CONTENTS

Dear Colleagues,

This annual report presents an account of the first year of the second mandate of the present Institute Administration. The landmarks of the year 2004 were three: the election for Corresponding Members of the Bulgarian Academy of Sciences, the 13th issue of our International School on Condensed Matter Physics in Varna and the joint Seminar and session of the Scientific Council in "Koprivkite". One of our coworkers: Lozan Spassov, was elected Corresponding Member of the Bulgarian Academy of Sciences. The 13th School provided, as usual, a vivid international forum to report and discuss our present achievements. The Seminar marked a change in the strategy of the Institute with a new target of financial stabilization of each one of the Laboratories that would bring to a financial stabilization of the Institute as a whole.

In this respect, it is our great pleasure to acknowledge the commitment of our administration and staff to various responsibilities, scientific and administrative as well. Despite difficult economic situation, it is this devotion of the staff that keeps the Institute going. Special thanks are due to the Heads of Labs that contributed significantly to the Institute budget. Support by Development Fund of the Bulgarian Academy of Sciences, National Council "Scientific Studies", NATO, European Union, is gratefully acknowledged. Scientists working on internationally funded projects enjoyed a far better perspective and recognition of their results.

By the end of the year Alexander G. Petrov was awarded the Freedericksz Medal of the Liquid Crystal Society "Sodruzhestvo" for his outstanding results in liquid crystal physics. Albena Paskaleva received an equipment for micro- and nanoelectronics from "Humboldt" foundation. The Marin Drinov Award for young scientists of the Bulgarian Academy of Sciences was given to Emilia Pecheva. K. Kolentsov and T. Kehlibarov received the George Nadjakov Sign of Honour 1st degree (gold-plated medal on a ribbon), while P. Pramatarov received the 2nd degree Sign of Honour. Teams lead by K. Stoychev, N. Vuchkov and M. Petrov received diplomas for the best scientific achievements of the year.

Alexander G. Petrov

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The Institute of Solid State Physics "Acad. G. Nadjakov" (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, 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 Iinternational School-Simposium on contemporary problems in condensed matter physics (ISCMP). Co-organizers of the last few schools are the Department of Electronic Materials Engineering, University of Wales (Swansea, U.K.) and other British scientific organizations.

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, X-ray diffraction with topographic, diffractometric and spectrometric facilities, ellipsometric measurements, spectroscopy in visible and IR regions, EPR spectroscopy;
- 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 Langmuir-Bloddget layer deposition on various substrates for molecular electronics; polarization measurements in mesophases and polymer liquid crystals for display techniques; equipment for videomicroscopy and micromanipulation of lipid membranes.
- Lasers of various systems - metal vapor, 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 George 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. Mrs. P. Lazarova

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

SCIENTIFIC COUNCIL

Head: Prof. N. Tonchev, D.Sc.

Deputy Head: Prof. V. Kovachev, D.Sc.

1. Acad. A. G. Petrov, D.Sc.
2. Acad. N. Sabotinov, D.Sc.
3. Prof. M. Petrov, D.Sc.
4. Prof. S. Rashev, D.Sc.
5. Prof. M. Gospodinov, D.Sc.
6. Prof. N. Vuchkov, D.Sc.
7. Prof. K. Blagoev, D.Sc.
8. Assoc. Prof. S. Andreev, Ph.D.
9. Assoc. Prof. S. Aleksandrova, Ph.D.
10. Assoc. Prof. D. Nesheva, Ph.D.
11. Assoc. Prof. V. Gueorguiev, Ph.D.
12. Assoc. Prof. M. Mitov, Ph.D.
13. Assoc.Prof. I. Bivas, Ph.D.

LABORATORY

THEORETICAL DEPARTMENT

HEAD: **Prof. Dimitar I. Pushkarov, D.Sc.**
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TOTAL STAFF: **9**
RESEARCH SCIENTISTS: **8**

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

RESEARCH ACTIVITIES:

The investigations were focused on the problems traditional for the Theoretical Department: linear and nonlinear elementary excitations in condensed matter, propagation of solitary pulses in low-dimensional structures with extended defects, quantum and classical models of complex magnetic systems, fundamental problems of phase transitions in finite systems, theory of neuron nets etc. The results obtained were published in 26 articles, and were reported to international conferences and invited talks in European universities and institutes. A DSc thesis was defended and another one was presented for consideration.

Phase transitions near the 3He-4He separation line were investigated and the role of the delocalized vacancies and quantum impurities was considered. This is the case where the quantum nature of vacancies in quantum solutions is best manifested. The nonequilibrium vacancions become centres of the Andreev-Pushkarov's nanoclusters. The effect these nanoclusters on the phase separation as well on the impurity diffusion were studied.

The interaction of bright solitons (solutions of the nonlinear Schröedinger equation) with extended defects, exceeding the width of the soliton, was investigated analytically and numerically. Inhomogeneities in the linear potential, the nonlinear and dispersion coefficients were investigated. For a given range of the parameters, the increase of the width of the inhomogeneity leads to periodically repeating regions of transmission, capture and reflection. The observed effects were explained by the excitation and a following resonant absorption of dispersive modes at the boundaries of the inhomogeneity. The interference of these modes with the soliton yields shape oscillations of the latter inside the defect region.

On the base of the earlier developed phenomenological theory of phase transitions in $Po_{0.6}Ca_{0.4}MnO_3$ the susceptibilities related with the different phases are calculated. A useful asymptotic expansion away from the Boltzman-Gibbs limit for the thermodynamic study of black-body radiation in the framework of Tsallis statistics is suggested. A new integral relation between the finite-size propagators for the case of classical and quantum finite-size systems with short-range and long-range interactions is established. As a result the finite-size effects in systems with developed classical and quantum fluctuations may be considered in an unified form. The Casimir effect in classical systems with long-range interaction is considered. The influence of the interaction range on various thermodynamic quantities is discussed.

Potentials for modelling interactions in Al and Au has been proposed and used in molecular dynamics simulation for the investigation of structural and mechanical properties. Good agreement with the experimental results has been obtained.

PUBLICATIONS:

1. D.I. Pushkarov, Vacancy-Impurity Nanoclusters in Solid Solutions of ^{3}He —^{4}He, Phys.Rev.B. **70** 72506 (2004)
2. D.I. Pushkarov, Quantum Diffusion, Central Eur. J.Phys. **2,** 420-455 (2004)
3. D.I. Pushkarov, Vacancy-Impurity Nanoclusters in Solid Solutions of 3He—4He, arXiv cond-mat/0405010
4. D.I.Pushkarov, Vacancy-Impurity Nanoclusters in Phase-Separated Solid Mixtures ^{3}He -^{4}He, Preprint ICTP Trieste IC/2004/116
5. K.Korutchev and E.Korutcheva, Spatial Asymmetric Retrieval States in Symmetric Hebb Network with Uniform Connectivity, Preprint ICTP, Trieste, (2004).
6. V. Ravi Chandra, D. Sen, N.B. Ivanov, and J. Richter, Antiferromagnetic sawtooth chain with spin-1/2 and spin-1 sites, - Phys. Rev. B, **69**, p.214406, (2004).
7. N.B. Ivanov and J. Richter, Phase diagram of a frustrated mixed-spin ladder with diagonal exchange bonds, Phys.Rev.B, **69**, p.214420, (2004).
8. H.D. Jennings, P.Ch. Ivanov, A.M. Martins, P.C. da Silva, G.M. Vishwanathan, Variance fluctuations in nonstationary time series: a comparative study of music genres, Physica A, **336**: 585, (2004).
9. K. Hu, P.Ch. Ivanov, Z. Chen, M.F. Hilton, H.E Stanley, S.A. Shea,Intrinsic Patters of Human Activity: Scaling and Nonlinear Dynamics in Forearm Motion,Physica A, 337:307, (2004).
10. P.Ch. Ivanov, A. Yuen, B. Podobnik, Y. Lee,Common Scaling Patterns in Intertrade Times of U. S. Stocks, Physical Review E, 69, p.056107 (7), (2004).
11. L. Angelini, M. De Tommaso, M. Guido, K. Hu, P. Ch. Ivanov, D. Marinazzo, G. Nardulli, L. Nitti, M. Pellicoro, C. Pierro, S. Stramaglia,, Steady-state visual evoked potentials and phase synchronization in migraine, Physical Review Letters, 93 (3), p.038103(4), (2004).
12. P. Carpena, P. Bernaola-Galvan, and P.Ch. Ivanov., New class of level statistics in atomic chains with correlated disorder, Physical Review Letters, 93 (17), p.176804(4), (2004).
13. C.-C. Lo, T. Chou, T. Penzel, T. Scammell, R.E. Strecker, H.E. Stanley, and P.Ch. Ivanov, Common scale-invariant patterns of sleep-wake transitions across mammalian species, Proc. Natl. Acad. Sci., 101(50), pp.17545—17548, (2004).
14. P.Ch. Ivanov, K. Hu, M.F. Hilton, Z. Chen, R.T. Ayers, H.E. Stanley, S.A. Shea, Endogenous circadian rhythm in an index of cardiac vulnerability independent of changes in behavior, (shared first authorship with K.Hu), Proc. Natl. Acad. Sci., 101(52), pp. 18223-18227, (2004).
15. H. Chamati, M.S. Stoytcheva and G.A. Evangelakis, Immersed nano-sized Al dispersoids in an Al matrix; effects on the structural and mechanical properties by Molecular Dynamics simulations, J. Phys. Condens. Matter 16 pp.5031-5042, (2004).
16. H. Chamati and N.I. Papanicolaou, Second-moment interatomic potential for gold and its application to molecular-dynamics simulations, J. Phys: Condens. Matter 16, pp. 8399-8407, (2004).

17. H. Chamati and D.M. Danchev, Critical Casimir forces for ***O***(n) systems with long-range interaction in the spherical limit, Phys. Rev. E **70,** p. 066106; (13), (2004).
18. H. Chamati, A.Ts. Djankova and N.S. Tonchev, The black-body radiation in Tsallis statistics, Preprint IC/2004/26, ICTP, Trieste, Italy; 12 pages; cond-mat/0311234.
19. H. Chamati and D.M. Danchev, Casimir force, excess free energy and ***C***-function in ***O***(n) systems with long-range interactions in the $n\to\infty$ limit, preprint IC/2004/32, ICTP, Trieste, Italy.
20. K.T. Stoychev, M.T. Primatarowa and R.S. Kamburova, Resonant scattering of nonlinear Schrödinger solitons from potential wells, Phys. Rev. E **70**, p. 066622 (5), (2004).
21. J.E.Prieto, E.Korutcheva and I.Markov, Formation and self-assembly of coherent quantum dots: some thermodynamic aspects, Chapter in "Progress in Quantum Dot Research", Nova Science, 2004.
22. P.Ch. Ivanov, Zhi Chen, Kun Hu, H. Eugene Stanley, Multiscale aspects of cardiac control, Physica A, 344(3-4), pp.685-704, (2004).
23. B. Podobnik, P. Ch. Ivanov, I. Grosse, K. Matia, H.E. Stanley, ARCH-GARCH approaches to modeling high-frequency financial data, Physica A, 344(1-2): 216-220, (2004).
24. N.B. Ivanov and D. Sen, Spin wave analysis of Heisenberg magnets in restricted geometries, Lect. Notes Phys. **645**, pp. 195-226 (2004) in: Quantum Magnetism, ed. by U. Schollwoeck et al. (Springer-Verlag, Berlin Heidelberg, 2004)
25. P.Ch. Ivanov, Random Walks in Physiologic Dynamics, in ``Advances in Condensed Matter and Statistical Physics", editors E. Korutcheva and R. Cuerno (Nova Science Publishers, New York, (2004) pp.155-175
26. P.Ch. Ivanov, A. Yuen, B. Podobnik, Y. Lee, Distributions and Long-Range Correlations in the Trading of US Stocks, in "The Application of Econophysics: Proceedings of the Second Nikkei Econophysics Symposium", editor H. Takayasu (Springer-Verlag, Tokyo, 2004) pp.51-57.

ONGOING RESEARCH PROJECTS:

Financed by Deutsche Forshungsgemeinschaft:

1. DFG Project: Grant No 436BUL 113/106

Financed by the National Foundation for Scientific Research at the Ministry of Science and Education:

1. F911: Quantum Effects on Transport Phenomena in Solids
2. F1414: Spectra and Nonlinear Dynamics of Low-Energy Elementary Excitations in Quasi-One-Dimensional Systems

INTERNATIONAL COLLABORATION:

1. Invited visits at the International Centre for Theoretical Physics – Trieste, Italy
2. Study visit at RWTH – Aachen, Germany
3. Guest Professor at University Cergy-Pontoise, Paris
4. Post Doc. Specialization at the University of Pavia, Italy

LABORATORY

COLLECTIVE PHENOMENA
in Condensed Matter

HEAD: **Prof. Dimo I. Uzunov, PhD, DSc**
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TOTAL STAFF: **3.5**
RESEARCH SCIENTISTS: **2**
Associate Professor D.V. Shopova, PhD; Post-graduate students: Velin G. Ivanov (January-June 2004; rest part of 2004 – due military service), Tsvetomir E. Tsvetkov, Svetlana S. Savova (in 2004 and currently, resident of USA).

RESEARCH ACTIVITIES

1. Establishment and description of stable homogeneous (Meissner) superconducting phases in ferromagnetic superconductors with a spin-triplet Cooper pairing [1, 4, 7-9]. The domains of stability of superconducting and ferromagmetic phases are determined and the phase diagram is outlined. The properties of the phase of coexistence of ferromagnetism and superconductivity are established. These theoretical results are consistent with the available experimental data.
2. Investigation of BEC of low-dimensional Bose fluids at natural constraints (constant volume and constant pressure) [3, 10].
3. A considerable progress in the description of many-body systems with strong inter-particle interactions has been achieved [2, 6]. The phenomenon of ``growing of the length scale of statistical correlations'' near phase transition points is described within a new theory [2, 6] of fluctuation correlations near phase transition points. Preliminary analytical calculations within this new self-consistency theory yield quite precise values of the critical temperature and the ground state energy.

PAPERS

1. D. V. Shopova, D. I. Uzunov, Phys. Lett. A 328 (2004) 232. ``Comment on: ``First-order phase transitions of type-I superconducting films [Phys. Lett. 322 (2004) 111].''
2. D. I. Uzunov, Communication E17-2004-175 (JINR-Dubna). [see, also, arXiv: cond-mat/0411020]. "A new treatment of fluctuation correlations near phase transition points.''
3. V. G. Ivanov, D. I. Uzunov, in: *Equation of State and Phase Transition Issues in Models of Ordinary Astrophysical Matter,* ed. by V. Celebonovic, W. Dappen, D. Gough (AIP Conf. Proceedings, New York, 2004) p. 295-301. Title: ``On phase transitions in Bose gases at constant density and constant pressure.''
4. D. V. Shopova, T. E. Tsvetkov, D. I. Uzunov, in: *Equation of State and Phase Transition Issues in Models of Ordinary Astrophysical Matter*, ed. by V. Celebonovic, W. Dappen, and D. Gough (AIP Conf. Proceedings, New York, 2004) p. 302-310. Title: ``Phase transitions to spin-triplet ferromagnetic superconductivity in neutron stars.''
5. D. I. Uzunov, World of Physics, vol. XXVII, No I (2004) pp. 3-20. ``The Nobel Award in Physics for 2003: For the theory of superconductivity and superfluidity.''

6. D. I. Uzunov, Preprint ICTP-Trieste; in press (2004-2005). ``On the derivation of effective field theories.''
7. D. V. Shopova, D. I. Uzunov, (Preprint-ICTP-Trieste; in press; 2004-2005). ``Meissner phases in spin-triplet ferromagnetic superconductors.''
8. D. V. Shopova, T. E. Tsvetkov, D. I. Uzunov, J. Phys. Studies. (2005; in press). [see. Also, arXiv: cond-mat/0411503]. ``Phenomenological study of spin-triplet ferromagnetic superconductors.''
9. D. V. Shopova, D. I. Uzunov, ``Phases and phase transitions in spin-triplet ferromagnetic superconductors''; Chapter of the book: *Progress in Ferromagnetism Research* (Nova Publ, New York, 2004); in press.
10. V. G. Ivanov, in: *Meetings in Physics at Sofia University*, ed. by A. Proykova (Heron Press, 2004-2005); in press. Title: ``Effects of constraints on the phase transition to Bose-Einstein condensation.''

CURRENT RESEARCH PROJECTS

1. Phases and phase transitions in superfluid, superconducting and magnetic materials (contract with BAS).
2. Theory of superconductivity (EC – 6^{th} FP, European Superconductivity Network).
3. Ferromagnetic superconductors (Contract 10/98-2004 – JINR-Dubna).

SEMINARS, LECTURES, CONFERENCE REPORTS

1. A lecture course of 40 hours on Physics of Phase Transitions for PhD students of BAS.
2. Seminar and Conference talks (reports): total number 8 (Cambridge University - 1, ICTP-Trieste - 1, Istambul University - 1, JINR-Dubna - 1, Leiden – Lorentz Center – 2, MPI-Dresden – 1, Salamanka - 1).
3. A lecture at a Meeting of middle school teachers in Physics: ``Modern trends in superfluidity and superconductivity.'' (July, 2004, Sofia University, Sofia Branch of Bulgarian Union of Physicists).

TRAINING OF POST-GRADUATES, DISSERTATIONS

In 2004 three post-graduate students advanced their research and scientific skills in CP Laboratory. A 40 - hour lecture course has been presented by the head of CP Laboratory for doctorate students from BAS and Sofia University. In 2004, a PhD thesis was defended by I. P. Takov (our former PhD student).

INTERNATIONAL COLLABORATION

1. Memberships (D. I. Uzunov) of the Editorial Boards of J. Phys. Studies (Lviv, Ukraine), The Institute of Physics (London, UK), and the Board of Advisors of the American Biographical Institute (USA).
2. Collaborative visits, including seminar talks (D. I. Uzunov): 60 days in MPI-PKS (Dresden), 4 days in Istanbul University, 12 days in JINR-Dubna, 4 days – EC (Brussels), 30 days in ICTP-Trieste.
3. Activity of post-graduate students: 4 participations in International Schools and Workshops: Lorentz Center of Leiden University (T. E. Tsvetkov, and V. G. Ivanov), Winter School, Cambridge University, UK (Velin G. Ivanov), Summer Scenet School, Salamanka, Spain (T. E. Tsvetkov).

4. Expert activity (D. I. Uzunov) for EC projects (6fp): evaluation of 35 project, and rapporteur of 18 projects (M. Curie Actions).

POPULARIZING PHYSICS

A quite popular description [5] of the fascinating discoveries in the theory of superfluidity and superconductivity which have led to the Nobel Award (2003) for V. L. Ginzburg, A. A. Abrikosov, and A. Leggett has been published with the aim to satisfy the considerable interest of the Bulgarian scientific community (schoolars and researchers from other fields of physical sciencies (physics, chemistry, biology), mathematics, engineering.

LABORATORY

ELECTRON-PHONON INTERACTIONS

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TOTAL STAFF: **8**
RESEARCH SCIENTISTS: 6

Prof. M. Georgiev, Ph.D., D.Sc.; Assoc.Prof. O. Ivanov, Ph.D.; L. Mihailov, Ph.D.; Z. Dimitrova, Ph.D.; Assist.Prof. G. Kamisheva; G. Georgiev, physicist; M. Ivanova, chemist

RESEARCH ACTIVITIES:

SYMMETRY LOWERING, VIBRONIC EFFECTS AND WAVES IN HIGH-TEMPERATURE SUPERCONDUCTORS AND OTHER CRYSTALS

A theory of ball lightning is presented after which ball lightning is due to release of energy as electromagnetic radiation of energy in the range of 1-2 eV from a cluster of condensed system of atmospheric gases. The system is first excited by thunderstorms, Frenkel excitons are formed, which relax to self-trapped, vibronic and paired exciton states by releasing the excess energy in the environment.
Bardeen-Christov's quantum-mechanical approach to the transition probabilities for elastic tunneling is applied to inelastic-tunneling associated with the absorption and emission of phonons. The analysis shows the interconnection between reaction-rate and multiphonon relaxation rates. The relaxation rate of 1-phonon processes increases linearly with the temperature T at low T. The deduced reaction rate compares favorably with calculations on specific systems.
A simple theory is proposed for the dispersive molecular binding of unusually high magnitude due to an enhanced polarizability. When one combines two ways known to the polarizability enhancement, concrete expressions for the colossal binding energy are obtained. It is shown that the Van der Waals binding is most likely to cause to in hard and less so in soft condensed matter.

Exlpicitly correlated wave functions (WF):relativistic and mass effects of isoelectronic series.
The non-relativistic energy magnitudes for the ground state of 1s helium isoelectronic series with atomic number Z from 2 to 54 are calculated. Calculations are performed using an explicity correlated trial WF of the generalized Hylleraas type. We have developed a variational procedure that allows solving the two-particle Schrödinger equation for an unlimited number of parameters in a series of trial WF. The contributions to the energy for the various parameters and the so-called mass-polarization correction to the non-relativistic energy are also studied. One should note that up to now such data have been computed only for Z from 2 to12.

MECHANICAL STRESS (MS) IN FILM-SUBSTRATE SYSTEMS

The results of XPS of fresh and treated $Ge_xSb_{40-x}S_{60}$ films, deposited by thermal evaporation, are interpreted on the point of view of building structural units of the film. An inherent for the film matrix Sb_2S_5 phase is formed during film deposition. Thus, due to its existence, a suitable to glass-forming systems way to define the coordination number (CN) is the initiation of a system of network formers (F) and network modifiers (M). In our case, the structural units related to Sb_2S_5 are M, and the film CN is now counted as the difference of F CN and M CN. Sb_2S_3 and Ge_2S_3 are F. The binding energies (BE) of Sb atoms in Sb_2S_3 phase of the films are different of those in the mere chemical compound Sb_2S_3, depend on *x* and on the type of treatments. This implies that the local geometry and the arrangement of the building units are statistically distributed and are changed after treatments. These results show that one of the main building units in the films is SbS_3 pyramid. Its local geometry depends on *x* and on film treatments. In addition, ethane-like chains of GeS_3 pyramids of the Ge_2S_3 phase exist together with SbS_3 pyramids in the film.The heat-treatment decreases BE of Sb_2S_3 for films at $x>5$, while the photo-treatment - only for films at $x=25$. The annealing raises the disorder. The illumination induces structural changes, related to SbS_3 pyramids, decreases disorder, and the BE change at x=25 is related to the structural changes into Ge_2S_3 phase, however. From the results of intrinsic stress and BE changes at photo- and heat-treatments, a conclusion is drawn that both treatments provoke changes in Ge_2S_3 phase, which turn it into GeS_4 bonded tetrahedra. Thus, this re-ordering of the film matrix changes SbS_3 BE.

Film structure, MS and some optical properties of CVD produced tungsten oxide (WO_3) thin films were studied depending on the deposition conditions. It was found the coexistence of WO_3 and $WO_{2.9}$ phases by XRD analysis. The type of MS is changed, the film transmission increases, and the film density decreases at higher oxygen flow-rate values during the deposition. The growth window for preparation of WO_3 films with very low density, facilitating the kinetics of the electrochromic effect, was also found.

SURFACE PHOTO-CHARGE EFFECTS (SPCE) AND ITS APPLICATION

The experimental results on SPCE show that by irradiating a solid with electromagnetic field, alternating potential difference is induced in the sample. The frequency of the measured potential is equal to the frequency of the irradiating field. It was found that the amplitude of the signal increases by increasing the bulk of the irradiated sample, and also that this signal could be used for control of the processes that happen inside the bulk of dielectrics. A laboratory sample of a device for express, contactless recognizing of false coins is done.

DYNAMIC TRACTION FORCE INTEGRATOR (DTFI)

Software development project of the system “Optimal distribution of traction force in rolling composition” goes further, using DTFI, which has already made. Requirements to the programs are to optimize the distribution on time and distance criteria, and response time to be less than 30 s.

HISTORY OF PHYSICS IN BULGARIA

The activity and contribution in creating the department of theoretical physics at Sofia University by Prof. Georgi I. Maneff is explored. It is cleared up that Prof. Georgi Maneff has given lectures on all the subjects in theoretical physics all 23 years long.

PUBLICATIONS

1. A. Andreev, S. Tsintsarska, I. Polyanski, M. Ivanovich, M. Georgiev, and A. Gochev. Polarons in axial transport in single-layer high-Tc superconductors. Central Eur. J. Phys. 2 (2) April 16 (2004)
2. L. Dabrowski, A. Andreev, and M. Georgiev. Carbon diffusion in α-iron: Evidence for quantum mechanical tunneling. Raport IEA, Otwock-Swierk (2004)
3. O. Ivanov. Charging of solids by irradiation with electromagnetic field. Optics Communications, 231, 212-217 (2004)
4. Z. Dimitrova, N.Vitanov. Chaotic pairwise competition. Theor.Popul.Biology, 66, 1-12 (2004)
5. R.K. Debnath, A.G. Fitzgerald, K. Christova, A. Manov. X-ray photoelectron spectroscopy of $Ge_xSb_{40-x}S_{60}$ films. Compt. rend. Acad. bulg. sci. 57, 11, 13-18 (2004)
6. O. Ivanov. Investigating solids, liquids and gases by Surface photo-charge effect. VII Moscow International Exhibition for Inventions and Industrial Properties, Moscow 30. 03-02. 04. 2004
7. O. Ivanov. Investigating solids, liquids and gases by Surface photo-charge effect, XIV International Exhibition for Inventions, INPEX, Pitsburg, 2004
8. O. Ivanov, Y.Maneva. Discovery of false coins by control of the chemical composition. 3rd Conference – Measures Against Means and Instruments of Payment and Identification Documents Counterfeiting, Sofia, 2004
9. O. Ivanov. Investigating solids, liquids and gases by Surface photo-charge effect (SPCE). East-West Euro Intellect , 12th International Exhibition, Sofia, **Silver medal,** 2004
10. R.K. Debnath, A.G. Fitzgerald, K. Christova, A. Manov. Characterization of heat- and photo- treated $Ge_xSb_{40-x}S_{60}$ films by X-ray photoelectron spectroscopy. J. of Optoel. & Adv. Materials.
11 Z. Dimitrova, D. Gogova . On the structure, stress and optical properties of CVD Tungsten oxide films. Mater.Res.Bulletin
12. G. Kamisheva. Lectures in Theoretical Physics by Professor Georges Maneff (1921-1944). Proceedings of the International Conference "Contemporary aspects of Astronomy, Theoretical and Gravitational Physics, dedicated to G. Manev, May 20-22, 2004, Sofia.
13. Г. Камишева, Сесия в памет на акад. М. Борисов, Светът на физиката, 1, 68-70 (2004).
14. Г. Камишева, Музей на физическите науки в България, Светът на физиката, 4, 371-372 (2004).

ONGOING RESEARCH PROJECTS:

1. Light-induced effects in low-temperature plasma and solid state surface - photoresonant and surface photo-charge effects.
2. Analysis of multi – component materials – problems and applications.
3. Possibilities of hollow cathode discharge as a plasma sputtering source for production and investigation of new materials.
4.Investigations of optogalvanic effect in gas mixture hollow cathode discharge plasma – peculiarities and interpretations.
5. Correlation properties of non-linear systems.
6. Extracting information from time series.
7. Optimal distribution of traction force in rolling composition.
8. XPS and structure of amorphous films of GeSbS family.
9. History of mathematical and theoretical physics in Sofia University until 1939.

LABORATORY

ELECTRON MICROSCOPY AND ELECTRON DIFFRACTION

HEAD: **Assoc.Prof. Maria Kalitzova, Ph.D.**
tel: 7144-340; e-mail: markaliz@issp.bas.bg

TOTAL STAFF: **4**
RESEARCH SCIENTISTS: 3

Prof. N. Pashov; A. Peeva, Ph.D.; M. Georgieva, technical ass.

RESEARCH ACTIVITIES:

1. Superstructured nanocrystals in high-dose implanted Si.

• Nano-sized precipitation in high-dose implanted Si has been investigated using high-resolution transmission electron microscopy of cross-sectional specimens (XHRTEM). Zn and Bi (50 keV) have been implanted in Si at doses of $5x10^{16}$ cm^{-2} and $1x10^{16}$ cm^{-2}, respectively. By cleaning out the noice and intensifying the extra spots in the power spectrum of the experimental images, the authors identify a complex structure consisting of lattice planes alternating along privileged directions, i.e., the Si (111) and Si(311) for Zn and Bi inclusions, respectively. An evidence is found of the formation of nano-inclusions composed of Si-Zn and Si-Bi superlattices.

2. Effect of post-implantation high-frequency electromagnetic field on implanted Si.

• The analysis of high-frequency electromagnetic field (HFEMF) effect on the microstructure and electrical properties of Te^+ implanted (001) Si is reported. XHRTEM demonstrates the formation of Te nanoclusters (NC) embeded in the Si layer amorphized by implantation (a-Si) at fluences $\geq 10^{16}$ cm^{-2}. Post-implantation treatment with 0.45 MHz HFEMF leads to enlargement of Te NCs, their diffusion and accumulation at the a-Si surface and formation of laterally connected extended tellurium network above the percolation threshold, appearing at an ion fluence of 10^{17} cm^{-2}. AC electrical conductivity measurements show nearly four orders of magnitude decrease of impedance resistivity in this case, which is in a good agreement with the corresponding structure. The results so obtained are discussed in terms of the two-phase isotropic spinodal structure.

• Bi nanoclusters embedded in amorphized Si have been formed by ion implantation. Post-implantation treatment with HFEMF reorganizes the cluster shape and distribution of Bi nanoclusters. The NCs occur as a broad band at a nucleation depth correspnding to the projected ion range, Rp, of the Bi^+ ions. Bi ions form metalic NCs with hexagonal phase in the a-Si at fluences $\geq 10^{16}$ cm^{-2}. HFEMF treatment provokes crystallization of the a-Si matrix in the surroundings of the Bi NCs. Such effect was not observed when the samples were furnace annealed only. A hypothesis has been put forward that the effect of HFEMF is connected with the additional local heating at the metalic NCs bounderies due to the induced local currents through the metalic NCs.

PUBLICATIONS:

1. G. Zollo, M. Kalitzova, D. Manno, G. Vitali Precipipitation of superstructured nano-crystals in high-dose implanted Si: an XHRTEM study. Journal Physics D: Applied Physics 37, 2730-2736 (2004).
2. M. Kalitzova, E. Vlakhov, Y. Marinov, K. Gesheva, V. Ignatova, O. Lebedev, C. Muntele, R. Gijbels Effect of high-frequency electromagnetic field of Te+-implanted (001) Si. Vacuum 76, 325-328 (2004).
3. M. Kalitzova, K. Gesheva, E. Vlakhov, Y. Marinov, D. Gogova, T. Ivanova, Ch. Angelov, N. Pashov, G. Zollo, G. Vitali, High frequency electromagnetic field processing of amorphous silicon layers containing nanoclusters produced by implantation of metal ions in Si(100) matrix, Nuclear Instruments and Methods in Physics Research B.229, 65-72 (2005).
4. M. Kalitzova, G. Zollo, A. Peeva, O. Lebedev, G. Vitali, HRTEM of ion beam assisted Bi nanocrystallization in Si: the post-implantation effect of high-frequency electromagnetic field, Proc. 13th European Microscopy Congress, Antwerp, Belgium, 2004, published by the Belgian Society for Microscopy.

ONGOING RESEARCH PROJECTS:

Financed by the National Foundation for Scientific Research at the Ministry of Science and Education
Ф-1310: Ion-activated crystal nucleation in amorphous media: effects of high-dose implantation with heavy ions.

COLLABORATION:

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

2. ISSP – Bulgaria / Institute of Ion Beam Physics and Materials Research Forschungszentrum Rossendorf – Germany, " Radiation defects and ion beam synthesis of nanoclusters in semiconductors and insulators for microelectronic purposes".

3. ISSP – Bulgaria / University of Reims – France, "Investigation of defects created by heavy ions implantation in diamond type monocrystals by electron microscopy and electron diffraction".

LABORATORY

X-RAY DIFFRACTION AND MAGNETIC RESONANCE

HEAD: **Assoc.Prof. Malina Baeva, Ph.D.**
tel: 7144-275; e-mail: malina@issp.bas.bg

TOTAL STAFF: **6**
RESEARCH SCIENTISTS: **3**

Assoc. Prof. L. Pramatarova, Ph.D.; Assist. Prof. A. Boianova; P. Botev, physicist; E. Pecheva, physicist; H. Paskovski

RESEARCH ACTIVITIES:

1. X-RAY STRUCTURAL INVESTIGATIONS OF SINGLE CRYSTALS AND POLYCRYSTALLINE MATERIALS

1.1. X-ray diffraction of the zeolite class of minerals. The zeolite mineral class has high absorbtion properties, thus the zeolites belong to the group of so-called molecular seeds. Rock natural samples from the zeolite deposit "Beli plast" were investigated by X-ray analysis, after that thermally treated at 200os C and studied by the same method. It was established that no changes appear in the diffraction pattern of natural and heat treated zeolites. It was proved that the Bulgarian zeolite conserves its crystal structure and no crystal changes appear at thermal treating.

1.2. X-ray topography of single crystals. X-ray orientation of single crystals along different crystallographic directions is carried out. The topographic patterns of CdTe and BGO single crystals are obtained.

1.3. Neutron diffraction of Fe-based alloys. By neutron elastic scattering (neutron diffraction) the evolution of the phase composition of fourth-component alloys Fe-20Cr-↑Mn-0.6N was investigated at increasing Mn content and the functional dependence phase composition – chemical composition was established for these alloys. The experiments were carried out on the IBR-2 reactor for fast neutrons (Joint Institute for Nuclear Reaserch-Dubna). Neutron diffraction spectra allowed us to make the identification of the phases and to determine their quantity. At the Mn doping rise the ferrite phase amount increases, and vice versa - the austenite phase amount decreases. The 1 wt. % Mn addition lowers the austenite amount by the coefficient 1.07. In the case of Mn substitute the neutron diffraction gives more reliable information (in comparison to the X-ray diffraction) about the available phases and the used by us Rietveld analysis of neutron spectra show the presence of only two crystal phases in the alloys. Besides, these experiments gave us an opportunity to prove the absence of the Mn-N nitrides even at high manganese concentrations.

PUBLICATIONS:

1. M. Baeva, A. Boianova, N. Izmirova, "X-ray structural analysis of the phase composition of zeolite in the East Rodopes", submitted to Compt.rend.Acad.bulg.Sci.

2. T.I. Milenov, P.M. Rafailov, M.M. Gospodinov, P.A. Botev, "X-ray diffraction topography observation of the core in $Bi_{12}SiO_{20}$ crystals doped with Mn", Materials Science and Engineering B 106 (2004) 148-154.

3. M. Baeva, A. Beskrovnyi, E. Jadrovski, Phase composition of the Fe-20Cr-↑Mn-0.6N alloys measured by neutron diffraction", Journal of Materials Science and Technology, in press.

2. DEVELOPMENT OF AN IN-VITRO SYSTEM FOR STUDYING THE PROCESS OF BIOMINERALIZATION

Scientific subject of the project:

The current project for development of controllable in-vitro system for growth of hydroxyapatite (HA) layers on solid state substrates with leader Assoc. Prof. Dr L. Pramatarova is related to national and international important topics, such as Improving Human Potential and Quality of life, Nanostructures and Nanotechnologies of the 6 FP of the EC. The progress in understanding the process of biomineralization, particularly the HA growth, as well as the interactions between an implanted in the living body material and different cells, is attained through in-vitro experiments.

Results of scientific activity for 2004

Aim of the project: On the base of the developed *in vitro* system for layer growth in simulated body fluid on modified solid substrates to elucidate the possibility of the system for obtaining of medical implant coatings.

Results:

- As a result of the scientific activity controllable *in vitro* system for growth of hydroxyapatite layers on solid state substrates is created.
- The modification of silicon, stainless steel and silica glass substrates is attained by ion implantation of Ca and P ions through a mask, by nanostructuring of CdSe in thin layers of SiOx, as well as by growth of porous silicon and poy-silicon, and extracellular matrix of proteins.
- Hydroxyapatite layers are grown by a novel method of simultaneous laser-liquid-solid interaction in cooperation with SME "Pulslight" Ltd, Sofia.
- With the collaboration of the lab of Prof. Altankov, Institute if Biophysics, BAS, the experiments of macroscopic cellular responses to material interaction were realized.
- The initial human fibroblast interaction with three different types of materials, including stainless steel, silicon and silica glass, which were further coated with extracellular matrix or with extracellular matrix and hydroxyapatite was investigated. The initial steps of cellular interaction *in vitro* may be approximated with the process of cell adhesion and spreading. The particular effects of fibronectin were evaluated.

- The results show that the developed in-vitro system could find application for obtaining hydroxyapatite coatings for medical implants because the structure and the chemistry of the grown hydroxyapatite resemble those of the biological apatite.

Publications: The results are presented on international scientific conferences and symposiums and published in the scientific journals.

1. E. Pecheva, L. Pramatarova, M. F. Maitz, M. T. Pham, A. Kondyuirin, Kinetics of hydroxyapatite deposition on solid substrates modified by sequential dual implantation of Ca and P ions. Part I. FTIR and Raman spectroscopy study, Applied Surface Science 235 (1-2) (2004) 176-181
2. E. Pecheva, L. Pramatarova, M. F. Maitz, M. T. Pham, A. Kondyuirin, Kinetics of hydroxyapatite deposition on solid substrates modified by sequential dual implantation of

Ca and P ions. Part II. Morphological, composition and structure study, Applied Surface Science 235 (1-2) (2004) 170-175

3. E. Pecheva, L. Pramatarova, M. F. Maitz, M. T. Pham, A. Kondyurin, Extracellular matrix used in an in-vitro model system for hydroxyapatite formation, Annals of Transplantation 9 (1A) (2004) 58-60
4. L. Pramatarova, E. Pecheva, M. F. Maitz, M. T. Pham, A. Kondyurin, Growth of hydroxyapatite layers on solid surfaces patterned by ion implantation, Annals of Transplantation 9 (1A) (2004) 40-42
5. L. Pramatarova, E. Pecheva, D. Dimova-Malinovska, R. Pramatarova, U. Bismayer, M. Kamenova, T. Petrov, N. Minkovski, Porous silicon as a substrate for hydroxyapatite growth, Vacuum 76 (2-3) (2004) 135-138
6. L. Pramatarova, E. Pecheva, M. F. Maitz, M. T. Pham, A. Kondyurin, Ion beam patterning of solid surfaces for hydroxyapatite deposition, Vacuum 76 (2-3) (2004) 335-338
7. L. Pramatarova, E. Pecheva, T. Petrov, A. Kondyurin, R. Pramatarova, N. Minkovski, Ion beam and laser processing for hydroxyapatite formation, Vacuum 76 (2-3) (2004) 339-342
8. E. Pecheva, L. Pramatarova, M. F. Maitz, M. T. Pham, A. Kondyurin, R. Pramatarova, Analysis of hydroxyapatite films grown on whole-surface ion implanted substrates for studying the process of biomineralization, Nanoscience and Nanotechnology, eds. E. Balabanova, I. Dragieva. Heron Press, Sofia, issue 4 (2004) 305-308
9. L. Pramatarova, E. Pecheva, T. Petrov, N. Minkovski, A. Kondyurin, R. Pramatarova, Ion beam modified surfaces as substrates for hydroxyapatite growth induced by laser-liquid-solid interaction, Proceedings of SPIE, v. 5449 (2004) 41-45
10. L. Pramatarova, E. Pecheva, T. Petrov, N. Minkovski, A. Kondyurin, R. Pramatarova, Enhancement of hydroxyapatite formation by laser-liquid-solid interaction, Proceedings of SPIE, v. 5449 (2004) 46-50

Papers accepted for publication in 2005 г.

1. L. Pramatarova, E. Pecheva, D. Nesheva, Z. Aneva, A. L. Toth, E. Horvath, F. Riesz, Hydroxyapatite growth on glass/CdSe/SiO_x nanostructures, Journal of Metastable and Nanocrystalline Materials, 2005
2. L. Pramatarova, E. Pecheva, R. Presker, M. Stutzmann, M. Maitz and M. Pham, Patterned surfaces for hydroxyapatite in vitro growth, Journal of Optoelectronics and Advanced Materials, 2005
3. L. Pramatarova, E. Pecheva, T. Petrov, R. Presker, M. Stutzmann, Hydroxyapatite kinetic deposition on solid substrates induced by laser-liquid-solid interaction, Proceedings of SPIE, 2005
4. L. Pramatarova, E. Pecheva, D. Dimova-Malinovska, R. Presker, M. Stutzmann, U. Schwarz, R. Kniep, A novel laser-liquid-solid interaction process for hydroxyapatite formation on porous silicon, Proceedings of SPIE, 2005
5. L. Pramatarova, E. Pecheva, R. Presker, M.T. Pham, M.F. Maitz, M. Stutzmann, Hydroxyapatite growth induced by native extra cellular matrix deposition on solid surfaces, European Cells and Materials Journal, 2005
6. L. Pramatarova, E. Pecheva, R. Presker, U. Schwarz, R. Kniep, Natural opal as a model system for studying the process of biomineralization, Journal of Metastable and Nanocrystalline Materials, 2005

Postres presented on the international conferences

1. E. Pecheva, L. Pramatarova, George Altankov, Investigation of the fibroblast behaviour on different material surfaces, 9th Ceramics, Cells and Tissues Meeting, 28 September- 1 October 2004, Faenza, Italy

2. L. Pramatarova, E. Pecheva, R. Presker, M. Stutzmann, M. Maitz, M. Pham, Patterned surfaces for hydroxyapatite in vitro growth, NATO Advanced Study Institute: Nanostructured and advanced materials for applications in sensor, optoelectronic and photovoltaic technology, 6-17 September 2004, Sozopol, Bulgaria
3. L. Pramatarova, E. Pecheva, D. Dimova-Malinovska, R. Presker, M. Stutzmann, U. Schwarz, R. Kniep, Mechanism of hydroxyapatite formation on porous silicon in simulated body fluid, NATO Advanced Study Institute: Nanostructured and advanced materials for applications in sensor, optoelectronic and photovoltaic technology, 6-17 September 2004, Sozopol, Bulgaria
4. E. Pecheva, Growth of inorganic calcium phosphate layers from aqueous solution on modified solid substrates for studying the process of biomineralization, Summer School on Physics of Advanced Materials, 28 June-9 July 2004, Thessaloniki, Greece
5. E. Pecheva, L. Pramatarova, G. Altankov, Fibroblast interaction with different material surfaces, European Cells and Materials Conference, 28-30 June 2004, Davos, Switzerland; extended abstract, published in European Cells and Materials Journal, v.7, July-December 2004
6. L. Pramatarova, E. Pecheva, R. Presker, M.T. Pham, M.F. Maitz, M. Stutzmann, Hydroxyapatite growth induced by native extra cellular matrix deposition on solid surfaces, European Cells and Materials Conference, 28-30 June 2004, Davos, Switzerland; extended abstract, published in European Cells and Materials Journal, v.7, July-December 2004

Obtained awards of PhD student, working on the project

1. PhD student Emilia Pecheva was awarded in the youngest scientist presentation in the annual young awards of Bulgarian Academy of Science, May 2004, Sofia
2. PhD student Emilia Pecheva was awarded 1st place in the Student Poster Presentation in the conference, European Cells&Materials V: Cell Biomaterial Reaction, June 28th –30th, 2004, Davos.

LABORATORY

LOW TEMPERATURE PHYSICS

HEAD: **Prof. Nikolay Tonchev, Ph.D., D.Sc.**
tel: 7144-276 or 677; e-mail: tonchev@issp.bas.bg

TOTAL STAFF: **20**
RESEARCH SCIENTISTS: **17**

Prof. V. Kovachev, Ph.D., D.Sc.; Assoc.Prof. V. Lovchinov, Ph.D.; Assoc.Prof. M. Bushev, Ph.D.; Assoc.Prof. E. Vlakhov, Ph.D.; Assoc.Prof. B. Terziyska, Ph.D.; Assoc.Prof. D. Dimitrov, Ph.D.; Assoc. Prof. K. Kalaydjiev, Ph.D.; Assoc.Prof. N. Balchev, PhD; Assoc.Prof. E. Nazarova, Ph.D.; Assist.Prof. K. Nenkov; Assist.Prof. N. Todorov; Assist.Prof. Chr. Popov; Assist.Prof. M. Kirov; Assist.Prof. M. Baychev; Assist.Prof. A. Stoianova-Ivanova; S. Terzieva, physicist; G. Mihova, chemist; P. Simeonova, chemist; K. Lovchinov, technologist

RESEARCH ACTIVITIES:

1. SUPERCONDUCTING AND NEW MATERIALS

The possibility of increasing of carriers and centers of pinning were studied for superconducting Y123 phase by means of suitable chemical substitutions with Ca and Pr. The optimum effect was recorded at 30 % substitution of Y with Ca.

The synthesized polycrystalline material $Y_{1-x}Cu_xBa_2Cu_3O_z$ with x=0 and x=0.3 was used for obtaining of superconducting tapes by OPIT method. It was measured that the T_c of the tape was unchanged in comparison to the initial material however the critical current density (at H=0 and T=77K) was enhanced by two order of magnitude.

The obtaining of the bulk samples of MgB_2 by different way of synthesis was studied. In order to produce MgB_2 in nanophase it was used two step technique for mechanical activation of high temperature synthesis. The current pulse was 30 A/cm ^{2}.

Magnetic and transport properties of samples with nominal composition $RuSr_2R_{1.4}Ce_{0.6}Cu_2O_{10-\delta}$ (R=Eu, Sm) obtained by solid state synthesis in oxygen were investigated. The sample with R=Sm was studied for the first time. It was observed the superconducting transition at T_{on} = 40 K for R=Eu and T=32 K for R= Sm.

Low temperature thermal properties (specific heat C, thermal conductivity K, thermal diffusivity D) of selected compositions of $Ge_xAs_{40-x}S_{60}$ system have been investigated in order to clarify the influence of microstructure (2D layered structure, 2D-3D transition, 3D network) on heat transfer processes as well as to establish the mechanisms controlling scattering processes in these glasses. A correlation between fragility and specific parameters of these chalcogenides is found and a dependence of its specific parameters on the average coordination number is proven. Analyses of the experimental results have been made within but also independently of the soft-potential model. Some scaling laws are proposed.

A design for precise low temperature thermal diffusivity measurements of thin solids in high magnetic fields using **DC** и **AC** pulse heating methods was developed for research in ILHMFLT, Wroclaw, Poland.

The effect of high-frequency electromagnetic field (HFEMF) on the electrical properties of metal ion beam implanted silicon was studied. Silicon wafers, (100) oriented,

were implanted with Zn^+, Te^+ or Bi^+ with energy of 50 keV and doses from $1x10^{15}$ to $1x10^{17}$ cm^{-2}. Post-implantation treatment with 0.45 MHz HFEMF leads to decreased sheet resistance values for samples with formed nanoclusters (NCs) only. AC electrical conductivity measurements were used at frequencies in the range of 1 Hz to 100 kHz. A correlation between the NCs evolution (as a function of implantation dose and post-implantation processing) and the samples impedance dependence on these frequencies was found. An explanation based on potential barriers and HFEMF effect on the NCs is given.

2. MAGNETIC AND TRANSPORT PROPERTIES OF MANGANITES

Investigations of monocrystals with perovskite structure are settled as separate part of laboratory activities. Efforts in the past year were devoted to Sm-Pb-Mn-O, Ho-Mn-O and Pr-Sr-Mn-O systems. It was established that strong variations of carrier density due to appearance of itinerant electrons. Changes in strength of their localization and type appear simultaneously with magnetic rearrangements connected with electron, orbital and lattice rearrangements. For first time Sm-Pb-Mn-O monocrystals with low percentage alkaline element was obtained and investigated. The results are an attempt to clarify the data existing in the literature for the Samarium system. Two different types of Ho-Mn-O monocrystals – hexagonal and orthorhombic were obtained and are under investigation.

Magnetotransport properties of thin films of $La_{1-x}Ca_xMnO_3$ (x=0.3; 0.51) deposited on $LaAlO_3$ and STO_3 substrates have been investigated. Compressively strained $La_{0.7}Ca_{0.3}MnO_3$ layers reveal semiconducting behaviour and charge ordered insulating (COI) state which melts to ferromagnetic metallic (FMM) above a certain magnetic field, accompanied by a significant hysteresis. The $La_{0.49}Ca_{0.51}MnO_3$ samples possess stable COI state. Variable Range Hopping (VRH) mechanism well fits the conductance in zero magnetic field. The change of the slope of VRH dependence and magnetotransport of strained thin films are consistent with the model of inhomogeneous material: coexistence and competition of FMM and COI phases.

3.THE PROBABILISTIC APPROACH OF DYNAMIC SYSTEMS AND INTERPRETATION OF RELATIVISTIC QUANTUM MECHANICS

The work concerning the development of interpretation of the relativistic quantum mechanics has continued. This theory is based on the assumption of existence of non-zero size $\sim \hbar / mc$ of elementary particles (electrons, etc).

4. ENVIROMENTAL AND ECOLOGY RESEARCH

Chemometric evaluation was conducted on data obtained from monitoring of river waters in Germany and aerosol samples from Austria.

PUBLICATIONS:

1. E.S. Vlakhov, K.A. Nenkov, T.G. Donchev, E.S. Mateev, R.A. Chakalov , Ferromagnetic and charge ordering competition in strained thin films of $La_{1-x}Ca_xMnO_3$ system, Vacuum 76, Nr. 2-3, 249-252 (2004).
2. E.K.Nazarova, A.J.Zaleski, A.L.Zahariev, A.K.Stoyanova-Ivanova, K.N.Zalamova, “Effects of substituting calcium for yttrium on the superconducting properties of $YBa_2Cu_3O_z$ bulk samples”, Physica C 403 , 283-289 (2004).

3. N. Balchev, K. Nenkov, B. Kunev, J. Pirov, M. Baychev, A. Souleva , Synthesis and Magnetic Properties of $L_{0.5}Sr_{0.5}Mn_{0.5}M_{0.5}O_3$ (L = Y, Pr; M = Cu, Ru), Journal of Superconductivity 17, Nr. 3, 363-367 (2004).
4. N. Balchev, B. Kunev, J. Pirov, A. Souleva, K. Nenkov, Synthesis, magnetic and transport properties of highly doped with Cu or Ru manganites, Journal of Superconductivity, 17, Nr.4, 519-523 (2004).
5. V. Simeonov, S. Tsakovski, T. Lavric, P.Simeonova, H. Puxbaum, Multivariate Statistical Assessment of Air Quality: A Case Study, Microchimica Acta, 148, 3-4 , 293-298(2004).
6. V. Simeonov, P.Simeonova, R. Tsitouridou, Chemometric Quality Assessment of Surface Waters: Two Case Studies, Chemistry and Engineering Ecology, 11, 6 , 449-469(2004).
7. M. Kalitzova, E.Vlakhov, Y.Marinov, K.Gesheva, V.Ignatova, O.Lebedev, C.Muntele and R.Gijbels, High-Frequency Electromagnetic Field Effect on Te^{+-}- implanted (001) Si, Vacuum ,Volume 76, Issues 2-3 , 325-328, (2004).
8. P. Gierlowski, A. Szewczyk, A. V. Abal'oshev, E. S. Vlakhov, T. I. Donchev , B. Blagoev, $La_{0.7}Sr_{0.3}MnO_3$ Thin-Film Grain-Boundary Junctions on Bi-Crystal Substrate, ACTA PHYSICA POLONICA A, Vol.106, No5 , 715 –719 (2004).
9. V.Gencheva, R.Djulgerova, V.Mihailov, A.Stoyanova-Ivanova and T. Dohnalik, "Multi-component material sputtering by hollow cathode discharge" , Czehoslovak Jornal of Physics, Vol 54, Suppl. C, 903-907, (2004).
10. J. Cwik, T. Palewski, G.S. Burkhanov, O.D. Chistyakov, K. Nenkov, Some physical properties of ScNi2, Physica Status Solidi (a) 201 Nr. 3, 445-449 (2004).
11. C.H. Booth, L. Shlyk, K. Nenkov, J.G. Huber, L.E. De Long , X-ray absorption fine structure and field-dependent specific heat measurements of non-Fermi liquid U3Ni3Sn4, Physical Review B 69 Nr. 10, 104430/1-9(2004) .
12. J. Cwik, T. Palewski, K. Nenkov, N.V. Tristan, J. Warchulska, G.S. Burkhanov, O.D. Chistyakov, Some physical properties of YxHo1-xNi2 solid solutions, Journal of Alloys and Compounds 373 Nr. 1-2, 78-85 (2004).
13. L. Shlyk, B. Schuepp, G. Krabbes, K. Nenkov, G. Fuchs, Microstructure and superconducting properties of melt-processed YBCO with periodic morphology, Physica C 406 Nr. 1-2, 107-114 (2004).
14. L. Shlyk, G. Krabbes, G. Fuchs, K. Nenkov, B. Schuepp , Flux pinning and magnetic relaxation in melt-processed YBa2Cu3O7- doped with Li, Journal of Applied Physics 96 Nr. 6, 3371-3378 (2004).
15. A.Wälte, G. Fuchs, K.-H. Müller, K.Nenkov, V. Narozhnyi, S.-L. Drechsler, S. Shulga, L. Shultz, "Evidence for strong elektron-phonon coupling in MgCNi3", Phys. Rev. B 70, 174503 (2004).
16. A. Handstein, O. Perner, W. Haessler, C. Fischer, G. Fuchs, O. Gutfleisch, K. Nenkov, C. Rodig, J. Eckert, B. Holzapfel, K.-H. Mueller, L. Schultz , Critical currents in nanostructured MgB2 hot-pressed pellets audiron-sheathed tapes, Conference on Processing and Fabrication of Advanced Materials (PFAM XIII), Singapore, 6.-8.12.04 (2004) .
17. N.V. Tristan, K. Nenkov, K. Skokov, T. Palewski , Specific heat and magnetic susceptibility of intermetallic compounds R3Ni, Physica B 344 Nr. 1-4, 462-469 (2004).

ONGOING RESEARCH PROJECTS:

1. Thermal Properties of HTSC Tapes for Practical Applications, Universite de Liege, Institute d'Electricite – SUPRATECS, Liege, Belgium.

2. Tailoring of manganite thin films structures, Joint Research Project between BAS (ISSP-Sofia, Bulgaria) and PAS (IP- Warsaw, Poland).
3. Low temperatures' investigations of electrical and thermal properties of HTSC and new materials, Joint Research Project between BAS (ISSP-Sofia, Bulgaria) and PAS (ILTSR-Wroclaw, Poland).
4. Mounting the experimental set-up for thermal diffusivity measurements of thin samples at low temperature and high magnetic fields, ILHMFLT, Wroclaw, Poland.
5. Obtaining and investigations of high temperature superconductors, Ss"Cyril and Methodius" University, Skopje, Makedonia.

INTERNATIONAL COLLABORATION:

1. Universite de Liege, Institute d'Electricite – SUPRATECS, Liege, Belgium.
2. Institute of Physics, Polish Academy of Sciences, Warshaw, Poland .
3. Institute of Low Temperatures and Structural Research (ILTSR), Polish Academy of Sciences, Wroclaw, Poland.
4. International Laboratory for High Magnetic Fields and Low Temperatures – Wroclaw, Poland.
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LABORATORY

CRYOGENIC TECHNOLOGY

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TOTAL STAFF: **8**
RESEARCH SCIENTISTS: **3**

Assoc.Prof. J.K. Georgiev, Ph.D.; Assist.Prof. A.L. Zahariev, Ph.D.

RESEARCH ACTIVITIES:

NEW SUPERCONDUCTIVE MATERIALS

The effect of hole doping, on the transport and magnetic properties of Ca substituted YBCO bulk samples, has been investigated. The existence of bulk pinning (established by measurements of third harmonics of ac magnetic susceptibilities) and increasing of critical current density is found for 30% Ca substitution.

Ag-sheathed $Y_{1-x}Ca_xBa_2Cu_3O_{7-y}$ superconducting tapes has been prepared by OPID method. The influence of temperature and deformation treatment on the T_C and J_C of the tapes has been investigated.

PUBLICATIONS:

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2. A.Stoyanova-Ivanova, S.Terzieva, A.Zahariev, V.Mihailov, H.Ignatov, Obtaining of YBCO tapes by OPIT method, Advanced studies on superconducting engineering, Budapest, 10-20 July, 2004, Hungary, Proceedings, 56-59.
3. A.Stoyanova-Ivanova, S.Terzieva, K. Zalamova, Ch. Angelov, A. Zahariev, H. Ignatov and V. Kovachev, The influence of Pr-Ca substitution on phase formation, microstructure and oxygen content in YBCO bulk samples, Journal of Optoelectronics and Advanced Materials, **7**, 431-434 (2005).
4. E.Nazarova, K.Nenkov, A.Angelow, A.Zahariev, Effect of silver addition on the superconducting properties of $LaBa_2Cu_3O_{(7-y)}$ oxides, Journal of Optoelectronics and Advanced Materials, **7**, 427-430 (2005).

ONGOING RESEARCH PROJECTS:

BAS budget financial support:

Investigation of weak links in the superconductive YBCO System in order to lower them
Head: Prof. D.Sc. V.T.Kovachev

LABORATORY

PHYSICAL PROBLEMS OF MICROELECTRONICS

HEAD: **Assoc.Prof. Stefan Andreev, Ph.D.**
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RESEARCH SCIENTISTS: **14**

Prof. E. Atanasova, D.Sc.; Assoc.Prof. L. Popova, Ph.D.; Assoc.Prof. V. Gueorguiev, Ph.D.; Assoc.Prof. G. Beshkov, Ph.D.; Assoc.Prof. S. Georgiev; Ph.D., Assoc.Prof. N. Nedev, Ph.D.; Assoc.Prof. J. Koprinarova, Ph.D.; Res.Assist. A. Paskaleva, Ph.D.; Res.Assist. D. Spasov; Res.Assist. J. Pazov; Res.Assist. E. Manolov; Res.Assist. Ts. Ivanov; Res.Assist. M. Georgieva; Res.Assist. D. Virovska; L. Petkanov, physicist; E. Gajdarzhieva, physicist; S. Tsvetanov, technologist; K. Kozareva, technologist; L. Stamenov, technologist; V. Grigorova, technologist; Ph.D. student P. Dimitrova; Ph.D. student P. Aleksandrova

RESEARCH ACTIVITIES:

1. HIGH-K DIELECTRICS FOR NANOELECTRONICS

The parameters of thin (12 nm) Ta2O5 layers (equivalent of is SiO2 oxide thickness below 2 nm) has been optimized by interpretation of an wide range of electrical and structural investigations. It is shown that the bulk conductivity is not a basic property of Ta2O5 but depends of layer's microstructure, which could be technologically changed. The interface Si- Ta2O5 strongly influences the electrical parameters of MOS structures. The system parameters could be improved by alternative metals used as well as nitridation of the silicon surface before deposition of the Ta2O5 layer. The results obtained are important for the long stability properties of high-K dielectrics, used in the up to date nanoelectronics.

It is shown that Nd:YAG laser oxidation could be successively used for local nanoscale oxidation of silicon surface.

Thin HfTi-silicate layers are obtained with the electric constant from 9 to 30 depending on HfTi ratio. With increasing the Ti contante transition of Poole-Frenkel conduction to a phonon- assisted tunneling is observed. This is connected with phase segregation and forming of TiO2, HfO2 and SiO2 clusters in the bulk of the layer.

Thermal stabilized layers of $Hf_xSi_yO_2$ are investigated. Two types of conductivity are observed- Fower-Nordheim at room temperature and Poole-Frenkel at higher temperatures.

2. SENSORS LAYERS AND CHARCTERISTICS

Self-alignment polycrystalline silicon thin film transistors (PS TFTs) with different phosphorus channel doping have been investigated by conduction method. It is found that the hydrogenation by ion implantation improves the performance of the TFTs and confirmed that the hydrogenation is a promising technology for improvement of the PS TFTs performance.

The influence of γ- irradiation on the transient characteristics low noise characteristics and the effects of hot carriers on TFT are investigated after the electrical

stress. It is found that electron mobility and leaking currents are increased. The irradiated devices have shown better stability against degradation from hot carriers.

The structural changes in as- sputtered thin a-Si layer, and after boron doping with rapid thermal annealing are investigated by transmission electron microscopy. Stable hexagonal amorphous/crystalline series of SiO_2 structures signed as $SiO_2(SnO_2$ - V), not revealed in high temperature SiO_2 layers are observed in all films investigated. Different types of crystalline and high ordered SiO_2 structures are obtained in the BSG film, used for doping. Boron penetration in the a-Si layer starts the crystallization at B/Si ratios lower 10^{-3}. RTA process leads to inhomogeneous disordered polycrystalline silicon layer, with large areas of poly- and monocrystalline silicon, coexisting with various crystalline SiO_2 structures. Faster crystallization and larger monocrystalline silicon regions are observed at higher temperatures and durations of the annealing process.

3. THIN FILMS AND RAPID THERMAL ANNEALING FOR MICROELCTRONIC APPLICATION

The technology conditions for rf-magnetron deposition of metal oxide layers as InO2/SnO2,WO3,Ta2O5,TiO2,Al2O3,ZrO2 are optimized. The layers of AlN on Si and sapphires are obtained by RTA suitable for microelectronics devices based on GaN. Conduction mechanisms of the layers deposited on polycrystaline silicon are investigated. In the range of low currents for the first time are observed effects of field increasing due to diamond like phase of β-SiC at RTA.

The electrical properties of MOS structure based on SiC with dielectrics SiO2 and Al2O3 are compared. Structures with Al2O3 on p-4H-SiC show better electrical properties then corresponding SiO2 structures.

4. MAGNETORESISTIVITY COMPONENTS FOR ELECTRONIC APPLICATIONS

A technology flow for production of AMR devices is developed based on annealing of the deposited AMR layer and successive magnetization during the process of cooling down to room temperature and outside the annealing oven. This allows the use of high magnetic fields (~800Oe) and results in well ordered and stable thin films. The effectiveness of this technology flow is proved by producing a long single-stripe magnetoresistors and AMR bridges with and without barber pole structure. The produced devices exhibit parameters that are equal to those of the best worldly known producers. Sital ceramic plates are found to be a very good competitor to the oxidized silicon wafers as substrates for AMR devices. Equal (and sometimes higher) parameters of the AMR devices implemented on sital are obtained. This leads to broadening of the possibilities for integration in order to create multifunctional smart systems integrating CMOS chips and other devices. A description of the basic mechanisms of the normal AMR effect and of the so-called “barber pole” effect is represented and some of the main problems that have to be solved when designing and producing AMR devices are underlined. A model is proposed for estimation of the effectiveness of real barber pole structures. Experimental results are reported and discussed on the design and production of single-stripe resistors barber pole bridges based on a technology with magnetization after annealing.

The structure of the AMR devices and the AMR technology are flexible and compatible with the conventional ICs technology (CMOS in particular).By careful estimation of the main risks and trade-offs single-stripe and barber pole AMR devices could be produced on conventional for the microelectronic industry equipment without any upgrading. Sital is a very good material as a substrate for AMR devices. It is readily

processed by laser technologies and suitable for flexible design and production of application specific subsystems integrating AMR devices and CMOS chips.

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15. G. Beshkov, K. Grigorov, H. Mociel, I.C. Oliveira, St. Georgiev, Plasma Enhanced Chemical Vapour Deposition of AlN Nanolayers, Electrochemical Society, Proc. of Int. Symposium CVD and EUROCVD 14, vol. 08 (2004) pp. 1094-1097.
16. N. Nedev, G. Beshkov, E. Fortunato, S.S. Georgiev, T. Ivanov, L. Raniero, Shibin Zhang and R. Martins, Influence of the Rapid Thermal Annealing on the Properties of

Thin a-Si Films, Advanced Materials Forum II, Materials Science Forum vol. 455-456, p. 108 (2004), Trans. Tech. Publ., Switzerland..
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22. S.Andreev and P.Dimitrova , Anisotropic-magnetoresistance integrated sensors, invited lecture, 13 ISCMP, Varna 2004
23. S.Andreev, J.Koprinarova and P.Dimitrova, Magnetic properties of thin film AMR sensor structures implemented by magnetization after annealing, 13 ISCMP 2004, poster presentation**,** Varna 2004
24. P. Aleksandrova, V. Guerguiev, Tz. Ivanov, L. Popova "Characteristics of hydrogenated by ion implantation p-channel polysilicon TFTs", Proc. of International School of Condensed Matter Physics, 2004, Varna, in press
25. R.Djulgerova,V.Mihailov,V.gencheva,L.Popova,B.Panchev,Z.Petrovic, Depth profile analysis of new materials in hollow cathode discharge, 22-nd Summer School and Int.Sympos.on Physics of Ionized Gases,Tara,Serbia and Montenegro,(2004) 280 8. P. Aleksandrova, "Ferromagnetic shape memory materials", Proc. of Summer School Physics of Advanced Materials, Thessaloniki, June 2004
26. P.Aleksandrova, Computer simulation of photosensitive sensors based on polysilicon p/I and p/i/n structures,IEEE Intern.Spring Seminar on electronics technology, 27-th ISSE, may 2004
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29. G. Beshkov, K. Grigorov, AlN films prepared by nitrogen ion bombardment of Si-Al structure, 13th ISCMP, Varna, Sept. 2004.

CURRENT RESEARCH PROJECTS:

Physics and technology of thin layers for the modern microelectronics
Conductivity mechanismes and organization of the leakage currents in microstructures Ta2O5-Si for 64 - 256 Mbit dynamic memories.
Sensor effects in thin metaloxide layers with practical application.
Development of technology for production of magnetoresistive components with practical application.

INTERNATIONAL COOPERATION:

Production and charactertization of Ta2O5 by laser assisted oxidation - TUBITAK, Turkey.
Solid state microsensors for g-radiation, based on Ta2O5-Si structures - NANU, Kiev, Ukraine.
Thin Ta2O5 layers deposited on Si for high density dynamic memories, Skopje, Macedonia.
Oxide and interface properties of thin and ultrathin layers of SiO2, SixNyOz and Ta2O5 deposited on Si for submicroelectronics and nanoelectronics, Nish, Serbia
CVD materials for micro - and nanoelectronics, Moskva, Russia

LABORATORY

PHOTOELECTRICAL AND OPTICAL PHENOMENA IN WIDE BAND GAP SEMICONDUCTORS

HEAD: **Assoc.Prof. Diana Nesheva, Ph.D.**
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TOTAL STAFF: **11**
RESEARCH SCIENTISTS: **8**

Assoc.Prof. E. Skordeva, Ph.D; Assoc.Prof. Z. Ivanova, Ph.D.; Assoc.Prof. D.Arsova, Ph.D.; Assoc.Prof. V. Pamukchieva, Ph.D.; Assoc.Prof. Z. Aneva, Ph.D.; Assist.Prof. L. Yurukova; Assist.Prof. Z.Levi; A. Rachkova, chemist; I. Bineva, chemist; E. Zaharincheva, technologist; G. Tschauschew, physicist.

RESEARCH ACTIVITIES:

1. DISORDERED MATERIALS - CHALCOGENIDE GLASSES AND THIN FILMS

Photoinduced structural changes in Ge-As-S films have been investigated. The compositions of the samples belong to three lines in the glass-forming region and their networks have different rigidities. The influence of the photostructural changes on the electronic properties of the constituent elements has been confirmed by X-ray photoelectron spectroscopy. Changes in the spectra of the valence band have been established. Strong surface oxidation has been observed after illumination.

Glasses from As_2S_3-As_2Se_3-Ge system have been synthesized and thin films have been evaporated. Thermo- and photoinduced changes in these films have been investigated using IR and X-ray diffraction techniques. Special attention has been paid to the influence of the rigidity and the nano-phase separation on the photostructural changes.

Raman scattering from low-coorinated As_xS_{1-x} glasses has been measured over a large temperature range. A well resolved Boson peak has been detected and its parameters have been analysed depending on the composition of the glasses and on the temperature. Information of the short- and medium-range order in the structure of $(GeS_2)_x(As_2S_3)_{1-x}$ and $(Ge_2S_3)_x(As_2S_3)_{1-x}$ glasses has also been obtained. The temperature dependence of the Boson peak parameters suggests that the rate of disorder in $(Ge_2S_3)_x(As_2S_3)_{1-x}$ glasses is higher than in the $(GeS_2)_x(As_2S_3)_{1-x}$ ones.

The kinetics of glass transition and crystallization of $Ge_xSb_{40-x}Se_{60}$ glasses have been studied by differential-thermal and X-ray diffraction analyses. It has been found that the compositions at x = 25 and 27 cannot be crystallized by the applied non-isothermal regime.

For the first time, the glass-forming regions and basic physicochemical parameters of multicomponent $GeSe_2$-As_2Se_3-X (X = SnTe, Ag_4SSe, CdSe, Bi_2O_3) glasses have been determined with a view to their applications in the ion-selective potentiometry.

The influence of temperature on the photoluminescence (PL) properties of Er-doped $(GeS_2)_{80}(Ga_2S_3)_{20}$ glasses at different excitation sources has been evaluated. The PL intensity increases considerably by temperature decreasing from to 300 to 4.2 K. The PL emission band excited at 982 nm has been found to be stronger and broader than that at 532 nm.

2. LOW-DIMENSIONAL SYSTEMS

Nanocrystals of CdSe having four different average sizes and embedded in a GeS_2 thin film matrix were produced by consecutive thermal evaporation of both materials in high vacuum. Raman scattering spectra were measured when exciting with four different lines of an Ar^+ laser (514.5, 488, 476.9 and 459.5 nm) and six temperatures in the range 20-293 K. Resonance Raman scattering has been observed in all samples but, depending on the nanocrystal size, it has been seen at different wavelengths of the exciting light and temperatures. These observations have been explained with resonant absorption in excitons in CdSe nanocrystals whose energy is greater than the optical band gap of nanocrystals. The results obtained indicate that quality of CdSe nanocrystals in GeS_2 is very high i.e. nanocrystals are characterized by a narrow size distribution and good crystallinity. It has also been shown that resonance Raman scattering can be successfully applied for precise determination of average nanocrystal size of high-quality nanocrystals. The effect of nanocrystal incorporation on the level of disorder in the GeS_2 amorphous matrix has also been investigated. It has been observed that presence of CdSe nanocrystals with average diameter >3 nm in the GeS_2 matrix results in appreciable disorder increase and impedes photoinduced structural changes in GeS_2.

3. AC ELECTROLUMINESCENCE. ELECTROLUMINESCENT STRUCTURES AND DISPLAYS

Hybrid electroluminescent structures (ELSs) with high brightness, containing organo-silicon protective layer, have been prepared and photoluminescence (PL) from the protective layer has been investigated. Two maxima have been observed, disposed in the field of EL emission of the used electroluminophor. The PL from the protective layer is considered as a possible reason for the brightness increase (6 to 10 times) in the new hybrid ELSs. The new ELSs have an encapsulating layer from the used organo-silicon polymer, deposited on these structure electrodes and preserve good mechanical, thermal, chemical properties and adhesion resistance.

The impedance characteristics of two types of ELSs with green emission having various protective inorganic layers (TiO_2 or As_2S_5) have been investigated. High interface charge has been measured in the ELSs with As_2S_5 layer which leads to a decrease of surface potential of each separate luminescent grain in the matrix and increases the number of carriers, responsible for the electroluminescent emission.

Electric, dielectric and photoluminescence properties of several kinds of conjugated polymers have been investigated and ELSs have been prepared. It has been obtained that, for the present these polymers cannot be used as emitting layer in ELS.

PUBLICATIONS:

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9. K. Velitchkova, K. Krezhov, S. Balabanov, DC surface transport properties of selenium-implanted polymethylmetacrylate, Vacuum, 76, 319-323 (2004).
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11. L. Yourukova, K. Kolentsov, E. Radeva, Effect of a second protective layer in AC EL display structures on their characteristics, Vacuum, 76**,** 199-202 (2004).
12. T. Takov,K. Kolentsov, Z. Uzunov, Characteristics of electroluminescent display cells on flexible substrate, Electrical Engineering and Electronic, 39, № 3-4, 20-25 (2004) (in Bulgarian).
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14. L. Kazakova, K. Tzendin, M. Tagirdjanov, V. Pamukchieva, E. Skordeva , D. Arsova, Photoinduced changes in chalcogenide vitreous Se-As and Ge-Sb-Te films, Extended Abstracts of the 4th Inter. Conf. "Amorphous and microcrystalline semiconductors", St. Petersburg, p. 254 (2004) (in Russian).
15. K. Kolentsov, L. Yorukova, E. Radeva, D. Zhechev, E. Dimova, Inorganic electroluminescent light sources with an organic protecting layer, Proc. 10-th Int. Symp. Sci. Technol. of Light Sources,"Light Sources' 2004",Toulouse, France, 18-22 May 2004, p. 365-366.
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19. K. Kolentsov, L. Yorukova, S. Balabanov, H. Yossifov, Electrii and dielectric properies of organic and inorganic properies, Proc." ELECTRONICS' 2004 ", Sofia, Bulgaria, May, 21-22 2004, p. 39-42 (in Bulgarian).

20. K. Kolentsov, Z. Uzunov, Characteristics of inorganic electroluminescent elements on hard and flisible substrate, Proc."ELECTRONICS' 2004 ", Sofia, Bulgaria, May 21-22 2004, p.43-49 (in Bulgarian)
21. K. Kolentsov, L. Yorukova, K.I. Ivanova, Impedance and brightness characteristics of AC electroluminescent display structures, Proc."ELECTRONICS' 2004 ", Sofia, Bulgaria, May, 21-22 2004, p.50-56 (in Bulgarian).
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ONGOING RESEARCH PROJECTS:

Financed by the Bulgarian Academy of Sciences:

1. Investigation of amorphous low-coordinated As-S materials
2. Semiconductor nanoparticles in SiO_x thin film matrix: formation, structure and properties
3. Fabrication of electroluminescence structures based on new materials and investigation of their electroluminescence characteristics
4. Luminescence of chalcogenide glasses doped with rare earth elements

Financed by the Bulgarian Ministry of Education and Sciences:

1. Photoinduced structural changes in Ge-As(Sb)-S glasses and films (F 1307)
2. Defect states in photoconductors of various dimensionality (F 1306)

TEACHING ACTIVITIES:

Technical University, Sofia: "Semiconductor electroluminescence displays", 10 hours lectures and 2 diploma works prepared by students from the Technical University.

COLLABORATION:

1. Nano and micro scale structural transformations in thin films from glassy semiconductors: physical problems and possible applications, Physico-Technical Institute of the Russian Academy of Sciences, St. Petersburg, Russia.
2. Thermodynamical and optical investigations on chalcogenide glasses, Joint Laboratory of Solid State Chemistry, Pardubice, Czech Republic.
3. Raman scattering and photoluminescence from semiconducting nanoparticles, Institute of Physics, Belgrade, Serbia.
4. Structure and photoinduced changes in Ge-As-S glasses and amorphous films, Laboratory of molecule aggregates and inorganic materials, (UMR 5072 CNRS), Montpellier, France & LCTPCM (UMR 5624 CNRS), University of Pau, Pau, France (NATO PST.CLG.980343 Grant).

LABORATORY

SEMICONDUCTOR HETEROSTRUCTURES

HEAD: **Assoc.Prof. Simeon Simeonov, Ph.D.**
tel.: 7144-228; e-mail: simeon@issp.bas.bg

TOTAL STAFF: **9**
RESEARSCH SCIENTISTS: **7**

Prof. S. Kaschieva, D.Sc.; Assoc.Prof. S. Alexandrova, Ph.D.; Assoc.Prof. P. Danesh, Ph.D.; Assoc.Prof. A. Szekeres, Ph.D.; Assoc.Prof. N. Peev, Ph.D.; E. Kafedjiiska, Research Scientist; E. Vlaikova, Research Scientist, A. Gushterov, Ph.D. student; T. Nikolova, Ph.D. student, Silvija Bakalova Ph.D. student

RESEARCH ACTIVITIES:

1.ELECTRICALLY ACTIVE DEFECTS IN MOS STRUCTURES WITH SiO_xN_y AND SiO_2 DIELECTRICS

Electrically active defects in SiO_xN_y dielectric films in MOS structures are studied. For film deposition two low-temperature methods have been applied, namely: (a) decomposition of SiH_2Cl_2 in a LPCVD reactor in N_2O+NH_3 mixture at a pressure of 50 Pa and at a temperature of 860 ^oC; and (b) decomposition of $Si(OC_2H_5)_4$ in a remote plasma-assisted CVD reactor in N_2 and O_2 ambient at a pressure of 1 Pa and at a temperature of 200 ^oC. The analysis of the capacitance-voltage (C-V) and parallel conductance (G-V) characteristics has shown that the defect densities in the SiO_xN_y films are in the order of 10^{11} cm^{-2} and they are comparable with those of conventional thermally grown SiO_2 dielectrics with thickness of few nanometres. It is concluded that the low densities of the fixed oxide charge and interface traps, of the order of 10^{11} cm^{-2}, are achieved by the replacement of strained Si-O and weak Si-H bonds by strong and rigid Si-N bonds.

Electrically active defects in the interface region of SiO_2/Si structures formed on hydrogenated Si are studied by analysis of the frequency dependence of their C-V characteristics. Correlation between the fixed oxide charge, oxide stress and the initial Si surface roughness is established. It is shown that the presence of hydrogen leads to lower interface traps density, lower oxide stress level and smaller surface roughness yielding an oxide structure with improved properties.

It has been shown that the tunnel conductance via deep levels in SiO_2 films affects the capacitance and parallel conductance of hydrogen implanted MOS structures in regime of accumulation.

The analysis of the infrared spectra of SiO_2 films deposited on Si by decomposition of $Si(OC_2H_5)_4$ in a remote plasma-assisted CVD reactor in O_2 ambient at 200 ^oC has shown that at the given technological conditions the oxide is stoichiometric but contains hydrogen and carbon atoms forming Si-H, SiOH and C-H bonds in the oxide network, which bonds act as a source of electrically active defects.

A simple C-V variable frequency method has been developed for an estimation of the intrinsic fixed oxide charge in MOS structures eliminating the contribution of charges trapped at interface states. The method reveals also the type of interface traps (donor or acceptor) and determine their capture cross sections. This method is applied for

characterization of MOS structures with SiO_2 thermally grown on hydrogenated Si and of MOS structures with LPCVD SiO_xN_y films. The results have shown that the positive fixed charge depends monotonically on the flow ratio of the reacting gases during deposition. It has been demonstrated that the intrinsic oxide charge can differ substantially from the estimated value from the flat-band voltage, which is the most frequently used parameter for the technological control.

By comprehensive analysis of the spectral ellipsometric data the optical constants (*N, k,* ε) of vacuum evaporated SiO_x films have been determined. The influence of annealing conditions on the film composition has been considered by modelling the film structure. It has been shown that the annealing leads to a reduction of the oxide thickness, an increase of the refractive index values and a change in the film composition because of the appearance of Si nanoparticles in the SiO_x matrix. The temperature of 1000 ^oC promotes the crystallization of these Si clusters.

2.HIGH-ENERGY ELECTRON AND γ IRRADIATION OF SiO_2-Si STRUCTURES

The experiments performed on n- and p-type MOS structures with <100> oriented Si wafers and equal oxide thickness show that high-energy electrons create new radiation defects at the Si-SiO_2 interface. The nature of radiation-induced interface traps and their concentration depend on the conduction type of Si wafers, the total concentration of electron irradiation induced defects at the Si-SiO_2 interface of MOS structures is higher inn n-type Si wafers. In the result of electron irradiation, the nature of generated defects depends on the dopant type in Si substrates.

It was shown that the density of γ-irradiation induced defects in ion implanted silicon MOS structures also depends on the type of Si wafers used. It was found that gamma irradiation increases the concentration of all sorts of defects, created by Si ion implantation. Most of the defects created by γ irradiation in n-type samples correspond to shallow levels in the silicon band gap such as V-O or divacancy. The generation of radiation-stimulated defects takes place more efficiently in implanted p-type silicon samples.

The influence of γ-irradiation on the interface traps density of ion-implanted MOS structures and the influence of high-energetic electron irradiation on the MOS structure with 22 nm thick thermally grown SiO_2 layers are studied. It has been established that same dose of γ-irradiation generates larger amount of defects in MOS structures formed on p-type Si substrates.

3. HYDROGENATED AMORPHOUS SILICON

The investigations of the role and behaviour of hydrogen in hydrogenated amorphous silicon prepared by plasma decomposition of hydrogen-diluted silane have been continued in 2004. Using the nuclear reaction analysis for quantitative evaluation of hydrogen concentration and the experiments on the post-deposition change in the hydrogen content (thermal annealing, plasma post-hydrogenation and ion implantation) it has been established that the hydrogen concentration of 15-16at% in the films is equal to its solubility limit in the specific amorphous network. The analysis of the mechanism of the light-induced degradation (Staebler-Wronski effect) has suggested that a higher stability of the studied kind of films is definitively related to the high hydrogen concentration. A model has been proposed, which defines the structural properties of the amorphous silicon leading to a weaker Staebler-Wronski effect.

PUBLICATIONS:

Papers published in journals and proceedings

1. *S. Simeonov A. Szekeres, E. György, I.N. Mihailescu, A. Perrone,* CN_x/Si thin heterostructures for miniaturized temperature sensors*, J. Appl. Phys***. *95(9), 5111-15, (2004)***
2. S.Kaschieva, S.N.Dmitriev, W.Skorupa, *Reduction of the annealing temperature of radiation-induced defects in ion implanted MOS structures*, Appl.Phys. A **78**, 607-610, (2004)
3. P. Danesh, B. Pantchev, K. Antonova, E. Liarokapis, B. Schmidt, D. Grambole and J. Baran : *Hydrogen bonding and structural order in hydrogenated amorphous silicon prepared with hydrogen diluted silane*, J. Phys. D: Applied Physics, **37**, 249-253, (2004)
4. B. Pantchev, P. Danesh, E. Liarokapis, B. Schmidt, J. Schmidt and D. Grambole: *Effect of post-hydrogenation on the structural properties of amorphous silicon network*, Jpn.J.Appl.Phys.43, 454-457, (2004).
5. S. Simeonov, I.Yourukov, E. Kafedjiiska, A. Szekeres, *Inter-trap tunneling in thin SiO_2 films*, Phys. status solidi (a), **201(13**), 2966-2979 (2004)
6. F. Hamelmann, A. Brechling, A. Aschentrup, U. Heinzmann, P. Jutzi J. Sandrock, U. Siemeling, T. Ivanova, A. Szekeres, K. Gesheva, *"Thin molybdenum oxide films produced by molybdenum pentacarbonyl 1-methylbutylisonitrile with plasma assisted chemical vapor deposition"*,Thin Solid Films, **44(6),** 167-171, (2004).
7. P. Danesh, B. Pantchev, B. Schmidt, and D. Grambole: *Hydrogen solubility limit in hydrogenated amorphous silicon,* Semicond. Sci. Technol**. 19**, 1422-1425, (2004).
8. A.Gushterov, S. Simeonov, *Trap-assisted tunneling in ion-implanted nSi/SiO_2 struktures,* Vacuum **76(2-3),** 315-318, (2004)
9. F. Hamelmann, A. Aschentrup, A. Brechling, U. Heinzmann, A. Gushterov, A. Szekeres, S. Simeonov, "*Plasma assisted deposition of thin silicon oxide films in a remote ECVD reactor and characterization of films produced under different conditions"*, Vacuum **75** (4), 307-312, (2004).
10. S. Alexandrova, A. Szekeres, E. Halova, I. Lisovskyy, V. Litovchenko, D. Mazunov*,"Oxide And Interface Charges In thin SiO_2 Films Thermally Grown On RF Plasma Hydrogenated Silicon",* Vacuum , **75 (4),** 301-305, (2004).
11. S. Simeonov, A. Gushterov, A. Szekeres and E. Kafedjiiska, *"Defects Induced By Hydrogen Implantation In n-Si/SiO_2 Structures",* Vacuum , **76(2-3),** 303-306, (2004).
12. F. Hamelmann, A. Aschentrup, A. Brechling, U. Heinzmann, M.Abrashev, A. Szekeres, K. Gesheva, *"Plasma assisted deposition of thin carbon films from methane and the influence of the plasma parameters and additional gases",* Vacuum **76**, 139-142, (2004).
13. S.Kaschieva, Zh. Todorova and S.N.Dmitriev, *Radiation defects induced in n- and p-type MOS structures by 20 MeV electrons***,** Vacuum **76**, 307-400 , (2004)
14. S.Kaschieva, Zh. Todorova, *Radiation defects in n- and p-Si caused by ion implantation and gamma irradiation of MOS structures*, Vacuum **76**, 311-314, (2004)
15. V. Pamukchieva, A. Szekeres, K. Todorova, *"Photo-Induced Changes Of The Optical Constants Of Chalcodenide $Ge_{19}Sb_1Te_{80}$ Films*", 7th Conf. on Optics Proc. SPIE-ROMOPTO 2003, 5518**,** 608, (2004).
16. E. Halova, S. Alexandrova and A. Szekeres, *"Silicon Oxynitride as Advanced Material for the Semiconductor Electronics: Electrical Characteristics*" Annuaire de L'Universite de Sofia, Faculte de Chimie, **96**, 69, (2004)
17. S. Alexandrova , P.Danesh and I. A. Maslyanitsyn "*Amorphous Si:H – Nonlinear Optical Properties***"** Annuaire de L'Universite de Sofia, Faculte de Chimie**, 96**, 63, (2004)

18. Simeonov, A. Gushterov, A. Szekeres, E. Kafedjiiska, *" Inter-trap tunnelling in SiO_2 films of hydrogen implanted n-Si/SiO_2 structures"*, Proceedings of CAS 2004 Conference, Sinaja, Romania, pp.337-340**.**
19. P.Lisovskyy, V.G.Litovchenko, D.O.Mazunov, S.Kaschieva, J.Koprinarova, S.N.Dmitriev, *Infrared spectroscopy study of Si-SiO_2 structures irradiated with high-energy electrons,* ISCMP, Varna, Bulgaria, 2004, Journal of Optoelectronics and Advanced Materials, 7, 325, (2005)
20. K. Gesheva, A. Cziraki**,** T. Ivanova, A. Szekeres, "*Thermally Induced Structural Transformations in CVD Transition Metal Oxide Thin Film",* I SCMP, Varna, Bulgaria, 2004, Journal of Optoelectronics and Advanced Materials, 7, 557, (2005)
21. A.Szekeres, S. Simeonov, A. Gushterov, T. Nikolova, F. Hamelmann, *"Electrical Properties of Plasma-CVD Deposited Thin Silicon Oxynitride Films",* I SCMP, Varna, Bulgaria, 2004, Journal of Optoelectronics and Advanced Materials, 7, 553, (2005)
22. S. Simeonov, E. Kafedjiiska, A. Szekeres, C. Parlog, M. Gartner, *"Electrical Characterization Of MIS Structures With Sol-Gel TiO_2 (La) Dielectric Films",* I SCMP, Varna, Bulgaria, 2004, Journal of Optoelectronics and Advanced Materials, 7, 545, (2005)
23. F. Hamelmann, A. Szekeres, T. Nikolova, N. Kirov, *"Deposition of Silicon Oxide Thin Films in TEOS With Addition of Oxygen to the Plasma Ambient: IR Spectra Analysis",* I SCMP, Varna, Bulgaria, 2004, Journal of Optoelectronics and Advanced Materials, 7, 389, (2005)
24. S. Simeonov, A. Gushterov, " *Inter-trap tunnelling in hydrogen implanted n-Si/SiO_2 structures"*, I SCMP, Varna, Bulgaria, 2004, Journal of Optoelectronics and Advanced Materials, 7, 541, (2005)
25. F.Hamelmann, K.Gesheva, T.Ivanova, A.Szekeres, M.Abrashev, U. Heinzmann, "*Optical and Electrochromic Characterization of Multilayered Mixed Metal Oxide Thin Films*", I SCMP, Varna, Bulgaria, 2004, Journal of Optoelectronics and Advanced Materials, 7, 393, (2005)
26. Lisovskyy, V. Litovchenko, D. Mazunov, A. Szekeres, "*IR Spectroscopy analysis of structure and composition of Si-O phase in ultrathin (10-15 nm) SiO_2 films*", Ukrainan Physical Journal, 2004, ***in press***
27. E. Halova, S. Alexandrova, A. Szekeres, M. Modreanu, "*LPCVD-Silicon Oxynitrides Films: Interface Properties"*,Microelectronics Reliability, ***in press***
28. A.Szekeres, S. Alexandrova, P. Lytvyn, M. Kompitsas, "*Oxidation of Hydrogenated Crystalline Silicon as an Alternative Approach for Improvement of Ultrathin SiO_2 Properties",* J.of Phys, ***in press***
29. Andreev, B. Pantchev, P. Danesh, B. Zafirova, E. Karakoleva, E. Vlaikova, E. Alipieva*: A refractometric sensor using index-sensitive mode resonance between single-mode fiber and thin film amorphous silicon waveguide,* Sensors and Actuators B (***in press***, available online).

Papers in full size in proceedings of conferences, in press

1. B. Pantchev, A. Andreev, P. Danesh, B. Zafirova, E. Karakoleva, E. Vlaikova, E. Alipieva: *High sensitive in-line fiber-optc structure for refractometric measurements*, SPIE 13th International School on Quantum Electronics: Laser Physics and Applications, 20-24 Sept. 2004, Burgas, Bulgaria.

ONGOING RESEARCH PROJECTS:

Financed by the Bulgarian Academy of Sciences

1. "Structure and defects in micro and nano-sized heterostructures"

COLLABORATION:

1. "Investigation of oxygen concentration changes in implanted SiO_2/ Si structures after high energy electron irradiation", *with JINR, Dubna, Russia*
2. "Micro and nanotechnologies going to Eastern Europe through Networking", Specific Supportive Action, with Coordinator National National institute for research and development in microtechnologies, *Bucharest, Romania*
3. "Optical, magnetic and electrical properties of nano-structured layers obtained by pulsed laser deposition", with Institute of Atomic Physics, RA, *Bucharest, Romania*
4. "Optical and electrical properties of semitransparent metal layers on semiconductors" *with Institute of Semiconductor Physics, NASU, Kyiv, Ukraine.*
5. "Investigation of structure, structure stress and properties of thin dielectric – silicon structures for micro- and nano electronics", *with Institute of Semiconductor Physics, NASU, Kyiv, Ukraine*
6. "Preparation and investigation of thin oxide layers and semiconductors for microelectronics and optoelectronics", *with Institute of Physical Chemistry, RA, Bucharest, Romania*.
7. Structural, optical and electrical properties of nanostructures, *with "Eotvos L." University, Hungary*
8. "Second Harmonics Generation in thin semiconductor and optoelectronics heterostructures", *with RAS, Moskva, Russia*
9. "Investigation of semiconductor structures", with Institute of Metal Physics, RAS, Ekaterinbourg, Russia
10. "Investigation of defects in semiconductor structures with double irradiation", *with Institute of Semiconductor Physics, NASU, Kyiv, Ukraine*

LABORATORY

ACOUSTOELECTRONICS

HEAD:**Corresponding member of BAS Lozan Spassov, Ph.D, D.Sc.**
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TOTAL STAFF: **18**
RESEARCH SCIENTISTS: **9**

Assoc. Prof. A.Manov, Ph.D.; Assoc. Prof. I.Avramov, Ph.D.; Assoc. Prof. V.Georgieva, Ph.D; E.Radeva, Ph.D; R.Velcheva, Ph.D; Ts.Yordanov; M.Atanassov; V. Gadjanova; Z.Raicheva, chemist; L.Vergov, engineer; Y.Boradjiev, physicist; S.Sokolova-Shumkova, engineer; S. Harbova, physicist; V.Nikolova, Techn. Ass.; S. Staikov, technician; G, Grigorov, technician; J.Lazarov, Ph.D student

RESEARCH ACTIVITIES:

1. THERMOSENSITIVE QUARTZ RESONATORS

Several new lots of thermosensitive quartz resonators (TSQRs) – ppc and strip-type were manufactured. The problems at the mechanical treatment of thin rectangular quartz plates (100μm) were solved. Correlation dependence between quartz plates etching temperature and the resonators motional parameters were determined. The morphology of the deposited electrodes as a function of vacuum evaporation conditions was investigated as well as the reasons for the appearance of the surface defects. The dependence of the frequency versus the temperature of the strip-type resonator in the range 4,2K÷420K was investigated. The experimental work on the strip-type resonator is still in progress. A technology for its production is under development for which the experts from the laboratory drew up documentation. The newly designed strip-type temperature resonator is the smallest device from the thermosensitive quartz resonators family with the widest temperature range of 4,2K÷420K.

2.RAPID THERMAL ANNEALING OF THE RESONATOR'S STRUCTURES

The influence of the process of the rapid thermal annealing (RTA) on the parameters of resonators structures with different electrodes (Au, Al and Ag) obtained by the thermal evaporation was investigated. The type of the metal and its thickness determined the surface morphology of the thin metal layers. The RTA process led to morphological changes of the electrodes. The material of the electrode and the consequent RTA affect on the equivalent dynamic parameters of the resonators structures in different degree at the same mass loading. The resonators with silver electrodes gave the best parameters. The obtained results can be used for accurate selection of the system metal-quartz at the aim of creating new resonators for ecological control. Referring to this, the project "Investigation of resonator systems quartz-metal after rapid thermal annealing" (F-902) in association with the National Fund for Scientific Investigations was successfully completed in 2004.

3. SORPTION OF QUARTZ RESONATORS WITH THIN SnO_2 FOR NH_3 DETECTION

The effect of the surface relief of the quartz plates during forming the quartz resonators covered with thin SnO_2 in the process of ammonium vapor sorption was investigated. In order to determine different roughness obtained as a result of deferent abrasive treatments, Scanning Electron Microscopy (SEM) was used.

Increasing the roughness of the resonators' quartz surface leads to enhancing the resonators sensitivity at NH_3 vapor at the same concentration by increasing the effective surface of gas molecules sorption. This dependence is even better expressed at higher NH_3 concentrations (1000ppm - 5000ppm), which confirms our suggestion concerning the defining role of the surface sorption as a function of the unfolded surface. The experimental results obtained will be used for increasing the sensor elements sensitivity based on the quartz crystal microbalance.

4. STUDY ON PHYSICAL PROPERTIES AND THE MORPHOLOGY OF PLASMA POLYMER FILMS OBTAINED FROM HEXAMETHYLDISILOXANE

The optical properties and morphology of the surface of polymer layers, obtained from hexamethyldisiloxane (HMDSO) with and without modification with ammonia vapours are investigated by infrared spectroscopic ellipsometry and atomic force microscopy. The optical constant of the polymer, and thus data for the vibrational band analysis are provided. The data about surface morphology reveals that the NH_3 treatment had causes distinct micro-structural modification on the top layer structure.

The photoluminecsent and optical properties of polymer layers, obtained from hexamethyldisiloxane (HMDSO) in order to use as protective layer in electroluminescent structure are studied. The plasma polymer protective layer improves all the working characteristics of the structure, i.e. the brightness, stability to electrical breakdown, reliability and period of exploitation.

The new hybride electroluminescent structure has received a gold medal in Exhibition for transfer of intellectual products and selling of goods " East-West Euro Intellect – Way to the 21st Century, 2004, Sofia, Bulgaria.

5. X-RAY PHOTOELECTRON SPECTROGRAPHY

The measured XPS spectra of fresh and heat-and photo-treated $Ge_xSb_{40-x}S_{60}$ films, deposited by thermal evaporation, are interpreted on the point of view of building structural units of the film. The deposition process itself and preliminary film non-stoichiometry determine the existence of Sb_2S_5 phase, the surprising lack of Sb_2O_3 and depending on Ge content Sb_2S_3/Sb_2S_5 ratio.

The film non-stoichiometry is increased and an inherent for the film matrix Sb_2S_5 phase appears during the (film) deposition. (Thus,) due to the existence of that phase, the average coordination number (ACN) is necessary to be re-calculated. Analogically to the glass-forming systems that the film matrix consists of building units (network formers) and modifying units (network modifiers) in our case units related to Sb_2S_5 are network modifiers. The film ACN is now counted as the difference of the network formers ACN and network modifiers ACN.

Sb_2S_3 and Ge_2S_3 are the basic compounds in $Ge_xSb_{40-x}S_{60}$ films. The binding energies of Sb atoms in Sb_2S_3 phase of the films are different of those in the mere chemical compound Sb_2S_3, and depend on the Ge content. The binding energies also depend on the

type of treatments. This implies that the local geometry and the arrangement of the building units are statistically distributed and are changed after treatments. These results certainly show that one of the main building units in the films is SbS_3 pyramid. The Ge content and film treatments have an affect upon local geometry of SbS_3 pyramid. In addition, ethane-like chains of GeS_3 pyramids of the Ge_2S_3 phase exist together with SbS_3 pyramids in the film.

The heat-treatment decreases binding energy of Sb_2S_3 for films with Ge > 5 at. %, while the photo-treatment decreases the binding energy only for films with 25 at. % Ge. The annealing raises the disorder and makes the structure looser. The illumination induces structural changes, related to SbS_3 pyramids, decreases disorder and improves the chemical order of the films. The binding energy change at 25 at. % Ge is, however, related to the structural changes, but into Ge_2S_3 phase. From the results of intrinsic stress and binding energy changes at photo-and heat-treatment a conclusion is drawn that both treatments provoke changes in Ge_2S_3 phase, which turn it into GeS_4 bonded tetrahedra. Thus, this re-ordering of the film matrix changes SbS_3 binding energy.

6. SURFACE TRANSVERSE WAVES (STW) AND APPLICATIONS

Unique surface transverse wave (STW) based clock oscillators operating on very low supply and tuning voltages (1.2 to 3.3V) have been developed. These clocks can drive new generation CMOS circuits directly, without the necessity of using integrated level shifters that generally compromise the noise immunity of systems based on such CMOS technology. For the first time, the "buck-boost" principle, commonly used in dc-dc converters has been applied to the proposed GHz range clock oscillators allowing them to generate output drive pulses with an amplitude, exceeding the supply voltage. This makes the STW clocks compatible also with older generation CMOS circuits operating on higher supply voltages than the STW clock itself. This development has received "Silver Medal" at the East-West-Euro-Intellect Exhibition, 2004 in Sofia.

A novel method for precise measurements of the series resonant frequency and motional resistance of a quartz crystal microbalance (QCM) operating under highly viscous liquid load conditions has been proposed. By means of impedance transformation networks in a Pi-circuit configuration, the QCM is released from the additional electrical loading imposed by the measurement system, providing a well-behaved symmetric low-loss resonance and a steep 0-phase crossing at series resonance. This QCM-based liquid-sensor method has been applied to measuring the density-viscosity products of a variety of liquids. Even at extremely high liquid viscosities, such as 100% glycerol, the measurement error was within 1% and much lower compared to existing methods for liquid characterization.

PUBLICATIONS:

1. V. Georgieva, P. Stevchev, P. Vitanov, L. Spassov "Quartz resonator with TiO_2 for NH_3 detection. Vacuum, 76,203-206 (2004)
2. L. Yourukova, K. Kolentsov, E. Radeva, Effect of second protective layer in AC EL display structures on their characteristics, Vacuum, 76, 199-202 (2004).
3. I. D. Avramov, "The RF-Powered Surface Wave Sensor Oscillator - a Successful Alternative to Passive Wireless Sensing", IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control, Vol. (UFFC-51), No. 9, Sept. 2004, pp. 1148-1156.

4. D. Tsankov, E. Radeva, K. Hinrichs, A. Roseler, E.-H. Korte, Infrared spectroscoic ellysometri and atomic force microscopy study of plasma polymerized hexamethyldisiloxane layers post-treated by NH_3 plasma, Thin Solid Films, in press.
5. R.K. Debnath, A.G. Fitzgerald,, K. Christova, A. Manov "Christalizatio of heat-and photo-treated $Ge_xSb_{40-x}S_{60}$ films by X-ray photoelectron spectroscopy", J. of Optoelectronics and Advanced Materials Vol.**, June 2005.
6. 1. R.K. Debnath, A.G. Fitzgerald, K. Christova, A. Manov, "X-ray photoelectron spectroscopy of $Ge_xSb_{40-x}S_{60}$ films", Compt. rend. Acad. bulg. sci. 57, 11,13-18, 2004.
7. B.Dulmet, L.Spassov, Ts.Angelov, "Finite element analysis (FEA) for a new design of NLC-cut quartz crystal resonant temperature sensor", Proc. of the 18-th EFTF, Univ. of Surrey, UK, 5-7 April 2004, (in press).
8. V. Georgieva, L. Spassov, I. Manolov, "Influence of the surface roughness on the sorption sensitivity of quartz resonators", Proc. of the 18th EFTF, Univ. of Surrey, UK, 5-7 April 2004, (in print).
9. L.Spassov, R.Velcheva, L.Vergov, R.Bourquin, A.Ivan, B.Dulmet, "Investigations of electrical parameters and mode patterns of NLC-cut quartz resonator at low temperature", Proc. of the 18-th EFTF, Univ. of Surrey, UK, 5-7 April 2004, (in press).
10. Е. Радева, К. Коленцов, Л. Юрукова, Д. Жечев, Е. Дамянова-Арнаудова, П. Зубов, Фотолюминисцентные спектры полимерных пленок, содержащих кремний, IV Международная научная конференция," Химия твердово тела и современные микро- и нанотехнологии", 19-24 сентября 2004 г., Кисловодск, Русия, Изд. Северо-Кавказ. Госуд. Техн. Университета, Ставрополь, 2004, стр. 420-425.
11. K. Kolentsov, L. Yourukowa, E. Radeva, D. Zhechev, E. Dimova, Inorganic electroluminescent light sources with an organic protective layer, Proc. Of the 10th International Symposium on the Science and Technology of Light Sources, Toulouse, France, 2004, pp. 365-366.
12. I. D. Avramov, "Low Voltage Surface Transverse Wave Oscillators for the Next Generation CMOS Technology", Proc. IEEE Int. Ultrasonics, Ferroelectrics and Frequency Control 50-th Anniversary Joint Conference, August 24-27, 2004, Montreal, Canada.
13. I. D. Avramov, "A Quartz Crystal Sensor Oscillator Appropriate for Highly Viscous Liquid Measurements", 18th European Frequency and Time Forum, Guildford, UK, 5 - 7 April, 2004.
14. D. Avramov, "A 0-Phase Circuit for QCM-Based Measurements in Highly Viscous Liquid Environments", IEEE Sensors Journal (приета за печат с писмо от редактора от 30. 03. 2004 г.).
15. E. Radeva, Thin plasma polymer films for sensor applications, Nanoscience&Nanotechnology, 4, Heron Press, Sofia, pp.45-447, 2004.
16. K. Kolentsov, L. Yourukova, E. Radeva, T. Kehlibarov, New hybrid AC EL displays – preparation and application, Proc. of XII National Conference Illumination'2004, pp. 156-158.

RESEARCH PROJECTS:

1. Project financed only by Bulgarian Academy of Sciences

1.1. "Investigation of the structure and physicochemical properties of thin layers based on polymers obtained by plasma for sensor application".

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

2.1. F-902 “Investigation of Resonators Systems Quartz-metal After Rapid Thermal Annealing”
2.2. Institute of Solid State Physics - Bulgarian State Railways “Optimal distribution of traction force in rolling composition”

3. Financed by international sources

3.1. Institute of Solid State Physics - Joint Institute of Nuclear Research, Dubna, Russia “Measurement of the helium flow in the cryogenic complex “Nuclotron” – second stage
3.2. Institute of Solid State Physics - Russian Academy of Sciences - GEOHI “Development of piezoresonance chemical sensors for pollution detection in the atmosphere”

4. Project financed by 5 FP of European Community

4.1. “Growth Programme of 5 Framework of EU: “Multi – Channel Measurement and Control System Based on Resonant Piezoelectric Crystal Sensors – QxSens”.

COLLABORATION:

1. “Measurements of Helium Flow in Cryogenic Accelerator Complex - “Nuclotron” - Joint Institute for Nuclear Research, Dubna, Russia
2. “Research of Chemical Sensors based on piezoresonance type for pollution detection in the environment” - Russian Academy of Sciences

LABORATORY

CRYSTAL GROWTH

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TOTAL STAFF: **8**
RESEARSCH SCIENTISTS: **7**

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

RESEARCH ACTIVITIES

The research work of the Laboratory of Crystal Growth was focussed on three main tasks:

-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

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

The AC conductivity of undoped and doped with Os, Re, Ru and Rh $Bi_{12}SiO_{20}$ (BSO) crystals was investigated. BSO crystals with diameter of about 40 mm and length of 80- 100 mm were grown by the Czochralski method. The dielectric constant and the dielectric loss were measured in the temperature interval 290- 600 K and the frequency range 10^4- 10^7 Hz. The AC measurements were carried out with LRC Hewlett Packard 4275 unit. The dependencies of the real and imaginary parts of the AC- conductivity on the temperature and the frequency are investigated. It was concluded that charge transport via localized states took place in the investigated samples. The length of localized states' chains is in the range of 4- 7 at room temperature and about $(3\text{-}5).10^2$ at 450- 600K. The obtained results would not be associated still neither with intrinsic nor with extrinsic defects in the crystal lattice.

$Bi_{12}SiO_{20}$ doped with Ru as well as $Bi_4Ge_3O_{12}$ doped with V are successfully grown and the optimal crystal growth conditions are established. Absorption spectra are measured and magneto- optical effect is investigated in the visual part of the spectra. Some basic parameters of photo- induced phenomena in these crystals are determined.

The core region in a bismuth silicate- $Bi_{12}SiO_{20}$ doped with Mn (BSO:Mn) was examined by X- ray double crystal diffraction traverse topography. Specific features were observed in the topographies as lines and contrast differences that point to defects occupying the central part of the crystal. The nature of these defects is discussed and an explanation in terms of stacking faults arranged in different structures is proposed.

Spatially resolved polarized Raman measurements were performed on a Czochralski grown $Bi_4Ge_3O_{12}$ crystal and observed significant spot-dependent changes in the relative scattering intensity of some A_1, E and F_2 modes. In view of the different selection rules for these modes such a behaviour implies that there are regions of different crystal orientation. These experimental findings were explained with presence of two-dimensional structural defects with high concentration and strongly non-uniform distribution in the investigated crystals.

The phase diagrams of $LaMnO_3$ (La = Dy, Ho, Er, Tb, Yb, Tm, Lu) and manganese oxides are investigated and optimal conditions for crystal growth by high temperature solution growth (HTSG) method are determined. Crystals of $HoMnO_3$, $HoMn_2O_5$ and $TbMn_2O_5$ are also grown by this method. Ferro- magnetic as well as ferro- electric phase transitions of $HoMnO_3$ crystals in the temperature range 1- 300 K are investigated. Anomalies in the field- induced dielectric plateau at sharp changes of the magnetic field as well as the dependence of the orientation of the ferro- electric domains on changes in the magneto- striction effect are established.

Raman spectra at low temperatures of $HoMn_2O_5$ and $TbMn_2O_5$ crystals are measured. Any structural changes in $HoMn_2O_5$ crystals are not established at phase transition temperatures (about 50K) by Raman spectroscopy.

Raman as well as infra- red active phonons are observed in hexagonal $HoMnO_3$. The effects of magnet- ordering are investigated. The presented conclusions about the ordering of Mn- atoms at about the phase transition at 76 K are based on the carried symmetry analysis, compared with the results of the lattice dynamics calculations. Nano- scale structure and mechanisms of the formation of diffuse phase transition in relaxor ferro- electric of type $PbB'_{0.5}B''_{0.5}O_3$ (in в $PbSc_{0.5}Ta_{0.5}O_3$ (PST) and $PbSc_{0.5}Nb_{0.5}O_3$ (PNT)) were investigated by polarized Raman spectroscopy and far- infra- red elipsometry. It was shown that the determined double enlarging of the unit cell in areas with linear dimensions of few nm is not depended on the B- cathion far- ordering. The temperature dependence of the optical properties of PST crystals in the area of the para- ferro electric diffuse phase transition. Crystals of $PbSc_{0.5}Ta_{0.5}O_3$, doped with Sn (PST:Sn), as well as mixed crystals $PbSc_{0.5}(Ta,Nb)_{0.5}O_3$ (PSTN) were synthesized for evaluation of the influence of the compositional cathion disordering. The dielectric behaviour of these crystals was compared with those of stoichiometric $PbSc_{0.5}Ta_{0.5}O_3$, as well as of annealed crystals of $PbSc_{0.5}Ta_{0.5}O_3$. The dielectric measurements are carried out at 0.01- 1 MHz and 243- 573K. It was established a very serious influence of the doping with Sn on the ε(T).

The temperature dependence of the dielectric loss and susceptibility (ε and tgδ) at different frequencies are measured in $La_{1-x}Pb_xMnO_3$ (x = 0.3) crystals.

Crystals of $Pb_5GeO_4(VO_4)_2$ and $Bi_2Mo_3O_{12}$ were grown by the Czochralski method. The absorption spectra in the infra- red range of the spectra are measured in the temperature interval 9- 400 K. The absorption peak of the vibrational bending modes of the hydroxyl $[OH]^-$ group is determined at 3561,5 $см^{-1}$ in $Pb_5GeO_4(VO_4)_2$ crystals. Two absorption peaks at 3467,4 $см^{-3}$ and 3337,4 $см^{-3}$ at 9 K and anomalies in the temperature dependence of the vibrational frequencies of the peak at 3337,4 $см^{-3}$ are observed in $Bi_2Mo_3O_{12}$ crystals.

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3. T. I. Milenov, P. M. Rafailov, M. M. Gospodinov and P.A.Botev, *X-ray Diffraction Topography Observations of the Core in $Bi_{12}SiO_{20}$ Crystals Doped with Mn*, Materials Science and Engineering **B106** (2004) pp. 148 - 154

4. P. M. Rafailov, T. I. Milenov, M. I. Veleva, C. Thomsen and M. M. Gospodinov, *A Raman Spectroscopic Study of Defects in $Bi_4Ge_3O_{12}$ Crystals*, Journal of Optoelectronics and Advanced Materials, №1 (2005) - in press.

5. A.P.Litvinchuk, M.N. Iliev, V.N. Popov and M.M. Gospodinov, *Raman and infrared-phonons in hexagonal $HoMnO_3$ single crystals: magnetiv ordering effects*, J. Phys.: Condens. Matter **16** (2004) pp. 809 – 819
6. B. Lorenz, A. P.Litvinchuk, M.M. Gospodinov and C.W. Chu, *A Field-Induced Re-Entrant Novel Phase and A Ferroelectric-Magnetic Order Coupling in $HoMnO_3$*, Phys. Rev. Lett. **92**, № **8** (2004) pp.087204-1 – 087204-4
7. B. Lorenz, F. Yen, M.M. Gospodinov, C.W. Chu, *Field-induced phase in $HoMnO_3$ at low temperatures,* Phys. Rev. B (2005) - in press
8. B. Mihailova, M.M. Gospodinov, B. Gutter, F. Yen, A.P.Litvinchuk, M.N. Iliev, *Temperature-Dependent Raman Spectra of $HoMnO_3$ and $TbMn_2O_5$*, Phys. Rev. B. (2005) - in press
9. B. Mihailova, U Bismayer, B. Güttler, M. Gospodinov, A. Boris, C. Bernhard and M. Aroyo: *Nanoscale phase transformations in relaxor-ferroelectric lead scandium tantalite and lead scandium niobate*, Zeitschrift für.Kristallographie, (2005) (accepted)
10. Y. Sarov, V. Marinova, M. Gospodinov and S. Sainov, "*Optical investigation of Pb2ScTaO6 crystals with room temperature phase transition*", J. of Optoelectronics and Advanced Materials, №1 (2005) - in press
11. D. Kaisheva, D. Doshkova, B. Mihailova and M. Gospodinov, *Dielectric behavior of Sn doped and annealed ferroelectric lead scandium tantalate single crystals*, Journal of Optoelectronics and Advanced Materials, №1 (2005) - in press
12. D. Doshkova, D. Kaisheva, B. Mihailova and M. Gospodinov. *Crystal growth, structure and dielectrical properties of ferroelectric mixed $Pb_2ScTa_xNb_{1-x}O_6$ single crystals,* Journal of Optoelectronics and Advanced Materials, №1 (2005) - in press
13. L. Kovacs, A. Peter, M. Gospodinov and R. Capelletti, *Hydrohyl ions in acousto-optic $Pb_5(GeO_4)(VO_4)_2$ and $Bi_2(MoO_4)_3$ single crystals*, Phys. Stat. Sol. (c) **2** (2005) pp. 689 -692

ONGOING RESEARCH PROJECTS

Financed by the Bulgarian National Scientific Research Foundation at the Bulgarian Ministry of Education and Science:
F 1207: Growth of comlpex oxide crystals from mixed valence compounds. Investigations of their structure, defects, electrical, optical and magnetic properties.
F 1308: Growth and investigation of wide band gap semiconductor and oxide crystals with application in photorefractive optics and nuclear detectors

COLLABORATION

Growth and investigation of wide band gap semiconductor and oxide crystals and layers including SiN and GaN- Institute of Common and Inorganic Chemistry, Russian Academy of Sciences, Moscow, Russia

Growth and magneto- optical investigations of sillenite and manganite crystals- Ioffe Institute of Physics, Russian Academy of Sciences, St. Petersburg, Russia

Growth and characterization of oxide crystals for optical applications- Research Institute of Solid State Physics and Optics, Budapest, Hungary

Static moments of short- lived exotic nuclei studied via hyperfine interaction on the nuclear spins with crystalline electric field gradients- Instituut voor Kern en Stralingsfysica, Leuven, FWO- Flanders, Belgium

LABORATORY

MOLECULAR BEAM EPITAXY and SURFACE ANALYSIS

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

Asist. Prof. T. Mincheva, PhD; L.M. Trendafilov, physicist

RESEARCH ACTIVITIES:

1.1 "Investigation of the surface reconstruction and the epitaxial crystal growth micro mechanisms self-consistency in vacuum" – BAS Project.

To model the MBE processes an empirical formula for calculation of absolute electron impact ionization cross sections of atoms was developed. This universal formula is a simple analytical dependency of the ionization cross section on the impact electron energy, three basic atomic parameters, and three experimentally determined energies that are of basic importance for the process of ionization. The formula was tested for the atoms available in the background atmosphere of MBE System over the electron energy range from threshold ionization energy to 1000eV. It was found an in - the – error – limits conformity between calculated cross section values and the experimentally obtained cross sections for these atoms over the energy range indicated.

1.2. "Preliminary estimation and modeling of the feasibility for operation of efficient multi – layer staggered – lineup heterostructures for producing a photocell with energy conversion coefficient close to unity" – BAS Project.

A computer modeling of "staggered" III-V heterostructures containing Ga, In and As, Sb, P, and Bi was performed. The dependence of radiation energy conversion on the composition (i.e. $In_{1-x}Ga_x/GaSb_{1-y}As_y$, $In_{1-x}Ga_xSb_{1-y}As_y/GaSb$, $In_{1x}Ga_xP_{1y}As_y/GaSb_kAs_1P_{1-(k+1)}$, $In_{1-x}Ga_xSb_{1-y}As_y/ GaSb_kAs_1Bi_{1-(k+1)}$) was cleared. Four compositional ranges have distinguished and were targeted for more detail investigation.

1.3. "Studying human chromosomes structure by analyzing their topography obtained through Scanning Tunnelling Microscopy on ultrathin coating water films" – BAS Project.

The Scanning Tunneling Data Logger is adapted for investigation of topographic structure of soft matter objects covered with ultrathin water layer. In this course new preamplifier is designed and builded, and modification of scanning head hardware and software has been made. An experimental protocol, optimal for human chromosomes sample preparation, has been established. Writing of software for soft matter objects experiments have been started.

1.4. Scanning Tunneling Microscope (STM) for solid state samples study is created in the frame of equipment building program. This first modification is intended for visualization and automated analysis of surface structures on a typical area of 2x2 micrometers with a resolution of 10 nanometers.

ONGOING RESEARCH PROJECTS:

1. Preliminary estimation and modeling of the feasibility for operation of efficient multi – layer staggered – lineup heterostructures for producing a photocell with energy conversion coefficient close to unity.
2. Investigation of the surface reconstruction and the epitaxial crystal growth micro mechanisms self-consistency in vacuum.
3. Studying human chromosomes structure by analyzing their topography obtained through Scanning Tunneling Microscopy on ultrathin coating water films.

LABORATORY

LIQUID CRYSTALS

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RESEARCH SCIENTISTS: **7**

Corr.mem. Prof. A. Derzhanski, Ph.D., D.Sc.; Assoc.Prof. H. Hinov, Ph.D.; Assoc.Prof. A. Zheliaskova, Ph.D.; Assoc.Prof. I. Bivas, Ph.D.; Assist.Prof. Radoslav Marinov, Ph.D.; Assist. Prof. V. Vitkova, Ph.D; J. Genova, Ph.D. student

RESEARCH ACTIVITIES:

Four projects have been developed in the Laboratory of Liquid Crystals during 2004 year on different contracts: two with BAS, one with NSF, one with RAS. Dr. V. Vitkova specialized in *Laboratoire de Spectrométrie Physique,* CNRS UMR 5588, and the University J. Fourier, Grenoble, France. Dr. I. Bivas prepared a D.Sc. thesis on "Mechanical, Electrical and Rheological Properties of Lipid Membranes".

The DC voltage threshold (U_c) and the wave number (q_c), characterizing the flexoelectric domains of Vistin'-Bobylev-Pikin have been experimentally measured in the liquid crystal p-n-butyl-p-methoxyazoxy-benzene (BMAOB) with strong-strong and strong-weak anchoring, at simultaneously acting DC (U) and high frequency (>5 kHz) orienting AC (U_{ac}) electric fields. The Pikin-Bobylev's theory for this case is further elaborated in the approximation of anisotropic elasticity and the threshold characteristics $U_c(U_{ac})$ and $q_c(U_{ac})$ are obtained. Computer calculations of these characteristics and their fit to the experimental data permitted to determine important material parameters of liquid crystal BMAOB, that are in good agreement with measurements of others [5].

The Romanov-Sklyarenko's theory for the liquid crystal fluctuations in the presence of flexoelectric effect (ЖЭТФ, v.112, 1675, 1997) and for the behaviour of Vistin'-Bobylev-Pikin's flexoelectric domains in homeotropic nematic layers (ЖЭТФ, v. 116, 543, 1999) is further elaborated and the precize values of the threshould characteristics $U_c(U_{ac})$, $q_c(U_{ac})$ и $U_c(q_c)$ are obtained in the case of anisotropic elasticity and flexoelectricity with strong liquid crystal anchoring assuring its homogeneous planar orientation. Computer numerical calculations (using maximum of 5 parameters) of these characteristics determined theoretically the optimal material parameters for the "variable grating mode" of Vistin'-Bobylev-Pikin's domains and more generally fot their use as electrically controlled diffraction graitings [Y.G.Marinov and H.P.Hinov, "Optimization of the material parameters of the longitudinal flexoelectric domains (a variable grating mode) under the joint action of ac and dc voltages", Opticheski Zhurnal (Russia), 2004 (submitted)].

The simultaneous application of DC and high frequency AC electric fields permits the experimental realization of well oriented flexodomains with period depending on the applied field. This permits to avoid the appearance of disclinations, walls and other non regularities characteristic of the "variable grating mode" leading to worsening of the diffraction pictures obtained by these domains [5].

A theory, permiting to calculate the free energy of flat lipid monolayer containing charged lipids in contact with an electrolyte has been developed. To describe the electrical

double layer the Guy-Chapmann approach is used. It is demonstrated that the clasical results of Vervey-Overbeck for the free energy of a double layer due to adsorption of ions from the electrolyte in contact with the monolayer are not applicable to this system.

The passive water permeability of a lipid bilayer, due to the hydrostatic pressure difference, created by sucking a giant vesicle in a micropipette at given sucking pressure has been studied. The length of the membrane, sucked into the micropipette, as a function of time is measured. According to our theory, the initial changes are due to the membranes defects smoothing leading to an increase of the membrabe area, while the changes that follow up are due mainly to the loss of water volume because of the membrane permeability. The analysis of the experimental data permits to determine the water permeability and the hidden membrane area [1].

The "tumbling" motion of flacide vesicles containing viscouse fluid in nonviscous medium has been studied. The experiment reveled the strong effect of deformability on the "tumbling" motion in the viscouse field: the vesicle shape changes sigfnificantly during the tumbling influencing the relation between the angle and the rotational velocity [7].

The flow of the water suspension of giant liposomes of elipsoidal shape through a capilary of comparable diameter has been experimentally studied. The vesicle deformations are observed and recorded during their passage through the capilary. The deformations increase with the flow velocity, when increasing the vesicle diameter and when decreasing the vesicle normalized volume (the ratio of the vesicle volume to the volume of a vesicle of equal membrane area). The dependence of the vesicle mobility (the ratio of the vesicle velocity to the fluid velocity in the capilary) on the vesicle size has been determined experimentally [2].

PUBLICATIONS:

1. V.Vitkova, J. Genova, and I. Bivas, “Permeability and hidden area of lipid bilayers”, Eur. Biophys. J. **33,** N 8, pp 706-714 (2004).
2. V.Vitkova, M. Mader, and T. Podgorski, “Deformation of vesicles flowing through a capillary”, Europhys. Lett. **68** (3), pp. 398-404 (2004)
3. V.Vitkova, J.Genova, M.D.Mitov, and I. Bivas, “Mechanical properties of lipid mono- and bilayers in the presence of small carbohydrates in the aqueous phase”, C.R.Acad.Bulg.Sci. **57** (6) 55-60 (2004).
4. V.Vitkova, J.Genova, O. Finogenova, Y. Ermakov, M.D. Mitov, and I. Bivas, Surface Charge Effect on the Lipid Bilayer Elasticity”, C. R. Acad. Bulg. Sci. **57**(11) (2004).
5. Y.Marinov, H.P.Hinov, and A.G.Petrov, “Longitudinal flexoelectric domains in BMAOB nematic layers under the joint action of dc and ac voltages”, 13-th Int. Scool on Condensed Matter Physics, Varna, Bulgaria, 30.08-5.09 2004, J. Optoel. Adv. Mat., 7(1)(2005)277.
6. J Genova, V.Vitkova, L.Aladgem, and M.D.Mitov, “The stroboscopic illumination gives new opportunities and imp[roves the precision of the bending elastic modulus measurement” 13-th Int. School on Condensed Matter Physics, Varna, Bulgaria, 30.08-5.09 2004, J. Optoel. Adv. Mat., 7(1)(2005)257.
7. V. Vitkova, M. Mader, T. Biben, and T. Podgorski, “Tumbling of Deformable Lipid Vesicles, Enclosing a Viscous Fluid under a Shear Flow”, 13-th Int. Scool on Condensed Matter Physics, Varna, Bulgaria, 30.08-5.09 2004, J. Optoel. Adv. Mat., 7(1)(2005)261.

COLLABORATION:

1. “Influence of surface electric charges on mechanical properties of lipid membranes and monolayers” - Institute of Electrochemistry, Moscow, Russia.

LABORATORY

BIOMOLECULAR LAYERS

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RESEARSCH SCIENTISTS: **6**

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RESEARCH ACTIVITIES:

1. Electric properties of model lipid membranes of soya lecithin containing photoactive azo-dye molecules were investigated. It was found that photo-isomerization process is fully reversible.
2. Monolayer LB films of azobenzene and trans-stilbene derivatives both of pure compounds and in mixture with stearic acid have been prepared and investigated using second harmonic generation and polarization microscopy. The combination of the two methods allows one to estimate the size of the film domains. The influence of stearic acid in mixed LB films on the domain size is discussed.
3. Homeotropic nematic layers of MBBA and BMAOB liquid crystals, oriented by self-assembled films of dilauroyl phosphatidyl choline (DLPC) and chromolan have been studied by a phase-sensitive flexoelectric spectroscopy method. The viscoelastic spectra of these layers reflecting the surface dissipation of orientational energy have been analyzed taking into account a strong (DLPC) or weak (chromolan) surfactant desorption. Temperature dependence of the thickness of desorbed subsurface layer of surfactant was revealed. Surface viscosity was also obtained from the theoretical fits of the spectra.
4. The flexoelectric domains of Vistin'–Pikin–Bobylev have been investigated experimentally in p-n-butyl-p-methoxyazoxy–benzene (BMAOB) layers with strong-strong and strong-weak anchoring under the joint action of d.c. and a.c. voltages. The joint action of a d.c. voltage with a high magnitude applied on the oriented by the a.c. voltage nematic layer improves the arrangement of the domains, considerably rising the quality of the diffraction gratings built on the basis of these domains.
5. Electro-optical properties of holographycally formed gratings in polymer-dispersed liquid crystals are studied. A significant increase of the diffraction efficiency in the case of field-applied recording was found.
6. Micrometer sized droplets of high-temperature liquid crystal OOBA were formed in a NOA 65 photopolymer by photo-polymerisation. By the method of polarizing microscopy the PDLC morphology was investigated.

PUBLICATIONS:

1. Characterization of micron and submicron scale lateral structure of optically nonlinear organic films, A. Maslyanitsyn, V.D. Shigorin, L. Todorova, Y. Marinov, A. G. Petrov, *Mol. Cryst. Liq. Cryst.,* **408**, 71–81, (2004).
2. Surface energy dissipation in homeotropic nematic layers: the role of

flexoelectricity and surfactant desorption, S. Ponti, G. Barbero, A. Strigazzi, Y. Marinov, A.G. Petrov, *Mol.Cryst.Liq.Cryst*. **420**, 55-72, (2004).

3. Effect of high-frequency electromagnetic field on Te^{+}-implanted (001) Si , M. Kalitzova, E. Vlakhov, Y. Marinov, K. Gesheva, V. Ignatova, O. Lebedev, C. Muntele, R. Gijbels, *Vacuum*, 76, 325-328, (2004).
4. Investigation of Bragg gratings recorded in polymer-dispersed liquid crystals, K.Beev, S.Sainov, T.Angelov, A.G.Petrov, *J.Optoelec.Adv.Mat*., **6**, 799-803, (2004).
5. Interaction of Cd^{2+} ions with bilayer lipid membranes, S. Naydenova, M. Dencheva-Zarkova, R. Ugrinov, A. G. Petrov, *Nanoscience&Nanotechnology*, **4**, 192-194, (2004).
6. Temperature Dependence of Chromaticity in Polymer-Dispersed Cholesteric Liquid Crystal, P. Pavlova, E. Borisova, H. Naradikian, and T. Angelov, *Nanoscience&Nanotechnology*, **4**, 220-222, (2004).
7. Физика на меката материя, А.Г. Петров, *Наука*, **XIV**, 4, 40-44, (2004)
8. Electro-optical Properties of Polymer-dispersed Liquid-crystals, T.Angelov, K.Beev, S.Sainov, A.G.Petrov, *J. Optic. Mat.*
9. Surfactant desorption in homeotropic nematic layers studied by flexoelectric spectroscopy, L. Todorova, Y. Marinov, I. Maslyanitsyn, S. Torgova and A.G. Petrov, *J.Optoelec.Adv.Mat*. **7**, 269-272 (2005).
10. Longitudinal Flexoelectric Domains in BMAOB Nematic Layers under the Joint Action of DC and AC Voltages, Y. Marinov, H. P. Hinov, and A.G. Petrov, *J.Optoelec.Adv.Mat.* **7**, 277-280 (2005).
11. Temperature Dependance of Chromaticity in polymer-dispersed cholesteric liquid crystal: reflection and transmission characteristics , P. Pavlova, L. Avramov, H. Naradikian, T. Angelov, and A.G. Petrov, *J.Optoelec.Adv.Mat.* **7**, 285-288 (2005).
12. High Temperature Formation of Polymer-Dispersed Hydrogen Bonded Liquid Crystals , T. Angelov, B. Katranchev and M. Petrov, *J.Optoelec.Adv.Mat.* **7**, 281-284 (2005).

ONGOING RESEARCH PROJECTS:

Financed by the Bulgarian Academy of Sciences and by the Bulgarian National Council "Scientific Studies":

1. Project F-1003/00: "Opto-mechano-electricity in photoactive nano liquid crystal systems".
2. Project DNP-03/04: "Liotropic liquid crystalline nanostructures for the biology and medicine"

COLLABORATION:

1. "Ordered molecular nano structures for the optoelectronics" - Institute of General Physics - Moscow, Joint Research Project between BAS and RAS, Russia
2. "Confined and nanostructured liquid crystals studied by the method of flexoelectric spectroscopy"- Dipartimento di Fisica, Universita degli Studi della Calabria, Joint Research Project between BAS and CNR, Italy

LABORATORY

OPTICS AND SPECTROSCOPY

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TOTAL STAFF: **30**
RESEARCH SCIENTISTS: **27**

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RESEARCH ACTIVITIES:

1. OPTICS AND SPECTROSCOPY OF WAVEGUIDES

Proton-exchanged optical waveguides in $LiNbO_3$ и $LiTaO_3$ crystals having different crystallographic orientations were obtained by various technological regimes. Their phase content was analysed using the combination of waveguide mode-spectroscopy, IR absorption and reflection spectroscopy as well as Raman-spectroscopy. The results obtained were used for estimation of the phase composition and for determination of the distribution of different phases in the depth of the protonated layers. These studies allow to control the phase content and therefore the opical and electro-optical properties of the waveguides.

Thin $LiNbO_3$ - layers deposited by laser ablation on Al_2O_3 and MgO substrates were studied by waveguide mode spectroscopy. Formation of Li-defficite phase was observed depending on the substrate orientation and not affected by using of Li-enriched targets. Li-enriched epitaxial layers of Li_3NbO_4 were obtained on (100) MgO-substrates with no dependence on the target used and the deposition parameters. Most of the layers supported waveguiding light propagation.

The investigations of the role and behavior of hydrogen in hydrogenated amorphous silicon prepared by plasma decomposition of hydrogen-diluted silane have been continued in 2004. Using the nuclear reaction analysis for quantitative evaluation of hydrogen concentration and the experiments on the postdeposition change in the hydrogen content (thermal annealing, plasma posthydrogenation and ion implantation) it has been established that the hydrogen concentration of 15-16at% in the films is equal to its solubility limit in the specific amorphous network. The analysis of the mechanism of the light-induced degradation (Staebler-Wronski effect) has suggested that a higher stability of the studied kind of films is definitively related to the high hydrogen concentration. A model has been proposed, which defines the structural properties of the amorphous silicon leading to a weaker Staebler-Wronski effect.

Optical and structural characteristics of Z-cut proton-exchanged optical waveguides in $LiNbO_3$ were studied. The proton exchange was performed in melt containing benzoic and adipic acids in different ratios. The influence of adipic acid concentration on the crystallographic phases, the diffusion coefficient, the dispersion and the refractive index was investigated. The depth of the waveguiding layers in β_1 and β_2 phases could be controlled by varying the concentration of the adipic acid in the melt.

2. FIBER OPTICS

The characteristics of an optical fiber bandpass filter were investigated. The waveguide structure includes a single-mode optical fiber coupled with a planar waveguide formed by amorphous silicon layer. In interaction with TM_1 and TE_1 planar waveguide modes a sensitivity of 10^{-3} and 3.10^{-3} RIU correspondingly were observed. Experiments with a fiber-optic depolarizer based on fiber recirculating ring were carried out. The characteristics of the device with different combinations of isotropic and anisotropic fibers were investigated. A new detector module for simultaneous measurements of both polarizations in optical fibers was prepared. Numerical modeling of Bragg grating fiber refractometer were carried out. The dependencies of the parameters of single-mode and two mode optical fibers were investigated.

3. HOLOGRAPHIC DIFFRACTION GRATINGS

1. *HIGH DIFFRACTION EFFICIENCY RESONANT GRATING*

The record value of 99% absolute diffraction efficiency in the -1^{st} order was registered in a grating, consisting of a mirror, a dielectric layer and a corrugation at the layer-air interface. The high efficiency is due to the excitation of a leaky mode of the layer.

2. *PULSE COMPRESSION GRATINGS*

It was established that when a spectrally broad laser pulse is incident on a pair of parallel oriented diffraction gratings, the peak power greatly increases, while total energy remains nearly the same.

If the pulse is diffracted by a pair of antiparallel arranged gratings maximum stored energy is exstracted from the pulse and the possible damage of optical components is reduced.

Resonant gratings are especially suited for use in laser pulse compression experiments. High diffraction efficiency, in combination with good spectral quality and high damage resistance makes these gratings useful in all kinds of laser pulse applications both pulse compression using grating pairs, and for amplification of pulses with chirped pulse amplification.

3. *RESONANT GRATING FOR THE POLARIZATION CONTROL OF THE SOLID-STATE LASER*

A coupling grating made in the last high index layer of a highly reflective multilayer laser output mirror, located at the outside of the laser cavity induces a significant fall of the reflection coefficient for one of the polarizations. The polarising mechanism, which uses a grating etched at the outside of the output multilayer can be used in laser couplers of close to 100% reflection coefficient. This extends the applicability of the resonant polarising effect to high power CW lasers which can be solid-state as well as gas lasers.

4. *DEVELOPMENT AND APPLICATION OF THEORETICAL AND NUMERICAL METHODS*

The functioning of some magneto-optical devices is based on the resonant excitation of surface plasmons. Plasmons of two types could be excited: either high-quality or

overdamped ones. It was shown that the best optimization depends not only on the orientation of the magnetic field but also on the magneto-optical coefficients.
The factorization rules of Li are generalized to a cylindrical geometry requiring the use of a Bessel function basis. A theoretical study confirms the validity of the Laurent rule when a product of two continuous functions or of one continuous and one discontinuous function is factorized. The necessity of applying the so-called inverse rule in factorizing a continuous product of two discontinuous functions in a truncated basis is demonstrated theoretically and numerically.

The recently developed fast Fourier factorization method, which has greatly improved the application range of the differential theory of gratings, suffers from numerical instability when applied to metallic gratings with very low losses. This occurs when the real part of the refractive index is small. This failure can be attributed to Li's inverse rule. Two ways of overcoming the difficulty are suggested and successfully proved.

The diffraction of an electromagnetic wave by a cylindrical object with arbitrary cross section was studied by taking advantage of recent progress in grating theories. The fast Fourier factorization method previously developed in Cartesian coordinates was extended to cylindrical coordinates taking into account the periodicity of both the diffracting object and the incident wave with respect to the polar angle. Thus Maxwell equations in a truncated Fourier space were derived and separated in TE and TM polarization cases. The method is suitable for an extension to conical (out-of-plane) diffraction, which will allow studying mode propagation along microstructured fibers.
It was theoretically shown that the anomalous high IR transmission of a thin metal layer having a two-dimensional pinhole grid is due to the surface plasmon excitation at the layer interfaces. Similar bevior should be observed in thin metal layers, which have a periodical corrugation instead of a pinhole grid. This assumption was experimentally confirmed.

4. MICRO- AND NANO-PHOTONICS "Georgy Zartov"

1. *Photorefractive and other nonlinear effects in optical resonators*

We have carried out experimental work on nonlinear optical Fabry-Perot resonator that incorporates $LiNbO_3$ slab (x- and c- cut). The time scales involved in the newly discovered regime of self-pulsating were experimentally investigated. The unstable dynamical behaviour is a manifestation of competing nonlinearities, thermal ones due to optical absorption and photorefractive ones due to the excitation and trapping of electrical carriers and the consequent electro-optical effect.

Electrically induced bistable response and electrical control of bi- and tristable action are demonstrated using the electro-optical and the thermo-optical and anisotropic properties of the $LiNbO_3$ crystal.

2. *Experimental and theoretical investigations on dynamical and polarization behavior of VCSELs.*

We have developed a variational approach model to estimate the amount of enhancement of the polarization stability and the single transverse-mode operation in oxide confined Vertical-Cavity Surface-Emitting Lasers with a shallow etch relief of cylindrical and elliptical shape. Furthermore, we developed full vectorial plane-wave method that is capable of taking into account both the material and the form anisotropy in waveguides of arbitrary shape. The results of the different models are in good agreement, as well as with those from the experiment.

We have investigated experimentally and theoretically the region of elliptically polarized dynamical states in the polarization dynamics of vertical-cavity surface-emitting lasers. These states can occur in the vicinity of a polarization switching from the fundamental transverse mode with lower emission frequency to the mode with higher frequency. It is

demonstrated experimentally that these states may occur in a single as well as in a double switching scenario. The existence of the dynamical states is shown to be independent from the ellipticity of the state of polarization at the lasing threshold. Furthermore, the influence of the detuning between the band gap and the cavity resonance on the occurrence of the dynamical states is investigated.

We have investigated theoretically the interplay of spatial hole burning and dynamical self-focusing and showed that it may give rise to temporal instabilities. We have developed a fully numerical model that solves self-consistently the carrier diffusion and the optical problems in VCSELs and that captures the regime of operation responsible for the self-pulsing operation. Next to it, we have developed a more phenomenological rate equation model that accounts for the self-focusing by using a variational approach. Our results are in good agreement with experiment.

3. *Theoretical and experimental investigation of VCSELs with optical feedback*

We have carried out in-depth experimental and numerical study of spectral and polarization properties of VCSELs subject to polarization insensitive OF from an extremely short (few microns) external cavity (EC). We demonstrated that the total output power and the wavelength of laser emission are sinusoidal, in-phase, modulated with the EC length. The period of modulation is equal to half of the wavelength of VCSEL emission. Furthermore, we show that such phase sensitive OF influences strongly the polarization properties of VCSELs changing the current at which polarization switches between the two orthogonal linearly polarized (LP) VCSEL fundamental modes occurs, as well as the width of the polarization bistable region. These characteristics are also sinusoidally modulated with the EC length with the same half-wavelength period. We explain our experimental findings by the modulation of the OF induced losses. These losses are (slightly) different for the two LP modes with (slightly) different wavelength. In order to quantify this explanation we develop a two modes rate equation model that takes into account the multiple reflections in the EC and the coupling efficiency to the EC. Our numerical results show an excellent agreement with the experiments.

We study the influence of delayed optical feedback from a short external cavity on the emission dynamics of semiconductor lasers using the Lang and Kobayashi rate equation model. We present the bifurcation scenario leading to regular pulse packages (RPP) and give examples of bistability between RPP and time-periodic or steady state solutions. We analyze regions of feedback parameters for which RPP occurs. Detailed mapping shows that with increasing the delay time the windows of RPP broaden, merge and finally shrink when approaching the relaxation oscillation (RO) period. In such a way the largest region of RPP occurs for delays around half of the RO period of the solitary laser. Moreover, the period of RPP also possesses a minimum as a function of the delay time corresponding to approximately the half of the RO period. For smaller delays the RPP period shows an oscillatory behavior with the delay which we identify as being due to the destabilization of the RPP in the vicinity of newly born external cavity modes. Furthermore, we reveal continuous increase of the period of the RPP with the feedback rate. Finally, we study the scaling of the frequency of the pulse package envelope with the injection current. Our results contribute to better understanding of the origin and the peculiarities of the RPP dynamics.

4. *Experimental and theoretical investigations of Coupled-Cavity VCSELs.*

We have conducted a comprehensive study of coupled-cavity VCSEL structure (or CC-VCSEL), i.e. two optical cavities that share a coupling mirror and that can be independently biased using three electrical contacts. We exploit the possibilities to realize high-speed polarization switching devices such as optical modulators and field-effect QW lasers for applications in large capacity optical communications systems.

5. *Optical injection effects on the polarization properties of the light emitted by VCSELs*

We continued our theoretical and numerical work on the polarization dynamics of optically injected VCSEL. Multiwave mixing, stable locking to elliptical states, period doubling cascade and wide region of locking to linearly polarized state are observed. We developed analytical theory for the polarization bistability and polarization switching time in optically injected VCSELs. We have built up experimental set up and first experimental results on polarization dynamical instabilities induced by optical injection are very promising.

5. OPTICS AND SPECTROSCOPY OF THERMOTROPIC LIQUID CRYSTALS

It has been observed, for the first time, a thermal dendrite-like texture growing in nematic liquid crystals (LC) with short range smectic C order (4,n-alkyloxybenzoic acids – nOBA, n=homologue number), constituted of dimer molecules, which at temperature variation transform in biphilic active molecular forms – monomers, open dimers and oligomers. We indicated that the thermal dendrites in nOBA growth only at rubbed hydrophobic coatings, which suppress the formation of hydrogen bonds of LC system with surface and as a result appear biphilic intermolecular interactions mostly in the bulk – aggregation of supramolecular dendrite-like structures. The mechanism of dendrite growth, taking into account the effect of fluid flow, which does not exist at thermal dendrites, in the case of electroconvective dendrites – parabolic type, was suggested. The dynamics of the dendrite growth is that typical for non-equilibrium nonlinear dissipative systems, driven outside of equilibrium. The observed subcritical (hysteretic) behavior of the EC dendrites refers this phenomenon to a first order phase transition, but in a thermodynamically monophase system.

It has been found that the hydrogen bond of dimer molecules in nematics with short range smectic C order and the molecules of 4-hydroxypyridine (HOPY) is one effective way to produce a nanosized LC complex with electrooptical properties of LC, but with improved mechanical properties typical of a physical ‘gel’.

The induced chirality in achiral (racemic) LC systems based on dimer molecules has been analyzed. The transition from an achiral (racemic) to a chiral liquid crystal (LC) state has been studied on microscopic and macroscopic levels. The induced chirality in achiral LC (nOBA) has been explained by the symmetry lowering of the liquid crystal system due to breaking of the hydrogen bonds (the transformation of the closed dimers in open dimers) caused by temperature or surface action variations.

High temperature formation of polymer-dispersed liquid crystals using the mixture, photo- pre-polymer NOA65/ 4-(octyloxy)benzoic acid/surfactant, was used. By polarization micro-textural analysis, we have observed, in the pre-polymer/liquid crystal mixture, droplets, which seem to be bifocal. These bifocal droplets indicate a twist of the optical axis as a result of temperature variation, and are fixed by photo-polymerization. A mechanism for the possible chiralization in the bifocal drops was suggested.

An improvement of the optical method for surface memorization strength study was proposed. It has been found that the surface polar angle θ, imposed by the suitable surface coatings, can be used as a convenient element for surface memorization (recording) of oriented smectic C textures. This is a possibility to identify the information, coded in the memorized pictures.

We studied the growth of nematic and smectic C liquid crystal textures of nOBA using a holographic diffraction grating as orienting solid surfaces. A smectic A state, which does not exist in the bulk phase diagram of nOBA, and a rotation of the single local monocrystals (SML) was observed by imposing a bulk twist on the LC system. We compare both the erasure activation energy of the smectic C textures, memorized in the nematic temperature range, and the azimuthal surface energy Q and δQ, provided by holographic

diffraction grating topography. We proposed a model for the SML rotation and smectic A induction.

6. THEORETICAL METHODS IN MOLECULAR PHYSICS

Large scale calculations were carried out on the vibrational energy level structure of highly vibrationally excited benzene and ammonia. From a comparison with the experimentally measured frequencies, the values of a large number of harmonic and anharmonic force constants have been determined for the two molecules.

A very good agreement of the calculated with the experimentally measured frequencies was achieved.

THE PHYSICAL MODELS OF VACUUM, PHOTONS AND GLUONS

We found the existing mathematic analogy between three forms : one of the kinetic energy and others of the electric field and magnetic field energy. It turn that in many formulas there are some analogy between the masses and the permeabilities of the electric and magnetic fields, others between the velocity of the motion and the intensities of the electric and magnetic fields and such analogy between the impulse and inductions of the same electric and magnetic fields. It is turn that by means of these obvious analogy we can understand how need to write equation of motion for free electric and magnetic fields. It is well known that the charge disperse within the space determine only a scalar potential of the electric field and the current disperse within the space determine a vector potential of the electric and magnetic fields. It is appear, that the opposite motions of the opposite electric charges within every dynamide, which increases or decreases their dipole moments and creates an electric field , creates also a magnetic field with direction, which is a perpendicular to direction of the electric field and electric current, which is a parallel to the electric field direction. It is turned, that the free electromagnetic field is forced to move in space as a result of the magnetic interaction between the electric current and the magnetic field, created by it. The direction of this motion is perpendicular of the directions of the interacting electric current and the magnetic field. It is naturally that the velocity of the free electromagnetic field is determined by the mechanical properties of the vacuum, which are determined by its electric and magnetic permeabilites ε_o and μ_o and must don't depend on the velocities of its radiator and receiver.

7. MANYPHOTONIC PROCESSES. NONLINEAR OPTICS

Different solid modifications formed by thermotropic liquid crystalline systems are investigated by calorimetry and vibrational spectroscopy. The correlation between their formation and molecular structure is found. Our analysis shows that three factors play significant role for the existence of the solid polymorphs: the flexibility of molecular core, rotational isomers of the paraffinic chains and intermolecular forces. Molecules with loosely held dangling side groups which will tend to loosen the molecular structure, will exhibit glassy and/or other intermediate solid state. The structural factors increasing the stiffness and the size of the moving segments will tend to decrease the probability for other solid phase. The formation and the structure, as well as the temperature behaviour and the phase transitions of the observed solid states are studied.

8. LASER SPECTROSCOPY APPLIED TO BIOLOGICAL SYSTEMS: CHROMATIN STRUCTURE AND DYNAMICS

Emphasis is placed on the study of structural transitions within in vitro reconstituted mono-nucleosomes and nucleosomal arrays induced by the remodeling complexes ACF, and SWI/SNF. Aur main goal is to understand structural-functional properties of chromatin containing histone variants such as: macro H2A, H2ABbd, CENP-A. We also try to understand how and why some transcription factors are able to invade a nucleosome and others are not.

The histone variant H2ABbd was recently identified, but its function is totally unknown. Our functional and structural analysis of nucleosomes and nucleosomal arrays reconstituted with this histone variant showed that H2ABbd can replace the conventional H2A in the nucleosome, but this replacement results in alterations of the nucleosomal structure. The remodelling complexes SWI/SNF and ACF are unable to mobilize the variant H2ABbd nucleosome. However, SWI/SNF is able to increase restriction enzyme access to the variant nucleosome and assist the transfer of variant H2ABbd–H2B dimer to a tetrameric histone H3–H4 particle. Most importantly, the p300- and Gal4-VP16-activated transcription is more efficient for H2ABbd nucleosomal arrays than for conventional H2A arrays (1). These novel properties of chromatin templates that contained the histone variant H2ABbd is another example of how the cell can use the diversity of histone variants to regulate gene expression. Beside, another mechanisme of gene regulation upon binding of the transcription activator NF-kB to nucleosomes has been studued at physico-chemical level (2). Finally the photophysical fetures of laser-induced DNA photochemistry has benn studied by DNA "photofootprinting" technique. The results, generalysed in term of energy-migration mediated biphotonic ionization ane hole transport towards guanines (3, 4), are fundamental in understanding the mechanisms of UV laser indiced DNA-protein "photofootprinting" and covlent crosslinking.

Our interdisciplinary research uses an original combination of physical methods (Cryoelectron, and Atomic Force Microscopy, Optical Tweezers, and the new laser footprinting and protein-DNA crosslinking techniques we developed) together with the state of the art molecular biology methodologies to study a very hot and important biological problem.

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54. D. Angelov, F. Lenouvel, F. Hans, C. V. Müller, P. Bouvet, J. Bednar, E. Mourdianakis, J. Cadet, S. Dimitrov (2004) The histone octamer is « invisible » when NF-kB binds to the nucleosome. *J. Biol. Chem.* **279**, 42374-42382 2004.
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1. J. Hoose, R. Frankel, and E. Popov: "Lamellar grating structure with polarization-independent diffraction efficiency" US patent No. 6,724,533/20 April 2004
2. J. Hoose, R. Frankel, E. Popov, and M. Nevière: "Grating device with high diffraction efficiency" US patent application, 20040021946/February 2004

ONGOING RESEARCH PROJECTS:

1. Spectroscopical investigations of materials for new liquid crystal displaies- PAS Poland-BAS joint research project (Prof. M. Petrov, Ds.C.).
2. Investigation of the role of the light polarization in photonic devices for optical processing of information- Brussels, Belgium-ISSP contract (Assoc. Prof.K. Panayotov Ds.C.).
3. VI EU Framework - Project, 2004-2008, Network of Excellence: (3DTV) Integrated Three-dimensional Television – Capture, Transmission and Display; Contract No. 511568. Growth of amorphous silicon layers with low values of the mechanical tension (Assist. Prof. B. Panchev).
4. Nonlinear optical phenomena in periodical and anisotropic structures - National grant for science Ф1011 (Assoc. Prof. R. Peeva Ph.D.).
5. Investigation of achiral and with induced chirality thermotropic liquid crystals - National grant for science Ф1307 (Prof. M. Petrov, D.Sc.).
6. Relaxation processes in polyatomic molecules - National grant for science Ф1415 (Prof. S.Rashev, D.Sc.).

COLLABORATION:

1.Institute of Low Temperature and Structural Research, Polish Academy of Sciences, Wroclaw, Poland.
2. Free University of Brussels, Departmet of Photonics, Belgium
3. Forschungszentrum Rossendorf, Institut fuer Ionenstralphysik und Materialforschung, Germany.
4. 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” .

TEACHING ACTIVITIES:

Boyko Katranchev, Ph.D. students - thesis in liquid crystals field.

LABORATORY

ATOMIC SPECTROSCOPY

HEAD: **Prof. Kiril Blagoev, Ph.D., D.Sc.**
tel.: 7144-646; e-mail: kblagoev@issp.bas.bg

TOTAL STAFF: **8**
RESEARCH SCIENTISTS**: 7**

Prof. D. Zechev, D.Sc.; Assoc. Prof. P. Pramatarov, Ph.D.; Assoc. Prof. R. Dyulgerova, Ph.D.; Assoc. Prof. M. Stefanova, Ph.D.; V. Mihailov, Ph.D.; E. Dimova, Ph.D.; G. Malcheva, MSc.; PhD student: N. Parvanova

RESEARCH ACTIVITIES:

1. ATOMIC STRUCTURE, SPECTRA AND CONSTANTS

Radiative lifetimes of excited 11 levels belonging to the 5s5p $^1P^o_1$, 5snd $^3D_{1,2}$ (n=6-9) and 5sns $^3S_1$ (n=7, 8) series of Cd I, and of 5 levels of Cd II (i.e. $4d^{10}5p\ ^2P^o_{1/2,3/2}$, $4d^{10}6s\ ^2S_{1/2}$ and $4d^{10}5d\ ^2D_{3/2,5/2}$) have been measured using a time-resolved laser-induced fluorescence technique. Single - or two-step excitation of atoms and ions produced by laser ablation was employed. Branching fractions of Cd II transitions have been measured by laser-induced breakdown spectroscopy. Theoretical data for radiative constants of Cd I and Cd II obtained by MCHF method, taking into account core polarization agree well with experimental values.

Experimental transition probabilities arising from $4d^8\ 5s^2$, $4d^9$ 6s and $4d^9$ 5d levels of Ag II were measured. A time-resolved system with an Nd-YAG laser that produced free neutral and ionized silver plasma by ablation was used. Transition probabilities were deduced by measured branching ratio and theoretical data for radiative lifetimes. Theoretical data were obtained by MCHF method, taking into account core polarization. The agreement of the theoretical and experimental data is good in the experimental error bars.

Excitation transfer process between $^{4,3}He(2^1P, 2^1S)$ and N_2 is investigated by means of time resolved method after pulse electron excitation. The corresponding rate constants and cross sections are obtained.

2. HOLLOW CATHODE DISCHARGE - PROPERTIES AND APPLICATION

The instrumental contributions of the opto-galvanic circuit have been studied by using two types of deconvolutions, i.e. *time*- and λ-dependent. In this way the transient and nonselective light-induced instrumental functions have been found.

The stability of a micro hollow cathode discharge system has been analyzed.

Depth profile element analysis has been made in hollow cathode discharge of Ag covered tapes containing YCaBCO and YBCO high temperature superconducting ceramics. The results clarify the cause for higher critical current for the YCaBCO ceramics: Ag doesn't penetrate into the ceramics core after the thermal and mechanical tapes treatment so the higher critical current is caused by the improve orientation in the sample with Ca substitution.

In order to optimising the technological conditions the investigations performed by depth profile analysis in hollow cathode discharge, Auge- and XPS- spectroscopy of the $SnO_2/SiO_2/Si$ structure modified by hexametildisilazane were summarized as a function of the rapid thermal annealing.

Experimental and theoretical investigations have been carried out of Hydrogen negative ion concentration as a function of the Hydrogen quantity in ($Ne+H_2$) hollow cathode discharge mixture. The results obtained show that this concentration has maximum value in ($Ne+10\%H_2$) discharge and here it has one order of magnitude higher value than in pure Hydrogen hollow cathode discharge.

3. HOLLOW CATHODE DISCHARGES IN ACTIVE LASER MEDIA

Experimental and theoretical investigation on the negative glow plasma of the hollow cathode discharge in ^{3}He-Ne и ^{4}He-Ne gas mixtures is completed. The observed enhanced laser operation on the NeI 1.15 μm line in ^{3}He-Ne is explained.

The electron temperature is lower and the gas temperature is higher in ^{3}He-Ne gas mixture. This results in increased ambipolar diffusion, enhanced recombination of He ions and more effective production of He metastable atoms. The inner multiplet mixing of 2p levels plays an important role in the inversion population mechanism. The enhanced laser operation is due to the increased rate constant of the process of excitation transfer between He (2^3S_1) and Ne ground state atom and increased role of the process of three body recombination of He ions.

Calculations are carried out of the gain on the UV neon ion lines in the region 0.33 nm – 0.37 nm. Using the computing model of 3He-Ne laser it is established that in the pulsed high current hollow cathode discharge there exist conditions for laser oscillations. An experimental study of the UV lasing on the neon ion lines is in progress.

PUBLICATIONS:

1. K. B. Blagoev, G. Malcheva, V. Penchev E. Biémont H. L. Xu, A.Persson and S.Svanberg Physica Scripta,69,433 (2004). "Radiative Lifetimes of Zn I, II Excited States"

2. K. Blagoev, E. Dimova and G. Petrov, J. Quan.Spectr. Rad. Tran.**87,** 69 (2004). "Quenching of ^{4}He(2^1S, 2^1P) and ^{3}He(2^1S, 2^1P) states by collisions with Ne($^1S_0$) atoms"

3.E. Dimova, G. M. Petrov and K. B. Blagoev, VACUUM,**76**,405 (2004). "Quenching of ^{4}He and ^{3}He excited states by collisions with N_2"

4. H. L. Xu, A. Persson, S. Svanberg, K. Blagoev, G. Malcheva, V. Penchev, E. Biemont, J. Campos, M. Ortiz, R. Maio, Phys. Rev. A70, 042508,2004 "Radiative Lifetimes and Transition Probabilities in Cd I and Cd II"

5. H. Xu, A. Persson, S. Svanberg, K. Blagoev, G. Malcheva, V.Pentchev, E.Biémont, Proc. at ILLA'2003 Conference, SPIE, **v. 5449**, p.359 "Radiative lifetimes of Cd I and Cd II excited states"

6.E. Dimova, G. M. Petrov and K. B. Blagoev, ILLA 2003, Smolian,Bulgaria,Proc. SPIE **v. 5449**, p. 350, "Processes of quenching of ^{4,3}He (2^1S, 2^1P) states in $He+N_2$mixture"

7.G. Dobrikov, K. Kolentsov, D. Zhechev, L. Yourukova, M. Rassovska, H. Yosifov and N. Parvanova, Photoluminescent effects in conjugated polymer layers, Vacuum **76,** 227(2004)

8.D. Zhechev, Nely Parvanova and V. Grigorieva, "$Ar^+ \rightarrow Cd$ sputtering-atomizing and coherent-galvanic effects in hollow cathode discharge", Vacuum **76,** 401(2004)

9. N. Parvanova, John Costello and D. Zhechev, "The effect of atomic alignmentand orientation in HCD light-induced conductivity" Proc 22nd Summetr School and International

Symposium on the Physics of Ionized Gases Belgrade 2004 417-20

10. E.Radeva, K. Kolentzov, L. Yurukova, D. Zhechev, E. Dimova-Arnaudova, P. Zabov "Photolumincence spectra of polymer materials, containing Silicon". Int. Conference "Chemistry of solid state and modern micro and nano technologies",2004

11. R. Djulgerova, L. Popova, V. Mihailov, G. Beshkov, A. Szytula, L. Gondek, Z. Lj. Petrovic - "Depth profile analysis of surface modified SnO_2 gas sensors performed in hollow cathode discharge" - Spectrochimica Acta **B59**, 905 (2004)

12. V. Gencheva, V. Mihailov, R. Djulgerova - "Multi-component material sputtering by hollow cathode discharge" - Czechoslovac Journal of Physics, **54**, 903 (2004)

13. L. Popova, R. Djulgerova, , G. Beshkov, V. Mihailov, A. Szytula, L. Gondek, Z. Lj. Petrovic - "SnO_2 thin films for gas sensors modified by hexametildisilazane after rapid thermal annealing" - Sensors and Actuators **B100**, 352 (2004)

14. V. Gencheva, V. Mihailov, R. Djulgerova, "Modeling of ($Ne+H_2$) positive column and hollow cathode glow discharges" Proc. IV Intern. Workshop and School "Towards Fusion Energy – Plasma Physics, Diagnostics, Applications", Poland (2004) 638-642

15. A. Stoyanova-Ivanova, S. Terzieva, A. Zahariev, V. Mihailov, H. Ignatov "Obtaining of YBCO tapes by OPIT method" – Proc. Advanced Studies on Superconducting Engineering(2004), 56-59, I. Vajda, H. Farkas (Eds.),

16. V. Gencheva, V. Mihailov, R. Djulgerova "On hydrogen negative ions concentration measurements depending on H_2 concentration in (H_2+Ne) hollow cathode discharge"

Proc. Contributed Papers 22nd Summer School and Intern. Symposium on the Physics of Ionized Gases (2004), Tara- Serbia and Montenegro, 401-404, Lj. Hadzievski (Ed.)

17. V. Mihailov, R. Djulgerova, M. Todorov, J. Koperski, M. Ruszczak, Z. Lj. Petrovic

"Obtaining of the true dynamic optogalvanic signal from registered one in hollow cathode discharge" Proc. Contributed Papers 22nd Summer School and Intern. Symposium on the Physics of Ionized Gases (2004), Tara- Serbia and Montenegro, 481-484, Lj. Hadzievski (Ed.)

18. P.M.Pramatarov, M.S.Stefanova, A.V.Karelin, Enhanced IR Hollow Cathode Laser in ^{3}He -Ne Gas Mixture", Proc. 10 Int. Symp. on Sci. and Techn. of Light Sources, p.655 Toulouse, France, 2004

TEACHING ACTIVITIES:

PhD student - N. Parvanova, supervisor Prof. D. Zhechev

Organization of the 7th winter seminar of young scientists

R.Djulgerova – Lectures for PhD students "Physical bases of the recent methods for surface and layer analysis"

V. Mihailov - supervisor of M. Terzieva (Sofia University, Faculty of Physics - Master thesis: "Obtaining of YBCO tapes by OPIT method"

ONGOING RESEARCH PROJECTS:

1. Photo-induced effects in low temperature plasma and solid state surface: photo-resonant and surface photo-charge effects" project in the framework of BAS.
2. Micro Hollow Cathode Discharge and applications (supported by Nat Sci Fund, 2003-2006)

3.Radiative lifetimes and transition probabilities of excited atomic and ionic states project in the framework of BAS.
4.Interaction of He (and He isotope) metastable and resonance states with Ne, N, H atoms. - project in the framework of BAS.
5. Recombination and ionization processes in nonequilibrium low temperature plasma project in the framework of BAS.

INTERNATIONAL COLLABORATION:

1. EC Program "Access to Research Infrastructures" RII-CT-2003-506350. – Prof. DSc. K. Blagoev

2. EU Program COST 529 Efficient Ligthning of 21th century – Prof. DSc. K. Blagoev

3. “Possibilities of hollow cathode discharge as a plasma sputtering source for production and investigation of new materials " - Institute of Physics of Jagellonian University, Poland – Dr. R. Djulgerova

4." Investigations of optogalvanic effect in gas mixture hollow cathode discharge plasma – peculiarities and interpretations" - Institute of Physics of Belgrade, Serbia and Montenegro – V. Mihailov (2004-2006)

5. “Analysis of multy-component materials – problems and applications " – Institute of Physics of Belgrade, Serbia and Montenegro – Dr. R.Djulgerova

6. International collaboration under the Problem "Laser spectroscopy of low-living isomers" with Laboratory of Nuclear Reactions, Dubna, Russia – Prof. DSc. D. Zhechev

LABORATORY

METAL VAPOR LASERS

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Blagovela G. **Blagoeva**; Georgi D. **Toshev**; Ivan S. **Radkov**

RESEARCH ACTIVITIES

International and national scientific projects

In 2004 the scientific team at the Laboratory of Metal Vapor Lasers worked on totally seven research projects, as follows: two international projects with additional funding from the NATO Programme Science for Peace and the European Union - the 5th Framework Programme, respectively; two international research projects under agreements for cooperation between Academies and Institutes, one project with the National Council for Scientific Research at the Ministry of Education of Bulgaria, one project with a foreign industrial company and one project with a Bulgarian industrial company.

Scientific activities abroad

In 2004 scientists from the Laboratory of Metal Vapor Lasers visited foreign scientific institutions in pursuance of scientific tasks as follows: for long-term scientific investigations: 1, for giving lectures: 1; and 1 as a member of the International Advisory Committee in the organization of an international conference.

TEACHING ACTIVITIES

PhD students: 3
Graduate (Diploma theses) students: 2

Scientific achievements

1. Metal vapour ion lasers

Studies of the effect of different admixtures on the lasing regime in a pulsed CuBr UV laser were made. It was found that small admixtures of hydrogen (0.2-0.4 torr) resulted in an increase of twice in the laser output power. A stability of up to 5h for the lasing regime was achieved with regular refreshment of the gas.

The pulsed CuBr UV laser created under the Project NATO SfP-971989 'NATO SfP-Excimer Laser' has been used in the laboratory in a project with a French company for processing layers.

Experiments were carried out in a longitudinal hollow cathode discharge for excitation of metal ion laser lines under different conditions with respect to geometry, discharge current and buffer gases. The spectrum of AlI in the UV spectral region was investigated.

Experiments were made for excitation of laser action in thallium ions in the positive column of a pulsed discharge. Investigations continue.

2. Pulsed self-terminating lasers

The possibility of controlling the laser beam from a CuBr laser MOPA system by changing the gas medium parameters and the delay of the amplifier pulse with respect to the oscillator pulse was explored. A new type of diffraction limited unstable resonator was investigated.

Investigations of a strontium recombination laser, emitting in the infrared spectral region have been undertaken. A maximum average output power of 11.5 W was obtained. These investigations are supported by a contract with the company Pulslight.

3. Technological applications of the copper bromide vapor laser

Parametric studies of the interaction between the laser output from a copper bromide vapour laser and different materials were carried out in order to optimize the processes of laser drilling, cutting and marking.

4. Investigations of solid state laser and optical elements

Investigations of a thermo-stabilizing system for the active medium of a solid state fs laser with a ceramic active medium were performed. Investigations were made in Japan and the investigated system was prepared in Bulgaria.

An optical system for adaptive phase control of spectrally broadened fs pulses was built. The result was a decrease of more than twice in the duration of the initial laser pulse. The investigations were made in Greece under the Project COCOMO in the FP5 of the EC.

5. Theoretical studies in non-linear optics

Theoretical studies of coherent excitation of a two-level system and a Gaussian field were made. An effect of dephasing on stimulated Raman adiabatic passage was reported. These studies were under the Project COCOMO in the FP5 of the EC, completed in 2004.

PUBLICATIONS

Papers published and accepted for publication in international journals and proceedings

1. Nikola V.Sabotinov, Development of deep ultraviolet metal vapour lasers, Invited paper, Eighth International Conference on Laser and Laser Information Technologies, edited by Vladislav Ya. Panchenko, Nikola V. Sabotinov, Proceedings of SPIE Vol.5449, pp.79-84, SPIE Bellingham , WA, (2004)
2. Nikola V.Sabotinov, Development of new high power copper bromide lasers, Eighth International Conference on Laser and Laser Information Technologies, edited by Vladislav Ya. Panchenko, Nikola V. Sabotinov, Proceedings of SPIE Vol.5449, pp.103-110, SPIE Bellingham , WA, (2004)

3. N.K.Vuchkov, K.A.Temelkov, P.V.Zahariev, N.V.Sabotinov, A new laser tube construction for the UV Cu+ Ne-CuBr laser, Eighth International Conference on Laser and Laser Information Technologies, edited by Vladislav Ya. Panchenko, Nikola V. Sabotinov, Proceedings of SPIE Vol.5449, pp.173-176, SPIE Bellingham, WA, (2004)

4. N. K. Vuchkov, P. V. Zahariev, K. A. Temelkov, N. V. Sabotinov, Output parameters and a spectral study of UV Cu+ Ne-CuBr laser, Optics and Laser Tech., vol.36, pp.19-25, (2004).

5. Ivailo I. Balchev, Nikolai I. Minkovski, Krassimir D. Dimitrov and Nikola V. Sabotinov, High-precision machining with copper bromide laser, Eighth International Conference on Laser and Laser Information Technologies, edited by Vladislav Ya. Panchenko, Nikola V. Sabotinov, Proceedings of SPIE Vol.5449, pp.5-9, SPIE Bellingham , WA, (2004)

6. I.P.Iliev, S.G. Gocheva, N.V.Sabotinov, On the stability of radio-frequency discharge, Eighth International Conference on Laser and Laser Information Technologies, edited by Vladislav Ya. Panchenko, Nikola V. Sabotinov, Proceedings of SPIE Vol.5449, pp.131-135, SPIE Bellingham , WA, (2004)

7. N.V.Vitanov and B.Girard, Adiabatic excitation of rotational ladder by chirped laser pulses, Phys. Rev. A 69, 033409(13) (2004)

8. Z. Kis, A.Karpati, B.W.Shore, and N.V.Vitanov, Stimulated Raman adiabatic passage between degenerate levels, Phys. Rev. A 70, 053405(20) (2004)

9. P.A. Ivanov, N.V.Vitanov, and K.Bergmann, Effect of dephasing on stimulated Raman adiabatic passage, Phys. Rev. A 70, 063409(8) (2004)

10. K. Takaichi, H. Yagi, J. Lu, J. Bisson, T.Petrov, A. Shirakawa and K. Ueda, T. Yanagitani and A. Kaminskii, "Yb3+-doped ceramic lasers", OSA TOPS Vol. 94, Advanced Solid-State Photonics, 217 – 221, (2004)

11. L. Pramatarova, E. Pecheva, T. Petrov, N. Minkovski, A. Kondyurin, R. Pramatarova, Ion beam modified surfaces as substrates for hydroxyapatite growth induced by laser-liquid-solid interaction, Proceedings of SPIE, v. 5449, 41-45 (2004)

12. L. Pramatarova, E. Pecheva, T. Petrov, N. Minkovski, A. Kondyurin, R. Pramatarova, "Enhancement of hydroxyapatite formation by laser-liquid-solid interaction", Proceedings of SPIE, v. 5449, 46-50, (2004)

13. L. Pramatarova, E. Pecheva, D. Dimova-Malinovska, R. Pramatarova, U. Bismayer, M. Kamenova, T. Petrov, N. Minkovski, Porous silicon as a substrate for hydroxyapatite growth, Vacuum 76 (2-3), 135-138, (2004)

14. L. Pramatarova, E. Pecheva, T. Petrov, A. Kondyurin, R. Pramatarova, N. Minkovski, Ion beam and laser processing for hydroxyapatite formation, Vacuum 76 (2-3), 339-342, (2004)

Accepted for publication

1. N. K. Vuchkov, K. A. Temelkov, N. V. Sabotinov, Effect of hydrogen on the average output power of the UV Cu+ Ne-CuBr laser, IEEE J. of Quantum Electron, vol.41, No1, pp.62-65, 2005.

2. N. K. Vuchkov, K. A. Temelkov, N. V. Sabotinov, UV Cu+ Ne-CuBr laser – some problems with the discharge tube resource, in print in Proceed. of SPIE.

3. N. K. Vuchkov, K. A. Temelkov, N. V. Sabotinov, A comparative investigation on the output characteristics of the UV Cu+ Ne-CuBr laser excited by the Blumlein and IC electrical schemes, in print in Proceed. of SPIE.
4. D. Mihailova, M. Grozeva, and N. Sabotinov, Proc. SPIE, 13th. International School on Quantum Electronics: Laser Physics and Applications (Sept. 2004), Effect of cathode length on the excitation efficiency of a sputtering hollow cathode metal vapor laser.
5. V. Gencheva, D. Charalambidis and N. Sabotinov, Adaptive phase control compression of spectrally broadened fs pulses through self phase modulation in bulk material, in Proceedings SPIE. XXIII International school on Quantum Electronics: "Laser Physics and Application " at Burgas (Bulgaria)(2004)(in press).
6. Ognian Sabotinov, Nikolai Minkovski, Elena Stoykova, and Renzo Salimbeni, Fast Optical Shuttering and Wavelength Selection in Copper Vapor Lasers and Copper Bromide Lasers by Intracavity Polychromatic Acoustooptic Modulation, IEEE J. of Quantum Electron, vol.41, No1, pp.62-65, 2005
7. T. Petrov, K. Takaichi, H. Yoneda, A. Shirakawa, K. Ueda and N. Sabotinov, Novel cooling technique for operation of quasi four level solid state laser, XV GCL/HPL 2004, Proc. of SPIE.
8. L. Pramatarova, E. Pecheva, T. Petrov, R. Presker, M. Stutzmann, Hydroxyapatite kinetic deposition on solid substrates induced by laser-liquid-solid interaction, Proceedings of SPIE, 2005

Papers published in full size in proceedings of conferences

Abroad

1. M. Grozeva, D. Mihailova, and N. Sabotinov, Spectroscopic studies of a sputtering hollow cathode metal vapour laser, 22-st SPIG - Summer School and International Symposium on the Physics of Ionized Gases, Tara, Serbia and Montenegro 2004, ed. L.Hadzievski, Contributed papers, pp.405-408
2. N.K.Vuchkov, K.A.Temelkov, N.V.Sabotinov, UV Cu+ Ne-CuBr laser – laser tube lifetime and some problems with gas mixture, XV International Symposium on gas Flow and Chemical Lasers & High Power Laser Conference, GCL/HPL 2004, Prague, Czech Republic, Book of Abstracts, P1-51, p.137
3. T.Petrov, H.Yoneda, K.Takaichi, A.Shirakawa, K.Ueda, N.Sabotinov, Novel cooling technique for operation of quasi four level solid state laser, XV International Symposium on gas Flow and Chemical Lasers & High Power Laser Conference, GCL/HPL 2004, Prague, Czech Republic, Book of Abstracts, S8-6, p.56