ABSTRACT AND REFERENCES

APPLIED PHYSICS

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INVESTIGATION OF THE EFFICIENCY OF A NOISE PROTECTION SCREEN WITH AN OPENING AT ITS BASE (p. 4-11)

Vitaly Zaets
National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-2232-9187

Svetlana Kotenko
National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-6804-1413

We stated and solved the problem on calculating a sound field around the noise protection screen with a slit at its base, through which noise penetrates. When solving this problem, we also took into consideration the presence of an acoustically rigid road surface in front of the screen and behind it. Such a statement of the problem makes it possible to assess effectiveness of the noise protection screens constructed not only on the horizontal sections of the terrain, but at higher elevations or on bridges. The proposed method implies splitting a field around the screen into canonical regions containing a solution to the wave equation. Then these regions are "sewn" by the values of velocity potential and its first derivative. Such an approach allows us to solve a problem on finding sound fields with a rather complex geometry.

An analysis of the results showed the existence of a maximum in the efficiency of the screen, as well as allowed us to determine effect of the size of the opening in the screen on the reduction of noise behind the screen. At the width of the opening of up to 0.2 m, efficiency of the screen at a distance 30 m and further is reduced by no more than 0.5 dB. The given screen model could be applied to estimate effectiveness of the screen with finite soundproofing or to analyze noise reduction of the screens available in Ukraine.

Keywords: noise protection screen, opening, effectiveness, partial areas method, finite element method, soundproofing.

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RESEARCH INTO NONSTATIONARY TEMPERATURE FIELD IN THE PROTECTED METALLIC STRUCTURE UNDER CONDITIONS OF FIRE (p. 11-20)

Vasyl Loik
Lviv State University of Life Safety, Lviv, Ukraine
ORCID: http://orcid.org/0000-0002-3772-1640

Oleksandr Lazarenko
Lviv State University of Life Safety, Lviv, Ukraine
ORCID: http://orcid.org/0000-0003-0500-0598

Taras Bojko
Lviv State University of Life Safety, Lviv, Ukraine
ORCID: http://orcid.org/0000-0002-0882-2637

Sergiy Vovk
Lviv State University of Life Safety, Lviv, Ukraine
ORCID: http://orcid.org/0000-0001-7007-7263

We tackled a problem of research into temperature field that makes it possible to determine effectiveness of the fire-retardant coating applied onto metallic wall. When stating the problem, we took into account a nonstandard temperature regime and conditions for a non-ideal thermal contact on the conjugating surfaces “metallic wall – flame-retardant coating”. To solve a nonstationary heat conduction problem, the integral Laplace transform by time was employed.

By using the devised mathematical model, we determined a non-stationary temperature field in the examined structure under condition of a non-ideal thermal contact. In the process of research, the time needed to reach a critical temperature was calculated, which is 45 minutes under condition that the value of the critical temperature on the unheated surface is 480 °C. Comparison of experimental data with the obtained numerical results showed that the difference is 9.7 %.

The devised adequate and experimentally confirmed mathematical model makes it possible to determine effectiveness of a fire-retardant coating without conducting expensive experimental studies. In future, based on the results obtained, it is necessary to find new formulations for the fire-retardant coating that would enable increasing the time needed to reach the critical temperature for the structure “metallic wall – flame-retardant coating”.

Keywords: stationary temperature field, metallic structure, convection heat exchange, flame-retardant coating, fire-retardant efficiency of coating.

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A STUDY OF THE THIRDORDER NONLINEAR SUSCEPTIBILITY AND NONLINEAR ABSORPTION OF INAS IN THE MIDDLE INFRARED REGION (p. 20-25)

Musaver Musaev
Azerbaijan State Oil and Industry University, Baku, Azerbaijan
ORCID: http://orcid.org/0000-0001-8151-8159

Ibrahim Abbasov
Azerbaijan State Oil and Industry University, Baku, Azerbaijan
ORCID: http://orcid.org/0000-0001-8111-2642

Aliashraf Baxtiyarov
Azerbaijan State Oil and Industry University, Baku, Azerbaijan
ORCID: http://orcid.org/0000-0001-5042-9794

Nonlinear susceptibilities of the third order $\chi^{(3)}$ and the coefficient of nonlinear absorption in n-type InAs with a different degree of doping are measured at room and nitrogen temperatures. The values of the third-order nonlinear susceptibilities $\chi^{(3)} \simeq 10^{-7}$ esu derived from these measurements essentially exceed the values calculated on the basis of the model featuring the nonlinear susceptibility of the electrons, being in conduction-band nonparabolicity. It is shown that the observed discrepancy is eliminated, if to consider a dissipation of energy of electrons in the calculation. The growth of efficiency in four-wave mixing in narrow-gap semiconductors is restricted to nonlinear absorption of interacting waves. It has been found that; nonlinear absorption in InAs is due to free holes that arise as a result of three-photon absorption. The breakdown threshold on the surface and constant of the nonlinear absorption in InAs were measured.

Keywords: nonlinear third-order susceptibility, four-wave interaction, narrow-band semiconductors, breakdown threshold.

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FORMATION OF CARBON FILMS AS THE SUBGATE DIELECTRIC OF GaAs MICROCIRCUITS ON SiSUBSTRATES (p. 26-34)

Stepan Novosiadlyi
Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0002-9248-7463

Mykhailo Kotyk
Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0002-1483-0051

Bogdan Dzundza
Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0002-6657-5347

Volodymyr Gryga
Nadvirna College of the National Transport University, Nadvirna, Ukraine
ORCID: http://orcid.org/0000-0001-5458-525X

Svyatoslav Novosiadlyi
SoftServe Company, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0003-0807-5771

Volodymyr Mandzyuk
Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0001-6020-7722

The technological aspects of the formation of thin α-C:H carbon films, the peculiarities of the ion-plasma Q-DLTS spectra of heterostructures α-C:H-Si and α-C: H-GaAs are considered, and activation energy, cross-trapping and density of deep traps, responsible for charge state, are determined. The correlation between the technological regimes of the α-C:H film formation and trap density is established. The technological methods and regimes that allow obtaining structures with a relatively small surface state density $N_{ss} \leq 10^{12}$ cm^{-2} are determined. This allows using these structures as a subgate dielectric in GaAs-CMOS structures of LSICs.

Low-temperature epitaxy of GaAs-layers on silicon substrates with the use of excimer lasers is developed, where germanium film acts as a buffer layer between Si and GaAs. The technology of carbon films formation by deposition from the carbon target is developed. The use of carbon films as a subgate dielectric allows the formation of CMOS-transistors on GaAs-epilayers with symmetric threshold voltages, which opens a new direction for the development of the sub-micron technology of LSICs and enables to increase the LSICs speed and reduce their production cost.

Keywords: complementary structures, heterostructures, epitaxy, integrated circuits, technological features, carbon films.

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FORMATION OF THE STEAM PHASE IN SUPERHEATED LIQUIDS IN THE STATE OF METASTABLE EQUILIBRIUM (p. 35-42)

Anatoliy Pavlenko
Kielce University of Technology, Kielce, Poland
ORCID: http://orcid.org/0000-0002-8103-2578

Hanna Koshlak
Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0001-8940-5925

The results of studies of vaporization processes in liquids in a metastable state were presented. Regularities of heat and mass exchange in thermodynamically unstable liquids (superheated liquids) were considered. A mathematical model of the mutual dynamic effect of boiling drops of a multicomponent liquid was developed with the help of which the level of dynamic effects was estimated from the point of view of possibility of fragmentation of drops of the primary mixture. Accuracy of the known criterion equations for the described homogenization technology was estimated. It was shown that instability of the Rayleigh-Taylor type has the greatest effect on fragmentation of drops.

In the study of the velocity and pressure fields, data were obtained that show that in the inter-bubble space of the ensemble, even with monotonically expanding bubbles, there are sharp jumps in pressures and velocities characteristic of the turbulent flow. This type of flow contributes to intensification and stimulation of heat and mass exchange and hydrodynamic processes in the liquid phase of the bubble system.

The obtained dependences make it possible to qualitatively assess critical forces sufficient for the thermodynamic fragmentation of the secondary phase. The time and energy parameters necessary for fragmentation of drops were determined. They depend on the temperature and size of the disperse phase. The proposed method for determining basic thermodynamic parameters of superheated liquid and vapor is necessary for predicting energy parameters of the thermodynamic homogenization technology.

Keywords: superheated liquid, vaporization, heat and mass exchange in metastable liquids, mathematical modeling.

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STUDY OF THE EFFECT OF THERMOBARIC CONDITIONS ON THE PROCESS OF FORMATION OF PROPANE HYDRATE (p. 43-50)

Anatoliy Pavlenko
Kielce University of Technology, Kielce, Poland
ORCID: http://orcid.org/0000-0002-8103-2578

Bogdan Kutnyi
Poltava National Technical
Yuri Kondratyuk University, Poltava, Ukraine
ORCID: http://orcid.org/0000-0002-0548-7925

Yurii Holik
Poltava National Technical
Yuri Kondratyuk University, Poltava, Ukraine
ORCID: http://orcid.org/0000-0002-5429-6746

The study presents results of the development of a mathematical model of an oscillating gas bubble. It takes into account inertial and thermodynamic components of oscillation of gas bubbles in a liquid, mass transfer processes near a surface of a bubble and phase transition processes in a liquid. Considering mentioned features in the mathematical model, it is possible to get values of temperatures of gas, liquid and solid phases, pressure of a gas medium and a size of a bubble, a rate of a side movement, localization and a rate of phase transitions in a liquid, intensity of heat and mass transfer processes at a bubble boundary and many other data at any time.

We performed a series of estimating calculations of the hydrate formation of the propane-butane mixture with the help of the proposed mathematical model. We investigated the influence of initial temperature and pressure of the gas mixture on the hydrate formation process. We obtained graphs of the hydration formation and temperature regime of a gas bubble, distribution of temperature fields in a liquid under conditions of phase transition processes and accumulation of hydrate in separate layers of a liquid. The performed studies show that the whole period of hydrate formation consists of three parts: the initial heating of gas in a bubble, the period of oscillations and the period of stationary heat transfer. The maximum rate of hydrate formation is observed during the period of heating of a gas in a bubble. It has a short duration of 2÷40 μs, but it is the most productive. The duration of the oscillation period depends on thermobaric conditions and may exceed 200 μs. We established that there exists a region of gas temperatures where the rate of the hydrate formation is maximal.

We can use the proposed mathematical model to determine thermophysical characteristics of gas bubbles, liquid and steam in various technological processes associated with the formation of gas hydrates, dissolution of gases in liquid, hardening of foam, and others. The conducted study can be useful for optimization of technological processes connected with formation of gas hydrates.

Keywords: gas hydrates, gas bubble, thermophysical characteristics of gas-saturated liquid, heat exchange in two-phase medium, phase transformations.

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APPLICATION OF SPECTRAL ANALYSIS FOR DIFFERENTIATION BETWEEN METALS USING SIGNALS FROM EDDY-CURRENT TRANSDUCERS (p. 51-57)

Anton Abramovych
National Technical University of Ukraine
«Igor Sikorsky Kyiv Polytechnic Institute», Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-0286-6516

Volodymyr Poddubny
National Technical University of Ukraine
«Igor Sikorsky Kyiv Polytechnic Institute», Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-9329-9405

The authors theoretically and experimentally substantiated the use of the spectral method for processing a signal of the vortex-current metal detector for dichotomous differentiation between metals. Results of experimental research that prove the possibility of using spectral analysis for differentiation between metals were presented.

The vortex-current method for detection of hidden metal objects was analyzed. It was indicated that amplitude of output VCD signal is determined by electric conductivity of material of a hidden object and its magnetic permeability. It was shown that the spectral density of a signal can be an informative feature.

The authors designed and fabricated a mockup of the vortex-current device, the special features of which include modularity, which, if necessary, makes it possible to replace quickly each of the modules. The developed algorithm of normalization of signals allows an operator to choose freely a scan mode and compare correctly VCD signals with reference signals.

Research results show that it is possible to distinguish easily between the spectra of ferrous metals and those of non-ferrous metals. Spectral methods can be applied both for dichotomous analysis of hidden metal objects and for analysis of the type of metal in the subgroup of non-ferrous metals under condition of using highly sensitive spectroanalyzers with measurement error not exceeding 1 %.

It was shown that advantage of the spectral method for analysis of signals of vortex-current transducer is identification of hidden objects by type of metal. The use of spectral methods for detection of hidden metals offers a new property – distant analysis of composition of detected metal objects.

Keywords: dichotomy, vortex-current metal detector, VLF metal detector, PI metal detector, Foucault currents, microcontrollers.

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WAVE PROPAGATION IN A THREELAYER SEMI-INFINITE HYDRODYNAMIC SYSTEM WITH A RIGID LID (p. 58-66)

Olga Avramenko
Volodymyr Vynnychenko Central Ukrainian State Pedagogical University, Kropyvnytskyi, Ukraine
ORCID: http://orcid.org/0000-0002-7960-1436

Maria Lunyova
Volodymyr Vynnychenko Central Ukrainian State Pedagogical University, Kropyvnytskyi, Ukraine
ORCID: http://orcid.org/0000-0002-7838-1013

Volodymyr Naradovyi
Volodymyr Vynnychenko Central Ukrainian State Pedagogical University, Kropyvnytskyi, Ukraine
ORCID: http://orcid.org/0000-0001-5187-8831

Research into propagation and interaction of waves in a three-layer hydrodynamic system is one of the relevant problems of modern theoretical and experimental hydrodynamics. The authors studied propagation and interaction of waves along contact surfaces of the three-layer hydrodynamic system “liquid half-space – layer – layer with a rigid lid”. By applying a method of large-scale approximations, the first three linear approximations of the correspondent weakly nonlinear problem were obtained. The structure of wave motions on contact surfaces was explored. Dependence of amplitudes of waves-responses on contact surfaces at various geometrical and physical parameters was analyzed. In particular, for large values of thickness of the upper layer, it was found that a change in value of the wave number leads to rapid convergence of amplitudes of waves-responses to the common limited value. The authors showed the need for a detailed study of the limited case in the absence of density jump, in which one of the solutions of dispersion equation tends to zero. Results of the present research can be used in the design of algorithms for detection of wave motions in various liquid media.

Keywords: interaction of waves, three-layer hydrodynamic system, amplitude of waves, ratio of amplitudes.

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MODELING AND ANALYSIS OF THE PROCESS OF POLYMERIC FILM COOLING ON THE DRUM WITH A LIQUID COOLING AGENT (p. 67-74)

Ihor Mikulionok
National Technical University of Ukraine
“Igor Sikorsky Kyiv Polytechnic Institute”, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-8268-7229

Oleksandr Gavva
National University of Food Technologies, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0003-2938-0230

Anton Karvatskii
National Technical University of Ukraine
“Igor Sikorsky Kyiv Polytechnic Institute”, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0003-2421-4700

Mykola Yakymchuk
National University of Food Technologies, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-1905-3546

Using the developed mathematical model, we performed an analysis of the process of cooling an extruded polymeric film on the drum with inner cooling. Dependence of average and local temperatures of a polypropylene film and the drum’s shell under condition of drum’s settling under stationary thermal mode was studied. It was shown that temperature difference between the surface of the shell and the refrigerant in the drum at film cooling can reach 40–65 °C and higher, which affects intensity of cooling of a polymeric film. With an increase in the minimum thickness of a film and (or) a decrease in its velocity, the influence of drum’s warm-up on the intensity of film cooling increases. Ignoring the drum’s warm-up process can lead to the insufficient cooling of a polymeric film and thus, to a decrease in its quality. The developed mathematical model could be used to analyze the process of cooling of not a film only, but also of other roll polymeric materials, obtained both by extrusive and rolling-calender method.

Keywords: extrusion, flat polymeric film, cooled drum, established thermal mode, temperature field.

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