ABSTRACT AND REFERENCES

APPLIED PHYSICS

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DEVELOPMENT OF A TECHNIQUE FOR RESTORING THE EFFICIENCY OF FILM ITO/CdS/CdTe/Cu/Au SCs AFTER DEGRADATION (p. 6-12)

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A study into the influence of direct polarity on the output parameters of ITO/CdS/CdTe/Cu/Au solar cells (SC) has been conducted. We have experimentally registered the effect of an electric field of direct polarity on the output parameters and light diode characteristics of ITO/CdS/CdTe/Cu/Au SCs, which underwent a degradation of efficiency. When a shaded SE is exposed for not less than 120 minutes to the electric field, induced by an external DC voltage of magnitude (0.5–0.9) V, whose polarity corresponds to the forward bias of n-p heterojunction, there is an increase in efficiency coefficient. This becomes possible if, during degradation of the instrument structure, such defects did not have time to develop, which, over the specified time of exposure, lead to resettable alternating electric microbreakdowns. It has been established that an increase in efficiency coefficient comes at the expense of the increased density of a photocurrent, decreased sequential and increased shunt resistances of SC. Improvement of diode characteristics occurs due to several physical processes. When a SC is fed a forward bias voltage, an electric field forms inside the diode structure of SC, which amplifies the built-in electric field of the rear p-p^+ heterojunction and suppresses the built-in electric field of the frontal n^+-p heterojunction. That occurs because the diodes are turned on towards each other. The magnitude of a forward bias voltage must not exceed the height of the potential barrier in a heterojunction. In this case, at the rear p-p^+ heterojunction and in its adjoining areas from both sides the processes will be intensified that are associated with the transport of copper atoms, the restructuring of complexes of point defects containing copper, and the phase transformations of $Cu_{1,4}Te$ into $Cu_{2-x}Te$. In addition, under the influence of the field induced by a forward bias voltage, the Cu_{Cd}^- particles from the depletion area of a CdS layer will start moving towards the absorber. That should reduce the resistance part of the CdS layer and lead to a decrease in the depletion area width from the absorber's side, thereby increasing the spectral sensitivity of SC in the shortwave and medium-wave fields of solar spectrum. Electrodiffusion of additional amount of Cu_{Cd}^- to the absorber must enhance the above-described and related effect of the increased spectral sensitivity and thus J_{ph} of instruments. Based on the conducted research, we have constructed an algorithm for restoring the efficiency of ITO/CdS/CdTe/Cu/Au SCs and for rejecting the irrevocably degraded instrumental structures included in a running module.

Keywords: cadmium telluride solar cell degradation, recovery technique, output parameters, light diode characteristics.

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FEATURES OF FORMATION OF MICROWAVE GaAs STRUCTURES ON HOMO AND HETERO-TRANSITIONS FOR THE SUB-MICROCONNECTION OF THE LSIC STRUCTURES (p. 13-19)

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The features of the formation of microwave GaAs structures are considered and a set of studies is carried out to create a serial technology of large-scale integrated circuit structures (LSIC), including the number of microwaves on GaAs epitaxial layers deposited on monosilicon substrates.

The conditions for the formation of a two-dimensional electron gas in hetero-structures with the determination of electron mobility depending on the orientation of the surface were investigated. For hetero-structures on the surface of a semi-insulated GaAs substrate rotated from the plane (100) at an angle of 6–10° with oxygen content on the initial surface C_0=10–50 % relative to the gallium peak of the Auger spectrum, a strong mobility anisotropy was found due to an increase in the angle of reorientation and incomplete annealing of carbon from the initial surface of the GaAs substrate.

For the deposited layers of gallium arsenide on monosilicon substrates epitaxial technology is used, which can significantly improve the purity of the obtained material, namely, significantly reduce the level of oxygen and carbon isoconcentration impurities, which strongly affect the charge state of the interface.

For the formation of structural layers on GaAs, the technology for the formation of nitride layers of Si_3N_4, AlN, BN by the magnetron method at low substrate temperatures and a given stoichiometry was developed and investigated. The combination of gallium epitaxial nano-silicon arsenide technology to silicon substrates became realistically possible only with the development of technology of magnetron precipitated buffer layers of germanium.

The technology of the formation of logical elements NOT, OR-NOT, AND-NOT of high speed with low threshold voltage is developed, which allows to build high-speed chips of combination and sequential types on complementary structures.

Keywords: complementary structures, low-temperature epitaxy, integrated circuits, buffer layer, magnetron deposition.

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DETECTION OF SPECIFIC FEATURES IN THE FUNCTIONING OF A SYSTEM FOR THE ANTI-CORROSION PROTECTION OF UNDERGROUND PIPELINES AT OIL AND GAS ENTERPRISES USING NEURAL NETWORKS (p. 20-27)

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The information was reviewed to orderly arrange theoretical provisions and to devise practical recommendations for the diagnostic examination of a system for the anti-corrosion protection of underground metal oil and gas pipelines.

A set of informative parameters for modeling functional relations and determining polarization potential in the system "underground metal structure – cathodic protection plant" was formed.

It was proposed to apply the algorithm of prediction of corrosive current, the approach of non-linear programming, as well as the neural network, including the corresponding methods of learning, for a pipeline section, taking into account the polarization potential on the outer surface. The test set to evaluate the effectiveness of a neural network was formed.

The above-mentioned information is essential for the improvement of the equipment of distant control of metal structures of oil and gas enterprises, that is, the procedures for correct measuring and evaluating direct and alternating voltages, as well as polarization potential in a pipeline.

The methods and algorithms of neural networks, which are used to control the anticorrosive protection of underground pipelines, were explored. The study of the effectiveness of artificial neural networks, specifically, a two-layer network of direct propagation with the function of prediction of the resource of metal pipes. Using the polarization potential, we detected the capability of neural networks to perform inaccessible for conventional mathematics operations of processing, comparison, classification of images, capability of self-learning and self-organization relative to underground pipelines. The qualimetric quality criterion for a pipeline section, taking into consideration the optimal range of polarization potential was improved.

We developed the method for prediction of the polarization potential of a cathodic protection plant and transitional specific resistance of the insulating coating on the surface of an underground metal structure using a neural network. Taking into consideration the results of analysis of polarization potential and transitional specific resistance, the methodology of formation of information support for procedures of degradation of anticorrosive dielectric coating and metal on the outer surface of an underground metal structure, as well as for predicting its resource, was designed.

Keywords: neural network, underground pipelines, polarization potential, DC voltage distribution, oil and gas enterprises.

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CONSTRUCTION AND INVESTIGATION OF A METHOD FOR MEASURING THE NON-STATIONARY PRESSURE USING A WAVELET TRANSFORM (p. 28-34)

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Automated control systems badly need measurements of fast-changing non-stationary physical quantities in real time, or close to that. In this area, there is a separate group of tasks on measuring the non-stationary pressure in liquids and gases.

This paper demonstrates that measuring the non-stationary pressure in real time, or close to that, represents a problem on restoring an input signal, which, in terms of mathematics, belongs to the class of ill-posed problems (according to J. Hadamard). We have derived a solution to the inverse problem of measurement that is based on a mathematical model for measuring transformation enabled by a pressure sensor. Based on this solution, we have constructed a measuring method, which implies the wavelet processing of the sensor's output signal. In this case, we suggest that such basic functions of

wavelet transformation should be selected that are the modification of the pulse transition function of the sensor.

This paper reports an experimental study into the feasibility of the developed method, based on the measurement of the simulated pressure pulse. A pressure pulse is simulated by dropping a ball of the calibrated mass onto the sensor's membrane. We have proposed a measurement scheme for determining the duration of touch between the ball and the membrane. Testing the accuracy of the method implies comparing the actual mass of the ball with that derived from the sensor's output signal. The proposed method has demonstrated high accuracy because the maximum relative error in determining the mass of the falling ball was only 0.65 %.

The proposed method for measuring the non-stationary pressure could be used in control systems that require the high-speed dynamic correction of a measurement error. Specifically, these include control system in aerospace engineering, testing complexes, military technology, scientific research.

Keywords: measurement of non-stationary pressure, inverse measurement problem, real-time measurement method, wavelet transform.

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EXPERIMENTAL STUDY INTO THE HELMHOLTZ RESONATORS' RESONANCE PROPERTIES OVER A BROAD FREQUENCY BAND (p. 34-39)

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We have investigated the distribution of sound pressure levels in the Helmholtz resonators over a wide range of frequencies. Computer simulation of the sound field at the resonator was performed by using a finite element method and an experimental research.

We have established the existence of many resonance frequencies at the resonator and show the distribution of the maxima and minima

of sound pressure levels within the volume of the resonator. It has been revealed that the distribution of the resonator's resonance frequencies does not obey the harmonic law. That makes it possible to consider resonance properties of the resonator similarly to the oscillations in a membrane or a bell. The second resonance frequency of the resonator is 6–9 times higher than the first resonance frequency corresponding to the Helmholtz resonance. Simulation of sound field in the resonator showed the presence of nodal lines in the distribution of the sound pressure in both the resonator's volume and its throat. It has been established that the number of nodal lines for the first frequencies is one unity less than the resonance number.

A common feature to all distributions is that when a measuring point approaches the edge of the resonator throat, the level of sound pressure decreases. In addition, the study has found the possibility to generate resonance only within the resonator's volume without distinct nodal lines in the throat.

Comparative analysis of data acquired from experiment and during computer simulation has revealed a high level of reliability of the results obtained. Error in determining the resonance frequency did not exceed 0.8 %. That makes it possible, when further determining the sound field in the systems of resonators, to employ computer simulation instead of resource-intensive experimental studies.

The existence of many resonances at the Helmholtz resonator enables the construction of broadband devices, which could be based on using a given type of resonators.

Keywords: Helmholtz resonator, resonance frequencies, sound field, finite element method.

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MODELING OF THE PROCESS OF THE SHOT BASED ON THE NUMERICAL SOLUTION OF THE EQUATIONS OF INTERNAL BALLISTICS (p. 40-46)

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The study of the process of firing a firearm, taking into account the degree of wear of the barrel, requires an assessment of the losses of powder gases due to their breakthrough between the barrel walls and the projectile. Currently, the known methods for solving the equations of internal ballistics do not provide for obtaining results wich take into account the loss of part of the powder gases. As a result, there was a need to overcome the contradiction between the needs of applied ballistics and the capabilities of the existing scientific and methodological apparatus for solving the equations of internal ballistics.

The principles of construction of the difference scheme for the numerical solution of the equations of internal ballistics on the

condition of the influence of typical defects of the barrel channels and ammunition are stated. Recurrent expressions for step-by-step calculation of ballistic elements of the shot are given, initial conditions for the first and second periods of the shot are defined. The practical testing of the difference scheme by the numerical solution of the equations of internal ballistics for characteristic combinations of initial data is carried out and its adequacy is confirmed. The expediency of creating a database of ballistic shot elements for typical defects of the barrel channels and powder charges is substantiated.

As a result of researches, the difference scheme for the numerical solution of the equations of internal ballistics wich provide the possibility of taking into account the influence of typical defects of the barrel channels and ammunition on ballistic elements of the shot is obtained. This opens the way to improving the operational control of the technical condition of weapons and ammunition by advancing its reliability and efficiency.

Based on the numerical solution of the equations of internal ballistics, it is possible to simulate the influence of the deviation of the geometrical parameters of the barrel channel and the degradation of the powder charge on the course of the shot process. This explains the importance and usefulness of the work for applied ballistics.

Keywords: barrel bore, ammunition, technical condition, ballistic element of the shot, internal ballistics, difference scheme, numerical method.

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FEATURES OF THE ESTIMATION OF THE INTENSITY OF HEAT EXCHANGE IN SELF-VENTILATED DISK-SHOE BRAKES OF VEHICLES (p. 47-53)

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Analysis of the energy load of a cargo vehicle self-ventilated disk-brake system, which significantly affects the operational parameters of its friction pairs is made. Plastic deformation of the disk friction belts can be observed under cyclic loading of the brake friction pairs, and the deformation process is aggravated by the fact that the yield strength of the material drops in their local zones. Due to plastic friction during compression of the disk friction belts heated zones, therefore they bulge, further leading to the formation of microcracks.

The research is based on the fact that during the vehicle braking moment, the intensity of heat transfer from the outer and inner, matte and polished surfaces of the self-ventilating braking disk by convection is much lower than the intensity of heat dissipation processes in the right and left body of the half-disks under heat conduction. This is explained by the fact that the rate of heating is ten times higher than the rate of forced air cooling.

As a result of the research, the regularities of the thermal conductivity change in the half-disk side surface, the inverse of which is the thermal resistance of the half-disk were revealed. The design and heat transfer processes in the self-ventilated disk-shoe brake of the vehicle are considered. The intensity of heat transfer of a vehicle's self-ventilated brake disk is investigated in relation to speed and with account of heat transfer coefficients from external and internal surfaces of the disk. The influence on the intensity of the heat transfer process on the surface areas through the disk thickness is established.

Keywords: disk-shoe brake, self-ventilated brake disk, friction belt, friction pair, heat-exchange surface, coefficients: heat emission, heat transfer.

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DEVELOPMENT OF PRAXEOLOGICAL PRINCIPLES TO MODEL/STUDY HEAT GENERATION AND HEAT CONSUMPTION PROCESSES IN THE ENGINE OF RAPID INTERNAL COMBUSTION (p. 54-65)

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We consider a technology for modeling/studying phenomena of heat formation, heat transfer, heat utilization in the engine of rapid internal combustion, underlying which are the principles of praxeology. It is recognized that further development of classic approaches to modeling working processes in the engine relying purely or mainly on the analytical-algorithmic descriptions is almost impossible. It is therefore proposed to additionally introduce to the model an actual workspace of the engine, systemically connecting it to the virtual, implemented in the software-algorithmic environment, thereby introducing part of the reality to the model of the same reality. Within the framework of this study, we used, as a full-scale workspace, a cylinder from the tested engine BRIGGS&STRATTON, mounted at a special test bench.

In this case, there is a possibility to greatly simplify the analytical component of the modeling representation of working processes in the engine, building it on the basis of classical analytical ratios that reflect the law of conservation of matter, the law of preservation of energy, a heat transfer law, as well as equations of thermodynamic state of a working body. The model acquires specificity not due to special empirical descriptions, but by acquiring current information from the real information space based on the principles of similarity theory.

The required effectiveness of the model is provided by a simulation in the programming environment of interaction amongst itself and the environment of two zones into which a modeled engine workspace is split. A dual-zone model is opposed to the so-called multi-zone models, within which there is always a high risk of errors, almost uncontrolled, which require a complex and labor-intensive information support and maintenance. It is in the case of a two-zone representation of the modelled working space that it becomes possible to abandon the analytical control over chemical equilibrium in a working environment and there are no reasons that would predetermine the exchange of substances between zones. Therefore, it becomes possible to determine heat transfer to the walls of a working space similar to a single-zone model.

It follows from the study conducted that it is expedient to apply a Wiebe function for the virtual simulation of a heat formation phenomenon. Quality of simulation is improved by acquiring information obtained in the process, so to speak, of "on-line communication" between a virtual (in the form of software) and an actual (in the form of a full-scale workspace) parts of the modelling environment.

The presentation of the material is accompanied by illustrative material, which reflects information, obtained by modeling tools, about a change in: the working pressure in the engine working space, the temperature of a working body, an excess air coefficient, a heat transfer coefficient. We also included examples of change in the intensity of heat formation and intensity of heat transfer at the surface of: the working space in general, a cylinder liner, a cylinder lid, a piston head. Among the illustrations are the characteristics of the internal (intra-zone) heat exchange.

Keywords: rapid internal combustion engine, heat formation, heat consumption, praxeological base of modeling.

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