"BRIEF" PROPOSITIONS OF CHERNIVTSI UNIVERSITY
(Present state and "hot" researches)
Department of Electronics and Energy Engineering

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Our research:

- Deposition of different pure and doped thin films: TiO_2, TiN, SnO_2, ZnO, CdTe, $CuInS_2$, Cu_2SnS_3, $CuZnSnS_2$ by means of the DC and RF magnetron sputtering, the electron-beam evaporation and spray pyrolysis techniques.
- Investigation of optical and electrical properties of thin films.
- Growth of different pure and doped semiconductor single crystals (CdTe, CdZnTe, HgInTe and other) by means of the Bridgman method and investigation of their magnetic, kinetic, optical and photoelectrical properties.
- Fabrication of different heterojunctions and metal-oxide-semiconductor structures (TiO_2, TiN, SnO_2, ZnO / Si, CdTe, CdZnTe, CdHgTe, $CuInS_2$, Cu_2SnS_3, $CuZnSnS_2$,) for application in electronics, optoelectronics and photovoltaics.
- Investigation of electrical and photoelectrical properties of heterojunction solar cells (current transport mechanisms, impedance spectroscopy, apparent quantum efficiency).
- Development of new methods and approaches for the analysis of electrical and photoelectrical properties of semiconductor heterojunctions.

We are interested in our common research on:

The fabrication of new nanostructured semiconductor heterojunctions, in particular, based on TiO_2 and TiN, using different technological techniques as well as the detail analysis of their physical properties under different conditions.

Also, we would like to carry out a number of measurements of our thin films and heterojunctions in cooperation with your institution (if necessary equipment is available):

SEM and *AFM* (the analysis of the morphology of the thin films and heterojunctions);
Energy-dispersive X-ray spectroscopy, *Raman spectroscopy* and *X-ray diffractometry* (the analysis of elemental composition and structural properties, respectively, of the thin films and heterojunctions);
Ellipsometry (the analysis of optical properties of the thin films);
Ultraviolet photoelectron spectroscopy and *impedance spectroscopy* (the analysis of the energy distribution of interface state density at the heterojunction interfaces);
Photoluminescence (the analysis of the surface recombination velocity under different conditions)

Electrical and photoelectrical properties of the heterojunction solar cells: *current-voltage characteristics at different temperatures (4.2 – 360 K) and illumination conditions (intensity and wavelength), capacitance-voltage characteristics at different frequencies of the small amplitude AC signal (wide range 0.1 Hz – 500 MHz), the spectral distribution of quantum efficiency and open-circuit voltage under monochromatic illumination at different temperatures*.

Our main recent publications:

1. V.V. Brus, M.I. Ilashchuk, Z.D. Kovalyuk, P.D. Maryanchuk, K.S. Ulyanytskiy Electrical and photoelectrical properties of photosensitive heterojunctions n-TiO_2/p-CdTe, *Semicond. Sci. Technol.* 26 (2011) 125006.
2. V.V. Brus, On quantum efficiency of nonideal solar cells, *Solar Energy* 86 (2012) 786-791.
3. V.V. Brus, M.I. Ilashchuk, Z.D. Kovalyuk, P.D. Maryanchuk, Light dependent *I-V* characteristics of TiO_2/CdTe heterojunction solar cells, *Semicond. Sci. Technol.* 27 (2012) 055008.

4. V.V. Brus, L.J. Pidkamin, S.L. Abashin, Z.D. Kovalyuk, P.D. Maryanchuk, O.M. Chugai, Optical constants and polarimetric properties of TiO_2-MnO_2 thin films, *Optical Materials* 34 (2012) 1940-1945.
5. V.V. Brus, M.I. Ilashchuk, Z.D. Kovalyuk, P.D. Maryanchuk, O.A. Parfenyuk, Surface-barrier heterojunctions TiO_2/CdZnTe, *Semicond. Sci. Technol.* 28 (2013) 015014.
6. V.V. Brus, The effect of interface states continuum on the impedance spectroscopy of semiconductor heterojunctions, *Semicond. Sci. Technol.* 28 (2013) 025013.
7. M.M. Solovan, V.V. Brus, P.D. Maryanchuk, T.T. Kovalyuk, J. Rappich, M. Gluba, Kinetic properties of TiN thin films prepared by the reactive magnetron sputtering, *Physics of the Solid State* (in press).
8. M.M. Solovan, V.V. Brus, P.D. Maryanchuk, M.I. Ilashchuk, J. Rappich, N. Nickel, S.L. Abashin, Fabrication and characterization of anisotype heterojunctions n-TiN/p-CdTe (submitted to *Semicond. Sci. Technol.*).

The brief proposal of Correlation Optics Department

Contact persons:
Head of department: Prof. Dr. Oleg Angelsky, angelsky@itf.cv.ua
Prof. Dr. Igor Mokhun, mokhun@itf.cv.ua, igmokh@rambler.ru

1. Singular Optics and Applications

In our opinion the relevant scientific topics, where Correlation Optics department can collaborate with your Institution may be:

1. New kind of optical tweezers
2. Transformers of "smooth" laser beams to singular one.
3. Microspectropolarimeter for biomedical application

The first topic is high line in modern optical technology. The Correlation Optics department works in this field more than 10 years and has, first of all, the fundamental results [1-8].
In this aspect we propose join project for *elaboration of optical tweezers with changeable optical traps: light Gaussian trap, Dark Vortex trap, Dark Vortexless trap.* Such tweezers may capture the micro object independently from the optical characteristics of particle, due to the simple change of optical trap type.

The *advantages* of elaborated device (relatively the known ones) are:

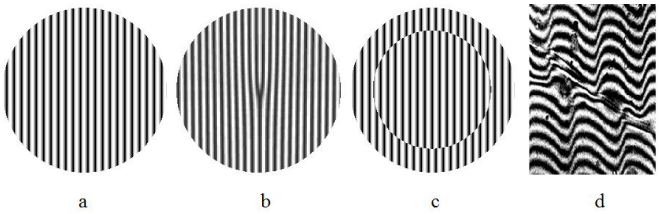
- High energy efficiency.
- Relatively simplicity for production.
- Relatively low cost.

The fields of application of join investigations are: Biotechnology, Material technology, Chemistry, may be Medicine. In other words all fields, where we need to capture microobject and transport it in other space point.

What we need?

We need the technology of production of high efficient computer generated holograms (like kinoform).

Types of holograms, there structure maybe similar to the structure illustrated by figure.



a-b – structure of hologram fringes, d – interferogram of hologram structure.
The "period" of grating is about 0.01 – 0.05 mm.

It seems to us that your possibilities are enough for such holograms production.

As to the second topic, we can propose, at least, *two new methods of obtaining of azimuthal (radial) polarized optical beams*. Such beams may be focused into the spot, with dimension less than diffractive one. Correspondingly the new types of transformers "smooth" beam – azimuthally polarized may be realized.

The *application*s of such transformers may be *very wide*, for example: devices with superresolution, optical tweezers, precise micro welding etc.

What we need?

We need the efficient computer generated holograms *of optical axicons* with specially calculated period, which can work both like transmitting and like reflecting elements. The characteristics of holograms are similar to the mentioned above.

Recent main publication of our department devoted the our propositions

1. Angelsky, O.V., Bekshaev, A.Ya., Maksimyak, P.P., Maksimyak, A.P., Hanson, S.G., Zenkova, C.Yu. Orbital rotation without orbital angular momentum: mechanical action of the spin part of the internal energy flow in light beams". *Optics Express*, **20** pp.3563-3571, (2012).

2. A.Y. Bekshaev, O.V. Angelsky, S.G. Hanson, and C.Y. Zenkova, "Scattering of inhomogeneous circularly polarized optical field and mechanical manifestation of the internal energy flows," *Phys. Rev. A* **86**, 023847 (2012).

3. Angelsky, O.V., Bekshaev, A.Ya, Maksimyak, P.P, Maksimyak, A.P, Mokhun, I.I, Hanson, S.G, Zenkova, C.Yu, Tyurin, A.V. „Circular motion of particles suspended in a Gaussian beam with circular polarization validates the spin part of the internal energy flow", *Optics Express*, **20**, pp. 11351-11356 (2012).

4. Mokhun I. Galushko Yu., Kharitonova Ye., Viktorovskaya Yu., Khrobatin R Elementary heterogeneously polarized field modeling. *Optics Letters*, **36**, p. 2137- 2139, (2011).

5. Mokhun I., Arkhelyuk A., Galushko Yu., Kharytonova Ye., Viktorovskaya Ju. Experimental analysis of the Poynting vector characteristics. *Appl. Opt*. **51**, pp. C158-C162, (2012).

6. I. Mokhun, R. Khrobatin. "Shift of application point of angular momentum in the area of elementary polarization singularity", *Journ. of Optics A: Pure and Appl. Opt*., **10,** 064015 (2008).

7. C.Yu. Zenkova, M.P. Gorsky, P.P. Maksimyak, and A. P. Maksimyak "Optical currents in vector fields". *Applied Optics*, **50**, pp. 1105-1112 (2011).

8. O.V. Angelsky, P.V. Polyanskii, P.P. Maksimyak, I.I. Mokhun, C.Yu. Zenkova, H.V. Bogatyryova, Ch.V. Felde, V.T. Bachinskiy, T.M. Boichuk, A.G. Ushenko, "Optical measurements: polarization and coherence of light fields". [in] Modern Metrology Concerns. – *Monograph*, ed. by Luigi Cocco. – InTech, ISBN 959-953-307-336-0, (2012), (54 pp). *http://www.intechopen.com/books/modern-metrology-concerns/the-state-of-the-art-ande-prospects-of-metrology*.

2. Microspectropolarimeter for biomedical application

This device is practically ready for production. Only small additional work is required.

Relevance development.

Optical diagnosis of cancer occurrence and progression of human diseases is extremely important for a range of pathologies , like cervical dysplasia and its transition into malignance phase , skin cancer , benign and malignant forms of human prostate cancer, breast cancer, etc.

The advantages of the proposed spectral-polarization method of diagnosis is: invasiveness, rapidity, increased in comparison with the accuracy of other methods, compact and convenient device that implements the method, comparative cheapness of the device.

Purpose of development.

The developed device allows polarization- spectral measurements in systems imaging of biological tissues as a mode in vitro, and visualization of pathologies in vivo.

Applications and specific problems preclinical biomedical diagnostics:

- early cancer changes of soft tissue , skin, gynecological and urological tissue areas,
- collagen diseases,
- amyloid diseases (Alzheimer's disease , primary systemic amyloidosis),
- bone and degenerative- dystrophic human disease (osteoarthritis, osteopathy, osteoporosis).

Underway.

Similar problems are involved in such countries as the USA, Canada, France and others.

However, existing prototypes have the following disadvantages:

- Enough equipment cost (the cost is much higher than proposed instrument)
- The complexity of the technical implementation in a clinical setting,
- Cumbersome systems and the unavailability of software.

Created by the Department of Correlation Optics Chernivtsi National University appliance - spectromicropolyarimeter is almost devoid of these shortcomings: a simple and familiar to service in a clinical setting framework (microscope) , high accuracy in determining the spectral and polarization characteristics , the ability to operate in the results not only images of biological tissues , but their spectral polarization maps.

The software of the micropolyarimeter can count biosamples of statistical characteristics of images . The results of diagnostic displays in digital and cartographic form on the monitor using the original software.

Intellectual property.
The main ideas and results of studies that form the basis of development, scientists received the Department of Correlation Optics Chernivtsi National University and published in monographs and numerous articles in refereed journals, have been reported at international conferences. The methods used in this development by a number of declarative patents of Ukraine.

Necessary steps for further implementation of the device:
1. Conducting patent protection and declarative method in the West (patent techniques and gear).
2. Search Marketing in Ukraine, Europe, Japan and USA.
3. Improvement of endoscopic techniques for in vivo diagnostics.
4. Clinical trials.

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Articles:

1. Angelsky O.V., Demianovsky G.V., Ushenko A.G., Burkovets D.N., Yu.A. Ushenko. “Wavelet analysis of two-dimensional birefringence images of architectonics in biotissues for diagnosing pathological changes” // J. Biomed. Opt. – 2004. – V.9, No.4. – P.679-690.
2. Oleg V. Angelsky, Steen G. Hanson, Alexander P. Maksimyak, Peter P. Maksimyak “On the feasibility for determining the amplitude zeroes in polychromatic fields”, Optics Express, V. 13, No. 12, pp. 4396-4405, 2005.
3. O.V.Angelsky, A.G. Ushenko, D.N. Burkovets, Yu.A.Ushenko “Polarization visualization and selection of biotissue image two-layer scattering medium”, Journal of Biomedical Optics (SPIE press), V. 10, No. 1, pp.1-12, 2005.
4. O.V. Angelsky, A.G. Ushenko, and Ye.G. Ushenko, “2-D Stokes Polarimetry of Biospeckle Tissues Images in Pre-Clinic Diagnostics of Their Pre-Cancer States,” J. Holography Speckle 2, 1-8 (2005).
5. O. V. Angelsky, S. B. Yermolenko, O. Prydij, A. G. Ushenko, Yu. A. Ushenko, and Ye. G. Ushenko ”Polarization-Interference Structure of Speckle Fields of the Rough Skin Surface” // J. Holography Speckle 3, (2006), p.27–34.
6. Angelskaya A., Gruia I., Yermolenko S., Ivashko P., Gruia M. Manifestation of linear dichroizm changes in cancer biotissues// *Romanian Reports in Physics, Vol. 65, No. 3, P. 1052–1062, 2013.*

3. Portable device for roughness measurements

This device is practically ready for production. Only small additional work is required.

The device is assigned for surface roughness control and would be comparable on performance but much cheaper (by 1 to 2 orders of magnitude) in comparison with analogues, such as Taylor Hobson, WYKO, ZYGO. The proposed devices compare favorably with the mentioned analogues by parallelism and non-contact nature of data surveying and processing, being applied directly in production process for on-line and final control of quality of the product. Protection against vibrations and high rate (one-measurement time is by one order of magnitude less in comparison with analogues) are the important advantages of the proposed devices.

The principles:

- heights of surface irregularities are less of the wave length of the probing radiation, and correlation length of irregularities is larger than a wave length;
- phase variance is measured at the boundary field (object surface is imaged to the plane of analysis), and amplitude dispersion is measured at far field; the transverse coherence function of the field is measured at arbitrary zone;
- surface roughness diagnostics is performed using a wave front whose form is equal to the macroform of the surface of interest; statistical parameters of a field are measured using interferometric arrangements with zero (infinitely extended) interference fringe. Fields of application:

- space industry, to monitor the quality of mirrors fabricated by diamond micro-sharpening
- polishing machine tool, this device was used for a surface quality control during making of the detail
- device can be made either as a measuring head, or as a stationary instrument, depending on the size and the position of the object to be controlled.

Size: 150 mm x 50 mm x 20 mm
Weight: 300 g

Department of Optics and Publishing

Contact person – Head of department: Prof. Dr. Alexander Ushenko, o.ushenko@chnu.edu.ua

Main Directions of Scientific Research

Scientific research of the Department of Optics and Publishing is performed by 1 doctor of physical-mathematical sciences, 1 doctor of technical sciences, 4 candidates of physical-mathematical sciences, 1 searcher on doctor degree and 4 post-graduate students (the state on 2013 year). The main field of research is the laser polarimetry of biological tissues and biological liquids. The research is performed in the following directions:

1. Search for possibilities of death coming diagnostics due to acute coronary insufficiency by means of determining correlation and fractal parameters characterizing the distributions of "phase" $Z_{44}(m \times n)$ Mueller matrix elements of myometrium tissue histological sections.
2. Analysis of coordinate distributions of the fourth Stokes vector parameter in laser images of two types of biological phase-inhomogeneous layers, namely: rough and bulk scattering layers. To characterize this parameter for all the types of phase-inhomogeneous layers, the authors have offered to use three groups of parameters: statistic moments of the first to the fourth orders, autocorrelation functions, logarithmic dependences for power spectra. Ascertained are the criteria for diagnostics and classification of phase-inhomogeneous layers optical properties.
3. Investigating the processes of laser radiation transformation by biological crystals networks using the singular optics techniques. The results obtained showed a distinct correlation between the points of "characteristic" values of coordinate distributions of Mueller matrix elements and polarization singularities (S- and C-points) of laser transformation of biological crystals networks with the following possibility of Mueller-matrix selection of polarization singularity. The technique of Mueller-matrix singular diagnostics of pathological changes of women's reproductive sphere tissue (myometrium) is proposed.
4. Analysis of coordinate distributions for azimuths and ellipticity of polarization (polarization maps) in laser images of three types of biological phase-inhomogeneous layers (PhIL) - bulk scattering layers. To characterize polarization maps for all the types of PhIL, the authors have offered to use three groups of parameters: statistical moments of the first to fourth orders, autocorrelation functions, logarithmic dependences for power spectra related to distributions of azimuths and ellipticity of polarization inherent to PhIL laser images. Ascertained are the criteria for diagnostics and classification of PhIL optical properties. The possibilities of the local wavelet-analysis of polarization-inhomogeneous laser image of myocardium tissue histological sections were considered. The criteria for the differentiation of the transformation of birefringence optical-anisotropic structures of blood plasma at different scales of their geometric dimensions were determined.
5. Phase tomography of optical-anisotropic multilayered biological structures. The superposition approach of polarization manifestation of optical anisotropy of polycrystalline protein networks is proposed. The optical model of polycrystalline networks of biological tissues protein fibrils is presented. The technique of phase tomography based on determining the coordinate distributions of Mueller-matrix elements of biological tissues is suggested. The results of investigating the interrelation between the values of statistical (statistical moments of the 1^{st}-4^{th} order) parameters are presented. They characterize the coordinate distributions of phase shifts of biological tissue layer of different optical thickness and the degree of muscle dystrophy.

Recent main publications of the research group

1. O.V. Angelsky, A.G. Ushenko, Yu.A. Ushenko, V.P. Pishak, A.P. Peresunko, "Statistical, Correlation and Topological Approaches in Diagnostics of the Structure and Physiological State of Birefringent Biological Tissues" in *Handbook of Photonics for Biomedical Science* / ed. by Valery V. Tuchin, CRC Press, Taylor&Francis group: Boca Raton, London, New York, 21-67, 2009.

2. O. G. Ushenko, A.V. Dubolazov, V.O. Balanets'ka, A.V. Karachevtsev, M. Sydor "Wavelet analysis for polarization inhomogeneos laser images of blood plasma", Correlation Optics ' 11, Chernivtsi, Ukraine, 2011.
3. Yu. A. Ushenko; A. V. Dubolazov; A. O. Karachevtcev; N. I. Zabolotna "A fractal and statistic analysis of Mueller-matrix images of phase inhomogeneous layers ", Optics and Photonics for Information Processing V, San Diego, USA, 2011.
4. Dubolazov O. V. On the Feasibilities of Using the Wavelet Analysis of Mueller Matrix Images of Biological Crystals / O. V. Dubolazov, A. G. Ushenko, V. T. Bachynsky, A. P. Peresunko, O. Ya. Vanchulyak //Advances in Optical Technologies, Article ID 162832, 9 pages, 2010. doi:10.1155/2010/162832.
5. O. V. Dubolazov. On the Feasibilities of Using the Wavelet Analysis of Mueller Matrix Images of Biological Crystals / A. G. Ushenko, V. T. Bachynsky, A. P. Peresunko, O. Ya. Vanchulyak //Advances in Optical Technologies, vol. 2010, Article ID 162832, 9 pages, 2010. doi:10.1155/2010/162832. http://www.hindawi.com/journals/aot/2010/162832.html
6. Yu.A. Ushenko, "The feasibilities of using the statistical, fractal and singular processing of hominal blood plasma phase images during the diagnostics and differentiation of mammary gland pathological states," *J. Innov. Opt. Health Sci. 5*(1), 1150001 (2012). DOI No: 10.1142/S1793545811500015
7. Yu. A. Ushenko, A. V. Dubolazov, A. O. Karachevtsev, "Evolution of statistic moments of 2D-distributions of biological tissues Mueller matrix elements of the optically thick biological tissues in the process of their birefringent structure changes," *Proc. SPIE* **8338**, 83380H, 2011.
8. Yuriy Ushenko, Yuriy Tomka, Yuriy Marchuk, Valentine Balanetcka, "Statistical and fractal processing of phase images of human biological fluids," Advances in Electrical and Computer Engineering 10(4), 161-166, 2010.

Department of Physics of Semiconductors and Nanostructures

Contact person – Head of department: Prof. Dr. Andriy Savchuk, a.savchuk@chnu.edu.ua

Research group of Department of Physics of Semiconductors and Nanostructures is activated in the field of synthesis of semiconductor materials in different form (bulk single crystals, thin films, multilayer structures and nanocrystals) using the following technological routes.

- Bulk crystals : Bridgman method; Zone crystal growth; Sublimation method; Chemical Vapour Deposition.
- Thin films and multilayer structures: Thermal deposition; Magnetron deposition; Plasma-ion deposition; Pulsed laser deposition.
- Nanocrystals: Mechanosynthesis (ball milling); Melting of the semiconductor-doped fine powder borosilicate glasses; Pulsed laser ablation technique; Colloidal chemistry technique; Spray pyrolis technique.
- Semiconductor materials under investigation are: binary compounds II-VI, III-VI, IV-VI and diluted magnetic semiconductors on their base with magnetic components Me (where Me - Fe, Mn, Co, Ni).

On the other hand, at present the Chernivtsi National University has problem concerning to lack of modern experimental technique which is necessary for characterization of the grown semiconductor crystals and nanostructures.

The scientific program of joint project will highlight, but not limited to:

- Determination of shape, size and size distribution of semiconductor nanoparticles with different chemical content using transmission electron microscopy and scanning electron microscopy;
- Study of incorporation of magnetic ions Me (Fe, Mn, Co, Ni) into II-VI, III-VI and IV-VI semiconductor nanoparticles by electron paramagnetic resonance in wide temperature range of (4.2-300) K ;
- Peculiarities of distribution of magnetic ions Me into layered crystals of lead diodides, III-VI semiconductors and related nanocrystals probed by electron paramagnetic resonance and Raman scattering techniques;
- Studies of interaction between semiconductor nanoparticles and model proteins or other biomaterials by optical and magneto-optical spectroscopy;
- Surface morphology of semiconductor crystals, thin films and nanostructures probed by atomic force microscopy;
- Electron microscopy and optical investigations of exciton-plasmon interactions in semiconductor-metal multilayer films and nanostructures.

Recent publications of the research group

1. A.I. Savchuk, I.D. Stolyarchuk, T.A. Savchuk, M.M. Smolinsky, O.A. Shporta, L.M. Shynkura, Monitoring of incorporation of magnetic ions into II-VI semiconductor nanocrystals by optical and magneto-optical spectroscopy, Thin Solid Films, 2013,Vol. 541, pp. 79-82.
2. A.I. Savchuk, I.D. Stolyarchuk, I. Stefaniuk, I. Rogalska, E. Sheregii, V.V. Makoviy, O.A. Shporta, Electron paramagnetic resonance spectra of $PbMnI_2$ bulk crystals and nanocrystals, Journal of Magnetism and Magnetic Materials, 2013,Vol. 345, pp. 134-137.
3. A. Perrone, A.I. Savchuk, H. De Rosa, I.D. Stolyarchuk, V.V. Makoviy, M.M. Smolinsky, O.A. Savchuk, Magnetic field sensing properties of diluted magnetic semiconductor based nanocomposites, Sensor Letters, 2013,Vol. 11, No. 1, pp. 145-148.
4. V.M. Katerynchuk, Z.D. Kovalyuk, A.I. Savchuk, Diffraction properties of the nanostructured surface, Journal of Nanoscience and Nanotechnology, 2012, Vol. 12, pp. 8856-8859.
5. A.I. Savchuk, V.I. Fediv, S.A. Ivanchak, V.V. Makoviy, M.M. Smolinsky, O.A. Savchuk, A. Perrone, L. Cultera, Formation and transformation of II-VI semiconductor nanoparticles by laser radiation, Journal of Optoelectronics and Advanced Materials, 2010, Vol. 12, No. 3, pp. 561-564.

6. V.I. Fediv, A.I. Savchuk, V.M. Frasunyak, V.V. Makoviy, O.A. Savchuk, Magnetic and magneto-optical properties of CdS:Mn quantum dots in PVA matrix, Journal of Physics: Conference Series, 2010, Vol. 245. pp.1-4.
7. A.I. Savchuk, G.Yu. Rudko, V.I. Fediv, A.G. Voloshchuk, E.G. Gule, S.A. Ivanchak, V.V. Makoviy, Evolution of. CdS:Mn nanoparticle properties caused by pH of colloid solution andf ultrasound irradiation, Phys. Status Solidi C, 2010, Vol. 7, No. 6, pp. 1510-1512.

Department of Optoelectronics

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RESEARCH THE NANOSTRUCTURE OF SURFACES OF MODIFIED SUBSTRADE II–VI AND III-V COMPAUND

Progress of modern semiconductor electronics is requires of development and creation of highly sensitive sensors with a high speed of response, low level of intrinsic (own) noises, the sensitiveness in a wide spectral region including a UV-, X- and G-diapasons and others like of that. These conditions to some extent satisfying rectifying structures on a base wide-gape of II-VI and III-V compound, which known for its excellent of the wonderful luminescent and photo-electric properties. Among different straightening structures it follows to distinguish the type of superficially-barrier diodes (SBD) that have a row of advantages before barrier structures from p-n-transition. The most important from them is simplicity of technology of creation of SBD on a semiconductor with an expensive size and type of conductivity, absence of toxic reagents and materials, and also ecological unconcern of technological processes.

Our previous researches showed that some types of treatments(modifications) of surface of the semiconductor lining before creation of barrier contact cause the improvement of physics-technical parameters of SBD. More detailed analysis of results bring in a conclusion, that the most substantial changes take place then, when on a surface as a result of modification there is a quantum-size structure. Thus speed of superficial recombination diminishes sharply. It results is increasing both a sensitivity in a short-wave area and efficiency of boundary luminescence. As the marked parameters are related to the nano-size effects, then for their optimization it is necessary realization of complex researches of structure the modified surfaces. Besides important is connection of structure of surfaces with other physical properties of material – by an electrophysics, photo-electrics, luminescent and others like that. A project envisages implementation of row important and constrained inter se tasks:

- analysis and choice of technological methods of modification of surface and single-crystal lining of II-VI and III-V of connections for creation of nano-crystal structure;
- research of structure of surfaces of the base and modified lining by the methods of атомно-of power microscopy(APM);
- research of surface of base and modified standards by the methods of sweepable electronic microscopy(SEM);
- research of structure at superficial layers by diffraction methods;
- research of electric, luminescent and optical properties of the modified standards;
- establishing a connection between the parameters (lateral sizes, dispersion and others like that) of nano-structural surface of the semiconductor lining and her by physical properties.

Department of Theoretical Physics

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Main Directions of Scientific Research

Scientific research at the Department of Theoretical Physics is performed by 5 doctors of physical-mathematical sciences, 5 candidates of physical-mathematical sciences, 1 searcher on doctor degree and 4 post-graduate students (the state on 2013 year). The main field of research is the physics of low dimensional heterosystems (quantum dots, wires and nano-films). The general theory refers to the investigation of the conditions of optimal operation of quantum cascade lasers and detectors, studying the properties of open and closed nanoheterosystems placed into the outer constant and time-dependent fields.

The research is performed in the following directions:

1. The theory of electron, hole and exciton spectra in closed and open quantum dots, quantum wires and quantum films.
2. The theory of confined and interface phonons and electron-phonon interaction in low dimensional nanoheterosystems.
3. The theory of electrons interacting with electromagnetic field; constant electric and magnetic field in quasi-plane nanoheterosystems such as resonant tunneling structures which are the base of active bands and injectors for the quantum cascade lasers and extractors for the quantum cascade detectors.
4. The theory of the interaction between electrons, holes and excitons with the impurities in nano-structures of different spatial shapes.
5. The theory of electron- and exciton-phonon interaction in the arrays of quantum nano-tubes.

The operating mathematical methods of the scientific research are the stationary and complete Schrodinger equations and thermo dynamical Green's functions used together with the Feinman diagrams technique.

Recent main publications of the research group

1. Ткач М.В. Квазічастинки у наногетеросистемах. Квантові точки та дроти: Посібник. – Чернівці: Чернівецький національний університет імені Юрія Федьковича. (2003). (Tkach M.V. Quasiparticles in nanoheterosystems. Quantum dots and wires: A Manual. – Chernivtsi: Chernivtsi University Press, 2003.)

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Our brief propositions are the following:

1. The influence of nanoparticles on FOOD SECURITY and ARGICULTURAL SECURITY.
2. Technology: phase transition in alloys of metals in liquid and solid states, especially under the influence of laser radiation, laser processing of carbon steel and high-speed steels, liquid state and metal crystallization (nano-level).

We study the process of CdTe and other compounds crystallization, so in this area we can found collaboration.

Recent main publications of the research group

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