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INVESTIGATIONS AND ACHIEVEMENTS IN SENSORICS AREA IN 2008

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Abstract. The review of the basic results of investigations in sensorics area is presented which were coordinated by Sensorics Section of NAS Ukraine Scientific Council on "Physics of semiconductors and semiconductor devices" for year 2008.

The review contains the results of investigations, which were carried out by scientific schools, subunits of NAS Ukraine, Ministry of Education and Science of Ukraine, the named below research organizations:

– V.E. Lashkarev Semiconductors Physics Institute;
– Institute of Physics of NAS Ukraine;
– O.V.Palladin Institute of Biochemistry of NAS Ukraine;
– Institute of Molecular Biology and Genetics of NAS Ukraine;
– Taras Shevchenko Kyiv National University;
– National Technical University "Kyiv Polytechnical Institute";
– Lviv Ivan Franko National University;
– National University "Lviv Polytechnica";
– Kharkiv National University of Radioelectronics;
– Odesa National Polytechnical University;
– Odesa I. I. Mechnikov National University;
– Odesa State Academy of Communication
– Odesa National Maritime Academy;
– Dnepropetrovsk National University;
– Yu. Fed'kovich Chernivtsy National University.

Investigations were carried out in the following basic scientific and applied science directions:

– physical, chemical and other phenomena on the basis of which sensors could be developed;
– sensor design and mathematical modeling;
– physical sensors;
– chemical sensors;
– biosensors;
– radiation, optical and optoelectronic sensors;
– acousto-electronic sensors;
– nanosensors (physics, materials, technology);
– sensors and information systems;
– materials for sensors;
– technological problems of sensor controls;
– microsystem technologies (MST);
– sensor's degradation, metrology and certification.

We propose to attribute the following to the basic scientific results and achievements on section interest directions:

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Electrophysical and adsorption properties of surface barrier structures created at silicon surface through modification by particle irradiation with the purpose of gas-sensitive structures creation that was carried out together with Institute of Nuclear Research of NAS Ukraine were studied in the papers [1, 2].

It is shown, that the sensitivity of structures based on gold — radiation-modified silicon junction to ammonia is higher than for structures gold — non-irradiated silicon. The saturation current of gold — radiation-modified silicon hetero-junction changes nonlinearly with temperature. The account of the resonance-tunnel current allows explaining the dependences observed qualitatively for samples irradiated by dozes 10^{15} and 10^{17} protons/cm^{-2}. This effect is connected with the increase of the effective adsorption area owing to irradiation [3-6]. The new

type sensitive optoelectronic gas sensor is proposed on the basis of the silicon photo-converter (diffusive p-n junction with a thin layer of porous silicon on the back side) with photo-electric transducer. The parameter being sensitive to the adsorption of molecules is the photocurrent which arises at illumination silicon back surface by light from region of silicon heavy absorption and depends on the surface non-equilibrium carriers recombination change which, in turn, depends on the type and concentration of adsorbed molecules. The multi-sensor structure with the optical addressing and 2D cartography of the given photocurrent which is at use of the main components method allows to analyze liquids or gases mixes is created and investigated [7,8].

National University "Lviv Polytechnica"

With the purpose of creation of radiation-resistant physical sensors for cryogenic temperatures, the investigations of irradiation with high-energy electrons influence on jumping conductivity of thread-like Si crystals and p-type $Si_{1-x}Ge_x$ solid solutions with impurity concentration near junction metal — dielectric are carried out.

Strong (up to 14 Tl) magnetic field influence on the conductivity of alloy Si micro-crystals, solid $Si_{1-X}Ge_X$ solutions and poly-silicon layers on insulator (SOI-structures) is investigated at cryogenic temperatures [9, 10].

The opportunity Si nano-wires with diameters 10-100 nm, creation by the gas-core epitaxy method for sensors development on their basis is shown. The technology of sub-micron sizes auto-emitting silicon cathodes creation with the use of the micron sizes photo-masks on SMIS technologies for device structures creation is developed [11].

With the purpose of sensor operational temperature increase in magnetic field at radiation conditions diagnostics, the technology is created of growing from a gas phase solid solutions $InAs_{1-x}Sb_x$ micro-crystals with a different ratio of the fifth group components (As and Sb), where x = (0,02-0,16) [12, 13].

The lattice parameters and structure of brought up $InAs_{1-X}Sb_x$ micro-crystals are defined. Brought up micro-crystals electrophysical parameters' research is carried out and the received solid solutions' forbidden zone width is determined.

Multi-functional magneto-sensing probe for simultaneous measurement of three component of a magnetic field and/or its spatial gradient is developed [14].

The analysis of conditions of spatial magnetic heterogeneity visualization by magneto-optic methods is carried out. The way of reception of quantitative characteristics of spatial distribution of magnetic fields by display film method is offered [15].

Silicon and the modification of porous silicon for photo-electric converters — solar elements (SE) creation are investigated. Effective and profitable technological processes in manufacture SE structure elements, first of all a frontal surface — structure with low integral reflection factor are proposed [16].

The technology and new hetero-structures is developed on the basis of organic and inorganic semiconductors (nickel phthalocyanine alloyed with oxygen) for sensor engineering [16].

V.E. Lashkarev Semiconductor Physics Institute, NAS Ukraine

The γ — and β — radiations detecting blocks are developed and produced on the basis of CdTe:Cl and CdZnTe semiconductor materials with use of laser evaporation methods and contact metal fusion [17].

The device for radiating monitoring of environment which consists of γ-radiation semiconductor detector and the monitoring block which contains the programmed processor as well as the information preservation blocks on γ-radiation doze power and the signaling about the γ-radiation doze power amount excess above the programmed maximum permission is developed [18].

X-rays dispersion by multilayered structures peculiarities are investigated, and also mechanisms quantum points and threads ordering in multilayered structures with use of high resolution diffractometry methods are investigated [19].

It is established, that for multi-layered systems of InGaAs/GaAs (100) spatial ensemble ordering of quantum points (QP) on flat GaAs substrate is vertically correlated with insignificant inclined transformation and is laterally built in a primitive oblique-angled lattice which forms a three-dimensional file as the disfigured tetragonal cell.

The nature of interrelation of anisotropy of initial and residual deformations in multi-layered (In, Ga)As/GaAs structures with the quantum threads, subjected fast thermal annealing is established and analyzed. The role of micro- and macro-defects during the self-organized nano-islands growth is established [20].

It is established, that at fast thermal annealing in a temperature interval of 500-800 ^{0}C for structures with quantum threads, the significant changes of three-dimensional order of quantum points in the multilayered structure occur, caused by it macro-elbow and intensive diffusion processes. It is shown, that the crystallographic orientation of substrate significantly influences the form, the size and density of quantum points at weak influence on character planar ordering [21].

The opportunity of management in parameters nano-dimensional Ta_2O_5, Cd_2O_3, TiO_2, Er_2O_3 films; Ta_2O_5-Si, Cd_2O_3(TiO_2, Er_2O_3)-SiC structures and Al(W, TiN)-Ta_2O_5-Si MDS structures at the influence on them of dosing microwave radiation is shown.

The software for computer modeling and reception of authentic quantitative parameters of probe — surface contact capacity and semiconductor nanostructures local areas doping level (some tens of nanometers) on results of mapping of a surface by a method of scanning capacitor microscopy is advanced. It is shown, that the basic fluctuations break-down layers characteristics are caused by films thickness variations (0.2-0.5 nm) and electrically active defects density distribution heterogeneity [22-24].

Yu. Fed'kovich Chernivtsy National University

Research is carried out and some model developments for quantitative spectrum characteristics of simultaneously several types of defects in crystals high-resolution multi-crystal diffractometry are realized [25].

Some model developments for oblique asymmetrical topography in geometries Laue, Bragg and sliding beams diffraction for diagnostics defects selective on depth in the excited surface layers of mono-crystals and multilayered epitaxial structures (level-by-level diffracto-topography) are realized [26].

Combined investigations by methods X-ray diagnostics of multilayered A^3B^5 structures and structural changes in surface layers materials subjected ionic and high-power electronic irradiation are continued [27].

I. I. Mechnikov Odesa National University

The model of relaxation phenomena in non-ideal hetero-junction is developed, and recommendations for memory elements on the basis of non-ideal hetero-junctions manufacturing techniques are offered. The model, which allows the theoretical sensito-metrical characteristics' calculation of the investigated elements is created, the calculations of such characteristics as well as its comparison with experimental one are carried out. The numerical calculation of a characteristic curve with use of generation and recombination model in non-ideal hetero-junction is carried out [26, 29].

The photoluminescence of the nano-dimentional tin dioxides films at room temperature was registered and the dependence of a photoluminescence on gels composition for their reception, which considerably expands the opportunities of these films use in optoelectronics and sensor electronics is established [30].

The structural and electro-physical characteristics of adsorptive sensitive complex compounds are investigated and systematized [31, 32]

It is shown that the mechanism of analyzed compound's interaction with layered structures of complex compounds are determined by the supramolecular complex compound with macromolecular branched structure, and also the functional material nano-dimensional hollows and the developed surface, and nano-hollows atoms group form physical bond between the analyzed molecule and sensitive layer material [33].

The basic laws of adsorption-desorption phenomena concerning the distribution of acoustic waves in polymeric compound — piezoelectric material layered structures are established [33].

The technique microelectronic sensors creation is developed on the basis of layered structures and acousto-electronic element, which can be introduced at the enterprises of the instrument-making industry [34-36].

The significant part of the received results of investigations is published in the list of the literature given below.

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