Institute of Solid State Physics
University of Latvia

ANNUAL REPORT

2001

Riga 2002

Annual Report 2001, Institute of Solid State Physics, University of Latvia.
Editor: A.Krumins. Composed matter: A.Muratova. Set up at the Institute of Solid State Physics, University of Latvia, *Kengaraga Str.8, Riga LV – 1063, Latvia.*

Riga, Institute of Solid State Physics, University of Latvia, 2002, p. 130

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INTRODUCTION

The research in solid state physics at the University of Latvia restarted after World War II. The **Institute of Solid State Physics** (ISSP) of the University of Latvia was established on the basis of Laboratory of *Semiconductor Research* and Laboratory of *Ferro- and Piezoelectric Research* in 1978. Since 1986 the ISSP has the status of an independent organization of the University.

Four laboratories from the Institute of Physics of the Latvian Academy of Sciences, working in the field of solid state physics joined our Institute in 1995. Twenty scientists of the former Nuclear Research Centre joined the ISSP in 1999 and established Laboratory of Radiation Physics.

Research and training in optometry and vision science is taking place in the Laboratory of Optical Materials of the ISSP since 1992. Co-located with the Institute, the Optometry Centre has been established in 1995 with facilities for primary eye care and serving as a technological research basis for student and staff .

The research of the ISSP includes:

- studies of electronic and ionic processes in wide-gap materials with different degree of structural ordering;
- development of new inorganic materials (single crystals, glasses, ceramics, thin films) for optics and electronics;
- design and manufacturing of scientific instruments and instruments for analytical tasks and environmental monitoring;
- vision research, development of new technologies for psycho-physical testing and primary vision care.

The highest decision-making body of the Institute is the Council of 23 members elected by the employees of the Institute. Presently Dr. hab. M.Springis is the elected chairman of the ISSP Council. The Council appoints director and its deputy.

The International Supervisory board of ISSP was established in 1999.

Recently the ISSP has intensified its teaching activities. Three research staff members of the Institute have been elected as professors of the University of Latvia. Post graduate and graduate curricula are offered in solid state physics, material science, chemical physics, physics of condensed matter, semiconductor physics, and experimental methods and instruments.

The Scientific Board of the ISSP is eligible to award PhD degrees in physics in the specialities mentioned above and in medical physics.

The annual report summarizes research activities of the ISSP in 2001. The staff of the Institute has succeded in 31 national science grants and in the national cooperation project (Intelligent Materials and Structures for Microelectronics and Photonics) with the total financing of 238.8 thous. lats (Ls) (exchange rate: 1 Ls ~ 1,8 EUR), see Table 1 and Fig.1.

Additional funding from the state budget in 2001 was 64.5 thous. Ls as a support for participation in international conferences (10 thous. Ls), development of scientific equipment (39 thous. Ls) and support to the Centre of Excellence CAMART (15.5 thous. Ls)

Table 1

INCOME OF ISSP, THOUSAND Ls, FROM 1993 - 2000

Year	Total financing	Grants and programs from budget	Other financing from budget	Contracts, market oriented research	Internat. funds	Rent of space
1993	100.7	56.8	-	40.8	-	3.1
1994	211.4	127.8	-	64.2	9.6	9.8
1995	281	145.7	45	38.2	40	12.1
1996	322.5	167.1	11.7	62.4	68	13.3
1997	370	192.1	39	93	26	15.2
1998	414 + 156	205.2	26	114	42	26.5
1999	475.6+186	238.1	48.8	156.5	16.5	15.6
2000	478.8 + 77	238.3	36.9	146.3	43	14.3
2001	617.3	238.8	64.5	116.5	183	14.5

2001 was not so successful for national contracts: the market oriented contracts reached 72.8 thous. Ls, contracts with Latvian companies including SMEs – 43.7 thous. Ls. The drop is due to high international activities of the scientific staff. The descriptions of some instruments and materials developed at the ISSP as a result of contracts are enclosed in the Appendix.

The ISSP income dynamics for 1993 – 2001 is given in Table 1 and Figure 1.

The international funding in 2001 had a remarkable increase – 183 thous. Ls. The main part came from the EC 5th Framework programme:

- for the Centre of Excellence CAMART - 158 thous. Ls;
- for project "Optical devices using photosensitivity for their elaboration" - 7.5 thous. Ls;
- for project "Polar electroceramics" (Growth programme) – 11.2 thous. Ls

Additional support was from the University of Marselle (France) and some Japanese and Canadian SMES.

The Institute obtained 14.5 thous. Ls from leasing part of its space. The rent money decreased since more space has been used by the Institute for its own activities.

Due to the increase of international support deductions for infrastructure from grants and projects has been reduced to 17% in 2001 (see Figure 2).

The interdisciplinary nature of research at the ISSP is reflected by its highly qualified staff (see Figure 5). At present there are 175 employees working at the Institute, 31 of 88 numbers of the research staff hold Dr. hab. degrees, 46 hold Dr. or PhD. At the end of 2001 there were 8 post-graduates and 44 undergraduate and graduate students in physics and optometry programmes working at the ISSP. Educational activities of the Institute were continued and extended in 2001.

In 2001 the reorganization of the ISSP local area computer network (LAN) was completed. More than 80 PC and network equipment elements were connected to the LAN by UTP (unshielded twisted pair) technology instead of the antiquated BNC

Fig.1. Grants, investments in reconstruction and total financing of the ISSP

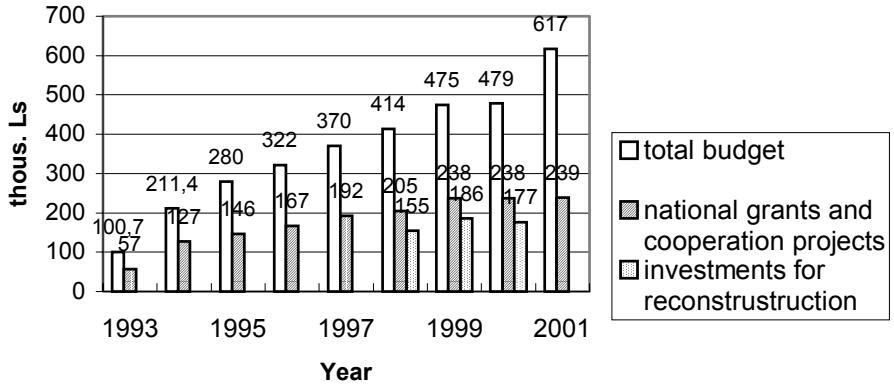


Fig.2. Deduction % from grants to the infrastructure

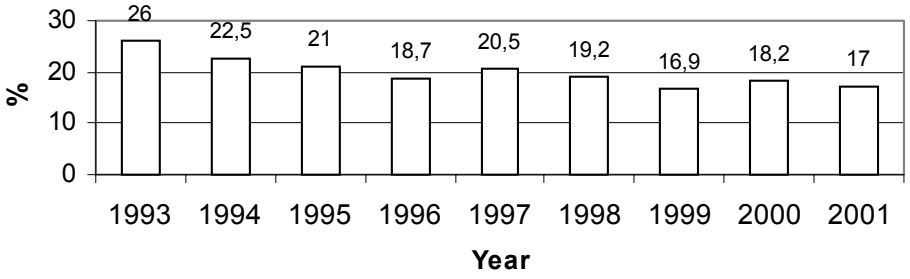


Fig.3. Staff

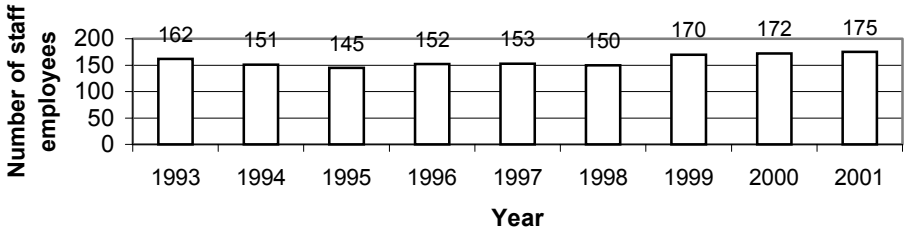
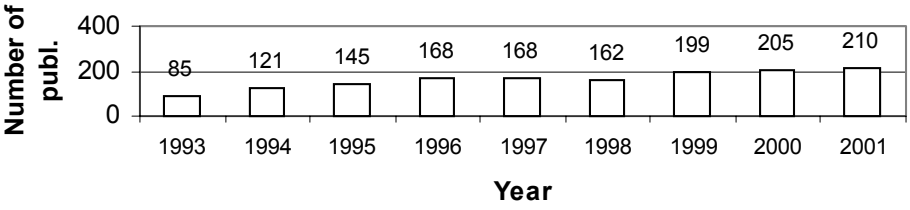
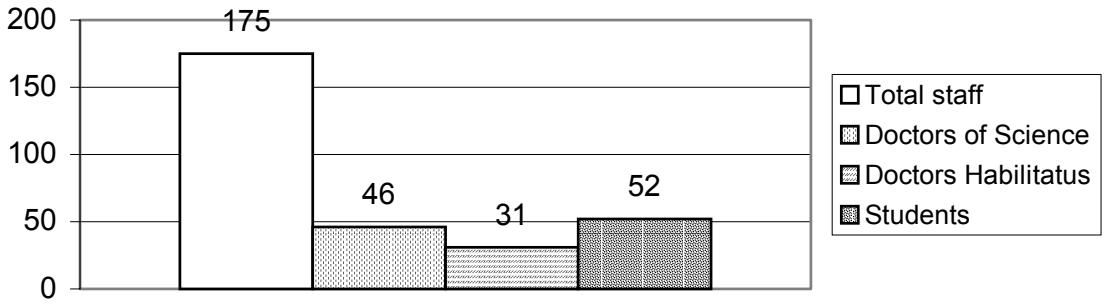


Fig.4. Number of publications



(bayonet nut connector) one. It means that now the LAN of the ISSP uses the UTP and 3M Volition optical fibre technologies with the IBM RS6000 43R-140 main network server and IBM 8274Nways LAN RouteSwitch, installed two years ago. The optical fibre network between the ISSP and the Department of Information Technology (DoIT) of the University of Latvia was completed in such a way that Lattelekom arranged the optical cabling, but ISSP and DoIT funded and upgraded the basic equipment (routers, switches etc.). This communication provides a data transfer rate of 10 Mbps with the upgrade possibility up to 100 Mbps.

Fig.4. Staff number and students in ISSP at 2001



Main achievments in 2001:

1. Establishment of the Centre of Excellence CAMART (see the next chapter): at the ceremonial, opening the Centre The President of Latvia Mrs. Vaira Vike – Freiberga and Prime Minister Mr. Andris Berzins on January 12, 2001 were present;
2. Prof. A.Krumins was elected a member of the Latvian Academy of Sciences;
3. Dr.hab. M.Ozolins was elected as an associated professor of the Department of the Optometry University of Latvia;
4. V.Pankratovs and G.Zvejnieks were acquired degree of doctor in physics;
5. Succesful organization of:
   - Regional seminar of Solid State Ionics, Riga, 22. - 26. September, 2001;
   - NATO Advanced Study Institute "Computational Materials Science" Lucca, Italy, 9. – 22. September, 2001.
6. Two issues of the International journal "Ferroelectrics" (vol.257, 258) have been prepared as Proceedings of the Fifth European Conference on Application of Polar Dielectrics (ECAPD 5) by guest editors Andris Krumins, Inta Muzikante and Vismants Zauls.

Many thanks to everybody who contributed to this report as well as to the organizations that supported the Institute financially: Latvian Council of Science, Science Department of the Latvian Ministry of Education and Science, EC 5th Framework Programme, European Community Council Program COST, NATO Scientific Affairs Division and to many foreign Universities and institutions.

Prof. Dr. A.Krumins

Table 2

ORGANIZATIONAL STUCTURE OF THE ISSP IN 2001

International Supervisory board

Council of Institute
Dr.hab. M.Springis

Director
Dr.hab. A.Sternberg

Deputy director
Dr.hab. A.Krumins

RESEARCH DIVISIONS AND LABORATORIES

Crystal Physics Division
Dr. P.Kulis

Disordered Material Physics Division
Dr.hab.D.Millers

Ferroelectric Physics Division
Dr.hab. A.Sternberg

Semiconductor Materials Division
Dr. A.Lusis

Lab. of Didactic Systems
Dr. J.Kuzmin

Lab. of Nonlinear Processes Theory
Dr.hab. J.Kotomin

Lab. of Optical Recording
Dr. J.Teteris

Lab. of Defect Physics in Ionic Materials
Dr.hab. B.Berzina

Lab. of Surface Physics
Dr.hab. J.Maniks

Lab. of Optical Materials
Dr.hab. I.Lacis

Lab. of Radiation Physics
Dr.hab. J.Berzins

ADMINISTRATION AND SERVICES

Finance and Accounting
A.Jozepa

Mechanical Workshop
J.Katkevics

Domestic services
R.Siatkovskis

Division of Electronic Engineering
Dr. A.Kristins

Library
L.Rihtere

Testing Laboratory
Dr. J.Klavins

ACTIVITIES OF THE CENTRE OF EXCELLENCE

2001 was the first activity year of the Centre of Excellence CAMART - the Centre of Excellence for Advanced Material Research and Technologies. The project was established by the 5th framework Programme of the European Comission, the main tasks of the Centre being:

- to promote restructuring of the science and technology sectors;
- to promote the economic and social needs of the regions;
- to attract young researchers;
- to adopt the best experience in collaboration with the European colleagues.

The support from EC is 703 000 EUR or 400 000 Ls for three years and the funding should be spent on:

- extended visits (more than one month of duration) of foreign colleagues at the ISSP (~ 31%);
- visits of the ISSP employees abroad, including attendance of conference (~ 35%);
- purchase of equipment and materials necessary for foreign colleagues during their visits (~9%);
- overhead expenses (~25%).

During the first year the following common activities of CAMART have been carried out:

1. Increased **activity** of the staff **in the research.** Intensification of collaboration with European universities and companies, increased participation at international conferences and collaboration with colleagues from EC Member States and Associated States.

2. Adoption of the best experience in **collaboration with the European colleagues**. 2001 was the first year when ISSP had a two way mobility. 9 visitors from EC Member States, 13 visitors from EC Newly Associated States, and one visitor from Russia, revealed a remarkable growth of the scientific status of the Institute (Table 3).

3. Improvement of **scientific seminar** of the Institute. In the first year 21 lectures have been presented by the visitors of CAMART to the staff and students of the Institute.

4. Joint **RTD projects with Latvian enterprises** for development prototypes of new multilayer solid state batteries (A/S Sidrabe), intelligent sensor instruments (RTU, A/S Alfa Pro), scintillators (Baltic Scientific Instruments), as well as development of technology of nitride thin films (A/S Alfa) and glass fibers (A/S Valmieras stikla skiedra). Presentation of these projects at international exhibition “Baltic Dynamic”, Riga, September 2001.

5. **Enhanced participation in other areas of 5th Framework Programme** and in other international projects.

In 2001 a contract of 87 500 EUR with EC (Growth programme G5RT-CT-2001-05024) was signed for “Polar Electroceramics” project (supervisor Dr. V. Zauls).

New proposals were submitted for EURATOM programme:

- “Radiation energy detectors and storage read-out materials”, supervisor Prof.I.Tale;
- “Diagnostics of metal ions in fusion plasmas using emission spectroscopy”, supervisor Prof. I.Tale;

- "Irradiation effects in ceramics for heating & current & drive diagnostics", supervisor Dr.A.Sternberg.

All proposals are accepted with the support from EC 37 250 EUR for 2002.

The proposal "Research and Development of Advanced Materials for Micro-electronics and Photonics" were prepared and submitted to "Growth" programme.

Two NATO Science projects and one COST project were supported in 2001.

6. **The regional seminar on Solid State Ionics** was organized at September 22-26, 2001 in Jurmala, Latvia. The Seminar was attended by 53 scientists and students from Belorussia (1), Estonia (2), Germany (1), Latvia (29), Lithuania (3), Poland (8), Russia (7) and Sweden (2). 39 talks were presented on fast ion conductors, intercalation electrodes and devices (batteries, sensors, supercapacitors and fuel cells). Part of these papers will be published in a special issue of "Journal of Solid State Electrochemistry".

7. About 25 **young researchers**, mainly students from Latvian University have been associated with the CAMART projects.

8. Due to financial support from Latvian government, on condition that a part of expenses in covered by EC through 5-th Framework Programme, the following **scientific equipment was purchased** during the second half - of 2001:

- ARS Closed Cycle Cryostat (Price 29 965 EUR, including 1 400 EUR from CAMART);
- Portable Handheld Gas Chromatograph (Price 34 575 EUR, including 2 400 EUR from CAMART)
- Ar laser tube; spectra Physics 08-171 (Price 19 200 EUR, including 10 000 EUR from CAMART).

9. **Activities of Network of Centres of Excellence** "Interfacial Effects and Novel Properties in Nanomaterials":

The second Workshop of Network took place October 5-6 in Ulm (Germany). Dr. D. Millers, Dr. L.Grigorjeva and Prof. E.Kotomin from as ISSP represent actives attended this Workshop and initiated collaborative research of advanced nanostructured materials for scintillators and microelectronics. As a result from the workshop, fruitfull collaboration was developed with the following Centres of Excellence:

- HIGH PRESSURE, Poland;
- CEBIOLA, Lithuania;
- ESTOMATERIALS, Estonia;
- KFKI-CMRC, Hungary;
- AMAS, Poland.

Table 3

ACTIVITIES of CAMART in 2001

Long term visits to CAMART in 2001:

From EC Member States:
Germany: 3
Sweden: 2
Italy: 2
Finland: 1
Austria: 1

From Newly Associated States:
Lithuania: 4
Estonia: 3
Czech Rep.:3
Poland: 3

From other States: Russia:1

Visits of ISSP staff to Conferences and Research Institutions

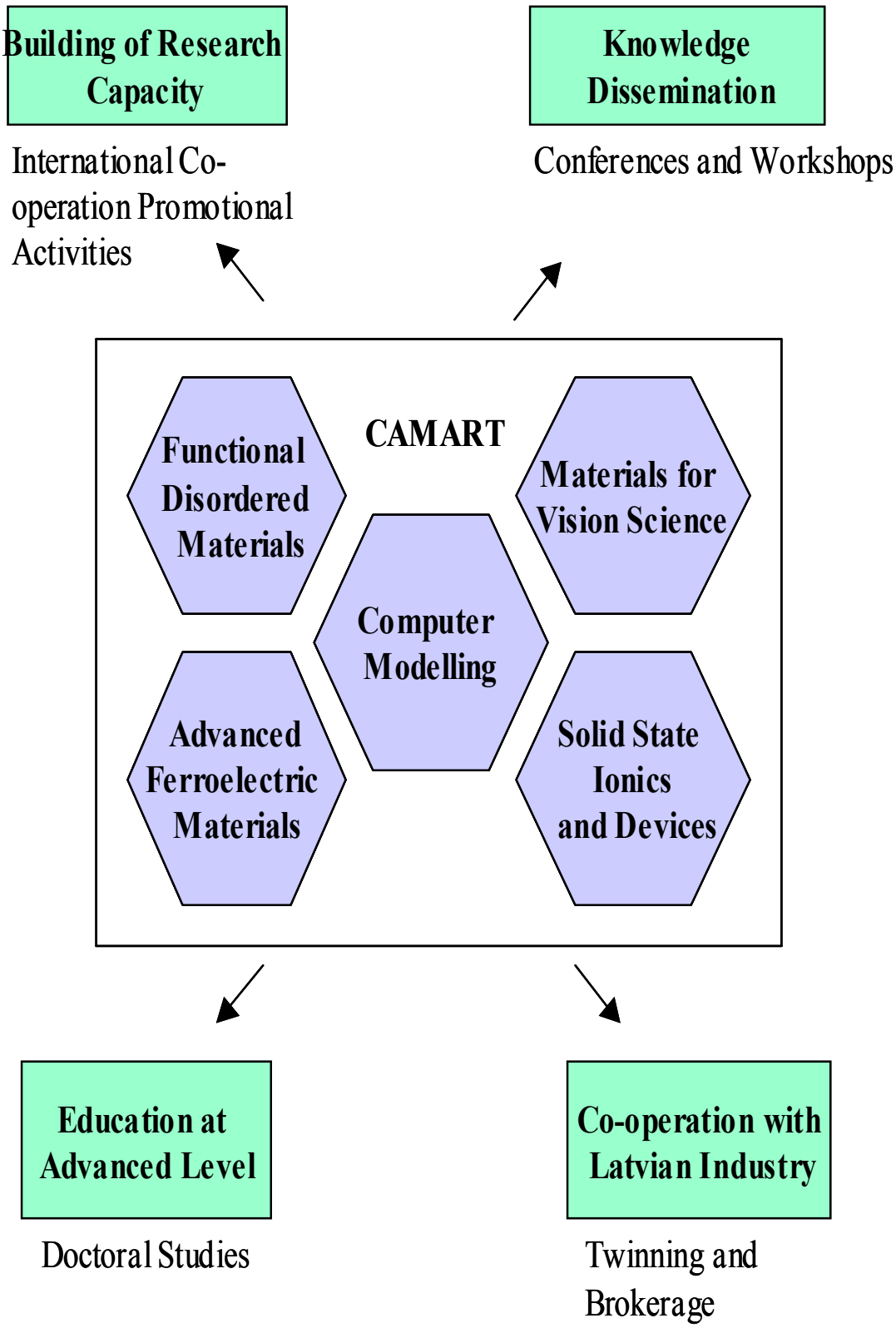
Germany: 13
Czech Rep.: 6
Spain: 4
Greece: 3
France: 3
Portugal: 3
UK: 2
Belgium: 2
Denmark: 2
Netherlands: 2
Israel: 2
Sweden: 1
Italy: 1
Poland: 1
Lithuania: 1
Russia: 1

Equipment and main consumables purchased in 2001 (EC and national funding)

No	Equipment and consumables
1.	Closed cycle cryostat
2.	Portable gas chromatograph
3.	Ar^+ laser tube
4.	Personal computers (3)
5.	Data base “Crystallographic Search Match” and programme “Mathematica”
6.	Computer service and electronic materials

Table 4

Activities of Centre of Excellence (CAMART)



CRYSTALS PHYSICS

Head of Division Dr. P.Kūlis

Research area and main problems

The research area of Division is concerned with three main projects:

1. Recombination mechanisms of the electronic excitations in new optical binary and ternary compounds - the project is aimed to investigate the exact mechanisms of annihilation, localization and recombination of the electronic excitations and their relationships in new binary and ternary inorganic compounds (nominally pure and doped with some active impurities).
2. Technology of Al-Ga nitride semiconductor heterostructures for light-emitting and laser diodes for violet and ultraviolet spectral regions - the goal of the project is the development of light-emitting diodes and laser diodes for violet and ultraviolet spectral region. The project involves synthesis and design of corresponding new materials on the basis of the third group nitrides, elaboration of the thin film heterostructures and further development of production of multifunctional fotonic devices in joint stock company ”Alfa”.
3. Magnetic resonance (EPR, optically detected EPR) investigations of the structure of the intrinsic and radiation defects, and their recombination processes in some actual wide gap scintillator, x-ray storage phosphor and dosimeter materials. The scientific cooperation with other magnetic resonance groups, especially with the University of Paderborn, Germany. A contribution to the better understanding of the defects and processes in luminescent detector materials is expected.

Scientific Staff

1. Mg. J. Jansons
2. Dr. P. Kūlis
3. Dr. A. Pujāts
4. Dr. hab. U. Rogulis
5. Dr. hab. M. Spriņģis
6. Prof. Dr. hab. I. Tāle
7. Dr. V. Tāle
8. Dr. J. Trokšs
9. Dr. Ā. Veispāls
10. Dr. hab. V. Zīraps

Technical Staff

1. A. Muhins

Students

1. Dz. Bērziņš
2. L. Dmitrichenko
3. R. Erts
4. A. Fedotovs
5. A. Guļāns
6. J. Latvelis

7. V. Ogorodņiks (PhD student)
8. P. Sarajevs
9. A. Sharkovkis
10. P. Zarāns

Visitors from Abroad

1. Prof. H.-J. Fitting, University of Rostock, Germany (1 month).
2. Dr. J. Rosa, Czech Acad. Of Science Prague, Czech rep. (1 month).
3. Prof. Dr. C.-C. Yang, Graduate Institute of Electro-Optical Engineering, National Taiwan University, Taipei, Taiwan Republic of China (2 days).
4. Prof. Dr. hab. A. Zukauskas, Institute of Materials Science and Applied Research, Vilnius University, Lithuania (2 days).

Scientific visits abroad

1. Dr. hab. U. Rogulis - University of Paderborn, Germany (6 months).
2. Mg. V. Ogorodniks - Czech Acad. Of Science Prague,Czech rep. (8 months).
3. Dr. hab. I. Tale - Czech Acad. Of Science Prague,Czech rep. (1 week).
4. Dr. hab. I. Tale – Kiev, Ukraine (1 week).
5. Dr. hab. I. Tale – Athens, Greece (1week).
6. Dr. P. Kulis - Athens, Greece (1week).
7. Dr. hab. V. Ziraps - Universite Claude Bernard Lyon 1, Lyon, France (1 week).
8. Dr. hab. V. Ziraps - Semiconductor Physics Institute, Vilnius, Lithuania (1 week).

Cooperation

Latvia

Joint stock company “Alfa”.

Germany

1. University of Paderborn, Germany (Prof. J.-M. Spaeth).
2. University of Rostock, Germany (Prof. H.-J. Fitting, Prof. H. Stolz).
3. University of Osnabruck, Germany (Dr. H. Reyher).
4. Greifswald University, Institute of Chemistry, Greifswald, Germany (Prof. H.Wulff).

Czech Republic

Czech Academy of Science, Prague, Czech Republic (Dr. J. Rosa, Dr. M. Nikl).

Main Results

MATERIALS AND METHODS FOR ADVANCED SLOW NEUTRON IMAGE DETECTION

I.Tale

In Neutron Radiography (NR) and Computed Neutron Tomography (CNT) there is an increasing interest for novel advanced neutron image detection systems.

Advantages in the material research for neutron detectors based on Cooled Charged Coupled Devices (CCD) or photoluminescent Imaging Plates (IP) will be considered.

For direct slow neutron imaging at present the active layer of IP contains a mixture of storage phosphor, usually $BaFBr:Eu^{2+}$ used for imaging X-rays, and a neutron converter material, usually Gd_2O_3, LiF, B or even Dy, and In. Neutron imaging characteristics of CCD cameras are reported. It is shown that IP-ND and CCD systems enables detectability of a single neutron with accurate determination its two dimensional position.

The main disadvantages of present neutron converter-storage phosphor mixture based IP is reduced inherent spatial resolution to the film/Gd metal converter systems anf high sensitivity to X-rays. Prospective further development of slow neutron IP is elaboration of neutron-active storage materials, based on ^6Li- and Ga- compounds having reduced effective Z. Progress in investigation of perspective slow neutron energy storage-read-out materials for IP , e.g. $LiBaF_3$; $LiYF_4$ is considered.

TRAP SPECTROSCOPY BY GLOW RATE TECHNIQUE USING BLEACHING OF COLOR CENTERS

*P. Kulis, I. Tale, and G. Rudlof**

An application of glow rate technique (GRT) for analysis of the parameters of thermostimulated decay of color centers is presented using the data on the decay of radiation defects in $LiBaF_3$:Fe crystals created by X-rays at 300 K. The GRT offers a procedure for evaluation of the mean activation energy as function of temperature in the case of arbitrary thermostimulated relaxation kinetics represented by trap distribution function. The experimental procedure involves at least two subsequent measurements of thermostimulated decay kinetics at different heating rates. It is shown that the decay of the F-type centers is governed by interaction of mobile anion vacancies with F_A- and F-centers leading to both the hopping migration and recombination of F-centers and the thermoactivated dissociation of the F_A-centers.

**Fachbereich Physik, Universitat Rostock, Universitatplatz 3, D-18051Rostock, Germany*

SELF-TRAPPED HOLES IN $LiBaF_3$ CRYSTALS

*I. Tale, M. Springis, U. Rogulis, V. Ogorodnik, P. Kulis, V. Tale, A. Veispals, H.-J. Fitting**

Self-trapped holes (V_K- centres) in x-irradiated $LiBaF_3$ crystals were investigated by electron paramagnetic resonance (EPR), recombination afterglow and thermo-stimulated luminescence (TSL). After x-irradiation at 77 K, an EPR of the self-trapped hole centre $V_K(F_2^-)$ oriented along the [110] axis is identified. The ^{19}F hyperfine interaction parameters of V_K- centres estimated from EPR angular dependencies are: A_{II} = 2520 MHz; $A_\perp$ = 200 MHz; the *g*-tensor parameters are: g_{II} = 2.002 and $g_\perp$ = 2.024. X-irradiation at temperatures below 200 K results in a creation of a long-term temperature-independent afterglow- tunnelling luminescence (TL), with main emission bands at 4.1 eV and 3.15 eV. The short wavelength TL bands are associated with the tunnelling recombination of the electron centre with the V_K- centre, with thermal stability estimated to be about 130 K.

**Physics Department, University of Rostock, Universitätsplatz 3, Rostock, Germany*

ROLE OF SHALLOW ELECTRON TRAPS IN THE FAST TRANSIENT OPTICAL PHENOMENA OF ALKALI HALIDE CRYSTALS

V. Ziraps

We present additional evidences that the same shallow electron traps - the atomic alkali impurity centres $[M^+]_c{}^0e^-$ are responsible for both classes (A and B) of the transient IR-absorption bands: (A) bands with maximum at 0.27–0.36 eV in NaCl, KCl, KBr, KI and RbCl (due to "shallow electron traps" or "bound polarons") and (B) bands with maximum at 0.15–0.36 eV in NaI, NaBr, NaCl:I, KCl:I, KBr:I, RbCl:I and RbBr:I (due to "on-centre STE" or "on-centre STE localised at iodine dimer"). Both classes of the IR bands have the same location, similar shape (exactly coincide for KCl:I and KCl at 10 K or 80 K), half-width, vibration structure. It is established that the same Mollwo-Ivey plot curves $E_o=a/d^n$ (d - nn anion-cation distance, n – exponent, a - constant) take place for both IR band classes, if we plot instead the IR band peak energy values the more definite values of the IR band zero-phonon line energy E_0 (for NaCl, KCl, KBr, RbCl and KCl:I) and/or the IR band low-energy edge energy E_0 (±0.03 eV) values (for NaBr, NaI, NaCl:I, KBr:I, RbCl:I and RbBr:I). Two types of the $[M^+]_c{}^0e^-$ centres are predominant: (i) $[Na^+]_c{}^0e^-$ in KX and RbX host crystals, for which the relation $E_0 \approx 6.15/d^{2.74}$ is valid, and (ii) $[Li^+]_c{}^0e^-$ in NaX host crystals for which the relation $E_0 \approx 29.4/d^{4.72}$ is valid. The Mollwo-Ivey relation $E_o \approx 18.36/d^{2.70}$ is valid as well for the F' band in NaCl, KCl, KBr, KI, RbCl, RbI, if we use the F' centre optical binding energy E_o.values. Under irradiation at 77 K or 4.2 K the shallow trapped electron centres ($[M^+]_c{}^0e^-$ and F' centres) and their associations with the V_k-type centres, *i.e.*, dipolar pairs $\{[M^+]_c{}^0e^-\ldots V_k\}$ and $\{F'\ldots V_k\}$ are created. Such a "quasi-molecular electronic transients" have a very wide lifetime spectrum ($\tau \geq 1$ ns) and can play great role in the intense pulsed excitation experiments.

ION DIFFUSION-CONTROLLED THERMALLY STIMULATED PROCESSES IN X-RAY IRRADIATED HALIDE CRYSTALS

V. Ziraps, V. Graveris, I. Krumins, P. Kulis, I. Tale

The ionic charge transport, trapping-detrapping and interaction processes, which lead to the ion diffusion-controlled thermally stimulated relaxation (TSR) processes in X-ray irradiated at RT wide-gap ionic crystals (alkali halides; CaF_2 and BaF_2; $LiBaF_3$), have been investigated at 290–650 K by means of complex techniques: (a) the electrical techniques - ionic conductivity, ionic TS polarisation current (TSPC), ionic TS depolarisation current (TSDC), TS current (TSC) and (b) the optical techniques - TS luminescence (TSL) and X-ray induced optical absorption spectra thermal bleaching. It is concluded that the ionic TSDC and TSPC data (vacancy and interstitial ion thermal release) above RT correlate with the optical and other TSR data for the X-ray irradiated at RT halide crystals: (a) the radiation-induced changes in the ionic conductivity curves, (b) the TS bleaching curves of the radiation-induced optical absorption bands and (c) the structure of the TSC and TSL curves. The TSR in halides above RT are strongly initiated and controlled by the ionic defect (vacancy and/or interstitial ion) thermal detrapping and interaction with the localised charges. It leads to the *dynamic disordering* of the lattice and the *ion diffusion-controlled TSR processes* in the ionic conductivity region.

RADIATION-INDUCED ELECTRONIC AND IONIC CHARGE STORAGE AND RELEASE IN SAPPHIRE

V. Ziraps, V. Graveris, I. Krumins, and P. Kulis

The radiation-induced charge transport, trapping, thermally stimulated (TS) release and relaxation (TSR) have been investigated at 80–650 K in X-ray or electron irradiated nominally pure sapphire (α-Al_2O_3 grown in different reducing conditions) by means of the TS current (TSC), depolarisation current (TSDC), luminescence (TSL) and electron emission (TSEE) techniques. The TSL peaks around 160 K, 250 K, 280 K, 360–380 K, 460–480 K and 520–550 K are accompanied by well-correlated and strong TSC, TSDC and TSEE peaks. A predominance of the monopolar (electron, c-band transport) component in the TSC, TSEE and TSL is observed at 80–650 K in irradiated sapphire. At the same time, the electron tunnelling recombination in donor-acceptor pairs, as well as electron (or hole) hopping transfer in some selective subsystems (complex relaxators, impurity rich regions, precipitates or even heterostructures) are important in some TSR stages.

After thermal (ionic) polarisation under DC-field of the reduced sapphire two ionic dipolar defects, resulted in the ionic TSDC peaks at T_{max}≈250 K (possibly due to OH^--related defect) and at T_{max}≈590 K (possibly due to an anion vacancy-related defect), have been detected. Above ~450–500 K the hopping of the anion vacancies starts and their interaction with trapped electrons and holes take place. It leads to lattice dynamic disordering and the anion diffusion-controlled TSR processes: (a) TSC, TSL, TSEE, thermal bleaching, (b) oxygen exchange at the grain boundaries, surfaces, dislocations and impurity-rich regions, as well as redistribution of impurities and (c) the F centre aggregation, colloid formation and structure change in the radiation-induced electrical degradation (RIED) phenomena (discovered above 550 K). The strong and wide (560–750 K) TSEE peak at T_{max}≈615 K correlates with the anion TSDC peak at T_{max}≈590 K, the rise of the RIED above 550 K and the TS heat release stage. The purity and surface structure of sapphire, surrounding atmosphere (vacuum or air, partial pressure of oxygen) and electric fields during irradiation highly determine the TSR and RIED phenomena.

STRUCTURE AND LUMINESCENCE OF GaN LAYERS

T.Barfels, H.-J. Fittinng*, J.Jansons, I.Tale, A.von Czarnowski*, H.Wulff***

The growth of thin GaN films on Si substrates by means of low pressure MOCVD technique in a horizontal flow quartz reactor is investigated. The polycrystalline hexagonal structure of GaN layers has been checked by means of grazing incidence X-ray diffractometry and IR spectroscopy. Cathodoluminescence spectra and their kinetics are studied. The mean decay time of the 3.44 eV UV bound exciton transition is below 1 ns, whereas the 3,26 violet band shows a slow hyperbolical decay over 1 μs. The third yellow band appears at 2.25 eV due to transitions via localized states.

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***Institute of Chemistry, Greifswald University, Germany*

MAGNETIC RESONANCE INVESTIGATIONS OF OXYGEN-RELATED LUMINESCENCE CENTRES IN AlN CERAMICS

U. Rogulis, S. Schweizer, J.-M. Spaeth*, L. Trinkler, B. Berzina*

The structure of oxygen-related luminescence centres in nominally undoped and Y_2O_3-doped AlN ceramics were investigated by electron paramagnetic resonance (EPR), electron nuclear double resonance (ENDOR) and optically-detected EPR. The photoluminescence-detected EPR lines having *g* values of 1.990 and 2.008 were attributed to neighbouring donor and acceptor pairs causing the recombination luminescence excited in the ultraviolet. The two EPR lines at $g = 1.987$ and $g = 2.003$, detected via the recombination luminescence in the afterglow, are thought to be due to a recombination between the same, but more distant donor and acceptor pairs. The donor is supposed to be an electron trapped at an oxygen impurity which substitutes for a nitrogen $(O_N)^-$. The defect structure of the acceptor was established by ENDOR to be a hole trapped at an O_N-v_{Al} complex (v_{Al} = Al vacancy).

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ELECTRON PARAMAGNETIC RESONANCE OF GaN DETECTED BY RECOMBINATION AFTERGLOW

*U. Rogulis, S. Schweizer, J.-M. Spaeth**

X-irradiation at 4.2 k of GaN produces a long lasting recombination afterglow (RL). This afterglow quenches in high magnetic fields, but it can be increased by applying microwave radiation (93 GHz) yielding resonance lines (RL-EPR) for appropriate magnetic fields. For a free standing GaN 'lift-off' layer two overlapping RL-EPR lines with different half-widths and almost isotropic *g*-values were observed. The spin-lattice relaxation times were in the range of several minutes. The two resonances are detected in the red spectral range of the RL; one of these resonances is observed in the photoluminescence-detected EPR (PL-EPR) as well. A different RL-EPR spectrum was recorded in a Mg-doped GaN layer. The RL-EPR showed the line of the shallow donor. The difference in the features of the RL-EPR spectra of the two different GaN samples shows, that RL in GaN involves additional electron and hole traps and thus provides additional information not attainable in PL-EPR.

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LUMINESCENCE AND ELECTRON TRANSPORT PROPERTIES OF GaN AND AlN LAYERS

T. Barfels, H.-J. Fitting*, A. Gulans, J. Jansons, M. Springis, H. Stolz*, I. Tale, A. Veispals*

Third group nitrides being wide gap semiconductors are prospective for application as materials for both the luminescence transformers and the selective photo - detectors in visible and ultraviolet spectral region. Thin GaN and AlN films were grown on sapphire substrates by means of low pressure MOCVD technique in a horizontal flow quartz reactor. In our preparation the growth temperature was 900 – 1000 °C. Trimethylgallium or trimethilalluminium with flow rates of 3 – 8 μmol/min and a N_2

flow of 10 l/min as the carrier gas were used as group-III source; NH_3 with flow rates 0.25 – 0.5 mol/min as group-V source. Luminescence, free electron density and Hall mobility of obtained monocrystalline GaN, GaN(Mg) and AlN films of thickness ranging from 0.1 μm to 0.2 μm was investigated.
**Physics Department, Rostock University, Germany*

Scientific Publications
Published in 2001

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2. S. Schweizer, U. Rogulis, S. Assmann and J.-M. Spaeth, *RbBr and CsBr doped with Eu^{2+} as new competitive x-ray storage phosphors.* - Radiation Measurements, 2001, vol. **33**. p. 483-486.
3. V. Ziraps, P. Kulis, I. Tale and I. Tale, *Ion Diffusion-Controlled Processes in Fluoride Crystals.* – Radiation Measurements, 2001, vol. **33**, p. 633-636.
4. T. Barfels, H.-J. Fitting, A. Gulans, J. Jansons, M. Springis, H. Stolz, I. Tale, A. Veispals, *Luminescence and electron transport properties of GaN and AlN layers*. - Radiation Measurements, 2001, vol. **33**, p. 709-713.
5. I. Tale, M. Springis, U. Rogulis, V. Ogorodnik, P. Kulis, V. Tale, A. Veispals and H.-J. Fitting, *Self-trapped holes and recombination luminescence in $LiBaF_3$ crystals*. - Radiation Measurements, 2001, vol. **33**, p. 751-754.
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7. P. Kulis, I. Tale, G. Rudlof, *Advanced trap spectroscopy using the glow rate technique based on bleaching of color centers.* - Radiation Measurements, 2001, vol. **33**, p. 829-832.
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9. V. Ziraps, *Shallow Electron Traps in Alkali Halide Crystals: Mollwo-Ivey Relations of the Optical Absorption Bands.* – Proceedings of SPIE, 2001, vol. **4318**, p.168-173.
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13. K. Michael, U. Rogulis, F.K. Koschnick, Th. Tröster, J.-M. Spaeth, B. Beaumont and P. Gibart, *ODEPR and yellow luminescence intensity in GaN under high pressure.* - Physica B, 2001, vol. **308-310**, p. 85-88.

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3. P.Kulis, V. Ziraps, V. Graveris, I. Krumins. *Radiation-induced electronic and ionic charge storage and release in saphire,* - Radiation Protection Dosimetry, (accepted).
4. V.Ziraps, *Role of Shallow Electron Traps in the Fast Transient Optical Phenomena of Alkali Halide Crystals.* – Material Science Forum, 2001, (accepted).
5. U. Rogulis, S. Schweizer, J.-M. Spaeth, L. Trinkler and B. Berzina, *Magnetic resonance investigations of oxygen-related luminescence centres in AlN ceramics,* Radiation Effects and Defects in Solids, 2001, (accepted).
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7. T. Klempt, S. Schweizer, O. Kanert, D. Suter, U. Rogulis and J.-M. Spaeth, *Magnetic resonance investigations of F centres in LiF caused by ionising radiation*, Rad. Eff. and Def. in Solids, 2001, (accepted).
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1. V. Ziraps, V. Graveris, I. Krumins, P. Kulis and I. Tale, Ionic and ion diffusion-controlled processes in halide crystals. – 17th Scientific Conference, Abstracts and Readings (Institute of Solid State Physics University of Latvia, Riga, 2001) p. 4, (oral presentation).
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4. L. Dimitrochenko, A. Pujats, M. Springis, Spectroscopy of defects in $LiBaF_3$ crystals, - Ibid. p. 50, (oral presentation).
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6. U. Rogulis, V. Ogorodniks, I. Tale, A. Veispals, EPR spectra of LiBaF3 crystals, - Ibid. p. 59, (oral presentation).

7. J. Jansons, I. Tale, LU Pusvadītāju fizikas problēmu laboratorijas dibinātājs profesors Ilmārs Vītols (1410.1931.-19.08.2000.), - Ibid. p. 101-105.

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1. P. Kulis, U. Rogulis, M. Springis, I. Tale, A.Veispals, Radiation defects in LiBaF3, - MRS Spring Meetings 2001, Abstracts, Session G, p.65.

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1. V. Ziraps, On nature of the transient IR-absorption STE-like bands at 0.15-0.35 eV in alkali halides. – Book of Abstracts, abstract P169, (poster presentation).

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1. V. Ziraps, V. Graveris, I. Krumins, P. Kulis and I. Tale, Ion diffusion-controlled thermally stimulated processes in X-ray irradiated halide crystals. – Programme and Book of Abstracts, abstract P-G.21, (poster presentation).

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1. P. Kulis, M. Springis, I. Tale, Annealing of Color Centers in $LiBaF_3$, - Abstracts, p. 87.

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1. U. Rogulis, S. Schweizer and J.-M. Spaeth, Electron paramagnetic resonance of GaN detected by recombination afterglow, - Abstracts p. 69 (oral presentation).
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1. S. Schweizer, U. Rogulis, and J.-M. Spaeth, Oxygen luminescence centres in the scintillator BaF_2 investigated by optically detected magnetic resonance, - Abstracts, p. 138, (poster presentation).
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1. M.L. Falin, K.I. Gerasimov, V.A. Latypov, O.A. Anikeenok, A.M. Leushin, Zh.S. Yakovleva, S. Schweizer, U. Rogulis and J.-M. Spaeth, EPR, ENDOR and magnetooptical spectroscopy of the tetragonal Yb^{3+} center in $KZnF_3$, - Abstracts, p. 137.

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1. J. Jansons. Fizikas sākums Latvijas Universitātē. – Zinātņu vēsture un muzejniecība: LU Raksti, 639. sēj. / Zinātniskais redaktors prof. M. Baltiņš. – Rīga: Latvijas Universitāte, 2001, 151. – 170. lpp.
2. J. Jansons. Profesors Fricis Gulbis – fizikas pamatlicējs Latvijā. – "Latvijas Zinātņu Akadēmijas Vēstis. A daļa: Sociālās un humanitārās zinātnes." 2001., 55. sēj., 3./4. (614./615.) nr. 99. – 107. lpp
3. J. Jansons. Fiziķis Fricis Gulbis, viņa pateicīgie skolnieki un laikabiedri.- "Tehnikas Apskats", Rīgā, 2001, nr. 137/138, 67. – 72. lpp
4. J. Jansons. Jāzeps Čudars – pirmais latgaļu fiziķis (1910-1990). – "Zvaigžņotā Debess", Rīgā, 2001. gada vasara, 69. – 77. lpp.
5. J. Jansons. Pirmajam Latvijas Universitātes Dr. math. Fizikā profesoram Reinhardam Siksnam – 100. – "Zvaigžņotā debess", Rīgā, 2001. gada rudens (173), 46.- 66. lpp.
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7. J. Jansons, I. Tāle. Latvijas Universitātes profesors Ilmārs Vītols. Biogrāfija latviešu, krievu un angļu valodā grāmatā "Profesors Ilmārs Vītols": bibliogrāfiskais rādītājs / LU Bibliotēka; sast. G. Treide; bibliogr. red. D. Paukšēna. – Rīga, 2001, 6. – 22. lpp.
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DISORDERED MATERIAL PHYSICS

Head of Division Dr.hab.phys.D.Millers

Research area and main problems

Advanced materials for nonlinear optics, radiation detectors, fiber optics and high-power UV laser optics are studied with optical absorption, luminescence and time-resolved spectroscopy methods. The key problems studied are:

- the mechanisms of charge self-trapping and trapping at different defects/impurities in complex perovskite oxides (congruent and stoichiometric $LiNbO_3$; $KNbO_3$; $SrTiO_3$);
- the nature and mechanism of scintillation formation in some tugstates ($PbWO_4$; $CdWO_4$; $CaWO_4$; $ZnWO_4$);
- The processes of charge transfer under pulsed electron beam excitation in thallium halides – materials for radiation detectors fabrication.
- the spectroscopic properties of intrinsic point defects in synthetic glassy silicon dioxide,
- Defect creation in glassy silica under laser irradiation and in thermal processes.

Scientific Staff, Solid state radiation physics laboratory

1. Dr. hab.phys. S.Chernov
2. Dr. hab.phys. L.Grigorjeva
3. Dr. hab.phys. D.Millers
4. Dr. hab.phys. I.Plavin
5. Dr.phys.V.Pankratov
6. Dr.phys I.Hinoverova
7. Dr.phys. A.Tale

Scientific Staff, Group of defects studies

1. Dr.hab.phys. A. Silins
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3. Dipl. phys. A. Lukjanska

Technical Staff

1. Eng. A.Sitdikov

Students

1. K. Shmits
2. A.Kalinko

Scientific Visits Abroad

1. Dr.hab.phys. L.Grigorjeva, Czech Republic, Charles University, Institute of Physics (30 days).
2. Dr.hab.phys. L.Grigorjeva, Portugal (7days).
3. Dr.hab.phys. L.Grigorjeva, Germany (30 days).

4. Dr.hab.phys. L.Grigorjeva, Hungary (5 days).
5. Dr.hab.phys. L.Grigorjeva, Poland (3 days).
6. Dr.V.Pankratov, Italy (15 days).
7. V.Pankratov, France (5 days).
8. Dr.hab.phys.D.Millers, Germany (15 days).
9. Dr.hab.phys.D.Millers, Poland (3 days).
10. Dr.hab.phys.D.Millers, Hungary (5 days).
11. Dr.hab.phys. A.Silins, United Kingdom, (5 days).
12. Dr.hab.phys. L.Skuja Portugal (5 days).
13. Dr.hab.phys. L.Skuja Italy, (4 days).
14. Dr.hab.phys. L.Skuja Japan (30 days).

Visits from Abroad

1. Dr. I. Bok, Czech Rep. (30 days).
2. Dr. V. Nagirnii, Estonia (30 days).
3. Mg. P. Potera, Poland (30 days).

Cooperation

Latvia

University of Latvia, (Prof. J.Tiliks).
University of Latvia, Institute of Biology (O.Mutere).
SIA "Baltic Scientific Instruments" (Dr.V.Gostillo).
SIA "Ritec" (Dr. V.Ivanov).

USA

Wake Forest University (Prof. R.T. Williams).

Czech Republic

Academy of Sciences, Institute of Physics (Dr.M.Nikl).
Charles University (Dr.M.Zvara, Dr.P.Hlidek, Dr.J.Bok).

Germany

University of Osnabruck, Department of Physics **(**Prof.S.Kapphan).
Physikalisch Technisches Bundesanstalt PTB Braunschweig (Dr. B. Guettler).

Italy

University of Palermo (Prof. R.Boscaino, Dr. M. Cannas, Dr. S.Agnello).
University of Milano (Prof. G. Pacchioni).

Japan

Tokyo Institute of Technology (Prof. H.Hosono, Dr. K.Kajihara).

Estonia

Institute of Physics, Tartu (Dr.V.Nagirnii).

Hungary

Hungarian Academy of Sciences, Research Inst. for Solid State Physics & Optics, Crystal Physics Laboratory (Dr.G.Corradi, Dr.K.Polgar, Dr.A.Watterich).

Russia

University of Kemerovo (Prof.E.Aluker).
GOI, St.Peterburg (Dr.L.Maksimov).
Ioffe Phys.Techn.Inst. RAS (Dr.V.Trepakov, Dr. A.Badaljan).

Ukraine

University of Lvov (Prof. Voloshinovskii).
State University "Lvivska Politechnika" (Prof. A.Matkovskii).

Poland

Polish Academy of Science, UNIPRESS (Prof.W.Łojkowski).

Main Results

TRANSIENT ABSORPTION OF POLARONS IN $KNbO_3$.

L. *Grigorjeva, V. Pankratov, D. Millers, G. Corradi[**], K. Polgar[**], R.T.Williams[*], Yong Qui[*], K.B.Ucer[*]*

Transient absorption spectra have been measured in a number of undoped $KNbO_3$ crystals following two kinds of electronic excitation: two-photon absorption of 200-fs laser pulses and 10-ns pulsed electron beam. A band peaking at 0.8 eV and broad, poorly resolved absorption in the range 1.3-3.3 eV were observed. Based on similarity to the 1-eV band in $LiNbO_3$ previously identified as the intrinsic electron polaron (electron self-localized on niobium in the regular lattice site), we suggest that the transient absorption band at 0.8 eV in $KnbO_4$ is also associated with the intrinsic electron polaron.

In cooperation with:[*] Wake Forest University, USA
[**] Hungarian Academy of Sciences, Research Inst. for Solid State Physics & Optics, Crystal Physics Laboratory

FAST RELAXING ABSORBTION IN TUNGSTATES

*V.Pankratov, L.Grigorjeva, D.Millers, S.Chernov, A.S.Voloshynovskii[**], A.Watterich**

The tungstate crystals are well known scintillators. The mechanism of luminescence center formation and the luminescence center model are under discussion up today. The results of time-resolved spectroscopy of luminescence center in $ZnWO_4$,

$CaWO_4$ $PbWO_4$ and $CdWO_4$ in wide temperature region was presented. The luminescence and induced absorption under pulsed electron beam excitation (pulse duration 10 ns, 0.26 MeV) were studied. The experimental equipment used allows obtaining the transient absorption spectra, luminescence decay kinetics and transient absorption relaxation times.

Crystallographically, tungstate crystals can form two structure modifications: sheelite-type and wolframite-type. The luminescence center in both types represents the tungstate-oxygen complex (WO_4^{2-} in $CaWO_4$ and $PbWO_4$ and WO_6^{6-} in $ZnWO_4$ and $CdWO_4$). In spite of different complex symmetry the efficiency of luminescence center formation in both type crystals is high. According to preconceived idea the luminescence is due to self-trapped exciton on the tungstate sublattice. The precursors for exciton formation are a self-trapped hole (O^-- type center) and electron temporary trapped at W site. The luminescence center excited state absorption was studied in Ca, Pb and Zn tungstates, the results for $CdWO_4$ are presented in our previous paper. Comparison of luminescence and induced absorption life-time temperature dependencies gives a strong evidence that absorption observed in Ca, Pb, Cd and Zn tungstates is due to electron transition from the luminescence center excited state (exciton) to some upper state.
Besides the luminescence center excited state absorption the transient absorption from trapped holes and electrons was observed in some tungstates studied. The delay between electron-hole creation and exciton formation observed in some tungstates indicates that a large fraction of excitons is not formed directly from band carriers.
In cooperation with: [**]*Hungarial Academy of Science, Research Inst. for Solid State Physics &Optics*; [*]*Franko National University of Lviv, Physics Department, Lviv, Ukraine*

THE MODEL OF RECOMBINATION PROCESS IN TlBr

L.Grigorjeva, D.Millers

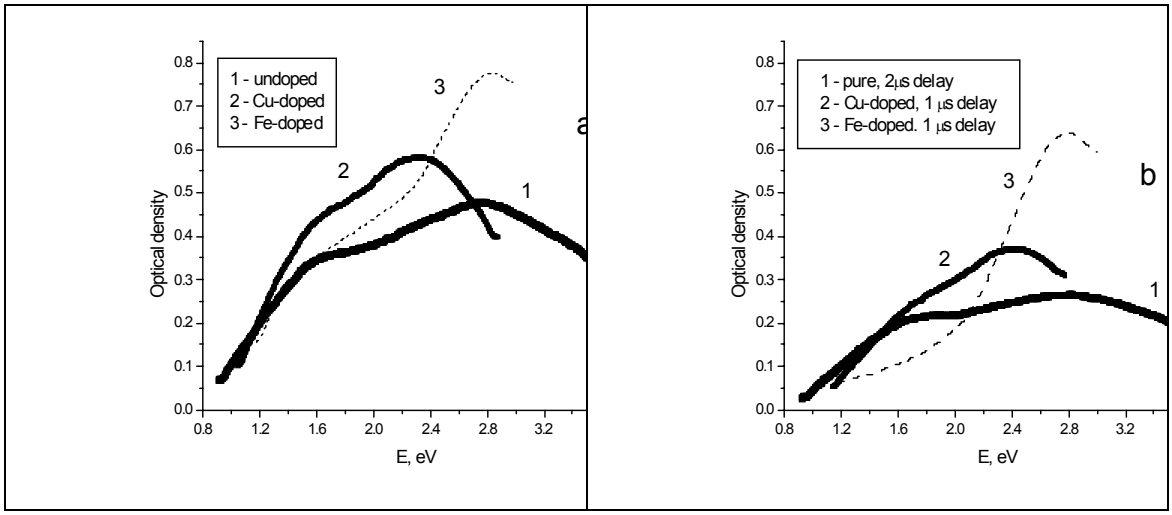
The time-resolved luminescence was used for the study of recombination process in different undoped TlBr crystals. The spectra and decay kinetics under electron beam excitation was investigated. A number of different luminescence bands with different decay rate shows that more than one recombination center is involved and recombination process is quite complicated. The band at ~2.5 eV is dominant under excitation pulse (electron beam and nitrogen laser pulses with 10 ns duration). The results from short-lived absorption and luminescence are used in analysis of possible recombination processes in TlBr.

THE ROLE OF THE Fe AND Cu DOPING TO ELECTRON-HOLE TRAPPING AND RELAXATION PROCESSES IN CONGRUENT $LiNbO_3$

V.Pankratov, D.Millers, L.Grigorjeva, A.O.Matkovskii[**], P.Potera[**], I.Pracka[***], T.Łukasiewicz[***]

The transient absorption spectra and optical density relaxation kinetics in undoped congruent $LiNbO_3$ as well as Fe and Cu doped crystals was studied. The pulsed electron beam (the pulse duration 10ns) was used for electron-hole pair creation.

The spectra measured after pulse (0 delay time) and after delay are shown in Fig.1 (a and b, respectively).



The shoulder at ~1.6 eV was observed in all samples under investigation. It is known that the electron polarons bound at antisite niobium gives rise to the absorption peaking at 1.6 eV. The number of these polarons is approximately the same for undoped and Fe-doped samples and somewhat larger in Cu-doped sample. The hole polaron are known to be responsible for absorption at ~2.5 eV. In this region the different absorption bands is observed for samples studied. The spectra shows that above 1.8 eV strong overlapping of several bands take place. Some contribution due to the dopands recharging is possible also. The models of relaxation processes are under discussion.

In cooperation with:**Institute of Physics HPS, Rzeszow, Poland*

****Institute of Electronic Materials Technology, Warsaw, Poland*

LASER-INDUCED COLOR CENTERS IN SILICA

L.Skuja, H.Hosono, M.Hirano**

A review of color centers contributing to the optical absorption spectrum of synthetic silica glass in the near infrared - to vacuum UV range is presented. Intrinsic defects related to oxygen deficiency are characterized: E'- centers, oxygen vacancies, divalent silicon and defects related to oxygen excess: oxygen dangling bonds, peroxy radicals, interstitial oxygen and ozone molecules. The optical properties of common impurities/dopants in synthetic silicas used in laser optics and their influence on laser toughness are discussed.

**In cooperation with*: *Tokyo Institute of Technology, Japan*

DEFECT GENERATION IN FUSED SILICA UNDER HIGH INTENSITY LASER INTERACTION

A. Silins

Interaction of high intensity laser radiation with fused silica mainly introduces strong temperature increase in the region where this radiation is absorbed. The local temperature rises up to 2500 K or higher. At these temperatures high concentrations of thermal intrinsic point defects are generated. Estimated concentrations of equilibrium oxygen excess defects at 2500 K reaches $7*10^{18}$ cm^{-3} and the main part of these defects are non –bridging oxygen atoms. Before equilibrium large part of oxygen excess defects are oxygen molecules. Presence of oxygen molecules in concentration $3*10^{18}$ cm^{-3} creates the local internal pressure 1.0 atm. at 2500 K. As the result, the boiling and

evaporation of the material from the region where high intensity laser radiation is absorbed occurs. Remaining material contains increased concentrations of oxygen deficit point defects, such as three – and two - fold coordinated silicon atoms, as well as oxygen excess point defects which are tightly bonded to the glass network, such as non - bridging oxygen atoms. Presence of these defects causes the strong increase of UV - wavelength laser radiation absorption. This stimulates additional laser interaction with fused silica. New features in defect generation appear when very short (femtosecond) laser pulses are used. In this case the laser pulse length is comparable with the period of main atomic vibrations in fused silica. Such conditions open new subtreshold intrinsic defect generation mechanisms.

FORMATION AND DECAY OF NON-BRIDGING OXYGEN HOLE CENTER IN SIO_2 GLASSES INDUCED BY F_2 LASER IRRADIATION: IN-SITU OBSERVATION USING A PUMP-AND-PROBE TECHNIQUE

K.Kajihara, L.Skuja, M.Hirano*, H.Hosono**

Formation and decay of nonbridging oxygen hole centers (NBOHC, an oxygen dangling bond) in SiO_2 glasses by F_2 excimer laser (7.9 eV) irradiation were *in situ* analyzed by monitoring 1.9 eV photoluminescence of NBOHC using a pump-and-probe technique. In wet SiO_2, the SiO–H bond was efficiently photolyzed by F_2 laser photons to form NBOHC with a quantum yield of around 0.2. However, the recombination with dissociated hydrogenous species suppressed the buildup of NBOHC. In dry SiO_2, in contrast, NBOHC formation by dissociation of strained Si–O–Si bonds was inefficient but NBOHC accumulated with the number of F_2 pulses due to a negligibly slow reverse recombination reaction.

**In cooperation with*: *Tokyo Institute of Technology, Japan*

Scientific Publications
Published in 2001

1. S.Chernov, D.Millers, L.Grigorjeva, V.Pankratov. *Transient absorption spectra and relaxation kinetics in the $PbWO_4$-Nb scintillation crystals*. Radiation Measurements, 2001, vol. **33**, No.5, p. 659.
2. L.Grigorjeva, D.Millers, S.Chernov, V.Pankratov, A.Watterich. *Luminescence and transient absorption in $ZnWO_4$ and $ZnWO_4$*-Fe crystals. Ibid., 2001, vol.**33**, No.5, p. 645.
3. L.Grigorjeva, V.Pankratov, D.Millers, G.Corradi, K.Polgar. *Transient absorption and luminescence of $LiNbO_3$ and $KNbO_3$*. Integrated ferroelectrics, 2001, vol. **35**, p. 137
4. A.Tāle, I.Pļaviņa, *Spatial correlation of latent image centres active in photostimulable luminescence of irradiated doped alkali halides*. In:''Advanced Optical Materials and Devices'' 16-19 August, 2000, Vilnius, Lithuania, Proc. SPIE, 2001, vol.**4318**, p.180-185.
5. И.К.Плявинь, А.К.Тале. *Пространственное распределение дефектов в фотостимулируемых щелочно-галоидных кристаллах*. Автометрия, N6, 2001
6. V.Pankratov, D.Millers, L.Grigorjeva, S.Chernov. *Transient optical absorption and luminescence in calcium tungstated crystal.* Phys.Stat.Sol.(b), 2001, vol. **225**, No.2, R9.

7. O.Muter, D.Millers, L.Grigorjeva, E.Ventina, A.Rapoport. *Cr(VI) sorption by intact and dehydrated Candida utilis cells: differences in mechanisms*. Process Biochemistry , 2001, vol. 37, p. 505-511.
8. L.Skuja, H.Hosono, M.Hirano *Laser-induced color centers in silica*. Proc. SPIE, 2001, vol. **4347**, p.155-168 (invited review article).
9. K.Kajihara, L.Skuja, M.Hirano, H.Hosono *Formation and decay of non-bridging oxygen hole center in SiO_2 glasses induced by F_2 laser irradiation: In-situ observation using a pump-and-probe technique.* Appl.Phys.Lett., 2001, vol.**79**, No12, p.1757-59.
10. L.Skuja *Color Centers and Their Transformations in Glassy SiO_2 – Lecture 12-L3, Proceedings of the Euro Summer School on Photosensitivity in Optical Waveguides and Glasses, (supported by the European Community),* Giens, Côte d'Azur France (July 8- July 14 2000, published on CD-ROM October 5 2001, ISBN 2-9517407-0-0).
11. A.Silins *Point defects in optical glasses*. In: *Invited papers of XIX International Congress on Glass*, International Commision on Glass, (Edinburgh, Scottland, July 1-6, 2001), p.215-225,
12. A.Silins *Defect generation in fused silica under high-intensity laser interaction*. Proc. SPIE, 2001, vol. **4347**, p.207-211.

In Press

1. V.Pankratov, L.Grigorjeva, D.Millers, S.Chernov. *Luminescence center excited state absorption in tungstates.* J. Luminescence, 2001, (accepted).
2. Yong Qiu, K.B.Ucer, R.T.Williams, L.Grigorjeva, D.Millers, V.Pankratov. *Transient absorption of polarons in $KNbO_3$.* Nucl.Instrum.and Methods In Physics Research, B, 2001, (accepted).
3. L,Grigorjeva, D.Millers. *The model of recombination process in TlBr.* Ibid, (accepted).
4. I.Plavin, A.Tale, *Luminescence responses of KBr:In at room temperature in the case of electron irradiation*, Latvian J. of Phys. and Techn. Sci., 2001, (accepted).
5. L.Grigorjeva, V.Pankratov, D.Millers, G.Corradi, K.Polgar. *Relaxation of electronic excitations in $LiNbO_3$ crystals*. Ferroelectrics, 2001, (accepted).
6. D.Millers, L.Grigorjeva, V.Pankratov, S.Chernov, A.Watterich. *Time-resolved spectroscopy of $ZnWO_4$.* Radiat.Effects and Defects in Solids, 2001, (accepted).
7. R.T.Williams, K.B.Ucer, H.M.Yochum, L.Grigorjeva, D.Millers. G.Corradi. *Self-trapped electron and transient defect absorption in niobate and tungstate crystals*. Ibid., 2001, (accepted).
8. L.Skuja, K.Kajihara, T.Kinoshita, M.Hirano *The behavior of interstitial oxygen atoms induced by F_2 laser irradiation of oxygen-rich glassy SiO_2.* Nucl.Instrum.and Methods In Physics Research, B, (accepted).
9. L. Skuja, M. Hirano, K. Kajihara, H. Hosono *Point Defect Creation By Photochemical Processes In Glassy Silica.* Physics and Chemistry of Glasses, (accepted).

Lectures on Conferences

17. Scientific Conference, Institute of Solid State Physics, University of Latvia, Riga, 19-23. February, 2001.

1. I.Pļaviņa, A.Tāle. Possible role of exciton polaitons in spatial correlated defect pairs generation in activated alkali halides at room temperature. Abstracts, p.51.
2. V.Pankratov, L.Grigorjeva, D.Millers, S.Chernov. Electron excitation and models of luminescence centers in tungstate crystal. Ibid, p.52.
3. L.Grigorjeva D.Millers, V.Pankratov, E.A.Kotomin, R.I.Eglitis. Polaron effects in $LiNbO_3$ and $KNbO_3$ perovskite crystals. Ibid, p.53.
4. V.Pankratovs. L.Grigorjeva, D.Millers, S.Chernov. Electron excitation and models of luminescence centers in tungstate crystal. Ibid, p.52.
5. A.Silins High intensity laser irradiation induced defects in fused silica, ibid, p.55.
6. L.Skuja, H.Hosono Interstitial oxygen atoms in silicon dioxide, ibid, p.56.

Workshop on "Defect Properties in oxidic crystals" Universitate of Osnabruck, June 9-12, October, 2001.

1. L.Grigorjeva, Recombination of polarons in complex oxides, (oral presentation)
3. D.Millers. Absorption due to polarons in $SrTiO_3$, (oral presentation).

Fourth Annual Meeting of the COST Action P2. Application of Nonlinear Optical Phenomena. Workshop on $LiNbO_3$. Budapest, 16-19 May, 2001

1. V.Pankratov, D.Millers, L.Grigorjeva, A.O.Matkovskii, P.Potera, I.Pracka, T.Lukasiewicz. The role of the Fe and Cu doping to electron- hole trapping and relaxation processes in congruent $LiNbO_3$. Abstract, p.PI21.
2. D.Millers, L.Grigorjeva, V.Pankratov, G.Corradi, K.Polgar. Comparison of polaron relaxation in stoihiometric, congruent and Mg-doped $LiNbO_3$. Ibid. p.PI.20.

Radiation Effects in Insulators (REI-11), Lisbon, Portugal, 03-07, September, 2001.

1. Yong Qiu, K.B.Ucer, R.T.Williams, L.Grigorjeva, D.Millers, V.Pankratov. Transient absorption of polarons in $KNbO_3$. Abstracts, p.60.
2. L.Grigorjeva, D.Millers. The model of recombination process in TlBr. Ibid, p.150.
3. D.Millers, L.Grigorjeva, V.A.Trepakov, S.E.Kapphan. Pulsed electron beam excited transient absorption in $SrTiO_3$. Ibid, p.148.
4. L.Skuja, K.Kajihara, T.Kinoshita, M.Hirano The behavior of interstitial oxygen atoms induced by F_2 laser irradiation of oxygen-rich glassy SiO_2. Abstracts, p. 149.

XIX International Congress on Glass, Edinburg, UK, July 2-6, 2001.

1. L. Skuja, M. Hirano, K. Kajihara, H. Hosono Point Defect Creation By Photochemical Processes In Glassy Silica. Extended Abstracts.
2. A.Silins *Point Defects in Optical Glasses* (Invited paper).

International Workshop "Physical aspects of the luminescence of complex oxide dielectrics" (LOD'2001), Kyev, Ukraine, 24-26 September, 2001.

V.Pankratov, L.Grigorjeva, D.Millers, S.Chernov, A.Voloshinovskii.. Fast relaxating absorption in tungstates. Abstracts, p.41.

18 Course Spectroscopy of Systems with Spatially Confined Structures. A NATO advanced Study Institute. Erice-Sicily, Italy, 15-30 June, 2001.

V.Pankratov. Luminescence Center excited state absorption in calcium and zinc tungstates. Abstracts, p.41.

International Conference on Dynamical Processes in Excited States of Solids (DPC'01). Lyon, France, 1-4 July, 2001.
V.Pankratov. L.Grigorjeva, D.Millers, S.Chernov. Luminescence center excited state absorption in tungstates. Abstract, p.P170.

II Workshop of the Network of Centers of Excellence "Interfacial effects in nanostructured materials". Ulm. Germany, 5-6 October, 2001.
D.Millers, L.Grigorjeva. Advanced scintillators from nanostructured materials. Proceedings, p.17.

PhD Thesis.

Mag.fiz.V.Pankratov. **The relaxation of electronic excitation and luminescence center formation in tungstate and niobate crystals.** Doctor of physics Thesis, Riga, 2001.

DISORDERED MATERIAL PHYSICS

Head of division Dr. hab. phys. D.Millers

SOLID STATE OPTICS LABORATORY

Head of Laboratory, Professor, Dr. hab. phys., A.Trukhin

Research area and main results

The electronic excitations, intrinsic and impurity defect of the ordered materials (crystals) and the disordered material (optical glasses) are the main objects of Solid State Optics Laboratory of DMP. The problem is electronic structure and peculiarities of electronic processes in glass-forming materials on example of optical glasses, related crystals or related gases.

The common property of electronic states in disordered materials is existence of localised states in spite of wavefunction overlapping. The problem is in search of these states and modelling of geometrical and electronic structure as well as electronic processes related to them. Understanding of that is will help in modern application of disordered optical materials such as optical telecommunication, information storage.

Scientific staff

1. Professor, Dr. hab. phys. A. Trukhin
2. Dr. Phil., Dr. phys. K.Truhins

Visitors from Abroad

1.V. Cannas, Lab. Physico-Chimie des Solides, France (ODUPE exchange), Universite Paris Sud, Orsay,

Scientific Visits Abroad

1. Dr. Phil., Dr. phys. K.Truhins, USA, Postdoctoral position at University of Illinois at Chicago, Chicago, Illinois 60607 USA.
2. Professor, Dr. hab. phys. A. Trukhin, University of Irkutsk, Russia (1 month).
3. Professor, Dr. hab. phys. A. Trukhin, Orsay, Lab. Physico-Chimie des Solides, Universite Paris Sud , France, (15 days).
4. Professor, Dr. hab. phys. A. Trukhin, Estonian Science Foundation, Tallinn, Estonia (10 days).

Cooperation

Russia

State University of Irkutsk, Institute of Geochemistry (Prof. E.A. Radzhabov, A.I. Nepomnyaschihk).

Germany

University of Rostock, Germany (Prof. Dr. H.-J. Fitting).

USA

Wake Forest University, Winston Salem , North Caroline (Prof. Ph.D. R.T.Williams).
Solid State Division, Oak Ridge National Laboratory, Oak-Ridge, TN. 37831 (Ph.D. Lynn A. Boatner).
University of Central Florida, CREOL (Prof. Dr.L.B.Glebov).
University of Illinois at Chicago, Illinois 60607-7061 (Professor, Robert J.Gordon).

France

Universite Paris Sud, Orsay, Lab. Physico-Chimie des Solides UMR8648,
(Dr.B. Poumellec).

Main Results

CATHODOLUMINESCENCE OF CRYSTALLINE AND AMORPHOUS SIO_2 AND GEO_2

H.-J. Fitting, , T. Barfels, A.N. Trukhin, B. Schmidt*

Cathodoluminescence (CL) and its temperature-dose behaviour are presented for different crystalline and amorphous modifications of SiO_2 and GeO_2 as well as for Ge-doped SiO_2 layers. The crystalline samples include four-fold coordinated Si and Ge in hexagonal quartz and quartz-like crystals, respectively, as well six-fold coordinated atoms in tetragonal rutile-like crystals. The detected luminescence bands, in general, are attributed to three optical active luminescence centres: the two-fold coordinated silicon (‹ Si:) and germanium (‹ Ge:) center, respectively, the non-bridging oxygen hole centre (NBOHC) and the self trapped exciton (STE). The frst ones, the oxygen deficient centers

(ODC), are especially developed in both, in the tetragonal crystal rutile-like modifications as well as in glassy states. The huge violet luminescence in Ge-implanted SiO_2-layers is attributed to the two-fold coordinated Ge in the silica matrix.
**In cooperation with: Physics Department, Rostock University, Institute of Ion Beam Physics, Research Center Rossendorf, Dresden*

ELECTRON BEAM INDUCED OPTICAL AND ELECTRONICAL PROPERTIES OF SIO_2

H.-J. Fitting, T. Barfels*, A. von Czarnowski*, A.N. Trukhin*

Ionizing radiation in dielectric and optically transparent silica as well as thin SiO_2 layers produces defect luminescence as well as charge storage. A comparison of different excitation–relaxation processes like cathodoluminescence, charge injection and trapping, secondary electron field emission, and exoelectron emission leads to a generally similar excitation dose behaviour described by an electron beam saturation dose of 0.01–0.1 C/cm^2 . This suggests a correlation of these four electron excitation mechanisms likely related to the same kind of defect in glassy SiO_2 , the 2-fold-coordinated silicon _Si: centre with typical electronic singlet –singlet and singlet –triplet transitions according the Skuja model.
**In cooperation with: Physics Department, Rostock University*

INFLUENCE OF OXYGEN AND SILICON IMPLANTATION ON SILICON DIOXIDE THIN FILM CATHODOLUMINESCENCE

T.Barfels, J.Jansons, H.-J.Fitting*, I.A.Tale, A.N.Trukhin*

The implantation of oxygen and silicon was performed in pure thin films of silicon dioxide on silicon. Then cathodoluminescence spectra were measured. The regimes for implantation and CL measurement were described in [1]. The idea of experiment is based on previous investigation of oxygen implanted silicon dioxide samples [2], where it was found that the blue cathodoluminescence could be activated in such a way. However, in general the blue luminescence of silica glass is ascribed to oxygen deficient luminescence centers (ODC).

The now performed experiment shows that all studied samples posses' three main bands: Red and Blue with a shoulder in the Green region developed at low temperatures, and a UV band especially under cathodoexcitation. The UV band is small in intensity for all cases as usual for excitation by ionising irradiation of ODC in silica. It is weakly depending on the irradiation dose in non-implanted samples, but being a little bit higher in implanted samples, however, decreasing with the excitation dose. The blue luminescence grows with the dose in non-implanted samples as well as in oxygen-implanted samples. It is somewhat higher in oxygen-implanted samples than in non-implanted ones. The blue luminescence is significantly higher in silicon-implanted samples and it exhibits a decrease with irradiation dose. Therefore we did observe a correlation of blue luminescence with excess silicon or oxygen deficiency. It is planned to check the influence of implantation on the cathodoluminescence decay kinetics.

1. H.-J. Fitting, T. Barfels, A.N.Trukhin, B.Schmidt, J. Non-Crystalline Solids, 279 (2001) 51-59.
2. R.A.Weeks, Int. J.Glass (Italy) 102 (1999) 46-54.

**In cooperation with: Physics Department, Rostock University*

OBSERVATION OF A NEW PHOTOLUMINESCENCE BAND AT 320 NM UNDER 270 NM EXCITATION IN GE-DOPED SILICA GLASS

J. Garapon, B. Poumellec*, S. Vacher*, A. N. Trukhin*

We investigate the influence of temperature on photoluminescence (PL) in Ge-doped silica glass. Under 270 nm excitation, we observe only one PL band at 424 nm at room temperature. This band shifts to 436 nm with cooling (4 K), and a new PL band is recorded at 320 nm. We assign these PL bands to triplet-to-singlet and singlet-to-singlet transitions of a same Ge-related defect, whose structure is still unknown. The shift of the PL band (from 424 nm at room temperature to 436 nm at 4 K) is explained by the decrease of the overlap between PLs from different centers.

In cooperation with: Lab. Physico-Chimie des Solides, Orsay, France

DIRECT OBSERVATION OF A BREIT-WIGNER PHASE OF A WAVE FUNCTION

J. A.Fiss, A. Khachatrian*, K. Truhins, L. Zhu*, and R. J.Gordon*, T. Seideman**

The Breit-Wigner phase of a wave function was obtained by measuring the interference between twoindependent ionization paths of a molecule. The state of interest was present in only one of the paths,thereby producing a phase shift in the

observed signal. An analytical theory was used to determine thephase of the wave function from the observable.
**In cooperation with: University of Illinois at Chicago, Illinois*

STUDY OF THE GERMANIUM LUMINESCENCE IN SILICA: FROM NON-CONTROLLED IMPURITY TO GERMANO-SILICATE CORE OF TELECOMMUNICATION FIBER'S PREFORM

A. Trukhin, B. Poumellec, J. Garapon**

We study the luminescence properties of doped silica with different concentration of germanium. The basic luminescence parameters such as spectral dependencies, decay kinetics and polarization at different temperatures were measured. Three spectral ranges 3.5 – 5.5 eV (I), 5.5 – 7 eV(II), 7 – 8 eV(III) in the optical transparency range of silica could be chosen from these data. The range I possess a weak variation of significant parameters of luminescence such as decay kinetics and polarization of the germanium related oxygen deficient center (GeODC) with the change of luminescence center concentration from extremely low in pure silica to germano-silica core of optical communication fiber preforms. The temperature dependence of luminescence intensity and spectral content including excitation band are more affected by change of concentration. The deviation of those parameters could be explained mainly within framework of inhomogeneous broadening and of center interaction with varying environment. However the influence of multi typicalness of the center structure also takes place in the range I. The changes of decay kinetics and polarization excited in the ranges II and III are also insensitive to the change of concentration but the spectral content is more sensitive to the history of sample preparation there, providing bigger changes in spectral bands relation. That could be explained as multi typicalness of similar centers due to different surrounding. The range III is more affected by host defect (ODC(I) providing an absorption band at 7.6 eV different in different samples by the way that there are in addition to intracentre transitions recombination mechanisms of luminescence excitation.
**In cooperation with: Lab. Physico-Chimie des Solides, Orsay, France*

COMPARISON OF THE LUMINESCENCE CENTERS CREATED BY GERMANIUM IN α-QUARTZ, SILICA GLASS AS WELL AS IN TETRAGONAL GEO_2 CRYSTAL

Anatoly Trukhin, Bertrand Poumellec

The luminescent properties of germanium related centers are reviewed for crystalline quartz, for silica and for germano-silica glasses as well as for germanium dioxide crystals with rutile and a-quartz structure.

The α-quartz doped with Ge exhibits optical absorption threshold at 7.5 eV. Luminescence excitation bands starts at the same energy also. A luminescence band with strong Stoke's shift is situated at 2.3 eV and its properties are very similar to that of self-trapped exciton in pure silicon dioxide or germanium dioxide crystals with a-quartz structure. The structure of the STE could be imagined as Si(Ge)-O broken bond with relaxation of non-bridging oxygen toward a bridging oxygen situated on opposite site of c-channel or x,y-channel. That new oxygen-oxygen bond determines thermal stability and orientation of the STE. This gives rise to two energies for the STE thermal

quenching and two different luminescence polarizations with respect to crystal orientations.

The luminescence properties of germanium centers in silica and germano-silica glasses never resemble the luminescence of Ge in SiO_2 or GeO_2 crystals with α-quartz structure. The luminescence Ge related centers in glasses is directly connected with oxygen deficiency and their properties are known among scientists working with telecommunication fibers. The luminescence spectrum shows two bands: a blue one with maximum at about 3.15 eV and an ultraviolet (UV) band at 4.3 eV. Both bands are polarized when excitation is done with polarized light. The blue band changes the polarization sign on excitation energy. The models of oxygen deficient germanium centers in silica are proposed as a twofold-coordinated germanium from one hand and oxygen vacancy or unrelaxed Ge-Ge bond between two GeO_4 tetrahedrons on the other hand.

The reduced pure germanium dioxide glass as well as alkali germano-silicate glasses possess oxygen deficient luminescence centers, modified in the last case by influence of alkali ions. The oxygen deficient luminescence centers was found in GeO_2 crystal with rutile-type structure grown from fusion of germanium dioxide and sodium bicarbonate solution. The center is very analogous to that of sodium-germanate glasses. On the basis of these data, a hypothesis was proposed that oxygen deficient luminescent center is not point defect in the network of tetrahedrons but in a sub-network of glass with octahedral coordination.

In cooperation with: Lab. Physico-Chimie des Solides, Orsay, France

PHOTOLUMINESCENCE AND CATHODOLUMINESCENCE SPECTROSCOPY OF 3.1 AND 4.3 EV BANDS IN H_2 LOADED GERMANOSILICA WAVEGUIDE

V.Cannas, B. Poumellec, A.N. Trukhin, J. Jansons

We report experimental results on the thermal and time behaviour at room and liquid nitrogen temperature of the photoluminescence and cathodoluminescence bands centred at 4.3 and 3.1 eV in germanosilica planar waveguide. The blue luminescence life-time is found at around 110μs and exhibits no changes with temperature while the UV luminescence life time is found to be around 7 ns at room temperature.

In cooperation with: Lab. Physico-Chimie des Solides, Orsay, France

Scientific publications

1. H.-J. Fitting, T. Barfels, A.N. Trukhin, B. Schmidt, *Cathodoluminescence of crystalline and amorphous SiO_2 AND GeO_2*, Journal of Non-Crystalline Solids, 2001, vol. **279**, p. 51-59.
2. H.-J. Fitting, T. Barfels, A. von Czarnowski, A.N. Trukhin, *Electron beam induced optical and electronical properties of SiO_2,* Materials Science and Engineering, 2000, vol. **B71**, p. 109–114.
3. Jeanette A.Fiss, Ani Khachatrian, Kaspars Truhins, Langchi Zhu, Robert J.Gordon , and Tamar Seideman*, Direct observation of a Breit-Wigner phase of a wave function*, 2000, vol. **85**, Physical Review Letters, p. 2096-2099.
4. A.N. Trukhin, B Poumellec, *Comparison of the luminescence centers created by germanium in a-quartz, silica glass as well as in tetragonal GeO_2 crystal, Euro Summer School On Photosensitivity in Optical Waveguides And Glasses*. POWAG 2000, Giens, Cote d'Azur France. 02RT1, (laser disk).

In press

1. J. Garapon, B. Poumellec, S. Vacher, A. N. Trukhin, *Observation of a new photoluminescence band at 320 nm under 270 nm excitation in ge-doped silica glass*, Journal of Non-Crystalline Solids .
2. V.Cannas [a], B. Poumellec [a], A.N. Trukhin [b], J. Jansons*, Photoluminescence and cathodoluminescence spectroscopy of 3.1 and 4.3 eV bands in H_2 loaded germanosilica waveguide*. Journal of Non-Crystalline Solids.

The 17 Scientific conference of ISSP dedicated to the 40th anniversary of Problem laboratory of Semiconductor Physics

1. T.Barfels, J.Jansons, H.-J.Fitting, I.A.Tale,A.N.Trukhin, Influence of oxygen and silicon implantation on silicon dioxide thin film cathodoluminescence.

Lectures at Universities, Institutes, Companies

1. A. Trukhin, Self trapped excitons in quartz and relevant crystals. Lectures at State University of Irkutsk and Institute of Geochemistry, Russia, March 11, 18, 2001.
2. A. Trukhin, Luminescence of wide gap oxide glasses. Lecture at Universite de Paris Sud, Orsay, Lab. Physico-Chimie des Solides, France, June 21, 2001.

PHYSICS OF FERROELECTRICS

Head of Division Dr. hab. phys. A.Sternberg

Research area and main problems

The basic research programme of the Department Ferroelectric Physics includes synthesis and structure determination, study of properties and application of functional ferroelectric materials. Chemical coprecipitation and hot pressing technologies have been used for ceramic production, and pulsed laser deposition and sol-gel processing for obtaining of ferroelectric thin films. Phase transitions and ordering effects in conventional ferroelectrics and ferroelectric relaxors are studied along with new relaxor materials, including doped multi-component systems and thin film heterostructures. A possible applications of "smart" ferroelectric materials in electronics, optoelectronics and microelectro-mechanics are considered.

The main areas of progress during 2001 are desribed under the following:

- application of field theory methods to structure transformations in ferroelectrics;
- precision X-ray diffractometry studies of polar and centrosymmetric single crystals, ceramics and thin films;
- preparation and study of properties in in lead scandoniobate ceramics doped with rare-earth oxides;
- nature of dielectric dispersion in PLZT ceramics at the diffused phase transition;
- study of dielectric and optical properties of multidimentional polar materials for microelectromechanical systems and application in photonics: new compositions of ferroelectric thin films and new non-linear optically active surfactant molecule layers; dielectric Fourier analysis and and reflectometry as a new experimental techniques;
- antiferroelectric $PbZrO_3$ thin films: structure, properties and irradiation resistance;
- application of PLZT passive and active optical elements in infrared laser systems for bio-optical experiments and medicine;
- use of PLZT ceramics controllable ligt scattering elements in design of “artificial eye” for vision research experiments.

Scientific staff

1. Dr. E.Birks
2. Dr. K.Bormanis
3. Dr. M.Dambekalne
4. Dr. hab. V.Dimza
5. Dr. E.Klotins
6. Dr. hab. A.Krumins
7. Dr. hab. M.Ozolins
8. Dr. hab. L.Shebanovs
9. Dr. hab. A.Sternberg
10. Dr. V.Zauls
11. Mg. M.Antonova
12. Mg. L.Chakare
13. Mg. M.Kundzins
14. Mg. M.Livins
15. . Mg. A.Spule

Technical staff

1. Mg. M.Kalnberga
2. Mg. A.Kalvane
3. M.Logins
4. A.Tupulis

PhD Students

1. Mg. K.Kundzins

Students

1. I.Aulika
2. R.Shorubalko
3. O.Avotins
4. V.Korsaks

Visitors from Abroad

1. Mg. C. Ziebert, University of Saarland, Saarbrucken, Germany (6 weeks).
2. Mg. R. Bittner, Atomic Institute of Austrian Universities, Vienna, Austria, (4 weeks).
3. Prof. R. Rotomskis, Laser Research Center, Vilnius University, Lithuania
4. (4 weeks).
5. 4. Prof. H.W. Weber, Atomic Institute of Austrian Universities, Vienna, Austria (4 days).
6. Dr. I. Hlinka, Institute of Physics, Academy of Sciences of the Czech Republic, Prague, Czech Republic (4 weeks).
7. Dr. M.Tyunina, Microelectronics and Materials Physics Laboratories, University of Oulu, Finland (6 weeks).

Scientific Visits Abroad

Stud. I.Aulika

1. International Meeting on Ferroelectricity, IMF-10, Madrid, Spain (1 week).

Dr. K.Bormanis

1. 6th International Workshop "High-Temperature Superconductors and Novel Inorganic Materials Engineering", Moscow - St. Petersburg, Russia (2 weeks).
2. International Meeting on Ferroelectricity, IMF-10, Madrid, Spain (1 week).
3. 5th International conference "Crystals: growth, properties, real structure, applications" VNIISIMS, Aleksandrov, Russia (2 weeks);
4. International conference "Interphase relaxation in polymaterials", Moscow, Russia (2 weeks).

Mg. L.Chakare

1. Jozef Stefan Institute, University of Lubljana, Slovenia, (12 months).

Dr. M.Dambekalne

1. 7th Conference and Exhibition of the European Ceramic Society (ECERS - VII), Brugge - Belgium (1 week).
2. International conference "Interphase relaxation in polymaterials", Moscow, Russia (2 weeks).

Dr. E.Klotins

1. 1st International Conference on Dielectric Spectroscopy in Physical, Chemical and Biological Applications ds2001, Jerusalem, Israel (1 week).
2. International Meeting on Ferroelectricity, IMF-10, Madrid, Spain (1 week).
3. Institute of Physics, Academy of Sciences of the Czech Republic, Prague, Czech Republic (3 weeks).

Dr. hab. A.Krumins

1. International Meeting on Ferroelectricity, IMF-10, Madrid, Spain (1 week).
2. "Hannoveres Messe", Hannovere, Germany (1 week).

3. CAMART meeting, Brussels, Belgium, (3 days).

Mg. K.Kundzins
1. International Meeting on Ferroelectricity, IMF-10, Madrid, Spain (1 week).
2. Institute for Solid State and Materials Research, Dresden, Germany (4 weeks).

Dr. hab. M.Ozolins
1. Prague Technical University, Prague, Czech Republic (4 weeks).
2. International Meeting on Ferroelectricity, IMF-10, Madrid, Spain (1 week).
3. Vilnius University, Vilnius, Lithuania (1 month).

Dr. hab. L.Shebanovs
1. International Meeting on Ferroelectricity, IMF-10, Madrid, Spain (1 week).
2. 7th Conference and Exhibition of the European Ceramic Society (ECERS - VII), Brugge - Belgium (1 week).

Dr. hab. A.Sternberg
1. Atomic Institute of Austrian Universities, Vienna, Austria, (2 months).
2. Atomic Institute of Austrian Universities, Vienna, Austria, (5 days).

Dr. V.Zauls
1. International Meeting on Ferroelectricity, IMF-10, Madrid, Spain (1 week).
2. Institute of Physics, University Potsdam, Germany, (6 weeks).
3. Dept.of Organic Chemistry, Umea University, Sweden, (4 weeks).
4. Coordination meeting on Polar Electroceramics, Brussels, Belgium, (3 days).
5. Coordination meeting on Polar Electroceramics, Ljubljana, Slovenia, (5 days).

Cooperation

Latvia

1. Daugavpils Pedagogical University (Dr. hab. G.Liberts).
2. Riga Technical University (Dr. hab. M.Knite; Dr. R.Cimdins).

Austria

1. Atomic Institute of Austrian Universities, Vienna (Prof. H.W.Weber).
2. Institute for Experimental Physics, University Vienna (Dr. A.Fuith).

Belarussia

1. Institute of Solid State Physics and Semiconductors, National Academy of Science (Prof. A.N.Salak).

Czech Republic

1. Institute of Physics, Academy of Sciences of the Czech Republic (Prof. J. Petzelt, Dr. I. Hlinka).
2. Prague Technical University, Prague (Dr. H. Jelinkova).

Denmark

1. Ferroperm, Ltd., Kvistgard (W.Wolny).

Finland

1. University of Oulu (Prof. S.Leppävuori).

Germany.

1. Institute for Solid State and Materials Research, Dresden (Dr. W.Häßler).
2. University of Saarland, Saarbrucken (Prof. H.Schmitt).
3. Institute of Optics, Berlin Technical University (Prof. H.J.Eichler).
4. Institute for Lasertechnology in Medicine, Ulm University (Prof. R.Steiner).
5. Institute of Condensed Matter, University Potsdam, Germany (Prof. L.Brehmer).

Japan

1. Shonan Institute of Technology (Prof. S.Sugihara).

Lithuania

1. Semiconductor Physics Institute, Vilnius (Prof. B.Vengalis).
2. Vilnius University, Vilnius (Prof. J.Grigas, J. Banys).

Norway

1. Kongsberg Optometric Institute, Buskerud Highschool (Dr. K.I.Daae).

Poland

1. Polish Academy of Sciences, Poznan (Prof. B.Hilczer).

Russia

1. Ural State University, Ekaterinburg (Prof. V.Shur).
2. Volgograd State Architectural and Engineering Academy, Volgograd (Prof. A.Shilnikov).
3. Russian Academy of Science, Moscow (Prof. A.Medovoi).
4. Joint Institute for Nuclear Research, Dubna (Dr. S.Tiutiunnikov).

5. Moscow State University, Moscow (Prof. B.A.Strukov).

Slovenia

1. Jozef Stefan Institute, University of Lubljana (Dr. M.Kosec).

Sweden

1. Chalmers Technical University, Göteborg (Prof. S.Lagerwall).
2. Medical Laser centre Lund University (Prof. S.Svanberg).
3. Umeå university, Umeå (Dr. B.Eliasson).

Ukraina

1. Institute for Problems of Materials Science, National Academy of Science (Prof. V. Pokropivny, Prof. M.D.Glinchuk).

Main Results

NONLOCAL INTERACTIONS IN POLAR SYSTEMS

E. Klotins

The outstanding properties and anomalies of ferroelectrics have fascinated and intrigued physicists for long. During the past years, interest in this unique field has grown rapidly because of many practical aspects in technology, which call for fundamental understanding in terms of nonlocal interactions being dominant in spatio – temporal behaviour of polar systems relaxing to lower symmetry state during formation a domain pattern. Recent developments focused on the nonlocal electroelastic and dipole – dipole interactions, are addressed to advanced ferroelectrics in strong fields and allow, in a selfcionsistent manner, to study the effect of three basic sources of nonlocality: electrostriction, dipole – dipole interaction and difusional ordering of defects. Specific for the relevant thermodynamic formulation is its extension beyond the scope of conventional Ginsburg – Landau free energy functional by including supplementary electrostriction controlled elastic field, dipole – dipole interaction and diffusional ordering of defects. Electrostriction controlled elastic field meets no conceptual problems and formally is given by series representation of elastic Green's functions valid both for infinite and finite bodies [1-3]. Nevertheless, test solutions in real space approach show its very demanding in the computational point of view. Recent developments focussed on the dipole – dipole interaction controlled contribution in the free energy rests on a formally continuum medium approach find by integrating the interaction energy for two distant dipole particles over the source space. This approach is valid for application to inhomogeneous ferroelectrics only in the absence of external field and at a zero polarization on boundaries [4]. Advancement in progress abandoning these limitations is based on dipole – dipole interaction in terms of the space charge. Diffusional reordering of defects compensates the space charge, appearing at nonzero divergence of the polarization field. Nevertheless, the existing treatments [5] consider the defects as frozen its contribution accounted for either by renormalizing the Landau coefficients or randomly distributed dipolar defects [6]. Advancement in progress concerns the kinetics of space charge modelled by the joint solution of Fokker – Planck and Poison's equations with the diffusion and drift coefficients given by a microscopic

model accounting for potential barriers, tunnelling, and temperature [7]. Aforementioned developments substantially modify the standard thermodynamic sheme with parameters being supplemented to the order parameter associating the behaviour of polar systems at the microscopic level with that at the macroscopic limit [8].

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1. E. Klotins, and A. Sternberg. Free-energy functional technique for finite ferroelectric bodies. Ferroelectrics, (accepted).
2. E. Klotins. Modelling of non – local elastic field in polarized ferroelectrics. Ferroelectrics, (accepted).
3. E. Klotins. Free – energy functional technique for finite ferroelectric bodies. Journ. of non – crystalline solids, (accepted).
4. Hong – Liang Hu, and Long – Quing Chen. Materials Science and Engineering, 1997, A238, p.182 – 191.
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STRUCTURAL STUDIES OF POLAR AND CENTROSYMMETRIC MATERIALS

L. Shebanovs

Formation and room temperature crystallographic parameters of PMN-PT and PluN-PSN single-phase solid solutions have been studied by precision X-ray diffractometry. An original method has been used to obtain PMN-PT ceramics of 100% perovskite structure from overstoichiometric MgO mixture. Interrelation between the main crystallographic properties and macroscopic electric parameters of piezoelectric and electrocaloric active materials and its theoretical background present the most significant results. The difference between the group of studied active materials and the classical solid solutions of modified lead titanate-zirconate (the so called PZT materials) is possession of a tetragonal-monoclinic or rhombohedral-monoclinic morphotropic phase transition with a large number of equivalent directions of spontaneous polarisation.

The "Crystallographica Search-match"(CSM) software for PDF-2 database revision and crystallographic phase identification has been installed in a Pentium 166 computer. The software is designed for identification and semi-quantitative phase analysis of organic and inorganic materials with the DRON UM1 measuring complex. Together with improvements of the control and data acquisition systems of the powder diffractometer DRON UM1 it has made the ISSP the leading centre for applied structure analysis in the Baltic countries. The laboratory of structural analysis may provide opportunities for research training of students and experts from Latvia and abroad.

The software has been tested for a wide class of materials including perovskite ferroelectric ceramics of different chemical composition, ferroelectric thin films of PZT 58/42 and composites obtained by sol-gel and laser ablation techniques, phosphoric apatite biomaterials, Co-Ni-Si and $CoSi_2$ thin films, C_{60} fullerene single crystals and thin films.

Special studies have been devoted to laser-induced changes of structure in PZT 58/42 thin films. An irreversible laser-induced transition from the non-ferroelectric pyrochlore phase to a tetragonal ferroelectric phase has been observed in PZT sol-gel films.

Prototypes of promising high-temperature piezoelectric materials have been obtained that may serve as a basis for different devices exploiting the direct and reversed piezoelectric effects, such as piezoelectric drivers, micropositioners and movers, piezodetectors, and other – for household, science, and medical application. The studied PZT sol-gel materials may also find possible application of their functional properties related to the structural changes induced by selective local laser treatment and being essential in producing multifunctional composite materials in silicon technologies.

PRODUCTION AND PROPERTIES OF LEAD SCANDONIOBATE FERROELECTRIC CERAMICS DOPED WITH RARE-EARTH OXIDES

M. Dambekalne, K. Bormanis, L.Chakare, M. Antonova, and A. Sternberg

Due to multifunctionality $PbSc_{1/2}Nb_{1/2}O_3$ (PSN) ferroelectric ceramic is attractive to solid state chemistry and physics as a promising material for active elements in different electronic devises.

The purpose of the present study is to continue a systematic investigation of ferroelectric PSN materials. The experimental work was carried out to produce PSN ceramics doped with 5 wt.% of rare-earth oxides and 10 at.% of lead substituted by rare-earth elements: Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu.

All compositions were obtained by solid state reaction from reagent grade oxides - PbO, Sc_2O_3, Nb_2O_5 and $Z_2(CO_3)_3$. nH_2O, where Z= Lu^{3+}, Yb^{+3} , Tm^{+3},Ho^{+3}, Dy^{+3}, Tb^{+3}, Gd^{+3}, Eu^{+3}, Sm^{+3}, Nd^{+3}, Pr^{+3}, Ce^{+3}. Source ingredients were mixed and grounded in agate ball mills in ethanol for 20÷24 hours. The size of particles was 0.3÷1.2 mm. The crucible was closed and a two step calcination followed: the first - 20 hours at 900 ^{0}C, the second - at 1000 ^{0}C for 5 hours. After each calcination the pellets were immersed in ethanol and grounded. The rare-earth doped ceramics was sintered at hot pressing during 1.5÷7 hours at 1060-1250 ^{0}C. The highest sintering temperature is in case of PSN (1350 ^{0}C), the lowest - in case of Lu doped ceramics (1060 ^{0}C). All rare-earth dopants decrease the temperature of sintering. Ceramics samples have a high density 96÷98% of the calculated, a low total porosity - less than 1.0%, negligible water absorption (about 0.02%).

e_m and T_m values decrease as the radius of rare-earth dopant ion increases, the effect being the stronger, the higher is the dopant concentration regardless to stoichiometric conditions. No essential difference of dielectric parameters has been observed between ceramic samples obtained by admixture (5%) or by substitution (x = 0.1).

Some of doped PSN ceramic samples are transparent, indicating to possible application of the material in electrooptic devices. Presently the best characteristics have been obtained with Lu - doped PSN (1 wt.%), transmittance of which is only slightly less compared to pure PSN, the difference decreasing with the inrease of wavelength. Only the hot pressing techniques can provide transparent ceramic samples. Preliminary hot pressing in vacuum (p=1 Pa) is found to improve transmittance of samples by 10-15%; the technological regime (i.e., hot pressing temperature and pressure) should be optimized for each composition.

The X-ray studies suggest that all the rare-earth elements are soluble in the lead scandium niobate up to 10 at. % concentration since all the doped compositions are single phase perovskites with a small admixture (0 - 7%) of the pyrochlore phase.

Additional studies are necessary to determine the solubility limit of the rare-earth elements.

NATURE OF DIELECTRIC DISPERSION IN PLZT CERAMICS

E. Birks, and A. Sternberg

The extremely broad spectrum of distribution times and Vogel-Fulcher dependence of its long time tail now dominates in description of dielectric dispersion at the diffused phase transitions in ferroelectrics. In this work the nature of dielectric dispersion is investigated in rhomboedral PLZT ceramics in terms of distribution function and its dependence on temperature and time. Obtained results, especially temperature dependence of memory effect allows to doubt critical slowing down of relaxation times ("freezing"), described by Vogel-Fulcher law. The combined effect of temperature dependence of static dielectric permittivity, possessing maximum and non-critical temperature dependence of relaxation times is proposed instead.

DIELECTRICAL AND OPTICAL PROPERTIES OF MULTIDIMENSIONAL POLAR MATERIALS FOR MICROACTUATOR AND PHOTONICS APPLICATIONS

V. Zauls, A. Sternberg, K. Kundzins, M. Kundzins, and I. Aulika

Dielectric studies on processing – microstructure - property relationships have been continued in various nanostructured ferroelectric (FE) thin films and heterostructures. Compounds under investigation included highly oriented perovskite structure PZ, PZT, PLZT, PMNT, (Ba,Sr)TiO_3 and PLuNT thin films of various compositions formed by pulsed laser ablation, rf sputtering and by the sol-gel process (*in cooperation with Institute for Solid State and Materials Research, Dresden, University of Saarland, Germany and Jozef Stefan Institute, University of Ljubljana, Slovenia)*

For investigation of relaxor films complete Fourier-analysis of dielectric response was used instead of common LCR-bridge or a lock-in amplifier measurements. The response of a thin-film sample under sinusoidal ac-drive was measured using a current-voltage converter in a virtual ground mode and digitized by a 2-channel 16–bit ADC board interfaced to a computer. The magnitude and phase of acquired response were analyzed up to 9th harmonic using Bartlet windowing, fast Fourier-transform and high resolution spectral zoom. Epitaxial heterostructures of $PbMg_{1/3}Nb_{2/3}O_3$, $PbSc_{0.5}Nb_{0.5}O_3$, $PbMg_{1/3}Nb_{2/3}O_3$–$PbTiO_3$, $PbSc_{0.5}Nb_{0.5}O_3$-$PbTiO_3$ thin films with $La_{0.5}Sr_{0.5}CoO_3$ bottom and Pt top electrodes fabricated by *in situ* pulsed laser deposition on MgO (100) and $LaAlO_3$ (100) of both relaxor and normal FE behavior have ben studied. Only odd harmonics were detected in relaxor FE, while both odd and even ones in FE films. Evolution of the Fourier-spectra with respect to amplitude of ac-drive, frequency, and temperature was studied in detail in relaxor FE films. The results are discussed using dynamic spherical random-bond-random-field model of relaxor FE. (*in cooperation with Microelectronics and Materials Physics Laboratories, University of Oulu.)*

Several new non-linear optically active surfactant molecules (oxadiazole derivatives) have been studied by reflected SHG techniques at the air-water interface with respect to their surface pressure dependent made to establish optimal experimental conditions for SHG investigation of molecular arrangements in self-assembled monolayers on gold bottom electrodes. (*in cooperation with Institut für Physik,*

Universität Potsdam, Germany and Dept. of Organic Chemistry, University of Umeå, Sweden)

Miniature CCD spectrometer with fiber optic probe has been used to develop reflectometry set-up for fast non-contact measurements of thin transparent films. Data of film refractive index can be estimated in the visible spectral range simultaneously with thickness determination.orientation and mutual interaction (aggregation). Preliminary tests were.

ANTIFERROELECTRIC $PbZrO_3$ THIN FILMS: STRUCTURE, PROPERTIES AND IRRADIATION EFFECTS

A.Sternberg, I.Aulika, K.Kundzins, V.Zauls, L.Čakare, R.Bittner**, and H.Weber***

Lead zirconate $PbZrO_3$ (PZ) is a typical antiferroelectric (AFE) material at room temperature, from which the ferroelectric (FE) state can be induced when subjected to a sufficiently large electric field usually exceeded the material breakdown strength. PZ sol-gel films with a thickness of up to 1.5 mm were deposited on $TiO_2/Pt/TiO_2/SiO_2/Si$ substrates by spin coating technique. Observation of a typical AFE double hysteresis loop in obtained PZ heterostructures at room temperature was attributed to the superior dielectric strength in case of thin film materials. The thermal behaviour of dielectric permittivity e of PZ film reveals a maximum near 225°C on heating and 219°C on cooling. The higher resistance of antiferroelectric PZ thin films as compared to ferroelectric (e.g., PZT) heterostructures to neutron irradiation[@] is recognized and discussed.

**In cooperation with Jožef Stefan Institute, Ljubljana, Slovenia*
***In cooperation with Atomic Institute of Austrian Universities, Vienna, Austria*
[@] Samples were irradiated in the TRIGA MARK II reactor[**].

PERFORMANCE OF MID-INFRARED ERBIUM LASERS WITH PASSIVE AND ACTIVE PLZT CERAMICS ELEMENTS

M. Ozolinsh, H. Jelinkova[*], M. Němec[*], J. Šulc[*], R.Rotomskis[**], and H.J.Eichler[***]

Transparent PLZT ceramics elements are used as Brewster plate polarizing elements, output mirrors, and electrooptic modulators for extracavity pulse shaping and Q-switching of Er:YAG (2.94 mm) and Er:Cr:YSGG (2.79mm) solid state lasers. These lasers are of interest in biomedical applications due to the spectral closeness of their irradiation to the strongest water absorption line. The high refractive index (»2.25 at 3 mm) of PLZT ceramics Brewster plate inside the laser resonator allows to obtain efficient laser polarization needed for electrooptical modulation (for Er: YAG laser the output of the linear polarized emission was up to 500 mJ at pump energy 338J). Similar plate performed as a solid state Fabry-Perot resonator serves as the output coupler for both lasers instead of the dielectric mirrors. We have used such configuration to obtain the laser output up to 90 mJ for Er: Cr: YSGG and 400mJ for Er:YAG laser). The high electrooptical effect in PLZT allows to construct small size modulators and Q-switches. Thus the thickness of such Q-switch equals to 3-4 mm for 6x6 mm aperture for the control voltage up to 1500V. The simultaneous action of the PLZT ceramics planeparallel plate as a high refractive Fabry-Perot interferometer instead of the output

mirror and the possibility to induce the birefringence in such element due to the electrooptic effect allows to incorporate the Q-switch function in the output coupler. Such bifunctional element allowed to obtain the Q-switched Er: Cr: YSGG laser output with energy of 14-20 mJ (single and multiple pulse emission)[1].

[1] *M.Ozolinsh and H.J.Eichler,. Appl.Phys.Lett.,* 1999, vol.**77**, p.615-617.

[*] *In cooperation with Czech Technical University, Prague, Czech Republic;*

[**] *In cooperation with Laser Research Center, Vilnius University, Lithuania;*

[***] *In cooperation with Institute of Optics, Berlin TU, Germany.*

EYE MODEL WITH CONTROLLABLE LENS SCATTERING

R. Paeglis, M. Ozolinsh, P. Cikmacs,
*and S. Andersson-Engels**

A model of human eye for experiments in vision research has been developed using PLZT ceramics. This "artificial eye" allows to simulate light scattering caused by cataract in the eye lens. Light scattering of a composite eye lens of the model depends on the electric field applied to a transparent electrooptic PLZT ceramics plate that is attached directly to the lens. The image degradation in such a model eye at various degrees of scattering is studied observing and recording the contrast of images on the "retinal plane" created by standard test objects with different spatial frequency or by a He-Ne laser source passing a diffractive transparent placed before the eye.

**In cooperation with Institute of Atomic Physics, Lund University, 22100 Lund, Sweden.*

Scientific Publications
Published in 2001

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2. K.Bormanis, M.Kalnberga, A.Patmalnieks, A.Sternberg, and M.Livinsh. *Surface morphology of ferroelectric and high temperature superconductor ceramics.* Ferroelectrics, 2001, vol. **258**, Part II, p.71-76 [363-368].
3. K.Bormanis, M.Kalnberga, M.Livinsh, A.Patmalnieks, and A.Sternberg. *Microscopic studies of the surface of ferroelectric and high temperature superconductor layers.* Proc. Intern. Conf. "Thin Film Deposition of Oxide Multilayers. Industrial-Scale Processing", TFDOM Vilnius University Press, 2000, p. 134-137.
4. A.I.Burkhanov, A.B.Shil'nikov, Yu.N.Mamakov, A.Zavjalova, A.Sternberg, and K.Bormanis. *Polarizarion and depolarization currents in* $Pb_{1-x}Ba_xSc_{0,5}Nb_{0.5}O_3$ *ferropiezoelectric ceramics.* Ferroelectrics, 2001, vol. **257**, No.1-4, Part I, p.85-90.
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6. M.Dambekalne, K.Bormanis, A.Sternberg, and G.Grinvald. *Dielectric nonlinearity of the* $PbB'B''O_3$ *ferroelectric solid solutions.* Integrated Ferroelectrics, 2001, vol.**33**, p.101-108.
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10. E.Klotins and A.Sternberg. *Free-energy functional technique for finite ferroelectric bodies.* Abstract of the Third International Seminar on Relaxor Ferroelectrics *(ISRF-III)*, June 14-17, 2000, Dubna, Russia, p.112.
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18. M. Ozolinsh and G. Papelba. *Polarization-optical visualisation of eye inhomogeneities.* In: "Photon Migration, Diffuse Spectroscopy, and Optical Coherence Tomography: Imaging and Functional Assesment," Ed. by Stefan Andersson-Engels and James G. Fujimoto, Proc.SPIE, 2001, vol. **4160**, p.254-256.
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21. A.V.Shilnikov, A.I.Burkhanov, Yu.N.Mamakov, A.A.Zavjalova, A.V.Sopit, A.Sternberg, and K.Bormanis. *Influence of a pre-history on polarization and depolarizations currents in lead scandium niobium system with the various additives of barium.* Abstract of the Third International Seminar on Relaxor Ferroelectrics (ISRF-III), June 14-17, 2000, Dubna, Russia, p.98.

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Guest Editorials

A. Krumins - "Ferroelectrics", vols **257, 258**.
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In Press

1. E.Birks, and A.Sternberg. *The nature of dielectric dispersion in PLZT ceramics. Ferroelectrics,* (accepted).
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18. L.Shebanovs, A.Sternberg, V.Zauls, M.Tyunina, and A.Krumins. *Some new $Pb(B'',Nb)O_3$ - $PbTiO_3$ systems: ceramics and thin films*. Ferroelectrics, (accepted).
19. L.Shebanovs, J.Maniks, and J.Kalnacs. *X-ray diffraction study of crystallographic parameters and Debye temperature of C_{60} single crystals*. J.Cryst.Growth, (accepted).
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21. L.Shebanovs, K.Bormanis, W.N.Lawless, and A.Kalvane. *Electrocaloric effect in some perovskite ferroelectric ceramics and multilayer capacitors*. Ferroelectrics, (accepted).
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Lectures on Conferences (with abstracts)

17. Zinātniskā konference, veltīta Pusvadītāju fizikas problēmu laboratorijas 40 gadu jubilejai. Latvijas Universitāte, Cietvielu fizikas institūts, 2001. g. 19.-23. februāris, Rīga, Latvija

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2. Ē.Klotiņš. Mikrostruktūras kinētika polārās sistēmās: CAMART WP-13 un apakšprojekts # 1. Spatio-temporal behaviour of polar systems: CAMART WP-13 and sub-project # 1 perspective. Referātu tēzes un vēstures lasījumi, 20. lpp.
3. L.Šebanovs, A.Šternbergs, M.Antonova, M.Līviņš. La modifikācijas ietekme uz $Pb(Lu_{1/2}Nb_{1/2})O_3$-$PbTiO_3$ binārās sistēmas fāžu diagrammas izskatu un pjezoelektriskajām īpašībām. La modification effects on phase diagram and piezoelecrtic properties of $Pb(Lu_{1/2}Nb_{1/2})O_3$-$PbTiO_3$ binary system. Referātu tēzes un vēstures lasījumi, 21. lpp.
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5. L.Šebanovs, J.Maniks, J.Kalnačs. C_{60} monokristālu kristalogrāfisko parametru un Debaja temperatūras rentgendifraktometriskie pētījumi. X-ray diffraction study of crystallographic parameters and Debye temperature of C_{60} single crystals. Referātu tēzes un vēstures lasījumi, 23. lpp.
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7. I.Aulika, K.Kundziņš, V.Zauls, M.Kundziņš, A.Šternbergs, L.Čakare. Neitronu apstarošanas iedarbība uz SOL-GELa PZT plānajām kārtiņām. Neutron irradiation effects on SOL-GEL PZT thin films. Referātu tēzes un vēstures lasījumi, 43. lpp.
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9. M.Ozoliņš, I.Lācis, S.Svanbergs, S.Andersson-Engels, J.Swartlings. Elektrovadāmās izkliedes PLZT keramikā spektrālās raksturlīknes. Spectral dependencies of electrically controllable scattering in PLZT ceramics. Referātu tēzes un vēstures lasījumi, 66. lpp.
10. R.Paeglis, M.Ozoliņš. Acs makets ar iebūvētu vadāmu izkliedi. Model eye with artifitially induced scattering. Referātu tēzes un vēstures lasījumi, 68. lpp.
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12. M.Ozoliņš, G.Papelba. Apmiglojuma ietekme uz stereoskopisko redzi. Blurring influence to stereoscopic vision. Referātu tēzes un vēstures lasījumi, 71. lpp.
13. G.Ikaunieks, M.Ozoliņš, G.Papelba. Interokulārā supresija stereoattēlos un attēlu pārklāšanās gadījumā. Interocular supression of stereoscopic images and in case of overlaid images. Referātu tēzes un vēstures lasījumi, 72. lpp.

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1. Maris Ozolinsh and Hans J. Eichler. Er:Cr:YSGG laser with electrooptic PLZT ceramics Q-switching Fabry-Perot interferometer output mirror. Techn. Digest of CLEO/QELS - Baltimore, 2001, p. 321.

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1. M.Knite, and L.Shebanovs. Photothermal optimization of coefficient temperature resistance of Co-Ti-Si thin films. Abstracts, p. L34.

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1. Maris Ozolinsh and Hans J. Eichler. Er:Cr:YSGG laser with electrooptic PLZT ceramics Q-switching Fabry-Perot interferometer output mirror. Abstracts, p. 98.
2. D. Racene, P. Cikmacs, and M. Ozolinsh. Measuring of the wavefront aberrations of the eye. Abstracts, p.90.

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1. R. Paeglis, P. Cikmacs, M.Ozolinsh, and S. Andersson-Engels. Artificial eye model with controllable lens scattering. Abstracts, p.39.

6th International Workshop "High-Temperature Superconductors and Novel Inorganic Materials Engineering, MSU-HTSC VI, June 24-30, Moscow - St. Petersburg, Russia.

1. K.Bormanis, M.Kalnberga, A.Patmalnieks, and A.Sternberg. Structure and superconductivity of melt textured grown YBCO layers. Book of abstracts, p. PII-22.

II Pasaules Latviešu Zinātnieku kongress, 2001. gada 14. un 15. augustā, Rīga, Latvija.

1. K.Bormanis, A.Patmalnieks, A.Šternbergs un M.Kalnberga. Supravadošu kārtiņu virsmas topogrāfija. Tēžu krājums, 247. lpp.
2. A.Krūmiņš, D.Millers. Eiropas Komisijas finansētā Ekselences centra *CAMART* uzdevumi un pusgada darbības pieredze. Tēžu krājums, 15. lpp.

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1. L.Shebanovs, A.Sternberg, V.Zauls, M.Tyunina, and A.Krumins. Some new $Pb(B^{3+},Nb)TiO_3$ - $PbTiO_3$ systems: ceramics and thin films. Abstracts, p. 24.
2. H.Schmitt, C.Ziebert, A.Sternberg, V.Zauls, M.Kundzins, K.Kundzins, I.Aulika, K.-H.Ehses, and J.K.Krüger. Nanocrystalline ferroelectric / relaxor multilayers. Abstracts, p. 54.
3. A.Sternberg, K.Bormanis, A.Kalvane, A.V.Shil`nikov, A.I.Burkhanov, and Yu.N.Mamakov. Nonlinearity of dielectric parameters of $PbNi_{1/3}Nb_{2/3}O_3$ - $Pb(Zr,Ti)O_3$ ferroelectric solid solutions. Abstracts, p. 79.
4. L.Shebanovs. X-ray studies of Debye temperature and lattice dynamics of some ABO_3 perovskites. Abstracts, p. 92.
5. M.Dambekalne, K.Bormanis, A.Sternberg, M.Antonova, and M.Livinsh. Synthesis and properties of lead scandium niobate solid solutions containing rare earth elements. Abstracts, p. 110.
6. K.Bormanis, M.Dambekalne, G.Grinvalds, and A.Sternberg. On application of $PbMg_{1/3}Nb_{2/3}O_3$ - $PbZn_{1/3}Nb_{2/3}O_3$ - $PbNi_{1/3}Nb_{2/3}O_3$ solid solutions in tuneable capacitors. Abstracts, p. 121.
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8. M.Tyunina, K.Kundzins, V.Zauls, and J.Levoska. Dielectric Fourier-spectroscopy in relaxor and normal ferroelectric thin films. Abstracts, p. 122.
9. V.Ya.Shur, G.G.Lomakin, S.V.Slovikovski, O.V.Yakutova, A.Sternberg, and A.Krumins. Evolution of fractal nanodomain structures in relaxor X/65/35 PLZT ceramics. Abstracts, p. 127.

10. J.Levoska, M.Tyunina, A.Sternberg, and S.Leppävuori. Structural aspects in epitaxial thin film heterostructures of relaxor ferroelectric perovskites. Abstracts, p. 139.
11. E.Klotins. Modeling of non-local elastic field in polarized ferroelectrics. Abstracts, p. 151.
12. E.Birks, and A.Sternberg. The nature of dielectric dispersion in PLZT ceramics. Abstracts, p. 189.
13. I.Lacis, M.Ozolinsh, A.Sternberg, S.Savanberg, S.Andersson-Engles, and J.Swartling. Electrooptic ceramics PLZT devices for vision science applications. Abstracts, p. 243.
14. L.Shebanovs, K.Bormanis, W.N.Lawless, and A.Kalvane. Electrocaloric effect in some perovskite ferroelectric ceramics and multilayer capacitors. Abstracts, p. 243.

V Международная конференция "Кристаллы: рост, свойства, реальная структура, применение", 10-14 сентября 2001. года, ВНИИСИМС, Александров, Россия.

1. А.Калване, М.Антонова, М.Ливиньш, А.Спуле, А.Штернберг, К.Борманис. Получение и исследование физических свойств поликристаллической сегнетокерамики бинарных систем $Pb(B',B'')O_3$-$PbTiO_3$. Тезисы докладов, с. 237-238.
2. К.Борманис, М.Калнберга, А.Штернберг, А.Патмалниекс. Проблемы оптимизации синтеза толстых пленок высокотемпературных сверхпроводников $YBa_2Cu_3O_{7-\delta}$. Тезисы докладов, с. 239-241.
3. К.Борманис, М.Дамбекалне, А.Штернберг, Г.Гринвалд. Диэлектрическая нелинейность сегнетоэлектрических твердых растворов PMN-PNN-PZN. Тезисы докладов, с. 241-243.

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1. M. Ozolinsh, H. Jelinkova, , M. Němec, J. Šulc, R.Rotomskis, and H.J.Eichler. Performance of mid-infrared Erbium lasers with passive and active PLZT elements. Abstracts, p.80.
2. H. Jelínková, M. Němec, J. Šulc, M.Čech, M.Ozolinsh."Er:YAG laser giant pulse generation." Abstracts, p.113.

Lectures on Conferences (without abstracts)

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1. E. Klotins, Free –energy functional technique for finite ferroelectric bodies, Journ. of Non – Crystalline Solids.

6th International Workshop "High-Temperature Superconductors and Novel Inorganic Materials Engineering, MSU-HTSC VI, June 24-30, Moscow - St. Petersburg, Russia.

1. K.Bormanis, (M.Kalnberga, A.Patmalnieks, and A.Sternberg). Structure and superconductivity of melt textured grown YBCO layers
2. K.Bormanis, A.Kalvane, M.Antonova, M.Livinsh, A.Spule, and A.Sternberg. Physical properties of high piezoelectric coupling $Pb(B' B'')O_3$ - $PbTiO_3$ binary systems.
3. K.Bormanis, M.Dambekalne, A.Sternberg, and G.Grinvald. Novel nonlinear dielectric materials of PMN-PNN-PZN solid solutions.

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1. A.Sternberg, L.Shebanovs, M.Antonova, and M.Livinsh. Features of phase diagrams of binary $Pb(B_{1/2}Nb_{1/2})O_3$ - $PbTiO_3$ systems in vicinity of morphotropic phase boundaries.
2. M.Dambekalne, K.Bormanis, L.Chakare, M.Antonova, and A.Sternberg. Production and properties of lead scandoniobate ferroelectric ceramics doped with rare-earth oxides.

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1. V.Zauls. SHG studies of thin films: air-water interface and poled polymers.

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1. М.Дамбекалне, К.Борманис, Н.П.Вышатко, М.Антонова, М.Ливиньш, А.Н.Салак, Н.М.Олехнович. Синтез и исследование твердых растворов $PbSc_{½}Nb_{½}O_3$ - $PbLu_{½}Nb_{½}O_3$.
2. Ю.В.Радюш, Н.М.Олехнович, Н.П.Вышатко, А.Н.Салак, К.Борманис, А.Штернберг, М.Дамбекалне. Структурные и диэлектрические характеристики твердых растворов $PbMg_{1/3}Nb_{2/3}O_3$ - $PbAl_{½}Nb_{½}O_3$.
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SEMICONDUCTOR MATERIALS AND SOLID STATE IONICS

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Research Area and Main Problems

Research areas:

- Electrophysics and electrochemistry of specific semiconductor materials, mixed conductors, ion conductors, high temperature superconductors (transition metal oxides, bronzes, metal hydrates, solid electrolytes, etc.);
- Material preparation methods: thin and thick film technologies, sol-gel process;
- Material characterisation by spectroscopic methods (Raman scattering, optical and X-ray absorption, electrical and electrochemical impedance, magnetic susceptibility, ESR, etc);
- Solid state ionics and optics:
  - electro-, photo-, chemo- or gaso-chromic phenomena,
  - structural changes due to ion intercalation,
  - lattice dynamics and structural and electronic phase transitions,
  - solid state reactions at interfaces electrode – solid electrolyte,
  - solid state reactions in bulk of electrode and solid electrolyte materials,
  - two and three phases electrode reactions,
  - gases and ions sensing phenomena and detection technologies;
- Functional coatings and multi layer electrochemical systems;
- New measurement technologies and instruments with artificial intelligence;
- Miniaturisation of solid state ionic devices:
  - physical and chemical sensors and actuators for MST, ASIC or MCM (smart devices),
  - variable optical coatings for micro optics
- Application specific semiconductor materials and solid-state ionic devices in micro systems for electronic nose.

Research problems and tasks:

1. Stability of materials for electrochemical multi layer systems and electrochromic coatings.
2. Improvements in x-ray absorption spectroscopy methodology and local structural anomalies in the mixed transition metal oxide compounds.
3. Inter-grain activity of solid electrolyte layers based.
4. Ion (H^+, OH^-, Li^+) insertion (extraction) in solid electrolytes and electrodes.
5. Metal hydride electrode for Ni / MH battery.
6. Microwave absorption of high temperature superconductors.
7. Research and development of an electronic nose
   - 7.1. Software Environment for Electronic Nose and Electronic Nose Module;
   - 7.2. Preparation of sensor elements and testing their sensitivity and selectivity;
   - 7.3. Application technologies of electronic nose for food quality and water pollution control.
8. Environmental pollution monitoring methods and instrumentation.
9. Testing and certification of materials and accreditation of testing laboratories.

Scientific staff:

1. Dr.chem. G.Bajars
2. Dr.phys. P.Cikmacs
3. Dr.phys. V.Eglitis
4. Dr.phys. J.Gabrusenoks
5. Dr.phys. R.Kalendarjovs
6. Dr.phys. U.Kanders
7. Dr.phys. J.Kleperis
8. Dr.phys. J.Klavins
9. Dr.phys A.Kuzmins
10. Dr.phys. A.Lusis
11. Dr.phys. E.Pentjuss
12. Dr.hab.phys. J.Purans
13. Dr.phys. M.Shirokovs
14. Dr.chem. G.Vaivars
15. Dr.chem. A.Vitins
16. Dr.chem.. Ģ.Vitins

Technical staff:

1. A.Kursitis
2. J.Pinnis
3. M.Purane

Postgraduate students:

1. Ģ.Vēveris
2. J.Zubkāns
3. L.Grīnberga
4. K.Paegle

Students:

1. U.Klavins
2. L.Jēkabsone
3. I. Graudinsh
4. L. Kirmele
5. I. Micko

Visitors from abroad

1. Prof. A.Czerwinski, Department of Chemistry, Warsaw University (2 month).
2. Prof. A.Orliukas, Department of Physics, Vilnius University (1 month).
3. Prof. F.Scholz, Department of Chemistry, Greifswald University (1 week).
4. Prof. Y.Mathey - GPEC, Universite de la Mediterranee (Aix-Marseille II), Marseille, France (3 days).
5. Dr. A.Ukshe, Institute of Problems of Chemical Physics Russian Academy of Sciences (1 month).
6. Dr. J.Sinius, Department of Physics, Vilnius University (1 month).
7. Ph.D. student Z.Rogulski, Department of Chemistry, Warsaw University (1 month).
8. Eng. D.PAILHAREY– GPEC, Universite de la Mediterranee (Aix-Marseille II), Marseille, France (7 days).

Scientific visits abroad

1. Dr. P.Cikmacs: University of Roma (Tor Vergata), Italy (1 months.).
2. MS. L. Grinberga – Hanovere Messa, University of Tuebingen (Germany), March 9-12, 2001.
3. Dr. J.Kleperis
   1) Hanovere Messa, University of Tuebingen (5 days)
   2) Warwick (Great Britain) (5 days).
   3) Confrence, Paris (France), June 19-21.
   4) Conference,Ancona, Brescia (Italia), September 11-16, 2001.
   5) Partner meeting, Kiev (Ukraine), October 19-20, 2001.
   6) EST, Newbury Park (USA) (10 days).
4. Dr.A.Lusis
   1) Warsaw University (5 days).
   2) ITEK, DI, Copenhagen (2 days).
5. Dr. R.Kalendarevs: 1) Universita della Calabria, Arcavacata di Rende, Italy (3 months).
   2) St.Petersburg State University, Russia (7 days).

6. Dr. A.Kuzmins: 1) CNR CeFSA, Trento, Italy (4 months).
2) GPEC, Universite de la Mediterranee (Aix-Marseille II), Marseille, France (2 weeks).
3) Polish Academy of Science, Warshaw, Poland (Invited talk, 1 week);
7. Dr.hab. J.Purans: 1) GPEC, Universite de la Mediterranee (Aix-Marseille II), Marseille, France (3 month).
2) University of Trento, Trento, Italy (1 month).
3) LURE, Orsay, France (1 month).
4) University of Lausanne, ICMA, Lausanne, Switzerland (1 month).
8. Dr. M.Shirokov: 1) Laboratory of Inorganic Materials Structural Chemistry, Moscow State University (2 weeks).
2) Laboratory of Spin Tracer Biophysics (prof. A. Tikhonov), Moscow State University(2 weeks).
3) Magnetic Resonance Laboratory (Dr. A. Timoshin), Cardiology Centre, Moscow (2 weeks).

Dr. G.Vaivars: 1) Workshop, Helsinki,. September 27-28, 2001.
2) Cape Town University, South Africa (7 month).

Ph.D. stud. G.Vēveris: 1) Warsaw University (7 days).
2) St.Petersburg State University, Russia (7 days).

Dr. A.Vitins: Conference, June 17-22, 2001, Brno, the Czech Republic.

Dr. G.Vitins: Sauthemton University, UK (9 month).

Cooperation

Latvia

1. Riga Technical University (RTU) – Faculty of Electronics and telecommunications (Doc. I.Slaidins, Doc. P.Misans).
2. Riga Technical University - Institute of Inorganic Chemistry (Dr. J. Grabis, Dr. I.Zalite, Dr. A. Dindune).
3. Departament of Information Technology, University of Latvia (Doc. H.Bondars).
4. Certification Centre of Latvian Academy of Science (Prof. J.Matiss).
5. Institute of Physical Energetics of Latvian Academy of Science (Prof. N.Zeltins).
6. Laboratory for Mathematical Modelling of Environmental and Technological Processes, University of Latvia (Dr.A.Jakovics).

Denmark

Technical university of Denmark (Dr. K.West).

France

1. LURE, Lab. of Synchrotron Radiation (Orsay, France) – Prof. S. Benazeth, Dr. Ph. Parent.

Italy

1. University of Roma (Tor Vergata) – Department of Physics (Prof. M.Iannuzi).
2. University of Trento – Department of Physics (Prof. G.Mariotto, Prof. G.Dalba).
3. University of Cosenza – Department of Physics (Prof. E.Cazzanelli).

Lithuania

University of Vilnius, Department of Physics (Prof. A.Orliukas).

Poland

Poznan Central Battery Laboratory (Dr. M.Kopczyk, Dr. G.Wojcik).
University of Warsaw , Department of Chemistry (Prof. A.Czerwinski).

Russia

1. Moscow State University: Faculty of Physics (Prof. A.Tihonov), Chemistry division (Prof. E.V. Antipov).
2. Joint Instute for Nuclear Research, Dubna (Dr. S.I. Tjutjunnikov).
3. Moscow State Engineering Physics Institute, Moscow (Prof. A.Menushenkov).

Sweden

1. Uppsala University (Prof. C.-G. Granqvist, Dr. A.Azens).
2. Stockholm University, Arrhenius laboratory (Dr. J.Greens).
3. Linkoping University – Laboratory of Applied Physics (Prof. I.Lundstrom).

Switzerland

Universite de Lausanne – Prof. A.E. Merbach.

NEXUS – Network of excellence in multifunctional microsystems (EC program ESPRIT). (Dr. A.Lusis).

NOSE – EC Network of Excellence on Artificial Olfactory Sensing (Partners from ISSP: Dr.J.Kleperis, Dr.A.Lusis).

COST programme: Project D18 "Lanthanide Chemistry for Diagnosis and Therapy" (Dr.J.Purāns – member of project management comity).

Main Results

ION – ELECTRON PHENOMENA IN WO_3

A.Lusis, J.Kleperis, E.Pentjuss

We are developing model of electrochromic and related phenomena in tungsten oxide thin films based on assumption that the constitution of such films is heterogeneous and built up of nano size particles, pores and adsorbed substances (mainly water). There are discussed, why high efficiency reversible blue colour is observed in amorphous tungsten oxide films as well as why such porous thin films with polycrystalline or amorphous constitution and with variety of particle properties can be easily obtained by physical vapour deposition process in low-pressure vacuum in presence of water. For substrate temperature in range 450 – 550 K corresponds some plateau on water desorption curves, which divided physically adsorbed water from chemically. The main role in formation of film constitution has two types of structural units based on tetrahedral and octahedral coordinated tungsten ions. The tetrahedral structural units have glass-forming function, but octahedral ones have function of modification. From

electrochemistry point of view the internal multiphase interfaces in such films are distributed multiphase electrodes. The adsorbed water together with defects of oxide particles provides reagents for reversible coloration reactions in the film. The colour centres can be induced thermally (oxygen non-stoichiometry) or electrically (injected ions) or by radiation (photo injected hydrogen). The electrochromism and related phenomenon of a-WO_3 films can be directly related to ion insertion / extraction processes controlled by external forces.

The stabilisation of electrical properties of anodically prepared WO_3 electrode and water-acid electrolyte electrochromic cell was studied. The literature sources and presented results indicates that stabilisation processes are mainly directed towards equilibrium between liquid electrolyte and porous tungsten oxide film. The stabilisation associates with water insertion in pores, high increasing of injection and extraction currents and increasing of film thickness. The cycling mainly accelerates the stabilisation process. Proposed explanation for temporary decreasing of injection current at the beginning of stabilisation, based on high "building in" velocity of water molecules in to WO_3 structure. There are observed independence of stabilised injected and extracted current values on oxidation charge. It can be determined by high ion conductivity of pores to compare with an electron conductivity of hydrated tungsten oxide fragments of film at the end of stabilisation, that envisage higher coloration of film near the metallic surface.

INFRARED AND RAMAN SPECTROSCOPY OF WO_3 AND CdO_4

J.Gabrusenoks

Infrared reflection and Raman spectroscopy have been applied to study the vibrational modes of tungsten trioxide and cadmium tungstate. Kramers-Kronig relations are employed to yield the refractive index as vell as TO and LO functions of these materials at frequencies from 50 to 1200 cm-1.

The tungsten trioxide WO_3 has several polymorphous phases. These WO_3 phases have more or less distorted ReO_3 - type crystal structures. Raman spectra were measured in successive phases of WO_3

Zone centre phonons of $CdWO_4$ were determined by the analyses of the Raman and infrared spectra. The modes were identified with respect to their symmetry types and compared to corresponding modes of the wolframite structure

MERCURY CUPRATES: SUPERCONDUCTIVITY, IONS PAIRS AND ELECTRON SPIN RESONANCE.

V.A. Alyoshin, E.V. Antipov*, M.I. Shirokov**, A.A. Timoshin****

Microwave magnetoabsorption (MA) of $HgBa_2CuO_{4+\delta}$ (1-2-0-1), $HgBa_2CaCu_2O_{4+\delta}$ (1-2-1-2) superconductors with T_c=95 K and 123 K, respectively, is investigated. At liquid nitrogene temperature T_N=77.3 K MA hysteresis line position drift and oscillations, of the hysteresis amplitude order, are found during repeated hysteresis cycles and the hysteresis line selfintersection effect is observed. It is shown that both the features are due to wide spread and mutual interactions of shielding currents contours, pushing out outer magnetic field from superconductor. Magnetic energy is transferred from short contours with critical current to long precritical ones, at the sample perimeter, containing weak sites, where superconductivity degrades, and this process irreversibly is repeated through the cycles. The distributed currents turn-over

after each changing of magnetic field scan direction takes place in distributed magnetic field from already turned ones. This leads to effective magnetic field displacement for "back" branch of the hysteresis curve and to the curve selfintersection if "forward" branch is steep enough. All this phenomena are dependent on weak sites and weak links (superconductor-isolator-superconductor thin junctions) defects nature in these compounds. We searched them by resonant part of microwave magnetoabsorption, electron spin resonance. Two peaks, at g-factors g=2.12 and g=4.34 are observed at different concentrations in five specimen versions: 1-2-0-1, T_c=95 K; 1-2-0-1, T_c=70 K (unannealed); 1-2-1-2, T_c=123 K, with ~2% of $BaCuO_{2+\Delta}$ phase determined by rentgen spectra structure analysis; 1-2-0-1, T_c=30 K (unannealed); 1-2-0-1, degraded to green phase, isolator. Factor g=2.12 is typical for Cu^{2+} paramagnetic ion, g≈4.3 - for Fe^{3+} ion. The same shape peak g=2.12 with similar superfine structure is observed for version 3 specimen with technological $BaCuO_{2+\Delta}$ impurity, but at ~50 times more concentration, than in version 1, evaluating Cu^{2+} concentration in superconducting matrix as 10^{-4}. Factor g=4. , observed earlier in Y-1-2-3 superconductor, T_c=90 K, is supposed to arise from Cu^{2+} - Cu^{3+} - Cu^{2+} intervalence transfer chain fragment and corresponds in this case to $-1 \rightarrow 1$ spin transition of excited level. Small polaron, equivalent to intervalence transfer, spin relaxation mechanism is investigated rather slightly in these compounds where interzone contributions (Cu d-zone - O p-zone) can dominate instead of existing simple s-zone model. Enriched by Fe samples measurements are also desirable. Nevertheless fine and superfine structure of the peaks gives possibility right now to advance Cu^{2+}-Cu^{2+} pair defect. For example,unusualy large number of superfine structure lines demands two comparable contributions from "host electron spin - host nucleus spin" and "host electron spin - neighbour nucleus spin" interactions, which is possible in such a pair. In perfect 1. version compound both peaks are really of the same order of concentration. In versions 4. and 5. g=2 centre concentration at room temperature is two-three orders higher than of g=4 one, that is the pairs practically disappear. Another interesting feature is complicated fine structure and pronounced nonresonant magnetoabsorption at low fields (60-1000 Oe) at room temperature, which indicates molecular or paired oxygen ions presence. In conclusion we can preliminary suggest ions pairs presence in superconducting mercury cuprates crystal defect structure, which can organize pinning centres and serve as weak links and weak sites constituents.

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X-RAY ABSORPTION SPECTROSCOPY OF TRANSITION METAL AND RARE-EARTH OXIDE COMPOUNDS

J. Purans, A. Kuzmin, R. Kalendarev

We performed x-ray absorption spectroscopy (XAS) studies of transition metal (TM) and rare-earth (RE) oxide materials (crystals, thin films, glasses, liquids, molecules) using synchrotron radiation facilities such as LURE DCI and SUPER ACO (Orsay, France) and ESRF (Grenoble, France). High quality experimental data and top level theoretical analysis allowed us to gain unique information on the local structural and dynamic properties of oxide materials, breaking the pico-metre barrier (10^{-12} m), i.e. conducting research at the picoscopic (10^{-2} Å) and subpicoscopic (10^{-3} Å) scale.

Main directions of our studies were concerned

- research and development of advanced materials for electrochromic applications;
- investigation of the rare-earth ions structure in water and bio-inorganic molecules;

- development of ab initio theoretical methods for the local structure reconstruction from x-ray absorption spectra.

In particular, a set of thin film materials as pure and mixed TM:TM WO_3-IrO_2, MoO_3-RuO_2, WO_3-RuO_2, IrO_2-TiO_2, prepared by magnetron sputtering, was studied by several experimental techniques as XAS, x-ray diffraction, Raman spectroscopy, IR and UV-VIS optical spectroscopies, atomic force and scanning tunnel microscopies. A relationship between the local atomic and electronic structures and the film microscopic morphology and properties was established. It was found that some systems show promising results for their practical use in high-density memory.

The local structure of RE aqua ions and bio-inorganic molecules was studied within the framework of the European COST D18 program. The main objectives of our group are to gain further insight into microscopic picture of the water molecules around a Gd(III) chelate by x-ray absorption fine structure method.

In spite of x-ray absorption spectroscopy is widely used during last 10-15 years in fundamental and applied research, there are still many open questions both in experimental and data analysis fields. Main data analysis problems are related to (1) an account of static and dynamic disorder, (2) an approximation of multiple-scattering contributions (they are related to the multi-atom distribution functions), (3) understanding of internal electronic effects at the absorbing atoms. Since these problems are very complicated and cannot be solved by analytical way, it is necessary to use numerical approaches such as regularisation technique, Monte-Carlo or molecular-dynamics methods and full multiple-scattering approach. All these methods are used for interpretation of x-ray absorption spectra during not so long time and still require further development and understanding. To address these problems, the EXAFS data analysis software package, called "EDA", was developed and is under continuous improvement. It consists of a set of interactive programs, written for IBM PC compatible computers, and allows to perform all steps of standard analysis approach as well as has several advanced possibilities.

THE CONCEPT FOR STUDY OF LIFE TIME AND PERFORMANCE OF SOLID STATE BATTERIES

A.Lusis, J.Kleperis, E.Pentjuš, G.Vaivars, A.Vitins, G.Vitins,

Now our 20 year experience in electrochromic devices and materials (intercalation oxide electrodes and solid electrolytes) is directed to study the life time and performance of solid-state batteries. The electrochromic devices are functioned as a rechargeable battery and structure of battery cell the same. Such cells can be a good model system for investigating electrochemical processes at electrode / electrolyte interfaces and their products in volume of materials not only by electrochemical methods and impedance spectroscopy, by electro-optical spectroscopy. The value of electrochemical potential is changing for both devices in dependence of charge (colour) – discharge (bleach) state. We used impedance and transient electrochemical methods to determinate the characteristics of electrochemical systems, and all this experience is fully transformable for the rechargeable battery systems. There were elaborated original potential sweeping method in our laboratory, using dc signal perturbed with small ac signal to investigate state -of-charge and state-of-colour of sealed electrochromic systems.

For electrochromic devices the life time (service time) and performance have generally the same dependence from the same physical and chemical processes as for batteries. The degradation of electrochromic devices during cycling and storing was one of the main problem for practical applications. The coloration / bleaching of

electrochromic devices are same process as charge / discharge of battery. The cycling capacity of electrochromic device as well as of rechargible battery are connected with unrevesible electrochemical reactions and mechanical streses inside cell and with gradually changes composition of cell components by ion-mass electro-transfere. The electrochromic cells have the similar relation (K^mN=const, K-optical contrast, N-number of cycles) to Peukert's equation (I^nt=const, I- discharge rate, t- discharge time), which is used for characterisation of batteries perfomence. It means that in bouth cases are some chemical capacity or resource which unreversible run out.

The test cell has been made in the workshop of the ISSP. Propylene carbonate has been distilled at 71-79 °C under reduced pressure (approximately $2 \cdot 10^2$ Pa).

ELECTRODES WITH HIGH ENERGY CAPACITY FOR Ni/MH and Li RECHARGEABLE BATTERIES

J.Kleperis, G.Vaivars, G.Vitins, A.Vitins, A.Lusis
A.Czerwinski;G.Mlynarek**, M.Kopczyk***

Metal hydride electrode impedance measurements for AB_2 electrode materials (synthesised in the Central Laboratory of Batteries and Cells (CLAiO) in Poznan) performed in CLAiO and Riga by G.Vaivars, made excellent basis for the test of "health" of rechargeable batteries. The electrochemical characteristics (charge transfer resistance, exchange current, equilibrium potential) and impedance measured in large frequency region allow to interpret electrode/electrolyte interfaces in sealed battery and determine main blocking layers. New conception is developed how to apply the possibilities of J/S company "Sidrabe" in preparation of metal hydride electrode based on polymer substrate. Review about metal hydride electrodes is finished and published in Journal of Solid State Electrochemistry.

* *Warsaw University, Poland*
** *Central Laboratory of Cells and Batteries (Poznan, Poland*)

RESEARCHES WITH AN ELECTRONIC NOSE AND SENSORS

J. Kleperis, J. Zubkāns, M.Veidemanis, K.Paegle, G. Miķelsons,
V.Eglītis, A. Lūsis, J. Zubkāns, P. Misans,

Different textiles were checked up with an electronic nose. It was proved that electronic nose is applicable not only to distinguish between different sorts of textiles, but also to investigate odour absorption capability of different clothes. Reference measurements in Tuebingen University (Germany) showed that different textile samples may differ only by the content of absorbed water (gas chromatographic measurements), but electronic nose based on different sensors (AlphaMoss equipment) proved results obtained in Riga. Different application technologies for electronic nose are developed based on food control and the tests of goods in customs. New electronic nose, so called zNose is obtained in Institute of Solid State of University of Latvia by thanks of EC project CAMART and support from Ministry of Science and Education of Latvia. The test bench of sensors is elaborated and new method developed for gas sensor calibration. Also ideas about new sensor construction are developed and will be realised soon.

STABILIZATION OF DC REACTIVE MAGNETRON SPUTTERING PROCESS

*G.Grīnvalds, U.Kanders, J.Kļaviņš, A.Āzens**

Among several transparent conducting materials - heavily doped metallic oxide films, one can find such as SnO_2 doped with Sb or F, In_2O_3 doped with Sn (ITO) and ZnO doped with In or Al. However, we have chosen ITO because of its technologically most important combination of properties. ITO is probably also one of the optical electrodes most widely studied of the material class considered. We have used the reactive DC magnetron sputtering method as such having some major advantages for production ITO films in large quantities. As the first advantage one can mention a high sputtering rate, and the other one is the large target dimension, allowing to obtain films with high thickness uniformity.

Optical emission intensity of excited indium species in the plasma was explored to design a feedback circuit to drive the target current supply and reactive gas flow to maintain the sputtering rate constant over long sputtering time. *In situ* monitoring of growing film properties also have been explored to monitor-control the deposition process. We prefer use of three component (argon, oxygen and hydrogen) sputtering gas and plasma emission monitor to achieve process control and stabilization. In this report we describe the plasma emission monitoring for *in situ* analysis of DC reactive magnetron sputtering from metallic In/Sn (90/10) target and consider our suggestions for process stabilization.

** In cooperation with Department of Technology, Uppsala University, Sweden*

RESONANCES AND FLUX-FLOW INVESTIGATIONS IN THE LONG INLINE Nb/Al-AlO/Nb JOSEPHSON JUNCTIONS

P.Cikmačs, M.Cirillo, J.Kļaviņš, V.Merlo*, R.Russo**

Resonances and flux-flow phenomena was studied in very long (4*300μm) inline Josephson junctions by experiments and numerical simulations. The existence of the phenomenon is evident through the appearance of linear resistive branches in the current-voltage characteristics. The results are found in very good agreement with the numerical simulations performed on the basis of real experimental parameters.

The fundamental difference existing between the experimental evidences of flux-flow and the features generated in the current-voltage characteristic by resonances between em modes in the tunnel barrier and Josephson ac-effect is demonstrated.
We discus the explanation of the resistive branches in terms of one-dimensional flux-flow along the extended side of the junction.

** In cooperation with Roma II University "Tor Vergata", Italy*

AIR POLLUTION CONTROL AND AIR QUALITY IN RIGA

*J. Kleperis, D. Danilane**

Air quality control in Riga is performed by differential optical absorption spectroscopy (DOAS) method by using instrument from company OPSIS (Sweden). We are responsible for DOAS measurement system, which belong to Riga City, and our job is to ensure continued measurements, calibration, data collection, data validity check, data analyse. Obtained data contains concentrations of different 6 gases in air. Results

are analysed by checking for correlation between different gases, meteorological parameters, and pollution sources. Different pollution dispersion models are used for calculations. Environmental reports are prepared about air quality in Riga for different environmental and political institutions in city council, ministries etc., as well us for inhabitants. Important aspects of data analyse is connected with air pollution impact on human health and different environmental aspects.

* *Environmental Department of Riga City Council*

REDUCTION OF GREENHOUSE GASES' POLLUTION LOAD TO THE ENVIRONMENT ON THE LATVIAN SCALE

U.Kanders, J.Kļaviņš, M.Čaikovska, I.Vīksna*, N.Zeltiņš**

In order to meet everyday growing human needs for more and more higher life quality the European national industries have to demand more and more all sorts and conditions of energy. The bigger is the specific weight of fuel consumption of the total energy supply for Gross Domestic Product (GDP) the heavier pollution load will necessarily be done on the environment. Energy production by combustion of different fossil fuels such as coal, shale and shale-oil, heavy oil and natural gas produces a huge amount of harmful emissions as sulphur, nitrogen and carbon oxides, besides of them a lot of volatile organic compounds (VOC) as well.

The minimum of greenhouse gas emissions in the Latvia has been observed in 1993, however, afterwards one can see a continued increase of greenhouse gas emissions until now reaching nearly the 1990 scale due to stabilizing macroeconomic measures applied in the national industry and growing up of the GDP. The latest inventory of CO_2 emissions manifests that 96-98% of them are implicitly caused by fuel combustion. Simple extrapolation according to UN IPCC methodology regarding the CO_2 emissions convinces that preventive measures for its emission limitation should be taken. In accordance with the Kyoto Protocol of UN FCCC of 10.12.1999 Latvia has to reduce the aggregate rate of greenhouse gas emissions up to 92% of their 1990 scale during the period from 2008 till 2012.

* *In cooperation with LAS FEI Energy Efficiency Centre*

Scientific Publications

1. J.Gabrusenoks, A.Veispals, A.von Czarnowski, K.H.Meiwes-Broer, *Infrared and Raman spectroscopy of WO_3 and $CdWO_4$* .Electrochim. Acta, **46,** 2001, 2229-2231.
2. A. Vītiņš. *Study of the alternating current electrical properties of ZrO_2-7.5 mol% Y_2O_3 ceramics at room temperature and at 457-595 K.* – J. Solid State Electrochem. 2001, vol. **5**, No. 7-8. p. 479-486.
3. E.A. Raekelboom, A.L. Hector, J.R. Owen, G. Vitins, M.T. Weller. *Syntheses, structures and prelimenary electrochemistry of a layered lithium and sodium Mn(IV) oxides, $A_2Mn_3O_7$.*// J. Materials Chemistry, accepted 09.2001, In press.
4. G. Vitins, G. Kizane, A. Lusis, J. Tiliks. *Electrical conductivity studies in the system Li_2TiO_3-$Li_{1.33}Ti_{1.67}O_4$.*// J. Solid State Electrochem., Published On Line 16.10.2001: DOI 10.1007/s100080100239.
5. A.Azens, G.Vaivars, M.Veszelei, L.Kullman and C.G.Granqvist. *Electrochromic Devices Embodying W Oxide/Ni Oxide Tandem Films*// J.Appl Phys. 89, 12 (2001) 7885-7887.
6. G. Vaivars, J. Kleperis, G. Młynarek, A. Lusis and M. Kopczyk. *AC impedance behaviour of the metal hydride electrodes* Brno 2001, "Advanced Batteries and

Accumulators. 17th - 21st June 2001". Ed. J. Vondrak and M. Sedlarikova, p. 48.1-48.2.
7. G. Vaivars, M. Furlani, B.-E. Mellander and C.-G. Granqvist. *Thermal Analysis of a Proton Conducting Poly(vinyl acetate)/Glycerine Gel Composite with Zirconium Phosphate*. In: Abstr. Of Regional Seminar on Solid State Ionics. Latvia, Jūrmala, 22-26 September, 2001, p. 9.
8. G. Vaivars, T. Mokrani, N. Hendricks and V. Linkov. *Application of the Zirconium Phosphate Based Inorganic Membranes in Fuel Cells.* In: Abstr. of Regional Seminar on Solid State Ionics. Latvia, Jūrmala, 22-26 September, 2001, p. 24.
9. G. Vaivars, T. Mokrani, N. Hendricks and V. Linkov. *Inorganic Zirconium Phosphate Based PEM for Fuel Cells*. In: Abstr. of NEFP Workshop on "New Materials and Technologies for Low Temperature Fuel Cells." 27-28 September, 2001, Helsinki.
10. J. Kleperis, G. Wojcik, A. Czerwinski, J. Skowronski, M. Kopczyk, M. Beltowska-Brzezinska, Review*: Electrochemical behavior of metal hydrides*, J. Solid State Electrochemistry, vol. **5**, 2001, p. 229-249.
11. J. Kleperis, L. Grinberga, A. Lusis, *Electronic nose: what it is and application examples.* Latvian Journal of Physics and Technical Sciences, No.5, (2001), p. 57-66.
12. D. Danilane, J. Kleperis, *Air quality monitoring and management in Riga.* In Book: Riga City Towards Sustainability, Riga, Riga City Environment Centre Agenda 21, 2001, p. 29-40.
13. J. Kleperis, D. Danilane, *Air pollution in Riga harbour region.* In Book: Riga City Towards Sustainability, Riga, Riga City Environment Centre Agenda 21, 2001, p. 41-45.
14. J. Kleperis, D. Danilane, *Air pollution from oil product transit enterprises: DOAS in Riga harbour region.* In book: Air Pollution IX, Editors: G. Latini, C.A. Brebbia, WIT Press, Southanpton, UK, 2001, p. 449-457.
15. V.L. Aksenov, A.Yu. Kuzmin, J. Purans, S.I. Tiutiunnikov, *EXAFS spectroscopy at synchrotron-radiation beams*, Phys. Part. Nucl. 32, 2001, 1-33 (*review*).
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19. J. Purans, A. Kuzmin, Ph. Parent and C. Laffon*, X-ray absorption study of the electronic structure of tungsten and molybdenum oxides at the O K-edge,* Electrochim. Acta 46, 2001, 1973-1976.
20. F. Rocca, M. Ferrari, A. Kuzmin, N. Daldosso, C. Duverger and F. Monti, *EXAFS studies on the local structure of Er^{3+} ions in silica xerogels co-doped with aluminium,* J. Non-Cryst. Solids 293-295, 2001, 112-117.
21. A. Kuzmin and J. Purans, *Local atomic and electronic structure of tungsten ions in scheelite and wolframite AWO_4 crystals*, Rad. Measurements 33, 2001, p. 583-586.
22. G. Moreau, L. Helm, J. Purans and A.E. Merbach, *Toward a pO2 responsive MRI contrast agent: an Eu(II) poly(aminocarboxylates) XAFS study,* LURE Users Meeting 2001.
23. G. Moreau, L. Helm, J. Purans and A.E. Merbach, *Eu(II) poly(aminocarboxylates): an XAFS study*, J. Inorg. Biochem. 86, 2001, p. 345.

In press

1. A. Lusis, J. Kleperis, E. Pentjušs Model of Electrochromic and Related Phenomena in *Tungsten Oxide Thin Films*, Submitted to Journal of Solid State Electrochemistry (2002).
2. Ē. Pentjušs, A.Lūsis *Stabilisation of electrochromic properties of as-prepared anodic WO_3 films in water-acid electrolyte*, Submitted to Journal of Solid State Electrochemistry (2002).
3. G. Vaivars, M. Furlani, B.-E. Mellander and C.-G. Granqvist. *Thermal Analysis of a Proton Conducting Poly (vinyl acetate)/Glycerine Gel Composite with Zirconium Phosphate*. Submitted to Journal of Solid State Electrochemistry, 2002).
4. G. Vaivars, T. Mokrani, N. Hendricks and V. Linkov. *Application of the Zirconium Phosphate Based Inorganic Membranes in Fuel Cells*. Submitted to Journal of Solid State Electrochemistry (2002).
5. G. Moreau, L. Helm, J. Purans and A.E. Merbach, *Structural investigation of the aqueous Eu^{2+} ion: comparison with Sr^{2+} using the XAFS technique*, Submitted to J. Phys. Chem. A (2002).
6. A. Kuzmin, J. Purans and R. Kalendarev, *Local structure and vibrational dynamics in $NiWO_4$,* Submitted to Ferroelectrics (2001).
7. F. Rocca, C. Armellini, M. Ferrari, G. Dalba, N. Diab, A. Kuzmin, and F. Monti, *X-ray absorption and diffraction studies of Pr^{3+}, Tb^{3+} and Er^{3+}-activated silica gels,* Submitted to J.Sol-Gel Tech.

Lectures on Conferences

17th Scientific Conference of ISSP UL, Rîga, February 21-23, 2000.

1) J. Gabrusenoks Vibrational spectra and structure of WO_3 .On Regional seminar on Solid State Ionics, Latvia, Jurmala, 22-26 Sep., 2001.
2) P.Cikmačs, M.Cirillo, J.Kļaviņš, V.Merlo, R.Russo, Resonances and flux-flow investigations in the long inline Nb/Al-AlO/Nb Josephson junctions.
3) G.Grīnvalds, U.Kanders, J.Kļaviņš, A.Āzens, Stabilization of dc reactive magnetron sputtering process.
4) U.Kanders, J.Kļaviņš, M.Čaikovska, I.Vīksna, N.Zeltiņš, Reduction of greenhouse gases' pollution load to the environment on the Latvian scale.
5) J.Kļaviņš, J.Maniks, E.Pentjušs, J.Pinnis, Quality management and testing of materials.
6) L.Grinberga, J.Kleperis, Comparison of odour absorbing capability of different textiles, p. 80.
7) K. Paegle, L. Grinberga, J. Kleperis, Electronic nose and aroma of beers, p. 82.
8) J. Kleperis, Troposphere ozone – cause and effect, p. 81.
9) M. Shirokov, Hg-Ba_2-Ca_0-$O_{4+\delta}$ high-T_c superconductor microwave magneto-absorption.

II Pasaules Latviešu Zinātnieku kongress, Rīga, 2001.g. 14.-15. augusts.

1. A.Lūsis, J.Kleperis, Mikrosistēmu tehnoloģijas un intelektuālie sensorinstrumenti: Izaicinājums Latvijas zinātnei, izglītībai un rūpniecībai.
2. J. Kleperis, G. Vaivars, A. Lūsis, Latviešu pētījumi par ūdeņradi metālos – no Fr. Gulbja līdz mūsdienām.

Latvijas Fizikas biedrības un Latvijas Astronomijas biedrības konference, Liepene, Latvija, 2001.g. 2.-4. jūnijs

J. Kleperis, Mākslīgais deguns.

Regional Seminar on Solid State Ionics, Latvia, Jurmala, September 22-26, 2001.

1. A.Lusis,Ionics and Functional Coatings.
2. A. Lusis, J. Kleperis, E. Pentjušs Model of Electrochromic and Related Phenomena in Tungsten Oxide Thin Films.
3. Ē. Pentjušs, A.Lūsis Stabilisation of electrochromic properties of as-prepared anodic WO_3 films in water-acid electrolyte.
4. J. Gabrusenoks Vibrational spectra and structure of WO_3.
5. J. Kleperis, New trends in metal hydride electrodes for rechargeable batteries.
6. G. Mikelsons, J. Kleperis, E. Zavickis, Measuring the rate of gas diffusion using a semiconductor gas sensor, p. 44.
7. L. Grinberga, J. Kleperis, The odour and the electronic nose, p. 43.
8. G. Veveris, V.Eglitis*Investigation of ions distribution of the Na-Al-Si glass fibres in leaching process.
9. V.A. Alyoshin, E. V. Antipov, M. I. Shirokov, A. A. Timoshin, Mercury cuprates: Superconductivity, ions pairs and electron spin resonance.
10. G. Vaivars, T. Mokrani, N. Hendricks and V. Linkov, "Application of the zirconium phosphate based inorganic membranes in a fuel cells".
11. G. Vaivars, M. Furlani, B.-E. Mellander, and C.G. Granqvist. Thermal Analysis of a Proton Conducting Poly(vinyl acetate)/Glycerine Gel Composite with Zirconium Phosphate.

Seminar on Moscow State University Inorganic Structural Chemistry division, 8 July, 2001.

M.Shirokov, Electron spin resonance and non-resonant microwave magneto-absorption data for superconducting family mercury cuprates structure.

6th International Workshop "High-temperature superconductors and novel inorganic materials engineering (MSU-HTSC VI)", June 24-30, 2001, Moscow-St. Petersburg, Russia.

M.I. Shirokov, A. A. Timoshin, E. V. Antipov, V. A. Alyoshin, Hg-Ba_2-Ca_0-$O_{4+\delta}$ high-T_c superconductor microwave magnetoabsorption.

Second Regional Conference "Magnetic and Superconducting Materials (MSM-01)", 9-13 September, 2001, Yarmouk University, Irbid, Iordan.

M.I. Shirokov, Microwave Losses Selforganization in HTSC.

3rd Forum on New Materials (CIMTEC 2002), 4th International Conference "Science and Engineering of HTC Superconductivity", SIII-1, 14-19 July, 2002, Florence, Italy.

V. A. Alyoshin, E. V. Antipov, M. I. Shirokov, A. A. Timoshin, Mercury cuprates: superconductivity and microwave responce.

The International Conference "Advanced Batteries and Accumulators" (2nd ABA), 17th – 22nd June 2001, Brno, the Czech Republic.

G. Vaivars, J. Kleperis, G. Młynarek, A. Lusis and M. Kopczyk. AC impedance behaviour of the metal hydride electrodes.

NERP workshop "New materials and technologies for polymer electrolyte fuel cells"., Helsinki,. September 27-28, 2001.

G. Vaivars, T. Mokrani, N. Hendricks and V. Linkov, “Inorganic zirconium phosphate based PEM for fuel cells”.

EURODEUR-AIRODEUR 2001, Paris (France), June 18-22, 2001.
J. Kleperis, L. Grinberga, Comparison of odour absorbing capability of different textiles, p. 122-127.

International Workshop MATCHEMS (Materials and Technologies for Chemical Sensors), Brescia (Italy), September 13-14, 2001.
J. Kleperis, G. Mikelsons, E. Zavickis, Simple calibration bench for metal oxide sensors, p. 82-83.

Air Pollution 2001, IX International Conference, Ancona (Italy), September 11-16, 2001.
J. Kleperis, D. Danilane, Air pollution from oil product transit enterprises: DOAS in Riga harbour region.

2. Zinātniski praktiskais seminārs “Satiksmes Problēmas Rīgā: Risināšanas Ceļi”, Rīga, Latvija, 2001.g. 7. decembris.
J.Kleperis, D.Danilāne, J.Janduļina, Motorizētais transports – galvenais gaisa piesārņotājs Rīgā.

10th International Conference on Bioinorganic Chemistry, Florence, Italy, August 26-31, 2001. J.Purans**.**

LURE Users Meeting, Orsay, France, January 18-19, 2001.
J.Purans.

International Workshop on "Extended X-ray Absorption Fine Structure Analysis", Institute of Physics, Polish Academy of Science, Warshaw, Poland, October 22-24, 2001.
A.Kuzmin (Invited Speaker).

Patents

A.Azens, G.Vaivars, M.Veszelei, L.Kullman and C.G.Granqvist. Electrochromic Device Comprising Tandem Layers of Cathodic/Anodic Materials. US patent (April 3, 2001) US 6211995.

Participation in exhibitions

Presentation E-NOSE technology at international exhibitions:

1) Hannover Messe, Germany, March 9-12, 2001; March 9-12, 2001;
2) Baltics Dynamic, Riga, 2001;
3) Baltic Industry, Tokyo, September 16-19, 2001.

NONLINEAR PROCESSES IN SOLIDS

Head of Division Dr. hab. phys. E. A. Kotomin

Research Area and Main Problems

Our theoretical research is focused on two classes of problems related to the kinetics of reactions and the atomic/electronic structure calculations of the defects in non-metallic solids, respectively. We combine many different techniques, including analytical formalisms and large-scale computer simulations (both quantum chemical methods and Monte Carlo/cellular automata modelling).

Scientific staff

1. Dr.hab. J.R.Kalnin
2. Dr.hab. E.Kotomin
3. Dr.hab. V.Kuzovkov
4. Dr. A.Popov
5. Dr. R.Eglitis
6. Dr. Yu.Zhukovskii
7. Dr. G. Zvejnieks

Students

V.Kashcheyevs

Scientific visits abroad

1. Dr.hab. E.Kotomin, Osnabrueck University, Germany (4 months), Max Planck Institute, Stuttgart, Germany (6 months).
2. Dr.hab. V.Kuzovkov, Eindhoven University of Technology, The Netherlands (3 months); Braunschweig University, Germany (3 months).
3. Dr. A.Popov, RIKEN Institute, Japan (3 months); Grenoble University, France (4 months).
4. Dr. Yu.Zhukovskii, University of Western Ontario, London, Canada (2 months), Uppsala University, Sweden (1 month).
5. Dr. G.Zvejnieks, Osnabrueck University, Germany (6 months).
6. Dr. R.Eglitis, Osnabrueck University, Germany (10 months)
7. V.Kashcheyevs, Oslo University, Norway (6 week); Tel Aviv University, Izrael (1 month).

Cooperation

Belgium	University of Antwerpen (Belgium, Prof. J.T.Devreese)
Denmark	University of Aarhus (Denmark, Prof. N.E.Christensen)
Great Britain	Royal Institution of Great Britain, London (Great Britain, Prof. C.R.A.Catlow)
	University College London (Great Britain, Prof. A.M.Stoneham)
Finland	Helsinki University of Technology (Finland, Prof. R.Nieminen)
France	CIRIL, Lab. CEA/CNRS, GANIL, Caen, (France, Prof. E.Balanzat)
Germany	University of Freiburg (Germany, Prof. A.Blumen)
	University of Osnabrück (Germany, Prof. G.Borstel)
	Gesellschaft für Schwerionenforschung (GSI) (Germany, Prof. R.Neumann)

	Max Planck Institut für Festkörperforschung (Germany, Prof. J.Maier)
	Braunschweig University of Technology (Germany, Prof. W.von Niessen)
The Netherlands	University of Groningen (the Netherlands, Prof. H.W den Hartog)
	University of Eidhoven (the Netherlands, Prof. A.P.J.Jansen)
Spain	University of Carlos III de Madrid (Spain, Prof. R.Gonzalez)
Sweden	University of Uppsala, (Sweden, Prof. K.Hermansson)

Main Results

DEFECTS AND SURFACES OF ADVANCES PEROVSKITES

E.A. Kotomin, R.I. Eglitis, Yu.F. Zhukovskii

Large scale first principles and quantum chemical calculations for a number of materials, including $SrTiO_3$, $BaTiO_3$, $KNbO_3$, $KTaO_3$ and their solid solutions, widely used in technological applications.

In collaboration with Osnabruck University, Germany, we performed *ab initio* Hartree-Fock (with electron correlation corrections) and semi-empirical INDO calculations, in order to simulate $SrTiO_3$ both bulk defects and surface relaxation as well as charge-transfer vibronic excitons in $KNbO_3$ and $KTaO_3$ ferroelectric crystals, and to suggest interpretation of the experimental luminescence energies. One of particular purposes of our study is identification of defects resonsible for the blue-light-induced-infrared-adsorption (BLIIRA) effect which strongly affects eficiency of laser frequency doubling in $KNbO_3$-based devices. In collaboration with Antwerpen University, Belgium we developed general theory of bound polarons in oxides and illustrated theory with calculations for hole polarons in basic ceramic materials - MgO and Al_2O_3.

THE KINETICS OF METAL COLLOID FORMATION UNDER IRRADIATION OF PROSPECTIVE MATERIALS

E.A. Kotomin, V.N. Kuzovkov, J.R. Kalnin, V. Kashcheyevs

Theoretical study of the kinetics of metal colloid formation in several important materials (alkali halide LiF and metal oxide MgO) using novel formalism of many-particle densities.

In collaboration with partners from GSI Institution, Darmstadt, Germany, we developed theory of the kinetics of primary defect aggregation (*F* centers) in tracks of swift heavy ions in ionic solids and suggested interpretation of existing experimental data. We predict metal colloid size to be very small, and thus non-detectable by EPR, in agreement with experiment. We developed also a novel theory predicting the growth mode of thin metallic films on insulating substrates, which is of great technological importance. We discussed joint studies with the Excellence Center in Tartu (Institute of Physics) on radiation defect aggregation in solids

SELF-ORGANIZATION IN SURFACE CATALYTIC REACTION

V.N. Kuzovkov, G. Zvejnieks, V. Kashcheyevs

Modeling of catalytic surface reactions, which are of enormous importance in industrial processes and environmental chemistry. Development of new computer codes and new analytical methods,

In collaboration with Braunschweig University, Germany we introduced and studied the standard Lotka-type model, which was introduced for a simplifed description of autocatalytic surface reactions. We generalized the model for a case of mobile and energetically inetracting reactants. The mathematical formalism is proposed for determining the dependence of transition rates on the interaction energy (and temperature) for the general mathematical model, and the Lotka-type model for determining the dependence of transition rates on the interaction energy (and temperature) for the general mathematical model, and the Lotka-type model, in particular. By means of Monte Carlo computer simulations, we have studied the impact of diffusion on oscillatory properties of the A+B->2B reaction. The diffusion leads to a desynchronization of oscillations and a subsequent decrease of oscillation amplitude. The energetic interaction between reactants has a dual effect depending on the type of mobile reactants. In the limiting case of mobile reactants B the repulsion results in a decrease of amplitude. However, these amplitudes increase if reactants A are mobile and repulse each other. An interpretation of the obtained results is given.

FIRST PRINCIPLES MODELING OF METAL OXIDATION AND CORROSION

E.A. Kotomin, Yu.F. Zhukovskii

Detailed first principles theoretical studies of the initial stages and mechanisms of the formation of metal coatings on the dense-packed surfaces of alumina and magnesia as well as oxidation of Al and Mg.

In collaboration with Uppsala University, Sweden, we performed *ab initio* calculations of the metal/oxide interfaces with emphasis on the effects of oxide surface coverage by metal, found optimal adsorption sites and adhesion energies for metal films of different thickness. Combining results of electron structure calculations with both kinetic and thermodynamic approaches we explain the growth mechanism of metallic films deposited on different metal oxides surfaces. In collaboration with the University of Western Ontario, Canada we have described mechanism of the initial stage of aluminium oxidation.

DEFECT PROPERTIES OF PROSPECTIVE OXIDE AND HALIDE MATERIALS

E.A. Kotomin, V.N. Kuzovkov, A.I. Popov

Use of optical spectroscopy for the characterization of radiation defect aggregation in oxide materials.

In collaboration with Madrid University, we performed measurements of optical absorption and luminescence in order to monitor the thermal annihilation in TCR MgO

single crystals. The annihilation rate depends on the F-center concentration: the higher concentration, the lower rate. For MgO crystals with low and intermediate F-center concentration ($<10^{17}$ cm^{-3}) their thermal destruction is due to more mobile defects, such as magnesium vacancies and impurities. In a sample where the F-center concentration is exceptionally high ($>10^{18}cm^{-3}$), intrinsic diffusion and aggregation of these defects results in unusual extended defects: magnesium-plated nanocavities. A theory of the nanocavity formation process is developed on diffusion-controlled aggregation of elastically interacting F centers and their annihilation at traps. We show that in contract to generally accepted viewpoint, the F centers in the bulk are not annealed out at the external sample surface but at internal defects, such as dislocations, subgrain boundaries and impurities.

Scientific Publications
Published in 2001

1. J.T. Devreese, V.M. Fomin, E.P. Pokatilov, E.A. Kotomin, R.I. Eglitis, and Yu.F. Zhukovskii, *Theory of bound polarons in oxide compounds*. - Phys. Rev. *B*, 2001, vol. **63**, 184304, p. 1-6.

2. V.N. Kuzovkov, A.I. Popov, E.A. Kotomin, M.A. Monge, R. González, and Y. Chen, *The kinetics of F-center aggregation in thermochemically reduced MgO single crystals.* - Phys. Rev. *B*, 2001, vol. **64**, 064102, p. 1-5.

3. E.A. Kotomin, V. Kashcheyevs, V.N. Kuzovkov, K. Schwartz, and C. Trautmann, *Modeling of primary defect aggregation in tracks of swift heavy ions in LiF*. - Phys. Rev. B, 2001, vol. **64**, 144108, p. 1-7.

4. E. Heifets, R. I. Eglitis, E. A. Kotomin, J. Maier, and G. Borstel, *Ab initio modeling of surface structure for $SrTiO_3$ perovskite crystals*. - Phys. Rev. B, 2001, vol. **64**, 235417, p.1-5.

5. V.N. Kuzovkov, O. Kortlüke, and W. von Niessen, *Comment on "Surface restructuring, kinetic oscillations, and chaos in heterogeneous catalytic reactions"*. - Phys. Rev. *E*, 2001, vol. **63**, 023101, p. 1-5.

6. G. Zvejnieks and V.N. Kuzovkov, *Monte-Carlo simulations for Lotka-type model with reactant surface diffusion and interactions*. - *Phys. Rev. E*, 2001, vol. **63**, 051104, p. 1-10.

7. V. Kashcheyevs and V.N. Kuzovkov, *Global oscillation mechanism in the stochastic Lotka model.* - *Phys. Rev. E*, 2001, vol. **63**, 061107, p. 1-8.

8. Yu.F. Zhukovskii, E.A. Kotomin, S. Dorfman, D. Fuks, and A. Gordon, *Hartree-Fock study of adhesion and charge redistribution on the Ag/MgO(001) interface.* - Surf. Sci., 2001, vol. **482-485**, p. 66-72.

9. S. Dorfman, D. Fuks, A. Gordon, E.A. Kotomin, and P. Wyder, *Some nonlinear properties of ferroelectric smart materials*. - Physica B, 2001, vol. **304**, p. 339-347.

10. A.I. Popov, M.A. Monge, R. González, Y. Chen, and E.A. Kotomin, *Dynamics of F-center annihilation in thermochemically reduced MgO single crystals.* - Solid State Commun., 2001, vol. **118**, p. 163-167.

11. Yu.F. Zhukovskii and R.I. Kalendarev, *Cluster simulations of structural transformations in yellow arsenic*. - J. Mol. Struct. *(THEOCHEM)*, 2001, vol. **544**, p. 111-121.

12. B. Savoini, C. Ballesteros, J.E. Muñoz-Santiuste, R. González, A.I. Popov, and Y. Chen, *Copper and iron precipitates in thermochemically reduced yttria-stabilized-zirconia crystals*. - Phil. Mag. Letters, 2001, vol. **81**, p. 555-561.

13. V. S. Vikhnin, R. I. Eglitis, S. E. Kapphan, E. A. Kotomin and G. Borstel, *A new phase in ferroelectric oxides: The phase of charge transfer vibronic excitons.* - Europhys. Letters, 2001, vol. **56** (5), p. 702-708.

14. R.I. Eglitis, E.A. Kotomin and G. Borstel, *Quantum chemical modelling of polarons and perovskite solid solutions.* - Comput. Mater. *Sci*., 2001, vol. **21**, p. 530-534.

15. K. Kimura, S. Sharma, and A.I. Popov, *Novel ultra-fast luminescence from incipient ion tracks of insulator crystals: electron-hole plasma formation in the track core.* - Radiat. Measurements, 2001, vol. **34**, p. 99-103.

16. R.I. Eglitis, S.V. Izvekov, and M.R. Philpott, *Modeling Metal Dissolution in Aqueous Electrolyte: Hartree-Fock and Molecular Dynamics Calculations*. In: Solid-Liquid Interface Theory (ed. J.W. Halley, ACS Symp. Ser., vol. **789,** 2001),

    p. 51-65.

17. J.T. Devreese, V.M. Fomin, E.P. Pokatilov, E.A. Kotomin, R.I. Eglitis, and Yu.F. Zhukovskii, *Theory of bound polarons in oxide compounds*. - Los Alamos Natl. Lab., Prepr. Arch., Condens. Matter, 2001, p. 1-13.

18. J.-R. Kalnin, E.A. Kotomin, and V.N. Kuzovkov, *Calculation of the effective diffusion coefficient in inhomogeneous solids.* - Defect and Diffusion Forum *(Proc.* Int. Conf. on Diffusion in Materials, Paris, 2000), 2001, vol. **194-199**, p. 163-168.

19. E.A. Kotomin, R.I. Eglitis, J. Maier and E.Heifets, *Calculations of the atomic and electronic structure for $SrTiO_3$ perovskite thin films*. - Thin Solid Films (Proc. E-MRS, Strasbourg, 2001), 2001, vol. **400**, p. 76-80.

20. E.A. Kotomin, V.N. Kuzovkov, and A.I. Popov, *The kinetics of defect aggregation and metal colloid formation in insulating solids under irradiation.* - Radiation Defects and Effects in Solids (Proc. Int. Conf. on Defects in Ionic Materials, ICDIM'2000), 2001, vol. **155**, 113-125.

21. V. Kashcheyevs, E.A. Kotomin, and V.N. Kuzovkov, *Modelling of metal colloid formation in tracks of swift heavy ions in ionic solids*. - ibid, 145-151.

22. Yu.F. Zhukovskii, E.A. Kotomin, B. Herschend, K. Hermansson, and P.W.M. Jacobs, *A first-principles study of the Ag/a-Al_2O_3(0001) interface*. - Int. J. Mol. Sci., 2001, vol. **2**, p. 271-280.

23. E. Heifets, E.A. Kotomin, R.I. Eglitis, and R.E. Cohen, *Calculations of perovskite surfaces relaxation.* - Mat. Res. Soc. Symp. Proc. (Spring MRS Meeting, San Francisco, 2001), 2001, vol. **654,** p. AA5.3.1-6.

24. R.I. Eglitis, E.A. Kotomin, and G. Borstel, *Computer modeling of Luminescence in ABO_3 perovskites.* - Mat. Res. Soc. Symp. Proc. (Spring MRS Meeting, San Francisco, 2001), 2001, vol. **667**, p. G1.8.1-6.

25. E. Heifets, R.I. Eglitis, E.A. Kotomin, and G. Borstel, *Calculations of Surface Structure for $SrTiO_3$ perovskite*. - Mat. Res. Soc. Symp. Proc. (Spring MRS Meeting, San Francisco, 2001), 2001, vol. **672**, p. O9.1.1-6.

26. V.S. Vikhnin, R.I. Eglitis, E.A. Kotomin, S. Kapphan, and G. Borstel, *New polaronic-type excitons in ferroelectric oxides: INDO-calculations and experimental manifestation.* - Mat. Res. Soc. Symp. Proc. (Spring MRS Meeting, San Francisco, 2001), 2001, vol. **677**, p. AA4.15.1-6.

27. G. Borstel, R.I. Eglitis, and E.A. Kotomin, *Computer modelling of KTN solid solutions.* - Proc. 12th IEEE Internat. Symp. Applications of Ferroelectrics (Honolulu, Hawaii, 2000), vol.**2**, 2001, p. 671-674.

28. E.Heifets, R.I.Eglitis, E.A.Kotomin, G.Borstel, *First-principles and semi-empirical calculations of atomic and electronic structure of the (100) and (110) perovskite surfaces.* - Proc. Williamsburg Meeting on Fundamental Physics of Ferroelectrics (ed. H.Krarauer, AIP Conf. Proc., N.Y., 2001), vol. **582**, p. 201-210.

29. V.S. Vikhnin, R.I.Eglitis, E.A.Kotomin, S.E.Kapphan, G. Borstel. *New polaronic-like excitons in ferroelectric oxides.* - Proc. Williamsburg Meeting on Fundamental Physics of Ferroelectrics (ed. H.Krarauer, AIP Conf. Proc., N.Y., 2001), vol. **582**, p.228-239.

30. O. Sychev, Yu.F. Zhukovskii, E.A. Kotomin, and Yu.N. Shunin, *Adhesion of silver on the Al-terminated corundum (0001) surface: Hartree-Fock simulations.* - Computer Modelling & New Technologies (Latvia), 2001, vol. **5**, Nr 1, p. 7-17.

31. J.-R. Kalnin and E.A. Kotomin, *A novel relation for the effective diffusion coefficient in inhomogeneous media.* . - Computer Modelling & New Technologies (Latvia), 2001, vol. **5**, Nr 1, p. 18-27.

32. Yu.F. Zhukovskii, D. Gryaznov, A, Finogenov, and Yu.N. Shunin, *Ab initio simulations of the Cu/MgO(001) interface*. - Computer Modelling & New Technologies (Latvia), 2001, vol. **5**, Nr 1, p. 28-41.

33. K. Kimura, S. Sharma, and A.I. Popov, *Dynamics of incipient ion tracks in wide-band-gap materials: electron-hole plasma luminescence from ion tracks and initiation of defect formation.* – RIKEN Accel. Prog. Rep. (Japan), 2001, vol. **34**, p. 159.

34. A.I. Popov, S. Sharma, and K. Kimura, *Ultrafast luminescence of CsI scincillator crystals under heavy-ion irradiation.* – RIKEN Accel. Prog. Rep. (Japan), 2001, vol. **34**, p. 160.

Popular Science Articles

1. J.Miķelsons, J Stirna, J.R.Kalniņš, A Kapenieks, G. Jirgensons. *A Hyperknowledge project for the Riga City Council*. Baltic IT&T Review 2001, vol. **22**, p.44-46.
2. J.R.Kalniņš. *Zināšanu apgūšana un pārvaldīšana informācijas laikmetā.* Ziņojumu krājumā "Izglītota sabiedriba un jaunā ekonomika kvalitatīvā mijiedarbībā". Starptautiskā zinātniskā konference.Banku augstskola. Rīga, 2001. p. 166-169.
3. J.R.Kalniņš. *Kā mācīties*. "Mans īpašums", 2001, No 11, p. 50-52.

Lectures on Conferences

1. V. Kashcheyevs, E.A. Kotomin, and V.N. Kuzovkov. *Modeling of Primary Defect Aggregation in Tracks of Swift Heavy Ions in Alkali Halides*, 12th International

Conference of Surface Modification of Materials by Ion Beams, September 9-14, 2001, Marburg, Germany, p.2.13.

2. V.S. Vikhnin, R.I. Eglitis, E.A. Kotomin, S.E. Kapphan, *New polaronic-type excitons in ferroelectric oxides: nature and experimental manifestation*, 2001 Workshop on Fundamental Physics of Ferroelectrics, February 4-7, 2001, Williamsburg, VA, USA.
3. E. Heifets, R.E. Cohen, R.I. Eglitis, E.A. Kotomin and G. Borstel, *First-principles and semi-empirical calculations of atomic and electronic structure for SrTiO3 (100) and (110) surfaces*, APS March 2001 Meeting, March 12-16, 2001, Seattle, Washington, USA.
4. R.I. Eglitis, M.R. Philpott and S.V. Izvekov, *Computer modelling of corrosion*, 2001 MRS Spring Meeting, April 16-20, 2001, San Francisco, California, USA, p. 331, (Invited talk).
5. R.I. Eglitis, E.A. Kotomin and G. Borstel, *Computer Modelling of Luminescence in ABO_3 Perovskites*, 2001 MRS Spring Meeting, April 16-20, 2001, San Francisco, California, USA, p. 142.
6. V.S. Vikhnin, R.I. Eglitis, E.A. Kotomin, S.E. Kapphan and G. Borstel, *New Polaronic-type excitons in ferroelectric oxides: Nature and Experimental Manifestation*, 2001 MRS Spring Meeting, April 16-20, 2001, San Francisco, California, USA, p. 435.
7. R.I. Eglitis, A.V. Postnikov and G. Borstel, *Computer Modelling for Single and Interacting Li Impurities in $KTaO_3$*, 2001 MRS Spring Meeting, April 16-20, 2001, San Francisco, California, USA, p. 436.
8. E.Heifets, R.E. Cohen, R.I. Eglitis, E.A. Kotomin and G. Borstel, *Calculations of Surface Structure for SrTiO3 perovskite*, 2001 MRS Spring Meeting, April 16-20, 2001, San Francisco, California, USA, p. 289.
9. E.A. Kotomin, R.I. Eglitis, J. Maier, and E. Heifets, *Calculations of the atomic and electronic structure for ABO_3 perovskite thin films*, E-MRS 2001 Spring Meeting, Symposium N, June 5-8, Starsbourg, France.
10. E.A. Kotomin, R.I. Eglitis, and G. Borstel, *Calculations of radiation-induced point defects, polarons and excitations in ferroelectric perovskites*, Radiation Effects in Insulators, REI –11, 2001, Lisbon, Portugal, September 03-07.
11. R.I. Eglitis, E.A. Kotomin, and G. Borstel, *Computer Modeling of point Defects in Perovskite Crystals*, 10th International Meeting on Ferroelectricity, September 3-7, 2001, Madrid, Spain, p. 44.
12. V.S. Vikhnin, R.I. Eglitis, S.E. Kapphan, E.A. Kotomin and G. Borstel, *New Type Charge Transfer States in Ferroelectric Oxides: Theoretical and Experimental Studies of Charge Transfer Vibronic Exciton Phase*, 10th International Meeting on Ferroelectricity, September 3-7, 2001, Madrid, Spain, p. 61.
13. R.I. Eglitis, E.A. Kotomin, G. Borstel, E.Heifets and R.E. Cohen, *Ab initio Calculations of Atomic and Electronic Structure for $SrTiO_3$ (100) Surfaces*, 10th International Meeting on Ferroelectricity, September 3-7, Madrid, Spain, p. 69.
14. R.I. Eglitis, V.S. Vikhnin, S.E. Kapphan, E.A. Kotomin and G. Borstel, *Structure and Recombination Luminescence of Nre-Polaronic Type Excitons in Ferroelectric Oxides*, 10th International Meeting on Ferroelectricity, September 3-7, Madrid, Spain, p. 80.
15. E.A. Kotomin, R.A. Evarestov, *Large-scale ab initio modelling of defects in perovskites: Fe impurity in $SrTiO_3$. - Abstr*. E-MRS meeting, Strasburg, June 5-8, 2001, symp. A, p.A-1.
16. S. Dorfman, D. Fuks, E.A. Kotomin, Yu. Zhukovskii, A.M. Stoneham, *Theoretical analysis of the growth mode for thin metallic films on oxide surstrates. - Abstr*. E-MRS Meeting, Strasburg, France, June 5-8, 2001, symp.A, p.A-I9.

17. D. Fuks, S. Dorfman, Yu.F. Zhukovskii, and E.A. Kotomin, *Theory of the growth mode for a thin metallic film on an insulating substrate. - Abstr*. Europ. MRS'2001 Spring Meeting, Strasbourg, France, 2001, p. A3.
18. E.A. Kotomin, *Atomistic theory of thin metal film growth on ionic surstrates. - Abstr. NATO Advanced Research Workshop on Atomic Aspects of the Epitaxial Growth*, Corfu, July 26-31, p.16.
19. R. Gonzalez, E.A. Kotomin, A.I. Popov, V.N. Kuzovkov, *Diffusion-controlled annihilation and aggregation of F-centers in thermochemically reduced MgO crystals. - Abstr*. 11 Intern. Conf. on Radiation Effects in Insulators, Lisbon, September 3-9, 2001, p. 116.
20. K. Hermansson, B. Herschend, Yu. Zhukovskii, E.A. Kotomin and P.W.M. Jacobs, *Metal-oxide bonding in the Ag/MgO (100) interface: an effect of metal coverage. - Abstr.* Europ. Conf. on Molec. Mechanisms of Heterog. Catal., San Feliu de Guixols (Spain), 2001, p. 24.
21. Yu. Zhukovskii, E.A. Kotomin, B. Herschend, K. Hermansson, and P.W.M. Jacobs, *The adhesion properties of the Ag/a-Al_2O_3 (0001) interface: an ab initio study. - Abstr*. Europ. Conf. on Molec. Mechanisms of Heterog. Catal., San Feliu de Guixols (Spain), 2001, p. 58.
22. E.A.Kotomin, *Models of defects in crystalline solids*, Talks at NATO ASI on Computational Materials Science (Il Ciocco, Italy, 9-22.09.01).
23. E.A.Kotomin, *Optical properties and defect diffusion in ceramics*, Talks at NATO ASI on Computational Materials Science (Il Ciocco, Italy, 9-22.09.01).
24. E.A.Kotomin, *Large scale modeling of defects and polarons in perovskites*, Talks at NATO ASI on Computational Materials Science (Il Ciocco, Italy, 9-22.09.01).
25. S. Piskunov, Yu.F. Zhukovskii, E.A.Kotomin, and Yu.N. Shunin, "*Hartree-Fock calculations on the $SrTiO_3$ crystal in cubic phase" – Abstr*. Europ. Summerschool Model. Solid State Chem. (MSSC'2001), Torino, Italy, 2001, p. 25.
26. O. Sychev, Yu.F. Zhukovskii, and E.A. Kotomin, *Adhesion properties of Ag/α–Al_2O_3(0001) interface: Hartree-Fock calculations. - Abstr.* 17th Meet. Inst. Solid State Phys., Univ. Latv., Riga (Latvia), 2001, p. 17.
27. A. Kovalevska, Yu.F. Zhukovskii, and P.W.M. Jacobs, *DFT simulations of the interaction between oxygen and an Al(111) substrate. - Abstr.* 17th Meet. Inst. Solid State Phys., Univ. Latv., Riga (Latvia), 2001, p. 19.
28. L. Grigorjeva, D. Millers, V. Pankratov, E.A. Kotomin and R.I. Eglitis, *Polaron effects in $LiNbO_3$ and $KNbO_3$ perovskite crystals, - Abstr.* 17th Meet. Inst. Solid State Phys., Univ. Latv., Riga (Latvia), 2001, p. .

PhD Thesis

G. Zvejnieks, "**Catalytic Surface Reactions: Monte Carlo Simulations of Systems with Creation, Annihilation and Diffusion of Interacting Reactants**". University of Osnabruck, Germany, 2001.

OPTICAL RECORDING

Head of Laboratory Dr. J.Teteris

Research Area and Main Problems

Synthesis and research of amorphous chalcogenide semiconductor (As-S, As-Se and As-S-Se) thin films for optical recording and electron beam lithography have been performed. Photoinduced changes of optical properties, holographic recording and hologram self-enhancement effects, and relaxation processes in amorphous films were studied. The main task is R&D of high sensitive photoresists in the visible region for holography and electron-beam resists for production of diffractive optical elements. Rainbow hologram production technology based on chalcogenide semiconductor photoresists was developed. R&D of grating structures for optical communication DWDM systems in planar wavequides based on amorphous chalcogenide semiconductor thin films were started.

Scientific Staff	PhD Students
1. Prof. Dr.hab. A.Ozols	1. K.Jefimovs
2. Dr. M.Reinfelde	
3. Dr. P.Stradins	
4. Dr. J.Teteris	

Technical Staff	Students
1. J.Gurovs	1. I.Kuzmina
2. D.Popele	

Visitors from abroad

1. Dr. A.Peckus, Institute of Physics, Lithuania (3 days).

Scientific visits abroad

1. Mg. K.Jefimovs, University of Joensuu, Finland (12 months).
2. Dr. P.Stradins, Thin Film Silicon Solar Cells Super laboratory, Electrotechnical Laboratory, Japan (12 months).

Cooperation

Latvia

1. Riga Technical University (Prof. A.Ozols).
2. Daugavpils Pedagogical University (Dr. V.Paškēvics and Dr. Vj.Gerbreders).

Finland

3. University of Joensuu (Prof. T.Jaaskelainen and Prof. J.Turunen).

USA

4. University of Arizona, Optical Science Center, Tucson (Dr. O.Nordman and Dr. N.Nordman).

Japan

1. Electrotechnical Laboratory, Thin Film Silicon Solar Cells Super Lab. (Dr. P. Stradins).

Main Results

HOLOGRAPHIC STUDIES OF AZOBENZENE OLIGOMERS

A.Ozols and M.Reinfelde

Experimental holographic studies of azobenzene ologomer layers brought on the glass substrates have been started this year. Azobenzene oligomer samples were prepared at Riga Technical University in the group of Professor V.Kampars. The aim of these studies is to produce efficient materials for scalar and vectorial holographic information recording, and to investigate the photoinduced processes in this new class of media.The composition of layers is varied to fit the He-Ne line of 632.8 nm. Diffraction efficiency exposure and grating period (Λ) dependences have been measured. Now the maximal diffraction efficiency is 0.028% at Λ=0.7 μm for scalar recording. The best specific recording energy is about 1 kJ/(cm^2%). Recording is reversible. Holograms can be easily erased by recording light, after that recording can be repeated many times at the same spot. Composition optimization of azobenzene oligomer layers is continued as well as their holographic studies.

MILLISECOND HOLOGRAM RECORDING IN AMORPHOUS As-S-Se FILMS

A.Ozols and S.Lazarevs

Millisecond impulse hologram recording is experimentally carried out and studied in amorphous semiconductor films, for the first time to our knowledge. The maximal diffraction efficiency (0.32%) in 4.7 μm thick amorphous As-S-Se films is about five times lower in comparison with CW recording whereas the specific recording energy (≈ 2.7 kJ/(cm^2%)) is more than 500 times lower. for similiar recording light intensities of about 10^3 W/cm^2 at 632.8 nm. The dark relaxation time of millisecond holograms is about 100 minutes. Diffraction efficiency and specific recording energy are increasing with exposure up to about 300 J/cm^2. It is established that the recording mechanism differs from the usual photoinduced structural changes.

Instead, the photoinduced recharging of localized states takes place. Millisecond impulse holograms in amorphous semiconductors can be applied for real time optical information processing.

RECORDING OF HOLOGRAPHIC GRATINGS IN AMORPHOUS As-S-Se FILMS BY UNFOCUSED AND FOCUSED LASER BEAMS

A.Ozols and S.Lazarevs

We have experimentally compared holographic gratings with the periods Λ=0.51-21.7 μm recorded in As-S-Se films by unfocused and focused (by F=5 cm lense) He-Ne laser beams at the wavelength of 632.8 nm. Recording intensities (I) were 0.19 and 0.39 W/cm^2 for unfocused beams and 0.47-1.38 kW/cm^2 for focused ones. The conclusion is made that focusing increases both diffraction efficiency (DE) and specific recording energy (W). The best results are DE=0.56%, W=0.17 J/(cm^2%) at Λ=0.71 μm and I=0.19 W/cm^2 for unfocused recording beams, and DE=1.61%, W=0.59 MJ/(cm^2%) at Λ=2.30 μm and I=1.38 kW/cm^2. Thus focused recording brings about 3 times higher DE but more than million times lower recording sensitivity. The mechanism of this effect is under study.

DIFFRACTIVE ANISOTROPY STUDIES IN AMORPHOUS As-S-Se FILMS

A.Ozols and M.Reinfelde

As known, optically isotropic materials can be made optically anisotropic by creating small perod ($\Lambda<\lambda$, λ being the readout wavelength) grating in it. This phenomenon is called diffractive anisotropy or form birefringence. It can be used to make a new type of diffractive optical elements such as thin polarization rotators, phase retarders, etc. We have studied diffractive anisotropy(DA) both experimentally and theoretically in a-As-S-Se films. For this purpose transmission holographic gratings with small perods Λ=0.20-0.86 μm were recorded by a He-Ne laser (λ=632.8 nm) and zero order beam diffraction efficiencies (η_0) for TE and TM polarizations were measured. They were compared with the TE and TM transmittances before the recording. DA should manifest itself by the difference of the TE and TM transmittance and zero order diffraction efficiency ratios.Without DA this ratio (γ) should be one when corrected for polarization dependent Fresnel reflection losses. DA, in our case the diffractive dichroism makes this ratio different from one. We have measured γ in the range 0.700-0.875 but it is mainly determined by Fresnel reflections. Calculations according to Kogelniks coupled wave theory give γ=0.997 due to DA alone for Λ=0.42 μm. This effect is within the experimental error. No DA is found at normal incidence neither theoretically nor experimentally.

In the case of the first order diffraction efficiency (η) DA and Fresnel reflections act in opposite ways: DA mainly decreases η_{TM} whereas Fresnel reflections mainly decrease η_{TE}. Again, Fresnel reflections are dominant, however, at much lesser extent than for η_0.

Weigert effect can also mask DA but both these effects should be much weaker (as shown by our measurements) than polarization dependent Fresnel reflections.

RECORDING OF HOLOGRAPHIC GRATINGS IN AMORPHOUS As-S-Se FILMS

J.Teteris and I.Kuzmina

The holographic recording in amorphous As-S-Se films was studied. The changes of the diffraction efficiency were measured as a function of the aging time and the recording light intensity. The role of the internal mechanical stress of the films in the self-enhancement phenomenon has been discussed. It was shown that the RSE has a vectorial character owing to the uniaxial periodically distributed stress relaxation. A model based on the photo-induced stress relaxation and viscous flow of amorphous film is proposed to explain the experiments qualitatively.
The dependence of the holographic recording self-enhancement on the illumination intensity of the holographic gratings has been experimentally studied in amorphous as-evaporated As-S-Se films. The relaxation time of the self-enhancement was found to decrease exponentially as a function of the exciting laser beam intensity. Results were explained by assuming that light induces the decrease of the viscosity of amorphous films.

As-S-Se RESISTS FOR HOLOGRAPHY AND ELECTRON-BEAM LITHOGRAPHY

J.Teteris, D.Popele and M.Reinfelde

The photo- or e-beam stimulated changes in the rate of wet etching of amorphous As-S-Se thin films obtained by vacuum deposition method is the basis for development of a new class of inorganic resists. Such resists are characterized by very high resolution (> 10000 lines/mm), wide spectral range of photosensitivity (UV and visible up to 700 nm) and they have a number of peculiarities that make them very attractive for application in many photo- and e-beam lithographic processes. The possibility of light- and thermo-induced amplification of holographic recording in amorphous semiconductor films is especially important for the further improvement of the light sensitivity of these photoresists. The amorphous chalcogenide photoresists for production of embossed rainbow holograms have been used. The negative photoresist elaborated at Institute of Solid State Physics (University of Latvia) posseses light sensitivity of $\sim$100 mJ/cm^2 and spectral sensitivity range at $\lambda \leq 700$ nm. Thus it is possible to record holograms by means of semiconductor diode or solid state lasers.

PHOTOCARRIER CAPTURE PROPERTIES IN a-Si:H

P.Stradins

In hydrogenated amorphous silicon (a-Si:H) materials we usually observe the various photoconductivity even when the films contain almost the same number of defects. It

indicates that ability to capture the photocarrier by the defect is not unique. We have studied the photocarrier capture intothe light induced defects (LIDs) in a-Si:H. The ability of the LID to capture photocarriers would be influenced by microscopic enviroment around it. This microscopic enviroment is determined by several factors, such as hydrogen bonding structure and Si network order. What kind of structure is responsible for the observed photocarrier capture coefficients is the focus of this work. First we studied a-Si:H prepared at various substrate temperatures. Those films were then degraded by the exposure to the nanosecondlaser pulses. After each exposure step, the bandgap photoconductivity, subgap absorption spectra and spin density were measured. We observe a significantly stronger photocarrier capture in the film deposited at 150 ^{o}C, which is 10 times larger than those of the films deposited at higher temperatures up to 250 ^{o}C. This indicates that the microscopic structure around the defect, which governs the photocarrier capture ability, is different throughout those films. The film deposited at lower temperatures contains a large amount of hydrogen, whereas the higher temperature deposited films do not. The photocarrier recombination event would have much chance to release the recombination energy to Si-H bond rather than Si-Si bond due to their vibrational energy difference. Therefore, when the Si-H bond is located close to the defect, the ability to capture photocarriers is likely to become larger. We also studied the photocarrier capture coefficient in thea-Si:H films prepared under various hydrogen dilution ratio including the microcrystalline nucleation threshold regime. The a-Si:H network is modified by the change in deposition precursors due to the hydrogen dilution during the preparation, resulting in different microscopic environment around the defects. We also discuss the photocarrier capture coefficient in these films, as they approoach the transition region for the nucleation of crystallites.

Scientific Publications

1. A.Ozols, M.Reinfelde, O.Nordman and N.Nordman. *Photoinduced anisotropy and holographic recording in amorphous chalcogenides*. Proc.SPIE , 2001, vol. **4415**, p. 1-10.
2. A.Ozols and M.Reinfelde. *Holographic properties of dielectric crystals and amorphous semiconductor films*. Proc.SPIE, 2001, vol. **4358**, p**.** 64-75.
3. A.Ozols. *Dielectric crystals and amorphous semiconductor films as holographic information recording materials.* Scientific Proc. of Riga Technical University. Series: Material Science and Applied Chemistry, 2001, vol. **2**, p. 70-85.
4. A.Ozols and Ģ.Ivanovs. *Wavelength division multiplexing in fiber optical communications.* 42-nd Riga Technical University conference. Section on Electronics and Telecommunications. Conf. Proceedings. Faculty of Electronics and Telecommunications, RTU, 2001, p. 35-41.
5. J.Maniks, I.Manika, J.Teteris and R.Pokulis. *Identation creep and stress relaxation in amorphous As-S-Se and As-S films.* Proc.SPIE , 2001, vol. **4415**, p. 44-47.
6. J.Teteris and I.Kuzmina. *Amorphous chalcogenide semiconductor resists for holography and electron-beam lithography.* Proc.SPIE , 2001, vol. **4415**, p. 54-59.
7. J.Teteris and M.Reinfelde. *Holographic recording in amorphous chalcogenide semiconductor thin films.* Proc.SPIE , 2001, vol. **4149**, p. 81-90.

In Press

1. A.Ozols, S.Lazarevs, B.Berzina. *Millisecond impulse holograms in amorphous As-S-Se films.* Nuclear Instruments and Methods in Physics Research B, 2002.

2. J.Teteris. *Amorphous As-S-Se semiconductor resists for holography and lithography*. Journ. of Non-Cryst.Solids, 2002.
3. P.Stradins, S.Shimuzu, M.Kondo and A.Matsuda. *Less-understood phenomena in the light-induced degradation and photocarrier capture in a-Si:H*. Journ. of Non-Cryst.Solids, 2002.
4. S.Shimuzu, P.Stradins, M.Kondo and A.Matsuda. *Photocarrier capture properties in a-Si:H*. Journ. of Non-Cryst.Solids, 2002.
5. P.Stradins, M.Kondo and A.Matsuda. *Pump-probe pulse transient photoconductivity study in amorphous and microcrystalline Si:H*. Journ. of Non-Cryst.Solids, 2002.
6. P.Stradins, M.Kondo, and A.Matsuda. *Light-induced degradation and transport phenomena in disordered Si and transparent oxide films.* (review article). In series "Recent Developments in Non-Crystalline Solids" by Transworld Research Network, 2001 – 28 pages.

Lectures on Conferences

17th Scientific Meeting of Institute of Solid State Physics, University of Latvia, Riga, February 19-23, 2001.

1. A.Ozols, S.Lazarevs. Millisecond impulse holograms in amorphous As-S-Se films. Abstracts, p.64.
2. M.Reinfelde, J.Teteris and I.Kuzmina. Recording of two step transmission holograms. Abstracts, p.79.
3. J.Teteris. Application of amorphous chalcogenide semiconductor thin films in holography and diffractive optics. Abstracts, p.83.

Telecommunication day at the Faculty of Electronics and Telecommunications of Riga Technical University, Riga, May18.2001.

4. A.Ozols. Solitons and their future in telecommunications.

Materials Research Society Spring Meeting, USA.

5. P.Stradins, S.Shimizu, M.Kondo and A.Matsuda. Photocarrier capture properties of light-induced defects in a-Si:H. Proceedings **664** (2001) A12.1.
6. S.Shimizu, P.Stradins, M.Kondo and A.Matsuda.Investigation of light-induced defect depth profile in hydrogenated amorphous silicon films. Proceedings **664** (2001) A14.3.

19th Nordic Semiconductor Meeting, Copenhagen, Denmark, May 20-23, 2001.

7. J.Teteris. Amorphous As-Se-S semiconductor resists for holography and lithography. Abstracts, p.52.

Japanese Applied Physics Society Spring Meeting 2001.

8. P.Stradins, S.Shimizu, S.Suzuki, T.Nishimoto, M.Kondo and A.Matsuda. Relation between the light-induced defect creation and the degradation of the photoelectronic properties in a-Si:H and a-Si:D. Abstracts, N2, p. 938, 28p-ZL-11.
9. S.Shimizu, P.Stradins, M.Kondo and A.Matsuda. Light-induced degradation and photocarrier capture properties in a-Si:H, deposition temperature and hydrogen dilution series. Abstracts, N2, p. 937, 28 p-ZL-9.

6th Conference of the Latvian Physical Society, Liepene, Latvia, July 2-4, 2001.

1. A.Ozols.Forbidden energy gaps in solid state physics and telecommunications.

2. J.Teteris. Holography in Latvia.

2nd World Congress of Latvian Scientists, Riga, August 14-15, 2001.

10. A.Ozols and M.Reinfelde. Research of informatics optical materials at Riga Technical University and Latvian University. Abstracts, p. 21.

19th International Conference on Amorphous and Microcrystalline Semiconductors, Nice, France, August 27-31, 2001.

11. J.Teteris. Amorphous As-Se-S semiconductor resists for holography and lithography. Abstracts, p. Tu-C3/5.
12. P.Stradins, S.Shimuzu, M.Kondo and A.Matsuda. Less-understood phenomena in the light-induced degradation and photocarrier capture in a-Si:H. Abstracts, Mo-C1/1.
13. S.Shimuzu, P.Stradins, M.Kondo and A.Matsuda. Photocarrier capture properties in a-Si:H. Abstracts, Mo-C2/1.
14. P.Stradins, M.Kondo and A.Matsuda. Pump-probe pulse transient photoconductivity study in amorphous and microcrystalline Si:H. Abstracts, Th-P5/6.

International Conference Radiation Effects in Insulators REI-11, Lisbon, Portugal – September 3-7, 2001.

15. A.Ozols and S.Lazarevs. Millisecond impulse holograms in amorphous As-S-Se films. Abstracts, p.197.

Japanese Applied Physics Society 62nd Autumn Meeting 2001.

16. P.Stradins, M.Kondo and A.Matsuda. Pulse-probe transient photoconductivity measurements in disordered Si:H. Abstracts, N2, p. 708, 11p-W-9.
17. S.Shimizu, P.Stradins, M.Kondo and A. Matsuda. The relation between light-induced defects creation and hydrogen in the hydrogenated amorphous silicon.Abstracts, N2, p.707, 11p-W-7.

DEFECT PHYSICS IN IONIC MATERIALS

Head of Division Dr. hab. phys., Assoc. prof. B. Berzina

Research Area and Main Problems

The research field is connected with properties of radiation defects and their accumulation in ionic materials such as *alkali earth halides* and *aluminum nitride ceramics*. These defects are created or activated under irradiation of ultraviolet light. A special attention is paid to the behavior of oxygen-related defects in these materials. Optical research methods based on luminescence are applied.

Scientific Staff

1. Dr. hab., Assoc. prof. B.Berzina
2. Dr. L.Trinkler

PhD Student

1. J.Sils

Student

A.Ešenvalde.

Scientific Visits Abroad

1. J.Sils. Ludvigs Maximillian University Munich, Germany (9 month).

Cooperation

Latvia

Institute of Inorganic Chemistry, Riga TU (Dr. E.Palcevskis).

Denmark

RISO National Laboratory, Roskilde (Dr. A.Botter-Jensen).

Germany

Ludvigs Maximillian University Munich (Prof. M. Reichling).
Paderborn Universitaet (Dr. S.Schweizer).

Main Results

LUMINESCENT AND DOSIMETRIC PROPERTIES OF AlN CERAMICS

L.Trinkler and B. Berzina

Investigation of luminescence mechanisms of native defects and UV light induced energy accumulation in aluminum nitride crystalline lattice was continued. Two types of samples were used. They are: 1) AlN-Y_2O_3 ceramics sintered at Institute of Inorganic Chemistry, RTU and 2) partly transparent AlN ceramics without Y_2O_3 additive prepared in Japan. The first part of our investigations concerns the fundamental processes occurring in the crystalline lattice of AlN caused by the UV light irradiation in which the native defects are involved. At least three types of luminescence centers based on oxygen-related defects sensitive to UV light irradiation are found. Results of our spectral investigations together with that obtained by using a sensitive magnetic-resonance technique (at Paderborn University, Germany) allow interpretation of the luminescence center structure and the luminescence mechanism responsible for UV-blue luminescence caused by the oxygen-related defects. Study of other two types of luminescence centers, which also seems to be formed from the oxygen-related defects are in progress.

The second part of our work concerns the studies of the dosimetric characteristics of AlN-Y_2O_3 ceramics after UV irradiation. Results of our research allow consideration of the AlN ceramics as a perspective material for use in UV dosimetry. The studies of dosimetric characteristics of AlN are in progress.

LASER DAMAGE INVESTIGATIONS IN ALKALI EARTH FLUORIDES

J.Sils

Investigation of laser damage on CaF_2, which is one of the perspective materials for short wavelength laser light optics has been continued. In our previous investigations the damage mechanism has been studied using 14 *ns* laser pulses at 248 *nm*. At present a great work was put in building of a new set-up allowing generation of laser light pulses from *fs* time region. It allows us to examine not only the mechanisms of laser damage but also the exciton self-trapping and defect formation processes in CaF_2.

Scientific Publications
Published in 2001

1. L.Trinkler, L.Botter-Jensen, P.Christensen, B.Berzina. *Stimulated luminescence of AlN ceramics by ultraviolet radiation.* Radiation measurements. 2001, vol. **33**, p. 731-735.

2. L.Trinkler, B.Berzina. *Radiation-induced recombination processes in AlN ceramics*. Journ. of Physics: Condenced Matter. 2001, vol. **13**, p. 8931-8938.

3. B.Berzina, L.Trinkler, J.Sils and E.Palcevskis. *Oxygen-related defects and energy accumulation in aluminum nitride ceramics.* Radiation Effects and Defects in Solids, 2001, vol. **156**, p. 241-247.

In Press

4. L.Trinkler, L.Botter-Jensen, B.Berzina. *AlN ceramics – a potential UV dosimeter material.* Radiation Protection Dosimetry, 2002, (accepted).
5. A.Ozols, S.Lazarevs, B.Berzina. *Milisecond impulse holograms in amorphous As-S-Se films.* Nuclerar. Instr. Meth. B (NIMB), 2002, (accepted).

Lectures on Conferences

International Conference: Wide Gap 2000. Dopping Issues in Wide Gap Semiconductors, (Exeter, UK, 21-23 March, 2001).

1. B.Berzina, J.Sils. Natural dopants and their spectral characteristics in AlN crystalline lattice, (oral presentation).

International Conference: Wide Gap 2000. Dopping Issues in Wide Gap Semiconductors, (Exeter, UK, 21-23 March, 2001).

2. L.Trinkler. Controllable doping as a way to improve dosimetric properties of AlN Ceramics, (poster presentation).

13th International Conference on Solid State Dosimetry, (Athens, Greece, 9-13 July, 2001).

3. L.Trinkler, L.Botter-Jensen, B.Berzina. Studies of AlN ceramics as a material for UV dosimetry, (poster presentation).

International Conference: REI-11, Radiation Effects in Insulators, (Lisbon, Portugal, 3-7 September, 2001).

4. B.Berzina, L.Trinkler, J.Sils, K.Atobe. Native and light-induced defects in AlN crystalline lattice, (oral presentation).

International Conference: REI-11, Radiation Effects in Insulators, (Lisbon, Portugal, 3-7 September, 2001).

5. A.Ozols, S.Lazarevs, B.Berzina. Milisecond impulse holograms in amorphous As-S- Se films, (poster presentation).

42nd International Scientific Conference, RTU, (Riga, 11 –13 October, 2001).

6. B. Berzina, L.Trinkler. The oxygen-related defects and their optical properties in AlN, (oral presentation).

OPTICAL MATERIALS

Head of Division Dr. hab. phys. Prof. I.Lacis

Research Area and Main Problems

Lot of new materials are investigated for application or already are in use in a variety of noncontact and contact vision correction devices (goggles, telescopes, contact lenses, intraocular lenses, light protection goggles). Still there are lot of unsolved problems for advanced vision correction simple aids and devices. They exhibit high dispersion, thus resulting in a variety of aberrations in a lens and the eye. The most important aberration effecting the qualitative vision correction is the transversal chromatic aberration of the oblique beam propagation. The influence of spectacle lens aberrations on vision quality depending on task, environment and visual training are studied. The impact of different external parameters on visual fatigue will be analysed.

The electrooptically tuneable light scattering in PLZT ceramics for simulation of eye segments optical properties are applied in new instrument constructions on in new visual ability tests. The sensitivity of the binocular visual system to luminance and contrast distribution of two monocular half-images are studied.

Another field of search of the division is studies of various type retroreflective materials used in road and warning signs to find the optimum conditions for vehicle drivers at low illumination and at night.

The main aim of this laboratory is experimental studies of the newest optical materials and lenses usable for vision correction devices and model studies of the optical system eye - corrective element for evaluation of the human adaptation ability, especially binocular, to different geometry construction of the vision correction devices.

Scientific Staff

1. Dr.hab.phys. I.Lacis
2. Dr.hab.phys. M.Ozolinsh

Postgraduate Students

1. M.Sc. A.Balgalve
2. M.Sc. G.Papelba
3. M.Sc. J. Fridrihsons
4. M.Sc. A. Švede

Graduate Students

1. B.Sc. D. Rācene
2. B.Sc. J. Berziņš
3. B.Sc. L. Viesture

Visitors from abroad

1. Prof. O.Franzen, Mid Sweden University, Sundwall, Sweden (1 month);
2. Prof. S.Villani, Florence University , Italy (4 weeks).

Cooperation

Italy

Florence University , Italy, (Prof. S. Villani).
Universita` di Roma "Tor Vergata" (Prof. I. Davoli).

Sweden

Lund University (Prof. S.Svanberg).
Department of Clinical Science of Karolinska Institute (Dr. H. Richter).

Norway

Buskerud Høgskolan, Institut for optometri (Prof. K. I. Daae).

Great Britain

Bradford University.

Main Results

MODEL EYE WITH ARTIFICIALLY INDUCED SCATTERING

R. Paeglis, M. Ozolinsh

An artificial eye model allowing to stimulate controllable cataract caused light scattering in the eye lens is developed using electrooptic PLZT ceramics. Light scattering of such composite lens containing an active PLZT ceramics component depends on the electric field applied to the PLZT plate placed between two glass lenses. The optical transfer function of such eye at various degree of scattering is studied observing the contrast of the interference pattern on the “retinal plane” created by He-Ne laser source passing a diffractive transparent placed before the eye.

COMPARING OF THE THREE DIMENSIONAL PLANE’S STEREOTESTS WITH HAPLOSCOPICAL TESTS

A.Līcis, G. Papelba

The most used methods of testing stereoscopic vision are haploscopic tests. They are based on fusion in brains of different images from each eye. Objectives of our experiments are – to compare results of the three-dimensional tests, known as “Magical eye”, with results of the standart clinical haploscopic tests, and to show that the stereopsis in such conditions reveals the same quality as using standart tests (TNO, Lange). Another objective of experiments is to estimate time, needed for perception of the three dimensional image. It is easy to create such “Magical eye” three-dimensional stereotests on monitor of personal computer, and there are possibilities to gain different figures and texts by changing parameters of the tests.

Experiments show better precision in evaluation of stereoacuity using plane’s stereotests as compared with haploscopic tests, but it takes more adaptation time.

LENS INDUCED NEAR PHORIA CHANGES IN MYOPIC AND EMMETROPIC CHILDREN

L. Viesture, I. Hercoga

Purpose: Near phoria is one of the factors involved in the development of myopia. In the present study lens induced near phoria momentary changes in myopic and emmetropic children are investigated and compared.

Subjects and methods: There werw 20-early-onset myopes and 20 emmetropes 11-15 years old involved in this study. Near phoria was measured with the modified Thorington methods at 33 cm distance. The additional lenses were changed from +2.50 D to –2.50 D in 0.5 D steps and back, thus increasing and decreasing accommodation stimulus.

Results: Near phoria relative values increasing accommodation stimulus for myopes were lower than decreasing accommodation stimulus and lower than for emmetropes increasing accommodation stimulus. There was no statistically significant difference in near phoria relative values for myopes with esophoria and exophoria, neither changing from hypo- to hypercorrection or back. Myopes showed more esophoria and higer gradient stimulus AC/A ratio.

Conclusions: Myopes show relatively lower accommodation response changing from hypo- to hypercorrection. For myopes near phoria with distance correction doesn't influence the near phoria relative values, both increasing and decreasing accommodation stimulus.

RELATIONSHIP BETWEEN PROXIMAL CONVERGENCE AND TARGET DISTANCE

A. Švede

In recent days many eye function examination tests are computerized, also tests used for near vision examination. One of such tests is the computerized Hess screen used for eye extra-ocular muscles function. The author of the test W. D. Thomson thought that the results made by computerized test version differs from classical test results. The reason of this difference could be explained by the proximal convergence.

The purpose of this work is to look on the proximity influence on the vergence system by changing the target distance.

INTEROCULAR SUPPRESSION OF STEREOSCOPIC IMAGES AND IN CASE OF OVERLAID IMAGES

G. Ikaunieks, M. Ozolinš, G. Papelba

Images of one object formed on the retinas are fussed, and a human with a normal vision sees a 3-dimensional image. Dissimilarities between the retinal images can to conduce an interocular suppression. Thus a sensitivity of the suppressed eye reduces, and a stereo acuity can disappear.

A technique is developed to generate a stereopair on a computer monitor. The pictures of the stereopair are overlaid with prisms. In the central part of one picture (inside the field of the 3-dimensional part) the computer program creates an additional target. The contrast of the target varies in time. Such technique allows us: - to detect a

threshold when the presence of the target on one of the stereopair picture suppresses stereo sensitivity, or a threshold when the presence of stereopsis suppresses diplopia.

BLURRING INFLUENCE TO STEREOSCOPIC VISION

M. Ozolish, G. Papelba

Purpose: The main goal of this investigation was studies of the stereovision threshold under static and dynamic conditions of blurring of stimulus for one eye.

Method: Studies in static and dynamic conditions of correlation between the decrease of the monocular acuity and the stereothreshold using a light scattering obstacle placed between one eye and a random dot stereopair. The obstacle made of electrooptic PLZT ceramics provided a continuo quasistatic and dynamic change of blurring of a retinal image, thus decreasing the contrast of the stimulus.

Results: Contrast vision is more sensitive to the intensity of blurring than visual acuity. Quality of stereovision strongly depends on intensity of blurring and frequency of blurring appearance. It seems that, change of contrast vision is the most affecting to stereoscopic vision.

SPECTRAL DEPENDENCIES OF ELECTRICALLY CONTROLLABLE SCATTERING IN PLZT CERAMICS

M. Ozolinsh, I. Lācis*, S. Svanberg**, S. Andersson-Engels**, and J. Swartling***

PLZT ceramics have an unique property – a facility to change the light scattering efficiency with the applied electric field. This effect is well manifested especially in the visible, just where the transparency windows of PLZT begins. Formerly we developed eye occlusion devices for vision science applications to introduce a dynamic decrease of the image contrast in stereovision tests. The present work reports on spectral dependencies of such an eye occluder studied with the double optical integrated sphere technique.

Spectral characteristics of directly transmitted collimated beam T_{Col} at various electric field E applied to PLZT plate (a) and normalized characteristics $T_{Col}/T_{Col\ U=0V}$ vs wavelength (b). One can conclude that the field induced light extinction in the studied spectrum range is determined by the scattering processes – absorption would play only a secondary role through an increase of the photons efficient path through the sample. By applying the electric field up to 8kV/cm the investigated PLZT ceramics efficient scattering coefficient μ_8 is increasing up to 14 cm^{-1} at 660 nm and up to 30 cm^{-1} at 450 nm. For polarized incident illumination the scattered light loses its degree of polarization P_L with the applied electric field – $P_L \approx 80\%$ at 4 kV/cm compared with $\approx 15\%$ at 8 kV/cm at 660 nm.

* *Institute of Solid State Physics, University of Latvia*
** *Institute of Atomic Physics, Lund University*

RECOGNITION OF RETROREFLECTIVE ROAD SIGNS DURING NIGHT DRIVING

J. Berzinsh, M.Ozolinsh*, P.Cikmacs*, and K. Pesudovs***

Temporal waveforms of the illumination at the driver eyes position were determined at various night traffic and weather conditions (ideal weather and correct aligned lights as compared with a presence of dirty lamps and raindrops on the windscreen). The statistics of retinal illumination were analysed, and a computer controlled technique was developed to simulate similar changes of eye illumination. The participant fixated at retroreflective optical stimuli at a distance of 5 m. The participant was then subjected to dazzle and recovery from the glare took place. The background illumination was in the mesopic range. Experiments show that at background illumination 0.1 Lx no dazzling takes place in case of correct installed clean headlights. The participant was dazzled if the high beam lamps are incorrectly aligned and in cases where cycloplegia was used for pupil dilation. The dazzle time depended on the background illumination level and could increase to three seconds for the illumination dynamics corresponding to the equivalent speed of vehicles 50 km/h.
**Department of the Optometry and Vision Science, University of Latvia*
***Department of the Optometry, Bradford University*

Scientific Publications

1.M. Ozolinsh, D. Racene, and P. Cikmacs, *"Modified crossed-cylinder aberroscope,"* In: Hybrid and Novel Imaging and New Optical Instrumentation for Biomedical Applications, Eds.: Albert-Claude Boccara and Alexander A. Oraevsky, Proc. SPIE, 2001, vol. **4434**, p. 219-222.

2. M. Ozolinsh, I. Lacis, R. Paeglis, A. Sternberg, S. Svanberg, S. Andersson-Engels, and J. Swartling *"Electrooptic PLZT ceramics devices for vision science applications,"* Ferroelectrics, 2001 (accepted for publishing).

3. J. Berzinsh, M. Ozolinsh, and Peteris Cikmacs *"Recognition of road and warning signs with retroreflective coatings in night driving conditions."* Proc. HFES "Human factors in Transportation," 2001, (in print)

4. M. Ozolinsh and G. Papelba *"Polarization-optical visualisation of eye inhomogeneities"*, In: "Photon Migration, Diffuse Spectroscopy, and Optical Coherence Tomography: Imaging and Functional Assesment," Ed. by Stefan Andersson-Engels and James G. Fujimoto, Proc.SPIE, 2001, vol.**4160**, p.254-256.

Lectures on Conferences

7th Eur. Kraskin Symposium on Vision, May 2001, Skelskør, Denmark.
1. A. Balgalve "The dominant eye and features of refractive error correction."

Conference on Lasers and Electro-Optics and Quantum Electronics and Laser Science. May 2001, Baltimore, USA.

2. M. Ozolinsh , I. Lacis , S. Svanberg , S. Andersson-Engels , and J. Swartling. Spectral scattering dependencies of controllable PLZT occluder for vision science applications.

European Conference on Biomedical Optics, OSA-SPIE. June 2001, München, Germany.

3. D. Racene, P. Cikmacs, R. Paeglis. Modified crossed-cylinder aberroscope.
4. R. Paeglis, P. Cikmacs, S. Andersson-Engels. Artificial eye model with controllable lens scattering.

102 Tagung der Deutsche Gesellschaft für angewandte Optik. June 2001, Göttingen, Germany.

5. D. Racene, P. Cikmacs, M. Ozolinsh. Measuring of the wavefront aberrations of the eye.

11th European Conference on Eye Movements. Aug. 2001. Turku, Finland.

6. L. Viesture, I. Hercoga. Lens induced near phoria changes in myopic and emetropic children.

Tagung der Deutsche Ophthalmologische Geselschaft. Sept. 2001, Berlin, Germany.

7. G. Papelba, M. Ozolinsh. Blurring effect on stereoscopic vision.

10th International Meeting on Ferroelectrics. Sept. 2001, Madrid, Spain.

8. I. Lacis , M. Ozolinsh , A. Sternberg, S. Svanberg , S. Andersson-Engels, J. Swartling. Electrooptic ceramics PLZT devices for vision science applications.

Lithuanian Congr. of Ophthalmologists, Oct. 2001, Vilnius.

9. A. Svede "Influence of direction of gaze on proximal convergence."

European Conference "Human factor in Transportation". Nov. 2001,Turin, Italy.

10. J. Berzinsh, M. Ozolinsh, P. Cikmacs, K. Pesudov. Recognition of retroreflective road and warning signs in night driving condition.

17th Scientific Conference of the University of Latvia, February 19-23, 2001, Riga.

1. A. Līcis, G.Papelba. Comparing of three dimensional plane's stereotests with haploscopical tests.
2. R. Paeglis, M. Ozolinsh. Model eye with artificially induced scattering.
3. L. Viesture, I. Hercoga. Lens induced near phoria changes in myopic and emmetropic children.
4. M. Ozolinsh, G.Papelba. Blurring influence to stereoscopic vision.
5. G. Ikaunieks, M. Ozolinsh, G.Papelba. Intraocular suppression of stereoscopic images and in case of overlaid images.
6. M. Ozolinsh , I. Lācis , S. Svanberg , S. Andersson-Engels , and J. Swartling. Spectral dependencies of electrically controllable scattering in PLZT ceramics.
7. A. Švede. Relationship between proximal convergence and target distance.

SURFACE PHYSICS

Head of Laboratory Dr.hab.phys. J.Maniks

Research Area and Main Problems

Research areas:

- physical and micromechanical properties of fullerenes;
- micromechanical properties of near-surface layers of solids and thin films;
- the strength properties, adhesion and related processes on phase boundaries and interfaces in heterogeneous and nanostructured materials.

Research problems:

- photoinduced structural changes and environmental effects in fullerite C_{60} crystals and thin films;
- mechanical properties of phase boundaries in Al-based eutectic alloys, emission of hydrogen and intercrystalline brittleness of Sn-Al alloy;
- structural damage and hardening of LiF crystals under heavy ion irradiation.

Scientific staff

1. Dr.hab.J.Maniks
2. Dr.I.Manika
3. Dr.F.Muktepavela

Students

4. I.Stolere
5. Z. Jonelis
6. A.Garbuzovs
7. L.Gailīte

Scientific Visits Abroad

Dr. I.Manika , A.Joffe Physico-Technical Institute, St.Petersburg, Russia (7 days).
Dr.F.Muktepavela , Technion, Haifa, Israel (7 days).
Dr.I.Manika, GSI, Darmstadt, Germany (18 days).
Dr.F.Muktepavela, Alushta- Crimea, Ukraine (7 days).

Cooperation

Latvia

1. Institute of Physical Energetics, Latvian Academy of Sciences (Dr.J.Kalnacs).
2. Riga Technical University (Prof.V.Mironovs).
3. Daugavpils Pedagogical University (R.Pokulis).
4. Institute of Chemical Physics, University of Latvia (Dr.D.Erts).

Ukraine

Institute of Metal Physics, Ukrainian Academy of Sciences, Kiev (Prof. M.Vasylyev).

Israel

Technion, Haifa (Dr.S.Stolyarova).

Poland

Department of Chemistry, University of Warsaw (Dr.A.Czerwinski).
Industrial Chemistry Research Institute, Warsaw (Dr.Z.Rogulski).

Main Results

PHOTOPOLYMERIZATION AND DAMAGE OF FULLERITE C_{60} CRYSTALS UNDER LASER IRRADIATION

J.Maniks, I.Manika, R.Pokulis, J.Kalnacs**

The photoinduced hardening, substructure formation and damage of C_{60} single crystals under 632.8 nm He-Ne laser irradiation in air was investigated. C_{60} single crystals were grown from the vapour phase. A twice-sublimed fullerene powder (99.9 % C_{60}) was used for the crystal growth. The dislocation etch-pitting technique was applied here to examine the dislocation structure before and after light irradiation. The density of "grown-in" dislocations was about 10^3 cm^{-2}. An increase in the hardness and decrease of the dislocation mobility in the laser irradiated crystals was observed giving evidence for photoinduced change in bonding. Two phototransformed states of fullerite - "soft" (400-450 MPa) and "hard" (650-1000 MPa) have been observed. The"soft" state is recognized as the well-known fullerene photopolymer, which arises *via* photoinduced formation of covalently bonded fullerene dimers and oligomers in the molecular lattice of fullerite. "Hard" photopolymer appears in the subsurface layer <1μm at the saturation stage of phototransformation. It softens to 400-450 MPa at 340 K and reverts to non-polymerized state at 470-480 K. We suppose that the "hard" photopolymer is formed under the influence of environmental species (O_2, N_2) and exhibits higher degree of polymerization (contains larger polymer chains).

Photoinduced formation of the dislocation substructure and crystallographically oriented crack pattern on the (111) face was observed due to lattice contraction on polymerization and generation of stresses in the phototransformed layer and at the interface between irradiated and non-irradiated parts of the crystal. It has been found that the structurally weaker in polymerized fullerite are <112> directions while the deformation in pristine fullerite goes along the <110> directions. The effect of post-irradiation hardening has been discovered. It manifests as an increase of the hardness of laser-irradiated crystals during storage in air in the dark. The results show that the post-irradiation hardening is caused by the stress-driven substructure formation and reconstruction of bonds.

**In cooperation with Institute of Physical Energetics, Latvian Academy of Sciences, and Daugavpils Pedagogical University.*

HUMID ATMOSPHERE INDUCED PROCESSES OF HYDROGEN EMISSION AND EMBRITTLEMENT OF Sn-Al EUTECTIC

*F.Muktepavela , M.Vasylyev *, A.Czerwinski*[*]

The humid air induced processes of intercrystalline brittleness of Sn-Al alloy and emission of hydrogen from alloy were investigated by the Secondary Ion Mass-Spectrometry (SIMS), X-ray diffraction, optical and scanning microscopy as well as precision microhardness methods. It has been found that the changes in the strength of phase boundaries and chemical composition are caused by the influence of hydrogen and oxygen. Atomic hydrogen is formed as a result of water decomposition by aluminium at phase boundaries. The presence of atomic hydrogen near the interfaces and molecular hydrogen in bulk of alloy was detected by the SIMS depth profiling. The estimates according to the Griffitz criterion show the possible appearance of brittle interfacial cracks with the critical size of about 7 μm, that is in good agreement with data of structural investigations of areas from which the emission of hydrogen occurrs. Conseguently, the generation of interfacial stresses and crack formation can be attributed to hydrogen. It was found that after long time exposure to water vapor alloy split into a powder with 10-100 μm size due to hydrogen interaction with inner tin grains.

**In cooperation with Institute of Metal Physics, Ukrainian Academy of Sciences, and Department of Chemistry, University of Warsaw*

SCIENTIFIC PUBLICATIONS
Published in 2001

1. F.Muktepavela, I.Manika, J.Kalnacs, *Investigation of mechanically alloyed metal / oxide coatings by SIMS method*. Latvian Journal of Physics and Technical Sciences, 2000, vol. **6**, p.141-144.
2. V. Mironovs, F. Muktepavela, *Copper infiltration of iron powder items using magnetic-impulse compaction*. Proc. Int.World Congress on Powder Metallurgy-2000, Kyoto, Japan, 2000, p.78-83.
3. I.Manika, J.Maniks, R.Pokulis, J.Kalnacs, D.Erts, *Polymerization and Damage of C60 Single Crystals under Low Fluency Laser Irradiation*. Phys.stat.solidi (a) 2001, vol. **188**, 3, p.989-998.
4. J.Maniks, I.Manika, J.Teteris, R.Pokulis, *Indentation creep and stress relaxation in amorphous As-S-Se and As-S films.* In Optical Organic and Inorganic Materials, S.P.Ašmontas, J.Gradauskas, Editors, Proceedings of SPIE, 2001, vol. **4415**, p.284-289.
5. I.Manika, J.Maniks, R.Pokulis, J.Kalnacs. *Effect of light exposure on dislocation mobility in fullerite C_{60} crystals*. In Optical Organic and Inorganic Materials, S.P.Ašmontas, J.Gradauskas, Editors, Proceedings of SPIE, 2001, vol. **4415**, p.44-47.

In Press

6. L. Shebanovs, J. Maniks, J. Kalnacs, *X-ray diffraction study of crystallographic parameters and Debye temperature of C_{60} single crystals.* Journal of Crystal Growth*,* 2002, vol. **234**,1, p.202-206.

7. I.Manika, J.Maniks, R.Pokulis, J.Kalnacs, *Illumination time-evolution and wavelength dependence of the photoinduced hardening of C_{60} crystals*. Fizika Tverdovo Tela, 2002, vol. **44**, 3, p.417-418.
8. F.Muktepavela, J.Maniks, *Structure Evolution and Diffusion During Interphase Boundary Sliding in Sn-Based Binary Eutectic*. Interface Science, (accepted).
9. I.Manika, J.Maniks, R.Pokulis, J.Kalnacs, *Wavelength dependence and kinetics of photopolymerization of C_{60} single crystals studied by microhardness and dislocation mobility methods.* Fullerenes, Nanotubes and Carbon Nanostructures, (accepted).
10. F.Muktepavela, M.Vasiljev, *Hydrogen formation on phase boundaries of Sn/Al*. NATO Science Series, (accepted).
11. F.Muktepavela, M.Vasiljev, A.Czervinski, Z.Rogulski, *Investigation of hydrogen formation in Sn-Al alloy during contact with water vapour*. Journal of Solid State Electrochemistrym, (accepted).

Lectures and conferences

17th Scientific Conference, Institute of Solid State Physics, University of Latvia, Riga, February 19-23, 2001

1. J.Maniks, I.Manika, A.Kozelis, J.Kalnačs, Photopolymerization and damage of fullerite C_{60} crystals under laser irradiation. Abstracts, p.24.
2. R.Pokulis, I.Manika, J.Maniks, J.Kalnacs.Wavelength dependence of the photopolymerization in fullerite C_{60} crystals studied by micromechanical methods. Abstracts, p.25.

Regional Seminar on Solid State Ionics, Jūrmala, Latvia, September 22-26, 2001.

3. J.Maniks, I.Manika, I.Stolere. Hardening of LiF crystals irradiated with swift Pb ions. Abstracts, p.27.
4. F.Muktepavela, M.Vasiljev, A.Czervinski, Z.Rogulski. Investigation of hydrogen formation in Sn-Al alloy during contact with water vapour. Abstracts, p.28.

5th Biennial International Workshop "Fullerenes and Atomic Clusters (IWFAC'2001)", St.Petersburg, Russia, July 2-6, 2001.

5. I.Manika, J.Maniks, R.Pokulis, J.Kalnacs. Illumination time-evolution and wavelength dependence of the photoinduced hardening of C_{60} crystals. Abstracts, p.197.

10th International Conference on Intergranular and Interphase Boundaries (iib` 2001) Haifa, Israel, July 23-26, 2001.

6. F.Muktepavela, J.Maniks. Structure Evolution and Diffusion During Interphase Boundary Sliding in Sn-Based Binary Eutectic. Abstracts. p.30.
7. F.Muktepavela, A.Simanovskis, S.Stolyarova. Transition Zone Formation During Vacuum Deposition of low Soluble Materials. Abstracts, p.55.

VII International Conference on Hydrogen Materials Science and Chemistry of Metal Hydrides, Alushta-Crimea, Ukraine, September 16-22, 2001.

8. I.P.Manika, F.O.Muktepavela, J.J.Maniks, J.J.Kalnacs. Thermal and Stress-Promoted Oxidation of Fullerite C_{60}. Extended abstracts, p.610-613.
9. F.O.Muktepavela, M.A.Vasylyev, V.G.Kostyuchenko. Investigation of Air Moisture Induced Formation and Emission of Hydrogen in Plastically Deformed Sn-Al Eutectic Using SIMS Method. Extended abstracts, p.176-179.

LABORATORY OF RADIATION PHYSICS

Head of laboratory Dr. hab. J.Berzins

Research Area and Main Problems

The Laboratory consists of four groups – the nuclear spectroscopy and theory, applied nuclear physics, oxyde physics and high temperature superconductivity. The following main problems are developed in the laboratory:
experimental and theoretical investigation of nuclear structure at medium and high excitation energies:

- investigation of bioaccumulation of metals in pine needles by neutron activation analysis, total reflection X-ray spectrometry (TXRF) and electrothermal atomic absorption spectrometry;

- developing of new high sensitive gamma spectrometric and radiochemical methods for the detection of radionuclides in the nuclear technological scraps from nuclear facilities and environment and employ it for the detection of Sr - 90, Cs – 137, K – 40 and Th – 232, Ra – 226 radioactive decay products in environmental samples to obtain data for the accumulation and distribution of these radionuclides;

- the analysis of HANES , EXAFS, optical absorption and luminescence study of MeO - MgO solid solutions. The dependence of the Me-Mg , Me-O and Me-Me distance from the composition and its links with optical properties;

- radiation effects in the dielectric crystals (MgO, $YAlO_3$, $LiNbO_3$);

- the use of the physical methods (MORPHOQUANT, EPR and optical absorption and luminescence) in the medical physics (retrospective medical dosimetry);

- flux pinning in neutron irradiated 123 high temperature superconductors and its relationship to magnetic anisotropy.

Scientific Staff

1. Dr.hab. J.Berzins
2. Dr.hab. M.Balodis
3. Dr.hab. V.Bondarenko
4. Dr.hab. A.Afanasjevs
5. Dr. hab. U.Ulmanis
6. Dr.hab. N.Mironova - Ulmane
7. Dr. hab. J. Tambergs
8. Dr. L.Simonova
9. Dr. T. Krasta
10. Dr. D.Riekstina
11. Dr. V.Skvortsova
12. Dr. O.Veveris
13. Dr. A.Petrovs
14. Dr. J. Ruza
15. Dr. G. Smilskalne
16. Dr A.Kuzmins
17. mag. A.Pavlenko

Technical Staff

1. A.Afanasjeva
2. L. Neiburgs
3. A. Sotaks A. Dzalbs
4. M. Polakovs

Students

1. A. Andrejevs
2. A. Dzalbs

Visitors from abroad

Dr. K. Starosta New-York University Stony Brook, USA (4 days).

Scientific visits abroad

Dr. hab. A.Afanasjev Argonne Lational Laboratory, USA (5 months).
Dr. hab. A.Afanasjev Notre Dame University, Notre Dame,USA (2 month).
Dr. hab. J. Berzins New-York University Stony Brook, Stony Brook, USA (15 days).
Dr. hab. J. Berzins European Commisssion Euratom, Brussels,Belgium (10 days).
Dr. hab. V. Bondarenko Institute of Nuclear Physics, Prague, Czech Republik (30 days).
Dr. hab. N.Mironova - Ulmane Institute of Physics, Tartu, Estonia (7 days).
Mag. A.Pavlenko - IAEA (4 month).

Cooperation

Latvia

1. Medical Academy of Latvia (Dr. hab., prof. M.Eglite, Dr.T.Zvagule).
2. State Institute of Wood Chemistry (Dr. J.Hrols).
3. Ltd. "RAPA".
4. Lielriga Regional Board environment(A.Skujina).
5. Riga Technical University, Institute of Inorganic Chemistry(Dr. I.Vitina, Dr. E.Palcevskis).
6. University of Latvia, Chemical faculty (Dr. A.Viksna, Dr.hab. J.Tiliks).

USA

1. Lawrence Livermoor National Laboratory, California (Prof. R. W. Hoff).
2. Brookhaven National Laboratory, Upton (Prof. R.F. Casten).
3. New-York University Stony Brook, Stony Brook (Prof. D. Fossan).
4. Notre Dame University, Notre Dame,USA (Prof. S. Frauendorf).

Brasil

Instituto de Fisica Teorica, Universidade de Sao-Paulo (Dr.Castilho-Alcaras).

Czech Republik

1. Nuclear Research Institute, Řež (Dr. J.Honzatko).
2. Department of Nuclear Physics, Charles University (Prof. J. Kvasil).

Estonia

1. Institute of Physics , Tartu (prof. Ch.Luschik, prof. A.Luschik , Dr. A.Sildos Dr.T.Kärner).

Ukraine

1. State University " Lvivska Politechnika" , Lvov (Prof. A.Matkovskii).
2. R&D Institute of Materials RPA " Carat" Lviv (Dr. D.Sugak, Dr. S.Ubizskii).
3. Institue of Physics of the Ukrainian Academy of Science, Kiev (Prof. S. Nepijko).

Poland

Institute of Pysics, PAS, Warshaw (Dr. A.Suchocki).

Russia

Metal Physics Institute, Academy of Science , Ural Division (Prof. A.Menshikov).

Austria

Atomic Institute of Austrian Universities, Vienna (Prof. H.Weber).

Croatia

Ruder Boškovic Institute, Zagreb (Prof. S.Music).

Main Results

DEVELOPMENT OF ^{164}DY LEVEL SCHEME

J.Bērziņš, V.Bondarenko, T.Krasta

The work at the development of excited level scheme of even-even ^{164}Dy nucleus has been completed. The level scheme has been developed up to about 2.6 MeV energy, including levels with spins <=6. The depopulation of ^{164}Dy levels have been established, basing on the experimental data obtained in (n,γ) and (n,nγγ) reactions, measured at the nuclear reactor of ILL Grenoble, as well as on the (n,n'γ) reaction data, measured at the IRT reactor in Salaspils. The high precision gamma-transitions, for some of whom the multipolarities were established, allowed both to confirm the earlier known ^{164}Dy levels, providing for them more precise energies, spin and parity assignments, and also to propose several new levels. Preliminary results have been reported earlier [1]. In present report, more attention has been given to the interpretation of structure of ^{164}Dy excited levels, taking into account the latest experimental results [2], especially those of the nucleon transfer reactions.

The proposed level scheme of ^{164}Dy includes 7 positive parity rotational bands and 5 negative parity rotational bands, in addition, 6 positive parity and 1 negative parity band heads have been proposed. The level scheme has been interpreted in terms of quasiparticle-phonon model and now includes also the $K^{\pi}=0^{-}$ and 1^{-} octupole bands as well as the $K^{\pi}=4^{+}$ double gamma excitation band, proposed in [3]. The structure of two known 0^{+} states has been considered in detail.

Proposed level scheme of ^{164}Dy has been compared with that obtained on the basis of earlier quasiparticle-phonon model (QPNM) calculations [4]. The preparation of the manuscript of paper, comprising the results of our ^{164}Dy nucleus studies, is in progress.

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INVESTIGATION OF ATOMIC NUCLEI WITH GROUP THEORY METHODS

J. Tambergs, T. Krasta, J. Ruža, A. Dzalbs, A. Andrejevs

The systematic calculations of alpha-cluster type nuclei ground state binding and excited state energies has been performed in the frameworks of strictly restricted dynamics model using quadrupole type central nucleon-nucleon (NN) interaction potential. The aim of

calculations was to clarify the behaviour of the parameters of the effective NN-interaction potential in the wide range of nuclear mass number values $4 \leq A \leq 100$ in dependence of A. The degeneracy of quantum number K states has been cancelled by the use of the Bargman-Moshinsky operator Ω, mixing states with $\Delta K=2$. This operator approximately reproduces the mixing due to the exact accounting of collective NN-interaction density matrix. The obtained results can be used not only for the description of properties of alpha-cluster type nuclei states but also for the evaluation of characteristics of nuclear isospin multiplets along Z=N line.

THEORETICAL INVESTIGATION OF FINITE NUCLEI WITHIN MICROSCOPIC THEORIES

A.V. Afanasjev

The work on further development of cranked relativistic mean field theory continues. Recently, the blocking procedure, which allows very detailed specification of the structure of blocked state, has been incorporated into the cranked relativistic Hartree-Bogoliubov (CRHB) computer code. With that improvement, the description of odd- and odd-odd mass systems, incorporating the effects of nuclear magnetism and time-reversal symmetry breaking, can be addressed for the first time fully self-consistently in the framework of relativistic mean field theory. The investigation of a number of physical effects such as properties of rotational bands in odd and odd-odd mass systems, magnetic properties, evolution of the effects of nuclear magnetism towards drip lines, Gallagher-Moshkowski splittings in odd-odd nuclei etc. are in progress.

We continue the development of tilted (two-dimensional) cranking RMF theory with the goal of subsequent study of magnetic rotation and other properties (including impact of currents) of the so-called *magnetic* and *shears* bands. At present, the relevant computer code is already developed to a large degree.

We started the study of super-heavy nuclei within the CRHB theory. This includes the extensive and systematic study of deformation, rotational and quasi-particle properties of nuclei around ^{254}No, the heaviest nuclei for which detailed spectroscopic data have become available, with the goal to see how well the theory describes the experimental data. Based on these results it will be possible to estimate to which extent the extrapolations towards super-heavy nuclei are reliable. We are preparing a manuscript on the first part of this investigation which will be ready in the beginning of 2002.

The collaboration with experimental groups from USA, Sweden, Canada and United Kingdom with the aim to understand the high-spin properties of rotating nuclei is continued. These investigations involve a number of important physical questions such as anti-magnetic rotation (^{100}Pd), coexistence of superdeformed and spherical structures (^{40}Ca), properties of the superdeformed bands in the A ~ 130 and A ~ 60 (^{59}Cu) mass regions, possible role of proton-neutron pairing correlations (^{70}Br, ^{72,73,74,76}Kr), termination of magnetic and anti-magnetic rotational bands (^{105}In, ^{110,112}Te), rotational properties in plutonium region, and a number of other issues in different nuclei (^{112}Sn, ^{113}Sb etc.). A number of articles on these results have been published, while others will be presented in the forthcoming publications.

ROTATIONAL BANDS IN ^{124}BA

J. *Berzins, C.J. Chiara, D.B. Fossan, K. Starosta*

The high spin structure of nuclei in A=120÷130 mass region is very interesting due to the variety of shape coexisting effects. The structure of ^{124}Ba was investigated in the reaction ^{64}Zn(^{64}Zn,4p)^{124}Ba. The duble and triple gamma coincidence data processing were performed with the computer code escl8r and eight rotation bands were identified, the ground state band with the high spin levels till 34 ħ. Three strongly-coupled octupol bands and gamma vibrational band were observed. The evaluation of experimental data is in progress.

DISTRIBUTION OF CS-137 IN LATVIAN PINE WOOD

D.Riekstiņa, O.Veveris, I.Taure, G. Smilskalne

The results demonstrated that the concentration of Cs-137 in the litter of pine forest has changed from 60 to 970 Bq/kg. The increased radioactivity was observed on the coast of the Baltic Sea in Kurzeme (the western part of Latvia) mainly near the Lithuania border. Data show, that the radioactive pollution of Cs-137 in Latvia has mosaic-like structure.

INVESTIGATION OF BIOACCUMULATION OF METALS IN PINUS SYLVESTRIS BY INAA, TXRF AND ET AAS

D.Riekstina, A.Ludborzs, I.Taure, O.Veveris, A.Viksna

The concentrations of the 15 nutrition, trace and toxic elements in 3 age classes pine needles and in soils were established using INAA, TXRF and ET AAS. The pine needles and soils were taken from 7 different sites throughout Latvian territory. It was established, that only the concentration of Sr in the pine needles depends on the concentration Sr in the soil. Concentration of K, Rb, Fe, Mn (for low concentrations) decreases with the age classes of the needles, while concentration of Co, Mn(for high concentrations), Zn, Na,Ca, La increases. For some elements: Al, Ca, K and Mn variation depending from the soil pH and the branch orientation (DA, DR) was observed.

ANWENDUNG DER INAA IN ZERTIFIZIERUNG DER IAEA REFERENZMATERIALEN

D. Riekstiņa, I. Taure, O. Vēveris

No analytical methods can give accurate and precise results without checked up and certified standards with realisable concentration values of elements. Together with over hundred laboratories in many countries we participate in the intercomparision for about twenty years. Taking part in the comparison, we can check up the quality of own work, conclude about analytical methods used in the world, their distribution, accuracy and precision and their advantages and faults. Besides that the laboratory obtains the certified standard materials. One of the last samples for intercalibration was the estuarial sediment IAEA-405. 120 laboratories from 55 countries took part in this intercomparision and reported results for up to 58 elements. The results were obtained by 26 different analytical methods. After statistical evaluation results for our results 6 elements were accepted as recommended values and for 15 elements as information values.

DECONTAMINATION OF RADIOACTIVE POLLUTED WATER

O.Veveris, D.Riekstina

In the Salaspils nuclear reactor have a great experience in the field of decontamination of the radioactive polluted water using ion-exchange resin in a mixed layer. The column contains 80 % cation- and 20 % anion- exchange resin was used. Factor of decontamination, which characterizes the efficiency of the ion-exchange resin, in some cases goes up to 6200. The factor decreases with the decreasing of the radionuclide concentration. For different radionuclides with the same concentration difference in the factor of decontamination correlate with various chemical forms of these nuclides in water.

NEUTRON IRRADIATION INFLUENCE ON MAGNESIUM ALUMINIUM SPINEL INVERSION

V.Skvortsova, N.Mironova - Ulmane , U.Ulmanis

Grown by Verneuil method $MgO.nAl_2O_3$ single crystals and natural spinel crystal have been studied using X-ray difraction and photoluminescence spectra. The fast neutron irradiation up to fluence 10^{24} m^{-2} of magnesium aluminium spinel leads to the lattice parameter decrease. The bond lengths of Mg - O and Al - O vary with the u-parameter and the lattice parameter. In the luminescence spectra the fast neutron (fluence 10^{20} m^{-2}) radiation prodeces an increase in the intensity ratio of the N- to R - lines by 5 - 20 %.The changes of lattice parameters and photoluminescence spectra allow to conclude, that the neutron irradiation causes the increasing of the spinel inversion.

EXCITON - MAGNON INTERACTION IN $Ni_C Mg_{1-C} O$ SINGLE CRYSTALS

N.Mironova - Ulmane, V.Skvortsova, A.Kuzmin, I.Sildos

In the epitaxial grown $Ni_cMg_{1-c}O$ single crystals the temperature and the substitution of nickel ions by magnesium ions change the optical absorption spectra in the near-red region. It is shown that the dilution and the temperature influence the exciton - mgnon interaction. increase of magnesium ions concentration and of temperature results in a rapid decreaseof magnon intensity. The long – wavelength magnons do not contribute into optical absorption spectra well far from the macroscopic transition point from antiferromagnetic - to paramagnetic state.

Scientific Publications
Published in 2001

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2. V.A.Bondarenko, J.Honzatko, V.A. Khitrov, A.M. Sukhovoj, I. Tomandl: *Scissors mode and two-step cascades from the (n,\gamma) reaction.* -preprint Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, Dubna, Russia, 2001, (14 pages)

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7. D. Riekstina**,** A. Ludborzs, I. Taure, O. Veveris, A. Viksna *"Investigation of bioaccumulation of metals in pines sylvestris by INAA, TXRF and ET AAS"*, J. Ekologija. Iesniegta publicēšanai.

8. O. Veveris, D. Riekstina, I. Taure, A. Skujina *"Forest ecosystem as accumulator of radionuclides",* J. Ekologija. Iesniegta publicēšanai.

9. D. Riekstina, O. Veveris, I. Taure, G. Smilskalne *"Distribution of ^{137}Cs in Latvian pine wood*", Proceedings – IRPA Regional Congress on Radiation Protection in Central Europe, Dubrovnik, Croatia, May 20-25, 2001. Iesniegta publicēšanai konfereces Materiālos.
10. N.Mironova - Ulmane, V.Skvortsova, A.Kuzmin, I.Sildos - *Exciton - magnon interactions in $Ni_cMg_{1-c}O$ single Crystals*. Solid State Physics, Russian, (accepted).

11. V.Skvortsova, N.Mironova - Ulmane, U.Ulmanis - *Neutron Irradiation Influence on Magnesium Aluminium Spinel Inversion.* Nuclear Instruments and Methods in Phys. Res. B. (NUM B), (accepted).

Lectures on Conferences

17th Scientific Meeting of institute of Solid state Physics, University of Latvia, Riga, February 19.-23., 2001.
1. V.Bondarenko, J.Berzins, P.Prokofjevs, Ļ.Simonova et al. Interplay of quasiparticle and phonon excitations in ^{181}Hf observed through (n,γ) and (d,p) reactions, p. 40.

2. M.Balodis, J.Bērziņš, N.Krāmere. Level scheme of ^{194}Ir at medium excitation energies, p.41.

3. Ņ. Mironova - Ulmane, T.Zvagule, T.Kärner - Černobiļas AES avārijas "likvidātoru"retrospektīvās dozimetrijas problēmas. g. Tēzes, 45.lpp.

4. V.Skvorcova, Ņ.Mironova-Ulmane, U.Ulmanis - Kobalta oksīdu optiskās īpašības. ibid 60.lpp.

5. J.Bērziņš, D.Riekstiņa, J.Tambergs, U.Ulmanis - LZA kodolreaktors un tā izmantošana. ibid 30-39.lpp.

6. A.Andrejevs, A.Dzalbs, T.Krasta, J.Ruža, J.Tambergs, J.A.Castilho Alcaras, O.Katkevičius. Classification of Nuclear States and Strictly Restricted Dynamics Model Calculations with Quadrupole Interaction., ibid 42.lpp.

7. O. Vēveris, D. Riekstiņa "Radioaktīvi piesārņota ūdens attīrīšana", 44.lpp.

II Pasaules latviešu zinātnieku kongress, Rīga, 14.-15. augustā, 2001.
1. J. Bērziņš, J. Tambergs, D. Riekstiņa, Kodolfizikas pētījumi Latvijā (1961-2001), Tēzes, 245.lpp.
2. V.Gavars, U.Ulmanis - Latvijas kodolreaktors (1961 - 2001).Tēzes 607.lpp.

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1. N.Mironova - Ulmane, A.Pavlenko, T.Zvagule, T.Kärner, R.Bruvere, A.Volrate Retrospective dosimetry and clinical follow - up programme of Chernobyl accident clean-up workers in Latvia, Abstracts p. 147.

2. D. Riekstina, O. Veveris, I. Taure, G. Smilskalne "Distribution of ^{137}Cs in Latvian pine wood", Abstracts, p. 124.

II International Conference "Metals in the environment", Vilnius, Lithuania, September 23-26, 2001, p. 123-124.

1. D. Riekstina, I. Taure, O. Veveris, A. Viksna " Investigation of bioaccumulation of metals in pines sylvestris by INAA and TXRF", Abstracts p. 123-124.

2. O. Veveris, D. Riekstina, I.Taure, A. Skujina "Forest ecosystem as accumulator of radionuclides", Abstracts p. 156-157.

"Radiation effects in Insulators REI – 11", Lisabon, Portugal, Sept. 03 - 07, 2001

1. T.Kaerner, S.Dolgov, P.Liblik, A.Luschik, A.Maaroos, N.Mironova- Ulmane, S.Nakonechnyi - Interaction of electrons, holes and excitons with F centers and anion interstitials n MgO crystals. Int. conf.. Abstracts p. 122.
2. V.Skvortsova, N.Mironova - Ulmane, U.Ulmanis - Neutron Irradiation Influence on Magnesium Aluminium Spinel Inversion. ibid p. 127.

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1. V.Skvortsova, N.Mironova - Ulmane, U.Ulmanis, G.Bandurkina - Transition Metal Oxides Crystals Growth and Optical Properties, Abstracts p. 141.

XI-th Feofilov symposium on spectroscopy of crystals activated by rare and transition metal ions, Kazan, Russian Federation. September 24 - 28, 2001.

1. N.Mironova - Ulmane, V.Skvortsova, A.Kuzmin, I.Sildos - Exciton - magnon interactions in $Ni_cMg_{1-c}O$ single Crystals, Abstracts p. 90.

International Conference Eco – Balt '2001, Riga, 2001.

1. D.Riekstiņa, I.Taure, G.Smilškalne "Starptautisko standartu interkalibrācija, esturiārie sedimenti IAEA-405", Tēzes: 107.lpp.

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1. J.Tambergs – report "Quantum Cosmology".
2. J. Bērziņš - report "Nuclear physics investigations in Latvia".

3rd International Conference "Natural Sciences and Education of Teachers", 21-23 March, 2001, Rīga.

1.J.Tambergs. The Role of the Quantum Theory Conceptual Foundations in the Dialogue between Science and Religion. Proceedings, p.90-91.

18. Seminar Aktivierungsanalyse, 25.-26. October, 2001, Berlin.

1. D. Riekstina, I. Taure, O. Veveris "Anwendug der INAA in Zertifizierung der IAEA Referenzmaterialen", S. P8.

Lectures at Universities, Institutes …

Juris Tambergs

Latvian University, Faculty of Phycis and Mathematics: 1) Basic principles of nuclear and particle physics; 2) Basics principles of general relativity and cosmology

Latvian University, Faculty of Theology: 1) Biblical and scientific conceptions of the Universe; 2) Dialogue between religion and science.

ELECTRONIC ENGINEERING

Head of Department Dr. phys. A. Kristins

Research areas and main problems

1. Implement developing and manufacturing of unique measuring and monitoring apparatus and systems, which:
   - provide authorised access on the base of Touch Memory™ elements and Proximity Cards to different objects, including
     - ⇒ entrance check-points (entrance gates, access control systems, systems for multilevel parking buildings etc.);
     - ⇒ computers and programmes;
     - ⇒ car and other technical devices (anti-theft systems);
   - execute electronic documentation functions (Touch Memory™ -based electronic invoices, credit cards and so on);
   - test power units (high-voltage switches, automatic disconnecting switches, power-transformers);
   - determine a content of heavy metals (As, Cd, Co, Cu, Fe, Hg, Tl, Ni, Pb, Sn, Zn, Bi, Mn) in liquids, ground, food-stuffs;
   - check various environment parameters (temperature, lighting, humidity, radiation level);
   - control temperature and lighting at the different objects (housings, hothouses, production storehouses);
   - are used in medicine and for determining of agricultural production parameters (digestion systems, fluorimetres, fall number determinators).
2. Provide physical measuring and manufacturing process automation.
3. Also solve the other problems, not afore-mentioned.

Scientifical Staff

1. Dr. A.Kristins
2. Dr. hab. A.Zelenkovs

Technical Staff

1. I.Guza
2. I.Gvardina
3. J.Melderis
4. J.Tibergs
5. J.Veinbergs
6. S.Zelenkovs
7. I.Zujevs

Cooperation

Latvia

1. Joint-stock company *Latvenergo*
2. *Latvijas Krājbanka*
3. *Kokarde* Ltd
4. Latvia Technology Park
5. Riga Technical University
6. Latvian Environment Agency
7. *Trafik* Ltd

8. IB *Biakss*
9. *GROG* Ltd
10. *RD Pentano* Ltd
11. *Apollo AS* Ltd
12. *AlarmLat* Ltd
13. *Mikoniks* Ltd
14. *Energoremonts Rīga* Ltd

Denmark

DanBalt Electronics

Russia

St. Petersburg I. Joffe's
Institute of Physics and Techniques

Estonia

OÜ Terg A&K

The prospects of the instruments look at appendix.

Lectures on Conferences

17th Scientific Meeting of Institute of Solid State physics, University of Latvia, Riga, February, 2001.

1. A.Plaudis, I.Ļuļko, A.Kristiņš, A.Zelenkov, S.Zelenkov. System of collection and processing of observation data for shallow water's quality on the basis of DBMS Oracle 8. Abstracts, p. 85.
2. P.Annus, I.Gvardina, A.Kristiņš, Flexible registration system for supervision. Abstracts, p.88.
3. S.Zelenkov. Development features of the database DOQE client/server in Delphi environment for action with DBMS Oracle. Abstracts, p.86.

TESTING LABORATORY

Head of Laboratory Dr.phys. J.Kļaviņš

Research area and main problems

ISSP commenced the evaluation of product conformity assurance since 1996, when the Department of Science of the Ministry of Education and Science rendered support from Market demanded research financing resources for the ISSP in Product testing and quality control pursuant to the requirements of the EU. Some of the staff members of the ISSP participated in the number of projects related to the testing and compliance assurance. Among projects was the establishment of the Testing laboratory (TL). The scope of this project includes a lot of activities. (1) TL preliminary measuring equipment has been supplemented by purchasing several new devices - equipment for determination of the waterproofness of building materials, computerized laboratory and analytical balances etc. (2) The already existing equipment has been repaired. (3) The premises of the laboratory have been repaired and equipped accordingly. (4) In the meantime 7 staff members of the ISSP have completed the training course "Preparing the Testing Laboratory Pursuant the Latvian and European Standards", organized by Certification Centre of Latvian Academy of Sciences, some of staff members – courses in Germany and England. (5) The quality system has been implemented in the laboratory. (6) TL is operating and currently performs testing according to 6 standard methods. New methods are being acquired.

On January 12, 2001 Latvian National Accreditation Office (LATAK) completed the accreditation of the Testing Laboratory at the Institute of Solid State Physics. It means that the quality system of one of the Institute units is recognized as comformit to international standard LVS EN 45001.

All the ISSP TL spheres applied for accreditation were accredited. They are: (1) concrete watertightness; (2) adhesion and cohesion of adhesives of ceramic linings; (3) release of lead and cadmium from enemalled metallic ware, (4) from ceramic ware, glass – ceramic ware, glass dinner ware, (5) glass hollow ware and (6) ceramic cookware subjected to heating and as in 3, 4, 5, 6 in contact with food.

In the 2001 TL sphere was extended with (7) the test for determination of breaking strength of glass fiber yarns, (8) the test for determination of breaking strength and alkaline durability of glass fiber mesh, (9) the test for determination of density of hardened concrete, (10) the test for determination of moisture content of building materials.

Test methods and corresponding standards in the scope of accreditation are:

1. Testing hardened concrete. Part 8: Depth of penetration of water under pressure. EN 12390:2000;
2. Testing of adhesives for ceramic linings; testing of the deformation of bondings; dispersion adhesives. DIN 53265:1988;
3. Ceramic ware, glass-ceramic ware and glass dinnerware in contact with food. Release of lead and cadmium. Part 1: Test method. ISO 6486-1: 1999;
4. Vitreous and porcelain enamels. Release of lead and cadmium from enamelled ware in contact with food. Part 1: Method of test. ISO 4531-1: 1998;
5. Glass hollowware in contact with food. Release of lead and cadmium. Part 1: Test method. ISO 7086-1: 2000;
6. Ceramic cookware in contact with food. Release of lead and cadmium. Part 1: Method of test. ISO 8391/1 – 1986;

7. Textile glass - Yarns - Determination of breaking force and breaking elongation. ISO 3341: 2000;
8. Standard Test Method for Determining Tensile Breaking Strength of Glass Fiber Reinforcing Mesh for Use in Class PB Exterior Insulation and Finish Systems (EIFS), after Exposure to a Sodium Hydroxide Solution. ASTM E2098: 2000;
9. Testing hardened concrete - Part 7: Density of hardened concrete. EN 12390-7: 2000;
10. Hygrothermal performance of building materials and products - Determination of moisture content by drying at elevated temperature. EN ISO 12570: 2000.

Currently not accreditated test methods:

1. Floorings. Testing of watertightness. SIS 923511:1974;
2. Ceramic tiles - Part 3: Determination of water absorption, apparent porosity, apparent relative density and bulk density. ISO 10545-3: 1995.

Staff

1. Dr. J.Kļaviņš
2. Dr.hab. J.Maniks
3. Dr. E.Pentjušs
4. J.Pinnis

Support Staff

1. Dr. V.Eglītis
2. Dr.hab. M.Spriņģis

Cooperation

1. Latvian National Accreditation Bureau LATAK.
2. Latvian Association of Testing Laboratories.
3. Certification Center of Latvian Academy of Sciences.
4. Testing Laboratory of fresh and hardened concrete of "Kalnozols Building", Ltd.

Lectures on Conferences and Seminars

17th Scientific Conference of the Institute of Solid State Physics, University of Latvia, Rīga, February 19-23, 2001.

1. J.Kļaviņš, J.Maniks, E.Pentjušs, J.Pinnis, Quality management and testing of materials.

17th Scientific Conference of the Institute of Solid State Physics, University of Latvia

Riga, February 19 – 23, 2001

The anual Scientific Conferences of the ISSP are held at the Institute of Solid State Physics in February the 17th was dedicated to the 40th Anniversary of the Laboratory of Semiconductor Physics.

The 17th Conference worked in 6 sections:
- structure and phase transitions (12 reports);
- non – linear optical properties and problems of optometry (12 reports);
- optical spectroscopy and luminescence (13 reports);
- materials and applications (11 reports);
- nuclear reactions and radiation physics (7 reports);
- solid state electronics and ionics (10 reports).

On February 23 was the Plenary session dedicated to the 40th anniversary of the Laboratory of Semiconductor Physics and the 10th aniversary of Optometry. The Institute of Solid State Physics was established on the basis of the Laboratory of the Semiconductor Physics.

Alltogether 71 reports of 15 – 30 minutes were presented. Apart from staff members of ISSP and the Department of Optometry, represesantives of the Faculty of Physics and Mathematics, the Riga Technical University, and of the Institute of Inorganic Chemistry participated in the Conference.

The aim of the Conference was to inform the physicists community of Latvia about the most important results obtained in the previous the last year.

Abstracts of the scientific reports presented at the Conference were published in Latvian and English and were available to participants before the meeting.

Conference chairman
Prof. A.Krumins

The seminar “RS-SSI 2001” (which was in Jurmala, Sept.22-26, 2001, Latvia) got together scientists and students (53) from Belorussia (1), Estonia (2), Germany (1), Latvia (29), Lithuania (3), Poland (8), Russia (7) and Sweden (2). On seminar had been presented 39 papers (9 of them was invited). Part of these papers will be published special issue of “Journal of Solid State Electrochemistry”.

The aim of Seminar was realized. The Seminar organizers got together researchers, engineers and users from Baltic region for discussion and exchange of information and to dissemination of knowledge of fast ion conductors, intercalation electrodes and devices (batteries, chemical and electrochemical sensors, supercapacitors and fuel cells) as well as renewed the tradition from Soviet time, i.e. the SMD of ISSP continued organization such seminars, like former ten All Union (USSR) annual seminars on Solid State Ionics in Riga, 1981-1990, which now extended with regional partners from Nordic, Eastern and Western countries.

The main topics of Seminar were:

1) Ionics and Functional coatings
2) Batteries and Fuel Cells
3) Materials and Technologies
4) Intercalation electrodes and Electrode reactions
5) Fast ion conduction phenomena and Solid electrolytes
6) Sensors

Chairman Dr. A. Lusis

APPENDIX

Radioelectronic Department
Institute of Solid State Physics
University of Latvia

Car parking and access control systems

The car parking and access control systems are designed for both - ordinary and multilevel parking places. The systems can service casual as well as regular clients.
The systems consists of one PC or some personal computers, connected in network, that are connected with peripheral devices for service, control and execution (check's printers, cash machines, control devices for barriers and signal lights, readers for Dallas electronic keys, proximity cards, bar codes etc.). The system is corresponding to LR law about fiscalisation.

Software of the system allows controlling peripheral devices, to provide registration of clients and calculate service fees in accordance to client category and parking time, as well as to create necessary database.

Systems can operate with MS Windows 98, Windows NT or Windows 2000.

These systems (in cooperation with "Alarm Lat" Ltd) are put into operation at multilevel parking places "Rīgas Pirmā Garāža" and "Arēna Plus".

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Register system on supervision of route checkpoints

This system is designed to monitor the schedule of visiting route checkpoints by guard patrol. The system also allows monitoring arrivals (and optionally leavings) the object (optionally remote) if there is a checkpoint at this object.

The system consists of one or more portable data readers (DR), identification keys (IK) as checkpoints and software.

The system doesn't require permanent use of computer. Data readers are completely autonomous and the information about attendance of checkpoints (codes of checkpoints and time of making corresponding checks) is saved in non-volatile memory (EEPROM), where it can be stored until the device is connected to computer.

The code-keys of checkpoint identification (Dallas Semiconductor) do not require power supply and also do not require installation. The checkpoint identification keys are attached at necessary place with a special holder. Sizes of checkpoint identification keys are ∅17.35 x 5.89 mm.

Program software allows programming the rules of passing route, but after receiving the data from data readers it allows to analyze adequacy of the guards activities; compose reports and print the reports or send by E-mail if necessary.

The user interface is in Latvian and operates under Win9x/2000/NT. The language of user interface can be changed in accordance with special order.

The fact of date reading by ICK is confirmed with sound and light signals.

The information of the same ICK can be written in the data-reader repeatedly if the next reading takes place no sooner than after one minute. The memory volume of the data-reader is designed for registering 1700 events. A special cable is used for data transmitting to PC. Date reader sizes do not exceed 26x40x160mm.

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Security Drawers and Safes for the Cash Points

There are some versions of safes produced by Solid State Physics Institute & Co for storage of banknotes, coins and forms. A safe has an electromechanical lock, activated by electronic system with time delay.

The safe-drawer SF-1 has the keys based on Dallas Semiconductor firm Touch Memory™ identification chips with unique registration number (up to $2{,}81 \cdot 10^{14}$ numbers), but safes KT-2F may be completed both TM and mechanical key. The electronic time delay system can be activated by TM or control button, then a red LED flashes intermittently until the delay time has run out. At that moment a buzzer beeps and a green LED flashes for access time. During of that time the safe may be pulled open.

	SF-1	**KT-2FA**	**KT-2FB**
Delay times (minutes)	3, 5, 10, 15	3, 5, 10, 15	3, 5, 10, 15
Access times (s)	5, 10, 15, 20	5, 10, 15, 20	5, 10, 15, 20
Dimensions (mm)	400 x 370 x 140	300 x 300 x 300	300 x 300 x 200
Weight (kg)	12	14	10,5

The safe is connected to the mains (50 Hz, 220 V A.C.) by a transformer or to the 9 V 300 mA D.C. source.

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High-voltage Breaker Analyzer Device "OSKARS"

The device was designed for the verification of high-voltage (110 and 330 kV) breakers. 14 timing channels and the current in the driving solenoid are simultaneously controlled and necessary time parameters calculated.

Only one minute - and you have the operating sequence and the time control results printed out on the A4 format (210 x 297 mm) paper sheet by ordinary printer without using of the computer.

The device has four modes of operation: *OPEN (O), CLOSE (C), OPEN-CLOSE-OPEN (O-C-O), CLOSE-OPEN (C-O)*. The delay time between pulses (O-C) and (C-O) can be set on the thumbwheels (0 ÷ 0,15 s).

The device can be used for testing of 10 types of breakers: ВВШ-110; ВВБ-110; ВВУ-110; ВВН-110/6; ВВ-330Б; ВВН-330/15; HGF-115/2B; HPL-362/B2; LTB-145D1.

The time resolution is 0,001 s.

Dimensions are 490 x 480 x 165 mm.

Weight is 20 kg.

The device specifications may be changed according to customer‘s requirements.
The device may be used to study reaction velocity, delay and vibrations of different kinds of the relays and for registration of different processes in other branches of science and technique.

These devices are put into operation by power engineering departments of "LATVENERGO" and "LIETUVOS ENERGIJA".

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Device for Authorized One-Door Access System with TM Identification Code Keys and Event Registering

The device is constructed for creation of authorized access system for apartments.

The device controls electromagnetic keys of any construction.

Accessing in the apartment is implemented with the aid of the *Dallas Semiconductor* Touch Memory™ identification code keys. In the emergency case it is possible to enter the apartment with the aid of ordinary mechanical key.

Exiting of the apartment is provided either with the button or with the TM (if the second reader is available).

Reprogramming of the TM list, setting of the time and time access zones (optionally) and also transferring of the data on the events registered from the device to PC is realized with the assistance of the special identification Master-key with 64K bits of read/write nonvolatile memory.

This device is cheaper than most of similar ones.

Technical Specification

Power supply:	+(10 - 15) V
Consumption of system activated in access mode (defined by el. mech. lock):	< 0,5A (typically)
Access time (standard):	5 seconds
Sound signal on non-authorized opening of the door:	Immediately
Sound signal delay after authorized opening of the door:	5 seconds
Possible combinations of keys:	$2{,}8 \bullet 10^{14}$
Number of user keys (standard):	56 pcs.
Number of events registered:	500
Time of data retention in Master-key:	over 10 years

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Device for Authorized One-Door Access System with TM Identification Code Keys

The device is constructed for creation of authorized access system for apartments.

The device controls electromagnetic keys of any construction.

Accessing in the apartment is implemented with the aid of the *Dallas Semiconductor* Touch Memory™ identification code keys. In the emergency case it is possible to enter the apartment with the aid of ordinary mechanical key.

Exiting of the apartment is provided either with the button or with the TM (if the second reader is available).

Reprogramming of the TM list is operative - with the assistance of two Master keys.

The device has a sound and light indication and it provides an electrical signal for security service.

This device is cheaper than most of similar ones.

Technical Specification

Power supply:	+(10 - 15) V
Consumption:	
System armed in waiting state:	? 8 mA
System activated in access mode (defined by el. mech. lock):	< 0,5A (typically)
Access time:	5 seconds
Sound signal on non-authorized opening of the door:	Immediately
Sound signal delay after authorized opening of the door:	5 seconds
Possible combinations of keys:	$2{,}8 \bullet 10^{14}$
User keys:	? 56 pcs.
Dimensions:	83x55x35 mm

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Digestion System

The digestion system provides digestion of various samples in sulphuric acid, using the Kjeldahl method.

Into six deep hollows of electrical heater are placed tubes, containing samples and sulphuric acid. The temperature controller provides the thermal regime of heater. The thermal regime includes two plateaus of temperature: the first (in time) - in the temperature region of boiling water, and the second - in the temperature region of boiling acid. The temperature controller provides also three different heating rates for transition from starting temperature to the first and second plateau. The thermostation time control up to six hours is possible.

The digestion system is provided by water aspiration pump for the removal of exhaust gases, produced in digestion procedures.

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Electronic Documentation

There is a portable system based on Dallas Semiconductor firm Touch Memory™ chips for data saving and moving without paper. The silicon chip packs in TM memory more as 8000 signs (~ 4-5 pages).

TM replaces paper documents that are difficult to attach to objects and are prone to damage or illegibility. If copying is undesirable, lock bits, add-only memory, passwords and encryption can be employed.

TM based electronic documents are very convenient and safe for persons who have contacts with confidential or strict registration papers.

Each TM chip has a unique registration number up to $2{,}81 \cdot 10^{14}$ variants.

A personal computer with special interface and special software can read and write data from/to Touch Memory.

TM is housed in a durable hermetic stainless steel case (∅ 17,4 x 5,89 mm) and is tolerant to mechanical shock, static electricity, and electromagnetic fields and to other harmful environmental factors.

TM has an ambient temperature range -40°C to +85°C.

Touch Memories can accommodate over one million data changes.

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Vehicle Alarm System and Immobilizer with TM Identification Code Keys

This product is an electronic device for vehicle anti-thieves protection and can be activated and deactivated by Dallas Semiconductor firm Touch Memory™ identification keys with a brief touch of the key to the key-reader.

The electronic keys are all different, there are about $2.81 \cdot 10^{14}$ possible combinations and it is impossible to produce 2 equal keys.

The activated protecting system takes under its control vehicles hood, trunk and doors pin switches and disconnects one or two (optionally) main electric circuits of the vehicle (ignition coil, fuel pump, starter solenoid etc.). A flashing LED on the dashboard warns potential thieves of its presence. A protecting mode is switched on by connecting of power supply.

Additional sensors - shock detectors, ultrasonic sensors etc. may be connected to this system. Also the system remind about headlight state.

This system has some operation modes and gives information to driver by LED indicator and sound signals.

Technical Specification

Power supply:	+(10 - 15) V
Consumption:	
System armed (including LED):	? 8 mA
Armed only engine deactivation:	? 4 mA
Consumption by driving (immobilizer relay "on"):	? 35 mA
Disarming delay:	10 seconds
Rearming delay:	30 seconds
"Secret" button delay:	2 minutes
Possible combinations of keys:	$2{,}8 \bullet 10^{14}$
Duration of alarm signal sound - 2 minutes total by 4 secs sound and 4 secs pauses.	
Alarm relay contact capacity:	20 A
Immobilizer relay contact capacity:	20 A
Dimensions:	130x100x30 mm
Automatic switching on of the immobilizing mode after ignition switching off - in 20 secs.	

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Apparatus for Metal Determination in Liquids "AHPS-2"

The AHPS-2 is a device for determination of metals in water and other liquids. It is based on a very sensitive electro-chemical method and allows us to determine the concentration of

Cu, Zn, Cd, Sn, Au, Tl, Pb, Bi

at a low levels of contents as 0,1 ppb. In special cases the sensitivity of the AHPS-2 is even higher and allows us to determine metals at concentrations below 0,1 ppb. The upper limit of the metal concentration determination by the AHPS-2 is in the ppm region.

The sample preparing procedure for analysis is very simple and can be completed within a matter of minutes. In a single analysis process more than one metal can be detected. The analysis procedure is rather fast: for ppm region measurements it lasts approximately one minute and for measurements of levels within the 0,1 ppb region it takes no more than ten minutes.

The analysis procedure is fully controlled by the computer (preferably IBM PC compatible).

The AHPS-2 can be used in environmental control as well as for analytic tasks for determination of trace elements.

The AHPS-2 is produced in cooperation with Division of Disordered Material Physics.

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