ABSTRACT AND REFERENCES

APPLIED PHYSICS. MATERIALS SCIENCE

THE ADVANTAGES OF USING PHOTONIC CRYSTAL FIBERS INSTEAD OF THE CONVENTIONAL FIBERS IN OPTICAL GYROSCOPE (p. 4–11)

Haider Ali Muse

In this paper we proposed to use of a hollow core photonic crystal fiber 1550 nmλ , Ø10 μm instead of the conventional fibers in optical gyroscope .Two beams are again propagating through the fiber in opposite directions. Due to the Sagnac effect, the beam travelling against the rotation experiences a slightly shorter path delay than the other beam. The resulting differential phase shift is measured through interferometry, thus translating one component of the angular velocity into a shift of the interference pattern which is measured photometrically. Photonic crystal fibers present special properties and capabilities that lead to an outstanding potential for sensing applications according to these features we can elimination a lot of the problems that exist in the conventional fiber optic gyroscope and getting better and more accurate results in the same conditions when using Photonic Crystal Fibers.

Keyword: fiber optical gyroscope, hollow core photonic crystal fiber, Sagnac effect.

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CREATION OF DIRECTED UNDERWATER EXPLOSION (p. 12–16)

Sergey Dolya

To create a shock wave with a flat or concave spherical front, the explosive is formed as a spiral with a constant or variable pitch and radius of the spiral winding. Then, the propagation velocity of the blast wave becomes smaller than the propagation velocity of the detonation wave, and the velocity of the blast wave can be varied by both a pitch, and radius of the spiral winding. Such spirals are evenly arranged over the lateral surface of the cone.

With the spiral winding pitch h_{spiral}=40 cm, winding radius r_0=25 cm, hexogen thread diameter of 1 cm, arrangement n=36 of spirals over the lateral surface of the cone with an apex angle Θ=450, a cone with a base diameter D_{cone}=150 m, the mass of the explosive will be about 2 tons and, at a distance r=20 kilometers from the cone, the pressure on the blast wave front will be P>2 atm.

Keywords: shock wave, explosive, shock wave front, wave propagation velocity.

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MODIFICATION OF THE PROPERTIES OF POROUS SILICON FOR SOLAR CELLS BY HYDROGENATION (p. 17–23)

Valerij Yerokhov, Anatoliy Druzinin, Olga Ierokhova

The prospects of creating a solar cell with antireflection coating on porous silicon were shown, for which the process of electrochemical hydrogenation of porous silicon on p-type silicon substrates with a resistivity of 0.1...10 Om·sm and substrates with the formed emitter junction n^+-p was studied. For the process of electrochemical hydrogenation of porous silicon at its cathodic polarization, potentiostatic current-voltage curves of the system Pt (anode) – electrolyte – «porous silicon/silicon» (cathode) for electrolytes with different chemical composition were studied. A comparison of the photoluminescence spectra of as-grown, chemically processed and hydrogenated porous layers has shown that hydrogen saturation of the porous silicon surface during cathodic polarization increases photoluminescence intensity to a level typical for samples that previously have passed special chemical treatment. The research results of luminescent properties of hydrogenated porous silicon layers can be interpreted by an increase in photoluminescence intensity of hydrogenated porous silicon layers. These results are confirmed by experiments on the secondary ion mass spectrometer (SIMS), where, after hydrogenation, we can see a steady intensity (number of the read pulses) of secondary ions of the multicrystalline Baysix type silicon substrate surface in static mode with the presence of H_2+ ions. Through the model representation of the silicon PEC structure with the antireflection coating based on the porous silicon layer, the solar cell was developed and its parameters, which have shown that the conversion efficiency of the SC with hydrogenated porous silicon is by 1.28 times higher (16.1 %) than without it (12.6 %) were measured.

Keywords: solar cell, porous silicon, photoluminescence, electrochemical hydrogenation, mass spectra.

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RESEARCH OF EROSION RESISTANCE OF SUPERFICIAL LAYERS OF STEELS UNDER CAVITATION (p. 23–27)

Vladimir Kovalenko, Lyudmila Martynenko, Vladimir Marinin

Fracture resistance of low-alloy steels 15KH1M1F, 25KH1MF, 25KH1M1F, 20KH1M1FTR and steels 20KH13, 15KH11MF, 15KH12VNMF without and with thermomechanical treatment under intense cavitation on the sample surface was investigated. Cavitation was generated by exponential-profile ultrasound emitter. The emitter end surface varies with the frequency of 20 kHz and amplitude of 30±2 microns. Erosion measurements of samples were conducted by gravimetric method. Measurement accuracy was ±0,015 mg. According to the measurements, the dependences of the erosion on the cavitation exposure time were constructed. For quasi-linear plots of kinetic curves, the destruction rate of the samples was calculated and their cavitation resistance was determined. The interrelation of resistance ($\mathbf{Z}_L^h$) with microhardness (Hm) for low-alloy steels in the form of $\mathbf{Z}_L^h \sim C\,\mathbf{H}_\mu^{2,25}$ when measuring Hm in GPa was revealed. For more alloyed steels, the exponent is reduced to 2. Nitriding, hardening of coatings increase the resistance of the samples. When applying a vacuum arc coating on the heat-treated surface of the sample, its cavitation resistance is reduced by the value that depends on the coating formation process parameters.

Keywords: steel, superficial layer, modification, erosion, analytical relationship, resistance, microhardness, coating.

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FEATURES ROTATIONAL OF VIBRATIONS OF WATER MOLECULES (p. 27–35)

Nikolay Malafayev, Nikolay Pogozhikh

A local simulation of two-dimensional rotational vibrations of water molecules using the developed model of the dual-frequency spherical pendulum for inertia moment ratios $k=I_Y/I_X=1,5$ and 3, characteristic of water molecules was performed. The simulation was carried out in a non-uniform gravity field of the form $G_1=g\cos^n\theta$ with field non-uniformity indicators n=0...10. The possibility of transiting from independent two-dimensional rotational vibrations to one-frequency two-dimensional rotations was revealed. The regions of elliptic pendulum trajectories in nonuniform force fields were determined. The results are discussed in the framework of the model of the Jahn – Teller effect on the accountability of cooperative vibrations in the water. It is shown that the appearance of two-dimensional elliptic rotations of water molecule protons around the hydrogen bond axes in the water liquid phase requires a nonuniform, along the force field angle, intermolecular interaction forces and cooperative rotational vibrations.

Keywords: water molecule, nonuniform force field, dual-frequency spherical pendulum, cooperative vibrations.

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MATHEMATICAL MODEL, TECHNIQUE AND COMPUTER TOOLS FOR THE PROCESS OF GROWING OF SEMICONDUCTORS BY THE BRIDGMAN METHOD (p. 36–40)

Georgij Vorobets, Roman Rogov, Oleg Kopach

As a result of the research, based on the analysis of experimental studies, an adequate physical model for the processes of phase transformation of the CdTe crystal melt was found and its qualitative and quantitative evaluation was carried out. The technique and technical solutions for adaptive control and improvement of the crystal growth process using fuzzy logic methods, which has allowed to predict the critical and incorrect system states, including the lack of crystallization and onset of the supercooled melt condition, and, therefore, save time and money on repeated experiments was proposed. The approaches to creating technical computer tools for intelligent process control, which has allowed to improve the reproducibility of crystal parameters and predict the process flow correctness, as well as reduce the cost of the synthesized material were determined. Already on the synthesis stage, crystal cooling process monitoring has allowed to predict the generation probability of additional monoblocks and assess their characteristic sizes. The synthesis technique and structural and algorithmic solution of intelligent self-adaptive computer tools, built in the process system for improving the control process of furnaces for growing CdTe crystals by the Bridgman method were developed.

Keywords: semiconductors, CdTe, Bridgman method, process modeling, self-adaptive computer tools.

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COMPARISON OF THE RESULTS OF RESEARCHING THE GELIOROOF IN FIELD AND LABORATORY CONDITIONS (p. 41–46)

Stepan Shapoval

It is currently important to improve and create new solar panels that would allow us to reduce their cost and increase their efficiency. Therefore, we have suggested a connection between the solar collector and the building roof.The effectiveness of the gelioroof was tested in laboratory and field conditions. The energy efficiency of the roofing material has proved to be conducive to the solar collector productivity.

We have suggested a matrix of planning a trifactoral experiment that accounts for interaction of the factors. The revealed empirical and graphical dependencies allow estimating the temperature of the heat carrier in the gelio panel depending on the incidence angle of the thermal flow and its intensity. The effectiveness of the gelioroof at different thermal flow incidence angles changed from 30° to 90° declines by 41 %, which is 20 % lower than in conventional solar collectors. We have also disclosed the results of the solar radiation intake by the gelioroof during the day within the gravitational system of solar heating. Day-time temperature changes in the heat carrier were measured in the battery tank, at the intake and the output of the gelioroof. The temperature of the heat carrier in the battery tank rose to 52 °C, which confirms the effectiveness of the gelioroof.

Keywords: solar heating system, thermal flow, solar radiation, gelioroof.

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SIMULATION OF THE PROCESS OF SILICA FUNCTIONALIZATION IN THE MICROREACTOR (p. 46–53)

Yuliia Miroshnychenko, Yuriy Beznosyk

In this paper, we performed an analysis of the data on application of the innovative approach for the optimization of functionalized silica materials chemical synthesis in the flow microreactor. A detailed description of such materials is possible with the use of modern techniques and advanced modeling tools. On the basis of the quantum-chemical modeling of molecular clusters we examined the precise structural parameters and adsorptive properties of the investigated substances that can be used for water treatment. In accordance with the complexity of the functionalized materials synthesis it has been proved the expediency of the flow microreactor implementation to carry out the process of silica surface functionalization. A comparison between the fundamental advantages of the microdevices with the conventional chemical equipment has been discussed in the context of sustainable manufacturing. Several features that allow contributing flow microreactors to green and sustainable chemical synthesis were presented: process intensification; inherent reactor safety; broader reaction conditions including up-to the explosion regime; faster process development; easier scale-up of production capacity; lower costs for materials, energy and transportation; more flexible response to market demands. By virtue of these potential benefits of microreactors in technological and financial aspects, we showed that miniaturized reaction systems can be used to carry out a synthesis of such innovative materials as adsorbents. By means of the modeling of the functionalization process it is possible to provide clear guidance for the chemical synthesis of substances with useful properties in chemical industry and technology, biochemistry, pharmaceutics and medicine.

Keywords: functionalized silica material; microreactor; quantum chemical modeling; synthesis; sustainable manufacturing; water treatment.

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APPROBATION OF A STRUCTURAL APPROACH MODE FOR OPTIMIZATION PRODUCING COATINGS, INCREASES THE WEAR RESISTANCE OF THE TURBINE BLADES (p. 53–59)

Oleg Sobol', Vitaly Dmitrik, Nikolai Pogrebnoy, Natalia Pinchuk, Andrii Meylekhov

A complex analysis of the benefits of using a vacuum-plasma coatings to increase wear steam turbine components. The possibility of using a structured approach to surface engineering to monitor the efficiency used in the preparation of coatings, physical and technological parameters. As express structural parameters control the functional properties of the nitride coating with an fcc crystal lattice is proposed to use the degree of texturing to the [111] axis perpendicular to the growth surface, and the average size of the crystallites. It is shown that the use of high-voltage pulse stimulation technology to streamline the formation mononitride coatings, as well as multi-element nitrides highentropy alloys can increase the hardness of coatings by more than 1.5 times, and the abrasion resistance increased more than 1.7 times, compared with coatings currently used to protect the blades from wear and friction-slip gas turbine units.

Keywords: blade turbine, node friction-slip, coating, texture, crystallite size, hardness, wear resistance.

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INFUENCING PROCESSED COMPOSITE MATERIAL PRIPERTIES ON ACOUSTIC EMISSION (p. 60–64)

Sergii Filonenko

It is quite difficult to prove the informativeness of the parameters for acoustic emission during control, diagnostics and monitoring the technology of composite materials tooling as well as the parameters optimization. We have considered the resulting acoustic emission signals at tooling the composite material for a mechanical model of destroying its surface layer. We have studied the impact of a parameter determined by the properties of the destroyed surface layer of composite material on amplitude characteristics of the acoustic emission. We have proved that the influencing parameter does not alter the nature of the formed acoustic radiation. The resulting acoustic emission signals are continuous but very ragged.

A rising influencing parameter leads to falling amplitude characteristics of the resulting acoustic emission signals––with an average amplitude rate, its standard deviation, and dispersion. At a general decrease of the amplitude parameters of acoustic emission, the rising influencing parameter mostly affects dispersion of the average resulting signal amplitude. The obtained results show that optimization of parameters for the technology of composite materials tooling (where composite materials have various physical and mechanical characteristics) as well as devising methods of control, diagnostics and monitoring of such processes as an informative parameter requires to analyze the alteration patterns of dispersion of the average resulting signal amplitude.

Keywords: acoustic emission, composite material, signal, amplitude, tooling, area of fracture/fracture area.

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