

CONTENTS AND ABSTRACTS

RADIO ENGINEERING AND RADAR

P. S. Pokrovsky, S. N. Kirillov. SYNTHESIS OF UNIVERSAL QUASI-OPTIMAL DEVICE FOR PROCESSING SPECTRAL EFFICIENT RADIO SIGNAL WITH CONTROLLED COUPLING BETWEEN QUADRATURE COMPONENTS

Key words: spectral efficient radio signals, device synthesis, radio signal detector, noise immunity, universal shaper of radio signals, FQPSK, GMSK, TOQPSK.

The task of developing the universal quasi-optimal device for processing spectral efficient radio signal types is considered. The target is to synthesize one channel algorithm of detecting spectral efficient radio signals with controlled coupling between quadrature components. Quasi-optimal independent processing of signals of in-phase and quadrature components was analyzed in case of additive white gauss noise action. It is shown that in these environments a universal detector of radio signals considered is a sequential connection of a filter with impulse response depending on radio signal type and a solver. As a result the computer simulation has shown, that the universal processing device proposed provides noise immunity increase by 0,5...0,8 dB in comparison with detecting spectral efficient radio signals with OQPSK-detector. In addition, this device provides 0,3...0,7 dB gain relative to FQPSK-detector in GMSK-type signals and 0,1...0,5 dB loss in FQPSK-type signals. At the same time, this device loss to optimal detector of radio signal with controlled coupling between in phase and quadrature components depends on radio signal parameters and lies within 0 to 2,6 dB.

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D. I. Popov. ANALYSIS OF MULTI-FREQUENCY SIGNALS ADAPTIVE PROCESSING

Key words: adaptive processing, analysis, Doppler phase, correlation coefficients, multifrequency signals, adaptation errors, clutter, clutter cancellation, processing efficiency.

The efficiency of adaptive optimal processing of multifrequency signals on the background of clutter is considered in the article. The aim of the work is analysis of the processing efficiency of multifrequency signals, which establishes the relationship between clutter cancellation in the system and errors in the adaptation of Doppler phase shifts and the weighting coefficients of adaptive matrix filter (AMF) to unknown clutter parameters – Doppler phase and inter-period correlation coefficients. In this case, the asymptotic properties of maximum likelihood estimators and linear approximation of AMF weighting coefficients dependences from the estimation of interperiod correlation coefficient are used under the assumption of the known shape of interference correlation function envelope. The relationships obtained and the graphs of clutter losses dependences in the suppression efficiency obtained as a result of the analysis allow us to choose the training sample size depending on the set value of adaptation loss, spectral-correlation properties of clutter and signal processing algorithm.

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M. B. Kagalenko. ESTIMATING THE FREQUENCIES OF POLYHARMONIC SIGNAL BY REDUCING THE ORDER OF A PARAMETRIC MODEL

Key words: Wiener – Levinson algorithm, Adamyan – Arov – Krein theorem, Prony algorithm, least-squares method, Pisarenko algorithm.

We propose an algorithm for estimating multiple frequencies in a sampled signal. This algorithm first constructs a parametric model with excessive number of frequencies, and then per-

forms the optimal reduction of its order. The aim of this work is to compute the accurate estimates of the frequencies using a limited number of signal's samples. At the initial stage, we construct a parametric model of the signal that is a weight function on a unit circle. The poles of rational weight function are determined by the roots of a polynomial, the coefficients of which are given by a singular vector of the matrix constructed from signal's samples. We use the least squares method to determine the weights corresponding to poles. At the second stage, we use Adamyan-Arov-Krein theorem to compute the optimal in the Hankel norm approximation to the model that has an order chosen by a user. We demonstrate using Monte-Carlo simulations that the algorithm has better stability in the presence of uncorrelated white noise than a previously published related algorithm.

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D. V. Avramenko. SPECTRAL ESTIMATION OF MULTI-FREQUENCY REFLECTIONS FROM A ROTATING SPACE OBJECT BY AN IMPROVED PRONY'S METHOD OF LEAST SQUARES

Key words: linear vector autoregressive, Prony's method, weight vector, parametric spectral estimation, vector and time series modeling, Yule – Walker system of equations, pseudo inverse matrix, minimization of mean square error.

The problem of spectral analysis of light reflections from a rotating object at its simultaneous observations in different ranges of lengths of electromagnetic waves is considered. The aim of the work is to improve the accuracy of spectral estimation of multi-frequency reflections from space objects under conditions of smooth change in their brightness. It is proposed to use an improved Prony's method of least squares, which takes into account as a weight vector $\mathbf{w} = [w_t]$ with accuracy $1 \geq w_t \geq 0$ data samples, the reliability of which falls with the growth of their order due to the reduction of statistical material. The research has shown that for spectral analysis, which smoothly changes its intensity of \mathbf{X} light reflection process from a space object and a small (1...5) number of observed periods of its rotation, it is possible to significantly (from 85 to 240 times) reduce relative deviation ΔF of reflecting object rotation frequency estimation in comparison with the known Prony's method of the smallest squares.

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V. K. Klochko, M. Gudkov, X. K. Nguyen. ESTIMATION OF OBJECTS SPATIAL COORDINATES IN WARM – AND RADIOVISION SYSTEMS

Key words: multiposition systems, thermovision, passive radiovision, mutual orientation, the conjugate vectors, estimates of spatial coordinates, matrix *methods*.

Mathematical models and methods of objects spatial coordinates estimation in multiposition systems of thermovision in the infrared range of wave lengths and passive scanning systems of radiovision of millimetric range are considered.

The aim of the work – is to develop methods of objects spatial coordinates estimation in the specified observation systems on the basis of matrix *methods* with determination of mutual orientation of observer coordinate systems allowing to increase the accuracy of estimates due to increase in number of observers. The methods based on observations classifications in case of search of conjugate couples of basis vectors of the directions on objects, measurement of range to them and determination of mutual orientation of coordinate systems for two observers by the results of classification are offered. The concept to create the system with more than two observers allowing to increase reliability of system and accuracy of coordinates estimates is formulated. Results of computer simulation in case of methods implementation are given. Influence of basis vectors determination errors on the accuracy of spatial coordinate estimates in case of unknown mutual observers orientation is considered.

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S. M. Gudkov. RESEARCH OF OBJECT DETECTION RESEARCHING ALGORITHM IN RADIO-METRIC POSITIONING SYSTEM

Key words: radiometric system, positioning, object detection, spatial coordinates estimation, trajectory parameters, modeling. An algorithm for detecting moving objects in the positioning system of several spatially distributed radiometers is considered. Radiometers synchronously scan the area of space, changing the position of the line of sight of the antenna along the azimuth and elevation angle. The result of scanning is the matrix of a radiothermal image of several objects that undergo segmentation operations. Each segment is represented by a vector of parameters – the angular coordinates of object's sight in the center of the object, average radio brightness temperature and geometric invariants. The algorithm classifies vectors according to their belonging to certain objects and determines the trajectories of their movement in the sequence of scan cycles. The aim of the work – is to study the characteristics of the algorithm, depending on the conditions of objects observation by computer simulation. Based on the results of the study, a series of dependencies were constructed reflecting such properties of the algorithm as the probability of detecting all objects, the accuracy of determining their coordinates, the resistance to the influence of noise and noises in the form of false segments, not belonging to objects.

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SYSTEMS, NETWORKS AND DEVICES OF TELECOMMUNICATIONS**S. N. Kirillov, L. V. Aronov.** ESTIMATION OF UNDERWATER WIRELESS OPTICAL CHANNEL PROPERTIES ON DEEP DEPTHS

Key words: underwater optical communication channel, optical communication, wireless optical channel, mathematical model, underwater communication systems.

The problem of determining the energy budget and the maximum data rate for underwater wireless optical communication channel on deep depth is considered. The aim of this work is the estimation underwater wireless optical channel energy budget and the maximum data rate on deep depth. The article has shown that at a depth of more than 1000 m the water state is preserved, the salinity is kept at 34,5 ... 35 ‰, and the temperature is 3 ... 5 °C. The result of water properties stability is a small spread of the parameters of underwater wireless optical communication channel at the depth of more than 1000 m. The laser beam divergence by the particles suspension effects is calculated. The calculations results obtained have shown that at the distance of 100 meters the maximum data rate is from 2 Mbit / s to 1,5 Gbit / s and the diameter of suspension particles has the greatest influence on data rate.

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B. I. Filippov. QUANTITATIVE AND QUALITATIVE DISTINCTIONS OF RADIO AND HYDROACOUSTIC COMMUNICATION CHANNELS CHARACTERISTICS

Key words: radio and hydroacoustic channels; throughput; radio and hydroacoustic channel range; Doppler's effect.

Due to the strong attenuation of electromagnetic (e/m) waves in salt water, we use acoustic waves because they spread in water on bigger distance.

The article discusses the features of radio and hydroacoustic channels. The aim is to evaluate the basic qualitative and quantitative characteristics of hydroacoustic communication channels and how they differ from the basic characteristics of radio channels, and to experimentally evaluate the performance of these channels for practical use in extended channels in the regions of the Black Sea shelf. According to the results of simulation and experiments, the basic indicators of hydroacoustic channels throughput in implementation of digital communication at the distances of 4,5 – 5,5 km in the conditions prevailing in submerged areas of the Black Sea shelf (40 – 60 m) are recognized. In particular, in these ranges hydroacoustic channel throughput is shown to be about 3 – 4 kBit/s.

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S. N. Kuznetsov, B. I. Ognev, E. G. Chulyaeva. WIRELESS OPTICAL COMMUNICATION NETWORK BETWEEN MOBILE SEA OBJECTS

Key words: Wireless Optical Communication, Free Space Optics, optical communication terminal, MANET, Laser Mobile Communications, secure communication channel.

The task to organize wireless optical multi-node network (MANET) between surface ships is considered. The aim is to create computer model of such communication network, to choose the algorithm of logical network infrastructure organization and to determine the main technical requirements to optical communication terminals. The software «Wireless optical network emulator» was developed for simulation of the network of moving surface ships. For the organization of a communication network the well-known algorithms of discrete mathematics are used. The simulation of the network is carried out; technical requirements to optical communication terminals as an element of the specified network are formulated.

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V. I. Dmitriev, S. A. Grushevoy. OPTIMIZING THE ROUTE OF UNMANNED AERIAL VEHICLES WITH RADIOREPEATERS

Key words: route optimization, traveling salesman problem.

A comparative analysis of methods for optimizing the route of movement of unmanned aerial vehicles with radio communication repeaters in case of spatially distributed foci of emergency situations (forest fires, floods) is made on a certain example of practical importance. The aim of the paper is a comparative analysis of the methods for solving traveling salesman problem for a particular, practically important case. The task is presented in a logistical interpretation and solved using several methods for solving the traveling salesman problem known. The dimension of the problem makes it possible to implement a complete search of all variants as a standard of the optimal (shortest) route. The standard compares the results of applying methods: branches and boundaries, mu ravine colonies, genetic algorithm and the «greedy» algorithm based on the rule of the nearest neighbor.

The high quality of problem solution was confirmed with the use of the ant colony method, however, for a sufficiently large dimension of the problem, it is promising to solve multiple traveling salesman problem with the clustering of emergencies and the use of a complete enumeration of routes variants for the movement of unmanned aerial vehicles. The measure of problem solution quality is the proximity of the solution obtained to the ideal solution, which is obtained by a complete search of UAV routes variants.

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**COMPUTER ENGINEERING,
INFORMATION SYSTEMS AND TECHNOLOGIES**

S. F. Tyurin, R. V. Vikhorev. ADAPTIVE LOGIC PLD MODULE WITH FPGA ARCHITECTURE

Key words: programmable logical integrated circuit, adaptive logical module, conjunction, modeling, perfect disjunctive normal form.

Development of advanced devices of programmable logic is considered. New realization of the adaptive logical module with realization of systems of logical functions both in perfect disjunctive normal form (PDNF), as well as in disjunctive normal form (DNF) is offered. Modeling of the proposed solutions in the system of circuitry modeling NI Multisim 10 firm National Instruments Electronics Workbench Group is executed. Comparative assessment of complexity of the offered realization with other options of programmable logic is made. The aim of the work is development of an adaptive logical module for programmable logical integrated circuits, Field-Programmable Gate Array type which can be adjusted to realize not only the set function, but also the systems of logical functions.

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S F. Tyurin. INVESTIGATION OF THE ASYNCRONOUS ARBITER

Key words: Field-Programmable Gate Array, Arbiter, Flip-Flop.

Since the appearance in the 70s of the twentieth century of programmable logic – first programmable logic matrices (PLM) by Texas Instruments, and then in the 1980 s – programmable logic integrated circuits - FPGAs, the attempts to use them in asynchronous circuitry are being made. However, a synchronous method for calculating logical functions is still used. Synchronization frequency is calculated for the worst case, which leads to performance decrease. In addition, timing tools occupy a large area of crystal and impair energy efficiency. The asynchronous way of processing information is devoid of these shortcomings, but it gives rise to another, more complex synthesis of asynchronous schemes. In addition, there are known difficulties using standard FPGAs, for example, in the implementation of so-called arbiters, allowing to eliminate negative consequences of competition (races). In recent years, modified FPGAs have been proposed, which include additional elements necessary for realizing asynchronous circuits. But these elements, in turn, are also subject to the negative properties of transient processes in asynchronous circuits. The article examines a special arbiter, which is absent in synchronous FPGAs.

The aim of the work is to study the features of asynchronous arbiter scheme, in which there is a non-standard connection of inverters, the definition of transition function and the modeling of its operation as well as the development of the arbiter for radiation-hardened FPGAs.

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A. V. Prutzkov. INTERNET-RESOURCE FOR SCIENTIFIC AND EDUCATIONAL WORK RESULT PUBLISHING

Key words: Internet, Internet-resources, Internet-resource structure, Internet-resource software, Internet-resource operational results.

We have developed Internet-resource for scientific and educational material publishing. The aim of the paper is to describe the Internet-resource developed, its structure and the results obtained with the help of it. Before the beginning of Internet-resource programming, we have formulated the requirements to Internet-resource for minimizing its maintenance and hosting costs. Server software of Internet-resource has modular structure. The structure includes a module of dynamic pages generating, a module of generated pages caching, AJAX-request handlers, such as Internet-application for processing cardinal numbers of natural languages. Dynamic pages are generated using the single design template. The content structure includes the implementation of our models, methods and algorithms, scientific articles, educational manuals, information of student conferences, olympiads and contests of IC company. The Internet-resource expands the availability of materials published on it, for users around the world, for example, scientific articles, which increases article citation.

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V Ya. Tsvetkov, E. V. Voinova. MODIFICATION OF RASCH MODEL FOR FREE TESTING ASSESSMENT

Key words: Education, testing, regulation testing, free testing, Rasch model, comparative evaluation, algorithm, theory of preferences.

The aim of the work is to modify Rasch model and to justify this modification. The task of the work is the creation of a new method and algorithm for processing test results. Studies include comparison of normative and free testing. The paper provides critical analysis of Rasch model in education. Studies reveal the difference between the conditions of testing in education and psychology. The article recommends the transition from individual evaluation of testing to comparative evaluation. In this case, testing should be supplemented with estimates from the theory of preferences. The proposed method excludes the influence of one latent variable in Rasch model. This raises evaluation quality. The result of the work is a new method and algorithm for evaluating the results of testing. The method allows to carry out group analysis and compare the results of free testing. The method allows making a comparative assessment of the quality of students preparation by different teachers.

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INSTRUMENTATION AND INFORMATION MEASUREMENT SYSTEMS

A. V. Kuzmin. ANALYSIS AND MODELING OF ELECTRICAL ACTIVITY OF THE HEART WITH DYNAMIC MODIFICATION OF GEOMETRICAL PARAMETERS OF THE MODEL

Key words: electrical activity of heart, geometrical parameters, 3D model, contractive activity, visualization.

The problem of development of universal software unit of analysis and modeling of electrical activity of a heart for information-measuring cardiological systems and training information systems is studied. Existing systems of scientific-research, diagnostic and training purpose are investigated. Multi-dipole model of electrical activity of heart (L.I. Titomir model) is studied, namely the parameters that have the influence on the results of dipole moment's value calculations, especially geometrical parameters that are presumed as static. The aim of the work is to create the method of dynamical modification of geometrical parameters while simulating heart electrical activity. The scheme of modeling with dynamical modification of parameters of 3B model of a heart is proposed. The results of dynamical modification of 3D model with simplification due to retention of reference points' transition vectors are shown. The examples of application field of these results as well as the directions for future work are considered. The results of the research allow to develop information-measuring systems with new possibilities of modeling of electrical activity of a heart.

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Y. A. Podgornova. DETECTION OF BREAST TUMORS BASED ON THE ANALYSIS OF THEIR SHAPE BY X-RAYS

Key words: mammogram, mammary gland cyst, fibroadenoma, breast cancer, recognition, geometric features, BI-RADS, form, convex hull.

Mammography is the main method of visualizing the mammary glands for the diagnosis of pathologies. This method allows you to analyze any changes in the breast, for example, the visible symptoms of breast cancer are the entrained nipple, the accumulation of single microcalcines, vascularization around the tumor, the shape of the tumor with indistinct, uneven edges, a spicule-shaped contour. To standardize the analysis of results by scientists from the American College of Radiology, a BI-RADS system was developed. One of the classifications of neoplasms in this system is their form. In the work the technology of recognition of new formations of a mammary gland of three basic types is offered: a cyst, a fibroadenoma and a cancer, based on the analysis of their form. The aim of the work is to find the basic geometric characteristics of the new formations (area, perimeter, shape factor, convex hull surface, convex hull form factor), classification of neoplasms based on analysis of their shape. The obtained results of experimental research have shown the opportunity to use the given algorithm in mammographic screening.

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I. S. Kholopov. ALGORITHM FOR DETECTING MECHANICAL TAP BY THE SIGNALS OF TRIAXIAL MEMS ACCELEROMETER IN IDENTIFICATION PROBLEM

Key words: MEMS accelerometer, threshold processing, discrete derivative, correlator, Neyman – Pearson criteria.

The aim of the work is the development of an algorithm for identification by mechanical action, perceived by uncalibrated digital triaxial MEMS accelerometer. It is shown that for consumer accuracy triaxial accelerometers (with serial analog-to-digital conversion of signals from differential capacitors of each sensitivity axis) there is a high probability of false estimation of mechanical action primary direction when it is determined both by the maximum of acceleration signal and by the maximum of its derivative. The paper considers an identification algorithm in which the directions of elementary effects are estimated from the sign of acceleration derivative at the time of the first exceeding of detection threshold and the maximum of the sum of acceleration sample modules along sensitivity axis. Accumulation of the sum is carried out when the

threshold is exceeded for at least one of the sensor axes. During semi-real experiment the achieved probability of correct identification was more than 0,7.

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M. V. Zharov. INFORMATION MEASURING SYSTEM TO CONTROL PRODUCTION PROCESS WITH THERMAL COMPRESSIVE PROCESSING EQUIPMENT

Key words: information measuring system, elements of automation, ADC board, thermal power, information signal, application software, expansion hardware, thermal compressive equipment, process temperature, heating rate.

The system to control production equipment work on the basis of information systems is developed. The application software which allows to optimize the operating process of thermal compressive equipment has been developed. The aim of this work is to create an automated system that allows to create set temperature-speed deformation modes in the conditions of isothermal forging as well as forging in superplasticity state on the basis of data exchange by required and the actual elements heating.

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V. F. Odinokov, S. I. Kholopov. AUTOMATION OF THEORETICAL RESEARCH OF INFORMATION-MEASURING SYSTEM LCR-ELEMENTS

Key words: transmission function, linear circuits, topological model, LCR-connections, conductivity of elements, dependent and independent connections, automated research, topological search.

For operative theoretical research of the parameters of LCR-connections the specialized user-friendly set of corresponding receptions and facilities is needed. Such set has not been found in the known works. The aim of the work is to methodically and programmatically perform automated theoretical study of linear stationary LCR-connections on the basis of their topology. In methodical part of the article the concepts of research objects, dependent and independent parts of LCR- of connections, their topological models, conductivities of elements, virtual ideal receiver of output signals and initialising of topological models on the base of different structures are given. Approaches charts and mathematical formulae are offered for operative automated calculation of amplitude – and phase-frequency characteristics, entrance and output impedances, tensions of idling and currents of short circuit of LCR – of charts on the basis of transmission functions of different kinds. The examples of implementation of the methods offered and facilities of operative analysis of LCR- of connections are given.

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ELECTRONICS AND NANOELECTRONICS

V. K. Bazylev, A. M. Zhidkov, V. A. Korotchenko, V. E. Skvortsov, T. N. Andreasyan. DESIGN AND RESEARCH OF ORBITRON IONIZATION MANOMETRIC CONVERTER

Key words: vacuum gauge, ionization manometer converter, orbitron vacuum sensor, computer modelling, motion of electrons.

An electrode system was developed, an electric mode was determined, and experimental sample of ionization manometric converter of orbitron type with low (up to 300 V) anode voltage and high vacuum sensitivity was performed. Using numerical simulation, it was shown that at cathode potentials (10 – 50) V the characteristic values of retention time of electrons in orbitron trap are (0,1 – 1) μ s, but there are cases of retention for a long (up to 33 μ s) time. Data about mechanism of electron trap formation and characteristic of electrons motion are presented. It is shown that the steady-state mode of motion occurs approximately after 5 μ s. In the interval (5 – 33) μ s, the radius of shuttle spiral is stabilized on the level $6 \pm 0,3$ mm, and the energy is 95 ± 7 eV. Single pass time of the electron around anode is 6,5 ns, the axial oscillations period is 120 ns, lead of spiral is 4,6 mm, number of rotations is about 5000, path length is about 200 m. The ability of the orbitron developed to record gas pressure in the range (5 – 35) μ Torr at an average

value of orbitron gauges sensitivity equal to 2200 Torr^{-1} , which is approximately two orders of magnitude greater than for the widely distributed PMI-2 ionization manometer has been experimentally proved. The aim of the work is to improve ionization vacuum sensors by increasing their manometric sensitivity, reducing the level of gassing in sensors and reducing ionic pumping of gases during the operation of gauges.

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V. B. Nasedkin, V. V. Skripin, S. A. Kruglov, A. A. Baturinets, A. A. Serezhin. INCREASE OF ELECTRODES ADHESION TO GAS DISCHARGE INDICATOR PANEL SUBSTRATE

Key words: gas-discharge indicator panel, electrode, paste for making electrodes, titanium dioxide.

An experimental study was made of the dependence of electrodes adhesion of gas-discharge indicator panels (GIP) GIP768 * 576.0.145 and GIP320 * 256.0.42 after multiple heat treatments when adding refractory metal oxide to the paste. A survey of state and characteristics of the electrodes was carried out. The qualitative and quantitative composition of refractory metal oxide was determined and the method of introducing the material into paste was determined. It was found that the optimum variant of metal oxide is titanium dioxide when added to the charge in a ratio of 1,9%. Manufacture of electrodes according to the chosen formulation ensures that electrode material does not peel off from gas-discharge display panel under repeated heat treatments with intermediate deposition of other structural elements.

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S. A. Kozyukhin, Nguyen Thi Hang, A. A. Korlyukov, A. A. Polohin, A. V. Volkova, P. I. Lazarenko. OPTICAL PROPERTIES OF AMORPHOUS ARSENIC SELENIDE FILMS PREPARED BY SPIN-COATING TECHNOLOGY

Key words: amorphous As_2Se_3 thin films, spin-coating technology, optical properties, optical band gap, optical constants n and k .

The aim of this work was to study the optical properties of As_2Se_3 semiconducting amorphous films prepared by the spin-coating method. A distinctive feature of this method is the possibility of thin films preparation under the conditions close to equilibrium, and also the relative simplicity and accessibility in comparison with other technologies for preparing thin films based on chalcogenide compounds. The films prepared were characterized using X-ray diffraction, IR spectroscopy, atomic force microscopy and Raman scattering, which led us to conclusions about their phase state, impurity composition and structure. Optical transmission methods and spectral ellipsometry were used to study the optical characteristics of amorphous films and to perform a comparative analysis with similar parameters for thin film, which are known from the literature. It was shown that amorphous films prepared by spin-coating have an optical band gap $\Delta E_g = 1,64 \text{ eV}$ and a dispersion of refractive index in the visible range between 2.2 and 3.1.

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