CONTENTS

Dear Colleagues,

2008 is a successful year for ISSP. Due to the new system for achievement stimulation approved by the Scientific Council, the number of high impact papers in prestigious foreign and international journals is clearly increasing, as well as the number of book chapters prepared by invitation. A new monograph was published in 2008 by P. Simeonova and V. Lovchinov.

The new structure of the Institute adopted in 2006 by the Scientific Council and combining existing laboratories in divisions has further been established. Some small labs were merged in larger ones, other were transformed into research groups.

Four large scientific projects were funded by the National Science Fund of the Ministry of Education and Science with substantial levels of funding. Two applied projects received fresh funding from the National Innovation Fund at the Ministry of Economics and Energy to developed new scientific products in cooperation with SME business. Thanks to all these efforts, the annual income of the Institute has increased, despite the unfolding crisis.

For a third year the Institute implicated the system of internally funded projects. The results from the second session of the Internal Project Competition were quite encouraging and the third session was called. The interest of the groups that have no other funding sources, is considerable. 7 projects were funded with a total amount that was higher compared to 2007.

The Institute congratulates Prof. Elena Atanassova, the winner of the prestigious science award PYTHAGORAS of the Ministry of Education and Science. ISSP awards for the best scientific achievements of the year 2008 were presented to teams lead by Professor M. Gospodinov, Assoc. Professors T. Milenov and S. Andreev, and Asist. Professor V. Vitkova. Professor Nikolay Kirov was elected a Honorary Member of ISSP. Professors S. Rashev, A.G. Petrov and K. Blagoev were awarded the Georgi Nadjakov Sign of Honour 1st degree. Assoc. Professors R. Peeva and E. Vlahov were awarded the Georgi Nadjakov Sign of Honour 2nd degree. Academician A. G. Petrov received the Marin Drinov Medal of the Bulgarian Academy of Sciences on the occasion of his 60th anniversary and Corr. Mem. L. Spassov received the Sigh of Honour of the Bulgarian Academy of Sciences. Medals and diplomas brought pride and satisfaction not only to their winners, but to the Institute as a whole.

The first National Workshop on New Materials “Physical Properties of Optical, Ferroelectric and Ferromagnetic Crystals” took place in Gyulechica, 27-29 September 2008. It was funded by the National Science Fund and brought together the participants of three large projects on the topic, as well as a number of distinguished Bulgarian scientists from abroad.

The 15th edition of our broadly recognized International School of Condensed Matter Physics took place in September 2008. More than 160 colleagues from all over the world took part in the School, thus exceeding the participants’ number in the last 4 schools. Four Best Poster awards and a Vaseashta Foundation award were habded over to young scientists. The proceedings of the School are being published by JOAM, Buharest.

Alexander G. Petrov

GEORGI NADJAKOV INSTITUTE OF SOLID STATE PHYSICS
Bulgarian Academy of Sciences

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The Georgi Nadjakov Institute of Solid State Physics (ISSP) is specialized in fundamental and applied research in the field of condensed matter physics, microelectronics, optics, spectroscopy and laser physics.

The main scientific and applied achievements of the Institute are in the field of condensed matter theory, critical phenomena and phase transitions, superconductivity and superconducting materials, low temperature physics, liquid crystal physics, soft and living matter physics, structure and properties of crystals and amorphous materials, nanophysics, atom and plasma physics, high precision thermometers, integrated optics, optical fibres, acoustoelectric and microelectronic sensors, metal vapour lasers.

Every second year since 1980, ISSP organizes at the Black Sea coast an International School-Simposium on contemporary problems in condensed matter physics (ISCMP).

EQUIPMENT, METHODS AND TECHNOLOGIES

ISSP has at his disposal rich variety of equipment, precise methods and technologies:

- Equipment and methods for electron microscopy and electron diffraction investigations, atomic, electric and magnetic force microscopy, X-ray diffraction with topographic, diffractometric and spectrometric facilities, ellipsometric measurements, spectroscopy from VUV to IR spectral regions, time-resolved spectroscopy, EPR spectroscopy, UV/VIS/NIR Spectrometer Perkin Palmer Lambda 1050;
- Equipment and know-how for single crystal growth from oxide materials for laser techniques and photorefractive effect applications, techniques and technology for thin layer deposition for microelectronic, optoelectronic and acoustoelectronic sensors and laser technology, complex equipment for molecular beam epitaxy, equipment for synthesis and investigation of high temperature superconducting materials;
- Equipment for polarization measurements in mesophases and polymer liquid crystals for display techniques, equipment for videomicroscopy and micromanipulation of lipid membranes;
- Lasers of various systems - metal vapour, hollow cathode, picosecond lasers for plasma physics and laser analysis of materials with possible application in ecology.

HISTORICAL REFERENCE: *ISSP at BAS is created by a Decree No 362 / October16, 1972, of the Ministry Council of Bulgaria. This Decree splits the existing Institute of Physics with Atomic Scientific Experemental Center (IP with ASEC) at BAS, founded by Academician G. Nadjakov in 1946, into ISSP and INRNE (Institute of Nuclear Research and Nuclear Energy), starting January 1, 1973. Since February 16, 1982 the Institute of Solid State Physics is named after Academician Georgi Nadjakov. The first Director of (1973-1991) the Insitute of Solid State Physics was Academician Milko Borissov. The second Director (1991-1999) was Professor Nikolay Kirov.*

ORGANIZATION OF THE INSTITUTE OF SOLID STATE PHISICS

DIRECTORATE

Director:	Academician A.G. Petrov, D.Sc.
Deputy Directors:	Assoc. Prof. S. Andreev, Ph.D. Assoc. Prof. V. Lovchinov, Ph.D.
Scientific Secretary:	Assoc. Prof. M. Primatarowa, Ph.D.
Secretaries:	Mrs. L. Dedinska, Dipl. Eng. Assist. Prof. E. Vlaikova (FP7 of EU)

ADMINISTRATIVE STAFF

Administrative Director:	Assist. Prof. Chr. Popov, Dipl. Eng.
Administration's office:	Head: Mrs. I. Velkova, Dipl. Eng.
Accountant's office:	Head: Mrs. E. Popova

DIVISIONS

Theory	Head: Prof. D. Pushkarov, D.Sc.
Material Physics	Head: Prof. M. Gospodinov, D.Sc.
Nanophysics	Head: Assoc. Prof. D. Nesheva, Ph.D.
Micro- and Acoustoelectronics	Head: Assoc. Prof. S. Andreev, Ph.D.
Low Temperature Physics	Head: Prof. N. Tonchev, D.Sc.
Physical Optics and Optical Methods	Head: Prof. M. Petrov, D.Sc.
Soft Mater Physics	Head: Acad. A. G. Petrov, D.Sc.
Laser, Atomic, Molecular and Plasma Physics	Head: Acad. N. Sabotinov, D.Sc.

Innovation Department:	Head: Assoc. Prof. S. Andreev, Ph.D.
Education Department:	Head: Prof. K. Blagoev, D.Sc.

SCIENTIFIC COUNCIL

Chairman: Prof. N. Tonchev, D.Sc.
Secretary: Assoc. Prof. M. Grozeva, Ph.D.

1. Acad. A. G. Petrov, D.Sc.
2. Acad. N. Sabotinov, D.Sc.
3. Prof. V. Kovachev, D.Sc.
4. Prof. M. Petrov, D.Sc.
5. Prof. M. Gospodinov, D.Sc.
6. Prof. S. Rashev, D.Sc.
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11. Assoc. Prof. M. Mitov, Ph.D.
12. Assoc. Prof. M. Primatarowa, Ph.D.
13. Assoc. Prof. D. Dimitrov, Ph.D.

DIVISION THEORY

THEORETICAL DEPARTMENT

HEAD: **Prof. Dimitar I. Pushkarov, D.Sc.**
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TOTAL STAFF: **8**
RESEARCH SCIENTISTS: **8**

Prof. N.B. Ivanov, D.Sc.; Prof. P.C. Ivanov, D.Sc.; Assoc.Prof. M.T. Primatarowa, Ph.D.; Assoc.Prof. K.T. Stoychev, Ph.D.; Assoc. Prof. E.R. Korutcheva, D.Sc.; Assoc.Prof. H. Chamati, Ph.D.; Assist.Prof. R. S. Kamburova

RESEARCH ACTIVITIES:

The nature of the supersolid state found experimentally by Kim and Chan (2004) in solid 4-He was investigated. A critical analysis of the existing theories is carried out and the role of the defects in the nonclassical momentum of inertia was considered. A two-fluid model is presented based on the conservation laws without Landau criterion. It is shown that a superfluid behaviour in the crystal is possible if the defecton dispersion is not quadratic.

The critical dynamics of a system confined to a hypercubic geometry in the presence of quenched short-range correlated impurities was studied. By using the random Tc model and the renormalization group method, the scaling laws for the relaxation time has been derived and its behavior has been investigated.

By using models based on neural networks, a method for detecting the unusual objects in two and three-dimensional digital images has been developed. The method permits direct application in large medical databases and gives good results.

With statistical mechanics manners, a method for the analysis of written texts is developed, which permits a rapid and precise analysis of the structure of the text, as well as a direct application to the information transfer through communication channels.

A two-dimensional thermotropic nematic system, taking into account the excluded volume of the molecules is investigated. Using Monte Carlo simulation, we found evidence of a transition from an isotropic phase to a topological nematic phase.

A detailed analysis of the finite-size effects on the bulk critical behavior of the d-dimensional mean spherical model confined to a film geometry with finite thickness is reported. Different kinds of boundary conditions along the finite direction, describing different physical situations, are applied. A systematic method for the evaluation of the finite-size corrections to the free energy for the different types of boundary conditions is proposed. The free energy density and the equation for the spherical field are computed for arbitrary d along with some critical amplitudes.

The phase diagram of a spin-1/2 Heisenberg diamond chain with cyclic four-spin exchange interactions has been investigated, by using exact numerical diagonalisation and various

analytic techniques. The system is found to possess a rich phase diagram containing eight quantum spin phases. The properties of these macroscopic spin states and the phase boundaries between them are discussed, as well.

The interaction of solitons formed of nonlinear intramolecular excitations in a chain containing a guest molecule with modified site- and bond-energies is investigated. Analytical solutions are obtained for static solitons centered on the defect. A perturbed nonlinear Schrödinger equation is obtained which takes full account of the bond defects and involves three wavenumber (velocity) dependant terms. The interaction of propagating solitons with the guest molecule is studied numerically and the role of the bond defects is elucidated. The scattering of solitons from defect segments and from potential steps in the presence of transition layers is also studied. Periodic scattering patterns as a function of the length of the segment are obtained. The periods and their origin are different for weakly and strongly nonlinear solitons.

The interaction of slow and fast narrow solitons with modified bond defects in nonlinear lattices is studied numerically. Different evolutionary patterns are obtained and a phase diagram in the wavenumber - defect strength parametric space is constructed. Scattering of the two types of solitons from an array of consecutive defects is investigated. The obtained periodicity in the scattering patterns as a function of the number of defects for the two types of solitons is different and has a different nature.

The interaction of discrete (narrow) solitons with impurities in the integrable Ablowitz-Ladik lattice model has been studied in detail. It plays an important role in numerous physical systems, especially when the corresponding elementary excitations obey Pauli statistics,. Analytical solutions are obtained for bright and dark solitons bound to the defect. On-site and inter-site (bond) defects are considered. A comparison with the standard discrete nonlinear Schrödinger equation is made. Scattering of the discrete solitons from point defects of different types is studied numerically.

PUBLICATIONS:

1. D.I. Pushkarov, Is the supersolid superfluid?, ICTP 062, 2008
2. H. Chamati, Finite-size effects in the spherical model of finite thickness, J. Phys. A: Math. Theor. **41,** 375002 (2008), ISSN 1751-8113.
3. H. Chamati and R. Romano, Topological transitions in two-dimensional lattice models of liquid crystals Phys. Rev. E **77**, 051704 (2008), ISSN 1539-3755.
4. H.Chamati and E.Korutcheva, Critical dynamics in confined systems with quenched random impurities, Phys. Rev. B **77**, 184416 (2008), ISSN 1098-0121.
5. K.Koroutchev and E.Korutcheva, Detecting the most unusual part of a digital image, In: V.E. Brimkov, R.P. Barneva, H.A. Hauptman (Eds.), Combinatorial Image Analysis, LNCS Vol. 4958, Springer, Berlin, 284 (2008), ISBN 978-3-540-78274-2.
6. M.T. Primatarowa, K.T. Stoychev and R.S. Kamburova, Interaction of solitons with bond defects in discrete nonlinear Schrödinger chains, Phys. Rev. E **77**, 066604(5) (2008), ISSN 1539-3755.
7. K.Koroutchev and E.Korutcheva, Detecting the most rare part of a two and three-dimensional digital images, Pattern Recongnition (2008)
8. K.Koroutchev and E.Korutcheva, Fast algorithm for detencting unusual parts in two and three-dimensional digital images. Application to large medical databses, WSEAS Transactions on Computers (2008)

9. N.I. Papanicolaou and H. Chamati, Diffusion of a vacancy on Fe(100): a molecular dynamics study, Comput. Mater. Sci.
10. N. B. Ivanov, J. Richter, and J. Schulenburg, Diamond chains with multiple-spin-exchange interactions, Phys. Rev. B (2008), ISSN 1098-0121
11. N. B. Ivanov, J. Richter, and J. Schulenburg, Phase diagram of diamond chains with four-spin exchange interactions, JOAM 2009, ISSN 1454-4164.
12. K.T. Stoychev, M.T. Primatarowa and R.S. Kamburova, Interaction of solitons with point defects in molecular chains, JOAM 2009, ISSN 1454-4164.
13. R.S. Kamburova, K.T. Stoychev and M.T. Primatarowa, Interaction of discrete solitons with bond defects in NLS chains, JOAM 2009, ISSN 1454-4164.
14. K.T. Stoychev, M.T. Primatarowa and R.S. Kamburova, Interaction of solitons with defects and inhomogeneities in crystals, JOAM 2009, ISSN 1454-4164.
15. M.T. Primatarowa, R.S. Kamburova and K.T. Stoychev, Interaction of narrow solitons with point defects in nonlinear lattices, JOAM 2009, ISSN 1454-4164.

ONGOING RESEARCH PROJECTS:

1. Spectra and Nonlinear Dynamics of Low-Energy Elementary Excitations in Quasi-One-Dimensional Systems (NSF Project F-1414)
2. Defects and Nanoclusters in Classical and Quantum Crystals (NSF Project F-1517)

DIVISION THEORY

RESEARCH GROUP

COLLECTIVE PHENOMENA
in Condensed Matter

HEAD: **Prof. Dimo I. Uzunov, Ph.D., D.Sc.**
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TOTAL STAFF: **2**
RESEARCH SCIENTISTS: **2**

Assoc. Prof. D.V. Shopova, Ph.D.

RESEARCH

- A thermodynamic theory of the phases and phase transitions in a wide class of inter-metallic compounds – ferromagnetic superconductors with unconventional (spin-triplet) Cooper pairing of *d*- and/or *f*-electrons has been developed. The phases and the shape of the phase diagrams of this class of systems is described in some details in conformity with the recent experimental data. A quantitative criterion allowing for the classification of these materials in two different types with quite distinguishable physical properties is deduced from our thermodynamic theory [1, 2].

- A quite general theory of fluctuation correlations has been developed on the basis of a cumulant expansion. The theory can be applied to a wide class of lattice models of many-body systems. This approach allows for a more precise derivation of effective field theories and sheds some light on the interpretation of known approximations in theoretical physics such as, for example, the mean-field approximation. We have obtained corrections to the Landau parameters (vertex parameters) of the effective field theory corresponding to the Ising model with both short and long range inter-spin interactions [3].

- Gauge effects on the fluctuation properties of the normal-to-superconducting phase transition in bulk and thin film superconductors are reviewed in a Chapter of book [4] published in 2008 (see our 2007 ISSP report).

PAPERS

1. M. G. Cottam, D. V. Shopova, and D. I. Uzunov, Phys. Lett. **A 373** (2008) 152-155. "On the phase diagrams of the ferromagnetic superconductors ZrZn2 and UGe2".

2. D. I. Uzunov, Phys. Rev. **E 78** (2008) 041122. "`Derivation of effective field theories".

3. D. V. Shopova and D. I. Uzunov, (First Chapter in book) in: Progress in Superconductivity Research, edited by Oliver A. Chang (Nova Science Publishers, New York, 2008), pp. 1 -75; ISBN: 1-60021-694-3. Title: "Large Fluctuation and Gauge Effects on the Critical Behaviour of Superconductors".

CURRENT PROJECTS, GRANTS

1. Phases and phase transitions in super-fluids, superconducting and magnetic materials (Research contract, Central Administration of BAS).

2. National Foundation of Scientific Research Grant "Physics 1507/05: Coexistence of spin-triplet superconductivity and ferromagnetism in some metallic compounds."

INTERNATIONAL COLLABORATION

Memberships:

D. I. Uzunov, in**:**

1. The Editorial Board of J. Phys. Studies (Lviv, Ukraine).
2. The American Physical Society (APS) – New York, USA.
3. The Board of Advisors of the American Biographical Institute (USA).

Collaborative visits (D. I. Uzunov):

Four months at the University of Western Ontario (London, Ontario, Canada), and three months and half at the African University of Science and Technology (AUST) – Abuja, Nigeria.

Referee reports (D. I. Uzunov, and D. V. Shopova) on papers issued by:

1. American Physical Society (APS): Phys. Rev. Lett., and Phys. Rev. B.
2. The Institute of Physics - IoP (London, UK) : J. Physics **A**, **B, D**; J. Physics: Condensed Matter, Supercond.& Supercond. Techn., New J. Physics, etc.
3. North-Holland (Phys. Lett. A).

DIVISION MATERIAL PHYSICS

LABORATORY

ELECTRON-PHONON INTERACTIONS

HEAD: **Assoc. Prof. Kate Christova,Ph.D.**
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TOTAL STAFF: **6**
RESEARCH SCIENTISTS: **4**

Assoc. Prof. O. Ivanov, Ph.D.; L. Mihailov, Ph.D.;I. Boradjiev – physicist; B. Stoyanov and Z. Stoyanov -technical ass.

RESEARCH ACTIVITIES:

STRUCTURE AND DYNAMICS OF MANY-ELECTRON SYSTEMS

Multiply charged Helium ions are strongly responsible for the properties and characteristics of high-temperature astrophysical and laboratory plasma, as well as for the processes within plasma.

Our previous works present ground state electron energies, mass corrections and mass polarization effects of He isoelectronic ions, with charge from Z=2 to Z=54. Results were obtained by solving the two-electron Schrödinger equation. Explicitly correlated wave functions (ECWF) of a generalized Hylleraas type were used as trial wave functions, in the expansion series with positive powers of the Hylleraas coordinates. The numerical procedure for determination of coefficients in this expansion brings to a solving of algebraic system of non-lineal integro-differential equations of 4^{th} order. The developed method allows to obtain numerical data up to the 6^{th} decimal accuracy comparing to the most precisely obtained results for He isoelectronic ions, with charge from Z=2 to Z=10.

Our recent results include calculation of ground state electron energies, mass corrections and mass polarization effects of He isoelectronic ions with nuclear charge for the main nuclides from Z=2 to Z=118. The same type ECWF are used for the first time with Z>54. The variational procedure for determination of the coefficients is discrete, leading to an eigenvalue problem. The developed analytical and numerical method allows to obtain numerical results, which are practically coinciding with the most precisely obtained results. Using of the same method, we have the same accuracy for ions with charge Z>10. The dependence of the obtained energies versus Z is studied, as well as the relative and complex contributions of mass corrections and mass polarization effects in formation of the ground state electron energies.

The approach developed may be regarded as a base for investigation of: (i) nuclear deformation effects on the ground state energies; (ii) Staggering dependencies between Z and proton/neutron number and electron properties as well; (iii) relativistic corrections and QED effects. These topics will be studied at next stage. The accuracy of the obtained results allows directly usage in precise theoretical approaches for plasma diagnostics.

MECHANICAL STRESS IN FILM-SUBSTRATE SYSTEMS

Boron Nitride (BN) nanofilms (5-7 nm), prepared by rapid thermal annealing (RTA) of boron layers deposited on sapphire substrates in ammonia ambient have been studied. Mechanical stress results are discussed on the basis of the N/B ratio, respectively –in terms

of film structure and film formation mechanism. The type of stress is changing after RTA, compared to the first stage when only a boron film is deposited on sapphire. It is shown that stress is in good correlation with XPS analysis. At low temperatures, the physical adsorption of nitrogen is the prevailing mechanism for film formation. Thus, an intermediate phase BN_x is formed, which causes stress increase. At high temperatures, the responsible mechanism for film formation is the chemisorption of nitrogen. Typical for BN composition bonds are formed and the value of the N/B ratio becomes the closest to the stoichiometric one. For this reason a release of stress is observed.

SURFACE PHOTO-CHARGE EFFECT (SPCE) AND ITS APPLICATION

Two contracts with Bulgarian companies have been successfully accounted and two new projects with the same companies have been submitted to the Agency for small and middle enterprises. One of the contracts is classed and work on it has been started. Considerable amount of work has been done about establishing contacts with Bulgarian and foreign institutions and partners with main object: preparation of contracts. Several has been prepared and submitted. The results of experiments connected with food quality control that have direct practical application, have been processed. Work on the topic "Express control of material composition" has been done and the results have been applied for different purposes.

OPERATION AND DEVELOPMENT OF SCIENTIFIC APPLICATIONS IN PRACTICE

Our systems "Dynamic Traction Force Integration" and "Optimal Distribution of Engines" are implanted in the system for development of Train Schedules in Bulgaria. There are developed additional inquiries. The systems are in operation on 42 new working positions in the Ministry of Transport. Copyright belongs to L.Mihailov.

Future work is currently in negotiation stage concerning energetic calculations to be included in schedule projects.

PUBLICATIONS

1. R. L. Pavlov, J. Maruani, L. M. Mihailov, Ch. J. Velchev and M. Dimitrova- Ivanovich, Electron Correlation and Nuclear Motion Corrections to the Ground-State Energy of Helium Isoelectronic Ions, from Li to Kr **,** In: Progress in Theoretical Physics: **V**. Frontiers in Quantum Systems in Chemistry and Physics, Springer, The Netherlands, pp. 269-285, 2008, ISBN 9781402087066.

2. R. L. Pavlov, J. Maruani, L. M. Mihailov, Ch. J. Velchev, M. Dimitrova-Ivanovich, J. Stoyanov and D. Van Neck *,* Multiply Charged Helium Isoelectronic Ions with Charge Z to 118: I. Ground State Energies, MassCorrections, Mass Polarization, Proc. XXVII International Workshop on Nuclear Theory, p. 249, 2008.

3. Г. Бешков, Н. Велчев, Д. Спасов, К. Христова, В. Кръстев, Нанослоеве от борен нитрид (BN_x) получени чрез бързо термично отгряване, Електроника 2008 -Доклади, Национална Конференция с международно участие, май 2008, 123, 2008, ISSN 1313-3985.

4. R. L. Pavlov, J. Maruani, L. M. Mihailov, Ch. J. Velchev, M. Dimitrova-Ivanovich and D. Van Neck *,* Multiply Charged Helium Isoelectronic Ions with Charge Z to 118:I. Ground State Energies, MassCorrections, Mass Polarization, In: Progress in Theoretical Chemistry and Physics: VI. Springer, The Netherlands, ISBN 9781402087066.

5. O. Ivanov, A. Vaseashta and L. Stoichev, Rapid, contactless, and non - destructive testing of chemical composition of samples, in Functionalized Nanoscale Materials, Devices and Systems, Proceedings of the NATO Advanced Study Institute on Functionalized Nanoscale

Materials, Devices and Systems for Chem.-bio Sensors, Photonics, and Energy Generation and Storage, Sinaia, Romania, 4-15 June 2007, Vaseashta, Ashok K.; Mihailescu, Ion N. (Eds.) 331-334 (2008), ISBN: 978-1-4020-8901-5.
6. XIII Intenernatoinal Workshop "Quantum Systems in Chemistry and Physics" (QSCP XIII), July 6–12, 2008, Lansing, Michigan, USA, R. L. Pavlov, J. Maruani, L. M. Mihailov, Ch. J. Velchev and M. Dimitrova- Ivanovich, Effects induced by Nuclear Motion on the Ground State Energies of Helium Isoelectronic Ions, from Li to Kr.
7. XXVII Intenernatoinal Workshop on Nuclear Theory, 23-28 June 2008, Rila Mountain, Bulgaria, R. L. Pavlov, J. Maruani, L. M. Mihailov, Ch. J. Velchev, M. Dimitrova-Ivanovich, J. Stoianov and D. Van Neck , Multiply Charged Helium Isoelectronic Ions with Charge Z to 118.

ONGOING RESEARCH PROJECTS:

1. Experimental and theoretical study of many-electron and multicomponent systems (BAS)
2. Contemporary problems of the nuclei theory and other many-electron systems. (NSF)
3. Optimal distribution of traction force engines. (Bulg. State Railways)
4. Many-electron systems and their behaviour in electromagnetic field. (Equivalent, Belgium)
5. Possibilities of the hollow cathode discharge as a plasma sputtering source for production and investigation of new materials and metrology. (Inst. of Phys. of Jagellonian Univ., Poland)
6. Dynamic optogalvanic signals in a hollow cathode discharge as a plasma diagnostics technique. (Inst. of Phys., Academy of Sci. of Serbia)
7. Studying of the possibilities for carbon quantity control at brick manufacturing (Prolife technology firm}
8. Studying of the possibilities for scanning of metal surfaces as to develop hidden codes ("КЕИТ" ОД)

DIVISION MATERIAL PHYSICS

LABORATORY

STRUCTURAL METHODS

HEAD: **Assoc.Prof. Malina Baeva, Ph.D.**
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TOTAL STAFF: **5**
RESEARCH SCIENTISTS: **3**

Assoc. Prof. M. Kalitzova, Ph.D.; Assist. Prof. D. Kerina, Ph.D.; T.Malakova, physicist; V. Tomov, physicist; G. Avdeev, physicist

RESEARCH ACTIVITIES:

I. X-RAY STRUCTURAL INVESTIGATIONS OF POLICRYSTALS AND SINGLE CRYSTALS

1) The structure of cobalt ferrite nanoparticles ($CoFe_2O_4$ has been sinthesised by two different methods: thermal and mechanochemical) is investigated. Both the double and triple spinel ferrites are effective catalysts in many industrial processes.

2) Bragg-scattering of thermal neutrons has been examined by means of time-of-flight neutron scattering. The theoretical part of the profile analysis carried out by the Rietveld method using data from these experiments has been developed. The neutron spectra have been visualised and analysed using Fd.exe and Mria.exe codes.

3) In order to facilitate the recovery of the polymorphic conversion of their bioactive crystal structures, the so-called spherulites, patients have been administered orally clinoptilolite. Samples from the patients given the highest quantity of the mineral have been investigated. The X-ray structural analysis reveals that the maximum dose recovers the already significantly slowed-down due to intoxication polymorphism completely as well as brings to normal the most important function of the spherulites in the human body, being secondary absorbents.

4) The identifying of concrements' type in patients with kidney stones continues.

5) Single crystals X-ray topography. The experiments in this area will be cotinued. It is necessary in the first place that single silenite structured crystals to be oriented by the Laue method.

II. ELECTRON MICROSCOPY AND ELECTRON DIFFRACTION

1) Tellurium nanoclusters were synthesized in (100) Si by ion implantation followed by annealing for 60 min with High-Frequency Electromagnetic Field (HFEMF). The results were compared with previous ones for a 30 min treatment. Structural studies were done by cross-sectional high resolution transmission electron microscopy and fast Fourier transformation of the images. The results show that for the 60 min treatment, the dynamics of nanoclusters formation changes, larger clusters are observed, some of which crystallized (Te and $SiTe_2$ crystalline phases are identified) and were separated by high-resistive areas of amorphous Si. The structural changes are correlated with the electrical resistance as measured by ac impedance spectroscopy. For the 60 min HFEMF treatment, a four to seven orders of magnitude decrease was observed in the electrical conductance in comparison with as-implanted Si. This drastic change of the electrophysical behavior of the field treated nanomaterial is discussed in terms of potential barriers at the interface of different phases.

2) The dielectric behavior of $Bi_2Fe_4O_9$ single crystals is investigated in a wide temperature range. The dielectric constant and dielectric loss temperature dependences are obtained. X-ray diffraction analysis is made. The exact phase transition temperature ferroelectric-parraelectric of these materials is determined by Differential Thermal Analysis (DTA)

3) Mixed oxide W/Mo films are investigated. The investigation is related to optimization of films structure and the related optoelectronic properties in dependence on the chemical vapor deposition (CVD) process parameters. The study by reflection high energy electron diffraction (RHEED) reveals that the mixed oxide diffraction patterns can be interpreted as a mixture of triclinic WO_3/ monoclinic WO_2 and eventually monoclinic MoO_2.

PUBLICATIONS:

1) N. Izmirova, B. Aleksiev, E. Djurova, M. Baeva, P. Blagoeva, Tz. Mircheva, D. Presianov, "Modified clinoptilolite and its application as a food supplement", Patent № 106511 / 10.07.2008, published by Patent Government Office of Bulgaria (in Bulgarian) (2008)

2) N. Izmirova, P. Uzunov, I. Tomova, M. Baeva, B. Aleksiev, P. Blagoeva, Tz. Mircheva, K. Vatralova, "Natural zeolite for reduction of radiochemical elements action", IV-th National conference on nutrition –New foods and medications for prevention and cure of contemporary diseases, Sofia, Military-Medical Academy, 30 – 31 Oct., 2008.

3. M.Kalitzova, O.I.Lebedev, G.Zollo, K.Gesheva, E.Vlakhov, Y.Marinov, T.Ivanova "Dynamics of nanoclustering in Te+ implanted Si after application of high frequency electromagnetic field and thermal annealing" *Appl. Phys. A* **91**, 515-519 (2008).

4. K.A.Gesheva, T.Ivanova, B.Marsen, G.Zollo, M.Kalitzova "Vapor growth of electrochromic thin films of transition metal oxides" *J. Crystal Growth* **310**, 2103-2109 (2008).

5. V. Marinova, D. Petrova, S. H. Lin, M. L. Hsieh and K. Y. Hsu, "The influence of Rh dopping on the light - induced properties of Bi4Ge3O12 single crystals" *J. Opt. A: Pure Appl. Opt***. 11** (2009) 015201 (6pp).

6. M.Kalitzova, K.Gesheva, E.Vlakhov, Y.Marinov, T.Ivanova and O.Lebedev, "Te+ implanted silicon structure and electrical resistance dependence on high frequency electromagnetic field annealing", *J. Physics: Confer. Series* **113** 012040 (2008).

ONGOING RESEARCH PROJECTS:

1. "Georgi Nadjakov" ISSP – BAS Bulgaria / Energetics Department of Rome University, "La Sapienza" – Italy, "Ion beam synthesis nanoclusters and new structures in semiconductors and isolators for microelectronic purposes".

COLLABORATION:

1. ISSP – BAS Bulgaria / EMAT, RUCA, Iniversity of Antwerp, Belgium.
2. ISSP – BAS, Bulgaria / Laboratory Neutron Physics – JINR, Dubna, Russia.

DIVISION MATERIAL PHYSICS

LABORATORY

CRYSTAL GROWTH

HEAD: **Prof. Marin Gospodinov, D.Sc.**
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TOTAL STAFF: **8**
RESEARSCH SCIENTISTS: **7**

Assoc. Prof. Dr. T. I. Milenov, Assoc. Prof. Dr. S. G. Dobreva, Assist. Prof. Dr. M. N. Veleva, Assist. Prof. Dr. P. M. Rafailov, Assist. Prof. Dr. Z.I. Dimitrova- Vitanova; Assist. Prof. L. K. Yankova, Assist. Prof. D. I. Toncheva, O. B. Mihailov, Technician

RESEARCH ACTIVITIES:

The research work of the Laboratory for Crystal Growth was focused on four main tasks:

-growth and investigation of complex oxides with perovskite and spinel structures;

-growth of $Bi_{12}MO_{20}$ (M=Ge, Si and Ti) crystals with application in the field of non-linear optics and optical information storage;

-investigation of two- and three-dimensional defects in face-centered cubic (fcc) and body-centered cubic (bcc) structures;

-investigation of carbon and inorganic nanostructures.

$ErMnO_3$ single crystals are studied by pollarized first- and second order micro-Raman measurements as a function of temperature and are compared to previous studies of hexagonal $YbMnO_3$, $TmMnO_3$ and $HoMnO_3$. The magnetic properties of multiferroic hexagonal single crystals and polycrystalline $HoMnO_3$ with micro- and nanometer particle size are studied. The multiferroic $HoMn_2O_5$ as a frustrated magnetic system with a non-collinear commensurate structure in its ferroelectric state was studied by polarization measurements under isotropic pressure. The low AC- and DC- field magnetic susceptibilities of hexagonal $YbMnO_3$ single crystal have been measured along the *ab*- plane and along the *c*- axis.

Single crystals of $PbSc_{0.5}Ta_{0.5}O_3$ and $Pb_{0.78}Ba_{0.22}Sc_{0.5}Ta_{0.5}O_3$ were obtained by the high-temperature solution growth method in solvents of Pb_3O_4 и PbF_2. The temperature dependence of the structural parameters, the ferroelectric phase transitions and the dielectric behaviour was studied using Raman spectroscopy, powder and synchrotron diffractometry and dielectric spectroscopy. Raman spectroscopy and single-crystal X-ray diffractometry were applied to investigate the structural changes in PST single crystals at high pressures. Both crystals were used as a model in the investigation and the characterization of relaxors with perovskite-type structure. Basing on the results of these investigations in a broad temperature interval, the characteristic Burns temperature and the temperature of the maximum of the dielectric permittivity were determined, where the initial coupling of nano-sized polar clusters into micro-sized clusters occurs. The nano-sized polar clusters determine also the high dielectric-permittivity values in these compounds. It was established that these perovskite-type crystals exhibit relaxor behaviour; the local atomic ordering in the crystal lattice and the phonon anomalies were studied.

The fundamental (A and F) modes of groups in tetrahedral position in $Bi_{12}SiO_{20}$ (BSO), $Bi_{12}GeO_{20}$ (BGO) and $Bi_{12}TiO_{20}$ (BTO) sillenite-type crystals were studied by

Raman and FTIR absorption spectroscopy. $Bi_4Ge_3O_{12}$ crystal was examined by transmission electron microscopy and observed two- and three-dimensional structural defects are characterized.

Carbon layers with different structure are deposited by CVD with pyrolitical decomposition of acetone from gaseous acetone/Ar mixtures at different temperatures onto Si {001} substrates. The morphology of the deposited films was studied by scanning electron microscopy (SEM) and the elemental analysis was performed by energy-dispersive X-ray analysis (EDAX). The diamond-like sp^3-hybridized bonds in the micro-crystals were established by Raman spectroscopy. Diamond-like and diamond micro-crystals and diamond-like films are successfully grown by the same method.

Electrochemical experiments on carbon nanotubes revealed that a penetration of chlorine species begins into the nanotube bundles at potentials above 800 mV. Up to about 1100 mV, however, double-layer charging accompanied by physisorption-induced charge transfer is still the prevailing doping process. Above 1100 mV chemical reactions with covalent C-O and C-Cl bond formation increasingly take place, triggered by the creation of Cl_2 gas, leading to an electrochemical functionalization of the SWNTs, the smaller-diameter ones being most strongly affected. The degree of covalent functionalization is significantly higher in the HCl solution as compared to the KCl one. On the other hand, non-covalent functionalization prevails when processing the SWNT electrode in a KCl solution.

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1. Vermette J., Jandl S., Gospodinov, M. M., Raman study of spin-phonon coupling in ErMnO3, JOURNAL OF PHYSICS-CONDENSED MATTER Volume: 20 Issue: 42 Article Number: 425219 (2008).
2. Mihailova B., Angel R. J., Welsch A-M. et al., *Pressure-induced phase transition in PbSc0.5Ta0.5O3 as a model Pb-based perovksite-type relaxor ferroelectric*, Phys Rev Lett Volume: 101 Issue: 1 Pages: 017602 (2008).
3. Mihailova B., Maier B., Paulmann C. et al., High-temperature structural transforma-tions in the relaxor ferroelectrics PbSc0.5Ta0.5O3 and Pb0.78Ba0.22Sc0.5Ta0.5O3, PHYSICAL REVIEW B Volume: 77 Issue: 17 Article Number: 174106 (2008).
4. Fontcuberta J., Gospodinov M., Skumryev V., Magnetic response of YbMnO3 single crystal, JOURNAL OF APPLIED PHYSICS Volume: 103 Issue: 7 Article Number: 07B722 (2008).
5. dela Cruz, CR; Lorenz, B; Ratcliff, W, et al., The pressure effect on the magnetic commensurability and ferroelectricity in multiferroic HoMn2O5, PHYSICA B-CONDENSED MATTER Volume: 403 Issue: 5-9 Pages: 1359-1361 (2008).
6. Kovacs L., Capelletti R., Gospodinov M., Vibrational frequencies of the impurity-centred oxygen tetrahedra in sillenites., VIBRATIONAL SPECTROSCOPY Volume: 46 Issue: 1 Pages: 69-75 (2008).
7. Peter M. Rafailov, Christian Thomsen, Milko Monev, Urszula Dettlaff-Weglikowska and Siegmar Roth, *Electrochemical functionalization of SWNT bundles in acid and salt media as observed by Raman and X-ray photoelectron spectroscopy*, physica status solidi (b) **245**, 1967 (2008).
8. Peter M. Rafailov, Christian Thomsen, Urszula Dettlaff-Weglikowska and Siegmar Roth, *High Levels of Electrochemical Doping of Carbon Nanotubes: Evidence for a Transition from Double-Layer Charging to Intercalation and Functionalization*, J. Phys. Chem. B **112**, 5368 (2008).

9. T.I. Milenov, V.I. Dimov, P.M. Rafailov and M.M. A Gospodinov, *Electron Diffraction Study of Various Lattice Deffects in a Bi4Ge3O12 Crystal*, Applied Physics A Volume: **92** Issue: 3 Pages: 643-649 (2008).
10. T.I. Milenov, *Chemical-Vapour-Deposition-Initiated Growth and Characterization of Diamond and Diamond-like Micro-Crystals*, Journal of Crystal Growth Vol. **310**, 24 (2008) pp. 5447-5452.
11. N.K. Vitanov, K.Sakai and Z.Dimitrova, *SSA, PCA, TDPSC, ACFA: Useful combination of methods for analysis of short and nonstationary time series*, Chaos, Solitons & Fractals, vol. **37**, 187-202 (2008).
12. Zlatinka I. Dimitrova, *Effects of delay of populations substitution*, Proceedings of the Bulg. Acad. of Sciences, vol. **61**(12) pp.1541-1548 (2008)
13. T.I. Milenov, D. Petrova, P.M. Rafailov, M.N. Veleva, L. Yankova and G.V. Avdeev, *Growth and study of the dielectric properties of $PbSc_{0.5}Nb_{0.5}O_3$ crystals doped with La,* Journal of Optoelectronics and Advanced Materials (2008)- in press
14. D. Petrova, V. Marinova, L. Yankova, M. Veleva, D. Kaisheva, O. Petrov, M. Gospodinov, *Growth and Physical Ppoperties of Bi-doped: Pb_2ScNbO_6 and Pb_2ScTaO_6 Single Crystals,* Journal of Optoelectronics and Advanced Materials (2008)- in press
15. T .I. Milenov, P. M. Rafailov, G. V. Avdeev, C. Thomsen, *Chemical vapor deposition of carbon layers on Si {001} substrates*, Journal of Optoelectronics and Advanced Materials (2008)- in press
16. P.M. Rafailov, T.I. Milenov, M. Monev, G.V. Avdeev, C. Thomsen, U. Dettlaff-Weglikowska and S. Roth, *Spectroscopic studies on electrochemically doped and functionalized single-walled carbon nanotubes*, Journal of Optoelectronics and Advanced Materials (2008)- in press
17. T.I. Milenov, P.M. Rafailov, M.N. Veleva, S. Dobreva, L. Yankova, G.V. Avdeev and M.M. Gospodinov, *Growth and characterization of La_2CoMnO_6 crystals with double perovskite structure,* Journal of Optoelectronics and Advanced Materials (2008)- in press

ONGOING RESEARCH PROJECTS:

Financed by the Bulgarian National Scientific Research Foundation at the Bulgarian Ministry of Education and Science:
*** № ТК-Н-1712/2007**, Head Prof. Dr. Sci. M.M. Gospodinov:
"Growth, characterization and study of the physical properties of novel single crystals from the systems Bi-Co(Ni)-Mn(Ru)-O and La-Co(Ni)-Mn(Ru)-O with magnetoelectric/ multiferroic behavior"

Financed by the NATO Science for Peace and Security Programmes:
*** CBP.EAP.RIG.982322:** Monitoring Higher Levels of Electrochemical Doping of Carbon Nanostructures

COLLABORATION

1. Growth and investigation of photorefractive oxide crystals as well as wide band gap semiconductor crystals and layers of the SiN and GaN type – Institute of Common and Inorganic Chemistry, Russian Academy of Sciences, Moscow, Russia.
2. Growth and characterization of oxide crystals for optical application – Research Institute of Solid State Physics and Optics, Budapest, Hungary.

DIVISION MATERIAL PHYSICS

LABORATORY

BIOCOMPATIBLE MATERIALS

HEAD: **Assoc.Prof. Liliana Pramatarova, Ph.D.**
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TOTAL STAFF: **3**
RESEARCH SCIENTISTS: **2**

Assist.Prof. E. Pecheva, Ph.D.

RESEARCH ACTIVITIES:

The research activities of the Laboratory for Biocompatible Materials (BCM) in 2008 were:

1. Improving the developed universal in-vitro system for growth of biomaterials from simulated body fluids (SBF) on modified solid surfaces for obtaining controlled coating of bone implants with biomaterial layers like hydroxyapatite (HA).
2. Improving the developed method for controlled modification of solid surfaces on nano- and microlevel, typical for nature, through the simultaneous interaction of several stimuli, namely solid substrate, precipitated water-based salt solution and laser irradiation. The developed method of laser-liquid-solid interaction leads to an enhancement of the HA growth. The new method will aid in the quick coating of implants with bone-like HA and the possibility to coat implants with complex shapes.
3. The process of HA growth was investigated through the surface modification with detonational nanodiamond (DND) particles in three methods: simple soaking, electrodeposition and plasma polymerization of bioactive polymers. Novel HA-DND composite coatings with biomedical applications have been prepared with improved hardness and adhesion on various materials due to the incorporation of the DND particles in the HA coating. Cell culture experiments showed good cell adhesion and spreading over the HA coating grown on the modified surfaces and absence of toxic reactions.
4. Modification of the surface of various materials by plasma polymerization of hexamethyldisiloxane (bioactive polymer) was attained. It was observed that the modified surfaces are bioactive, i.e. they induce the growth of the biomaterial HA in the SBF. Additional treatment of the modified surfaces by NH_3 leads to the creation of surface hydrophilic groups and a decrease of the surface contact angle with liquids, which is an advantage for a better HA adhesion on the modified surfaces. The influence of standard polymers (polyethylene, Teflon) on the calcification is observed and it was found that the hydrophobic surface of these polymers prevents the calcification which is an advantage in applications where the implant surface should be protected from the deposition of Ca-based layers.
5. Development and improvement of novel technique for analysis of thick and rough HA layers by using adapted white light interferometry, based on the collaboration with the French partner from InESS, CNRS, Strasbourg, France. Topography, layer profile, roughness and optical parameters of HA and HA-DND layers were successfully investigated with the technique, named coherence probe microscopy (CPM) and the results were compared with classical techniques such as SEM, AFM, optical microscopy

and stylus profilommetry. It was possible to reveal the presence of hidden layers and interfaces by CPM. CPM is based on the interferometry of white light, combined with a precise scanning of the sample in depth and mathematical algorithms for analysis, and allows quick, non-destructive measurements of thick layers, and without any sample preparation for the measurement.

PUBLICATIONS:

1. E. Pecheva, T. Petrov, C. Lungu, P. Montgomery, L. Pramatarova, Stimulated in vitro bone-like apatite formation by a novel laser processing technique, Chemical Engineering Journal 137 (2008) 144-153 (invited article for the Special issue of CEJ: Porous Inorganic Materials for Biomedical Applications)
2. A. Kondyurin, E. Pecheva, L. Pramatarova, Calcium phosphate formation on plasma immersion ion implanted low density polyethylene and polytetrafluorethylene surfaces, Journal of Materials Science: Materials in Medicine 19 (2008) 1145-1153
3. L. Pramatarova, E. Pecheva, P. Montgomery, D. Dimova-Malinovska, T. Petrov, A. L. Toth, M. Dimitrova, Bioactivity of polycrystalline silicon layers, Journal of Nanoscience and Nanotechnology 8 (2) (2008) 924-930
4. E. Pecheva, L. Pramatarova, Z. Karagyozova, S. Stavrev, Advanced materials for metal implant coatings, Proceedings of the XX Congress of Chemists and Technologists of Macedonia and V Congress of the Metallurgists of Macedonia, 17-20 September 2008, Ohrid, Macedonia
5. E. Pecheva, L. Pramatarova, D. Dimova-Malinovska, Polycrystalline silicon: a biocompatibility assay, NATO Science Series, Functionalized Nanoscale Materials, Devices, and Systems for chem.-bio Sensors, Photonics, and Energy Generation and Storage, 2008, NATO Science for Peace and Security Series B: Physics and Biophysics, A. Vaseashta and I. Mihailescu (Eds.), vol. XIV, 2008, pp. 490

FUTURE RESEARCH PLANS OF THE LABORATORY INCLUDE:

1. Control of the process of plasma polymerization of hexamethyldisiloxane on the surfaces of stainless steel, titanium, titanium alloys and glass. Growth of HA and HA-DND composite layers on the modified by plasma polymerization surfaces. Preparation of titanium alloys with biomedical applications and DND incorporation and study of their bioactivity through the deposition of HA. Cell culture experiments with various cell lines for biocompatibility investigation of the prepared samples and layers. Investigation of the protein adsorption and reorganization on the modified surfaces for improving their biocompatibility with living cells (on the basis of a project with the Bulgarian Ministry of Education and Science, and a NATO grant; team leader Assoc. Prof. Dr. L. Pramatarova).
2. Study of the process of laser-liquid-solid interaction for stimulated HA growth by using different wavelengths, laser power, pulse repetition, time duration, etc. (on the basis of a project with the Bulgarian Innovation Fund and a SME “Lightsystems” Ltd, Sofia; team leader Assoc. Prof. Dr. L. Pramatarova).
3. Measurements by classical and novel techniques for complementary characterization of the surfaces (mainly through bilateral projects with the Hungarian Academy of Sciences, Latvian Academy of Sciences, Romanian Academy of Sciences and CNRS-France, as well as on the basis of a cooperation with the collaborators at the ISSP-BAS and other Institutes of BAS; team leader Assoc. Prof. Dr. L. Pramatarova).

DIVISION NANOPHYSICS

LABORATORY

PHOTOELECTRICAL AND OPTICAL PHENOMENA IN WIDE BAND GAP SEMICONDUCTORS

HEAD: **Assoc.Prof. Diana Nesheva, Ph.D.**
tel: 979 5686; e-mail: nesheva@issp.bas.bg

TOTAL STAFF: **13**
RESEARCH SCIENTISTS: **10**

Assoc.Prof. D. Arsova, Ph.D; Assoc.Prof. Z. Ivanova, Ph.D; Assoc.Prof. V. Pamukchieva, Ph.D; Assoc.Prof. Z. Aneva, Ph.D; Assoc.Prof. K. Kolentsov, Assoc.Prof. S. Balabanov, Ph.D.; Assist.Prof. L. Yurukova; Assist.Prof. Z.Levi, Ph.D; Asist.Prof. I. Bineva, Ph.D; A. Rachkova, chemist; E. Zaharincheva, technologist; Zh. Dimitrov, technologist

RESEARCH ACTIVITIES:

1. NANOSTRUCTURED THIN FILMS

Metal-insulator-silicon (MIS) structures Al/n-Si/SiO_x/SiO_2/Al (x = 1.3) were prepared in which only hole's capturing was observed. Parallel shift of capacitance-voltage (C-V) and conductance-voltage (G-V) characteristics was obtained at voltages considerably lower than those in structures with x = 1.15. The obtained lower defect density at the interface insulator/c-Si, as well as the lower voltages in the structures with x = 1.3, are important advantages for the application of such structures in stable memory devices. The differences in the behaviour of the two types of structures are connected with the different initial composition of the SiO_x layers. These results have been obtained in collaboration with scientists from Mexico.

The optical band gap (~ 2.6 eV) of amorphous silicon nanoparticles grown in SiO_x layers with x = 1.15 after annealing at 700^{o}C for 60 min has been determined from transmission spectra. The significantly lower energy of the photoluminescence band from the nanoparticles implies a great Stokes shift or a predominating radiative recombination via defect states in the band tails. The photoluminescence from a-Si-SiO_x layers has been studied at different temperatures. At $x \leq 1.3$ a strong temperature quenching was observed, while at x = 1.7 the quenching is very weak. This result has been explained assumming weak carrier confinement in the samples with lower x values and very strong confinement at high x. The results have been obtained in collaboration with scientists from Germany.

Structural, optical and photoelectric properties of nanocrystalline $AgBiS_2$ layers produced by chemical or sonochemical deposition have been investigated. Atomic force microscopy studies showed that layers are nanocrystalline with nanocrystal size < 10 nm. Quantum-size effect has been observed, which is an evidence for the existence of high potential barriers between the nanocrystals. Fine structure was observed in the absorption spectra of chemically deposited layers at energies higher than E_g, which indicates a narrow size distribution of nanocrystals. The results have been obtained in collaboration with scientists from Macedonia.

2. DISORDERED MATERIALS - CHALCOGENIDE GLASSES AND THIN FILMS

Photo- and thermally-induced changes in optical parameters of thin films belonging to the Ge_2S_3-AsS_3 line were studied. Compositions from regions with different kinds of

bonding of the structural units were chosen. So called self-organizing compositions with flexible bonding structure (coordination number $Z \approx 2.4$) as well as compositions with rigid structure ($Z = 2.6$-2.7) were explored. It was ascertained that the irreversible photobleaching in the first type of compositions is significantly lower than in compositions of the second type and it decreases with decreasing thickness down to 90-100 nm. Photo- and thermally-induced changes in thin films (~150 nm) of the second group were studied by means of spectroscopic ellipsometry. Illumination of as-deposited films causes a large photobleaching (up to 400 meV) along with a quite large increase of the film thickness (12-13 %). The subsequent annealing has a weak influence on the band gap value but it causes reduction of the film thickness which approaches the initial one. The large changes of the thickness were proved by electron- microscopy studies made by colleagues from Chech Republic. Neutron diffraction studies on glasses belonging to systems Ge-Sb(As)-(Te,S) have been continued. The spectra of Ge-Sb-(Te,S) glasses have been modelled by the MCGR simulation method. The two peaks observed at 2.3 and 2.8 Å in the first coordination sphere were associated with Ge-S and Sb-Te bonds and their position corresponds to the corresponding bond lengths. Main physical parameters (density, compactness, cohesive energy, band gap energy, degree of covalence of chemical bonds etc.) of the synthesized Ge-Sb-(Te,S) glasses were determined. The studies were performed in collaboration with colleagues from Hungary.

The results from studies of optical absorption and photoluminescence (PL) at 20 K of new GeSGa-CsBr chalco-chalide glasses doped with Er have been summarized. The influence of CsBr on the PL efficiency increase has been considered and the effect observed has been explained assuming creation of new $[GaS_{3/2}Br]^{-1}$ structural units with preferred coordination of Br ions around Er^{3+} ions by means of substitution of S by Br in the $GaS_{4/2}$ tetrahedra. Special attention was paid on the effect of Ga on the shape of emission section by means of deconvolution of PL spectra at compositions containing 25 and 33 mol % Ga_2S_3. Main parameters of the radiation have been determined for compositions containing 20 mol % Ga_2S_3 using Judd-Ofelt analysis for different irradiation sources, which is important from practical point of view. Preliminary studies on photoinduced changes in the transmission of amorphous GeSGa thin films were carried out. A bleaching effect has been observed which is stronger than in Ge-As-S thin films. The studies were performed in collaboration with colleagues from Chech Republic, Canada and Korea.

3. AC ELECTROLUMINESCENCE, ELECTROLUMINESCENT STRUCTURES AND DISPLAYS

The computer design and construction of photomasks for different layers of a seven-segment electroluminescent (EL) structures, included in the Programme of the project 204/06 financed by the Bulgarian Ministry of Education and Science under the program “Innovation enhancement in small and medium enterprises”, was completed. In collaboration with scientists from the Institute of Organic Chemistry-BAS and from Sofia Technical University, an AC EL structure with emission layer from an organic material with low molecular mass was produced for the first time and its electroluminescent properties have been studied. EL structures based on (Zn,Cd)(S,Sn):Cu,Ga and containing C_{60}/C_{70} fullerenes in the emission layer have been prepared and has shown red emission. The brightness characteristics, stability and lifetime of these structures have been studied. A new wavelength range of increase in the EL brightness has been distinguished in samples from microcrystalline ZnS:Cu in epoxy-oligomer binder with 2.10^{-2} - $2.5.10^{-3}$ wt.% C_{60}/C_{70} fullerenes added. Studies on waves of brightness in these structures have been performed in collaboration with colleagues from Russia.

PUBLICATIONS:

1. V.Pamukchieva, A. Szekeres, "Optical properties of $Ge_xSb_{20-x}Te_{80}$ thin films and their changes by light illumination", Optical Materials, **30,** 1088 (2008), ISSN 0925-3467.
2. V. Pamukchieva, A. Szekeres, E. Svab and M. Fabian, Z Revay, L Szentmiklosi, "Spectral ellipsometric determination of the optical constants of multicompoment chalcogenide films of Ge-Sb-S-Te system", J. Phys.: Conf. Series **113,** 012054 (2008).
3. D. Nesheva, N Nedev, Z Levi, R Brüggemann, E Manolov, K Kirilov and S Meier, "Absorption and transport properties of Si rich oxide layers annealed at various temperatures", Semicond. Sci. Technol. **23,** 045015-8 (2008), ISSN 0268-1242.
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7. N. Nedev, D. Nesheva, E. Manolov, R.Brüggemann, S. Meier, Z. Levi, and R. Zlatev, „MOS Structures Containing Silicon Nanoparticles for Memory Device Applications", J. Phys.: Conf. Series **113,** 012034 (2008), ISSN 1742-6588.
8. Z.G. Ivanova, E. Cernoskova, K. Melanova, "Structural characterization and topological threshold in $Ge_xSb_{40-x}Se_{60}$ glasses", J. Optoelectron. Adv. Mater., **10**, 2762-2764 (2008)**.**
9. Z.G. Ivanova, K. Koughia, G. Soundararajan, J. Heo, D. Tonchev, M. Jayasimhadri, S.O. Kasap, "The influence of CsBr addition on optical and thermal properties of GeGaS glasses doped with erbium", J. Mater. Sci.: Materials in Electronics, electronic version, (2008), ISSN (electronic): 1573-482X.
10. S. Balabanov, T. Tsvetkova, E.Borisova,L. Avramov and L. Bischoff, "Dose dependence of visible range diffuse reflectivity for Si^+ and C^+ ion implanted polymers", Journal of Physics: Confer. Series **113**, 012038 (2008), ISSN 1742-6588.
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12. T. Tsvetkova and S. Balabanov, "Ion beam modified of polymer surfaces", J. Technolog. Documents I.A.E.A, **25**,126 (2008).
13. S.S. Tinchev, P.I. Nikolova, S. Balabanov, N.Georgiev, "Amorphous hydrogenated carbon coatings for thermal solar collectors", Journal of Physics: Conf. Series **113**, 012026 (2008), ISSN 1742-6588.
14. E. Tsvetkova, H. Dikov, K. Kolentsov, L. Yourukova, V. Steflekova, "Hybrid AC EL structures with thin protective ZnO film", Journal of Physics Conf. Series **113,** 012016 (2008), ISSN 1742-6588.
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16. D. Nesheva, **"**Multilayer structures and nanocomposites for electronic applications", Advances in Bulgarian Science, National Centre for Information and Documentation, Bulgaria, pp.15-20 (2008).
17. L. Kazakova, K. Tsendin. E. Lebedev, D. Arsova, "Electron and hole drift mobility in glassy $Si_{12}Ge_{10}As_{30}Te_{48}$ and $Ge_{20}As_{20}S_{60}$ semiconductors", Thesis of 6th Int. Conference "Amorphous and Microcrystalline Semiconductors", St. Petersburg, 2008, 228-229.

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19. D. Tonchev, K. Maeda, K. Koughia, T. Sakai, J. Ikuta, Z.G. Ivanova, S.O. Kasap, "Thermal stability and optical activity of erbium doped chalcogenide glasses for photonics", Proc. NATO Advanced Study Institute "Functionalized Nanoscale Materials, Devices, and Systems for chem.-bio Sensors, Photonics, and Energy Generation and Storage", Sinaia, Romania, 2008, 351-356.
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23. E. Vateva, On the structural disorder and properties of amorphous materials, in "In Memoriam Radu Grigorovici", Ed. M. Popescu, 2008, INOE, Magurele, pp. 9-10.

ONGOING RESEARCH PROJECTS:

Financed by the Bulgarian Academy of Sciences:

1. Semiconductor nanoparticles in amorphous thin film matrix: formation, structure and properties.

Financed by the Bulgarian Ministry of Education and Sciences (BMES):

1. Multilayer structures and nanocomposite materials for applications in electronics. Modul 1: Multilayer structures containing silicon nanoparticles, suitable for fabrication of electronic memories and single electron deviices, Contract NNP-4-1.
2. Three –dimensional assembles of semiconductor quantum dots: structure, optical, electrical and photoelectrical properties, Contract BM-1.
3. Construction, development and preparation of digital electroluminescent displays, Contract D01–202.

COLLABORATION:

1. Investigation of Ge-chalcogenide glasses for optoelectronic use, Joint Laboratory of Solid State Chemistry, Pardubice, Czech Republic.
2. Nanostructures semiconductor thin films suitable for application as gas sensors, Institute of Physics, Belgrad, Serbia.
3. Structural and optical properties of multicomponent chalcogenide glasses, Institute of Solid State Physics & Optics, Budapest, Hungary.
4. Investigation of properties and characteristics of ZnS electoluminophores and making of set-ups of their base", MIIT (Moscow State University of Railway Engineering), Russia.

DIVISION NANOPHYSICS

RESEARCH GROUP

SEMICONDUCTOR HETEROSTRUCTURES

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RESEARCH ACTIVITIES:

1. CHARACTERIZATION OF NANOSTRUCTURED AlN FILMS

The frequency dependence, measured in the range of 1.23 MHz-19.05 MHz, of the accumulation capacitance of MIS structures with pulsed laser deposited AlN film as dielectric reveals that deep levels in the AlN film with time constants 5.25×10^{-8} - 8.13×10^{-7} s contribute to the increase of this accumulation capacitance with decrease of the test voltage frequency. The energy sheet concentration of these levels, estimated from this capacitance excess, is 5.7×10^{15} $cm^{-3}eV^{-1}$.

Formation of close to stoichiometric AlN nanoclusters by plasma ion implantation in matrix from thermally deposited SiO_2 was established. By varying the energy and dose of implanted ions nanostructured films with thicknesses 10-50 nm were prepared. The analysis of experimental results revealed a formation of near-stoichiometric AlN phase in an appreciable amount, together with Al–O bonds from different Al oxidation states and silicon oxynitride.

2. CHARACTERIZATION OF NANOSTRUCTURED SiOx FILMS

By modelling the spectroscopic ellipsometry data the thickness, complex refractive index and sizes of Si nanoclusters formed in nanostructured SiO_x film, prepared by vacuum evaporation of SiO and annealed at different temperatures between 700 and 1100 ^oC, have been determined. An increase of the intensity of measured photoluminescence (PL) spectra of annealed films was established. The PL peak shifted from 780 to 860 nm when the annealing temperature increases from 700 to 1100 ^oC. This result may be explained by different mechanisms of PL from amorphous and crystalline ~2.2 nm sized Si clusters.

3. DEFECTS IN IRRADIATED Si/SiO_2 STRUCTURES

The interaction between radiation-induced defects in $Si\text{-}SiO_2$ structures caused by Ar implantation and MeV electrons was studied. It was established that the concentration of shallower levels related to oxygen vacancies or divacancies decreases while the concentration of deep levels related to vacancy-impurity complexes increases. These defects are decisive in the MeV electron interaction. It was revealed by optically stimulated electron emission that the main defects generated by MeV electrons at $Si\text{-}SiO_2$ interface and in the oxide are E-center type vacancies.

4. HYDROGENATED AMORHOUS SILICON AND CHALCOGENIDE FILMS

Second harmonic generation in thin a-Si:H films has been studied theoretically and experimentally. A study of the dependence of optical nonlinearity on the film thickness has been performed. It was established that this nonlinearity consists of two components – permanent one, due to electric quadruple and magnetic dipole moments and variable one, due to bulk electric dipole moment.

Nanomechanical properties of plasma chemically deposited a-Si:H films have been studied by nano-indentation with a constant force in the 0.2 - 0.6 mN range using the Berkovich type diamond prism with a tip radius 170 nm as well as with a tip of cube with a radius 60 nm. The determined Young's modulus values (86 - 105 GPa) are lower than those of crystalline Si. The hardness' values reveal that a-Si:H is harder than the crystalline Si.

High doses of Ar, He and H ions with distribution maximum at 200 nm have been implanted in lithium niobate in order to study the influence of preliminary ion implantation on the formation of blisters. The distribution of hydrogen has been studied by means of nuclear reactions analysis (NRA). The Rutherford backscattering (RBS) has shown that the annealing of structural defects caused by He implantation is more difficult than that of defects caused by Ar implantation, while the depth profile of defects remains wide. The annealing of samples implanted with H ions at relatively low temperatures (300 ^{o}C) didn't lead to formation of blisters.

Ellipsometric studies of $Ge_xSb_{40-x}S_{50}Te_{10}$ (x=10, 20, 27) thin films have shown a decrease of the optical constants and an increase of the optical band gap energy with increasing the Ge and decreasing the Te content.

PUBLICATIONS:

1. V.Pamukchieva, A. Szekeres, "Optical properties of $Ge_xSb_{20-x}Te_{80}$ thin films and their changes by light illumination", Optical Materials, **30**, 1088 (2008), ISSN 0925-3467.
2. V. Pamukchieva, A. Szekeres, E. Svab and M. Fabian, Z Revay, L Szentmiklosi, "Spectral ellipsometric determination of the optical constants of multicompoment chalcogenide films of Ge-Sb-S-Te system", J. Phys.: Conf. Series **113**, 012054 (2008), ISSN 1742-6588.
3. S. Simeonov, „Charge profile at the oxide-semiconductor interface of MOS structure in accumulation", Intern. J. Electronics, **95**, 1-10 (2008), ISSN 1756-638X**.**
4. A.F. Zatsepin, S. Kaschieva, S.N. Dmitriev, E.A. Buntov, „Characteristics of the electron-emission defects introduced in Si–SiO_2 structures by MeV electron irradiation", Nuclear Instruments and Methods in Physics Research B, **266**, 5027–5031 (2008), ISSN 0168-583X.
5. P. Danesh, B. Pantchev, B. Schmidt, „Infrared absorption strengths of ion-implanted hydrogenated, amorphous silicon", Thin Solid Films, **516**, 3383–3386 (2008), ISSN 0040-6090.
6. A. Szekeres, T. Nikolova, A. Paneva, I. Lisovskyy, P.E. Shepeliavyi, G.Yu. Rudko, „Effect of Si nanoparticles embedded in SiOx on optical properties of the films studied by spectroscopic ellipsometry and photoluminescence spectroscopy", Optical Materials, **30**, 1115-1120 (2008), ISSN 0925-3467.
7. S. Georgiev, G. Beshkov, D. Sueva, E. Manolov, A. Szekeres, E. Vlaikova, „Influence of rapid thermal annealing on the properties of a-C:H/c-Si structures", J. Phys.: Conf. Series, **113**, 012013 (2008), ISSN 1742-6588.
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12. S. Bakalova, A. Szekeres, A. Cziraki S. Grigorescu, G. Socol and I. N. Mihailescu, XRD study of pulsed laser deposited AlN films with nano-sized crystallites, Procs. of the NATO-Advanced Study Institute on Functionalized Nanoscale Materials, Devices, and Systems for chem.-bio Sensors, Photonics, and Energy Generation and Storage, Sinaia, June 4-15, 2007, Eds. A. Vaseashta, I.N. Mihailescu, Springer, 2008, pp. 357-364.
13. S. Simeonov, A Szekeres, I. Minkov, K. Ivanova, M. Gartner, C. Parlog, Influence of deep levels on the admittance of MIS structures with sol-gel TiO_2 insulator film, Proc. on CAS'08 International Conference of Semiconductors, Oct. 3-5, 2008, Sinaia, Romania.
14. I. P. Lisovskyy, A. Szekeres, T. Nikolova, G. Huhn, K. Havancsak, S. Zlobin, I.Z. Indutnyy, P. E. Shepeliavyi, „Vibrational Properties Of Evaporated SiOx Films With Embedded Si Nanoparticles", Nanoscience & Nanotechnology, Vol. 8, eds. E. Balabanova, I. Dragieva, Prof Marin Drinov Academic Publishing House, Sofia, 2008, pp. 165-168.

ONGOING RESEARCH PROJECTS:

"Structure and properties of micro and nano-sized semiconductor heterostructures" ***Financed by the Bulgarian Academy of Sciences***

COLLABORATION:

1. "Radiation defect accumulation and clustering in Si/SiO_2 oxide film after high energy electron irradiation", ***with the Joint Institute for Nuclear Research, Dubna, Russia***
2. "Effects of ion implantation on micro- and nano-mechanical properties of amorphous silicon films," ***Program of EU for access to large scale facilities, , Research center Rossendorf, Germany***
3. "Effect of preliminary ion implantation on blister formation in $LiNbO_3$", ***Program of EU for access to large scale facilities, Research center Rossendorf, Germany***
4. "Ellipsometrical characterization of SiO_x films with embedded Si nanoparticles", ***Program for access to large scale facilities, EU-6FP-RIA-ANNA № 026134(R13).***
5. "Optimization of properties of nanostructures based on silicon, metal oxides and nitrides for nano-electronic usage", ***with the Eotvos L. University, Budapest, Hungary***.
6. "Investigation of nanostructures with doped oxide films for environment usage", ***with the Institute of Physical Chemistry, RA, Bucharest, Romania***.
7. "Preparation of Si-based nanostructured thin dielectric films and investigation of their structure and properties for micro- and nanoelektronics purposes", ***with the Institute of Semiconductor Physics, NASU, Kyiv, Ukraine.***
8. "Innovative nano-structured and nano-composite media: diluted magnetic semiconductors" ***with the National Institute for Lasers, Plasma and Radiation Physics, Bucharest, Romania.***

DIVISION MICRO- AND ACOUSTOELECTRONICS

LABORATORY

PHYSICAL PROBLEMS OF MICROELECTRONICS

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RESEARCH ACTIVITIES:

1. HIGH-K DIELECTRICS FOR NANOELECTRONICS

The effect of the dopant (Ti, Hf) and the metal electrode (W, Al, Au, Ru, RuO_2) on the long-term reliability of thin and ultrathin (5-8 nm) Ta_2O_5 layers subjected to constant current stress (CCS) or constant voltage stress (CVS) is investigated. It is established that the degradation is defined by the existing defects in the capacitor structure rather than by the stress-induced bond-breaking; *the strong dependence of electrical degradation on the metal gate is an inherent property of the high-k dielectric-based structures;* the processes of trapping and emission of electrons define the dominant conduction mechanism in doped Ta_2O_5 – a modified Poole-Frenkel effect with a temperature dependent degree of compensation; the breakdown characteristics are a strong function of the doping element and are less influenced by the level and the mode of the electrical stress. *Ti-doped Ta_2O_5 with Ru gate guarantee* parameters of the storage capacitor which satisfy the requirements for *future dynamic random access memory (DRAM) technology nodes.*

It is found that the microwave (μw) irradiation at room temperature of thin (~10 nm) Ti- and Hf-doped Ta_2O_5 layers significantly reduces their conductivity (~4 orders of magnitude) down to levels acceptable for storage capacitors in giga-scale DRAMs. A model involving radiation-stimulated annealing of electrically active defects has been proposed. It is shown that *the suggested μw irradiation* of pure Ta_2O_5 as an alternative to the standard annealing process *has more universal origin* and could be applied also to other high-k dielectrics.

For the first time, local I-V characteristics (a spot several nanometers in diameter) *of high-k dielectrics for DRAM applications* (Ta_2O_5, ZrO_2) have been measured by means of conductive atomic force microscopy (C-AFM). An approach to interpret the local characteristics is suggested; a method to assess the thickness of the interfacial SiO_2 layer and its very small changes (0.1-0.3 nm) as a result of post-deposition annealing steps is developed. C-AFM is demonstrated as a powerful tool to obtain information about the electrical behavior of high-k dielectric stacks at nanoscale (e.g. trapping of electrons and degradation mechanisms and processes which are forerunners of dielectric breakdown). This information could not be obtained by macroscopic I-V characteristics. It is shown that C-AFM could provide more reliable information even about the morphology of ultrathin (< 5

nm) films. The *results obtained are prioritaire* in the efforts to clarify the conduction processes within *nm dimension area of ultra-thin high-k dielectrics*. As a problem, the control of local conductivity of high-k stacks will arise in the next DRAM generations.

2. MAGNETORESISTIVE THIN LAYERS AND DEVICES

Several types of magnetoresistive multilayer sensors are developed,including passive and active components with hard magnetic layers of Co or $SmCo_5$. Extended structure investigations of the thin layers are carried out. The dependence of the coercivity of the hard magnetic layers on their structure is established. Based on the results obtained appropriate deposition processes are selected for production of thin layers with controlled parameters. Designed and fabricated are structures, containing W passive elements.

3. THIN FILMS FOR THE MICROELECTRONICS

Technology is developed for obtaining of pH-ISFET sensors with Zr-titanate or diamond-like ion-sensitive layers.The pH-ISFET sensors produced with ZrO_2 ion-sensitive layer demonstrate pH-sensitivity in the range of 50-55 mV/pH-dec.This sensitivity depends on the annealing processes and the thickness of the buffer layer of SiO_2.

Technology is developed for deposition if bio-compatible nanolayers of diamond-like carbon.The technology is dedicated to bio-compatible layers for implantable arterial stents. Designed and produced are several versions of probe for measuring the electron temperature and electron density of the plasma in hf reactors for microelectronic and nano –processes.

The electrical conductivity and field-effect transconductance of polymethylmethacrylate(PMMA) subjected to implantation with 50 keV silicon ions at doses in the range from10^{14} to 10^{17} ions/cm^2 were examined. The electrical response of Si^+-implanted PMMA was studied by direct current (DC) and alternating current (AC) measurements and was related to the structure formed in the host polymer. In addition to the sizable enhancement of the conductivity with the implantation dose, the field-effect transconductance found inSi^+-implanted PMMA shows the potential of this material for soft-electronic applications.

Hysteresis behaviour in sandwich structure — zirconium oxide/chemical silicon oxide, annealed at temperature of 850 °C in oxygen ambient, was studied. Formation of thin $ZrSi_xO_y$ layer due to the high temperature annealing was found. Metal–insulator semiconductor (MIS) capacitors using $ZrO_2/ZrSi_xO_y/SiO_x$ insulator were studied. High-frequency capacitance–voltage (HF C–V), current–voltage (I–V) and current– time (I–t) measurements were carried out on the $Al/ZrO_2/ZrSi_xO_y/SiO_x/Si$ capacitors. Two leakage current components were identified — tunneling current component at high electric fields and transient current component at low fields.

The properties of as-deposited and annealed thin SiO_2 films deposited by reactive r.f. magnetron sputtering at various partial pressure ratios R = (1-0.05) between oxygen and argon are studied. The layers are characterized by Energy Dispersive X-ray (EDX) measurements, Scanning Electron Microscopy (JEOL, model JSM 6360), FTIR spectroscopy and electrically - by measuring the high frequency capacitance/conductance-voltage and current-voltage dependencies. It is shown that for all R in the region studied the high temperature annealing at 1000^o C shifts the band due to the Si-O-Si symmetric stretching vibration to values typical of stoichiometric SiO_2. After the annealing a strong improve of the properties of all films regarding leakage current, as well as regarding the properties of the c-Si/SiO_2 interface is observed. Additional variation of the deposition parameters is necessary in order to obtain SiO_x layers enriched with Si, which can be used as a starting material for growing of Si nanocrystals in a SiO_2 matrix.

MOS structures containing amorphous Si nanoparticles in the dielectric layer were been fabricated by consecutively PVD deposition of SiO_x ($x < 2$) layer and RF sputtering of

SiO_2 and followed high temperature annealing in an inert gas ambient. Such structures are promising for application in non-volatile memory devices. The influence of the Si/SiO_2 interface defects and the defects in the SiO_2 close to the interface on the charging and discharging properties is studied. The obtained results are important for optimization of the structures regarding memory effect.

4. RAPID THERMAL ANNEALING (RTA) and γ-rays detectors

The influence of the rapid thermal annealing (RTA) on the properties of a-C:H/c-Si structures was investigated. The deposited carbon layers are deposited by plasma enhanced CVD at substrate temperature 350 ^oC from methanol (CH_3OH) vapors. C-V and V-I measurements show the formation of a p-n junction after 1000 ^oC and 1200^oC RTA treatments. By elypsometric measurements was proved the creation of an ultra-thin SiC layer with thickness about 5 nm at the a-C:H/c-Si interface.

During this period was designed the measurement system for strong gamma fields which consist of a current amplifier with large sensitivity (10^{-12} A) and γ-rays detector. The detector works in a current generation mode. This mode allows us to avoid the dependence of the output current on the reverse dark current of the detector which depend strongly on the deposited gamma dose on the detector. The investigations show a linear dependence between output current and the γ-dose rate.

It is improved the possibility for obtained nanolayers (5-7nm) of BNx (boron nitride) by Rapid Thermal Processes (RTP). Thin Boron films are deposited over Al_2O_3 (saphire) and this system was submited to RTP at the temperature in the range 800- 1400^oC for a time of 15 , 30 , 60 and 180 sec. in NH_3 ambient in vacuum $5x10^{-2}$ Torr. XPS investigation show formation of B-N bounds for a samples annealed at1400^oC for 180 sec. Surface morphology at the same condition is needle-like.Investigation are published in 4 scientific publications.

PUBLICATIONS:

1. E.Atanassova, R.V.Konakova, V.F.Mitin, D.Spassov, O.S.Lytvyn, Microwave irradiation effect on Ti-doped Ta_2O_5 stacked capacitors, Recent Patents on Electr. Eng. 1, 47-58 (2008), invited paper.
2. E.Atanassova, A.Paskaleva, N.Novkovski, Effects of the metal gate on the stress-induced traps in Ta_2O_5/SiO_2 stacks, Microel. Reliab. 48, 514-525 (2008).
3. E.Atanassova, V.F.Mitin, R.V.Konakova, D.Spassov, Microwave irradiation impact on Ta_2O_5 stack capacitors with different gates, Semicond. Sci. Technol. 23, 035004 (10pp) (2008).
4. E.Atanassova, N.Stojadinovic, A.Paskaleva, D.Spassov, L.Vracar, M.Georgieva, Constant voltage stress induced current in Ta_2O_5 stacks and its dependence on gate electrode", Semicond. Sci. Techn. 23, 075017 (9pp) (2008).
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6. E.Atanassova, D.Spassov, A.Paskaleva, M.Georgieva, J.Koprinarova, Electrical characteristics of Ti-doped Ta_2O_5 stacked capacitors, Thin Solid Films, 516, 8684-8692 (2008).
7. E.Atanassova, N.Stojadinovic, A.Paskaleva, Degradation behavior of Ta_2O_5 stacks and its dependence on the gate electrode, Microel. Reliab. 48, 1193-1197 (2008).
8. D.Spassov, E.Atanassova, Conducting mechanisms in Ta_2O_5 stack in response to rapid thermal annealing, Microel. Engin. 85, 214-222 (2008).

9. A.Paskaleva, V.Yanev, M.Rommel, M.Lemberger, A.J.Bauer, Improved insight in charge trapping of high-k ZrO_2/SiO_2 stacks by using tunneling atomic force microscopy, J. Appl. Phys. 104, 024108 (7pp) (2008).
10. V.Yanev, M.Rommel, M.Lemberger, S.Petersen, B.Amon, T.Erlbacher, A.J.Bauer, H.Ryssel, A.Paskaleva, W.Weinreich, C.Fachmann, J.Heitmann, U.Schroeder, Tunneling atomic force microscopy as a highly sensitive mapping tool for characterization of film morphology in thin high-k dielectrics, Appl. Phys. Lett. 92, 252910 (3pp) (2008).
11. P.Dimitrova, S.Andreev, L.Popova, Thin-film integrated AMR sensor for linear position measurements, Sensors and Actuators A 147 (2008) 387-390
12. G.Beshkov, V.Krastev, P. Stefsnov, S.Georgiev, and S.Nemsaka, XPS study of BNx nanolayers prepared by rapid thermal annealing in amonia, Journal of Physics – Conf.Series 113, (2008) 012046.
13. G.Beshkov, V. Bakardjieva and Z. Alexieva, Influence of rapid thermal vacuum annealing and hight temperature treatment on the properties of PSG films, Journal of Physics –Conf.Series 113, (2008) 012051
14. G.B. Hadjichristov, V.K. Gueorguiev, Tz.E. Ivanov, Y.G. Marinov, V.G. Ivanov, E. Faulques, Silicon ion implanted PMMA for soft electronics, Organic Electronics, Volume 9, Issue 6, December 2008, Pages 1051-1060
15. N. Nedev, D. Nesheva, E. Manolov, R. Brüggemann, S. Meier, Z. Levi and R. Zlatev, "MOS structures containing silicon nanoparticles for memory device applications" Journal of Physics: Conference Series 113 (2008) 012034.
16. D. Nesheva, N. Nedev, Z. Levi, R. Brüggemann, E. Manolov, K. Kirilov and S. Meier, "Absorption and transport properties of Si rich oxide layers annealed at various temperatures" Semiconductor Science and Technology, 23 (2008) 045015 (8 pp).
17. S Georgiev, A Szekeres, E Vlaikova, G Beshkov, D Sueva and E Manolov, Influence of the rapid thermal annealing on the properties of a-C:H/c-Si structures, Journal of Physics: Conference Series 113 (2008) 012013
18. P. Stefanov, G. Atanasova, E. Manolov, Z. Raicheva, V. Lazarova, "Preparation and Characterization of SnO_2 Films for Sensing Applications", Journal of Physics: Conference Series 100 (2008) 082046
19. D. Sueva, S. Georgiev, N. Chikov and I. Spassov, Measurement of strong gamma fields by silicon detectors working in a current-generation mode, Nuclear Instruments and Methods in Physics Research A 588 (2008) 375-379 (NIM in Physic research)
20. E.Atanassova, A.Paskaleva, D.Spassov, Ti-doped Ta_2O_5 stacked capacitors, Proc. 26th Intern. Conf. on Microel. (MIEL, 2008), Nish, Serbia, 11-14 May, IEEE El. Dev. Soc.Vol 2, 529-532 (2008).
21. N.Novkovski, E.Atanassova, A.Paskaleva, Model based analysis of 7 nm Ta_2O_5/SiO_xN_y stacks on Si, Proc. 26th Intern. Conf. on Microel. (MIEL, 2008), Nish, Serbia, 11-14 May, IEEE El. Dev. Soc. Vol 2, 533-536 (2008).
22. A.Skeparovski, N.Novkovski, A.Paskaleva, E.Atanassova, Constant current stress characteristics of Ti-doped Ta_2O_5, Proc. 26th Intern. Conf. on Microel. (MIEL, 2008), Nish, Serbia, 11-14 May, IEEE El. Dev. Soc. Vol 2, 579-582 (2008).
23. E.Atanassova, A.Paskaleva, D.Spassov, Constant voltage stress induced current in Ta_2O_5 stacks, Proc.7th Intern. Conf. on Advanced Semicond. Dev. and Microsystems, (ASDAM, 2008), Smolenice Castle, Slovakia, 12-16 Oct., IEEE El. Dev. Soc. 59-62 (2008).
24. M.Tapajna, E.Dobročka, A.Paskaleva, E.Atanassova, K.Fröhlich, Electrical characterization of Ru- and RuO_2/Ta_2O_5 gate stacks for nanoscale DRAM technology, Proc.7th Intern. Conf. on Advanced Semicond. Dev. and Microsystems, (ASDAM,2008), Smolenice Castle, Slovakia, 12-16 Oct., IEEE El. Dev. Soc. 267-270 (2008).
25. N. Nedev, D. Nesheva, E. Manolov, R. Brüggemann, S. Meier and Z. Levi, "Memory Effect in MOS Structures Containing Amorphous or Crystalline Silicon Nanoparticles"

Proc. 26th International Conference on Microelectronics (MIEL 2008), Vol. 1, Niš, Serbia, 11 – 14 May 2008.
26. E.Atanassova, P.Lytvyn, R.V.Konakova, V.F.Mitin, D.Spassov, Conductive atomic force microscopy characterization of Ta_2O_5/SiO_2 stacks and the effect of microwave irradiation, J. Non. Cryst. Solids, accepted for publication.
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28. A.Paskaleva, E.Atanassova, N.Novkovski, Constant current stress of Ti-doped Ta_2O_5 on nitrided Si, J. Phys. D: Appl. Phys. (proofs).
29. A.Skeparovski, N.Novkovski, E.Atanassova, D.Spassov, A.Paskaleva, Temperature dependence of leakage currents in Ti-doped Ta_2O_5 on nitrided Si, J. Phys. D: Appl. Phys. accepted for publication.
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32. G.B. Hadjichristov, V.K. Gueorguiev, Tz.E. Ivanov, Y.G. Marinov, V.G. Ivanov, E. Faulques, The transconductance of nano-clustered subsurface layer in Si+-implanted PMMA, J.Optoelectr.Adv.Mater., accepted for publication
33. G.B. Hadjichristov, V.K. Gueorguiev, Tz.E. Ivanov, Y.G. Marinov, V.G. Ivanov, E. Faulques: Electrical properties of PMMA ion-implanted with low-energy Si+ beam", Journal of Physics: Conference Series, accepted for publication.
34. P. Dankov, P. Stefanov, V. Gueorguiev, Tz. Ivanov, Hairpin-resonator probe design and measurement considerations, Journal of Physics: Conference Series, accepted.
35. J. M. Terrazas, N. Nedev, E. Manolov, B. Valdez, D. Nesheva, R. Brüggemann, "Properties of thin SiO_2 films deposited by r.f. sputtering", Journal of Optoelectronics and Advanced Materials (accepted for publication).
36. N. Nedev, E. Manolov, D. Nesheva, J. M. Terrazas, B. Valdez, M. A. Curiel, R. Zlatev, "Electrical and infrared characterization of thin SiO_2 films deposited by r.f. magnetron sputtering", Journal of Optoelectronics and Advanced Materials (accepted)
37. V. Georgieva, P. Stefanov, L. Spassov, Z. Raicheva, M. Atanassov, T. Tincheva, E. Manolov, L. Vergov "Thin MoO_3 films for sensor application", Journal of Optoelectronics and Advanced Materials (accepted for publication)
38. G. Beshkov, D. Spassov, T. Ivanova, K. Gesheva, D. Gogova, V. Krastev, Properties of BN_x nanolayers prepared by rapid thermal annealing, Journal of Optoelctronics and Advanced Materials, Accepted for publ.
39. K. Christova, I.Boradjiev, D. Spassov, G. Beshkov, Stress of boron nitride nandfilms prepared by rapid thermal annealing , Journal of Optoelctronics and Advanced Materials, Accepted for publ.
40. G. Beshkov, N. Velchev, K. Hristova, V. Krastev, Nanolayers from boron nitride (BNx) obtained by rapid thermal annealing, National conference with international participation – Electronica 2008, pp. 123-127.
41. E.Atanassova, A.Paskaleva, Doping of Ta_2O_5 as a way to extend its potential as a high-*k* dielectric, Proc. 7th Conf. of the Society of Physicists of Macedonia, Ohrid, Macedonia, 18-21 Sept. (2008) **invited lecture**.
42. L.Stojanovska-Georgievska, N.Novkovski, E.Atanassova, Constant voltage stress characteristics of thin Ta_2O_5, Proc. 7th Conf. of the Soc. of Phys. of Macedonia, Ohrid, Macedonia, 18-21 Sept. (2008).

43. N.Novkovski, E.Atanassova, Peculiarities of capacitance measurements of nanosized high-*k* dielectrics: case of Ta_2O_5, Cond. Matt. Phys. Conf. of Balkan Countries, Mugla, Turkey, 16-28 May, (2008), to be published in J. of Optoel. and Advanced Matter.
44. E.Atanassova, D.Spassov, A.Paskaleva, M.Georgieva, J.Koprinarova, Ti-doped Ta_2O_5 stacked capacitors, 15th Intern. School on Cond. Matt. Phys., Varna, Bulgaria,31 Aug-5 Sept, (2008), to be published in J. of Optoel and Advanced Matter.

ONGOING RESEARCH PROJECTS:

1. Physics and technology of thin layers for applications in the modern microelectronics.
2. Alternative dielectric layers based on Ta_2O_5, (Hf:Ta_2O_5; Al:Ta_2O_5; Ti:Ta_2O_5) for 65-70 nm generation integrated memories (supported by NSF).
3. Nanoengineering network, SONNET (supported by the Swiss NSF).
4. Synthesis and investigation of AlN and BN nanolayers (supported by NSF).
5. Investigation of the electronic states in amorphous silicon and materials based on it (supported by NSF).
6. High-stability magnetoresistive sensors (supported by the National SMEs Program).

INTERNATIONAL COOPERATION:

1. Institute of Semiconductor Physics ИФП-Kiev, Ukraine
2. Insitute of Physics ,Universty of Scopije, Macedonia
3. University of Nish, Serbia
4. Technical University, Ankara, Turkey

DIVISION MICRO- AND ACOUSTOELECTRONICS

LABORATORY

ACOUSTOELECTRONICS

HEAD: **Assoc.Prof. Velichka Georgieva, Ph.D.**
Tel.: 979 5681, e-mail: lazarova@issp.bas.bg

TOTAL STAFF: **14**
RESEARCH SCIENTISTS: **8**
Prof. Lozan Spassov, Ph.D., D.Sc., Corresponding member of BAS; Assoc.Prof. I. Avramov, Ph.D., D.Sc.; Assoc.Prof. E. Radeva, Ph.D.; R. Velcheva, Ph.D.; Ts. Yordanov, researcher; M. Atanassov, researcher; V. Gadjanova, researcher; Z. Raicheva, chemist; L. Vergov, engineer; J. Lazarov PhD, engineer, P. Angelova, physicist. Ass.; S. Staikov, technician; G. Grigorov, technician.

RESEARCH ACTIVITIES:

In 2008 the scientific and applicable activity of Acoustoelectronics laboratory at ISSP – BAS was focused on creation of new materials, technologies and elements in accordance with the Academy's basic strategic goal-delivery and maintenance of internationally competitive & high scientific quality. This year two of the laboratory's members successfully defended dissertation thesis - DSc - 1 and PhD – 1.
The scientific investigations in the laboratory are being carried out mainly in the following **directions:**

- Quarts temperature sensors (QTS)**.**
- Mass sensitive quartz sensors.
- Surface transverse acoustic waves (STW)**.**
- Plasma polymers - synthesis, structure, properties and application**.**

– SEMI-ANALYTICAL MODELING OF THERMOSENSITIVE STRIP RESONATORS

A method of semi-analytical modeling and analysis of thermosensitive quartz strip resonators is developed. It is applied to design and manufacturing of experimental series of miniature strip resonators working in a wide temperature range. The results of the performed analysis show a very good conformity of the experimental measurements with the semi-analytical modeling results. These results are included in the dissertation of PhD student Yuliyan Lazarov. This PhD work is defended successfully.

- PIEZOELECTRIC MICROSENSORS FOR CRYOGENIC TEMPERATURES
Basic research for novel piezoelectric temperature sensors for cryogenic applications was developed. The sensors are based on thermo sensitive quartz resonators. The target of this research activity is development and production of multifunction sensor for "Nuclotron" in JINR – Dubna.

- MASS – SENSITIVE QUARTZ RESONATORS

The laboratory of Acoustoelectronics is working on two of the four modules from the MON contract on project NT3 titled "Creating of acoustic sensor for detection of environment pollution" led by research scientist Dr. Velichka Lazarova- Georgieva

• Module NT3 – 04 “Designing and creation of sensor elements used in the quartz crystal microbalance”. Analysis of the constructive parameters of the AT – cut quartz resonators on their dynamic parameters and QCM’s sorption characteristics was carried out. Quartz resonators with Au electrode diameters of 3, 4 and 5 mm of resonance frequency 15- 16 MHz with thin SnO_2 and MoO_3 layers (thickness 200 nm) were used. The analysis showed that AT – cut quartz resonators with Au electrode diameter of 4mm are the most appropriate ones for QCM applications.

A technology for increasing the unfolded surface area of the mass-sensitive quartz resonators was developed, aiming at improving QCM’s sensitivity. Five experimental sets with different degree of unfolded surface area were manufactured: polished surfaces and for comparison quartz surfaces, abrasive treated with grain sizes of 3, 7, and 14 и 20 μm. The measured dynamic parameters of the samples from the first three sets have dynamic resistance (Rs) between 13Ω and 20Ω, while the samples from sets 4 and 5 have increased Rs values, respectively 65 Ω and164 Ω, due to the severely damaged surface caused by the roughening. The spectral characteristics of the samples were measured and analysis of the obtained results was carried out. Investigation of QCM’s sorption properties is forthcoming.

• Module HT3-03 -“Investigation of the Sorption Properties of the Metal-Oxide Layers by the Quartz Crystal Microbalance”.

During the review period, the laboratory of Acoustoelectronics (ISSP- BAS) developed a method for working with the experimental laboratory set, which was created in the first year of the contract, for measurements of the mass loading by the crystal microbalance method (QCM). It was determined that it allows working with gas mixtures in wide concentration range, which is a function of the initial concentrations.

As for the concentration and temperature, CRM’s mass loading is carried out under strictly defined conditions.

Based on the measured frequency – time characteristics (FTC) of the QCMs, with formed sensitive layers, the following facts were determined:

- the layers are stable during measurements and regenerate at repeatedly treatment;
- the layers’ sorption properties are function of the method of their obtaining;
- the sorption process has a physical character and is reversible;
- the measured FTC for different system QCM – metal oxides have the same character;
- the loading response is a function of NH_3 concentration, the layers nature and method of obtaining.

The results of the experiments carried out in accordance with the programmes of modules HT3-03 and HT3-04 were presented at three international forums in the country and abroad. In 2008, four articles on the projects’ subject matter were published.

– SYNTHESES AND STUDY OF PLASMA POLYMERS, OBTAINED FROM HEXAMETHYLDISILOXANE

The investigations on plasma polymer layers, obtained from hexamethyldisiloxane for electroluminescent application were continued under two projects (‘*Digital Electroluminescent Display – Design, Constructional Development and Preparation’ with* “TECHNOS” financed from Ministry of Education and Science and ‘*Investigation of properties and characteristics of zinc sulfide electroluminophors and making of setups of their base’ with* Moskow State University of Railway Engineering. By use of selected plasma polymer layer the samples with the best brightness and life time were prepared.

The investigations on medical materials containing polymers were started under the contract ““*New nanobiocomposite materials for bone implants”,* financed by NSF - Ministry of Education and Science). By varying polymerization conditions – gas phase pressure, monomer flow rate and glow discharge power the experiments at different deposition

regimes were made. The structure of the obtained polymer layers was studied by FTIR, AFM, XRD and PES. The preliminary experiments for hydroxyapatite growing on polymer surface were made. The existence of calcium and phosphoric groups was observed. Investigations with osteoblastic cells do not show changes in polymer surface, which is promising for polymer application in biocompatible materials.

- RESONANT STRUCTURES USING RAYLEIGH SURFACE ACOUSTIC WAVES (RSAW), SURFACE TRANSVERCE WAVES (STW) AND BULK ACOUSTIC WAVES (BAW) AND THEIR APPLICATIONS IN LOW-NOISE MICROWAVE OSCILATORS, COMMUNICATIONS AND SENSOR SYSTEMS

A DSc thesis entitled: "Surface transverse wave (STW) resonators and applications in low-noise microwave oscillators, communications and sensor systems" has been successfully completed and defended.

Within a collaboration with the Faculty of physics at Sofia University a quartz based STW sensor for volatile gases has been realized and investigated. A composite polymer layer containing nanoparticles of gold has been used as a chemosensitive layer with efficient gas sorption on the surface of the sensor.

Within a collaboration with the Research Center Karlsruhe Germany, a second iteration of a novel leaky SAW sensor on lithium tantalate for liquid phase detection has been optimized for improved electrical performance and maximum sensitivity under liquid load. This sensor is currently being manufactured by SAW Components Dresden, GmbH, Germany and will be used for further research purposes.

- TECHNOLOGY DEVELOPMENT FOR PRODUCTION OF PHOTOVOLTAIC (PV) BATTERIES AND A NEW TYPE ENERGY – EFFICIENT STREETLIGHTS

A photovoltaic (PV) panel and independent of energy source street luminaries was designed. The contract was finished with production of samples – PV panels and street luminaries. "Denima 2001" Ltd. is planning to complete technology line for mass production.

PUBLICATIONS:

1. L. Spassov, V. Gadjanova, R. Velcheva, B. Dulmet, "Short and Long Term Stability of Resonant Quartz Temperature Sensors", IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, vol. 55, No. 7, July 2008.
2. V. Georgieva, N. Donkov, L. Spassov, P. Petkov, V. Gadjanova " Detection of NH_3 by quartz crystal microbalance coated with TiO_2", Journal of Physics: Conference Series 113, 2008, 012053.
3. V. Strashilov, Kl. Branzalov, G. Aleksieva, V. Velichkov, I. Avramov, "Highfrequency quartz sensor for volatile gases", XXIII-th National conference"Days of non destroy control 2008" Vol. 2(105), June 2008, pp. 405-411, ISSN 1310-3946.
4. P. Stefanov, G. Atanasova, E. Manolov, Z. Raicheva,V. Lazarova (Georgieva) "Preparation and Characterization of SnO_2 Films for Sensing Applications ", Conference Series 100, 2008, 082046.
5. P. Stefanov, M. Shipochka, P. Stefchev, Z. Raicheva, V. Georgieva, L. Spassov " XPS characterization of TiO_2 layers deposited on quartz plates", Conference Series 100, 2008, 012039.
6. E. Radeva, K. Kolentsov, L. Yourukova, D. Zhechev, E. Dimova, Optical and photoluminescent properties of plasma polymer films used in electroluminescent display structures, J. of Physics and Chemistry of Solids 70, 2008, pp.169-172.

7. E. Radeva, L. Yourukova, K. Kolentsov, B. Amov, St. Balabanov, D. Zhechev and V. Steflekova, Study on organosilicon plasma polymers implanted by carbon ions, 15-th International Summer Scool on Vacuum, Electron and Ion Technologies, IOP Publishing, J. of Physics: Conference Series 113 012041, 2008.
8. V. Georgieva, L.Spassov, A.Mogilevsky, A.Grechnikov, N.Donkov, Ts.Jordanov, V.Gadjanova " Sorptiv prorerties of thin TiO_2 and humic acid layers to NH_3, estimated by QCM", J. of Optoelectronics and Advansed Materials, (in press).
9. V. Georgieva, P. Stefanov, L. Spassov, Z. Raicheva, M. Atanassov, T. Tincheva, E.Manolov, L.Vergov "Thin MoO_3 films for sensor applicatrion", J. of Optoelectronics and Advansed Materials, (in press).
10. Z. Raicheva, Y. Lazarov, L. Spassov, V. Georgieva, V. Gadjanova, Ts. Angelov, L. Vergov, M. Atanassov "Investigation of Quartz Resonators for QCM Application", J. of Optoelectronics and Advansed Materials, (in press).
11. Strashilov, Vesseline; Alexieva, Gergana; Velitchkov, Velitchko; Avramov, Ivan; Evans, Stephen, "STW-resonator with organo-functionalized metallic nanoparticle film for vapor sensing" MANUSCRIPT NO. TUFFC-02739-2008.R1, (in press).
12. P. Stefanov, G. Atanasova, E. Manolov, Z. Raicheva, V. Lazarova (Georgieva) "Preparation and Characterization of MoO_3 Films for Sensing Applications", VIth Stranski-Kaischew Workshop in Surface Science "Nanophenomena at surfaces: fundamentals of exotic condensed matter properties", September 20 – 26, 2008, Sunny Beach, Bulgaria.
13. L.Spassov, G. Kamisheva "Milko Borrisov to himself and the others to him"Publishing house "Prof. Marin Drinov" BAS, 2008.
14. E. Radeva, L. Pramatarova, R. Dimitrova, S. Popova, T. Hikov, D. Fingarova and E. Pecheva, Infrared analysis of plasma polymerized hexamethyldisiloxane for biocompatible composites, J. of Optoelectronics and Advanced Materials (in press).
15. T. Hikov, L. Pramatarova, E. Radeva, E. Iacob, L. Vanzetti, E. Pecheva, N. Krasteva, T. Spassov, R. Dimitrova, D. Fingarova, Study of Detonation Nano Diamonds/Hydroxyapatite Composite Layers, J. of Optoelectronics and Advanced Materials (in press).
16. K.M. Kolentsov, L.S. Yourukova, E.I. Radeva, P. Zubov, Digital electroluminescent device, prepared by hybrid technology, XI Int. scool-seminar on luminescence and laser physics, 2008, Irkutsk, Russian (Publ. in Journal Izvestia Vuzov, Physika)

RESEARCH PROJECTS:

1. Project financed by Bulgarian Academy of Sciences

1.1 Applications of surface transverse waves (STW), Rayleigh surface acoustic waves (RSAW) and bulk acoustic waves (BAW) in low-noise microwave oscillators, communications and sensor systems using thin polymers layers obtained by plasma.

2. Projects financed by National Foundation of Scientific Research at the Ministry of Science and Education

2.1 Digital Electroluminescent Display – Design, Constructional Development and Preparation
2.2 Designing and creation of sensor elements used in the quartz crystal microbalance.
2.3 Investigation of the sorption properties of metal dioxide layers by the quartz crystal microbalance method.
2.4 New nanobiocomposite materials for bone implants

3. Projects extra financed by departments and Bulgarian companies (Projects financed by Bulgarian SME Promotion Agency).

3.1 Technology Development for Production of Photovoltaic (PV) Baterries and a New Type Energy-Effecient Streetlights.
3.2 High stable magnetoresistive sensors
3.3 Formation and investigation of solid state and organic thin layers for sensor function

4. Projects financed by international sources:

4.1 Investigation of impurities in helium gases on the base of quartz crystal microbalance
4.2 Investigation of properties and characteristics of zincsulphiden electoluminophors and making of set-ups of their base.
4.3 Development of mass sensitive quartz resonators for operation at cryogenic temperatures.
4.4 Design of an improved Rayleigh surface acoustic wave (RSAW) resonator with gold electrode structure and improved corrosion immunity for sensor applications in highly reactive chemical gas-phase environment.
4.5 Investigation of impurities in helium gases on the base of quartz crystal microbalance

5. Projects in frames of Inter-academic and Inter-institute collaboration

5.1 Development of chemical sensors based on a piezoresonant type for hazardous substances in the air.
5.2 Piezoelectric crystal microsensors at cryogenic temperatures.

COLLABORATION:

1. "Development of mass sensitive quartz resonators for operation at cryogenic temperatures". - Join Institute for Nuclear Research, Dubna, Russia.
2. "Design of an improved Rayleigh surface acoustic wave (RSAW) resonator with gold electrode structure and improved corrosion immunity for sensor applications in highly reactive chemical gas-phase environment"- Research Center Karlsruhe, Germany.
3. "Development of chemical sensors based on a piezoresonant type for hazardous substances in the air"- Russian Academy of Science.
4. "Piezoelectric crystal microsensors at cryogenic temperatures". - ENSMM – Besanson, France.

DIVISION LOW TEMPERATURE PHYSICS

LABORATORY

LOW TEMPERATURE PHYSICS

HEAD: **Assoc. Prof. Elena Nazarova, PH.D.**
Tel:979 5679; e-mail: nazarova@issp.bas.bg

TOTAL STAFF: **16**
RESEARCH SCIENTISTS: **14**

Prof. V. Kovachev, Ph.D., D.Sc.; Assoc. Prof. M. Bushev, Ph.D.; Assoc. Prof. E. Vlakhov, Ph.D.; Assoc. Prof. B. Terziyska, Ph.D.; Assoc. Prof. K. Kalaydjiev, Ph.D.; Assoc. Prof. N. Balchev, Ph.D; Assoc. Prof. J. Georgiev, Ph.D.; Assist. Prof. A. Zahariev, Ph.D.; Assist. Prof. A. Stoianova-Ivanova, Ph.D.; Res. Assist. S. Terzieva; G. Mihova, chemist; Ph.D. student K. Buchkov; K. Lovchinov, physicist; G. Jeliazkov, engineer.

RESEARCH ACTIVITIES:

Analytical results for the finite-size scaling behavior of d – dimensional $O(\infty)$ magnetic spin systems. described by a model Hamiltonian with strong lattice and shape anisotropy are obtained. We consider systems confined to a d – dimensional layer with periodic boundary conditions across the finite dimensions. It is shown that there are dimensions d – between the lower and upper critical dimensions for which the finite-size scaling behavior of the model is uniquely determined by reduced numbers of model parameters and as a result some specific crossover rules take place.

Samples with nominal compositions $Ru_{1-x}Sn_xSr_2Gd_{1.4}Ce_{0.6}Cu_2O_y$ ($0\leq x\leq 0.1$), $MoSr_2HoCu_2O_{8-\delta}$ and $MoSr_2(Y_{1-x}Ca_x)Cu_2O_y$ ($0\leq x\leq 0.3$) were synthesized and their superconducting and magnetic properties were investigated. It was found that the Sn-doping enhances the upper critical field $H_{c2}(0)$ (extrapolated to T=0). The weak link behaviour occurs at the expense of the intragranular superconductivity in Ru-1222. The obtained Mo-1212 samples are Mo-deficient. The coincidence of the experimental value of the Curie constant (16.22 emuK/mol) and the theoretical one (16.136 emuK/mol) of $MoSr_2HoCu_2O_{8-\delta}$ shows that the observed magnetic properties are determined by the highly dominating phase Mo-1212. It was shown that the Ca-doped Mo-1212 samples are superconducting at T_c=15 K, 30 K and 20 K for x=0, 0.2 and 0.3 respectively. The observed phenomena were discussed.

Thin cobaltite films of $NdBaCo_2O_{5+x}$ system have been obtained by magnetron sputtering on the single crystal substrates of $SrTiO_3$ (100). The deposition regime has been optimised in order to tune the oxygen stoichiometry in the range of x=(0.45 -0.50). The magnetic and magnetotransport properties of $NdBaCo_2O_{5+x}$ thin films (20 nm and 40 nm) have been investigated at low temperature and high magnetic fields. A systematic analysis of the obtained magnetotransport characteristics is carried out.

Investigations of properties of high temperature superconducting materials, with a view to reach the requirements for fusion power plant application, were carried out. The intergranular flux dynamics in underdoped and overdoped $R_{1-x}Ca_xBa_2Cu_3O_z$ (R=Y, Gd) samples was studied in details. It was established that a close relation exists between the intragranular critical current and intragranular vortex dynamics. Overdoped samples have higher activation energy for TAFF and their intergranular critical current is governed by S-

N-S type connections. Underdoped samples show low activation energy and S-I-S type intergranular current. 2D pancake vortices are characteristic of underdoped samples, while 3D vortices exist in overdoped samples. As a result in the underdoped samples small magnetic fields already excites flux creep regime in the intergranular region. Even 20 times higher magnetic field is not enough to transfer the overdoped samples into the flux creep regime. In fact we demonstrate that Ca substitution not only increases carrier concentration, but improves the intergranular flux pinning too.

The superconducting tapes, with two type cores $Y_{1-x}Ca_xBa_2Cu_3O_{7-\delta}$ (x=0; 0.3), are obtained by OPIT method under two different regimes of cold (20˚ C) and hot (825˚ C) rolling. It was found that a higher degree of texturing in the out-of-plane direction is obtained after the hot rolling deformation in tapes with overdoped core. As a result, the highest critical current density at 77 K and zero magnetic field was achieved in them.

PUBLICATIONS:

1. N.S. Tonchev, Finite-size scaling and strong space anisotropy: $O(\infty)$ spin models, Communication JINR E17-2008-159, p.1-12 (2008).
2. H. Ignatov, E. Nazarova, A. Zahariev, V. Lasarova, J. Georgiev, A. Stoyanova-Ivanova, S. Terzieva, K. Kliavkov, V. Kovachev, Deformation effects on the structure and properties of $Y_{1-x}Ca_xBa_2Cu_3O_{7-\delta}$ (x=0;0.3) tapes produced by OPIT method in the Ag-tube, J. of Superconduc. and Nov. Magn. **21** (1), 69-73 (2008) ISSN:1557-1939(print),ISSN:1557-1947(online)
3. E. Nazarova, A. Zaleski, K. Nenkov, A. Zahariev, Intergranular flux pinning in underdoped and overdoped $R_{1-x}Ca_xBa_2Cu_3O_z$ (R=Y,Gd; x=0,0.2) samples., Physica C **468**/13, 955-960 (2008).
4. Angelina K. Styanova-Ivanova, Stanimira D. Terzieva, Boris L. Shivachev, Valdek Mikli, Latinka K. Vladimirova, Synthesis and superconducting properties of $Nd_{0.33}Eu_{0.08}Gd_{0.58}Ba_2Cu_3O_z$ materials, Central European Journal of Physics, 2008, 1, 76-79.ISSN:1895-1082(print),ISSN:1644-3608(online)
5. M. Kalitzova, O. I. Lebedev, G. Zollo, K. Gesheva, E. Vlakhov, Y. Marinov, T. Ivanova, Dynamics of nanoclustering of Te^+ implanted Si after application of high frequency electromagnetic field and thermal annealing, Appl. Phys. A91, 515-519 (2008).
6. N.Balchev, K.Nenkov, G.Mihova, B.Kunev, J.Pirov, "Structure, Superconducting and Magnetotransport Properties of $Ru_{1-x}Sn_xSr_2Gd_{1.4}Ce_{0.6}Cu_2O_y$ ($0 \le x \le 0.1$)", Journal of Physics: Condensed Matter V.20, 325203 (2008)
7. N.Balchev, K.Nenkov, G.Mihova, B.Kunev, J.Pirov, "Magnetic and Superconducting Properties of $RuSr_2Sm_{1.4}Ce_{0.6}Cu_2O_{10-\delta}$ Samples", J.Superconductivity and Novel Magnetism V.21, № 6, p.365-369 (2008)
8. N.Balchev, K.Nenkov, G.Mihova, B.Kunev, J.Pirov, D.A.Dimitrov, "Magnetic and Superconducting Properties of $MoSr_2HoCu_2O_{8-\delta}$", Journal of Optoelectronics and Advanced Materials, V.10, №10, p.2757 (2008)
9. N. Balchev, K. Nenkov, G. Mihova, B. Kunev, J. Pirov, D.A. Dimitrov, Structure, magnetic and superconducting properties of $MoSr_2HoCu_2O_{8-\delta}$J. of Optoelectronics and Advanced Materials, Vol. 10, No. 10, September 29th, 2008, p. 2757-2761.

TEACHING ACTIVITIES:

Ph.D. Student K. Buchkov, supervisor Assoc. Prof. E. Nazarova

ONGOING RESEARCH PROJECTS:

I. Projects financed by Bulgarian Academy of Sciences
   1. New materials and multifunctional magnetic materials
   2. Cryogenics, superconductivity and superconducting materials

II. Projects financed by National Science Found at the Ministry of Education and Science
   1. The influence of deformation treatment on the critical parameters of YBCO superconducting tapes

III. Internal projects financed by ISSP and Bulgarian companies
   1. Phase formation and microstructure of BSCCO superconductors with ferromagnetic additions
   2. Instructions for technical maintenance of transport cryogenic equipment

IV. Projects financed by international sources
   1. Overdoping of 1-2-3 HTS materials and its influence on the ac losses, critical current, flux pinning, activation energy-EURATOM-FU07-CT-2007-00059

INTERACADEMIC COLLABORATION:

1. Tailoring of thin film structures of magnetic oxides(manganites and cobaltites), Institute of Physics, Polish Academy of Sciences, Warshaw, Poland
2. Study of overdoped state in 1-2-3 superconducting system, Institute of Low Temperatures and Structural Research (ILTSR), Polish Academy of Sciences, Wroclaw, Poland
3. Flux dynamics studies in superconducting tapes obtained by OPT technology with overdoped core, Univ. Babes Bolyai, Kluj Napoka, Rumania

International Laboratory for High Magnetic Fields and Low Temperatures – Wroclaw, Poland.

DIVISION LOW TEMPERATURE PHYSICS

LABORATORY

ENVIRONMENTAL PHYSICS

HEAD: **Assos. Prof. Vasil Lovchinov, PhD**
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TOTAL STAF: **4**
RESEARCH SCIENTIST: **4**
Assos. Prof. V. Lovchinov, PhD; Assos. Prof. D. Dimitrov, PhD;
I. Radulov PhD; P. Simeonova PhD.

RESEARCH ACTIVITIES:

The scientific activity of the Laboratory of Environmental Physics during 2008 was mainly related to the two basic strategic directions being of substantial importance both for the Academy of Sciences and for the Laboratory - "Resources of the non-living nature" and "Global Monitoring of the Environment and Security" (GMES). The activity within the frame of the project "Life Quality Assessment by the use of Methods of the Environmental Physics" was finished and only in 2008 five scientific studies related to the project have been published.

As the most substantial achievement of the Laboratory for 2008 the appearance of the monograph "Introduction to Environmental Physics" with authors Dr. P. Simeonova and Assoc. Prof. Dr. V. Lovchinov could be accounted for. The monograph consists of 433 pages, 44 figures, 34 tables, 223 equations, and 146 references from Bulgarian and foreign scientists. It deals not only with topics of the traditional environmental physics but also with items like risk assessment of environmental pollution, sustainable development of technologies and society, management of the ecosystems, organization of the environmental monitoring as well as with interpretation of politically and economically correct solutions of the existing environmental problems. Although the monograph was officially presented in May 2008, it has been already cited many times.

Together with foreign scientists an original environmetric methodology for effective assessment of the marine environment using heavy metals pollution models for various marine compartments like sediments, waters, benthic organisms was created. Methods of the multivariate statistics like cluster analysis, principal components analysis, partial least squares regression were used to model the systems. The results obtained could be used for correct assessment of the marine systems state as well as for the mutual relationships between the different compartments and their impact on the marine basin sustainability with respect to pollution. This approach is of substantial importance for understanding and sustaining the ecological equilibrium.

A specific model study was carried out dealing with the impact of non-controlled natural events on the environment and humans. An original environmetric approach for assessment of the effects from a flood event in a given river catchment is offered with respect to the pollution of the water phase. Model estimates concerning the changes in the surface waters after flooding and the influence of local polluting sources during the flood event are calculated. This is a substantial contribution to the understanding and prevention of flood effects.

In 2008 a project entitled "Improving of the life quality by sustainable management of surface waters – application for the catchments of the rivers Struma and Mesta" was prepared and presented to the National Science Fund to the Ministry of Education and Science. The project was approved and financed by a 240000 leva grant.

In 2008 the young co-worker of the Laboratory (Dr. I. Radulov) defended successfully his PhD Thesis. The dissertation was financed by a NATO re-integration grant EAP.RIG № 981824. The same young scientist has won a competition in the field of educational ecological projects financed by the World Federation of the Scientists, Cern, Switzerland. The tutor within the frames of this educational project is the head of the Laboratory Assoc. Prof. Dr. V. Lovchinov.

During 2008 the EP Lab was involved in one of the promising research initiatives in the European Union, e.g. European Technology Platform (ETP). The ETP on Food for Life seeks to deliver innovative, new and improved food products to national, regional and global markets. Main obligation in realization of this initiative falls on the stakeholders in the food sector. The member of EP Lab. – D.Dimitrov participate as a stakeholder in the third key group of stakeholders – research community, and takes part in the ETP meetings .

Another field of activity of the Laboratory is magnetism and superconductivity. Members of the staff participated at 3 international conferences and published 5 scientific papers with respect to this topic. The international cooperation with L'Universite de Liege, Depart. Physique, Group SUPRA.TECS Liege, Belgium, continues successfully with the project: "Thermal and magnetic properties of HT superconducting and related magnetic materials" within the frames of a treaty for bilateral academic cooperation (EBP).

The members of the Laboratory participated in total in 9 conferences during 2008 in the country and abroad with oral and poster communications.

PUBLICATIONS:

Scientific books:

1. Pavlina Simeonova and Vasil Lovchinov. Monograph: Introduction to Environmental physics. *Avangard Prima*, ISBN 978-954-323-350-2, Sofia, (2008), 1- 433.

Papers:

1. Thomas Spanos, Vasil Simeonov, Pavlina Simeonova, Eleni Apostolidou and John Stratis. Environmetrics to evaluate marine environment quality, *Environmental Monitoring and Assessment,* 143(1-3)**,** 2008, 215-225.
2. D. Dimitrov, A. Apostolov, I. Radulov, V. Lovchinov, Magnetocaloric effect in orthorhombic manganese compounds, J. of Optoelectronics and Advanced Materials Vol. 10, No. 1, January, 18th, 2008, 205 – 208.
3. N. Balchev, K. Nenkov, G. Mihova, B. Kunev, J. Pirov, D.A. Dimitrov, Structure, magnetic and superconducting properties of $MoSr_2HoCu_2O_{8-\delta}$J. of Optoelectronics and Advanced Materials, Vol. 10, No. 10, September 29th, 2008, 2757-2761.
4. I. Radulov, V. Lovchinov, M. Daszkiewicz, Magneto and ferroelectric phase transitions in $HoMn_2O_5$ monocrystals. Journal of Magnetism and Magnetic Materials, vol.320, issues 1-2, Jan. 2008, 43 – 46.
5. Pavlina Simeonova, Vasil Lovchinov, Dimitar Dimitrov, Ilia Radulov. Chemometric assessment of river water during a flood event, *Ecol. Chem. Eng.* vol.15, No 3, (2008),187-198.

6. Pavlina Simeonova, Danail Simeonov and Lyubomir Spasov. Experimental design in monitoring procedure to determine heavy metals in marine sediments. *Ecol. Chem. Eng.* vol.15, No 4, (2008), 200-212.
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9. I. Radulov, V. Lovchinov, D. Dimitrov, P. Simeonova, V. Nizankovski. Correlation between magnetostriction and polarization in orthorhombic manganites. *Journal of Optoelectronics and Advanced Materials*, (2008) - in press.
10. I. Radulov, V. Lovchinov, D. Dimitrov, P. Simeonova, P.H. Vanderbemden Magnetic and transport properties of $HoMnO_3$ monocrystal. *Journal of Optoelectronics and Advanced Materials*, (2008) - in press.
11. P. Simeonova, V. Simeonov. Statistical data pretreatment and scaling to assist the classification of data from moss analysis, case study: urban environment of city of Gdansk, Poland. *Ann. Fac. Chem. Univ. Sofia,* vol. 100, (2008), 153-176.
12**.** P. Simeonova. Chemometric treatment of missing elements. *Ann. Univ. Sof.Fac.Chim.,* vol. 100, (2008), 177-192.
13. I. Radulov . Summary of PhD dissertation thesis "Magnetic properties of rare-earth manganites" Sofia, 2008, 1 - 32.

ONGOING RESEARCH PROJECTS:

1." Life quality assessment by methods of the environmental physics, N BK 0707/2.05.2007.

2. Reintegration Grant NATO- EAP.RIG № 981824.
3. "Thermal and magnetic properties of HT superconducting and related magnetic materials" -Liege, Belgium. L'Universite de Liege, Depart. Physique, Group SUPRA.TECS.
4. Global and local pollution in particular: Management of water quality - World Federation of Sciences – Switzerland.
5. Project NSF – VUH – MES -308/2007
6. Project NSF - MES
7. Improving of life quality by sustainable management of surface waters – application for the catchments of the rivers Struma and Mesta - № D002-352/31.12.2008
8. Investigation and development of new eco-technological method for electro motors corpuses and details - № TH -1512/05 (№ 812)
9. Investigation, development and optimization of eco-technological method for modification of lighten, bulk, thin film composites with complex nano-sized structures (including hard, polymer and gaseous)- № HT-2-02/2005

INTERNATION COLABORATION:

1. Universite de Liege, Belgium - L'Universite de Liege, Depart. Physique, Group SUPRA.TECS.
2. World Federation of Sciences – Switzerland.
3. International Laboratory for High Magnetic Fields and Low Temperatures – Wroclaw, Poland.

DIVISION PHYSICAL OPTICS AND OPTICAL METHODS

LABORATORY

OPTICS AND SPECTROSCOPY

HEAD: **Prof. Minko Petrov, D.Sc.**
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TOTAL STAFF: **30**
RESEARCH SCIENTISTS: **29**

Prof. N. Kirov, D.Sc.; Prof. S. Rashev, D.Sc.; Prof. K. Panayotov D.Sc.; Assoc. Prof. D. Angelov, Ph.D.; Assoc E. Angelova, Ph.D.; Assoc. Prof. L. Tsonev, Ph.D.; Assoc. Prof. A. Andreev, Ph.D.; Assoc. Prof. S. Tonchev, Ph.D.; Assoc. Prof. A. Angelov, Ph.D.; Assoc. Prof. G. Dyankov, Ph.D.; Assoc. Prof. E. Keskinova, Ph.D.; Assoc. Prof. G. Hadjihristov, Ph.D.; Assoc. Prof. T. Tsvetkova Ph.D.; Assoc. Prof. R. Peeva, Ph.D.; Assoc Prof. K. Antonova Ph.D.; Assoc. Prof. B. Zafirova, Ph.D.; Assoc Prof. T. Kehlibarov; Assoc. Prof. P. Pavlova, Ph.D.; Asist. Prof. M. Kaneva, Ph.D; Asist. Prof. T. Tenev, Ph.D.; Asist. Prof. B. Katranchev, Ph.D.; Asist. Prof. B. Panchev; Asist. Prof. H. Naradikian; Asist. Prof. B. Petrov; Asist. Prof. B. Bozhkov; Asist. Prof. E. Karakoleva; Asist. Prof. I. Savova; I. Milushev, Ph.D.; Y.Velkova

RESEARCH ACTIVITIES:

I. PHYSICAL OPTICS. PHOTONICS

- OPTICS AND SPECTROSCOPY OF WAVEGUIDES

The phenomenon of radiation-induced hydrogen migration has been studied in hydrogenated amorphous silicon (a-Si:H) using layer stacks of SiO_2/a-Si:H/SiO_2. The top and bottom SiO_2 layers were deposited by magnetron sputtering at room temperature. The intermediate a-Si:H layers were deposited using plasma-enhanced chemical vapor deposition at three temperatures – room temperature, 150°C, and 270°C. The samples were irradiated with MeV $^{15}N^{++}$ ions during nuclear reaction analysis of hydrogen concentration. The symmetric hydrogen concentration profile in the as-prepared layer stack becomes asymmetric after the irradiation due to increase in the hydrogen concentration in the bottom SiO_2 layer. Hydrogen concentration in the layer stacks decreases during the initial irradiation stage and then remains constant. In contrast, hydrogen loss from the a-Si:H layer proceeds gradually and continuously with increasing radiation fluence. It has been suggested that the hydrogen atoms liberated by the MeV ion irradiation do not recombine in molecules and the hydrogen migration in a-Si:H is related to the diffusion of the hydrogen atoms. The radiation-induced asymmetry of the hydrogen profiles in the layer stack implies that there is a difference in the diffusion parameters at the inner and outer interface.

Thin films of hydrogenated amorphous silicon (a-Si:H) prepared by plasma-enhanced chemical vapor deposition have been investigated by nanoindentation regarding their mechanical properties. The composite values of elastic (Young's) modulus, E_c, and hardness, H_c, of the film/substrate system have been evaluated from the load-displacement curves. The film-only parameters have been estimated employing a low contact depth approach, as well as the extrapolation of the depth profiles of E_c and H_c. Scanning Probe microscopy (SPM) has been employed to image the nano-indenter impressions. We find that the pile-up of material is significant for use of a cube corner tip, while it is less pronounced when using a Berkovich tip. For both indenter types the projected contact area directly measured from

SPM images agrees well with the values calculated using the respective calibrated area function. In addition, wear resistance of a-Si:H has been studied. After the roughness asperities have been removed and the film surface has been smoothened wear proceeds in the same way as for crystalline silicon.

Optical waveguides in Y-cut $LiNbO_3$ were obtained at different technological regimes resulting in a variety of phases composing the proton-exchanged layer. Mode spectra measurement, infrared absorption and Raman spectra recording were performed after obtaining of samples and after a period of ten years as well. The phase composition is estimated and some conclusions are made concerning the stability of such waveguides.

Proton exchanged waveguide layers in LiNbO3 obtained in crystals of the main crystallographic orientations under different diffusion parameters were studied. The problem of phase formation was treated in relation to them and the results were discussed in terms of the contemporary concept of the phase model for LiNbO3. The main methods which were used for the phase-composition analysis include waveguide mode, IR and Raman spectroscopy or their combinations.

A detailed review of the luminescence of rare earths in $LiNbO_3$ matrix was performed in 2007 in concern to the active integrated-optical waveguides. In 2008 the review was enlarged towards photo- and thermostimulated luminescence in quartz microcrystals. Such luminescent methods could be used for age determination of archaeological ceramical artifacts or stone-built objects.

Two almanacs including professors and lecturers of the University of Sofia "St. Kliment Ohridsky" and of the former Faculty of Physics and Mathematics were created in collaboration with the faculties of chemistry and mathematics at the University.

- FIBER OPTICS

In-line fibre-optic refractometers were fabricated consisting of a side-polished single-mode optical fibre covered with a pulsed laser deposition (PLD) ZnO thin film. The sensitivity was investigated for different sensor elements based on the interaction with the zero- and first-order modes of the ZnO planar waveguide. Three different isotropic single-mode fibres were used in compliance with the working spectral region. For the sensors utilizing interaction with the TE1 and TM1 modes of the planar waveguide, an average sensitivity of a 700–1100 nm/RIU change in the 800–1000 nm spectral region and a 1100–1700 nm/RIU change in the 1300–1600nm spectral region was demonstrated for superstrate refractive index changes between 1.333 and 1.458. Very high sensitivity (a 3000–6700 nm/RIU change for low values of the superstrate refractive index of 1.33–1.40) was obtained for sensor elements based on the interaction with the TE0 and TM0 modes of the planar waveguide. The thicknesses of the ZnO thin films for this interaction lie in the region 80–150 nm. These values guarantee the optical and mechanical stability of the films and make the refractometric elements that were investigated reliable sensors for chemical and biochemical applications.

- HOLOGRAPHIC DIFFRACTION GRATINGS

- Polarization control of solid state ceramic lasers by optical resonance.

The use of diffraction gratings optical resonance for a polarization control of solid state ceramic lasers was studied. The theoretical modeling of the structure shows that the optimal way for such action is to separate the functions of reflection from the multilayer mirror and control of polarization by resonant diffraction grating. Such configuration combines low reflection losses and high polarization selectivity and allows an effective linear polarization of high power laser radiation. The effect was demonstrated experimentally with ceramic Ytterbium doted YAG laser at 1030 nm wavelength. It was shown that the structure performs effective polarization control with constructive and destructive interference as well.

- Experimental study of the spectral dependence of the phase induced by reflection from a metal-dielectric diffraction grating close to the mode resonance.

Ellipsometrical technique was used for experimental analysis of the reflection spectra of TE-polarized light from a metal-dielectric resonant diffraction grating. The experimental results fit well with the theoretically predicted and allow the real dielectric constant of metal films to be measured. These resonant structures open new opportunities for development of a phase-filter having specific spectral functions. Such micro-optical components could be used for forming and processing of femto-second laser pulses.

- Effective excitation of multimode waveguide by metal-dielectric diffraction grating.

It was shown that a resonant diffraction grating could be used as a high efficient coupler for selective excitation of multimode waveguide. It was experimentally demonstrated that the structure ensures 61 % coupling of incident power in the waveguide when optical resonance with leaky modes was used.

- Replication of polymer micro-optical components and nano-structures.

The opportunity was demonstrated for industrial fabrication of cheep components by polymer replica preparation. A new technological process is developed which allows a precise replication of micro-optical components and nano-structures by founding under pressure and hot stamping.

- Development of a phase mask for immersion dynamic interference lithography

It was experimentally shown that a phase mask having a high refractive index could be used for immersion dynamic interference lithography. In the case when only ±1 diffraction orders exist, it is possible to completely suppress the zero order, even if the medium has a refractive index above 1. This makes possible the use of such mask in a regime of two-fold reduction of the period of the grating recorded by for immersion dynamic lithography.

- *MICRO- AND NANO-PHOTONICS "Georgy Zartov"*

We have been working on the following 4 main topics: physics of semiconductor lasers; nonlinear dynamics of semiconductor lasers induced by optical feedback and optical injections; chaos synchronization and photonics crystal lasers. On first topic we continued the experimental and theoretical work on the polarization properties of Vertical-Cavity Surface-Emitting Lasers. Now our work mainly concerns VCSELs with quantum dot active material. These investigations are done in collaboration with Technical University of Berlin, Germany and Supelec in Metz, France. In collaboration with Ioffe Phisicotechical Institute in St. Peterburg, Russia and York University, England we investigated shallow quantum wells for saturable electro-absorption in mode locked external cavity VCSELs. On the second topic we investigated theoretically and experimentally the stationary and dynamical regimes in feedback system with very small external cavity length and in optical injection system with orthogonal injection. These investigations were done in collaboration with Polytechnic University of Catalonia in Pamplona, Spain, Institute of Physics of University of Cantabria, Santarden, Spain and Supelec in Metz, France. On the third topic we have recently shown experimentally and theoretically, in collaboration with Saitama University in Tokyo, Japan the role of the polarization for chaos synchronization in VCSELs and the exchange of the leader-leggard role. On the last topic we have shown in a number of works done in collaboration with Politecnic University of Lodz, Poland that photonic crystal VCSELs can be properly modeled by a full vectorial three-dimensional model and we have predicted improvements of their modal and polarization properties by appropriate designs.

Stable wideband antireflection coatings for the visible and near infrared spectral regions have been constructed and realized using vacuum thermal evaporation. The refractive indices and dispersions for each material at different technological conditions have been investigated too.

Initial experiments have been performed for the laser mirrors preparation for the UV

spectral region. Mirrors for UV spectral region based on fluorides with R_{max}=90% at λ_0=230 nm, $\Delta\lambda_{0.5}$=25 nm and R<10% in the whole visible region were produced.

Narrow-band interference filters in the visible region with $\Delta\lambda_{0.5}$<2 nm were also designed and produced.

In the frame of a contract with OPTIX AD, multilayer interference structures such as laser mirrors, band-pass filters, beamsplitters, AR-coatings, etc. were designed and optimized. These coatings were manufactured in the firm and conforms the specifications. This made possible laser generation at an eye-safe wavelength (1540 nm).

II. OPTICS AND SPECTROSCOPY OF ANISOTROPIC AND NONLINEAR MEDIA

- OPTICS AND SPECTROSCOPY OF THERMOTROPIC LIQUID CRYSTALS

Electroconvection (EC) in nematic liquid crystals, which appears before smectic C phase at cooling, was studied. Three detached nematic regions with characteristic ECs were detected under temperature variation. The influence of the change of magnitude and sign of electroconductivity anisotropy, as well as the influence of the nematic director location (both driven by the temperature variation), on EC mechanism and the relevant optical patterns are discussed. The EC instability, known as prewavy ('wide domain') one, in the nearest to the nematic – isotropic (N-I) phase transition temperature range in the nematic liquid crystals with short range smectic C order (4,n-heptyloxybenzoic acids) was analyzed. We indicated that this non-standard EC appear due to the electrical conductivity σ increase (chevrons in conductive EC regime), accompanied with electrical conductivity σ_a and optical anisotropies decrease in the high temperature nematic range.

The laser diffraction technique for the electroconvection in smectics C and nematics with short range smectic C order for oblique illumination with coherent laser light was developed. The laser diffraction as a method for the direct quantitative determination of the amplitudes of the director field was used. We found that oblique incidence in general favours the reflexes of odd numbered order, which indicate the amplitude grating, produced by the director distortion in EC regime. The modification of the standard Carr-Helfrich mechanism, provoked by the diffraction study of the smectic C and nematic with short range smectic C order, was proposed.

The angular dependence of the surface anchoring energies of the smectic C with temperature independent tilt angle (type C_1) on two surfaces: SiO_x/ITO/glass and holographic diffraction grating were measured using a twist – cell method. The smectic C monodomains rotation, starting at a critical imposed bulk twist, revealed a surface anchoring bifurcation. The surface anchoring strengths of the SiO_x/ITO/glass and holographic grating were evaluated. A model for the bulk twist influence on the smectic C monodomain growth was suggested.

- THEORETICAL METHODS IN MOLECULAR PHYSICS

We have proposed and developd theoretically a general mechanism for involvement of rotational motion into the nonradiative transitions that occur in an isolated polyatomic molecule. The treatment is based on the different rotational constants and different (asymmetric top – symmetric top) molecular structure in the two combining electronic states. We focus our attention on the T1-->S0 intersystem crossing (ISC) transition in thiophosgene and show how the rotational mechanism could lead to a considerable enhancement of the effective level density for the process. Inserting the rotational mechanism into our recently developed technique and algorithm for combined spin-orbit coupling+intramolecular vibrational redistribution (SO+IVR) analysis, we have carried out large scale calculations that have lead to a better understanding of the ISC (T1-->S0) in thiophosgene.

-MULTY-PHOTON PROCESSES. NONLINEAR OPTICS

The third-order optical susceptibility of magnesium sulfite hexahydrate single crystal is experimentally studied by nonlinear laser spectroscopy. Third-harmonic generation and two-photon absorption in this crystal are examined within the 600 – 1500 nm range by picosecond optical parametric oscillator. Some important characteristics of the crystal such as the third-harmonic generation efficiency, the value of the cubic susceptibility, the dispersion of the third-order nonlinearity and the nonlinear refractive index, are determined.

The luminescence of europium coordination complexes containing diamine ligands is studied in solutions. The optical response characterizes the Eu complexes as emissive compounds suitable for fluorometric applications.

A field-effect transconductance is found in sandwich structure of the type dielectric/semiconductor/insulator created in ion-modified thin dielectric layers attractive for microelectronics. The proposed structure can be used for electrical bio-sensor and biomedical applications based on the detection of the field-effect induced on the subsurface region of ion-modified material when charged biomolecules are immobilized on its surface.

New theoretical model and expressions for rotational diffusion and the type of molecular vibrations by resonance Raman scattering of ordered liquid crystals are proposed. They allow to obtain a valuable information about rotational inter- and intramolecular dynamics, molecular geometry and orientational order parameters in the important case of uniaxially aligned systems (nematic and smectic A liquid crystals, polymeric liquid crystals, conducting organic polymers, Langmuir-Blodgett films) and other mesogens and materials of interest for molecular electronics and optoelectronics.

- *LASER SPECTROSCOPY APPLIED TO BIOLOGICAL SYSTEMS: CHROMATIN STRUCTURE AND DYNAMICS*

The dynamic of interaction of the transcription factor NF-κB with DNA has been investigated. For this reason, a new approach has been described for a millisecond dynamic study with high spatial resolution of non-equilibrium protein–DNA interactions in solution. The approach is based on mapping the time-resolved UV laser–induced biphotonic DNA oxidative lesions during DNA recognition and binding of a specific protein. Our laser "photofootprinting" approach was applied for studying the interaction of the human necrosis factor NF–κB p50 homodimer bound to a 37 base pair DNA. Evidence is provided for the occurrence of a two-step process: rapid (30 ms) formation of the pre-equilibrium complex and slow (1 s) protein rearrangement and DNA conformation accommodation.

- *COLORIMETRY AND ITS APPLICATIONS IN INDUSTRY AND ENVIRONMENT*

A programme was elaborated for the use of a miniature USB colorimeter.

PUBLICATIONS:

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2. David Pietroy, O. Parriaux, S. Tonchev, Spectral phase induced by the reflection on a mirror-based waveguide grating in the neighborhood of modal resonance**,** Optics Letters, Vol. **33**, No. 18, pp. 2053-2055, September 15, 2008. **ISSN**: 0146-9592.

3. O. Parriaux, J.F. Bisson, K. Ueda, S. Tonchev, E. Gamet, J.C. Pommier, S. Reynaud, Polarization control of a Yb:YAG ceramic microchip laser by constructive-interference resonant grating mirror, Journal of Modern Optics, Vol. **55**, No. 12, pp. 1899–191210 July 2008. **ISSN:** 1362-3044

4. M. Dems, T. Czyszanowski, H. Thienpont, K. Panajotov, Highly birefringent and dichroic photonic crystal VCSEL design, Optics Commun., 281, 3149, 2008. **ISSN:** 0030-4018
5. M. A. Arteaga, M. Lopez-Amo, J. Hernandez, H. Thienpont, K. Panajotov, Spectral properties of edge-emitting semiconductor laser subject to optical feedback from extremely short external cavity, Opt. Quant. Electr., 40, 69, 2008. ISSN: 0306-8919
6. T. Czyszanowski, R.Sarzala, L.Piskorski, M. Dems, M.Wasiak, W.Nakwaski, K. Panajotov, Threshold characteristics of bottom-emitting long wavelength VCSELs with photonic-crystal within the top mirror, Opt. Quant. Electr., 40, 149, 2008. ISSN: 0306-8919
7. M. Sciamanna, D. Wolfersberger, K. Panajotov, Introduction to the special issue of Optical and Quantum Electronics related to the workshops "PHysics and Applications of SEmiconductor LASERs" (PHASE 2007) and "Instabilities, Patterns and Spatial SOlitons" (IPSSO 2007, Opt. Quant. Electr., 40, 65, 2008. ISSN: 0306-8919
8. T. Czyszanowski, M. Dems, H. Thienpont, and K. Panajotov, Modal gain and confinement factors in top- and bottom-emitting photonic-crystal VCSEL J. Phys. D: Appl. Phys., 41, 085102, 2008. ISSN 0022-3727
9. B. S. Ryvkin, K. Panajotov, E. A. Avutin, Low saturation fluence in a semiconductor saturable electroabsorber mirror operated in a self-biased regime, Journ. Appl. Phys., 96, pp.103102, 2008. ISSN 0021-8979
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11. M. Petrov, E. Keskinova, B.Katranchev, 'The electroconvection in the nematic liquid crystals with short range smectic C order', Journal of Molecular Liquids, **138**, 130, 2008. ISSN: 0167-7322.
12. A. Andreev, B. Zafirova, E. Karakoleva, A. Dikovska, P. Atanasov, Highly sensitive refractometers based on a side-polished single-mode fibre coupled with a metal oxide thin-film planar waveguide, Journal of Optics A: Pure and Applied Optics, **10** (3), 035303 (2008). ISSN 1464-4258
13. S.S. Stanimirov, G.B. Hadjichristov, I.K. Petkov, "Emission efficiency of diamine derivatives of tris[4,4,4-trifluoro-1-(2-thienyl)-1,3-butanediono]europium", Spectrochim. Acta A: Mol. Biomol. Spectrosc. 67 (5) (2007) 1326-1332. **ISSN:** 1386-1425
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15. G.B. Hadjichristov, S.S. Stanimirov, I.L. Stefanov, I.K. Petkov, "The luminescence response of diamine-liganded europium complexes upon resonant and pre-resonant excitation", Spectrochim. Acta A: Mol. Biomol. Spectrosc. 69 (2) (2008) 443-448. **ISSN:** 1386-1425
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17. G.B. Hadjichristov, V.K. Gueorguiev, Tz.E. Ivanov, Y.G. Marinov, V.G. Ivanov, E. Faulques, "Silicon ion implanted PMMA for soft electronics", Org. Electron. 9 (6) (2008) 1051-1060. ISSN*:* 1566-1199
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22. X. Hachair, G. Tissoni, H. Thienpont, K. Panajotov, Linearly polarized bistable localized structure in a medium size vertical-cavity surface-emitting laser, Phys. Rev. A, (rappid comm.), accepted (November, 2008).
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26. M. Petrov, E. Keskinova, H. Naradikian and B. Katranchev, 'Diffraction grating effect in smectic C and nematic liquid crystals at obliquely incident coherent laser light', Journal of Optoelectronics and Advanced Materials, in press. ISSN 1454-4164
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ONGOING RESEARCH PROJECTS:

1. VI EU Framework - Project, 2004-2008, Network of Excellence: (3DTV) Integrated Three-dimensional Television – Capture, Transmission and Display; Contract No. 511568. (Assoc. Prof. S. Tonchev, PhD, Assist. Prof. M. Kuneva, PhD).
2. Contract No MRTN-CT-2003-505086 within the EC 6th Framework Programme (FP6) Selective formation and biochemistry of oxidative clastered and damage 'clustoxdna' contact person Dr. Dimitar Angelov
3. Ion Beam Modification of Polymer Surfaces 12924, MAAE, Assoc. Prof. T.Tsvetkova Ph.D.

4. Relaxation processes in polyatomic molecules - National grant for science 1415 (Prof. S. Rashev, D.Sc.).
5. Dynamic of DNA-protein interaction and mechanism of nucleosome remodeling, National Found of Science, grant K1402 to D. Angelov.
6. EC 6th Framework Programme (FP6) Contract Nº: MRTN-CT-2003-505086 to D. Angelov, "Selective formation and biochemistry of oxidative clustered DNA damage" (CLUSTOXDNA).
7. International project ECO-NET, Surface anchoring memory and surface gliding of liquid crystals, Prof. M. Petrov, Ds.C.
8. Commission of the European Communities, Research Directorate-General, Contract Number: RITA-025646, Forschungszentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, AIM – Center, POB 510119 01314 Dresden Germany (Assist. Prof. B. Pantchev).

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1. Free University of Brussels, Departmet of Photonics, Belgium
2. Forschungszentrum Rossendorf, Institut fuer Ionenstralphysik und Materialforschung, Germany.
3. Pluridisciplinary Laboratory Joliot Curie at the Ecole Normale Supérieure, Lyon (CNRS UMR 5161) France, The Institute Albert Bonniot, UJF & INSERM U309, and CEA, Grenoble, France and funded by Ministry of Education and Science BG (K 1402/ 2004), and 6th FP ECC MCRTN "CLUSTOXDNA".
4. Ecole Normale Supérieure de Lyon, Laboratoire Pluridisciplinaire Joliot-Curie, (CNRS USR 3010) France; UJF, Institute Albert Bonniot, INSERM U309 and CEA-CENG, Grenoble, France
5. Research Institute of Solid State and Optics, Budapest, HAS, Hungary.
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DIVISION SOFT MATTER PHYSICS

LABORATORY

LIQUID CRYSTALS

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RESEARCH SCIENTISTS: **7**

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RESEARCH ACTIVITIES:

Three projects were developed in the Laboratory "Liquid Crystals" during 2008 on different contracts: one of them with BAS, a second one with BAS in cooperation with Ljubljana University, Slovenia, and one with NSFB. A two year research project in the NSFB's programme "Bulgaria-Slovenia" has been submitted and accepted. A Ph.D. thesis "The influence of sugars on the elastic properties of lipid membranes" has been defended.

The solution of the Euler-Lagrange equations for the director components $n_y=f_1(z)\sin(qy)$ and $n_z=f_2(z)\cos(qy)$, where q is the wave number of the flexoelectric domains of Vistin'-Pikin-Bobylev, has been for the first time exactly found with the aid of matrix calculations for the case of a planar nematic layer with anisotropic elasticity and a negative dielectric anisotropy under the action of an inhomogeneous d.c. flexoelectrically deforming electric field. A comparison is made with another, approximate, solution for anisotropic elasticity and a homogeneous electric field. Discussion for eventual applications of this solution has been done.

The flexo-dielectric behaviour of a homeotropic MBBA nematic layer has been experimentally studied. Asymmetric strong-weak anchoring of the homeotropic nematic layer was achieved by treating the glass plates – one of them with lecithin ensuring the strong anchoring and the other with usual soap ensuring the weak anchoring. The application of a d.c. voltage with a sufficient amplitude led to the appearance of a complex texture consisting of gradient flexo-dielectric deformations including Schlieren texture with many singular points and zigzag flexoelectric walls. The application of additional orienting a.c. voltage brought clarification of the Schlieren texture resembling that of the smectic-C liquid crystal. Inversely, the application of an a.c. voltage across the homeotropic nematic layer led to formation of a nice Schlieren texture. The additional application of a d.c. voltage created complex zigzag gradient flexoelectric walls which connected the singular points in the Schlieren texture. In this way, one can determine for the first time how many points in the initial Schlieren texture are singular and how many are non-singular.

Expressions are obtained for the shape fluctuations of a quasi-spherical lipid vesicle in the case when its membrane contains an additive, which is soluble in the liquid phase, bathing the membrane.

The data for the specific heat of chalcogenide glasses are modeled by means of the phenomenologically modified Debye model.

The dynamics of viscous lipid vesicles in a linear shear field at the proximity of a non-deformable surface was investigated experimentally.

The rheology of erythrocyte and vesicle suspensions with high volume fraction of the deformable particles (>15%) was studied. The effective viscosity was determined experimentally as a function of the viscosity contrast between the internal and external solutions. The volume fraction of vesicles and erythrocytes was measured in each sample in order to obtain the so-called intrinsic viscosity. Thus, the experimental dependence of the intrinsic viscosity of concentrated red blood cell suspensions (haematocrit up to ~ 70%) on the viscosity of the external medium was obtained for the first time. The effects of hydrodynamic interactions between the particles on the rheology of red blood cell suspensions were studied with the increase of the erythrocyte volume fraction. Preliminary experiments on the viscoelasticity of erythrocyte suspensions with high volume fraction of the particles as a function of the viscosity of the suspending medium were carried out.

The dynamics of the thermally induced shape fluctuations of quasi-spherical lipid vesicles was studied. Vesicles were obtained from various synthetic lipids using the electroformation or the gentle hydration method in order to compare the membrane mechanical properties of vesicles with identical lipid composition but obtained with different methods. An evaluation of the intermonolayer friction coefficient of the lipid bilayer was made and its bending elastic modulus was estimated at blocked exchange of molecules between the two monolayers.

PUBLICATIONS:

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4. J. Genova, A. Zheliaskova, M. D. Mitov, "Influence of Hydrocarbon Inclusions on the Elasticity of SOPC Membrance", Compt. rend. Acad. bulg. Sci., 61, 879-884, (2008).
5. H. P. Hinov and Y. G. Marinov, “A complete solution of the mathematical problem for the behaviour of the flexoelectric domains in a d.c. voltage for the case of anisotropic elasticity”, JOAM, (in press), ISSN: PRINT: 1454 - 4164.
6. H. P. Hinov and Y.G. Marinov, "Theoretical Considerations and Experimental Illustration of the Electrooptic Behaviour of Longitudinal Flexoelectric Domains under the Joint Action of d.c. and a.c. Voltages: the Case of Strong Anchoring", Mol. Cryst. Liq. Cryst., (in press).Print ISSN: 1542-1406.
7. H. P. Hinov, Y. G. Marinov, A. G. Petrov, U. S. Hiremath, and C. V. Yelamagad: “Observations of flexo-dielectric walls in a bent-core-calamitic nematic liquid crystal”, JOAM (in press).
8. Bonka Terziyska, Isak Bivas, and Konstantin Nenkov, "Modeling of low-temperature specific heat data for Ge27As13S60 and As40S60 glasses by means of the phenomenologically modified soft potential model", Cryogenics (in press).
9. J. Genova, A. Zheliaskova, V. Vitkova, M. D. Mitov, "Stroboscopic Illumination Study of the Dynamics of Fluctuating Vesicles", JOAM, (in press).
10. V. Vitkova, G. Coupier, M.-A. Mader, B. Kaoui, C. Misbah and T. Podgorski, “Tumbling of Viscous Vesicles in a Linear Shear Field Near a Wall”, JOAM (in press).

DIVISION SOFT MATTER PHYSICS

LABORATORY

BIOMOLECULAR LAYERS

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RESEARSCH SCIENTISTS: **4**

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RESEARCH ACTIVITIES:

The role of chirality in membrane-forming lipids has been studied. We demonstrated that the chirality of phospholipids makes fluid lipid bilayers piezoelectric. Thus, chiral lipids would play a central role in the functioning of cell membranes as active mechanotransducers. By periodically shearing and compressing nonaqueous lamellar phases of left (*L*-α-phosphatidylcholine), right (D-α-phosphatidylcholine), and racemic (DL-α-phosphatidylcholine) lipids, we induced a tilt of the molecules with respect to the bilayer's normal and produced electric current perpendicular to the tilt plane, with the chiral lipids only. This effect is due to the Sm-A^* phase liquid crystal structure of the bilayers, which under molecular tilt becomes a ferroelectric Sm-C^* phase, where the polarization is normal to the tilt plane. This coupling allows for a wide variety of sensory possibilities of cell membranes such as mechanoreception, magnetosensitivity, as well as in-plane proton membrane transport and related phenomena such as adenosine triphosphate (ATP) synthesis, soft molecular machine performance, etc.

Experimental evidence of biomembrane flexoelectricity (including direct and converse flexoelectric effect) is reviewed. Flexoelectricity provides a reciprocal relationship between electricity and mechanics in membranes, i.e., between membrane curvature and polarization. Biological implications of flexoelectricity in mechanosensitivity, electromotility and hearing is underlined. Flexoelectricity enables membrane structures to function like soft micro- and nano-machines, sensors and actuators, thus giving important input to sensoric applications.

A method for instant visualisation of standard ingredients contained in alcoholic and non-alcoholic drinks was developed. The method utilizes texture analysis of thin liquid crystal layer spread onto dried beverage traces. The simplicity, efficiency and sensitivity of the method allow for application of the liquid crystal decoration in food industry.

Experimental observations on the electrooptic behaviour of the bent-core-calamitic 4-((3-(4-(4-(decyloxy)benzoyloxy)benzoyloxy)phenylimino)methyl)-3-hydroxyphenyl 4-(6-(4'-cyanobiphenyl-4-yloxy) hexyloxy) benzoate in the nematic phase with a positive dielectric anisotropy were performed for the first time. The flexoelectric behaviour of the nematic for the case of a d.c. or very low-frequency (up to 0.05 Hz) voltage applied across a highly tilted or homeotropic nematic layer with a thickness of 15 μm was regarded. Various flexo-dielectric domains, such as cross-like domains, π-walls, longitudinal flexo-dielectric walls, etc. appeared for voltages below 8 V. While cross-like domains were obtained in initially homeotropic nematic regions π-walls were observed in highly tilted nematic regions.

An interpretation that all these flexoelectric domains arise from the inhomogeneity of the electric field created by injection of ions from one of the electrodes was putted forward.

The electro-optical (EO) light-switching properties of wedge-formed microscale droplet-gradient single layers of polymer-dispersed liquid crystals (PDLC: NOA65/E7) are examined. Related to the wedge dimension, the liquid-crystal droplets in the layers reach several tens of micrometers. Being precisely controlled by the layer thickness, the variable droplet size can be of use for EO light control.

PUBLICATIONS:

18. John Harden, Nicholas Diorio, Alexander G. Petrov, Antal Jakli, Chirality of lipids makes fluid lamellar phases piezoelectric, Phys Rev E **79**, 1 (2009).
19. A.G.Petrov, Flexoelectricity: a universal sensoric mechanism in biomembranes and in chem.-biosensors, In: Functionalized Nanoscale Materials, Devices and Systems, A.Vaseashta and I.N.Mihailescu Eds., Springer 87-100 (2008), ISSN 1874-6500, ISBN 978-1-4020-8902-2, 978-1-4020-8903.
20. M. Kalitzova, O.I. Lebedev, G. Zollo, K. Gesheva, E. Vlakhov, Y. Marinov, T. Ivanova, Dynamics of nanoclustering in Te^+ implanted Si after application of high frequency electromagnetic field and thermal annealing, Appl. Phys. A, **91** 515-519 (2008), ISSN 0947-8396.
21. G. B. Hadjichristov, V. K. Gueorguiev, Tz. E. Ivanov, Y. G. Marinov**,** V. G. Ivanov, E. Faulques, Silicon ion implanted PMMA for soft electronics, Org. Electronics, **9**, (6), 1051-1060 (2008), ISSN 1566-1199.

ONGOING RESEARCH PROJECTS:

Projects, financed by the Bulgarian Academy of Sciences and additionally funded by contracts with the National Science Fund /NSF/:
1. Contract DNP1-03/04: “Lyotropic liquid crystalline nanostructures for the biology and medicine”.
Projects, additionally financed by contracts with Ministry of Education and Science:
1. Indo-Bulgarian intergovernmental programme, contract Bin-5/07, NSF, “Flexoelectric properties of liquid crystals”.

TEACHING ACTIVITIES:

Alexander G. Petrov - lecture courses on Bioelectronics for Chemistry Dept. of St.Kliment Ohridski University of Sofia.

DIVISION LASER, ATOMIC, MOLECULAR AND PLASMA PHYSICS

LABORATORY

ATOMIC SPECTROSCOPY

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RESEARCH ACTIVITIES:

1. ATOMIC STRUCTURE, SPECTRA AND CONSTANTS

Radiative lifetimes of 9 excited levels in Hf III ($5d6p\ ^3P°_{0,1}$, $^1D_2°$, $^3D°_{1,2,3}$, $^3F°_{2,3,4}$) and of 2 levels in Hf I ($5d^26s6p\ z\ ^3D°_{2,3}$) have been determined using the Time-Resolved Laser-Induced Fluorescence method. The investigated levels in Hf I were excited in a single-step process from the ground term ($5d^26s^2\ a\ ^3F$) whereas, in Hf III, we started from the low-lying $5d6s\ ^3D$ and ground $5d^2\ ^3F$ terms. For all of the investigated levels, the lifetimes have been measured for the first time. A multiconfigurational relativistic Hartree-Fock method, including core-polarization effects, has been used to compute branching fractions and radiative lifetimes of 15 Hf III levels, including those measured in this work. A first set of transition probabilities is also proposed for 55 transitions of Hf III.

2. LASER COOLING and TRAPPING

The dynamics of the excited state during the photoassociation of cold molecules from cold rubidium atoms is studied in a series of pump-probe experiments. Dipole transitions similar to those of the atoms are observed in the molecular signal. While such behaviour is characteristic of the long-range molecules, the photoassociation of bound molecules is confirmed in additional experiments.

The optimization procedure of MOPA system with external cavity diode laser and taped amplifier is investigated. This system will be used for an experiment of Bose-Einstein condensate of Rb atoms.

The experiment for cooling and trapping of Rb atoms is in progress.

3. HOLLOW CATHODE DISCHARGE AS AN ACTIVE LASER MEDIUM

The spontaneous UV emission of the lines 357 nm, 381 nm and violet line 406 nm of the nitrogen molecule is investigated in discharge tubes having different diameters at higher pressures. The spontaneous emission becomes bigger at higher currents and pressure. Stable and homogeneous discharge is obtained in He-Ar-N_2 mixture.

4. APLLICATION OF HOLLOW CATODE DISCHARGE

The data base of dynamic opto-galvanic signals of atomic transitions of Kr and Ne has been prepared for wavelength region 427-451nm, using hollow cathode lamps. The signals are compared with spontaneous emissions which allow to use the signals as a waveguides and for plasma diagnostic. The deconvolution procedure for dynamic opto-galbvanic signals has been employed, based on the two sinusoidal shape of function.

The connection between space structure and electrical properties of hollow cathode discharge has been investigated in the process of discharge formation. The peculiarities of V/A characteristics have been connected with translation of Townsend and normal discharge to the hollow cathode discharge.

PUBLICATIONS:

Articles

1. E. Radeva, K. Kolentsov, L. Yourukova, D. Zhechev, E. Dimova, Optical and photoluminescent properties of plasma polymer films used in electroluminescent display structures, J.f Physics and Chemistry of Solids,v. 70 (1), 169-172 (2009), ISSN 0022-3697
2. P. Palmeri, P. Quinet, É. Biémont, J. Gurell, P. Lundin, L.-O. Norlin, P. Royen, K. Blagoev and S. Mannervik, Lifetimes of metastable levels of singly ionized titanium: theory and experiment, J. Phys. B: At. Mol. Opt. Phys. 41 (2008) 125703 (9pp) ISSN:0953-4075
3. R. Djulgerova, V. Mihailov, J. Koperski, M. Ruszczak, T. Dohnalik and Z. Lju. Petrovic, "Dynamic optogalvanic Krypton and Neon spectra for 428-451nm range in hollow cathode discharge" Publ. Astron. Obs. Belgrade, №84, 297-300 (2008) ISSN 0373-3742
4. V. Mihailov, R. Djulgerova, J. Koperski, M. Ruszczak, T. Dohnalik and Z. Lju. Petrovic, "Argon dynamic optogalvanic spectrum in hollow cathode discharge" Publ. Astron. Obs. Belgrade, №84, 335-338 (2008) ISSN 0373-3742
5. N. Skoro, D. Marich, G. Malovic, Z. Lju. Petrovic, V. Mihailov and, R. Djulgerova, "Electical properties and spatiotemporal profiles of the low pressure hollow cathode discharge " Publ. Astron. Obs. Belgrade, №84, 331-334 (2008) ISSN 0373-3742
6. R. Djulgerova, V. Mihailov, M.D. Todorov, J. Koperski, M. Ruszczkak, T. Dohnalik, Z. Lju Petrovic, "Restoration of the pure dynamic optogalvanic signals in Ne hollow cathode discharge" IEEE – TRANSACTIONS ON PLASMA SCIENCE (2009)(in press)
7. Jovana Petrovic, David McCabe, Duncan England, Hugo Martay, Melissa Friedman, Alexander Dicks, Emiliya Dimova, Ian Walmsley, Pump-probe Study of the Photoassociation of Cold Rubidium Molecules, Faradey Discussions 142 – accepted
8. D. Zhechev, V. Steflekova, D. Slavov, G. Todorov, J. of Phys.B:At.&Mol.Optics: (Ref: B/294373/PAP/2534) Self-alignment and conductivity of a glow discharge ISSN:0953-4075
9. V. Mihailov, R. Djulgerova, J. Koperski, M. Strojecki, Z. Lju Petrovic, "Krypton dynamic optogalvanic signals in 427-451nm range for wavelength calibration" COMPTES RENDUS ACAD BULG SCI, Tome 61, 8, 979-984 (2008)
10. M. Todorov, R. Djulgerova, V. Mihailov, J. Koperski, "Procedure for Deconvolution of Time-Dependent Signals with Sinusoidal Shape" - APPLICATIONS OF MATHEMATICS IN ENGINEERING AND ECONOMICS: AIP Conf. Proc., Editor: Michail D. Todorov, Vol. 1067, 279-283 (2008)
11. N. Skoro, D. Maric, G. Malovic, Z. Lj. Petrovic, V. Mihailov and R.Djulgerova, "Volt-Ampere characteristics and spatial profiles of the low pressure hollow cathode disharge" – Proc. 19th ESCAMPIG, Granada, Spain, 3-20 (2008)
12. D. Zhechev and V. Steflekova, On a self-sustained oscillating mode for operation of a glow-discharge, Contributed papers, 24rd Summer School and International Symposium on the Physics of Ionized Gases, Novi Sad, Serbia, 25-29August, 2008, p.355-358
13. V. Steflekova, D. Slavov, D. Zhechev and G. Todorov, Self-sustained unstable modes for operation of glow discharge. An application, Contributed papers, 24rd Summer School and Int.l Symposium on the Physics of Ionized Gases, Novi Sad, 25-29 August, 2008, p.361-364
14. G. Malcheva; R. Mayo; M. Ortiz; J. Ruiz; L. Engström; H. Lundberg; H. Nilsson; P. Quinet; É. Biémont; K. Blagoev, Radiative data in the Zr I spectrum obtained by laser

induced fluorescence, 15th International School on Quantum Electronics: Laser Physics and Applications (Proceedings Volume), Proceedings of SPIE Volume: 7027 (2008).

Conference reports

1. G. Malcheva, K. Blagoev, R. Mayo, M. Ortiz, J. Ruiz, H. Nilsson, L. Engström, H. Lundberg, S. Svanberg, P. Quinet, and E. Biémont, "Radiative data in the Zr I spectrum", EGAS 40, Graz, Austria, (2008).
2. G. Malcheva, R. Mayo, M. Ortiz, J. Ruiz, L. Engström, H. Lundberg, H. Nilsson, P. Quinet, É. Biémont, K. Blagoev, Radiative data in the Zr I spectrum obtained by laser induced fluorescence, 15th International School on Quantum Electronics: Laser Physics and Applications (Proceedings Volume), Proceedings of SPIE Volume: **7027** (2008).
3. N. Skoro, D. Maric, G. Malovic, Z. Lj. Petrovic, V. Mihailov and R.Djulgerova "Volt-Ampere characteristics and spatial profiles of the low pressure hollow cathode disharge" – Proc. 19th ESCAMPIG, Granada, Spain, 3-20 (2008)

TEACHING ACTIVITIES:

PhD student: V. Steflekova, supervisor Prof. D. Zhechev
Organization of the 11th winter seminar of young scientists

NEW ACTIVITIES

1. Investigations of traces of elements in archeological artifacts using Laser Induces Breakdown Spectroscopy.

ONGOING RESEARCH PROJECTS:

1. Physics of atoms, molecules and plasma - project in the framework of Bulgarian Academy of Sciences
2. Radiative properties of ionic spectra (supported by the Bulgarian National Science Fond – contract 1516/2005)
3. Project "Radiative constants of Hf III excited states" (LLC 001431/2008) financed by EC, Laserlab-Europe project for Access to Research Infrastructures.
4. Project "Laser-induced breakdown spectroscopy (LIBS) analysis of finds from Trebeniste necropolis" (ULF-FORTH 001441/2008) financed by EC, Laserlab-Europe project for Access to Research Infrastructures.
5. Project "Laser diagnostic in archaeology" supported by the National Science Fond.

INTERNATIONAL COLLABORATION:

1. Radiative constants of Hf III excited states - LaserLab in Europe (LLC 001431/2008).
2. Laser-induced breakdown spectroscopy (LIBS) analysis of finds from Trebeniste necropolis" - LaserLab in Europe (ULF-FORTH 001441/2008).
3. International collaboration under the Problem "Laser spectroscopy of low-living isomers" with Laboratory of Nuclear Reactions, Dubna, Russia – Prof. DSc. D. Zhechev.
4." Possibilities of the glow discharge in hollow cathode as a plasma source for obtaining and investigation of new materials and in the metrology " Assoc. Prof DSc R. Dyulgerova
Institute of physics, University of Krakow.
5. Dinamic optogalvanic signals in a hollow cathode glow discharge as a technique for plasma, Institute of Physics of Belgrade, Assoc Prof. DSc R. Dyulgerova.

DIVISION LASER, ATOMIC, MOLECULAR AND PLASMA PHYSICS

LABORATORY
METAL VAPOUR LASERS

HEAD: **Acad. Nikola Sabotinov, D.Sc.**
tel./fax: (+359 2) 8756 009; e-mail: n.sabotinov@issp.bas.bg

TOTAL STAFF: **19**
RESEARCH SCIENTISTS: **14**

Nikolay Kirilov **Vuchkov**, D.Sc.; Peter Karolev **Telbizov**, Ph.D.; Dimo Nikolov **Astadjov**, Ph.D.; Margarita Georgieva **Grozeva**, Ph.D.; Todor Stefanov **Petrov**, Ph.D.; Krassimir Angelov **Temelkov**, Ph.D.; Krassimir Dimitrov **Dimitrov**; Vesselina Dimitrova **Gentcheva**, Ph.D; Nikolay Ivanov **Minkovski**, Ph.D.; Nikolay Vitanov **Vitanov**, Ph.D.; Peter Vassilev **Zahariev**, Ph.D.; Lubomir I. **Stoichev,** PhD; Ognian N. **Sabotinov**, PhD; Ph.D. student Nikolay Petrov **Denev;** PhD student: Radoy **Ekov**; Blagovela G. **Blagoeva**; Georgi D. **Toshev**; Ivan S. **Radkov**; Emilian P. **Atanasov**; Ivailo P. **Ivanov**

Scientific researches

In 2008 the following scientific activities were developed at **the Laboratory of Metal Vapor Lasers**:

1. Scientific researches for the creation of both copper ion lasers of new types generating in the deep ultraviolet region, and of infrared lasers oscillating on self-terminating transitions of Sr, (reported in 3 publication works).
2. Scientific investigations aimed at improving laser beam quality of high-power copper bromide vapor lasers generating in the visible spectral region: improving beam quality of a MOPA laser system and new types of diffraction laser resonators, (reported in 2 publication works).
3. Scientific studies of gas discharges in hollow cathode for the use in lasers and gas-discharge sources of non-coherent light, (reported in 2 publication works).
4. Scientific studies of the interaction of a laser beam with metals (Cu, Al, Ti) and of the processes on metal surfaces.
5. Scientific investigations of new materials for non-linear optics.
6. Scientific studies and theoretical scientific analysis in quantum physics (trapped ions, energy levels, quantum loops), (reported in 10 publication works).

Scientific research projects

Totally **11** projects including:
-- Projects supported only by the budget of BAS: **2**
-- Projects with additional support from the National Science Fund of the Bulgarian Ministry of Education and Science: **5**
-- Projects with additional support from ministries, institutions and companies in Bulgaria: **1**
-- Projects under agreements for cooperation between academies and institutes: **2**
-- Projects-contracts with external consigners incl. state and private companies, from both Bulgaria and abroad: **1**

Patents:

-- Patents: **6**
-- Patent applications: **2**

PhD students
-- PhD students: **2**

Scientific publications

1. K A Temelkov, N K Vuchkov, R P Ekov and N V Sabotinov, Determination of characteristic constants for some basic processes in plasma – diffusion, Penning ionization, asymmetric charge transfer, J. Phys. D: Appl. Phys, 41, 105203, (2008)
2. K A Temelkov, N K Vuchkov, R P Ekov and N V Sabotinov, Theoretical and experimental study of some basic processes in He-TlI and Ne-TlI plasma - asymmetric charge transfer, penning ionization and diffusion, Journal of Physics: Conference Series, 113, 012001, (2008)
3. D.Mihailova, M.Grozeva, G.J.Hagelaar, J. van Dijk, W.J.M.Brok and J.J.A.M van der Mullen, A flexible platform for simulations of a sputtering hollow cathode discharge for laser application, J. Phys. D: Appl. Phys. 41, 245202 (10 pp), (2008)
4. I.P. Iliev, S.G. Gocheva-Ilieva, D.N. Astadjov, N.P. Denev and N.V. Sabotinov, Statistical analysis of the CuBr laser efficiency improvement, Optics & Laser Technology 40, 641–646, (2008)
5. И.П.Илиев, С.Г.Гочева-Илиева, Д.Н.Астаджов, Н.П.Денев, Н.В.Саботинов, Статистический подход при планировании эксперимента для лазера на парах бромида меди, Квантовая электроника 38, 5, 436-440, (2008)
6. L. Pramatarova, E. Pecheva, P. Montgomery, D. Dimova-Malinovska, T. Petrov, A. L. Toth, M. Dimitrova, "Bioactivity of polycrystalline silicon layers", Journal of Nanoscience and Nanotechnology, 8 (2), 924-930, (2008)
7. E. Pecheva, T. Petrov, C. Lungu, P. Montgomery, L. Pramatarova, "Stimulated in vitro bone-like apatite formation by a novel laser processing technique", (invited article for the Special issue of CEJ: Porous Inorganic Materials for Biomedical Applications), Chemical Engineering Journal 137, 144-153, (2008)
8. I. E. Linington and N. V. Vitanov, Robust creation of arbitrary-sized Dicke states of trapped ions by global addressing, Phys. Rev. A 77, 010302(R)(4), (2008)
9. P. A. Ivanov and N. V. Vitanov, Synthesis of arbitrary unitary transformations of collective states of trapped ions by quantum Householder reflections, Phys. Rev. A 77, 012335(7), (2008)
10. S. S. Ivanov and N. V. Vitanov, Steering quantum transitions between three crossing energy levels, Phys. Rev. A 77, 023406(9), (2008)
11. A. A. Rangelov, N. V. Vitanov, and B. W. Shore, Population trapping in three-state quantum loops revealed by Householder reflections, Phys. Rev. A 77, 033404(7), (2008)
12. B. T. Torosov and N. V. Vitanov, Exactly soluble two-state quantum models with linear couplings, J. Phys. A: Math. Theor. 41, 155309(16), (2008)
13. I.E. Linington and N.V. Vitanov, Decoherence-free preparation of Dicke states of trapped ions by collective stimulated Raman adiabatic passage, Phys. Rev. A 77, 062327 (2008)
14. I. E. Linington, P. A. Ivanov, N. V. Vitanov, and M. Plenio, Robust control of quantized motional states of a chain of trapped ions by collective adiabatic passage, Phys. Rev. A 77, 063837, (2008)
15. P. A. Ivanov and N. V. Vitanov, and M. B. Plenio, Synthesis of cluster states of trapped ions by collective addressing, Phys. Rev. A 78, 012323(5), (2008)
16. S. S. Ivanov, P. A. Ivanov, and N. V. Vitanov, Simple implementation of quantum search with trapped ions, Phys. Rev. A 78, 030301(R), (2008)
17. V. Yannopapas and N. V. Vitanov, Ultra-subwavelength focusing of light by a monolayer of metallic nanoshells with an adsorbed defect, Physica Status Solidi – Rapid Research Letters 6, 287-9, (2008)

18. M. Ilieva, V. Tsakova, N. Vuchkov, K. Temelkov, N. Sabotinov, Surface modification of poly-3,4-ethylenedioxythiophene by deep UV laser irradiation, in Nanoscale Phenomena and Structure, ed. D Kashchiev, Prof. Marin Drinov Publ. House, Sofia, 89 - 92, (2008)
19. D. Mihailova, J. van Dijk, W.J.M. Brok, M. Grozeva and J.J.A.M. van der Mullen, *Sputtering hollow cathode discharges: modelling and comparison with experiments,* - Europhysics Conf. Abstracts: Invited Lectures and Contributed Papers, v. 32A (2008) topic 6 (2pp), F.J. Gordillo Vasquez Ed., CSIC, Madrid, ISBN: 2-914771-04-5, (2008)
20. K. A. Temelkov, N. K. Vuchkov, Mao B., E. P. Atanassov, L. Lyutov, N. V. Sabotinov, "High-power Sr atom laser excited in nanosecond pulsed longitudinal He-SrBr2 discharge", accepted for publication in IEEE Journal of Quantum Electronics.
21. I. E. Linington, P. A. Ivanov, and N. V. Vitanov, *Quantum search in a nonclassical database of trapped ions,* Phys. Rev. A, accepted (2008)

Scientific achievements

New type of $SrBr_2$ vapor laser tube

A new type of laser tube has been developed with increased volume of the active medium for the $SrBr_2$ vapor laser, excited in a nanosecond pulsed longitudinal discharge and oscillating on a few infrared Sr atomic and ion lines. Optimization has been performed for the four capacitors building the pulsed electrical excitation circuit as the He buffer gas pressure and average input power were optimized for every combination.

A record average output power of 4 Watts (this value exceeds more than twice the previous results) has been obtained at lasing on the 6.45 μm Sr atomic line.

The new laser tube construction for He-$SrBr_2$ lasers has been registered for patenting.

Losses were measured at varying the Sr dopant for 15 pieces of Ca1-xSrxF2 wafers for the 248.6-nm Cu line and 510.6-nm Cu atomic line generated by the Ne-CuBr laser, and for the 6.45-μm Sr atomic line generated by the He-$SrBr_2$ laser. Absorption losses were determined after calculating reflection losses. The radial distribution of gas temperature for He-$SrBr_2$ and Ne-CuBr lasers was calculated. For the temperature of the ceramic tubes a good coincidence was obtained between the calculated and experimentally determined values. For the He-$SrBr_2$ laser a detailed spectral investigation of the dependence of average output power for different laser lines on temperature of the ceramic tube was performed.

With a DUV Cu^+ Ne-CuBr laser at above-400-mW average output power of the 248.6-nm Cu^+ line irradiation was applied on conducting polymer films to be investigated in Trieste, Italy, under the program ELETTRA.

New multi-cathode laser construction for spattered-cathode ion lasers

Optimal length for hollow cathode segments has been determined as a result of experimental investigations and modelling of the plasma in different discharge configurations used to excite ion lasers with sputtered cathode. A dependence of optimal length on cathode diameter has been found. A new multi-cathode laser construction (patented) has been created as a result. The capability for independent control of cathode sputtering (metal vapor generation) and excitation of laser action was demonstrated experimentally in this construction.

Stable laser action has been obtained on the 533.7, 537.8 and 441.6 nm Cd^+ lines in a microsecond pulsed longitudinal He-Cd discharge, featured with a high amplitude of discharge current (>100 A). Optimal discharge conditions (diameter and temperature of the active zone, helium pressure and discharge current amplitude) have been determined for laser action on these lines.

APPLIED RESEARCH UNIT

MOLECULAR BEAM EPITAXY

HEAD: **Assoc.Prof. Gencho M. Minchev, Ph.D.**
Tel.: 9795683; E-mail: mbe@issp.bas.bg

TOTAL STAFF: **3**
RESEARCH SCIENTISTS: **2**

Assist. Prof. T. Mincheva, Ph.D.; L.M. Trendafilov, physicist.

RESEARCH ACTIVITIES:

BIOSENSOR SYSTEMS

The most natural and universal approach for identification of nano-sized biological objects (bacterial spores, viruses, macromolecules, molecular complexes etc.) is to immobilize them with respective antibodies on cantilever surface, followed by measuring of the cantilever mass change. Microcantilevers are among the most sensitive sensors for registration of mass changes.

Real world tasks of security, ecology, food-processing industry etc. require biosensor multi-channel measuring systems, sensitive to the nanodimensional structure of the, macromolecules and using conform reactions antigen-antibody.

During 2008 the work was directed to providing the needed basis for functionalization of the biosensors developed, and to the extending the understanding of their action and the ranges of their resources. The developed sensors achieved a unique sensitivity of 10 femtogram (10^{-14}g) differential sensitivity (between the channels), and 0.25 picogram ($2.5x10^{-13}$g) absolute sensitivity in the microcantilever mass change.

Investigation of microcantilever sensors with thermoactuators is accomplished, where these were considered/modeled as a system of aggregate thermal elements/values. The thermal system is described by a differential equations system for the thermoactuator and microcantilever temperatures. The solutions of these equations are periodic oscillations from several harmonics of the exciting periodic thermal flux frequency, and are determinate by the thermal resistances and thermal capacities. Their detailed analysis elucidates the functioning of this class of micro-electro-mechanical systems (MEMS) as thermal machinery, since the temperature oscillations generate mechanical oscillations (incl. resonances).

ONGOING RESEARCH PROJECTS:

Budget Project No 13: "Observation of the nano-sized structure of two-dimensional surface crystalline formations and the nano-sized structure of immobilized on the surface bio-makromolecules using purposely-modified Scanning probe microscopes" financed by the budget.

Innovation Project No 5IF-02-51/20.12.2008: "Nanoscope for enterprises and schools" financed by Ministry of Economy and Energy, NIF (250 000 BGN).

MUSEUM

HISTORY OF THE PHYSICS IN BULGARIA

CURATOR: **Assist. Prof. Ganka Kamisheva**
tel. 979 5831, e-mail: gkamish@issp.bas.bg, skype: physmuseum

TOTAL STAFF **1**
RESEARCH SCIENTIST **1**

The Museum aims to investigate History of Physics, collect and preserve sources, and welcome visitors in reading-room, and in Georgi Nadjakov permanent exhibition at the Institute of Solid State Physics, Bulgarian Academy of Sciences.

RESEARCH ACTIVITIES:

In commemoration of Milko Borissov book [1] and article [4] was published. Original manuscripts by Georgi Nadjakov, Milko Borissov, Christo J. Christov, Jordan Kasabov, and Paraskeva Simova show science results in Bulgaria at the second half of XX century. Milko Borissov worked with one hundred co-authors and made 403 publications in 30 different areas, because his experimental model has cycling direction between science reports, patented inventions, and manufactured technologies. Semi-transparent mono-crystal growth, started by him for the first time, has great importance in Bulgarian solid-state physics experiments. Brief history of European Physical Society puts a question for the beginning of Bulgarian membership, and shows present by Institute of Solid State Physics [2]. Peace of Report for 110 anniversary of Union of the Physicists in Bulgaria suppose two leaders Ivan Salabashev, Board president, and Emanuil Ivanov, Executive Committee president, in the beginning (1898) [3; 5]. Documentary film with historical elements shows Georgi Nadjakov's invention of Photoelectret state of matter and its applications [6].

PUBLICATIONS:

1. L. Spassov, G. Kamisheva, *Milko Borissov for himself and the Rest for him (1921 – 1998)*, M. Drinov Academic Publishing House, Sofia (2008) (in Bulgarian)
2. G. Kamisheva, *40 Years European Physical Society*, The World of Physics (2008) No 4, 451 – 452 (http://www.inrne.bas.bg/wop/wop_4_2008/EPS.pdf) (in Bulgarian)
3. G. Kamisheva, *Celebration of the 110 Anniversary of the Union of the Physicists in Bulgaria*, The World of Physics (2008) No 4, 448 – 449 (http://www.inrne.bas.bg/wop/wop_4_2008/phys_mat.pdf) (in Bulgarian)
4. G. Kamisheva, L. Spassov, *10 Years from the death of Milko Borissov*, The World of Physics (in print) (in Bulgarian)
5. G. Kamisheva, *Celebration* (http://www.youtube.com/watch?v=_xguv_pfnJo&feature=channel_page)
6. G. Kamisheva, *Photoelectret State of Matter* (http://www.youtube.com/watch?v=iqmOa3rOjTk&feature=channel)