic equipment with an increase in the functional capabilities leads to the growth of specific heat loads and their temperature modes that can cause failure of the entire device. Therefore, searching for effective systems of ensuring the set temperature modes of electronic device elements is a topical issue. Currently, passive evaporation-condensation devices in the form of closed two-phase thermosyphons have found wide use. Despite the considerable amount of studies on heat transfer characteristics of thermosyphons, there are difficulties in calculating the intensity of processes in them at the change in geometric parameters. One of the important parameters that affect the amount of transmitted heat energy of thermosyphons is their inner diameter.

The study of the influence of the internal diameter (5mm and 9mm) of two-phase 700 mm long thermosyphons on the heat transfer intensity in the heating zone for two heat-transfer agents (water and ethanol) is given in the paper.

It is shown that, at the inner diameter decrease, the heat transfer intensity in the heating zone reduces. The thermosyphon inclination angle does not practically affect heat transfer coefficients in the heating zone.

The dependence, allowing to calculate the heat transfer intensity during ethanol boiling in the heating zone of the thermosyphon with the inner diameter 9 mm and length 700 mm is obtained.

Experimental data, obtained during the study are important for designing thermosyphons with optimal heat transfer parameters, as well as for efficient cooling systems.

Keywords: thermosyphone, evaporation zone, condensation zone, heat flow, heat-transfer agent, heat-transfer coefficient, inclination angle, filling degree.

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