

## Summaries of All Articles

*Yu. V. Barbashov, A. D. Zalesskij, A. A. Astafiev, A. A. Gorenberg, A. V. Aiboushev, O. M. Sarkisov, V. A. Nadtochenko, O. A. Koksharova, I. A. Chmel*

### **Two-photon luminescence of cyanobacteria *Anabaena* sp. PCC 7120 in the presence of endogenously formed gold nanoparticles**

Two-photon luminescence and second-harmonic generation of cyanobacteria *Anabaena* sp. PCC 7120 in the presence of endogenously formed gold nanoparticles are found and studied. The level of two-photon luminescence in systems with nanoparticles is much higher than in cells without them. In this paper we show that this phenomenon could be explained by near-field enhancement by localized surface plasmon modes of Au nanoparticles. Also, we discuss a possibility to use Au nanoparticles for visualization of biological tissue in a two-photon laser scanning microscopy under near-infrared excitation by femtosecond pulses of Ti:sapphire laser.

**Key words:** two-photon luminescence, second-harmonic generation, gold nanoparticles, cyanobacteria, surface plasmon polaritons.

*E. G. Diryugina, A. G. Burenin, M. P. Nikitin, A. V. Orlov, P. I. Nikitin*

### **Real-time detection of autoantibodies in serum by a label-free biosensor Picoscope®**

An immunoassay is been developed for real-time detection of autoantibodies in complex media by a label-free biosensor Picoscope®. The assay functionality is been demonstrated by registration of autoantibodies against thyroglobulin and thyroperoxidase in human serum. Clinically significant limits of antibodies detection are obtained.

**Key words:** detection of biomolecules in complex media, label-free methods, biosensors, blood serum, antibodies against thyroglobulin, antibodies against thyroperoxidase.

*D. A. Zubtsov, Zh. I. Zubtsova, A. V. Lavrov, E. V. Legchenko, V. A. Aladinskiy, A. V. Poteriakhina, D. V. Goldshtein*

### **Circulating tumor cells in breast cancer: prognostic role and detection methods**

There are a lot of methods and approaches to detecting circulating tumor cells (CTC) in the blood of cancer patients. This mini-review describes most of available technologies with analysis of their advantages and disadvantages special attention paid, paying special attention to the specificity and sensitivity of the reviewed methods. The prognostics role and availability of CTC as early independent markers of a progressive disease are assessed. For the purposes of this review, articles are searched using specific key words in PubMed and eLibrary, as well as all citations from latest reviews are analyzed.

**Key words:** circulating tumor cells, disseminated tumor cells, breast cancer, prognosis disease, diagnosis, RT-PCR.

*A. V. Koval, Ev. V. Stepanov*

### **Method for precise comparison of isotopic CO<sub>2</sub> content in breath samples based on laser spectral analysis**

Method of precise isotopic contents comparison in breath samples based on use of laser spectral analysis is proposed. It permits precise analysis of relative <sup>13</sup>CO<sub>2</sub> / <sup>12</sup>CO<sub>2</sub> concentration changes in exhaled air caused by isotopic breath tests. By computer modeling of an algorithm of spectral data processing, a noise effect on the result of the analysis is investigated, and the best spectral regions are determined. Several approaches to eliminate interferences of different origin are proposed.

**Key words:** isotopic content analysis, CO<sub>2</sub> transmission spectra, laser spectral analysis, isotopic breath tests.

*D. A. Ovsyannikov, M. Yu. Popov, S. G. Buga, V. V. Aksenenkov, A. N. Kirichenko, R. L. Lomakin, S. A. Tarelkin, E. V. Tat'yanin, V. D. Blank*

### **Electrical properties of nanostructured Germanium and nanocomposite Germanium-fullerene C<sub>60</sub> materials**

Nanostructured Germanium and nanocomposite germanium-fullerene C<sub>60</sub> samples are synthesized by ball-milling and hot sintering under pressure with C<sub>60</sub> content up to 9 vol/%. The structure and electrical properties (electrical conductivity, the Hall mobility and free charge carrier density) are studied. The fullerene C<sub>60</sub> prevents the recrystallization of samples during sintering and allow us to vary the mean crystalline size of Ge nanoparticles  $\mu_H$  in the range of 15 to 100 nm. The electrical conductivity of the fullerene-free and Ge-C<sub>60</sub> nanocomposites increases by several times. The nonmonotonic dependencies of the electric conductivity  $\sigma$  and the Hall mobility of free charge carriers  $\mu_H$  on  $l$  value have been observed. Such  $\sigma(l)$  and  $\mu_H(l)$  dependencies can occur due to the high density of defect vacancies on the grain boundaries and the quantum-size effect.

**Key words:** nanostructuring, electric properties, fullerenes, Ge, semiconductor.

*Yu. S Semenov*

### **Mathematical model of an inductive measuring cell for contactless conductometry**

We study an inductive conductometric cell and give an equivalent circuit and a mathematical model of an inductive cell. The model takes into account sample-coil capacity (i.e. capacity formed by the coil and the sample under study) and eddy currents. It is the sample-coil capacity that makes the inductive cell applicable for measuring the currents. The model can be used to calculate the inductive cell impedance for different characteristics of samples, materials and the dimensions of a cell without numerically solving partial differential equations. The results of the electric conductivity of low conductive samples (with specific conductance less than 1 S/m) in numerical simulation are verified in experiment for several devices with an inductive cell. Some features an engineer has to remember while designing contactless conductometers with a conductometer based on an inductive cell are discussed. **Key words:** conductometry, inductive conductometric cell, L-cell, conductometer, capacitive effect in inductive cell, skin-effect in inductive cell.

**Key words:** conductometry, inductive conductometric cell, L-cell, conductometer, capacitive effect in inductive cell, skin-effect in inductive cell.

*A. V. Shuvalov, A. V. Orlova, N. A. Myasoedov, D. V. Belyaev, I. M. Andreev, Yu. V. Balnokin*

### **Functional identification of the Cl<sup>-</sup>/H<sup>+</sup>-antiporter in the membrane fraction from root cells of the halophyte *Suaeda altissima* (L.) Pall.**

The Cl<sup>-</sup> gradient dependent Cl<sup>-</sup>/H<sup>+</sup> exchange across the membranes is identified and characterized in the plasmalemma-enriched membrane fraction isolated from roots of a halophyte *Suaeda altissima*. The intravesicular pH and the transmembrane electric potential changes are detected with  $\Delta$ pH indicator acridine orange, pH indicator pyranine and electric potential indicator safranin O. The physiological role of the proposed Cl<sup>-</sup>/H<sup>+</sup> antiporter is thought to maintain chloride in the cytoplasm below toxic levels under salinity conditions.

**Key words:** halophyte *Suaeda altissima*, membrane preparation, plasmalemma, Cl<sup>-</sup>/H<sup>+</sup>-antiporter, Cl<sup>-</sup> homeostasis.

*A. P. Alekhin*, *I. P. Grigal*, *S. A. Gudkova*, *P. A. Starikov*, *A. M. Markeev*, *A. A. Choupruk*

### **Structural chemical and electric properties of $\text{Ti}_{0.3}\text{Al}_{0.7}\text{O}_y$ thin films grown by atomic layer deposition**

Ternary oxide  $\text{Ti}_{0.3}\text{Al}_{0.7}\text{O}_y$  thin films with thickness 3-40 nm are grown by an atomic layer deposition technique. The grown titanium aluminate films are shown to be a homogeneous alloy and exhibit the amorphous structure in the whole thickness range, while rapid thermal processing (RTP) induces the crystallization of  $\text{TiAl}_2\text{O}_5$  phase in the thickness range 20-40 nm. Thinner films remain amorphous after RTP. The permittivity  $k$  of annealed films varies in the range  $k = 14-19$  depending on film thickness. The 0.5-nm-thick  $\text{SiO}_x$  layer forms at the Si-film interface, while the deposition grows up to 2 nm upon RTP and presumably affects the leakage current decreasing three orders of magnitude upon annealing. The optimal temperature of RTP for the maximization  $k$  and minimization leakage current densities is  $T = 700$  °C.

**Key words:** atomic layer deposition (ALD), high- $k$  dielectrics, Al-Ti-O, leakage current, electrical characterization.

*A. A. Zameshin*, *M. Y. Popov*, *V. V. Medvedev*, *S. A. Perfilov*, *R. L. Lomakin*, *S. G. Buga*,  
*V. N. Denisov*, *A. N. Kirichenko*, *E. V. Tatyagin*, *V. V. Aksenonkov*, *V. D. Blank*

### **Electric conductivity of nanostructured and $\text{C}_{60}$ -modified aluminum**

Electric conductivity of nanostructured and fullerene  $\text{C}_{60}$ -modified aluminum is studied and a possibility for an optimization of electric and mechanical properties is demonstrated. A material electric conductivity model is proposed. Samples with different mass fractions of  $\text{C}_{60}$  and different Al crystallite sizes are produced and studied. The mean crystalline size, electric conductivity and samples hardness are tested. The suggested model shows good agreement with experimental data. An X-ray Photoelectron Spectroscopy and Raman Scattering studies of the material structure demonstrate the presence of covalent bonds between aluminum and fullerene molecules and agree with the structural model.

**Key words:** nanocomposite, electric conductivity, aluminum, fullerene.

*N. A. Zarkevich*

### **Perforated graphene as an information carrier: a punched card on the atomic scale**

Perforated two-dimensional crystals are considered as information carriers. For graphene, the maximal theoretical recording density is calculated:  $7 \times 10^{14}$  B/cm<sup>2</sup>,  $2 \times 10^{21}$  B/cm<sup>3</sup>, or  $10^{21}$  B/g. Nanopunched cards can be rolled or stacked into a porous crystal without information loss. Information can also be stored in perforated graphene nanoribbons — punched tapes on the atomic scale. Any two-dimensional crystals are suitable for perforation; graphene is only one of them.

**Key words:** punch card, two-dimensional crystal, graphene, nanotechnology, vacancy, information density.

*A. Y. Kuzin*, *P. A. Todua*, *V. I. Panov*, *A. I. Oreshkin*

### **Peculiarities of silicon reconstructed surface application for STM calibration in objects geometric parameters measurements**

The possibility to use  $7 \times 7$ -Si(111) surface and monoatomic steps on this surface as reference samples for an ultrahigh vacuum scanning tunneling microscope has been demonstrated.

**Key words:** scanning tunneling microscope, reconstruction, silicon, ultrahigh vacuum.

*A. I. Ryazanov, E. V. Semenov, T. I. Mogilyuk*

### **Development of theoretical models for calculation of electron multiplication in semiconductor materials irradiated by fast electrons**

The cascades of electronic collisions created as a result of irradiation of solids by high-energy electrons are considered. The solution of the problem is based on the investigation of the kinetic equation for moving electrons. For this equation, a model scattering indicatrix is constructed with an arbitrary form of the potential of particles interaction. The energy distribution of moving particles is obtained using the constructed model scattering indicatrix. On the basis of the energy distribution of moving particles for an arbitrary interaction potential, the cascade function is calculated.

**Key words:** electrons, irradiation, scattering cross section, indicatrix, cascades, electron multiplication.

*A. A. Shcherbakov, Ya. V. Lesnichiy*

### **Morphology and optical properties of single-walled carbon nanotube layers deposited by the airbrushing method**

We study the morphology and optical properties of single-walled carbon nanotube layers deposited by the airbrushing method from water suspensions. Deposited films are characterized by optical and electronic microscopy, optical transmission spectra and conductivity measurements.

**Key words:** single-walled carbon nanotube film, transparent electrodes.

*Yu. V. Baida, A. V. Butuzov, A. G. Efimov, M. S. Tsvetkov*

### **Converting the microprocessor software performance model to a hardware simulator based on field programmable logic arrays**

The development of new microprocessor architecture requires making a lot of decisions based on performance modeling. FPGAs can provide a cost effective solution with up to 3 orders higher simulation speed than that of conventional software simulators. In this paper, we describe a novel methodology for converting the existing software cycle-accurate simulator to a FPGA-based hardware model.

**Key words:** microprocessor, microarchitecture, cycle-accurate, simulator, simulation, FPGA, model, performance.

*A. P. Treshchalin*

### **The use of spacecraft opto-electronic devices for preliminary orbit determination of near-Earth objects**

We consider the problem of predetermining the orbit of a space object (eg space debris) using the equipment installed on board the spacecraft in Earth orbit. The necessary initial data can be obtained from devices in the system of navigation and orientation of most of today's spacecraft — the receiver global positioning system (GLONASS, GPS) and the star sensor. A model of the system is developed and used to obtain estimates of the achievable accuracy prior determination of the orbital parameters of the object in achievable accuracy of source data.

**Key words:** preliminary determination of orbits, space debris, star sensor, computer model.

*E. E. Khatko*

### **Method for testing of «mobile» applications**

This paper describes a method for testing the interface of «mobile» applications based on extended finite state machines usage. The basis of the method is extracting Finite State Machine states by decomposing the application and generating test cases using a graph traversal algorithm. A realization for a tests generation algorithm is proposed.

**Key words:** testing, finite state machines, traversal algorithm, graph traverse.

*V. G. Shinkarenko*

### **Doppler method's peculiarities in 3D laser radar imaging systems**

It is shown that by a remote determination of the spatial derivative of the scanning line, 3D laser radar imaging systems are able to form a gradient image. Its third dimension corresponds to the contour, height or slope of three-dimensional objects and the lay of land. It is determined that the Doppler frequency shifts of an optical signal envelope carry information about the value and sign of the slope of the three-dimensional objects and the lay of land. Analytic equations for the relation between the Doppler frequency shift of a probing signal subcarrier and the spatial derivative of the scanning line are deduced. The Doppler shift of onboard sidelooking laser radars is determined, which takes into account the lay of land.

**Key words:** laser radar imaging, gradient image, Doppler shift, third dimension, 3D image.

*V. Yu. Yurkin, T. I. Mokhseni*

### **Hierarchical approaches to self-organization in ultra-wideband wireless sensor networks based on chaotic signals**

The problem of self-organization in wireless sensor networks is described. Two algorithms are suggested to solve this problem. The time of network self-organization is estimated with respect to narrowband and ultra-wideband signals within the scope of both IEEE 802.15.4 and IEEE 802.15.4a standards.

**Key words:** self-organization, wireless sensor networks, ad hoc, TDMA.

*S. L. Babichev, K. A. Konkov, A. K. Konkov*

### **Using a statically planned thread pool for optimizing the protected virtual storage subsystem of a modified secure environment**

This paper discusses the aspects of implementing a modified secure environment to reduce the vulnerability of modern operating systems. We proposed a subsystem of protected virtual storage and the effective implementation of this subsystem, in particular, the fullest possible use of cores. We proposed a pool of the thread concept and the implementation of this concept and prove the absence of the implementation deadlock.

**Key words:** modified protected environment, protected virtual storage, thread pool, Petri nets, static planning, deadlocks absence.

*A. G. Birjukov, A. I. Grinevich*

### **Multiprecision arithmetic as a guarantee of the required accuracy of numerical calculation results**

This paper is devoted to the error analysis of numerical algorithms using arbitrary precision floating point numbers. The results of this paper are estimates or errors that depend on the mantissa length. Also, there are estimates for the required mantissa length to achieve required error bounds.

**Key words:** accuracy and precision, numerical algorithms, arbitrary precision arithmetic, Markovlike algorithms, guaranteed precision

*A. N. Myagkov, Y. I. Brodsky*

### **On time management in distributed simulation systems**

The paper discusses issues related to model time synchronization algorithms in complex distributed simulation models for whose components (or individual agents) certain rules of their interaction with one another are known, which allow us, in some cases, to optimize the time management algorithms. Some issues of the overall efficiency of these algorithms are also discussed.

**Key words:** time management, declarative programming paradigm, component, event.

*D. I. Ponomarev*

### **Gesture recognition by a remote computer controller**

The remote controller is based on MEMS-accelerometer tracks three dimensional movements of an operator hand. The controller driver generates a signal that controls the mouse cursor. It is shown that an intelligent driver uses the control signal repeatedly to monitor the operator actions and builds a portrait of operator arbitrary actions as a sequence of his hand gestures. For this purpose, pattern discovery algorithms are used for processing control signal records.

**Key words:** remote manipulator, accelerometer, control signal, pattern discovery, Prony method, dynamic time warping, Mueen-Keogh Motif Discovery algorithm, CUDA.

*N. E. Zubov, E. A. Mikrin, S. S. Negodyayev, V. N. Ryabchenko*

### **Synthesis of single-channel system unloading kinetic moment of inertia in the executive bodies of a spacecraft**

We consider the gravitational unloading kinetic moment of inertia problem in the executive bodies of the spacecraft pitch channel for pie and elliptic orbits using band criteria controllability. Control of gravitational unloading received laws and the stabilization of specified provisions of space is uniquely defined by the object parameters and the coefficients specified characteristic equation.

**Key words:** inertial executive bodies, unloading kinetic moment, state feedback, closed system, band criteria of controllability, orthogonal divisor of ze.

*R. Sh. Kalmetyev, A. S. Filippov, D. V. Mikhailovich*

### **Significance and sensitivity analysis of NPP probabilistic safety analysis results**

The main purpose of significance and sensitivity analysis is given. Classes and types of significance and sensitivity analysis are discussed. Techniques of significance analysis and sensitivity analysis are described.

**Key words:** significance analysis, sensitivity analysis, original data, model.

*V. S. Svitelman, O. Yu. Dinariev*

### **Geostatistical analysis of rock microstructure using the spherical harmonics expansion method**

Geological reservoir characterization is based on rocks' petrophysical properties. Nowadays, an important technique for retrieving these properties is X-ray microtomography, which allows for obtaining three-dimensional (3D) rock microstructure models. The detailed microtomographic information requires new theoretically substantiated techniques for data processing and systematization. Because the microtomographic models represent stochastic 3D objects, we assume that geostatistics is applicable. We find that the spherical harmonics analysis of the variogram field could be a method for the following characteristics detection: the complicated structure of the correlation lengths' spectrum and anisotropy on 1 different scales. The classification base of rock microstructures is being extended by variographic analysis.

**Key words:** geostatistics, variogram, spherical harmonics, microtomography.