YEARBOOK

2004

RESEARCH INSTITUTE FOR TECHNICAL PHYSICS AND MATERIALS SCIENCE

HUNGARIAN ACADEMY OF SCIENCES

http://www.mfa.kfki.hu

Research Institute for Technical Physics and Materials Science
Hungarian Academy of Sciences

Director: Prof. István Bársony

Address: H-1121 Budapest, Konkoly Thege Miklós út 29-33, Hungary
Postal: P.O.Box 49, H-1525 Budapest, Hungary
Phone: +36-1-392 2225
Fax: +36-1-392 2226
e-mail: info@mfa.kfki.hu

URI: http://www.mfa.kfki.hu

Yearbook 2004

Edited by: Z. Hajnal and P. Petrik
Published by: MTA MFA (Director: I. Bársony)

Contents

Foreword of the director

"A year of refocusing and restructuring"… that's how one could simply summarise the efforts of the Research Institute for Technical Physics and Materials Science - MFA in 2004.

After 14 years of skilfully leading the institute Prof. József Gyulai relinquished the directorship in January 2004. By the end of March a new, younger management was in place determined to streamline the widespread activities characterising the institute.

The leading idea was to develop and follow a strategy to allow a more flexible adaptation of existing capabilities to rapidly changing scientific trends as well as the needs of society regarding early application of research results in processes and products. The past decades have taught us, however, that in an institute belonging to the research network of the Hungarian Academy of Sciences this can only be realised by pursuing a good blend of fundamental and applied research, in which the ratio of the two components has to be adjusted to the given requirements and financing possibilities. Although severe constraints in research financing in Hungary still do not allow a consequential focus onto desirably narrow fields, in which an institute of 90 researchers could ideally carry out world class in depth research, regrouping of our existing human and material resources and redefinition of the tasks might be instrumental in improving the efficiency even in the short term.

For this reason we adopted a new structure of four scientific departments representing the four main directions of research into functional materials: Structure research, Photonics, Micro- and Nanotechnology. In fact, all of them deal with the exploration of low-dimensional and self-organised structures, and the exploitation of the results mainly in sensorics and the development of different non-destructive testing methods. An effective policy of rejuvenation of research staff and management while maintaining the high quality remains a foremost task for the long run.

At this point it is my duty to acknowledge on behalf of the scientific staff the help and support of our technical and administrative colleagues. Their share in the scientific achievements of MFA cannot be praised enough in the period of a flood of new regulations and a suffocating administrative load, not necessarily to be ascribed to EU accession alone. Thanks to collective efforts, by mobilising own resources in 2004 we were able to finish the renovation of several laboratories and establish a new laboratory supporting the integration of molecular biology results into sensor systems using optical readout.

This simple, transparent new structure of the institute enabled the targeted mobilisation of the resources of larger entities; thereby fostering a better internal collaboration among the research groups. The work of the Scientific Council of eight institute members, and the newly established Board of the Institute, whose members are top external experts proved to be a real help and support for the director. The management became more operative at every level, with the main responsibilities lying with the research group leaders. For this reason we have this time chosen to present the scientific results following the organisation scheme of the institute. Hence in some cases the same project appears in the report of different groups, collaborating in the joint effort.

I have to stress our senior scientists' active participation in graduate and postgraduate education at most of the scientific and technical universities of the country. Currently 23 PhD students conduct their research at MFA. By conducting courses and organising practicals at MFA or even by operating joint laboratories with universities, this non-subsidised, voluntary activity also serves as an investment for the future.

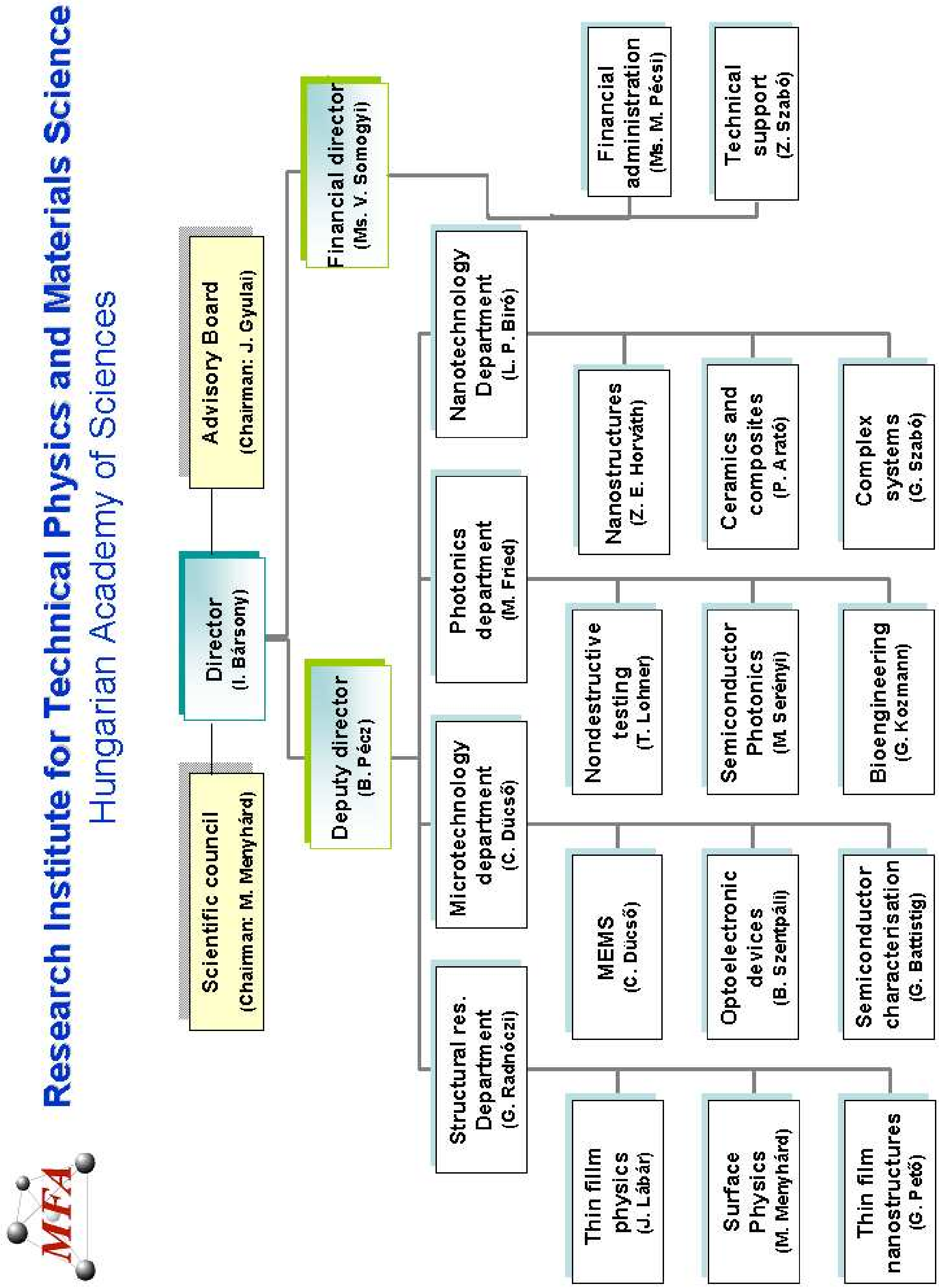
According to our intentions this booklet will be the first in a series annually presenting the scientific results obtained at MFA. As it approaches the 50th anniversary, this is a resumption of the tradition of publication of Yearbooks by its predecessor, the Research Institute of Technical Physics - MFKI. We sincerely hope that by sampling this booklet, the reader can get an overview about the current state of the main activities, and find all the necessary references to establish contact with the relevant scientists for potential co-operation. At the same time we also hope to provide an insight into the operation and life of the MFA research community and reflect the pleasant working atmosphere we cherish so much.

Budapest, 31 March 2005

István Bársony

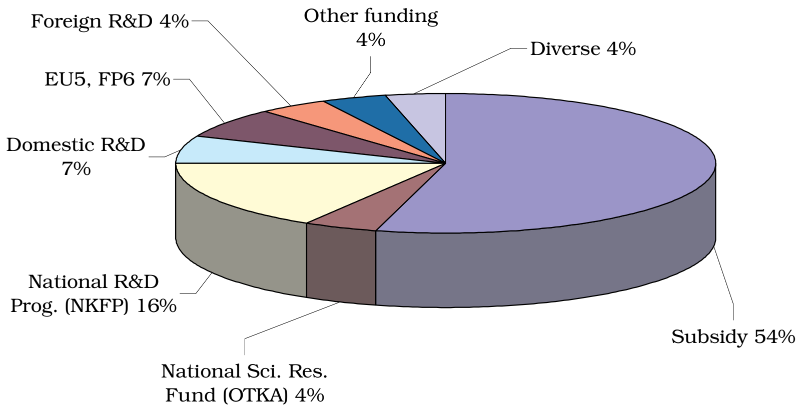
GENERAL INFORMATION

Organisation

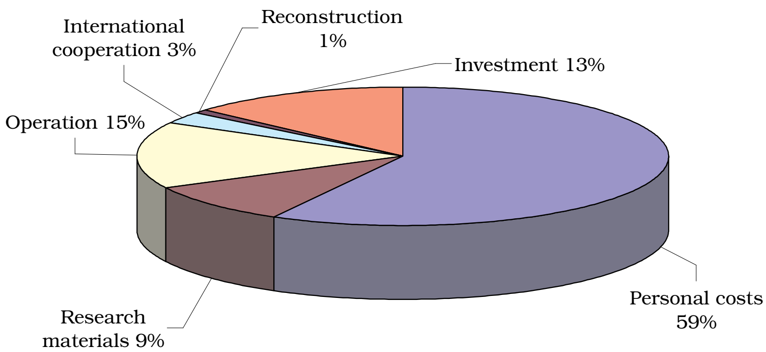


Financial Resources, Expenditures and Investment

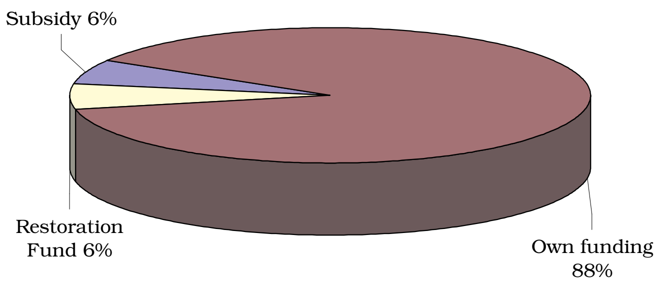
Resources in 2004
Total: 1 143 190 kFt (4 573 k€)



Expenditures in 2004
Total: 1 124 582 kFt (4.5 M€)



Sources of Investment in 2004
Total: 158 927 kFt (636 k€)



Prizes and Honours

Árpád BARNA, D.Sc. – MFA Senior Prize 2004

Péter FÜRJES, Ph.D. – MFA Postdoc Prize 2004

Krisztián KERTÉSZ – MFA Junior Prize 2004

György KOZMANN, D.Sc. – Professor of the year 2004 in Informatics, VISZ Prize

Ms. Vera SOMOGYI – Certificate of Merit by the Secretary General of the Hungarian Academy of Sciences

Péter SZÖLLŐSI – Students Scientific Conference (TDK) 1st prize, Budapest University of Technology and Economics, Faculty of Electrical Engineering and Informatics, for his work titled *"Electrical studies of annealed SiN_x layers containing excess silicon"*

Jeromos VUKOV – Excellent Student of Faculty (Eötvös University)

Patent Applications Submitted in 2004

P0401509 (2004.07.27.):

Corrosive chemical environment resistant diamond – diamond-like carbon protective layer-system and its preparation *(Korrózív kémiai közegben ellenálló gyémánt-gyémántszerű szén védőrétegrendszer és előállítása)*

Owners:

- MTA MFA (50%)
- MTA KKI (30%)
- BUTE (20%)

Inventors:

- G. Pető (16.66%)
- H. Kováchné Csorbai (16.66%)
- A. Karacs (16,66%)
- G. Kovách (10%)
- E. Kálmán (10%)
- P. Deák (10%)
- G. Molnár (10%)
- G. Hárs (10%)

P0402479 (2004.12.02.):

Method for multichannel sensing measurement in integrated optical waveguide systems *(Eljárás többcsatornás érzékelő mérések elvégzésére integrált-optikai hullámvezető szerkezetekben.)*

Owner:

- MTA MFA (100%).

Inventors:

- A. Hámori (75%)
- N. Nagy (25%)

P0402683 (2004.12.29.):

Modified flagellines, and flagellinic filaments applicable as receptors, and methods for their preparation *(Receptorként alkalmazható, módosított flagellinek és flagelláris filamentumok valamint eljárások előállításukra)*

Owners:

- University of Veszprém (70)
- MTA Institute of Enzymology (25%)
- MTA MFA (5%)

Inventors:

- F. Vonderviszt (70%)
- P. Závodszky (15%)
- S. Kamondi (10%)
- I. Bársony (5%)

Patents Obtained in 2004

EU: PCT/SE99/00603

Superficial implant surface structure
Owner:
- MTA MFA (100%).

Inventors:
- G. Pető (40%),
- A. Karacs (30%)
- Z. Pászty (10%)
- T. Divinyi (13%)
- F. Fuller (7%)

Technology Transfer in 2004

Proprietary know-how for environment preserving Mo dissolving from W filaments in the lighting industry. Responsible: Dr. K. Vadasdi

The automatic equipment for dissolving of Mo mandrels from 300-400 million filaments/year. Installed in 2004 at the Sae Han Tungsten Co. Ltd., Namyangju-city, S. Korea. Another installation has been operating in Sweden since 1992.

Visitors

G. Amsel, SAFIR, Institut des NanoSciences de Paris, Universite de Paris 6, Paris, France, CNRS-MTA research agreement

Ch. Angelov, Institute of Nuclear Research, Bulgarian Academy of Sciences, Sofia, Bulgaria, Characterisation of ion beam crystallised silicon samples, Academic exchange

D. Cooper, Dept. of Materials Science and Metallurgy, Univ. of Cambridge, UK, Co-operation/Research Field: Ion beam thinning, electron holography, Financed by Univ. of Cambridge.

C. Dezelah, Helsinki University of Technology, research field: ALD processes, Financed by TEKES/OM

R. E. Dunin-Bokowski, Dept. of Materials Science and Metallurgy, Univ. of Cambridge, UK, Cooperation/Research Field: Ion beam thinning, electron holography, Financed by Univ. of Cambridge.

Ch. Eisenmenger-Sittner, Institute für Angewandte und Technische Physik der Technische Universitat, Wien, Austria, financed by Hungarian-Austrian TeT cooperation project

C. Frigeri, CNR IMEM, Parma, Italy, Financed by MTA-CNR

H. Füredi-Milhofer, The Hebrew University of Jerusalem, Jerusalem, Israel. Research on surface improvement of metal implants Financed by EU FP5 project, NAS-SIMI, G5RD-CT-2000-00423

J.-J. Ganem, SAFIR, Institut des NanoSciences de Paris, Universite de Paris 6, Paris, France, CNRS-MTA research agreement

P.-I. Gouma, Department of Materials Science & Engineering, State University of New York, research field: sensing materials, financed by: NSF

B. Idzikowski, Institute of Molecular Physics, Polish Academy of Sciences, Development and application of novel soft magnetic materials, Academic exchange

J. G. López, Centro Nacional de Aceleradores, Sevilla, Spain, TéT Spanish-Hungarian bilateral cooperation

S. Lugomer, Materials Science Department “Ruđer Bošković” Institute, Bijenička c. 54, Zagreb, Croatia, Research on morphology of laser treated surfaces. Financed by the home institute of the visitor.

I. P. Mayer, The Hebrew University of Jerusalem, Jerusalem, Israel. Research on surface improvement of metal implants Financed by EU FP5 project, NAS-SIMI, G5RD-CT-2000-00423

F. Nemouchi, L2MP, Marseille, France

A. Nutsch, Universität Erlangen-Nürnberg, Application of Makyoh topography for the nanotopography studies of semiconductor surfaces, comparative studies on new type dielectric layers using spectroscopic ellipsometry, X ray diffraction and ion beam analysis, Financed by a DAAD-MÖB mobility project

L. Papadimitriou. Department of Physics, University of Thessaloniki, 54124 Thessaloniki, Greece. Cooperation in carbon film research. Financed by Hungarian-Greek bilateral cooperation.

Y. Pauleau, National Polytechnic Institute of Grenoble, CNRS-LEMD, Grenoble, France, financed by French-Hungarian Balaton Project

L. D. Pramatarova, Institute of Solid State Physics of the Bulgarian Academy of Sciences, Sofia, Characterisation of hyrdoxiapatite layers for biomedical applications, Financed by a bilateral academic collaboration scheme

Mária Ravasz, Babes-Bolyai University, pattern formation, financed by OTKA

L. Ryć, Institute of Plasma Physics and Laser Microfusion, Warsaw, semiconductor detectors for laser plasma diagnistics, Financed by a bilateral academic collaboration scheme

Ch. Schmidt, Universität Erlangen-Nürnberg, Application of Makyoh topography for the nanotopography studies of semiconductor surfaces, comparative studies on new type dielectric layers using spectroscopic ellipsometry, X ray diffraction and ion beam analysis, Financed by a DAAD-MÖB mobility project

M. Szilágyi, University of Arizona, game theory, sabbatical year

Ivan Tomáš, Institute of Physics, Academy of Sciences of Czech Republic, Nondestructive material characterisation, Academic exchange

I. Vickridge, SAFIR, Institut des NanoSciences de Paris, Universite de Paris 6, Paris, France, CNRS-MTA research agreement

Gy. Vizkelethy, Sandia National Laboratories, Albuquerque, NM, USA, cooperation

SCIENTIFIC REPORTS

Structural Research Department

Head: G. Radnóczi

The main efforts of the Structural Research Department are aimed at the exploration of atomic processes, taking place in thin films, small particles and surfaces during growth, thermal treatment, ion bombardment and solid state reactions in order to understand the physical and chemical behaviour and properties, needed in different applications. For this purpose we use methods like transmission (analytical: EDS, also EELS from the end of 2005 and high resolution) electron microscopy, RHEED, AES in combination with depth profiling and EPES in our own laboratories and STM/STS, X-ray diffraction, Scanning electron microscopy and FIB as well as XPS in co-operation with other laboratories of the institute. We grow thin films by thermal or e-beam evaporation and DC-sputtering in both HV and UHV systems.
The work is organised in three laboratories, being complementary to each other by their topics and equipment, and also co-operating with each other to a large extent.

Surface Physics

Head:
Dr. Miklós Menyhárd, D.Sc.

Staff:
Dr. György Gergely D.Sc.
Dr. Sándor Gurbán
Dr. Attila Sulyok Ph.D.
Dr. Péter Süle Ph.D.

PhD Students (Advisor):
L. Kótis (Dr. M. Menyhárd)

Thin Film Physics

Head:
Dr. János L. Lábár, D.Sc. habil.

Research Staff:
Dr. Árpád Barna, D.Sc.
Dr. Péter B. Barna , D.Sc.
Dr. Zsolt Czigány, Ph.D.
Dr. László Dobos, Ph.D.
Mrs. Olga Geszti
Dr. Éva Hegedűs, Ph.D.
Dr. Béla Pécz, D.Sc.
Dr. György Radnóczi, D.Sc.
Dr. György Sáfrán, Ph.D.
Dr. Lajos Tóth, Ph.D.
Dr. Bernadett Veisz, Ph.D.
András Kovács
István Kovács

Technical Staff:
Mrs. Árpád Barna
Sándor Csepreghy
Mrs. Ferenc Glázer
Andrea Jakab
Mrs. Antal Kovács
László Puskás
Mrs. András Tóth

PhD Students (Advisor):
György J Kovács (Dr. György Radnóczi)
Fanni Misják (Dr. Péter Barna B.)
Zsolt Makkai (Dr. Béla Pécz)
György Z Radnóczi (Dr. Béla Pécz)
Lajos Székely (Dr. Péter B. Barna)

Thin Film Nanostructures

Head:
Dr. Gábor Pető, D.Sc.

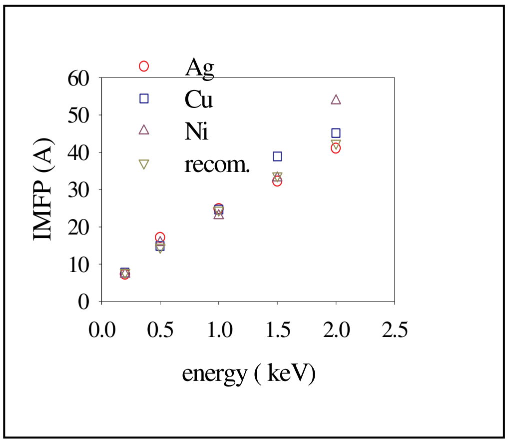
Staff:
Dr. György Molnár, Ph.D.
Dr. Tamás Horányi, Ph.D.
Albert Karacs
György Lehel

PhD Students (Advisor):
Gergely Kovách (Dr. Gábor Pető)

Surface Physics Laboratory (M. Menyhárd)

Determination of surface excitation parameter of Cu, Au, Ni, Ag, Ge and Pd and selected polymers based on Si and other reference standard materials (OTKA T 037709, Hungarian-Polish bilateral agreement)

G. Gergely, S. Gurbán, M. Menyhárd, A. Sulyok, A. Jablonski, B. Lesiak

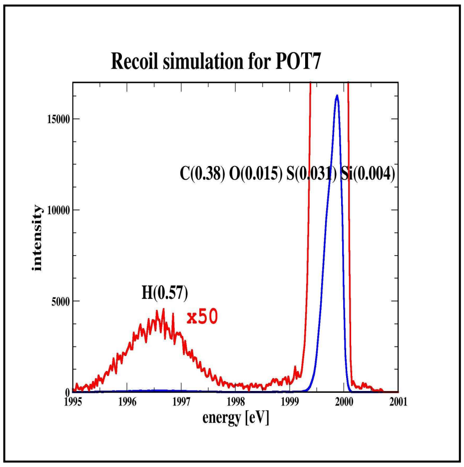


Elastic peak electron spectroscopy (EPES) method is the most reliable experimental method for the determination of the inelastic mean free path (IMFP). One of its main problem is that surface excitation occurs when the electron enters and or leave the solid and thus the surface excitation reduces the intensity of the elastic peak. (The surface excitation also affects the REELS spectra). Correction for surface excitation is necessary for determination of the IMFP. The experimental determination of the total surface excitation parameter was based on EPES spectra by measuring the integrated elastic peak ratio of sample (Cu, Au, Ni, Ag, Ge, Pd) and reference either Si or Ni [43]. As it is shown on the figure using these values for correction of the elastic peak intensity the IMFP values derived agree well with those derived by means of bulk optical data (shown on the figure as recommended).

In case of selected polymers the same procedure was followed [44, 108]. Here again the quality of the IMFP values improved if the correction was applied. These data were also used to choose between the available theoretically derived correction factors; Chen's data set seems to be the most reliable one.

H determination by means of recoil spectroscopy [108] (OTKA T 037709, Hungarian-Polish bilateral agreement)

G. Gergely, S. Gurbán, M. Menyhárd, T. Orosz, A. Sulyok, D. Varga, J. Tóth, A Jablonski, B. Lesiak

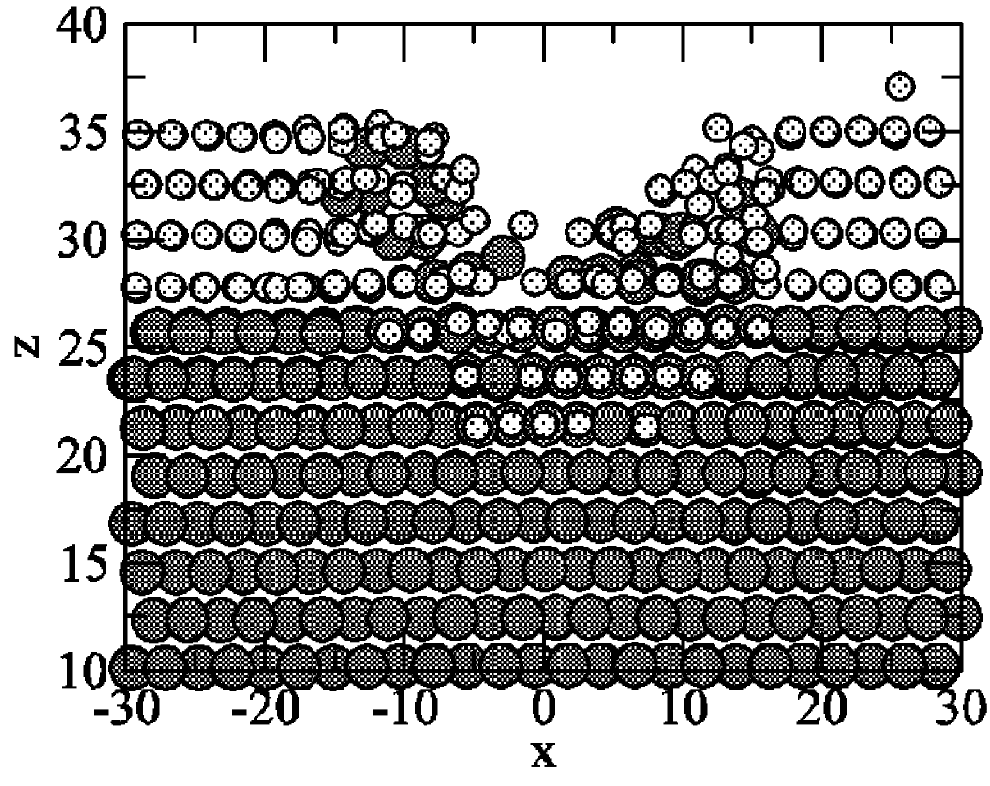


The "elastically" reflected electrons lose some energy due to the heavy (but not infinitely large) nucleus of the scattering atom. The energy loss depends on the mass of the nucleus besides several other factors amounting some hundreds of meV for H. Applying a reasonable good electron spectrometer this loss can be resolved. In the figure we show the result of MC simulation considering the energy transfer between the bombarding electron and the scattering nucleus for a given polymer. In this case due to the presence of H, in good agreement with the experiments a "new elastic" peak appears shifted more than 3 eV from the elastic peak due to Si.

Simulated ion-sputtering: the study of ion-bombardment induced interfacial mixing and surface roughening using atomistic simulations (OTKA F037710, NKFP3- 3/0064)

P. Süle, M. Menyhárd, K. Nordlund (Helsinki)

Classical molecular dynamics simulations have been used to study ion-sputtering induced atomic transport phenomena, such as radiation enhanced diffusion, collision cascades, thermal spike as well as interfacial mixing [142,143]. Our calculations support the importance of a ballistic mechanism during atomic mixing. In metal bilayers we find that the atomic mass anisotropy governs interfacial mixing. Moreover, in mass anisotropic systems (such as Ti/Pt or Al/Pt) the mixing process is asymmetric: first the heavy atoms are ejected to the overlayer from the substrate; the light atoms are injected (intermixed) to the bulk with some time delay. This peculiar behaviour of these bilayers has never reported before and is attributed to the backscattering of the light atoms from the heavy side of the interface.
We also investigated the ion-induced surface roughening in Ti/Pt. It has been found that atomic relocations normal to the surface are coupled with adatom diffusion on the surface. In particular, we characterised a new surface damage mechanism what we call mixing induced enhancement of surface roughening. The change of the atomic density at the interface will determine the final surface morphology. In Ti/Pt we find that the decrease of the atomic density of the mixed interface leads to the development of a nanohole at the free surface [142], in Al/Pt the contrary is found (nanoisland, nanodot formation) [143].
The ion-sputtering induced nanohole is shown in the figure (below) in Ti/Pt [142].
As mentioned above the surface damage is coupled with interfacial mixing in this mass anisotropic system.



Thin Film Physics Laboratory (J. Lábár)

Development of cross-sectional sample preparation with focused ionised-gas-beam sputtering (OTKA T035267)

A. Barna, B. Pécz, Z. Makkai, G. Z. Radnóczi

Within the framework of the project a new perforation detector system was developed with a red, (650nm) focused, (ϕ10-15 μm) impulse modulated laser beam. The sample is illuminated with the laser beam during ion beam thinning. The laser can be adjusted from outside of the vacuum chamber. The sensor in the vacuum chamber detects the light transmitted through the sample. For metal sample the perforation detector system stops the thinning if the diameter of the perforation is larger than 10 μm. Semiconductor samples are partly transparent for the red light. Therefore one can follow the thickness changes of the sample during the last period of the thinning process once the sample thickness has reached 10-20 μm. The Ga ion beam induced (IBID) deposition of Pt strap result in a thick amorphised layer on the top surface of single crystalline Si (Fig.1) The interface between the crystalline Si and amorphised layer is rough. One can investigate a similar effect bombing the Si with higher energy (3-10 kV) Ar ions. The interface roughness appears on the atomic scale and decreases with ion energy (Fig. 2). Low energy Ar ion bombardment (100-300eV) result in a near atomically smooth interface (Fig. 3)

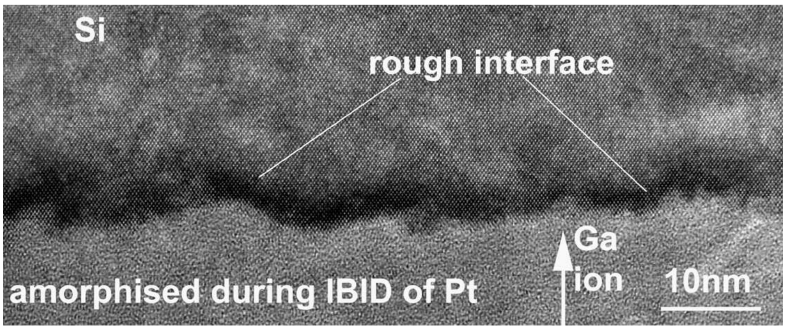


Fig. 1. Interface roughness caused by Ga ion beam induced deposition of Pt

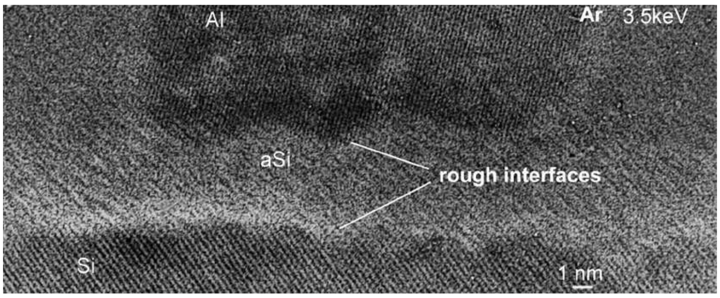


Fig. 2. Interface roughness caused by bombardment with 3.5 keV Ar ions

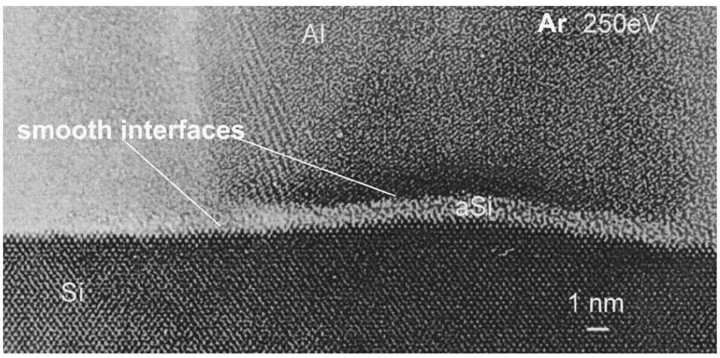


Fig.3. Bombardment with 250eV Ar ions results in near-atomically smooth interfaces

The formation of oriented semiconductors on non-oriented substrates (OTKA No. T035270)

G. Sáfrán, O. Geszti, S. Csepreghy

CdSe is one of the II-VI group semiconductors exhibiting photovoltaic effect and suitable band gap (1.74 eV) for photoelectronic applications.
Cd-Se thin films were prepared by the chemical reaction of the successively deposited constituents. Cd layers 30-60nm in thickness were deposited on (001) (011) and (111) NaCl, treated with Cl_2 surfactant and on thin carbon foil. For improving the condensation of Cd, a 1.5nm thick Ag seed layer was applied. Cd and Se were evaporated subsequently at 100-200 °C. The Cd-Se chemical reaction took place during the Se deposition.
The (0001) hcp Cd layers formed with two azimuths on the (001) and (011) and one azimuth on the (111) NaCl. On the amorphous carbon foil the Cd was random. The c-axis of the CdSe was normal to the surface with the orientation CdSe[10.0]$\parallel$Cd[10.0]. The partly selenised layers exhibited very small grains of CdSe layers with Kirkendall voids, suggesting remarkable diffusion of Cd.
Surprisingly, a recrystallisation of the CdSe occurred at a certain stage of the selenisation process. It caused grain coarsening and a reorientation of the layers. This may be related to the transfer from a two-phase (Cd/CdSe) to a one-phase (CdSe) system and that the new orientation of the grains is determined by the free surface energy of CdSe instead of the interface energy of Cd/CdSe. A polymorphic phase transformation including cubic structure is also not excluded. The results provide a way for tailoring the crystal orientation and grain size of CdSe thin layers.

OTKA T043437: Quantitative Electron Microscopy

J. L. Lábár, Mrs. Á. Barna, G. Czigány, A. Kovács, B. Pécz, L. Puskás, G. Radnóczi, B. Veisz

Electron diffraction based qualitative phase analysis is performed in the TEM with the computer program called ProcessDiffraction. Based on information from local composition (obtained independently with EDS or EELS) the list of possible phases is searched directly in the XRD database. Diffraction data of selected phases are overlayed over the measured distribution of diffracted intensity as Markers. Identification is done visually. Results are published and the program is tested by about 60 students in an International School. [*Lábár JL, „Phase identification by combining local composition from EDX with information from diffraction database”, Electron Crystallography, NATO ASI, Erice, 2004*].
Modelling of peaks and the background under them is built into the ProcessDiffraction program. Three alternative peak-shapes (Gauss, Lorentz and Pseudo-Voigt) and four alternative background shapes (polynomial, Spline and 2 different exponential) are offered by the program at the moment. Parameters in the model functions are optimised by the downhill SIMPLEX method.
Phase sequence in the formation of thin Al-Co films was studied. We showed that bifurcation in the phase selection is controlled by the structure of the components during heat treatment of excess Co with Al_9Co_2 (which is the first phase to form when Al is reacted with Co). Selection of the second phase is different for a continuous Co-layer than for the Co being present in the form of nanoparticles. [*42*]

Growth mechanism, synthesis and microscopy of wide band gap semiconductors (OTKA T047141)

B. Pécz, Á. Barna, J. Lábár, L. Tóth, L. Dobos, B. Veisz, Z. Makkai, G. Z. Radnóczi

The present research subject covers the growth mechanism of wide band gap semiconductors, silicon carbide (SiC), diamond and III-nitrides (GaN, InN and AlN), their contacts, solid phase reactions in them and the characterisation of the above structures by transmission electron microscopy.
Our goal is to synthesise new phases by ion implantation at high temperature in single crystals. High temperature stable contacts to SiC and GaN are prepared. Reaction products after annealing will be identified and new, non-reactive, epitaxial, single crystalline layers will be formed as contacts.
Lateral growth of GaN is studied and new methods are developed in order to decrease the dislocation density.
Nitride layers (AlN, AlInN) are prepared by magnetron sputtering. [162, 48]

New Nanocomposite-based Wear-resistant and Self-Lubricating PVD-coatings for Future Application in Tools and Components, EU-FP6 NANOCOMP EC-GRD2-2000-30299

P. B. Barna, D. Biro (Petru Mior University, Sapientia University, Tg-Mures, Romania), A. Kovács, F. Misjak, G. Radnóczi, M. Stüber, (Forschungszentrum Karlsruhe, Institute of Materials Research, Germany), T. Szüts (research fellow), B. Veisz

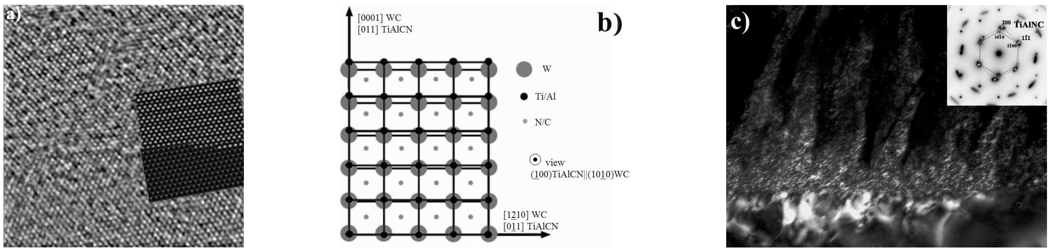


Fig. 1. FFT filtered HRTEM image (a) with simulated image of the transition between W-C substrate and TiAlNC film; b) the atomic view of the interface from the direction of the normal of the interface; c) DF image of the substrate-film system taken by (1-11)TiAlCn and (1-100)W-C reflections

The structure evolution of carbon doped TiAlN and Al films has been investigated by analytical and high resolution transmission electron microscopy. In case of TiAlN films correlation has been identified between the carbon concentration, structure and mechanical properties (hardness, wear, friction) of the coatings. The incorporation and distribution of carbon as well as the structure and morphology of the grains are changing with the carbon concentration. Carbon inclusions could be identified by HRTEM analysis at higher (> 9 at%) carbon concentrations. The epitaxial growth of the TiAlN(C) film and the epitaxial relationship between the TiAlN(C) and the WC(Co) crystals of the substrate (Fig. 1) have been determined. In case of carbon doped Al films deposited at room temperature a layered structure formed [14]. The structure is composed of sequentially grown Al/Al_4C_3 nanocomposite and metallic Al layers. The causes of this layered structure growth can be the intensive mutual segregation of both the excess Al and C species, each with long range diffusion and a strong decrease in the sticking probability of C on the pure Al crystal surface.

Nanocomposites for Piston/Liner Systems (EU-FP6 NMP3-CT-2003-505622)

B. Pécz, L. Tóth, É. Hegedűs, I. Kovács

Selflubricating Metal and Ceramic Matrix NanoComposites are materials consisting of a self lubricating matrix with dispersed metal or hartstoff nanoparticles. For Piston/Liner systems these particles may be a refractory metal like tungsten and chromium or a carbide or nitride of these metals, etc. The solid lubricant would be graphite, molybdenum disulfide, h-BN, etc. In this project two solutions are considered: Combining in a sputter deposition process selection of an appropriate metallurgy with the use of extremely short intense heat spikes to promote the appropriate segregation. In a combined arc+ sputter process, we will use the strong particle emission from a graphite source. It has been shown - at least for metals - that the particle size can be tailored by the choice of appropriate magnetic steering and filtering. MFA is responsible for the materials characterisation of the new coating layers. Mainly transmission electron microscopy is applied, but also X-ray analysis is used. The task requires an intensive application of high resolution microscopy.

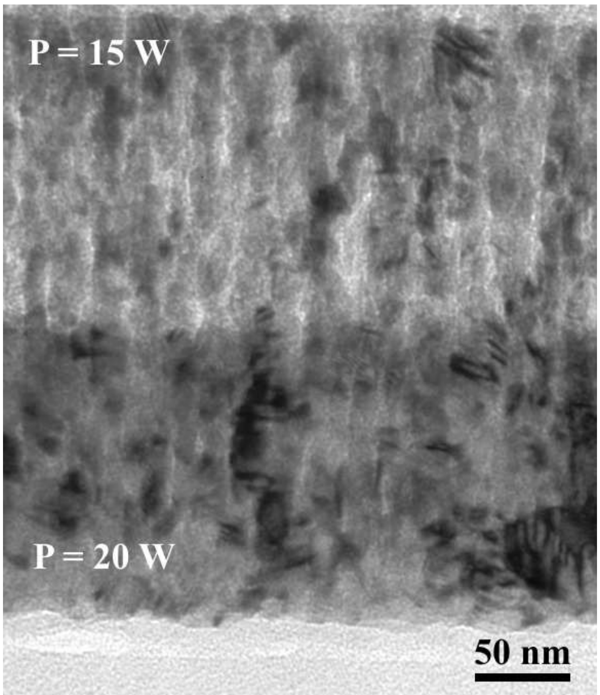
New Fullerene-like Materials (FULLMAT) EU5, HPRN-CT-2002-00209 (2002-2006)

G. Radnóczi, G. Sáfrán, Z. Czigány, Mrs. O. Geszti, G. Kovács, K. Sedlácková (PhD student), R. Grasin (grad. Student)

C(Ni) nanocomposite thin films were deposited by dc magnetron sputtering at temperatures between 20 and 800˚C. The films deposited below 400˚C show a columnar structure of hexagonal Ni_3C type crystalline grains separated by an amorphous carbon or graphite-like carbon (GLC) matrix. Above 400˚C the structure is consisting of globular, fcc Ni grains of size between 50 and 100 nm separated by GLC and fullerene-like carbon phase.

The phase of the Ni crystallites can be inferred from the magneto-resistivity measurements: Ni in the hcp Ni_3C type structure gives zero magnetoresistivity, and fcc Ni in the nanocomposite shows a small anisotropic magnetoresistance (AMR) effect (0.1%).

Correlation was found between the structure and electro- and magneto-transport properties of C(Ni) nanocomposites. Samples (T_S = 20 and 400˚C) exhibit tunnelling effect and



Cross-sectional TEM micrograph of C(Ni) nanocomposite thin film prepared at 200˚C showing a columnar character of crystalline grains. The composition of the lower (20W of Ni source) corresponds to 30 at% Ni, the upper layer (15W) to 20 at% Ni.

can be considered as insulator-metal nanocomposite with a 2-D network of insulating disordered carbon tunnel junctions connecting metallic Ni_3C type crystalline grains. The high temperature samples show metallic conductivity [84, 128, 129, 159].

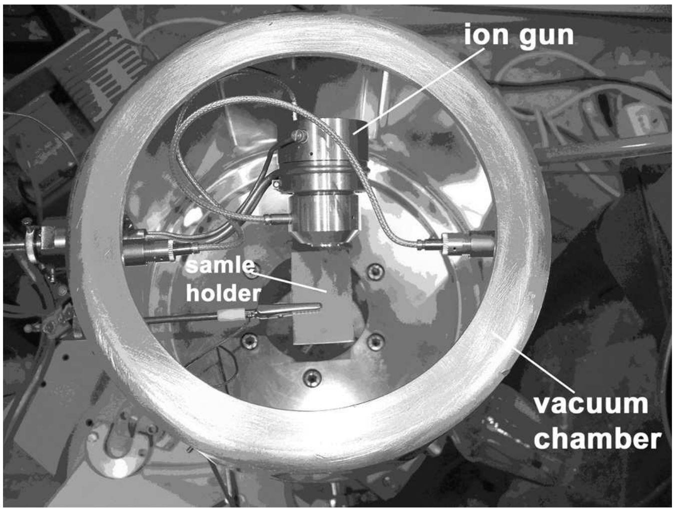
Construction of an ion gun for high sputtering speed (NKFP3/0064 -11)

J. Gyulai, M. Menyhárd, A. Barna

Within the framework of the project was constructed:

- a new high energy (20keV) focused gas ion gun
- two high voltage power supply (20/13,6 kV / 5mA)
- a new vacuum chamber (2x20kV + 4x 500V electrical feed throughs + sample manipulator).

The measured sputtering speed of the gun was 20 μm/min. for copper in the focus (ϕ 10-15 μm) of the ion beam.
The figure shows the ion gun in the vacuum chamber



Nanostructural study of perpendicular magnetic recording media (Consignment Agreement for Research)

Mrs. O. Geszti, Z. Czigány, B. Veisz, K. Barna, G. J. Kovács, A. Jakab, G. Radnóczi, P. Barna, K. Ouchi, N. Honda, J. Ariake (Institute of Advanced Technology – AIT, Akita, Japan), T. Asahi, T. Osaka, J. Kawai (Waseda University, Tokyo, Japan)

Perpendicular magnetic recording is the technology of the near future providing ~Tbit/in^2 recording densities. The recording media are composed of thin layers with nanostructures. Our interest was to study the formation mechanisms of thin nanostructures and their correlations to the magnetic properties.
Pd/Si dual thin film was developed for a seedlayer of Co/Pd multilayer in double-layered perpendicular magnetic recording media. The Pd/Si seedlayer sputter-deposited under Ar sputtering gas containing N_2 and post-annealed at 400°C reduced the intergranular exchange coupling of the Co/Pd multilayered film, resulting in a decrease in both the slope parameter defined as $4\Pi(dM/dH)_{H=Hc}$ and the magnetic cluster size. The Pd/Si dual seedlayer was effective to reduce the medium noise and to improve the signal-to-noise ratio of the Co/Pd recording media on a CoZrNb soft magnetic underlayer. The TEM investigation revealed that additive N_2 gas effectively decreased the grain size of Pd in the seedlayer. Post-annealing of the seedlayer promoted the diffusion of Si into the Pd upper-seedlayer. The Pd/Si seedlayer prepared with both processes exhibited a granular structure of fine Pd-rich crystals surrounded by Si-rich amorphous regions, and the seedlayer, which provided nucleation sites for the growth of well-separated Co/Pd multilayered grains. This structure is promising to be suitable for high density perpendicular magnetic recording. [11]

Thin Film Nanostructures Laboratory (G. Pető)

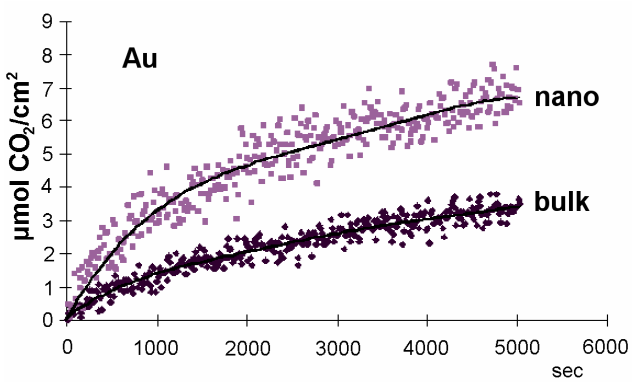
Formation, properties and interactions of low dimension (0D, 2D) silicon metal systems. (OTKA Grant, No. T 030427)

G. Pető, A. Karacs, C. S. Daróczi, G. Molnár

Gold nanoparticles on SiO_2/Si(100) were created by Ar^+ ion implantation of a bulk like Au/SiO_2/Si(100) thin film of 10 nm thickness. During the size reduction the Au 5d valence band redistributed given by photoemission spectra reduction in contrast to narrowing of these states given by previous papers. This is a first experimental evidence for the correlation between size and electron structure for Au nanoparticles.

The size reduction is, therefore, revealed in the activity enhancement of Au nanoparticles in the CO oxidation that can be unambiguously attributed to the changes in the valence band density of states of gold nanoparticles [50].

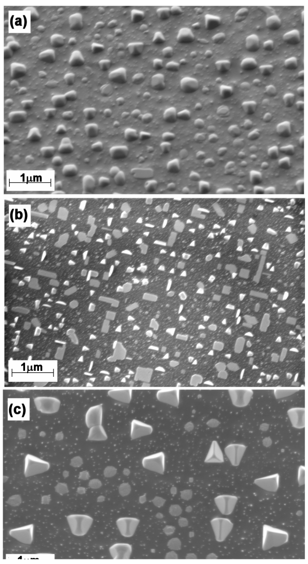
FeO_x deposition on the Au nanoparticles/SiO_2/Si(100) also produces a four times increase in catalytic activity in the CO oxidation showing the importance of the formation of the Au/FeO_x interface.



Catalytic activity of Au nanoparticles in comparison to bulk gold

Deformation induced assembly in heteroepitaxial thin films. (OTKA Grant, No. T 030419)

G. Molnár



SEM images of Fe silicide islands prepared by RDE and further 10 min heat treatment of samples (a) 5 nm Fe and 500ºC,

(b) 5 nm Fe and 600ºC,

(c) 10 nm Fe evaporation and 800ºC annealing

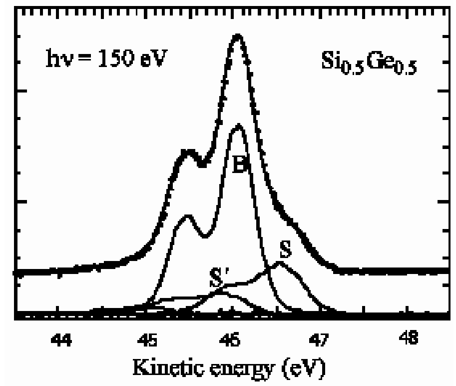
Iron-silicides were grown on Si by reactive deposition epitaxy (RDE) method and by conventional solid phase reaction on Si(001). Silicides were investigated by electron microscopy, atomic force microscopy, x-ray diffraction and by infrared reflectance measurement. Self-assembled, island like, oriented β-$FeSi_2$ and α-$FeSi_2$ were found to grow on Si(100) substrates under 15 nm initial Fe thickness. Generally two phases occurred together on samples, and their appearance depended on the evaporated Fe thickness, on the temperature and duration of the annealing. The size of the islands was between 20 and 500 nm, and three main shapes of aggregates appeared: circular, triangular and quadratic [97].

Investigation of the surface structure of $Si_{0.5}Ge_{0.5}$ (MaxLab Lund, Sweden: Synchrotron Facility "Transnational Access Activity" program 2004)

G. Pető, C. S. Daróczi

The purpose of the present study was to investigate the segregation effects in bulk relaxed $Si_{0.5}Ge_{0.5}$(100) alloy having 2x1 reconstructed surface.

Relaxed $Si_{0.5}Ge_{0.5}$(100) alloy layer having 2x1 reconstructed surface was grown by MBE with compositional grading technique at 800ºC onto Si(100) substrate. The surface composition was measured by photoemission experiments using synchrotron radiation at MAX I to investigate the strong oscillatory variations of Si and Ge with the depth, which were found theoretically in the equilibrium composition profile near the surface. Our experimental data are against the theoretical model of oscillatory segregation given earlier.

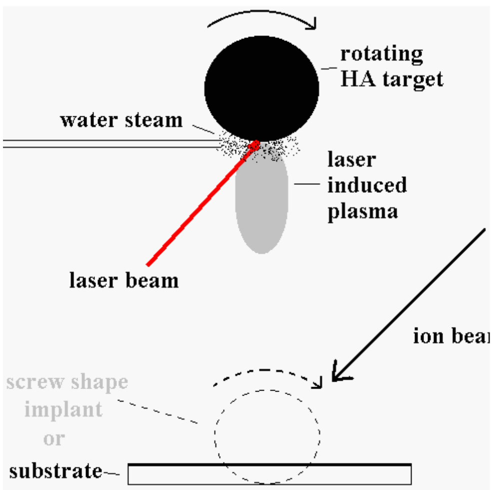


Si 2p spectra in normal emission, where B indicates the bulk states and S, S' the surface states

Surface improvement of metal implants: New preparation methods and new materials (EU FP5 project, NAS-SIMI, G5RD-CT-2000-00423)

G. Pető, A. Karacs, G. Molnár

Our work in the SIMI WP-2 project based on the use of advanced semiconductor technology methods during production of bioactive layers. The combination of pulsed laser deposition with ion bombardment and ion implantation processes gives a further extension of the preparation possibilities. These are: the improved adhesion, specially synthesized bioactive overlayer including metal components, special layer morphology in nanoscale range.



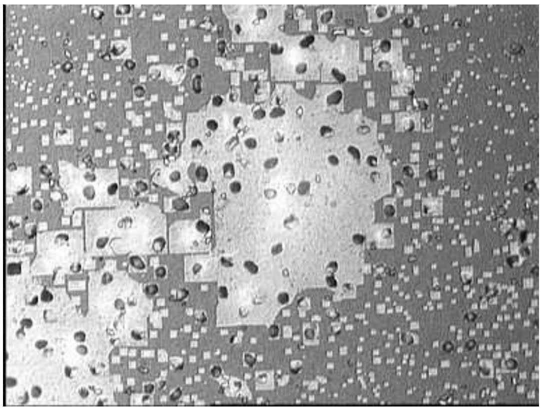
The principal arrangement of the ion beam assisted PLD process

The preparation process for Mn-HA (Manganese doped Hydroxyapatite) films we elaborated, involved the possibility to prepare layers in water steam atmosphere by pulsed laser deposition (PLD), whilst the surface temperature of the Ti substrate is kept under 300ºC, e.g. in order to avoid the intensive oxidation of the Ti surface and the consequent weakening of the layer adhesion. For the implementation of the project, new experimental devices were built. The samples prepared were analysed and evaluated by x-ray diffraction (XRD), x-ray photoelectron spectroscopy (XPS), Fourier transform infrared (FTIR) spectroscopy, microscopy methods and by direct pull adhesion measurements.

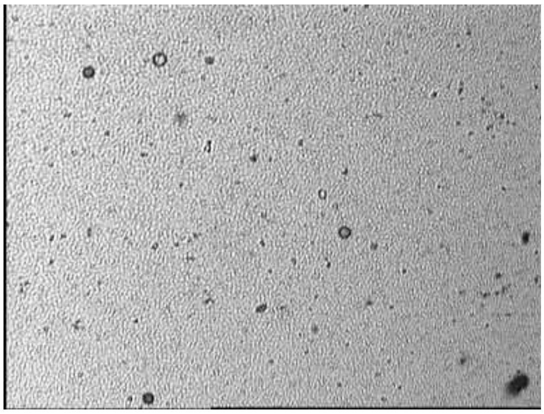
Nanostructured coatings developed by surface modification techniques (NKFP OM 00287/2002)

G. Pető, A. Karacs, G. Kovách

The protection of the sensors used in measuring tools can be done by applying a corrosion protective layer on top. CVD diamond is often used as protective layer but pinholes are present even in very good quality films. Applications require pinhole-free layers against chemically aggressive environment. We combined the Pulsed Laser Deposition (PLD) technique with MicroWave assisted Chemical Vapour Deposition (MW-CVD). CVD diamond films were prepared in different conditions and layer thickness. Then, these films were covered by PLD diamond like carbon (DLC) film to reduce the number of pinholes. We used special chemical etching to detect the remaining pinholes. As a result, we obtained a practically pinhole-free bilayer sample with 200 nm total thickness. In comparison, 2.5 μm thick CVD diamond layer have similar pinhole-free properties.



SEM image taken after chemical etching, for pinhole detection, of a polycrystalline CVD diamond film



SEM image taken after chemical etching, for pinhole detection, of a bilayer, consisting of a polycrystalline CVD diamond film and PLD-DLC film

Microtechnology Department

Head: C. Dücső

Research and development of physical, chemical/biochemical sensors and integrated systems:

- MEMS and MEMS related technology, with special emphasis on development of Si MOS embedding circuits.
- Development and applications of near IR light emitting diodes and detectors.
- Solar cells and their competitive technology.
- Acoustic wave devices and their application.

Fundamental research on:

- sensing principles
- novel materials and nanostructures
- novel 3D fabrication techniques
- ion-solid interaction for supporting MEMS development.

Device and material characterisation

MEMS

Head:
Dr. C. Dücső, Ph.D.

Staff:
György Altmann, technician
Mária Ádám, M.Sc., res. fellow
Prof. Dr. István Bársony, D.Sc.
Dr. Ferenc Beleznay, D.Sc.
Ábel Debreczeny, B.Sc.
Magdolna Erős, technician
Csilla Faragó, technician
János Ferencz, M.Sc., engineer
Dr. Péter Fürjes, Ph.D.
Alajos Gondos, technician
†Dr. Béla Keszei, dr. univ., res. fellow
Ákos Majoros, M.Sc., engineer
Attila Nagy, technician
Margit Pajer, technician
Dr. Imre Szabó, dr. univ., engineer
Éva Vázsonyi, M.Sc., res. fellow
János Volk Ph.D. applicant, res. Fellow

Visiting Research Scientist:
L. Fedák (University of Uzhgorod, Guest of the House of Professors and MFA)

Optoelectronic Devices

Head:
Dr. B. Szentpáli, Ph.D.

Staff:
Dr. Olga Krafcsik Homokiné Ph.D. mothercraft
Dr. Zoltán Lábadi, Ph.D.
Dr. Ákos Nemcsics Ph.D. habil. part time 30%
Dr. István Pintér Ph.D.
Dr. Bálint Pődör Ph.D.., part time 30%
Dr. Sándor Püspöki engineer, dr. univ.
Dr. Vilmos Rakovics Ph.D.
István Réti engineer
Varga Ferencné technician
Ms. Katalin Vörös Veresné engineer

PhD Students (Advisor):
Edvárd Bálint Kuthi (István Pintér)
Ágoston NémethH (Zoltán Lábadi)

Engineering trainee:
László Klagyivik

Semiconductor Characterisation

Head:
Dr. G. Battistig, Ph.D.

Staff:
Edvard Badaljan
Dr. László Dózsa Ph.D.
Dr. Zoltán Hajnal Ph.D.
Dr. Zsolt J. Horváth Ph.D.
Tibor Mohácsy
Dr. Nguyen Q. Khánh Ph.D.
Zsuzsa Püspöki
András Ster
József Waizinger

Visiting Research Scientist:
Yolanda Morilla,
(Centro Nacional de Aceleradores, Sevilla, Spain. TéT Spanish-Hungarian bilateral cooperation)

Ph.D. Students (Advisor):
Péter Basa (Dr. Zsolt J. Horváth)
Anita Pongrácz (Dr. Gábor Battistig)

MEMS Laboratory (C. Dücső)

Sensor Array for Fast Explosion-Proof Gas Monitoring "SAFEGAS" (EU-FP5 2000-2003, accepted in 2004)

M. Ádám, I. Bársony, C. Dücső, P. Fürjes, É. Vázsonyi

A Si based four element integrated calorimetric sensor was developed and constructed for olfactory detection of hydrocarbon mixtures up to their Lower Explosion Limit (LEL) concentration. The integrated sensor array chip consists of three pellistors and one heat conductivity sensor. In order to construct a four-wire, inherently explosion-proof transmitter, the power consumption of each sensor was reduced below 50mW and a sequential read-out scheme was adopted.

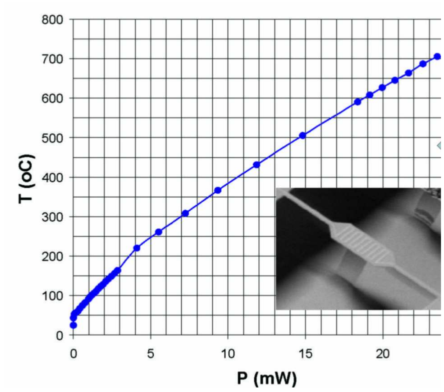


Fig.1: Power dissipation of the $100x100\mu m^2$ microhotplate developed at MFA

The role of MFA was the development of the sensor array chip. We have elaborated a novel technology based on porous Si micromachining for the formation of low power consumption microhotplates (Fig.1), which are the basic elements in both sensors. We applied dip & drop technique was for coating the hotplate's surface with Pt-catalysts and reference materials in the pellistors (Fig.2). The reference heater of the heat conductivity sensor was encapsulated by Si cap (Fig.3). Due to the reduced power dissipation of the sensor elements the driver and read-out electronics of the transmitter became inherently explosion-proof. Consequently, only the sensor chip must be explosion protected because of the high surface temperature of the calorimetric sensors.

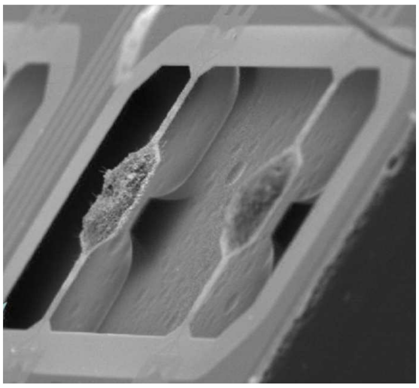


Fig.2: SEM view of a pellistor. Catalyst coated hotplate (left), the passive reference pair coated by pure Al_2O_3 (right)

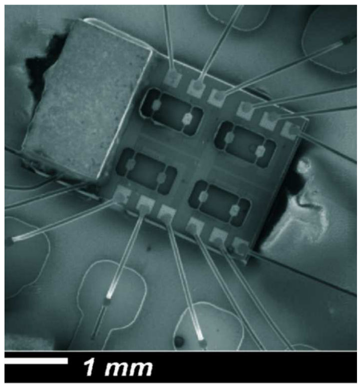


Fig.3: The sensor array chip consists of 3 pellistors and one heat conductivity sensor. Its reference element is encapsulated by a Si cap (left)

Olfactory detection is based on the method proposed by ALPHAMOS Co., France uses principal component analysis (PCA) and partial least square (PLS) fitting. The system developed by WESZTA-T Ltd., Hungary is capable to distinguish and measure methane, propane, butane and hexane mixtures.

Sensing Computers and Telepresence "TeleSense" (NKFP 032/2001)

M. Ádám, I. Bársony, C. Dücső, P. Fürjes, É. Vázsonyi

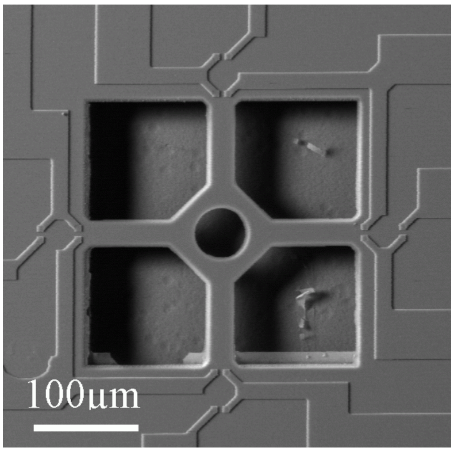


Fig.1: Scanning electron micrograph of the sensor structure. Characteristic dimensions: bridge 80x32x10 µm^3, plate 100x100x10 µm^3, hole 50 µm diameter, cavity depth cc. 35 µm.

One of the major goals of this project was the development of an integrable micro-force sensor capable of resolving the three vector components of the loading force. An array of this element will be used for tactile sensing.

We have successfully adopted the porous Si micromachining technique for the fabrication of single crystalline force sensor elements. Four piezoresistors were formed in an n-type perforated membrane, having their reference pairs on the substrate in order to detect the mechanical stress by four half-bridges. We successfully combined the HF based porous Si process with conventional doping and Al metallisation, thereby offering the possibility of integration with read-out and amplifying electronics. The 300x300 µm^2 membrane (Fig.1) size allows the formation of large area arrays for tactile sensing using single crystalline deforming elements of superior mechanical properties.

Although the bare structure meets the requirements set for force detection (Fig.2), a protective, flexible coating on top is essential for any real application. Therefore, we have started systematic investigation of the effects of various coverages on sensitivity and lateral resolution.

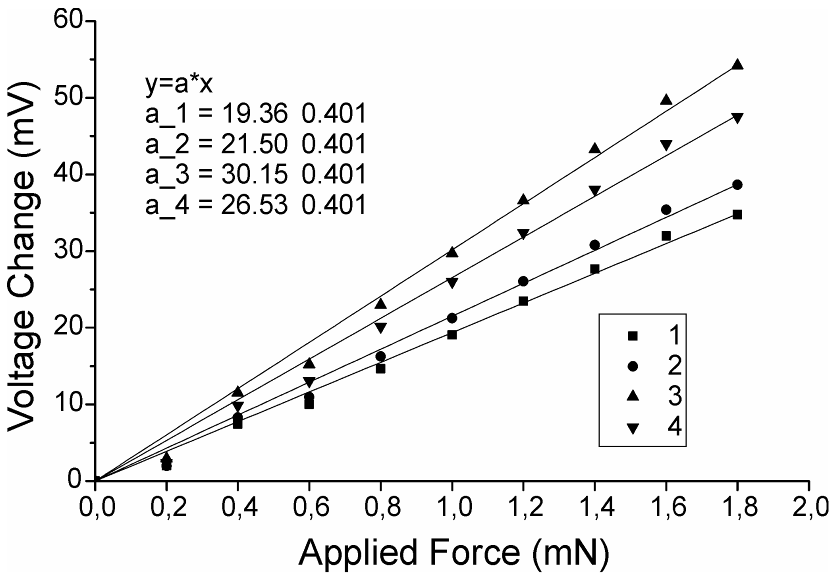


Fig.2: Linear responses of the four piezoresistive bridges of one sensing element for normal load. The difference in the slopes is the result of the non central positioning of the loading tip on the small area membrane. The sensitivity is 4-6 mV/mN/V

Ceramic Substrates for SAW Devices, "CERSAW" (NATO SfP)

F. Beleznay, J. Ferencz

The main objective of the project was to realise piezoceramic substrates as an alternative to single-crystals for SAW applications. The aim is to get cheaper, at-request and reliable substrates suitable for large-scale production.

Our task was to develop device technology and suitable filter structures to qualify piezoelectric substrates for SAW applications. We have adopted our SAW filters processing technology for the present material technology, developed at Köporc and TKI, Budapest, and made model filters on larger (40 mm diameter) wafers. Having fixed basic SAW parameters on these elements, we have designed special filter structures to separate and investigate degrading second order effects, such as diffraction, large dielectric permeability, spurious bulk waves, internal reflections between transducer and the electromagnetic leakage in the substrate. Since electromagnetic leakage dominating we have designed a "symmetric double-output" filter structure, where the outputs are shifted by half wavelength from each other, and in this way difference of the two output signals sums up the acoustic signals but subtracts the electromagnetic ones. Figures 1.a-c show characteristics of these filters made on standard $LiNbO_3$ substrates and on the investigated ceramic substrates, respectively.

a) *b)* *c)*

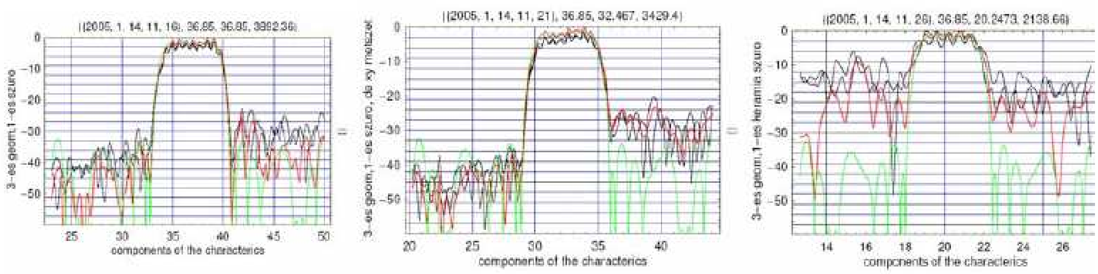


Fig.1a-c: Transfer characteristics of an "apodized symmetric double-output" filter on 128° cut $LiNbO_3$, XY cut $LiNbO_3$, and a ceramic filter. Two traditional outputs (black), the measured analog difference of these outputs (red) and the theoretical (green) characteristics are shown.

Each of the characteristics shows diffraction effects, which are due to the finite length of the individual electrode pairs, and are partly suppressed on the anisotropic crystalline $LiNbO_3$ surfaces. In isotropic ceramic materials diffraction can not be suppressed, hence characteristics are much less structured; this is seen in the band stop region next to the band pass one. Another characteristic is the spurious bulk wave. In general, bulk wave is also generated and detected by the interdigital transducers; this generation in crystalline material depends on the orientation of the surface and on the propagation direction. The 128° cut $LiNbO_3$ is best known where bulk wave gene-ration is minimal (a), on the other hand XY cut $LiNbO_3$ has spurious bulk wave, velocity of this is about 15% faster than the surface wave, as is seen on the higher frequency side of the pass-band. Ceramic filter has a much higher spurious at the high energy side.

Ceramic materials have inherent drawbacks such as **unavoidable diffraction, bulk waves generation and significant dielectric constant**. These all together makes most probable that they may have applications only in new fields, such as resonator structures, and/or composite layered structures. Application of **thin layers and confined (waveguide mode) surface wave may solve most of the problems** we have detected.

Porous Si Multilayers for Optical Devices

I. Bársony, J. Volk

Controlled formation of porous Si multilayers was elaborated in order to form optical elements, e.g. Bragg-reflectors, Fabry-Perot filters (Fig.1). The refractive index of the porous Si layer can be tuned by the porosity (the volume ratio of void and Si in the layer) i.e. by varying current density during the electrochemical etching process. The main advantage of the high/low optical density multilayered structure lies in its transferability for liquids and gases, therefore their application for sensing chemical or biochemical materials is feasible.

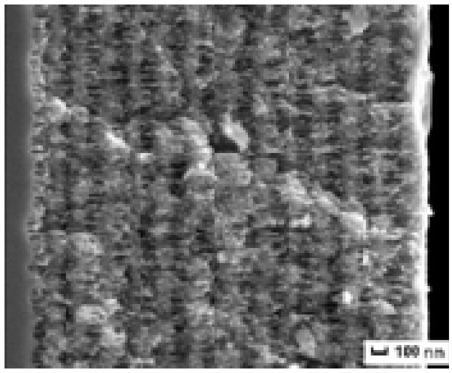


Fig.1: Fabry-Perot filter by 27 a element porous Si multilayer

Ellipsometric and reflectometric investigations of the multilayer structures show, that simple periodic variation of current density doesn't result in reproducible porosity in the corresponding layers. In order to investigate this effect we have constructed a dedicated system for measuring the reflectance spectra (λ=400-1100nm) of the multilayer during the formation process. The 1s sampling rate enables us to monitor the dynamic change of the optical properties in the forming multilayers. In a detailed analysis and comparison with optical model calculations we concluded that parallel with the electrochemical process at the porous-Si/Si front a continuous photochemical dissolution of the previously formed porous Si layers results in their lower optical density. This phenomenon effects on the optical parameters of the structure, e.g. results in a blue-shift of the resonant peak in a Fabry-Perot filter (Fig.2). The in-situ reflectance spectrum analysis may provide appropriate data for on-line controlling of porous Si multilayer formation.

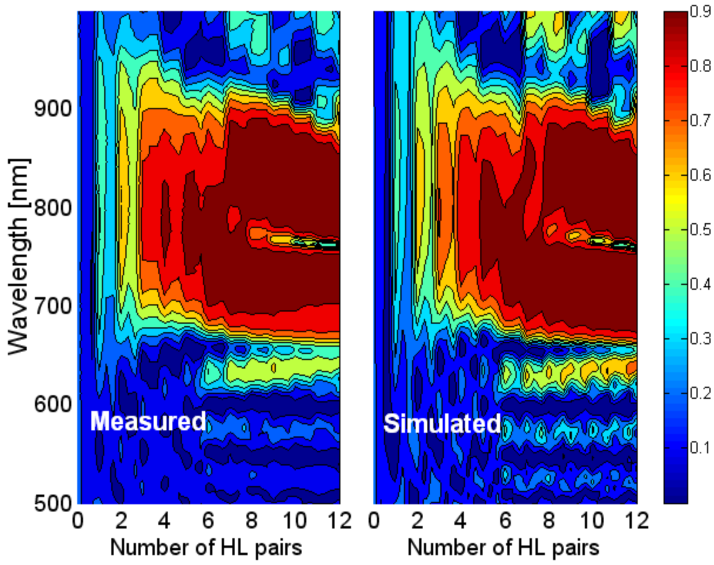


Fig.2: Blue-shift of the resonant peak in a Fabry-Perot filter by increasing the number of the high/low optical density pairs (denoted by H and L), i.e. the etching time. The resonant peak is present after the formation of the LL resonator (8^{th} HL pairs).

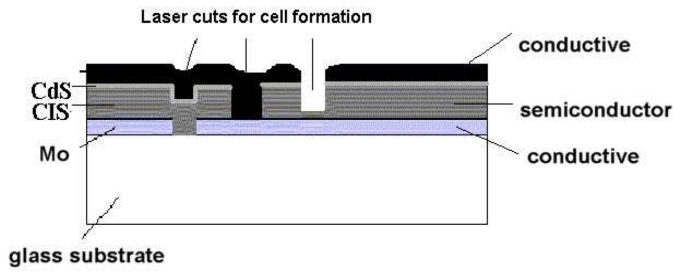
Laboratory of Optoelectronic Devices (B. Szentpáli)

Solar Cell Innovation Centre (NKFP 3/025/2001)

Z. Lábadi, Á. Németh, S. Püspöki; V. Rakovics, I. Réti, A. Tóth, Ms. Varga Ferencné, Ms. K. Vörös Veresné

Aim and achievements:
The overall aim of the project is to develop a thin film preparation system for R&D on solar cells with CuInGaSe active layer. MTA MFA conducts applied research in this project as a participant in a consortium.
In the frame of this overall scheme a magnetron sputtering module was installed by the KRAFT Rt and tested by the researchers of the institute.
The main technical features of the equipment include 30x30cm substrate size, DC and pulse mode electric supply, three target places for rectangular shaped targets and a software control facility.

<u>Deposition of contact layers for CIGS solar cells</u>
The purpose of this work is to develop an optimal technology for the deposition of transparent front contact layer for a CIGS solar cell. The structure consists of an undoped ZnO buffer layer and an Al doped conductive ZnO (ZAO) layer. The magnetron sputtering of the ZAO layer takes place from a Zn:Al (2%m/m) metallic target in $Ar:O_2$ atmosphere. Mechanical movement, gas pressure and composition, DC electric supply and additional pulse parameters are fully computer controlled.
The figure shows the construction of the solar cell.
Use of ceramic ZnO targets determines the parameters of the deposited film leaving little room for parameter optimalisation. Furthermore these targets are relatively expensive and the deposition rate is largely limited by the allowed thermal dissipation of the target. Our reactive sputtering method offers an alternative against deposition from ceramic targets and a possibility of scale-up the technology. A further advantage is that the transparency and conductivity of the layer can be controlled in wide range of parameters by technological means.



Construction scheme of a CIGS solar cell

The layers are qualified by spectral transparency, sheet resistance, SEM microscopy and XPS spectroscopy. Our experiments show that the pulse parameters, sputter power density and the gas composition are the critical parameters for finding the optimum between conductivity and transparency.
ZnO depositions for possible sensor applicationsIt was also shown that by appropriate setting of the sputtering parameters a non-stochiometric porous ZnO layer can be deposited (referred as por-ZnO below).
Layers were deposited in the 2-20 micron thickness range. All of those layers were non-transparent by visual inspection. They were subsequently characterised by SEM microscopy, Electron Dispersive Spectrum (EDS), ellipsometry, and four point probe sheet resitance.

SEM morphology of a typical por-ZnO layer exhibits 50 nm average crystallite size with uniform porosity. Semi-quantitative EDS examination shows substantial lack of oxygen compared to the stoichiometric material. Specific resistance of the material is in the 1E-2 Ohmcm range.
Due to the non-stoichiometric composition, nanoscale crystallite size and porous character of the layer this material seems to be a promising candidate for gas sensor applications.

CdS/InP model system for understanding CdS/CIGS interface
In thin film polycrystalline Cu(In,Ga)Se2/CdS/ZnO solar cells, the active CIGS/CdS interface plays a main role to further improvements of their performance. This interface is complex and its formation is under active investigation. We have undertaken a specific study of the interface indium chemical modifications during CdS growth using single crystalline InP wafers and CdS obtained by chemical bath deposition (CBD), as a reference system for the case of the CIGS/CdS interface. We have investigated the behaviour of the thin layer formed on the InP surface during the first minutes of the growth of the CdS layer on (100) oriented p-InP wafer. The composition of the interface is analyzed before by means of XRD. XRD rocking curve contains strong sharp peaks of β-In_2S_3. CdS/InP interface also contains small amount of Cd(OH)2 or CdSO3. These results are relevant to several aspects of to the CIGS/CdS interfaces as shown by parallel experiments.
β-In_2S_3 can replace CdS buffer layer, improving the environmental safety of the CIGS solar cell technology. We could prepare high quality β-In_2S_3 layers by successive evaporation of the elements.

ADVOKATE – Advanced Dry Process for Low Cost Thin Multicrystalline Silicon Solar Cell Technology (EU-FP6: ENK6-CT-2001-00562, 2001-2004)

I. Pintér, J. Ferencz, B. Forgács, G. Dóra, Á. Majoros, É. Vázsonyi, E. Kuthi, Ms. Payer Károlyné, A. Gondos, C. Faragó

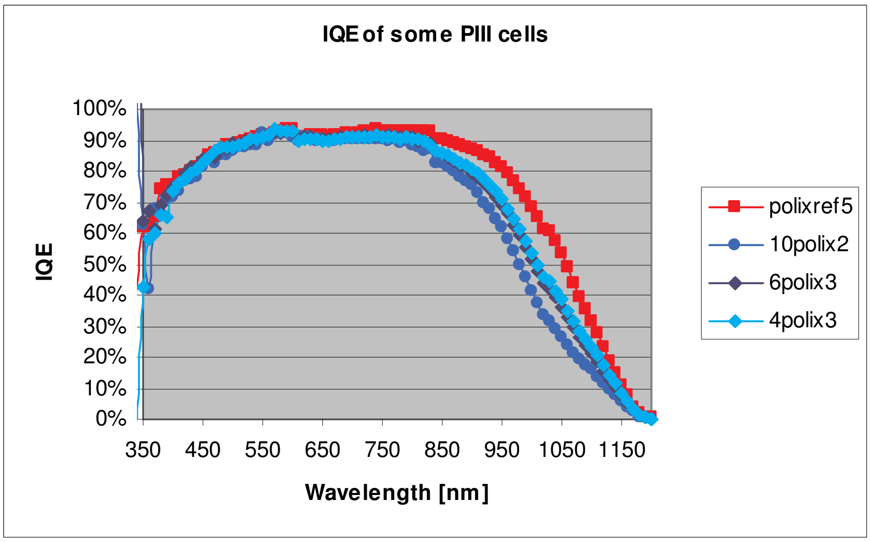
Aim and achievements:
Within the project our task was the R&D of Plasma Immersion Ion Implantation (PIII) technology.
The PIII technique is a very low energy (100-1000eV) implantation.
At MFA the PIII technique have been used for Phosphorous doping of the emitter of Silicon solar cells.
The advantage of the PIII are:

- very fast process (5-60s)
- good reproducibility and homogeneity of the dose
- can be integrated into dry solar cell processing technology

A vacuum chamber was constructed in which 4 pieces 10x10 cm^2 multicrystalline silicon wafers can be processed together. The system is also capable PIII processing of two 12.5x12.5cm^2 wafers or a single 15x15cm^2 wafer. The sheet resistance of the emitters can be adjusted in 25-300 Ohm/sq range, so it can be applied for either selective or homogeneous emitter cells.

Metallisation of solar cells are performed by two basic technologies:
a/ Lift-off technique of evaporated Ti/Pd/Ag layers
b/ screen printing of silver and Aluminium pastes (under development)

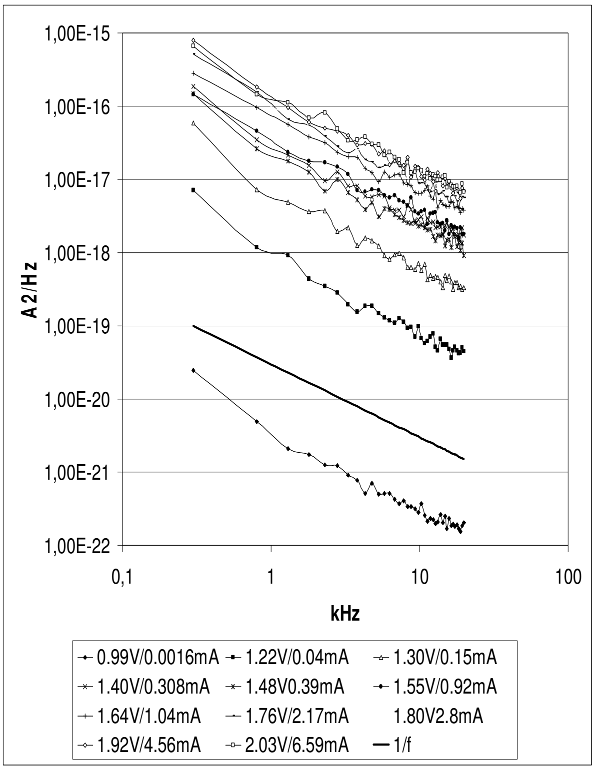
Results:
First not optimised selective emitters prepared by PIII resulted in **12.2-13.55%** cell's efficiencies on multicrystalline silicon.
Internal quantum efficiencies of the PIII cells prepared from Polix mc-Si from different batches showed similar and very good blue sensitivity.

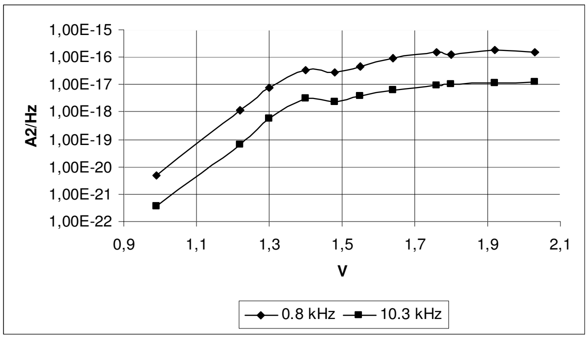


The origin of electronic noise in semiconductor sensors (OTKA T 037706)

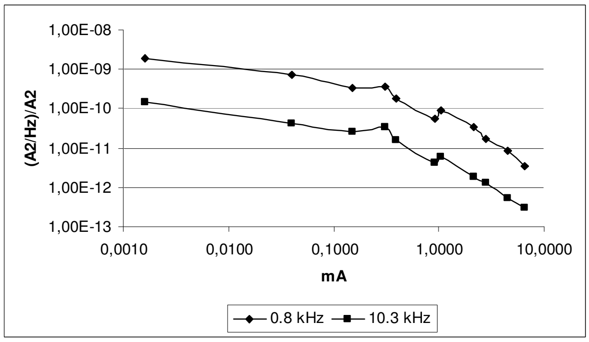
B. Szentpáli, V. Rakovics, T. Mohácsy, I. Bársony, I. Réti, Ms. M. Ádám Antalné, L. Klavigyik

Aim and achievements:
The lower limit of the sensitivity of any sensor is limited by the noise, fluctuation generated in them. The magnitude of this noise determines the dynamic range of the sensor too. Namely the maximum of the perceptible signal, which results in a proportional output signal, is also limited. This limitation follows from the working principle of the sensor [154]. The pressure-, temperature-, gas-sensors work in low frequency range from a few hundred Hz down to mHz. The output of sensors of high frequency signals (microwave, optical) is usually a filtered, averaged resulting in a slowly varying voltage. Therefore the noise of sensors in the low frequency range - from a few Hz to 100 kHz - has a great importance.
In 2004 two investigations were performed:
1. The noise in porous Si structures. As it is well known originally the porous Si was intend to apply for light emitting diode. These efforts have had no real success. Nowadays the porous Si is applied in micromachining technique for fabricating different sensors. In this respect the electric conduction mechanisms and the fluctuations in this material have importance. The current-voltage characteristics and the low-frequency noise spectra of p-type Si - Porous Si - Al diode like structures were investigated [151]. Over 1 V forward biases a reasonable fit was obtained in the Fowler-Nordheim plot. Any attempts of accurately fitting the I-V characteristic by other known transport mechanisms failed. At lower biases, however, an additional current-component appears which shows a saturating character. This current component is ascribed to trap-assisted tunnelling. The measured noise spectra show 1/f character; however the magnitude of the noise shows saturation with increasing biases instead of the usual case, where the noise power scales with I^2, or V^2. This finding is interpreted by a model of two parallel current paths. The noise arising from the smaller and saturating current determines the noise performance of the whole device.





b.



a. *c.*

a.: The measured noise spectra at different biases; b.: the current noise in the function of bias voltage at two frequencies; c.: the normalised current noise in the function of the mean current.

2. The **lead sulphide** has been used for a long time as infrared detector. Its spectral response extends to about 2.5 μm at room temperature. It exhibit excellent performance already at room temperature, and of course even better when cooled down. The main handicap of this material is its sensitivity to blue/ultraviolet light. Such exposures result in degradation: the dark conductivity will increase and subsequently the light/dark conductivity ratio decrease. We have followed the degradation process by the measurement of the low-frequency noise.

The PbS layers have been fabricated by the chemical deposition method onto glass substrates. The carefully cleaned glass was placed vertically in the aqueous solution at room temperature, for 10…25 minutes. The ohmic contacts were made by evaporation of Cr-Au contacts. The samples were mounted onto TO 5 transistor cases, the contact pads were bonded by thermocompressed gold wires. The sheet resistances of the layers were about 0.5…1 MΩsquare. The low-frequency (10Hz…20 kHz) noise characteristics were measured at different biases [152]. The forced degradation was produced by exposing the device to ultraviolet light. The noise spectra show 1/f type frequency decay. After the UV illumination the resistance of the samples decreased, however the noise characteristics were relatively unchanged. This behaviour is interpreted by the assumption that the noise arises from surface effects, while the resistance depends on the bulk properties.

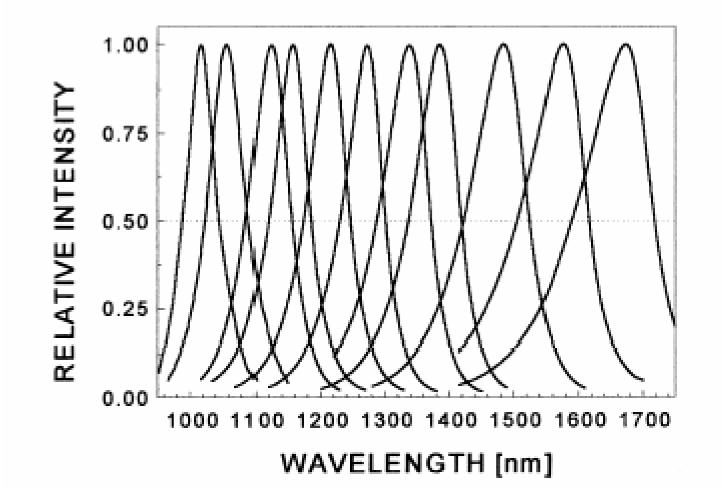
Research and development of custom wavelength IR sources and detectors

(in cooperation with the Ricola Ltd., Finland)

V. Rakovics, J. Balázs, S. Püspöki I. Réti, A. Tóth, Ms. Varga Ferencné, K. Vörös Veresné

Aim and achievements:

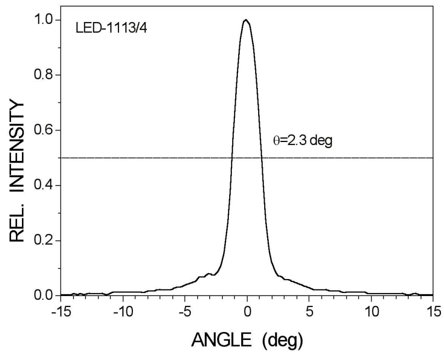
Portable IR spectrometers need efficient IR LEDs emitting in the 1000-1700 nm wavelength range.



Emission spectra of the 11 different type LEDs covering completely the 1000–1700 nm wavelength range

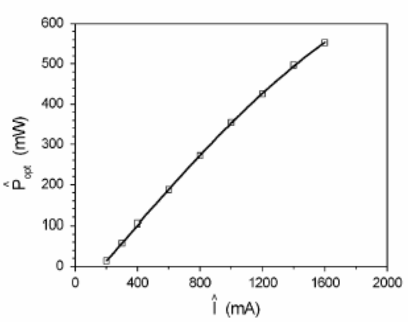
The peak wavelength InGaAsP/InP double heterostructure LEDs can be tuned by the composition of quaternary InGaAsP. The 1000-1700 wavelength range was completely covered by 11 IR LEDs developed in MFA. LPE technology was used, for the growth of the LEDs.

New surface emitting LED construction was developed for IR spectrometer used for alcohol measurements. These types of LEDs have narrow beam angle and very high brightness.



Intensity distribution of narrow angle InGaAsP/InP LEDs

Arrays of InGaAsP/InP single mode junction defined buried stripe heterostructure laser were grown on multi-channelled InP substrate by single-step liquid phase epitaxy [130]. The buried double heterostructure and the lateral current confining structure were formed in the same growth process. InGaAsP layer growth is dominated by the preferred orientation, with (1 0 0) growth favoured over other directions. As a result of low temperature single-step growth, the device yield is high. These laser arrays are characterised by output power close to 0.6W; high quantum efficiency, symmetrical far-field patterns and excellent linearity of the light–current curve. Stable single transverse mode operation obtained up to 600 mW emitted power.



Pulse light-current characteristics of the five element laser array.

Portable IR spectrometers contain a linear array of LEDs or detectors and a fixed monochromator. We developed a linear array of PbS photoconductors [152]. The detector array can be used up to 3000 nm and have 14 active elements. Such wide spectral sensitivity is important for food spectroscopy and for some important medical applications (noninvasive glucose and urea measurement).

Semiconductor Characterisation Laboratory (G. Battistig)

Thin film effects in semiconductor structures (OTKA T035272)

Z. J. Horváth; M. Ádám, L. Dobos, B. Pődör, V. Rakovics, I. Szabó

Al, Au, Al/Ti, and Au/Ti contacts were prepared on n-GaN and annealed up to 900 ºC. The structure and morphology were studied by cross-sectional transmission and scanning electron microscopy and the electrical behaviour by current-voltage measurements. It was obtained that annealing yielded interdiffusion, lateral diffusion along the surface, alloying and bowling up of the metal layers. The electrical characteristics indicated that the upper metal layer in the Al/Ti and Au/Ti contacts diffused in and/or through the Ti layer even during deposition. A Schottky barrier height of 1.07 eV was obtained for Au metallisation. This value is closed to the Schottky limit of 1.00 eV indicating a low interface state density in the studied Au/n-GaN contacts. The main characteristics of electrical behaviour are summarised in Table 1.

Table 1: The room temperature current-voltage behaviour and the estimated Schottky barrier height of Al/n-GaN contacts as a function of annealing temperature

Annealing temperature	Contact metal			
	Al	Al/Ti	Au	Au/Ti
As deposited	Rectifying, ϕ_b<0.23 eV	Rectifying, ϕ_b=0.38 eV	Rectifying, ϕ_b=1.07 eV	Rectifying, ϕ_b=0.49 eV
300 ºC	Linear*, ϕ_b<0.23 eV	Linear*, ϕ_b<0.35 eV	Rectifying, ϕ_b=0.93 eV	Rectifying, ϕ_b=0.50 eV
400 ºC	Linear*, ϕ_b<0.23 eV	Linear*, ϕ_b<0.35 eV	Rectifying, ϕ_b=0.66 eV	Rectifying, ϕ_b=0.44 eV
700 ºC	Rectifying, ϕ_b=0.27 eV	Linear*, ϕ_b<0.35 eV	Rectifying, ϕ_b=0.56 eV	Rectifying, ϕ_b=0.43 eV
900 ºC	No reliable measurement	No reliable measurement	No reliable measurement	Linear*, ϕ_b<0.36 eV

*Up to a current density level of 2 Amm^{-2}.

Studies of implantation and oxidation properties of SiC (OTKA T032029)

E. Szilágyi, G. Battistig, N. Q. Khánh, P. Petrik, Z. Zolnai

The oxidation kinetics of 4H SiC on both the carbon- and the silicon-terminated surfaces were determined. The oxidation behaviours were compared to that obtained on the implantation amorphised SiC surface. It was demonstrated that oxidation kinetics increases on the Si-terminated side but slows down on the C-terminated surface. The kinetics obtained on implantation amorphised SiC resembles very much to that on the non-polar (11-20) SiC surface [158].

The lattice damage created by implantation of Al ions into single crystalline 4H-SiC has been analyzed using a combination of Rutherford Backscattering Spectrometry combined with channelling (RBS+C), Spectroscopic Ellipsometry (SE) and high resolution Transmission Electron Microscopy (XTEM) in a co-operation with Centro Nacional de Aceleradores, Seville, Spain. [12, 98, 116] After medium dose Al implantation (150 keV, 2×10^{15} cm^{-2}) and high temperature annealing (1100 ºC, 1h, N_2) RBS+C showed, that highly damaged, amorphised layer remained at the surface. However SE demonstrated, that recrystallisation occurred, in the whole implanted region. Finally XTEM proved, that solid phase epitaxy takes place during the high temperature treatment. Recrystallisation starts from the bulk, non-damaged region as well as from the less damaged very surface region. However recrystallisation does not follow everywhere the original crystal structure, grains with different polytypes and slightly different orientations are formed. RBS+C senses the crystal structure under a rather large area, the diameter of the used beam-spot is in the range of 0.5 mm. SE investigates the material also on a macroscopic surface but it senses the average refractive index of the material, a physical parameter what depends highly on the structure of the matter. The results obtained help to understand the physical processes taking place during ion implantation and annealing processes.

Theoretical Investigation of Point Defects and the Elementary Steps of Oxidation at the SiC/SiO$_2$ Interface (DFG-MTA bilateral project No. 112)

Z. Hajnal, Á. Gali, P. Deák

Using a three-stage simulation framework – approximate DFTB for identification of possible defect configurations, DFT-LDA for precise formation energies, and hybrid DFT functionals with exact Hartree-Fock exchange for accurate defect levels – we study the (0001) interface of 4H-SiC and SiO_2. Our 2D slab model consists of a complete 4x4 layer of Si-terminated 4H-SiC with a double layer of SiO_4 tetrahedra on top. The upper and lower faces of the slab are saturated by H atoms. The structure has been constructed so, that it contains no dangling bonds, and no (or minimal) local stress. The energetics of various and Si-, O-, and C-defects as well as their complexes was determined using this 204 atom model, and supercells of bulk Si and SiO_2 (α-quartz). Assuming the oxidation of SiC proceeding in thermal equilibrium, the relative energies of reaction products can be used to draw possible reaction pathways of the system for O_2 addition and CO removal. Fig. 1. shows the resulting map with the energies of different resulting defect structures, and the final reaction equations of different paths.

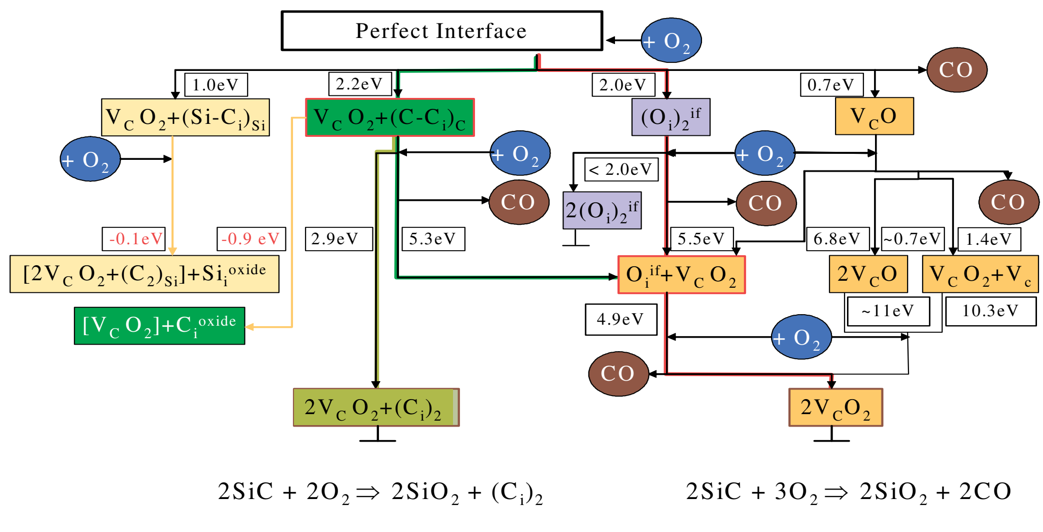


Fig. 1: Reaction pathways related to the oxidation of SiC at the SiC/SiO$_2$ interface.

Physics and Technology of Elemental, Alloy and Compound Semiconductor Nanocrystals - Materials and Devices, SEMINANO (EU FP6 No. 505285)

Z. J. Horváth, M. Ádám, J. Balázs, P. Basa, L. Dobos, L. Dózsa, T. Lohner, G. Molnár, P. Petrik, P. Szöllõsi

Dielectric layers with embedded semiconductor nanocrystals are studied in order to overcome difficulties of non-volatile memory devices connected with technology scale-down, and to develop Si-based LEDs. One of the methods used for creating Si nano-crystals in SiO_x, is the high temperature annealing of these films containing excess Si. In our work the effect of high temperature annealing was studied on the composition, homogeneity, microstructure, and thickness of Si-rich SiN_x layers by spectroscopic ellipsometry and cross-sectional transmission microscopy, and on their electrical behaviour by current-voltage, capacitance-voltage, conductivity-voltage, and memory hysteresis measurements.

The SiN_x layers were deposited by low pressure chemical vapour deposition (LPCVD) at 800 ºC or 830 ºC and 0.35 mbar using SiH_2Cl_2 and NH_3. The average deposition rate was 3.5 nm/min. Three different layers were prepared on Si wafers with SiH_2Cl_2 to NH_3 ratio of 4:1, 3:1 or 1:4 which yielded different composition of SiN_x layers with excess Si content of 6.9 %, 4.7 %, 0.2 %, respectively, as obtained by spectroscopic ellipsometry. Than the samples were cut for parts with an area of about 1 cm^2. Different parts of the wafers were annealed in forming gas in the temperature range of 800-1100 ºC for 1 hour. For electrical measurements Al capacitors were formed by evaporation and photolitography.

It has been obtained by cross-sectional transmission microscopy that the layers remained amorphous after each annealing step. No systematic dependence of the layer thickness has been obtained on the annealing conditions. It is likely, that the small scatter of layer thickness obtained by ellipsometry and XTEM measurements, is due to the lateral inhomogeneity of the original as-deposited samples. However, it has been obtained by spectroscopic ellipsometry that the Si content of the layers decreased slightly with increasing annealing temperature.

The electrical behaviour were strongly affected by annealing. Systematic dependences of the flat-band voltage and the electrical conductivity have been obtained up to annealing temperature of 1000 ºC, but annealing at 1100 ºC have degraded the layers. Consequently, the memory behaviour also have depended on annealing.

Front-End Models for Silicon Future Technology – FRENDTECH, (IST Project 2000-30129, 2002-2004)

G. Battistig, T. Lohner, M. Ádám, P. Petrik, P. Deák, K. Kamarás

The activation rate of shallow boron implants can be maximised by optimizing the subsequent annealing, which has to dissolve the boron-interstitial clusters (BIC) formed during implantation. This requires the knowledge of the formation energies of the dominant BICs. Previous theoretical analysis at *ab initio* level has found a large number of possible complexes and predicted their formation energies with an error bar of about 1 eV. Regarding the number of BICs (15-20) this error introduces uncertainties in kinetic simulations. Therefore, it is desirable to identify the dominant BICs by spectroscopic methods. For that purpose, the measurable properties of all possible BICs have to be calculated *a priori* with high precision.

Therefore, sophisticated *ab initio* calculations have been carried out systematically on a large-scale, to establish a data base for the vibration spectra (normal mode frequencies) and electronic structure (one-electron level positions in the gap) for all BICs. After the necessary convergence tests, the silicon crystal, containing the BICs, was simulated by an appropriate supercell model. The total energy and the equilibrium geometry were calculated using density functional theory (DFT) and norm conserving pseudopotentials. The vibration spectra have been determined in the harmonic approximation for all possible isotope composition, using generalised gradient approximation (GGA) and numerical atomic orbitals. The electronic structure was calculated with an optimised hybrid functional and Gaussian orbitals. As a by-product, some long standing controversies in the interpretation of experimental results on the simplest boron complexes could be solved.

Ion implantation of SiC using in channelling direction

N. Q. Khanh, T. Lohner, Z. Zolnai, A. Ster

500 keV N^+ implantation with different fluences and different orientations with respect to the <0001> crystallographic axis (the c-axis) of 6H-SiC has been performed using the EG-2R Van de Graaff accelerator. The implantation-induced damage distributions in both the Si and C sublattices were measured by 3.55 MeV $^4He^+$ backscattering spectrometry/channelling (BS/C) analysis. For an adequate energy-depth conversion in BS/C spectra, the electronic stopping power of the analyzing He ions along the c-axis of SiC has been determined. The damage distributions, provided by BS/C were compared to the results of Crystal-TRIM computer simulations. We have found that the dependence of the shape of damage distributions in function of the tilt angle between the N ions and the c-axis of 6H-SiC can be well reconstructed at relatively low fluences. Contrary, for highly damaged layers a large discrepancy has been observed between experiment and simulation, that can be attributed to secondary damage formation processes, dominating the amorphisation of SiC in the high-fluence region [176, 177, 178]. The results were published at the 5th European Conference on Silicon Carbide and Related Materials (ECSCRM 2004, Aug 31 - Sept 4, 2004, Bologna, Italy).

Nucleation of SiC nanocrystals at the Si/SiO$_2$ interface: effect of the interface properties

G. Battistig, A. Pongrácz, A. L. Tóth, Z. Makkai, Z. Hajnal

Significant work has been recently devoted to the growth of Si nanocrystals (NCs) because of their possible application for non-volatile memory devices and Si based LEDs.
Our group have proposed a simple method for SiC NCs growth at the Si side of the Si/SiO_2 interface during annealing in CO atmosphere. The size and shape of the crystallites are typically uniform. As the NCs grow epitaxially and void-free on the Si substrate this structure might be used as seed crystals at the epitaxial growth of SiC on Si.
Further oxidation of the Si/SiO_2 structure containing SiC grains produce a system, where the NCs sit in the oxide, which is suitable for flash memory applications. The nanometre sized SiC grains could have further importance in the optoelectronic applications.
Additional investigations are necessary to understand the nucleation and growth mechanism of the SiC NCs in order to control the nucleation density and grain size. Recently we examined the effect of the Si/SiO_2 interface properties on nucleation process.
(100), (110) and (111) Si substrates covered with 100 nm thick thermally grown SiO_2 layer were heat treated in CO containing ambient for several hours. Low voltage scanning electron microscopy (SEM) was used to obtain information about the microstruc-

ture of the system. Cross sectional and plan view images have been taken from the samples (Fig. 2.).

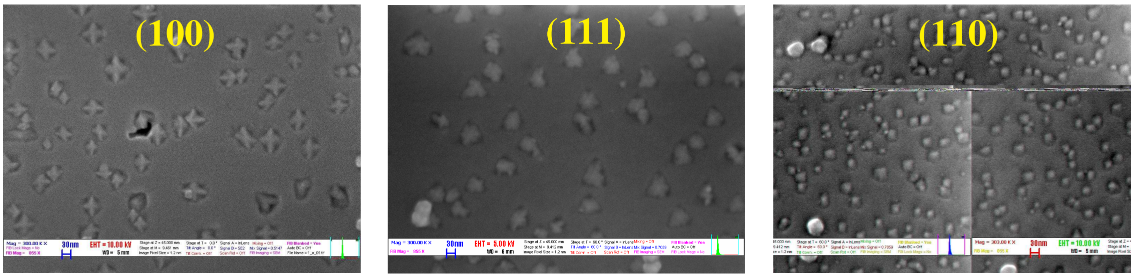


Fig. 2: SiC nanocrystals grown on (100), (110) and (111) Si substrates

Size, morphology and nucleation density of the nanocrystals have been found to depend strongly on the orientation of the substrates. Comparing the (110) plane with the other crystal planes the typical grain size is smaller and the nucleation density is one range higher.

Photonics Department

Head: M. Fried

PHOTONICS: The technology of generating and harnessing light and other forms of radiant energy whose quantum unit is the photon. The science includes light emission, transmission, deflection, amplification and detection by optical components and instruments, lasers and other light sources, fibre optics, electro-optical instrumentation, related hardware and electronics, and sophisticated systems. The range of applications of photonics extends from energy generation to detection to communications and information processing.

We perform non-destructive and no-contact measurements using photons and applying electromagnetic fields on different samples starting form thin films and whole semiconductor wafers playing important role in microelectronic technology, through cells of certain pathologic human tissue to the components of different machineries. We investigate the electrical and optical properties of the GaAs, InP, InGaAs, InGaAsP, and GaSb compound semiconductors and heterostructure devices. We develop new software and hardware units that support a more efficient diagnostics information extraction from the results of electrocardiac imaging methods especially body surface potential mapping.

The work is organised in three laboratories cooperating internally and with other laboratories within the Institute.

Non-destructive Analysis

Head:
Dr. Tivadar Lohner, Ph.D.

Staff:
dr. Csaba Daróczi dr. univ.
Imre Eördögh
Dr. Miklós Fried, Ph.D.
dr. György Juhász, dr. univ.
Dr. Péter Petrik, Ph.D.
Dr. Olivér Polgár, Ph.D.
Dr. Ferenc Riesz, Ph.D.
Károly Szász
Dr. Gábor Vértesy, D.Sc.

PhD Students (Advisor):
Essam Ramadan Shaaban* (Dr. Tivadar Lohner)
Antal Gasparics (Dr. Gábor Vértesy)
István E. Lukács (Dr. Ferenc Riesz)

Semiconductor Photonics

Head:
Dr. Miklós Serényi, Ph.D.

Staff:
János Balázs
dr. András Hámori, dr. univ.
Mária, Jankóné R.
Dr. György Kádár, D.Sc.
Dr. János Makai, Ph.D.
Ms. Erzsébet Mészáros
dr. Miklós Rácz, dr. univ.
Dr. Péter Török D.Sc.
Dr. Péter Varga D.Sc.
Prof. Dr. Ferenc Vonderviszt (50%) D.Sc.

PhD Students:
Norbert Nagy
Zoltán Vörös

Bioengineering

Head:
Prof. Dr. György Kozmann, D.Sc.

Staff:
Dr. József Laczkó Ph.D.,
Krisztina Szakolczai,
Szabolcs Póta,
Kristóf Haraszti,
Andrea Bolgár,
Tibor Vörös,

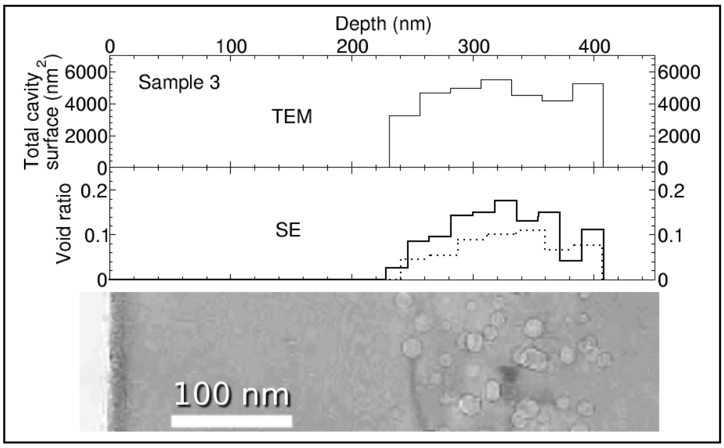
PhD Students:
Csaba Fazekas
Zoltán Keresztényi

Laboratory for Non-destructive Analysis (T. Lohner)

Ion beams in physical nanotechnology (OTKA T043704)

J. Gyulai, T. Lohner, P. Petrik

Ion implantation caused damage in SiC was measured by spectroscopic ellipsometry (SE) and cross-checked by Rutherford Backscattering Spectrometry (RBS). The relative damage was measured using the Bruggeman effective medium approximation combining the dielectric function of single crystalline and totally amorphised SiC. [12, 116]. Strontium–bismuth–tantalate (SBT), a new kind of dielectric layer material was characterised by SE using the Cauchy model as well as the Adachi model (Phys. Rev. B 35 (1987) 7454–7463). A comparison of both models was performed. Furthermore, these optical data were compared with compositional and structural properties examined by RBS and X-ray diffraction (XRD). [135].
Cavities created by He implantation into single-crystalline silicon and annealing were characterised by multiple angles of incidence spectroscopic ellipsometry [115]. Optical models of increasing complexity were developed. Cavity profiles of different annealing conditions were compared and cross-checked by transmission electron microscopy and secondary ion mass spectroscopy. A strategy for the ellipsometric evaluation was proposed to reduce the computation time and the probability of getting in local minima using complex models with numerous parameters.



Ion implantation induced lattice defects and their interaction upon annealing (OTKA T033072)

M. Fried, O. Polgár, P. Petrik

The depth distribution of disorder and cavities in high dose helium implanted silicon was characterised by spectroscopic ellipsometry (SE) and cross-sectional transmission electron microscopy (XTEM) [115]. Dose dependence of ion implantation-caused damage in silicon was studied by SE and RBS. SE measures more damage than RBS for lower dose and less damage than RBS for higher dose [35].

Development of optical models for ellipsometric study of multicomponent materials (OTKA T047011)

M. Fried, T. Lohner

In this study we use ion backscattering spectrometry combined with channelling (RBS-C), XTEM and X-ray diffraction (XRD) to cross-check the assumptions used to construct optical models for SE. We would like to establish correlation between the parameters of the dispersion relation and the microscopical structural properties of the materials studied.

Quantitative Makyoh topography (OTKA T037711)

F. Riesz; I. E. Lukács

A novel, mirror-based Makyoh topography set-up has been developed thus demonstrating the capability of the method for the study of the flatness of large-diameter wafer used in modern semiconductor technology [132].

Detection of the degradation of structural materials by electromagnetic non-destructive methods (OTKA T035264)

G. Vértesy; C. Daróczi; A. Gasparics

A novel way of non-destructive magnetic characterisation of structural variations of ferromagnetic samples was developed and applied for a series of cold worked austenitic stainless steel and cast iron specimens. It was found, that the outcome of the minor loops analysis was more helpful than that of the traditional hysteresis studies, and it was highly suitable for sensitive non-destructive characterisation of structural changes in such materials [164].

Development and application of special image processing methods

I. Eördögh, K. Szász

Special image processing methods were developed and applied for solving medical, dosimetric and fabrication-related technological tasks [113]

Basic processes in ion implantation, annealing-related effects and crystallisation (OTKA T034332)

I. Dézsi, T. Lohner

In this study silicon samples implanted with high dose iron ions and annealed by laser irradiation were measured by SE. A two-layer optical model was constructed for the interpretation. The layer adjacent to the substrate was 55 nm thick and contained about 90% $FeSi_2$. The thickness of the top oxide layer was 7 nm.

Semiconductor Photonics Laboratory (M. Serényi)

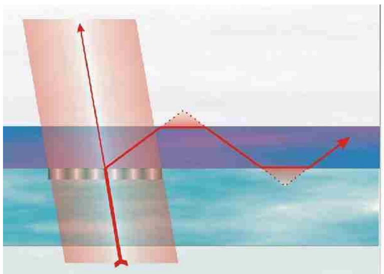
Optical setup for Makyoh topography (OTKA No. T037711)

J. Makai

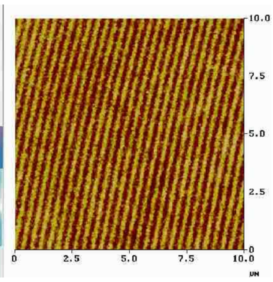
Opto-electronic devices based on the protein Bacteriorhodopsin (NATO Project Number: SfP974262)

M. Serényi, A. Hámori, N. Nagy

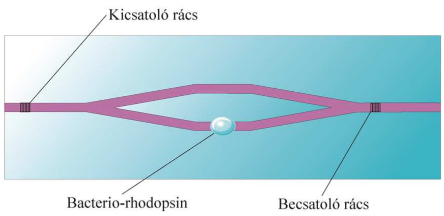
Monomode waveguiding sensor, different waveguides including in-, and outcoupling grating, and Mach-Zender interferometer was prepared on Suprasil substrate by Ta_2O_5 thin film.



incoupling grating



sub-micron grating



Mach-Zender interferometer

Solar cell made of CIGS (NKFP 3/025/2001)

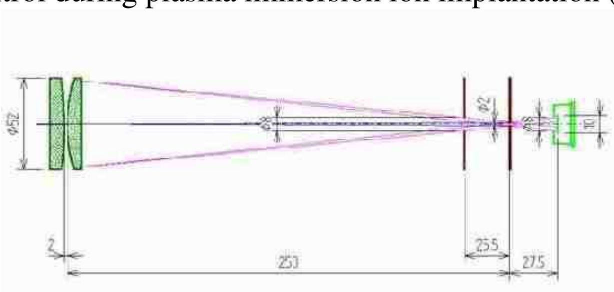
J. Makai; J. Balázs

We developed methods for in-situ control during the deposition of CIS/CIGS layers by measurement of transmission and reflection.

Development of long life-cycle human-body hip-prosthesis (NKFP 1/013/2001)

M. Serényi, M. Rácz

The aim of the project to enhance the life-time of human articular prosthesis by ion implantation. We developed an optical method for the in-situ control of the plasma immersion ion implantation caused hardness change on the surface of plastic prosthesis. The method is based on the spectral reflection of the surface depending on the implanted ion dose. The device (containing semiconductor diode-laser) is capable of *in-situ, real-time* control during plasma immersion ion implantation (PIII) of surfaces.

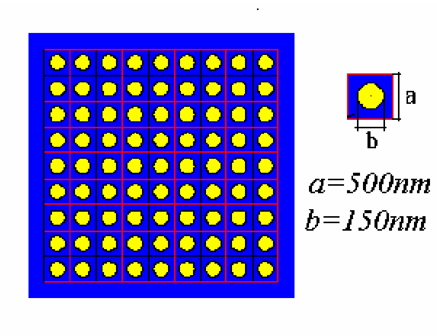


in-situ control of the plasma immersion ion implantation on the surface of plastic prosthesis

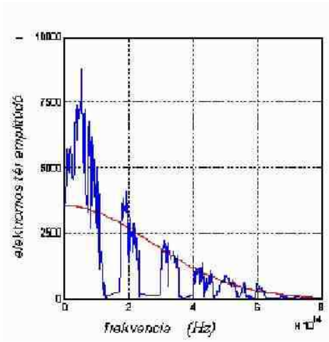
Electromagnetic waves in artificial periodical structures (OTKA T 046696

G. Kádár, J. Gyulai, I. Bársony, B. Szentpáli, G. Battistig, P. Varga, A. Hámori, A. Tóth, J. Balázs, J. Volk, N. Nagy, Zs. Szabó

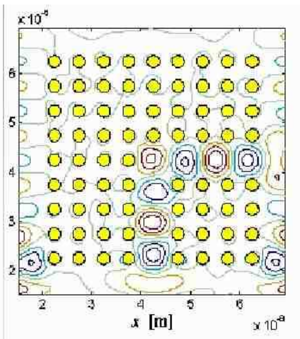
A research project for the modelling, fabrication and characterisation of photonic crystals (periodic structures of light wavelength scale) has been launched this year by a group of persons belonging to various departments of the Institute. Experimental results were obtained in porous silicon based one-dimensional periodic structures. In the first year the main effort was the development of a computer model for the simulation of the propagation of electromagnetic waves in one- and two-dimensional photonic crystals by using the finite difference time domain (FDTD) method. The model was tested and applied in rectangular two dimensional lattices for the calculation of the energy band structure and band-gaps as well as for the simulation of the propagation of a “forbidden energy” wave along a defect line of a photonic crystal model as seen in the figures.



photonic crystal model



calculated photonic band gaps



guided light in "defect"

Bioengineering Laboratory (G. Kozmann)

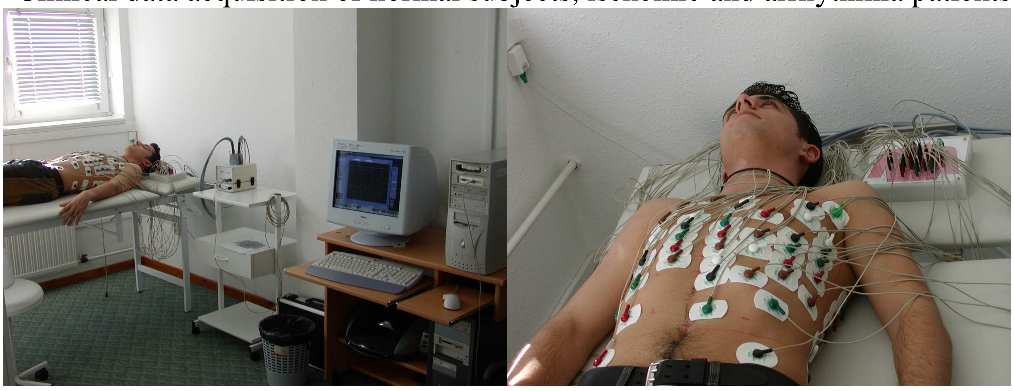
Information Technology for Cost efficient Health Conservation (NKFP 2/052/2001)

Subproject 1: Interpretation of body surface potential maps

G. Kozmann; A. Bolgár; K. Haraszti; K. Szakolczai

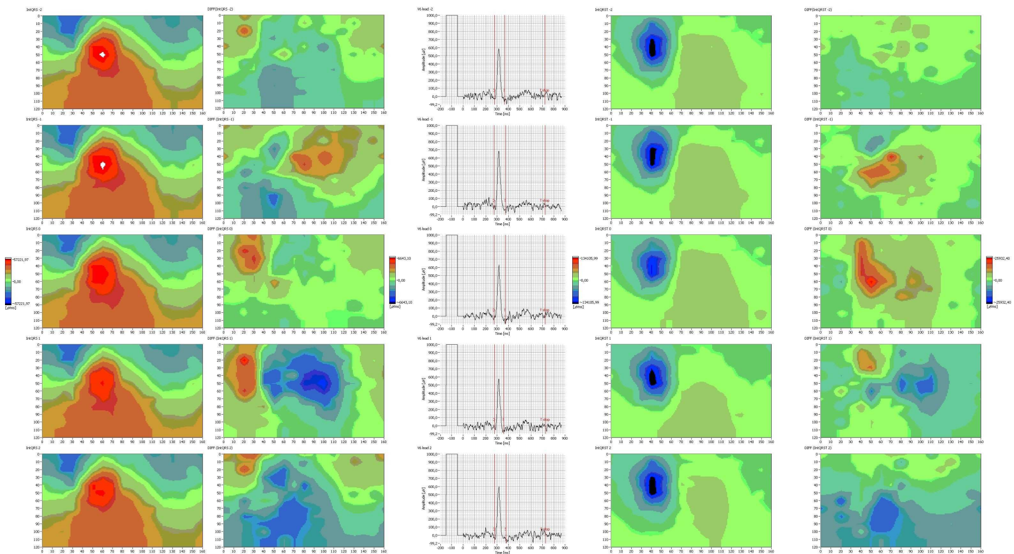
Major activity focused on:

- Clinical data acquisition of normal subjects, ischemic and arrhythmia patients



Body surface mapping in the Bioengineering Laboratory

- Model-based localisation of bioelectrical source changes due to ischemic heart diseases.
- Elaboration of new methodology to reveal the electrical substrate of malignant arrhythmias (risk of sudden cardiac death), including the detection of elevated repolarisation disparity and beat-to-beat variability of depolarisation and repolarisation



Beat-by-beat sequence of the surface manifestation of depolarisation sequence, depolarisation variability (1st and 2nd column) and repolarisation sequence and its spatio-temporal variability (4th and 5th columns)

<u>Subproject 2:</u> Status monitoring of stroke patients with internet based motion analysis

J. Laczkó, C. Fazekas, Z. Keresztényi

Methodology and program has been developed for the measurement and evaluation of hand movement tremor in normal subjects and stroke patients. The results were integrated in an Internet based telemonitoring system.
Statistical decision criteria were elaborated and validated based on the database of our clinical data acquisition program performed with different clinics and hospitals.

The control of multi-joint limb movements: electro-mechanical model (OTKA T034548)

J. Laczkó, C. Fazekas; Z. Keresztényi

A MATLAB based simulation study has been carried out, suitable quantitatively characterise limb movement as a function of motoral neuron activity. In cooperation with the New York University and the Semmelweis University the movement of rat limbs was analysed and validated by real experimental data.

Jini based Grid system with an integrated development environment (IKTA-5 00089/2002)

Z. Juhász, S. Póta

In cooperation with the Dept. Information Systems, Univ. of Veszprém, we have elaborated a distributed computing architecture, capable to discover computation resources world wide and execute parallel tasks. A new method has been introduced for computation resource optimisations.

Nanotechnology Department

Head: L. P. Biró

Research Fields:

- Carbon nanostructures
- Natural photonic crystals
- SPM/STM/STS & computer simulation
- SEM/EDS/FIB
- Silicon nitride
- Carbon nanotube ceramic composites
- Biocompatible ceramics
- HIP sintering
- Driven lattice gases
- Evolutionary prisoner's dilemma games
- Analysis of folk music and birdsong
- Non-equilibrium phase transitions

Nanostructures

Head:
Dr. Zsolt E. Horváth, Ph.D.

Staff:
Prof. József Gyulai, member of HAS, head of the Institute's Advisory Board (partly)
Dr. László P. Biró, Ph.D., head of Nanotechnology Department
Dr. Attila Lajos Tóth, Ph.D., senior research fellow
Dr. Zofia Vértesy, Ph.D., senior research fellow
Dr. Géza I. Márk, research fellow

PhD Students:
Enikő Horváth (Dr. Attila Lajos Tóth)
Krisztián Kertész (Dr. László P. Biró)
Antal A. Koós (Dr. László P. Biró)
Zoltán Osváth (Dr. László P. Biró)
Levente Tapasztó (Dr. László P. Biró & G. I. Márk)

Technician:
Margit Sárkány

Ceramics & Composites

Head:
Dr. Péter Arató D.Sc.

Staff:
Dr. Csaba Balázsi, Ph.D.
Dr. István Gaál, Ph.D.
Zsuzsanna Ilona Kövér
Dr. Judit Pfeifer, Ph.D.
Ferenc Wéber

PhD Students :
Judit Babcsan Kiss (Dr. Péter Arató)
Nikoletta Kaulics (Dr. Péter Arató
Balázs Fényi (Dr. Csaba Balázsi)

Complex Systems

Head:
Dr. György Szabó, Ph.D.

Staff:
Dr. István Borsos, dr. univ.
Dr. Géza Ódor, Ph.D.
Zoltán Juhász
Attila Szolnoki

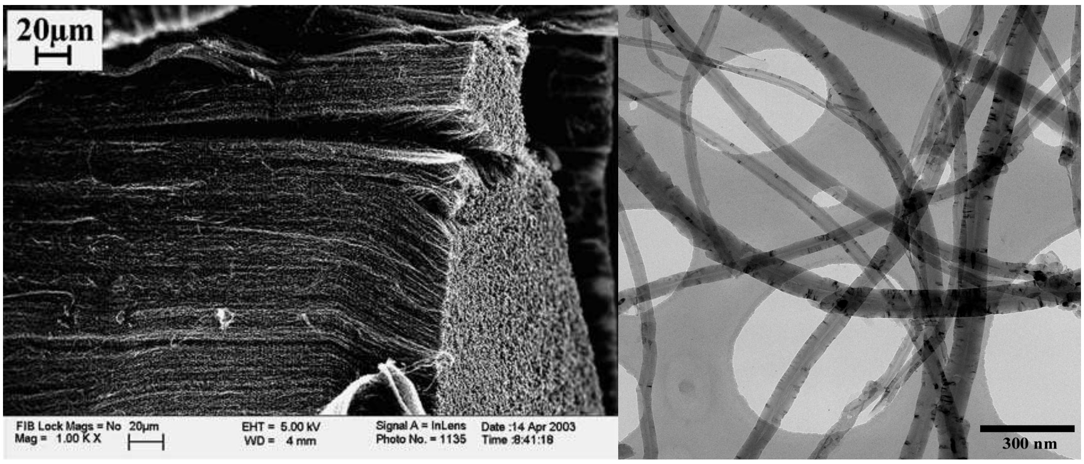
PhD Student:
Jeromos Vukov (György Szabó)

Nanostructures Laboratory (Z. E. Horváth)

Production, modification and characterisation of carbon nanotube-like nanostructures based on physical, chemical and simulation methods (OTKA T043685)

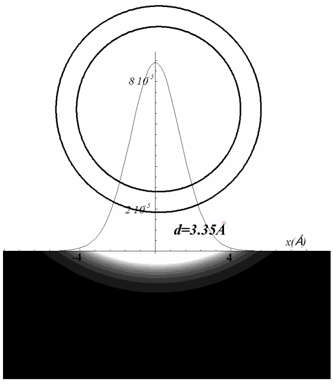
L. P. Biró; Z. E. Horváth, Z. Vértesy, G. I. Márk; K. Kertész; A. A. Koós; Z. Osváth

1. Multiwall carbon nanotubes (MWNTs), grown by injection CVD or "spay pyrolysis" method were characterised by SEM and TEM. The growth method is based on the simultaneous injection of the carbon source (e.g. benzene) and the catalyst source (e. g. ferrocene solved in benzene) through a sprayer into the reaction furnace. The reaction was optimised by varying the furnace temperature, the flow rate of the ferrocene-benzene solution and the ferrocene concentration. In certain cases, the growth of large areas of high purity aligned multi-wall carbon nanotube fields was found. STM studies showed the presence of single wall nanotubes in some samples together with multi-wall nanotubes. Other hydrocarbons (toluene, xylene, cyclohexane, cyclohexanone, n-hexane, n-heptane, n-octane and n-pentane) and metallocenes (cobaltocene and nickelocene) were found to be suitable carbon source and catalyst source, respectively. The highest yield and the best quality were obtained when a mixture of ferrocene-nickelocene was used as catalyst and xylene as carbon source.

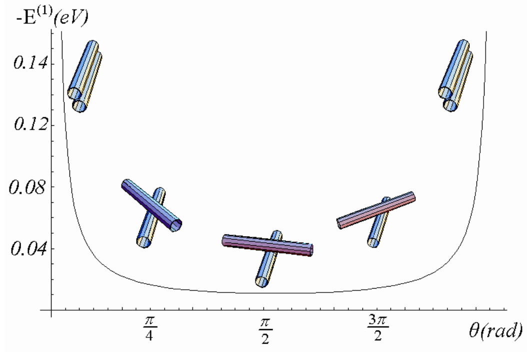


SEM image of aligned MWNT field and TEM image of MWNTs produced using ferrocene dissolved in xylene

2. Electron transport through carbon nanotubes (CNTs) is a basic phenomenon for the understanding of Scanning Tunnelling Microscopy (STM) investigation of these nanostructures and also provides the main operational principles for carbon nanotube based electronics. We investigated theoretically the effect of the substrate on the stationary states of the jellium model of nanotubes using a perturbation treatment. The calculations showed that only a thin surface layer of the substrate contributes to the perturbation (the thin oxide layers or impurities on the surface of the support might have a major importance). Understanding the electronic transport through two crossing nanotubes (a nanotube contact) is important in fabrication of multi-terminal devices. Our analytic calculations for this system show a strongly angular dependent energy shift.



Probability density of the nanotube m=0 angular momentum eigenstate inside the support



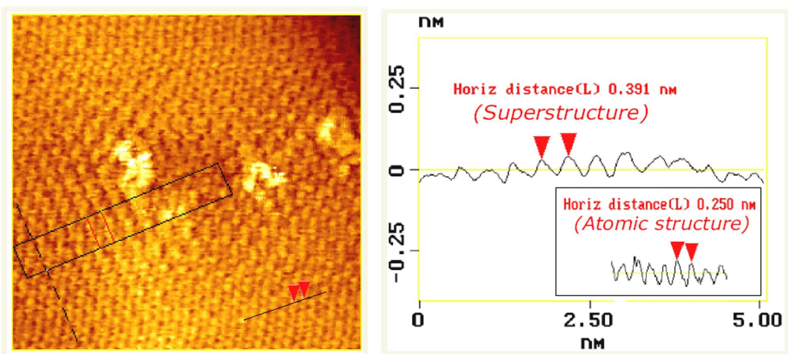
Angular dependence of the first order perturbation correction of the ground-state energy of a CNT, due to the presence of a crossing tube

3. Using proprietary wave-packed dynamical simulation software the tunnelling processes were investigated in full 3D description through: an infinite carbon nanotube, a capped carbon nanotube protruding from a step, a carbon nanotube quantum dot and a Y-junction carbon nanotube. The simulation showed that: a) the tunnelling current is determined by the STM tip/CNT junction; b) the tunnelling takes place in „pulses" which develop at the charge maxima produced by the interference of the electron density waves; c) in the case of the Y-junction, the defects in the junction region make their presence felt at distances as large as several nanometres.

Ion beam methods in the physical nanotechnology, IONNANO (OTKA T043704)

J. Gyulai, L. P. Biró, Z. Vértesy, Z. Osváth

1. Multi-wall carbon nanotubes (MWCNTs) dispersed on graphite (HOPG) substrate were irradiated with Ar^+ ions of 30 keV. The irradiated samples were investigated by scanning tunnelling microscopy (STM) and spectroscopy (STS) in air. The irradiation-induced defects appear as hillock-like protrusions on the nanotube-walls, similar to the hillocks observed earlier on ion irradiated HOPG. The results are in agreement with recent predictions, which attribute the STM features produced by ion irradiation to local modifications of the electronic structure. "$\sqrt{3}\times\sqrt{3}R$" type superstructures are also observed near some of the defects. After annealing at 450 °C in nitrogen atmosphere, the change of the defects were found by STM.

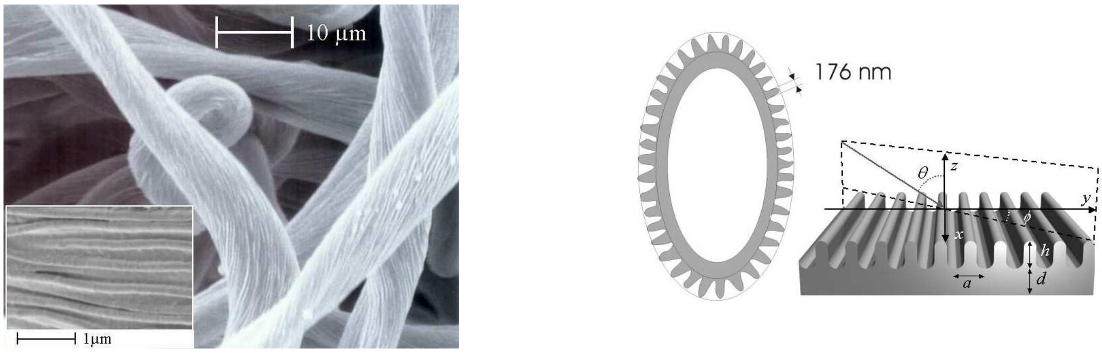


STM image of an irradiated MWNT showing defects and superstructure

Photonic crystal type materials of natural origin (partly funded by OTKA T042972 “Comparative morphological and thermal study of butterfly wing scales…”)

L. P. Biró, Z. Vértesy, K. Kertész

The optical properties of the inflorescence of the high-altitude *Leontopodium nivale* subsp. *alpinum* (edelweiss) were investigated, in relation with its submicrometer structure, as determined by scanning electron microscopy. The filaments forming the hair layer have been found to exhibit an internal structure which may be one of the few examples of a photonic structure found in a plant. Measurements of light transmission through a self-supported layer of hair pads taken from the bracts supports the idea that the woolly layer covering the plant absorbs near-ultraviolet radiation before it reaches the cellular tissue. Calculations based on a photonic-crystal model provide insight on the way radiation can be absorbed by the filamentary threads.



SEM image of the filaments covering the edelweiss flower and model of the filament cross section

Nanopatterning of thin layers by focused ion beam (without funding in 2004)

A. L. Tóth, Z. Vértesy, E. Horváth

The FIB nanopatterning was successfully applied for preparation of optically active thin layer structures and magnetic nanodot arrays used in quantum cellular automate research

Nanotube-based gas sensor (MEH-MTA strategic research grant NANOGAS)

J. Gyulai, L. P. Biró, Z. E. Horváth, Z. Vértesy, K. Kertész; A. A. Koós

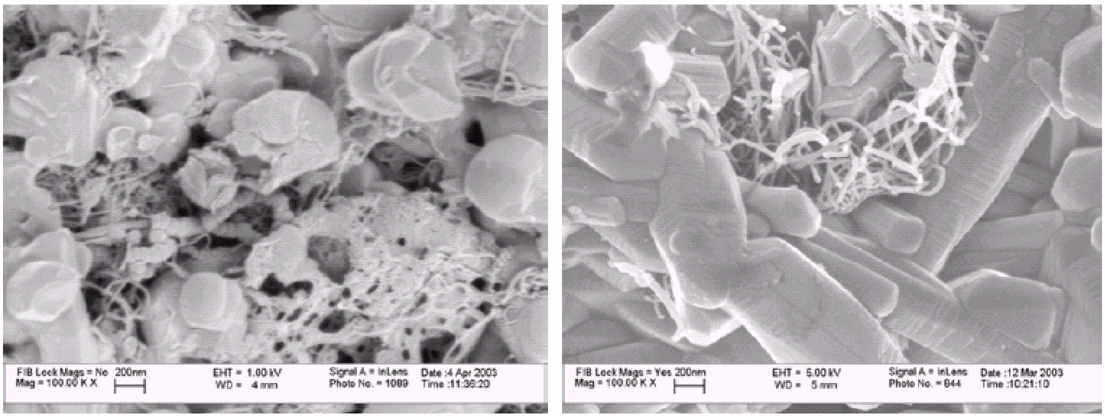
Multiwall carbon nanotubes were demonstrated to be suitable for gas sensing. Development of gas sensing devices based on electric resistance measurements has been started.

Ceramics and Composites Laboratory (P. Arató)

Silicon Nitride-Based Ceramics and Composites (OTKA D38478)

C. Balázsi; P. Arató, F. Wéber; Z. I. Kövér

The target of the research work is to work out new methods for preparing synergistic ceramic matrix composites with new properties. Primarily the interactions between silicon nitride matrix and graphite micrograins, carbon black nanograins, carbon fibres and carbon nanotubes were investigated. Carbon nanotubes present exceptional mechanical, superior thermal and electrical properties, there are high expectations for high level of nano- and microcomposites containing carbon nanotubes; despite of this, only modest improvements were reported. Our experimental work has been performed to control the preparation of colloidal ceramic slurry and the structural changes during shaping and sintering. Several sintering techniques PLS, HIP, HP, FAST (Field Activated Sintering) were applied. Structural, morphological and mechanical properties were examined to follow the interactions between ceramic matrix and different carbon additions. Silicon nitrides with controlled porosity and in-situ silicon carbide/silicon nitride composites were obtained by the help of fugitive (carbon) additions and by tailoring the complex reaction paths within sintering processes. The carbon nanotubes can be maintained by appropriate choosing the parameters of this procedure (see Figure below). The mechanical properties of carbon containing porous samples were better than samples without carbon at the same value of porosity [4, 5, 6, 7, 8].

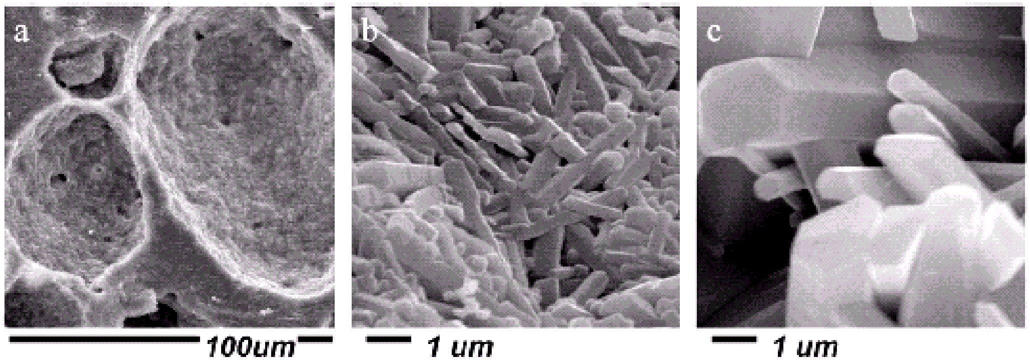


MWNT bundles covered by nanosized β-Si_3N_4 crystals showing a necklaces (left) β-Si_3N_4 grains connected by MWNTs (right). Fracture surfaces [7]

Effect of Structural Changes on the Mechanical Properties (OTKA T043704, NKFP 3/34/2001)

P. Arató, C. Balázsi, J. Pfeifer, F. Wéber; Z. I. Kövér; J. Babcsan Kiss

Strain-stress curves were determined on silicon nitride based ceramics and on composites with matrix silicon nitride and/or silicon carbide to determine the relationships between structure and properties. Special emphasis was given to porous materials (see Figure below). We introduced a new test method, some constituents of C/C-SiC composite bodies were eliminated and the obtained SiC skeletons were examined. The effects of advances techniques of surface modification were also studied. Mechanical properties of silicon nitride based ceramics after implantation of nitrogen or carbon ions were measured. Results suggested that effect of ion implantation is connected with the selective modification of defects; a part of them can be healed. The effect of oxidation as a function of temperature, compositions and type of starting powder was also investigated. After heavy oxidation new phases appeared, the effect of implantation was moderated. The structure and consequently the working temperature of advanced ceramics can be improved by combining the different methods of surface modification [3, 4, 5, 6, 7, 8].



'a' – macro-and micropores, 'b' – Si_3N_4 nano grains 'c' – Si_3N_4 m icro grains [5]

Ceramics-Based Bio-Compatible Composites (OTKA D38478)

C. Balázsi, F. Wéber

The project started in 2004. The aim is to develop composite materials for biomedical applications starting from natural raw materials. In the first stage hydroxyapatite and calcium phosphate powders were prepared; the size of grains was in the nano and micro region. A new method has been worked out for covering hydroxyapatite substrate by calcium phosphate nano and micro layers or fibres. A layered structure of this type may increase the strength of composite. In the next step different porous ceramics and layers will be prepared and examined to improve both the bio-compatibility and strength.

Development and Characterisation of Sensing Layers Based on Open Structure Tungsten Oxides and Related Materials (MTA-OTKA-SNF)

C. Balázsi, J. Pfeifer

This project started in the second half of 2004. In the beginning the planned work will concentrate on the preparation processes of new polymorphs of tungsten oxide, in bulk and thin film form. The target is to develop advanced gas sensors for high temperature applications. The Cupertino between State University of New York and MFA exploiting the complementary expertise of collaborators provides good chance. The first series of tungsten oxide samples were prepared in Budapest and examined in Stony Brook. The cubic tungsten oxide sample was sensitive to NH_3 and NO_2 gases. The temperature for better sensitivities was 500 ^oC.

Processes Limiting the Coarsening of Ultra-Fine Grains (OTKA T32730)

L. Bartha, I. Gaál, O. Horacsek

When the AKS-doped sintered tungsten ingots are processed into wire, the smaller potassium-containing pores appear to be less deformable than the larger ones. The effect of this selective pore deformation on the characteristics of the developing bubble dispersion in different heat-treated samples was investigated. The results indicated that the refinement of the potassium distribution during thermomechanical processing occurs more effectively if the potassium in sintered ingot is enclosed in relatively large pores. It was shown that an initial broad size distribution of potassium-pores in sintered ingot will be moderated during thermomechanical processing to a relatively narrow size distribution of the bubbles in the wire. The high temperature creep resistance and, hence, the quality of doped tungsten wires depend both on the size and the arrangement of bubbles [61,62].

Materials for Light Sources with Improved Properties (EU GRDI-2000-25471, NKFP 3/045/2001)

I. Gaál

Thoriated tungsten electrodes are often used in high intensity discharge lamps since thermionic emission of tungsten is markedly increased by the presence of Th atoms on the surface. The evolution of the surface composition of thoriated tungsten has been followed up by means of Auger electron spectroscopy after various heat treatment performed below 2300 K. It turned out that the evolution depends dramatically on the current density of the electron beam exciting the Auger electrons, and no Th adatom enrichment has been observed without electron beam irradiation in this temperature region. It has been shown that the sources of Th adatoms are thoria particles attached to the free surface of the wire. It is expected that the electron induced oxygen depletion of the thoria particles is the main reason for thorium release onto the free surface [18].

Group of Complex Systems (G. Szabó)

Nonequilibrium phase transitions (OTKA T-046129)

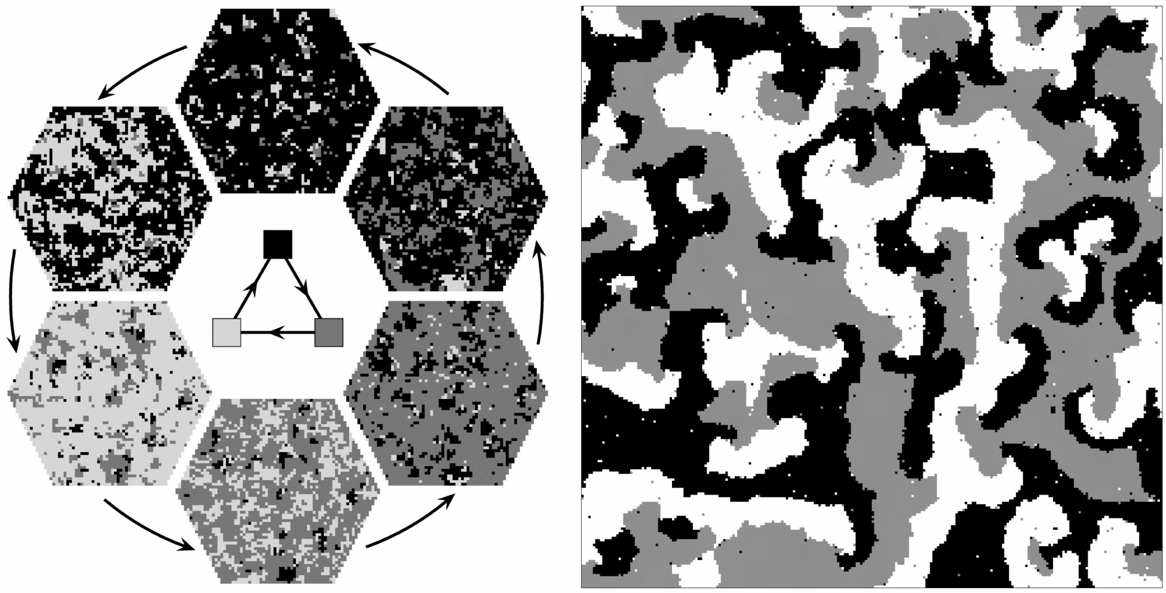
G. Ódor; A. Szolnoki

The nonequilibrium systems can also undergo phase transitions (i.e., extinctions) that can be classified by considering the universal features of the critical transitions. Our research is focused on some exceptions exhibiting unusual behavior. The recent results in this area were reviewed by Géza Ódor [182].

Evolutionary games (OTKA T-047003)

G. Szabó; A. Szolnoki; I. Borsos; J. Vukov

The measure of cooperation was investigated for the voluntary evolutionary prisoner's dilemma games allowing partially random partnerships. The Monte Carlo simulations show the emergence of global (synchronised) oscillations in the concentration of the three strategies (defector, cooperator, and loner) as indicated by the subsequent snapshots (left) meanwhile the same system on the square lattice exhibits a rotating spiral structure (right).

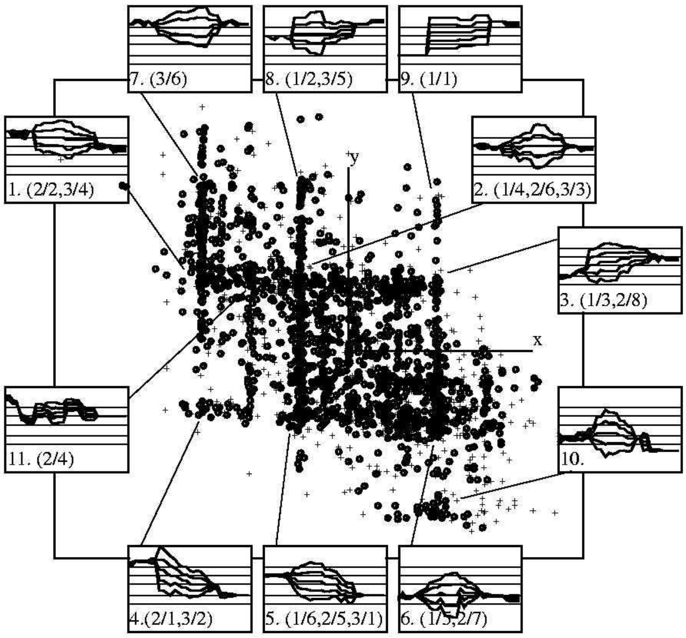


The relevant features of these systems were well described by the extended dynamical mean-field approximations [147]. Many consequences of the cyclic invasions were studied systematically by investigating the evolutionary rock-scissors-paper game on different regular structures [146,155,156].
Besides it we studied the formation strategy associations whose competition affects the evolutionary processes [145].

Analysis of folk music

Z. Juhász

Each melody can be represented by a point in the multi-dimensional melody space. The set of Hungarian folk songs has a particular structure if the melody space is projected on an adequate two-dimensional space [76].



Some aspect of this method is applied for the analysis of blood pressure pulses to diagnose some illnesses.

Scientific Promotions in 2004

Doctors of the Hungarian Academy of Sciences (MTA):

Géza ÓDOR, D.Sc.
Universality classes in nonequilibrium lattice systems

Béla PÉCZ, D.Sc.
Wide band gap semiconductor layers and their contacts (TEM studies)

Péter TÖRÖK, D.Sc.
Microscope Objectives with Large Numerical Aperture

Ph.D. degrees:

Abdulhadi Hassan ABDULHADI, Ph.D.
Budapest University of Technology and Economics
Characterisation of shallow pn junctions by plasma immersion ion implantation

Péter FÜRJES, Ph.D.
Budapest University of Technology and Economics
Heat transport in Si micromachined structures

Essam Ramadan SHAABAN, Ph.D.
Roland Eötvös University
Investigations of near surface modification induced by ion implantation

M.Sc. degrees:

Miklós ZSITVA, M.Sc.
Budapest University of Technology and Economics
Doping limitations of n-type Si islands formed by porous Si sacrificial layer

Sándor FÜRST, M.Sc.
Budapest University of Technology and Economics
Fabrication of macroporous Si for micromechanical applications

Nikoletta KAULICS, M.Sc.
University of Miskolc
Examination of SiAlON Ceramics by Instrumented Impact Test

Szabolcs MACZKÓ, M.Sc.
University of Miskolc
Preparation and Characterisation of Silicon Nitride Based Porous Micro- and Nano-Composites

Péter SZÖLLŐSI, M.Sc.
Budapest University of Technology and Economics,
Faculty of Electrical Engineering and Informatics
Electrical studies of annealed SiNx layers containing excess silicon

B.Sc. degree:

István JOÓ, B.Sc.
Kandó Kálmán Faculty of Electrical Engineering
PC control of a LEITZ MPV-CD critical dimension measuring system

Domestic Conferences and Symposia Organised in 2004

Hysteresis and Micromagnetic Modelling – HMM 2005, May 2005, Budapest

Conference on R&D activity in the field of Health Informatics (organised in cooperation of the University of Veszprem, and the J. von Neumann Society) 12 November 2004, Budapest.

Laser Tea, 19 Nov 2004, Budapest

MFA Seminar Talks

István Daruka, (Debrecen), **Modeling of surface nanostructures**, 14 January 2004

Philippe Lambin, (Namur, Belgium), **Structural characterisation of carbon nanotubes by diffraction**, 21 January 2004

Kazuo Morigaki, (Tokyo Univ.), **Light induced defect creation in amorphous silicon**, 28 January 2004

Zsolt Zolnai, (MFA), **Application of electron paramagnetic resonance for the study of point defects in SiC**, 25 February 2004

Miklós Fried, (MFA), **Wide angle ellipsometry**, 3 March 2004

Christian Schmidt (Erlangen), **FECLAM - Ferroelectric CVD Layers for Memory Applications and Andreas Nutsch** (Erlangen), **Chemical Mechanical Planarisation for Semiconductor Manufacturing**, 8 March 2004

István E. Lukács, (MFA), **Makyoh-topography for the investigation of mirror-like surfaces**, 24 March 2004

Anita Pongrácz, (BUTE), **SiC nanocrystals**, 7 April 2004

Jarek Domagala, (Inst.Physics, Warsaw), **Influence of defects on lattice parameter of thin GaMnAs/GaAs layers**, 28 April 2004

József Cserti, (ELTE), **Hybrid normal-superconducting mezoscopic systems**, 6 May 2004

Christo Angelov, (Sofia), **Ion Beam Induced Epitaxial Crystallisation of Amorphous Si Produced by Implantation of heavy ions**, 12 May 2004

Yvonne Gerbig and Henry Haefke, (Neuchatel), **Morphogenesis of Chromium Nitride Thin Films**, 26 May 2004

Géza Tichy, (ELTE), **Anizotropic surface strain**, 2 June 2004

Béla Szentpáli, (MFA), **Noise in sensors**, 9 June 2004

Tamás Horányi, (BUTE), **Lamellar liquid crystal systems**, 16 June 2004

Vörös Zoltán, (MFA-U. Pittsburgh), **Bose--Einstein-condensation in semiconductors**, 30 June 2004

Alexandra Imre, (U. Notre Dame), **Investigation of nano-magnets for Quantum-dot Cellular Automata applications**, 1 September 2004

Géza Márk and Levente Tapasztó, (MFA), **Axial flow of charge in carbon nanotube-like structures investigated by tunneling microscopy**, 8 September 2004

Andrea E. Pap, (Univ. Oulu, Suomi), **Manufacturing and investigation of porous silicon and oxidised porous silicon materials**, 29 September 2004

József Laczkó, (MFA), **Neuro-mechanical model for the control of limb movements**, 14 October 2004

András Kovács, (MFA), **Combinatorical investigation of phase formation in thin films**, 6 October 2004

Edvard Badaljan, (MFA), **Thermal noise**, 20 October 2004

Sándor Kugler, (BUTE), **Fotoinduced volume changes in chalcogenic glasses (amorphous selenium)**, 27 October 2004

Pelagia Irene Gouma, (SUNY, Stony Brook), **Processing and Characterisation of Nanostructured Materials for Bio/Chemical Sensors**, 29 October 2004

Antal Gasparics, (MFA), **Non destructive electromagnetic characterisation method based on the Fluxset sensor**, 3 November 2004

Tadeusz Figielski, (Inst. Fyziki, Warsaw), **Electrical effects of dislocations in semiconductors – in retrospect and nowadays**, 11 November 2004

Zoltán Juhász, (MFA), **Comparison of European folk-music by the help of self-organising maps**, 17 November 2004

Ian Vickridge, (GPS, Jussieu), **Oxidation Mechanisms of SiC,** 1 December 2004

Yu. V. Zhilyayev, (Yoffe Institute, St. Petersburg), **GaAs and GaN: Vapour phase epitaxy and properties**, 3 December 2004

V. Gorodynsky, K. Zdansky, and L. Pekarek, (Inst. Radio Eng. and Electronics, Czech Republic), **Our research towards particle and radiation detectors on InP**, 8 December 2004

Sándor Kurunczi, (AEKI), **Applications of X-ray fluorescent methods in the environmental research**, 15 December 2004

External Seminar Talks

A. Hámori: **Implanted grating coupler for single mode waveguides** Imperial College London, Blackett Laboratory, UK, 20 January 2004

Á. Barna: **Ion bombing and nanotechnology,** Technoorg-Linda, Budapest, 5 February 2004

G. Kádár: **Modelling of Magnetic Hysteresis**, V. Winter School on Nanocomposites with special properties, Keszthely, 13 February 2004

L.P. Biró: **Carbon nanotube-like nanoarchitectures: spirals, „necklaces of pearls" and others**, seminar of Dept. General Physics, Roland Eötvös University, 2 March 2004

G. Vértesy: **Magnetic hysteresis measurements on cast iron samples,** Tohoku University, Sendai, Japan, March 2004

G. Kovách: **Carbon Films with Changing Bonds,** Roland Eötvös Physical Society, Budapest, 19 May 2004

G. Kádár: **Photonic Band-gaps, Product model of magnetic hysteresis**, Oradea, Romania, 27 May 2004

I. Bársony: **Porous Silicon based integrated microsystems**, University of Notre Dame, South-Bend, USA, 18 June 2004

Zs. I. Kövér: **Calculation of the Equilibrium Phase Diagram by ESTPHAD Method Directly from Measured Data**, University of Miskolc, 23 June 2004

Cs. Balázsi: **Tungsten Oxides for Sensoric Applications**, State University of New York, Stony Brook, NY, USA, 11 July 2004

T. Lohner: **Investigation of thin film structures using ion beam analysis and complementary methods** Osaka University, Osaka, Japan, 28 July 2004.

Á. Barna: **Low energy ion beam thinning,** FEI, Eindhowen, 25 July 2004

Gy. Szabó: **Evolutionary games and statistical physics,** Roland Eötvös Physical Society, Szombathely, Hungary 25 August 2004

A. A. Koós: **Production of carbon nanotubes**, learning seminar of the Res. Inst. for Solid State Physics and Optics, Budapest, Hungary, 25 October 2004

Z. E. Horváth and *G. I. Márk*: **Structural study of carbon nanotubes - electron microscopy, tunnelling microscopy**, learning seminar of the Res. Inst. for Solid State Physics and Optics, Budapest, Hungary, 8 November 2004.

Gy. Szabó: **Competing associations**, Hungarian Academy of Sciences, Budapest, Hungary, 9 November 2004

Z. Hajnal: **Theoretical Models for the Elementary Reaction Steps of the Dry Oxidation of SiC**, Jussieu, Paris, 15 November 2004

A. Hámori: **Implanted grating coupler for integrated optics** Centro de Micro-Análisis de Materiales Universidad Autónoma de Madrid Cantoblanco, Madrid 16 November 2004

R&D Partners in International Cooperation

University of Pretoria, Pretoria, South Africa

Jozef Stefan Institute, Ljubljana, Slovenia

Institute of Physical Chemistry, Polish Academy of Sciences, Warsaw, Poland

Institute of Advanced Technology (AIT), Akita, Japan

Waseda University, Tokyo, Japan

Max Planck Institute, Munich, Germany

Institute for Solid State Physics, Technical University Vienna, Austria

National Polytechnic Institute of Grenoble, CNRS-LEMD, Grenoble, France

Institut für Angewandte und Technische Physik, Technische Universität, Wien, Austria

Centre of Advanced Studies in Physics, Romanian Academy of Sciences, Bucharest, Romania

Petru Mior University, **Sapientia University**, Tirgu-Mures, Romania

Paul Cézanne University, Marseille, France

Department of Materials Science and Metallurgy, University of Cambridge, Cambridge, UK

Chalmers Technical University, Göteborg, Sweden

MaxLab Synchrotron Facility, Lund, Sweden

Aarhus University, Aarhus, Denmark

Department of Physics, University of Thessaloniki, Thessaloniki, Greece

Fachhochschule Furtwangen, Furtwangen, Germany

Helsinki University of Technology, Espoo, Finland

FORTH, Heraklion, Greece

Nano Device Research Center, KIST, Seoul, Korea

Rikola Ltd, Oulu, Finland

Anton Paar GmbH, Graz, Austria

CNR IMEM, Parma, Italy

SAFIR, Institut des NanoSciences de Paris, Paris, France

Centro Nacional de Aceleradores, Sevilla, Spain

Magnetic Department, Institute of Physics, Academy of Sciences of Czech Republic, Prague, Czech Republic

Department of ECE, George Washington University, Washington, D.C., USA

Department of Magnetism, Institute of Molecular Physics, Polish Academy of Sciences, Poznan, Poland

Institute of Fluid Science, Tohoku University, Sendai, Japan

Universität Erlangen-Nürnberg, Erlangen, Germany

LMP, University of Tours, Tours, France

Universität Witten, Witten, Germany

Department of Inorganic Chemistry, Arrhenius Laboratory, **Stockholm University,** Stockholm, Sweden.

Ceramics Research Unit, University of Limerick, Limerick, Ireland

High Technological Ceramics and Composite Research Centre, Maslak, Istanbul, Turkey

Angstrom Nano Centre, Uppsala University, Uppsala, Sweden

Department of Materials Science and Engineering, State University of New York, Stony Brook, NY, USA

Institute for Ion Beam Physics and Materials Research, Research Centre Rossendorf, Dresden, Germany

Department of Chemical Engineering and Materials Science, College of Engineering, University of California, Davis, CA, USA

Department of Zoology, University of British Columbia, Vancouver B.C., Canada

Faculty of Agronomy, University of Buenos Aires, Buenos Aires, Argentina

Institute of Physiology, Slovakian Academy of Sciences, Bratislava

New York University, New York, USA

Publications

1. Amsel G, Battistig G, L'Hoir A: Paradoxical features of small angle multiple scattering in matter and their implications in depth profiling with IBA, NUCLEAR INSTRUMENTS AND METHODS, B219-220, 1037 (2004)
2. Andersson, JM, Czigany Z, Jin P: Microstructure of alpha-alumina thin films deposited at low temperatures on chromia template layers, JOURNAL OF VACUUM SCIENCE & TECHNOLOGY A-VACUUM SURFACES AND FILMS, 22(1), 117-121 (2004)
3. Babcsán J, Maros KMB, Arató P: Microstructural Features of the Post Heat-Treated Si3N4 Based Ceramics, SILICATES INDUSTRIELS, 69(7-8), 199-203 (2004)
4. Balazsi C, Cinar FS, Kasztovszky Z, Cura ME, Yesilcubuk A, Weber F: Investigation of hot pressed C/Si3N4 nanocomposites, SILICATES INDUSTRIELS, 69(7-8), 293-298 (2004)
5. Balazsi C, Cinar FS, Weber F, Arato P: Manufacture and examination of C/Si3N4 Nanocomposites, J. EUR. CERAM. SOC. 24(12), 3287-3294 (2004)
6. Balazsi C, Kosztovszky Z, Weber F: Manufacture and Compositional Analysis of Silicon Nitride Composites with Different Carbon Additions Communications, SCIENTIFIC LETTERS OF UNIVERSITY OF ZILINA, 1, 5-9 (2004)
7. Balázsi C, Konya Z, Kasztovszky Z, Weber F, Vertesy Z, Biro LP, Kiricsi I, Arato P: Examination of carbon nanotube reinforced silicon nitride composites, In: Proceedings of Fifth International Conference on High Temperature Ceramic Matrix Composites (HTCMC-5) New Frontiers and Horizons, (Ed. x x), he American Ceramic Society),, 2004, pp 107-112
8. Balázsi C, Weber F, Arato P: Examination of C/Si3N4 Nanocomposites, KEY ENGINEERING MATERIALS, 264-268, 2301-2304 (2004)
9. Barna A, Dunin-Borkowski RE, Twitchett AC, Midgley PA, Pecz B: The use of low energy Ar ion milling to reduce surface damage on silicon resulting from focused ion beam milling, In: Proc. EMC 2004 Antwerpen, Vol.II, (Ed. Van Tandeloo G), 2004, pp 779-780
10. Barna A, Menyhard M, Koos A, Biro LP: Topography in the ion beam cut surfaces due to sputtering rate differences; the role of sputtering parameters, In: Proc. EMC 2004 Antwerpen, Vol.II, (Ed. Van Tandelo G), 2004, pp 765-766
11. Barna PB, Barna A, Radnoczi G, Labar J, Pecz B, Safran G x, Toth L x: A Pócza Jenő által alapított vékonyrétegfizikai és elektronmikroszkópiai iskola, In: A magyar elektronikai ipar - múlt és jelen, (Ed. Mojzes I), Műegyetem Kiadó, 2004, pp 35-74
12. Battistig G, Garcia Lopez J, Morilla Y, Khanh NQ, Lohner T, Petrik P, Ramos AR: Effect of ion current density on damage in al ion implanted SiC, NUCLEAR INSTRUMENTS AND METHODS, B219-220, 652 (2004)
13. Belas E, Moravec P, Grill R, Franc J, Toth AL, Sitter H, Höschl P: Silver diffusion in p-type CdTe and (CdZn)Te near room emperature, PHYS STAT SOL (C), 1(4), 929-932 (2004)
14. Biró D, Kovács, A, Misják F, Barna PB: Self-organised structure formation in co-deposited Al-C films, SURFACE AND COATINGS TECHNOLOGY, 180-180, 425-428 (2004)
15. Biró LP, Lambin PH: SCANNING TUNNELING MICROSCOPY OF CARBON NANOTUBES, In: Encyclopedia of Nanoscience and Nanotechnology, Vol 9. (Ed. Nalwa HS), American Scientific Publishers, 2004, pp 415-427

16. Biró LP, Márk GI, Horváth ZE, Kertész K, Gyulai J, Nagy JB: CARBON NANOARCHITECTURES CONTAINING NON-HEXAGONAL RINGS: "NECKLACES OF PEARLS", CARBON, 42, 2561-2566 (2004)
17. Boroczki A, Gaal I, Gurban S, Menyhard M, Petras L, Balazs L: Dissociation of thorium oxide on the surface of free surface tungsten INSTITUTE OF PHYSICS CONFERENCE SERIES (182): 591-592 2004, In: INSTITUTE OF PHYSICS CONFERENCE SERIES (182), (Ed. x x), 2004, pp 591-592
18. Boroczki A, Gaal I, Gurban S, Menyhard m, Horvath E, Toth AL, Petras L, Balazs L: Electron stimulated thorium adatom enrichment on the surface of thoriated tungsten below 2300K, J. PHYS. D: APPL. PHYS. 38, 1-5 (2004)
19. Braun T, Rausch, H, Biró LP, Konya Z, Kiricsi I: DETERMINATION OF TRACES OF ELEMENTAL IMPURITIES IN SINGLE WALLED (SWNT) AND MULTI WALLED (MWNT) PRISTINE AND PURIFIED CARBON NANOTUBES BY INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS, J. RADIOANAL. & NUCL. CHEM. 262, 31-34 (2004)
20. Brunell IF, Pichon L, Hellgren, N, Czigany Z, Neidhardt J, Hultman L: In-situ stress measurement during the deposition of CNx thin films by unbalanced magnetron sputtering; formation of high levels of stress with 28 eV ion irradiation, PHILOSOPHICAL MAGAZINE LETTERS, 84(6), 395-403 (2004)
21. Bálint Z, Vértesy Z, Kertész K, Biró Lp: A LEPKÉK SZINEVÁLTOZÁSA, TERMÉSZET VILÁGA, 135, 311-313 (2004)
22. Bársony I, Fürjes P, Ádám M, Dücső C, Zettner J, Stam F: Thermal response of microfilament heaters in gas sensing, SENSORS AND ACTUATORS B-CHEMICAL, 103(1-2), 442-447 (2004)
23. Chaudhuri I, Sertl S, Hajnal Z, Dellnitz M, Frauenheim T: Global optimisation of silicon nanoclusters, APPLIED SURFACE SCIENCE, 226, 108-113 (2004)
24. Collins CL, MacKenzie M, Craven AJ, Tóth L, Vincze G, Szigethy D: Reducing ion damage in FIB-prepared HSLA steel TEM specimens using a low energy ion milling system, In: Proc. 13th European Microscopy Congress, Vol. II, (Eds Schryvers D, Timmermans) JP), 2004, pp 775-776
25. Cooper D, Twitchett AC, Dunin-Borkowski RE, Barna A, Pecz B, Midgley PA: Electron holography of a focused ion milled p-n junction examined after low energy, low angle Ar ion milling. In: Proc. EMC 2004 Antwerpen,Vol.II, (Ed. Van Tandeloo G), 2004, pp 783-784
26. Csányi J, Gömze AL, Kövér ZI: Néhány nagy tisztaságú Al2O3 műszaki kerámia hajlítószilárdsági vizsgálata, ÉPÍTŐANYAG, 56, 103-108 (2004)
27. Czeppe T, Rashkova V, Dobrev E, Litynska L, Morgiel J, Lábár J, Dutkiewicz: J: Glass forming ability and microstructure of Zr-Ti-Ni-Cu-Al and Zr-Ti-Ni-Cu-Ag melt spun ribbons, MATERIALS SCIENCE AND ENGINEERING A, 375-77, 260-264 (2004)
28. Diószeghy Z, Závodszky P, Namba K, Vonderviszt F: Stabilisation of flagellar filaments by HAP2 capping. FEBS LETTERS, 568, 405-409 (2004)
29. Dózsa L, Horváth ZE, Molnár G, Tóth AL, Vértesy Z, Vázsonyi E, Pető G: Characteristics of FeSi2 quantum dots on silicon, EUROPEAN PHYSICAL JOURNAL-APPLIED PHYSICS, 27, 85-88 (2004)
30. Dózsa L, Molnár G, Horváth ZJ, Tóth, AL, Gyulai J, Raineri V, Giannazzo F: Investigation of the morphology and electrical characteristics of FeSi2 quantum dots on silicon, APPL. SURF. SCI, 234, 60-66 (2004)
31. Dózsa L, Tóth AL, Horváth ZJ, Hubik P, Kristofik J, Mares JJ, Gombia E, Mosca R, Franchi, S, Frigeri P: Lateral Conductivity in GaAs/InAs Quantum Dot Struc-

tures, EUROPEAN PHYSICAL JOURNAL-APPLIED PHYSICS, 27, 93-95 (2004)

32. Emmerlich J, Hogberg H, Sasvari S, Persson POA, Hultman L, Palmquist JP, Jansson U, Molina-Aldareguia JM, Czigány Z: Growth of Ti3SiC2 thin films by elemental target magnetron sputtering, J. APPLIED PHYSICS, 96(9), 4817-4826 (2004)
33. Eppeldauer G, Racz M: Design and characterisation of a photometer/colorimeter standard, APPLIED OPTICS, 43, 2621-2631 (2004)
34. Flachner B, Kovári Z, Varga A, Gugolya Z, Vonderviszt, F, Náray-Szabó G, Vas M: Role of flexibility of MgATP phosphates in completing 3-phosphoglycerate kinase active site. BIOCHEMISTRY, 43, 3436-3449 (2004)
35. Fried M, Petrik P, Lohner T, Khanh NQ, Polgar O, Gyulai J: Dose-dependence of ion implantation-caused damage in silicon measured by ellipsometry and back-scattering spectroscopy, THIN SOLID FILMS, 455-456C, 404-409 (2004)
36. Fürjes P, Bognár G, Bársony i: Powerful Tools for Thermal Characterisation of MEMS, In: Proceedings of IEEE Sensors 2004, (Ed. Sarro PM), 2004, pp 231
37. Fürjes P, Dücső C, Ádám M, Zettner J, Bársony I: Thermal characterisation of micro-hotplates used in sensor structures, SUPERLATTICES AND MICRO-STRUCTURES, 35, 455-464 (2004)
38. Fürjes P, Légrádi G, Dücső C, Aszódi A, Bársony: I: Thermal Characterisation of a Direction Dependent Flow, SENSORS AND ACTUATORS A-PHYSICAL, 115, 417-423 (2004)
39. Fürjes P, Ádám M, Dücső C, Zettner J, Bársony I: Thermal effects by the sensitive coating of calorimetric gas sensors, In: Proceedings of Eurosensors XVIII, (Ed. Di Natale C), 2004, pp 694-695
40. Fürjes P, Ádám M, Dücső C, Zettner J, Bársony I: Thermal effects of sensitive coating in calorimetric gas sensors Eurosensors XVIII, In: Eurosensors XVIII, (Ed. Di Natale C), 2004, pp 899-900
41. Füzi J, Kádár G: A micromagnetic nanoparticle model of multaxis anisotropy, PHYSICA B, 343, 293 (2004)
42. Gas P, Bergman C, Lábár JL, Barna, PB, d'Heurle FM: Formation of embedded Co nanoparticles by reaction in Al/Co multilayers and impact on phase sequence, APPL. PHYS. LETT. 84, 2421 (2004)
43. Gergely G, Menyhard M, Gurban S, Toth J, Varga D: Experimental measurement of the surface excitation parameters of Cu, Au, Ni, Ag, Ge and Pd based on Si and other reference standard materials. SURF. INTERFACE ANAL. 36, 1098-1101 (2004)
44. Gergely G, Menyhard M, Sulyok A, Orosz T, Lesiak B, Jablonski A, Toth J, Varga D: Surface excitation of selected conducting polymers studied by elastic peak electron spectroscopy (EPES) and reflection energy loss spectroscopy (REELS). SURF. INTERFACE ANAL, 36, 1056-1059 (2004)
45. Gergely G, Ádám J: Si alapanyag és kristály kifejlesztése hazánkban, In: A magyar elektronikai ipar múlt és jelen, (Ed. Mojzes I), Műegyetem Kiadó, 2004, pp 23-34
46. Gergely G: A hazai félvezeto fizika elso 10 éve, 1954-1963. In: A magyar elektronikai ipar múlt és jelen. (Ed. Mojzes I), Műegyetem Kiadó, 2004, pp 15-22
47. Gergely G: Szigeti György öröksége. Szigeti György és Bay Zoltán-megemlékezés Szigeti György halálának 25 évfordulójáról, FIZIKAI SZEMLE, 1, 25 (2004)

48. Gogova D, Kasic A, Larsson H, Hemmingsson C, Monemar B, Tuomisto F, Saarinen K, Dobos L, Pécz B, Gibart P, Beaumont B: Strain-free bulk-like GaN grown by hydride-vapor-phase-epitaxy on two-step epitaxial lateral overgrown GaN template, J. APPL. PHYS. 96(1), 799-806 (2004)
49. Gogova D, Kasic A, Larsson H, Pécz B, Yakimova R, Magnusson B, Monemar B, Tuomisto F, Saarinen K, Miskys C, Stutzmann M, Bundesmann C, Schubert M: Optical and structural characteristics of virtually unstrained bulk-like GaN, JPN. J. OF APPLIED PHYSICS, 43, 1264-1268 (2004)
50. Guczi L, Pető G, Beck A, Pászti, Z: Electronic structure and catalytic properties of transition metal nanoparticles: the effect of size reduction. TOPICS IN CATALYSIS. 29, 129 (2004)
51. Gyulai J, Jones KS, Petrik P: Radiation Damage and Annealing in Silicon, In: Ion Implantation Science and Technology, (Ed. Ziegler JF), Ion Implantation Technology Co., Edgewater, USA, 2004, pp 239-268
52. Gyulai J: Anyagtudomány és anyagmódosítás ionsugarakkal, Akadémiai székfoglaló, In: Székfoglalók a Magyar Tudományos Akadémián 1995-1998, (Ed. x x), MTA, 2004, pp 1-9
53. Gyulai J: Micro- and Nanotechn ology Revolution - Its Impact with Machine Industry, Proc. 11th Int. Conf. on Machine Design and Production, In: Proc. 11th Int. Conf. on Machine Design and Production, (Ed. x x), (UMTIK, Middle-East Technical Univertsity, Ankara, Turkey), 2004, pp 335-340
54. Gyulai J: Micro- and Nanotechnologies, Some Recent Improvements, In: Proc. Int. Conf. on Tools, (Eds Dudas I, Szabo O), Univ. of miskolc, 2004, pp 3-8
55. Gyulai J: Nanotechnológia, In: Mindentudás Egyeteme 3.kötet, (Eds Hitseker M, Szilagyi Z), Kossuth Kiadó, 2004, pp 235-249
56. Haraszti K: Elaboration of a Method for the Detection of Preconditions of Sudden Cardiac Death with the Help of Informatical Tools, In: Proceedings of the 2nd PhD Mini-Symposium June 21, (Ed. x x), Univ. of Veszprem, 2004, pp 25-27
57. Haraszti K: Noise-Reduction and Data-Compressing of BSPM Signals with the help of Synchronised Averaging, PERIODICA POLYTECHNICA SER. EL. ENG. 47(1-2), 115-123 (2004)
58. Hastas NA, Dimitriadis CA, Dozsa L, Gombia E, Mosca R: Investigation of single electron traps induced by InAs quantum dots in GaAs layers using low frequebcy noise technique, J. APPL. PHYS, 96, 5735-5739 (2004)
59. Hastas NA, Tassis DH, Dimitriadis CA, Dozsa L, Franchi S, Frigeri P: Electrical transport and low frequency noise characteristics of Au/n-GaAs Schotky diodes containing InAs quantum dots, SEMICONDUCTOR SCIENCE AND. TECHNOLOGY, 19, 461-467 (2004)
60. Hayashi K, Takayama H, Ishikawa M, Abo S, Lohner T, Takai M: TOF-RBS with medium energy heavy ion probe for semiconductor process analysis, NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION B-BEAM INTERACTIONS WITH MATERIALS AND ATOMS, 219(20), 589-592 (2004)
61. Horacsek O, Bartha L: Development of the bubble structure from selectively deforming potassium-pores in doped tungsten wires. INT. J. OF REFRACTORY METALS AND HARD MATERIALS. 22, 9-15 (2004)
62. Horacsek O, Bartha L: Effect of size-dependent pore-deformation on bubble structure of potassium-doped tungsten. In: Proc. of PM2004 World Congress on Powdes Metallurgy (EPMA) Vienna, (Eds Danninger H, Ratzi R), 2004, pp 783-789

63. Horányi T, Halász L, Pálinkás J, Németh Z: Relationship between optical and rheological properties of polymer-added lamellar liquid-crystalline systems, LANGMUIR, 20(5), 1639-1646 (2004)
64. Horányi T, Pálinkás J, Halász L, Németh Z: Lamellás folyadékkristályos rendszerek domén-rendeződési folyamatainak optikai és reológiai vizsgálata, OLAJ, SZAPPAN, KOZMETIKA, 4(53), 142-148 (2004)
65. Horvath ZJ, Adam M, Szabo I, Orlov LK, Potapov AV, Tolomasov VA: Electrical behaviour of Al/SiGe/Si heterostructures: Effect of surface treatment and dislocations, APPL. SURF. SCI., 234, 54-59 (2004)
66. Horvath ZJ, Dozsa L, Krafcsik O, Mohacsy T, Vida G: Electrical behaviour of Al/SiO2/Si structures with SiC nanocrystals, APPL. SURF. SCI. 234, 67-71 (2004)
67. Horvath ZJ, Orlov LK, Ivina NL, Demidov ES, Vdovin VI, Adam M, Szabo I, Dozsa, L, Pashaev EM, Ivanov YM, Yakunin SN: Effect of dislocations in relaxed MBE SiGe layers on the electrical behaviour of SiGe/Si heterostuctures Functional Materials, 11, 381-385, 2004. FUNCTIONAL MATERIALS, 11,, 381-385 (2004)
68. Horvath ZJ, Orlov LK, Rakovics V, Ivina NL, Toth AL, Demidov ES, Riesz F, Vdovin VI: Effect of crystal defects on the electrical behaviour of InP and SiGe epitaxial structures, EUR. PHYS. J. APPL. PHYS. 27, 189-192 (2004)
69. Horvath ZJ, Toth AL, Rakovics V, Paszti Z, Peto G: Crystal defects in epitaxial InP layers - electrical and scanning electron microscope study, FUNCTIONAL MATERIALS, 11, 376-380 (2004)
70. Horváth ZJ, Dücső C, Lohner T, Petrik P, Ádám M, Szentpáli B, Fried M: Silicon-rich silicon-nitride films on silicon: electrical and optical properties, In: Proc. Int. Conf. Silicon - News in Science and Technology, (Eds Jurecka S, Müllerová J, Jurecka S, Müllerová J), Podbanské, Slovakia, 2004, pp 40-44
71. Horváth ZJ, Elsawirki AIA, Varga S, Csontos L, Karányi J, Somogyi K: Low temperature metal-semiconductor interaction in Al/n-GaAs and Al/n-AlGaAs junctions, In: Proc. Fifth Int. Conf. on Advanced Semiconductor Devices and Microsystems, (Ed. x x), x, 2004, pp 95-98
72. Horváth ZJ, Molnár G, Dézsi I, Caymax, M, Loo R, Pető G: Erbium silicide on silicon-germanium: electrical behaviour, In: Proc. Int. Conf. Silicon - News in Science and Technology, (Eds Jurecka S, Müllerová J), Podbanské, Slovakia, 2004, pp 45-49
73. Horváth ZJ: Vertical electrical behaviour of silicon-based MS and MIS structures, In: Proc. Int. Conf. Silicon - News in Science and Technology, (Ed. Jurecka S), Podbanske, Slovakia, 2004, pp 32-39
74. Ichihara S, Nakagawa T, Nitta M, Abo S, Lohner T, Angelov C, Ohta K, Takai M: Characterisation of dopant profiles produced by ultra-shallow As implantation and spike annealing using medium energy ion scattering, NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION B-BEAM INTERACTIONS WITH MATERIALS AND ATOMS, 219(20), 584-588 (2004)
75. Jones KS, Gyulai J: Annealing of Implantation Damage in Silicon, In: Ion Implantation Science and Technology, (Ed. Ziegler JF), Ion Implantation Technology Co., Edgewater, USA, 2004, 2004, pp 269-302
76. Juhasz Z: Segmentation of Hungarian Folk Songs Using an Entropy-Based Learning System, JOURNAL OF NEW MUSIC RESEARCH, 33(1), 5-15 (2004)
77. Kawaji J, AsahiT T, Hashimoto H, Hokkyo J, Osaka T, Matsunuma S, Sáfrán G, Ariake J, Ouchi K: Microstructure and magnetic prperties of a Co/Pd multilayer

on a controlled Pd/Si seed layer for double-layered perpendicular magnetic recording media, J.APPL.PHYS. 95(12), 8023-8029 (2004)

78. Kádár G, Szabó Z, Vértesy G: Product Preisach model parameters from measured magnetisation curves, PHYSICA B, 343, 137 (2004)
79. Kádár G, Szabó Z: Magnetisation process as a combined function of field and temperature int he product model of hysteresis, J. MAGN. MAGN MATERIALS, 272-276, E547-549 (2004)
80. Keresztenyi Z, Santolin S, Laczko J: The Variability and Stability of Drawing Movements in Respect of Parkinson's Desease. In: Proceedings of the First Hungarian Conference on Biomechanics, (Ed. x x), x, 2004, pp 191-197
81. Király Z, Veisz B, Mastalir A: CS2 poisoning of size-selective cubooctahedral Pd particles in styrene hydrogenation, CATALYSIS LETTERS, 95, 57 (2004)
82. Kollar E, Székely V, Ádám M, Rencz M: Integrated heat-flux sensor array for the thermal in IC packages, In: Eurosensors XVIII, (Ed. Di NATALE C), 2004, pp 979-980
83. Kovács A, Sato K, Sáfrán G, Barna PB, Hirotsu Y: The investigation of multiply twinned L10-type Fe-Pt nanoparticles by transmission electron microscopy, PHILOSOPHICAL MAGAZINE, 84(20), 2075-2081 (2004)
84. Kovács GJ, Sáfrán G, Geszti O, Bertóti I, Radnóczi G: Structure and mechanical properties of carbon-nickel and CNx-Ni nanocomposite films, SURFACE AND COATINGS TECHNOLOGY, 180-181, 331-334 (2004)
85. Köhler T, Frauenheim T, Hajnal Z: Tubular structures of GaS, PHYSICAL REVIEW B, 69, 193403 (2004)
86. Kövér ZI, Roósz A: Application of the ESTPHAD method to Calculation of the Equilibrium Phase Diagram of Al-Fe Alloy System, In: Proceedings of the fourth conference on mechanical engineering vol.1, (Ed. x x), 2004, pp 111-115
87. Kulinyi S, Brandszájsz D, Amine H, Ádám M, Fürjes P, Bársony I, Dücső C: Olfactory detection of methane, propane-butane and hexane using conventional transmitter norms, In: Eurosensors XVIII, (Eds Di Natale C, 463), 2004, pp 463-464
88. Kulinyi S, Brandszájsz, D, Amine H, Ádám M, Fürjes P, Bársony I, Dücső: C: Integrated pellistors and heat conductivity sensors for olfactory detection of methane, propane-butane and hexane, In: Proceedings of Eurosensors XVIII, (Ed. Courtois B), 2004, pp 371-372
89. Kuthi EB: Crystalline silicon solar cells with selective emitter and the self-doping contact, HÍRADÁSTECHNIKA, 59(6), 21-31 (2004)
90. Kuthi EB: Szelektív emitteres kristályos napelemek és az önadalékoló kontaktus, HÍRADÁSTECHNIKA, 59(1), 31-42 (2004)
91. Lukács IE, Riesz F: Error analysis of Makyoh-topography surface height profile measurements, EUR. PHYS. J. - APPL. PHYS, 27(1-3), 385-388 (2004)
92. Makkai Z, Pécz B, Vida G, Deák P: TEM characterisation of epitaxial 3C-SiC grains on Si (100) and Si (111), In: IOP Conf. Proc. Ser., 180, (Eds Cullis G, Midgley PA), Inst. of Phys. Publ., 2004, pp 265-268
93. Makkai Z, Vida G, Josepovits KV, Pongrác A, Bársony I, Pécz B, Deák P: Electron Microscopy of SiC nanocrystals, In: European Microscopy Congress, (Ed. van Tendelouu G), 2004, pp 191
94. Márk G, Biró LP, Lambin P: CALCULATION OF AXIAL CHARGE SPREADING IN CARBON NANOTUBES AND NANOTUBE Y JUNCTIONS DURING STM MEASUREMENTS, VIRTUAL J. NANOSCI. TECHNOL.(ON-LINE, SELECTED) (HTTP://WWW.VJNANO.ORG), 10, x (2004)

95. Márk GI, Biró LP, Lambin P: CALCULATION OF AXIAL CHARGE SPREADING IN CARBON NANOTUBES AND NANOTUBE Y JUNCTIONS DURING STM MEASUREMENTS, PHYS. REV. B, 70, 115423-1-115423-11 (2004)
96. Márk GI, Biró LP, Tapasztó L, Mayer A, Lambin P: ATOMIC PSEUDOPOTENTIAL MODEL FOR WAVE PACKET TUNNELING THROUGH A CARBON NANOTUBE;, In: AIP Conference Proceedings Vol. 723, Electronic Properties of Synthetic Nanostructures: XVIII International Winterschool on Electronic Properties of Novel Materials, (Eds Kuzmany H, Fink M, Mehring M, Roth S), 2004, pp 389-392
97. Molnár G, Dózsa, L, Pető G G, Vértesy Z, Koós A, Horváth ZE, Zsoldos E: Thickness dependent aggregation of Fe-silicide island on Si substrate. THIN SOLID FILMS, 459, 48-52 (2004)
98. Morilla Y, García López J, Battistig G, Cantin JL, Cheang-Wong JC, von Bardeleben HJ, Respaldiza MA: RBS-Channeling and EPR Studies of Damage in 2 MeV Al2+-implanted 6H-SiC Substrates, MATERIALS SCIENCE FORUM, 483-485, 291 (2004)
99. Nagy JB, Bister G, Fonseca A, Méhn D, Kónya Z, Kiricsi I, Horváth ZE, Biró LP: ON THE GROWTH MECHANISM OF SINGLE-WALLED CARBON NANOTUBES BY CATALYTIC CARBON VAPOR DEPOSITION ON SUPPORTED METAL CATALYSTS, J. NANOSCIENCE AND NANOTECHNOLOGY, 4, 326-345 (2004)
100. Neidhardt J, Hultman L, Czigány Z: Correlated high resolution transmission electron microscopy and X-ray photoelectron spectroscopy studies of structured CNx ($0 < x < 0.25$) thin solid films, CARBON, 42(12-13), 2729-2734 (2004)
101. Nemcsics A: A napelem Paradigmaváltás a technológiában; Természet Világa 135. évf. 9. sz. (2004) 420-422, TERMÉSZET VILÁGA, 135(9), 420-422 (2004)
102. Nemcsics A: Growth Information Carried by ReflectionHigh-Energy Electron Diffraction,;, In: Proc of. Int. Adv. Res. Workshop on Quantum Dots: Fundamentals, applications and frontiers, (Ed. x x), 2004, pp 221-237
103. Németh A, Kövér L, Tóth J, Balázs J, Tóth AL, Lábadi Z: Deposition and characteristics of ZnO transparent contacts of CIGS solar cells, In: NATO-ASI Sozopol, (Ed. Sendova-Vassileva M), 2004, pp 48
104. Németh A, Lábadi Z: Problems and results of developing a multifunctional vacuum system for CIGS solar cell production, In: ISBN 80-01-02973-5, 2nd Intl. Workshop on teaching in photovoltaics, (Ed. Benda V), 2004, pp 73
105. Orlov LK, Horvath ZJ, Potapov AV, Orlov ML, Ivin SV, Vdovin VI, Steinman EA, Fomin VM: Electrical characteristics and the energy band diagram of the isotype n-Si1-xGex/n-Si heterojunction in relaxed structures, FIZIKA TVERDOGO TELA, 46, 2069-2075 (2004)
106. Orlov LK, Horváth ZJ, Potapov AV, Orlov ML, Ivin SV, Vdovin VI, Steinman EA: Electrical characteristics and the energy band diagram of the isotype n-Si1-xGex/n-Si heterojunction in relaxed structures, PHYS. SOLID STATE, 46, 2139-2145 (2004)
107. Orlov LK, Potapov AV, Orlov ML, Horvath ZJ, Steinman EA, Vdovin VI: Barrier properties of isotype relaxed n-Si1-xGex/Si heterojunction (in Russian), In: Proc. Conf. Nanofotonika, (Ed. x x), Nizhniy Novgorod, 2004, pp 145-148
108. Orosz TG, Gergely G, Menyhard M, Toth J, Varga D, Lesiak B, Jablonski A: Hydrogen and surface excitation in electron spectra of polyethylene. SURF. SCI. 566-568, 544-548 (2004)

109. Osvald J, Horvath ZJ: Theoretical study of the temperature dependence of electrical characteristics of Schottky diodes with an inverse near-surface layer, APPL. SURF. SCI, 234, 349-354 (2004)
110. Osváth Z, Vértesy G, Pető G, Szabó, I, Gyulai J, Maser W, Biró LP: STM INVESTIGATION OF IRRADIATED CARBON NANOTUBES, In: AIP Conference Proceedings Vol. 723 Electronic Properties of Synthetic Nanostructures: XVIII International Winterschool on Electronic Properties of Novel Materials, (Eds Kuzmany H, Fink J, Mehring M, Roth S), 2004, pp 149-152
111. Palmquist JP, Czigány Z, Oden M, Neidhardt J, Hultman L, Jansson U: Corrigendum to 'Magnetron sputtered W-C films with C-60 as carbon source' (vol 444, pg 29, 2003), THIN SOLID FILMS, 457(2), 406 (2004)
112. Pauleau Y, Thiery F, Barna PB, Misjak F, Kovacs A, Dub SN, Uglov VV, Kulesov AK: Nanostructured copper/hydrogenated amorphous carbon composite films prepared by microwave plasma-assisted deposition process from acetylene-argon gas mixtures, RED.ADV.MATER.SCI. 6, 140-149 (2004)
113. Pálfalvi JK, Akatov YU, Szabó J, Sajó-Bohus L, Eördögh i: Evaluation of SSNTD Stacks Exposed on the ISS, RADIATION PROTECTION DOSIMETRY, 110(1-4), 393-397 (2004)
114. Pávó J, Gasparics A, Sebestyén I, Vértesy G: Calibration of Fluxset sensors for the measurement of spatially inhomogeneous magnetic fields, SENSORS AND ACTUATORS A-PHYSICAL, 110, 105-111 (2004)
115. Petrik P, Cayrel F, Fried M, Polgár O, Lohner T, Vincent L, Alquier D, Gyulai J: Depth distribution of disorder and cavities in helium implanted silicon characterised by spectroscopic ellipsometry, THIN SOLID FILM, 455-456C, 344-348 (2004)
116. Petrik P, Shaaban ER, Lohner T, Battistig G, Fried M, Polgár O, Gyulai J: Ion implantation-caused damage in SiC measured by spectroscopic ellipsometry, THIN SOLID FILMS, 455-456C, 239-243 (2004)
117. Pécz B, Tóth L, Dobos L, Szuts T, Heera V, Skorupa W, Dekorsy T: TEM study of GaAs implanted with high dose nitrogen ions, In: Thirteenth International Conference on Microscopy of Semiconducting Materials, Churchill College, University of Cambridge. IOP Conf. Proc. Ser., 180, (Eds Cullis AG, Midgley PA), IOP, 2004, pp 441-444
118. Pécz B: Bookreview on Physical methods for materials characterisation by P.E.J. Flewitt and R.K. Wild, CONTEMPORARY PHYSICS, 45, 531-532 (2004)
119. Polgar O, Fried M x, Lohner T, Barsony I: Evaluation of ellipsometric Measurements uing complex strategies, THIN SOLID FILMS, 455-456C, 95-100 (2004)
120. Poperenko LV, Essam Ramadan Shaaban x, Khánh NQ, Stashchuk VS, Vinnichenko MV, Yurgelevich IV, Nosach DV, Lohner T: Effect of ion irradiation on the optical properties and room temperature oxidation of copper surface, THIN SOLID FILMS, 455-456, 453-456 (2004)
121. Pota S, Kosztyan ZT: Implementation of Deterministic and Stochastic Optimal Resource Allocation, In: Proc. microCAD 2004, (Eds Lehocky L, Kalmar L), 2004, pp 365-370
122. Pota S: Toward New Requirements in Grid Computing, In: Proc. 2nd PhD Mini-Symposium, IEEE Hungary Section, (Ed. x x), 2004, pp 63-65
123. Póta S, Sipos G, Juhasz Z, Kacsuk P: Parallel Program Execution in the JGrid System, In: Proc. 5th Austrian-Hungarian Workshop on Distributed and Parallel Systems, Vol. 777, (Ed. Juhasz Z), 2004, pp 13-20

124. Pődör B, Kovács G, Remenyi G, Savel`ev IG: Non-universal scaling in the integer qunatum Hall effect in InGaAs/InP heterostructures, In: Proc. Int. Conf. Micro- and Nanoelectronics, Vol. 5401, (Eds Valiev KA, Orlikovsky AA), SPIE Proceedings, 2004, pp 386-391
125. Pődör B, Kovács G, Reményi G: Experimental study of the plateau-to-plateau transitions in the integral quantum Hall effect in InGaAs/InP heterostructures, In: Proc. Int. Conf. Advanced Semiconductor Devices and Microsystems, (Eds Osvald J, Hascik S), 2004, pp 107-110
126. Pődör B: Native acceptors in GaSb: Thermal ionisation energy and hole scattering on space charge regions, In: Proc. Int. Conf. Advanced Semiconductor Devices and Microsystems, (Ed. Osvald J), 2004, pp 49-52
127. Pődör B: Temperature scaling in the integer quantum Hall regime: Experimental studies, In: Proc. Int. Winter School on the Physics of Semiconductors, (Ed. x x), 2004, pp 21-29
128. Radnóczi G, Kovács GJ, Sáfrán G, Sedlácková K, Geszti O, Ujvári T, Bertóti I: Structure and properties of carbon/Ni and CNx/Ni nanocomposite films, In: Proc. Nanotechnology in Research and Application, (Ed. Horvath I), 2004, pp 23-24
129. Radnóczi G, Kovács GJ, Sáfrán G, Sedlácková K, Geszti O, Ujvári T, Bertóti: I: Structure and properties of carbon based nanocomposite films, In: Metallic Materials with High Structural Efficiency, (Eds Senkov ON, Miracle, DB, Firstov SA), Kluwer Acad.Publ, 2004, pp 101-112
130. Rakovics V, Serényi M, Püspöki S: Single-step growth of InGaAsP/InP laser array on structured InP substrate, PHYSICA E, 23, 334-338 (2004)
131. Ravasz M, Szabó G, Szolnoki A: Spreading of families in cyclic predator-prey models, PHYS. REV. E, 70, 012901 (2004)
132. Riesz F: Makyoh topography: a simple yet powerful optical method for flatness and defect characterisation of mirror-like surfaces, In: Proc. SPIE 5458,Photonics Europe, (Ed. x x), SPIE, 2004, pp 86-100
133. Ryć L, Dubecký F, Kozłowska A, Krása J, Králikowá B, Pfeifer M, Parys P, Pura P, Riesz F, Rohlena K, Skála J, Ullschmied J: Fast MSM InP detectors for measurement of X-ray emission from laser plasmas, In: Proc. 5th Int. Conf. Advanced Semiconductor Devices and Microsystems, (Eds Osvald, S. Hascik J, Hascik S), 2004, pp 183-186
134. Schiller R, Battistig G, Rabani J: Reversible electrochemical coloration of indium tin oxide (ITO) in aqueous solutions, RADIATION PHYSICS AND CHEMISTRY, 72, 217 (2004)
135. Schmidt C, Petrik P, Schneider C, Fried M, Lohner T, Bársony I, Gyulai J, Rissel H: Optical characterisation of ferroelectric Strontium-Bismuth-Tantalate (SBT) thin films, THIN SOLID FILMS, 455-456C, 459-499 (2004)
136. Serenyi M, Frigeri C: Investigation of silicon oxynitride and amorphous silicon multilayers, EUROPEAN PHYSICAL JOURNAL-APPLIED PHYSICS, 27(1-3), 329-332 (2004)
137. Shapaan M, Bardos A, Lábár J, Lendvai J, Varga LK: Thermal stability and glass forming ability of cast iron based CiP(x)B(4.35) bulk amorphous alloys, PHYS. STAT. SOL. A-APPL. RES. 201(3), 476-481 (2004)
138. Shapaan M, Lábár J, Varga LK, Lendvai J: Glass-forming ability and thermal stability of Fe62Nb8-xZrxB30 and Fe72Zr8B20 amorphous alloys, CENTRAL EUROPEAN J OF PHYSICS, 2(1), 104-119 (2004)

139. Shapaan M, Lábár JL, Lendvai J, Varga LK: Crystallisation behavior of Fe62Nb8-xZrxB30 bulk amorphous alloy, MATERIALS SCIENCE AND ENGINEERING A, 375-77, 789-793 (2004)
140. Simdyankin SI, Elliott SR, Hajnal Z, Niehaus TA: Simulation of physical properties of the chalcogenide glass As2S3 using a density-functional-based tight-binding method, PHYSICAL REVIEW B, 69, 14402 (2004)
141. Son NT, Magnusson B, Zolnai Z, Ellison E, Janzén E: Defects in high-purity semi-insulating SiC, MATERIALS SCIENCE FORUM, 457-460, 437-442 (2004)
142. Süle P, Menyhárd M, Nordlund K: Cooperative mixing induced surface roughening in bilayer metals: a possible novel surface damage mechanism, NUCLEAR INSTRUMENTS AND METHODS IN PHYSICS RES.. B222, 525 (2004)
143. Süle P, Menyhárd M, Nordlund K: What is the real driving force of bilayer ion beam mixing? NUCLEAR INSTRUMENTS AND METHODS IN PHYSICS RES. B226, 517 (2004)
144. Szabó A, Fonseca A, Volodin A, Van Haesendonck C, Biró LP, Nagy JB: SYNTHESIS, PROPERTIES AND POSSIBLE APPLICATIONS OF HELICAL CARBON NANOTUBES. In: XVIIIth International Winterschool on Electronic Properties of Novel Materials, (Eds Kuzmany H, Fink J, Mehring M, Roth S), American Institute of Physics CP 723, 2004, pp 40-44
145. Szabó G, Sznaider GA: Phase transition and selection in a four-species cyclic predator-prey model, PHYS. REV. E, 69, 031911 (2004)
146. Szabó G, Szolnoki A, Izsák R: Rock-scissors-paper game on regular small-world networks, J. PHYS. A: MATH. GEN. 37, 2599-2609 (2004)
147. Szabó G, Vukov J: Cooperation for volunteering and partially random partnerships, PHYS. REV. E, 69, 036107 (2004)
148. Szabó Z, Tugyi I, Kádár G: Identification procedures for Scalar Preisach Model, PHYSICA B, 343, 142 (2004)
149. Szegedi A, Kónya Z, Méhn D, Solymár E, Pál-Borbély G, Horváth ZE, Biró LP, Kiricsi I: SPHERICAL MESOPOROUS MCM-41 MATERIALS CONTAINING TRANSITION METALS: SYNTHESIS AND CHARACTERISATION, APPLIED CATALYSIS A: GENERAL, 272, 257-266 (2004)
150. Szegedi A, Pál-Borbély G, Meretei E, Kónya Z, Horváth ZE, Biró LP, Kiricsi I: SYNTHESIS AND CHARACTERISATION OF SPHERICAL MESOPOROUS MCM-41 MATERIALS CONTAINING TRANSITION METALS, In: Proceedings: 14th International Zeolite Conference, (Ed. van Steen E), 2004, pp 813-819
151. Szentpáli B, Mohácsy T, Bársony: I: Anomalous Bias Dependence of the Noise in Porous Si LED, FLUCTUATION AND NOISE LETTERS, 4, L355-L364 (2004)
152. Szentpáli B, Rakovics V: Noise in PbS IR Photoconductors, In: Proceedings of SPIE Vol. 5472 Noise and information in Nanoelectronics, Sensors and Standards II, (Eds Smulko JM, Blanter Y, Dykman MI, Kish LB), 2004, pp 367-374
153. Szentpáli B: Metamaterials and their Microwave Applications, In: Asia Pacific Microwave Conference 2004, (APMC'04), (Ed. x x), 2004, pp 302
154. Szentpáli B: Noise in solid-state sensors, In: Proceedings of SPIE Vol. 5472 Noise and information in Nanoelectronics, Sensors and Standards II, (Eds Smulko JM, Blanter Y, Dykman MI, Kish LB), 2004, pp 131-142
155. Szolnoki A, Szabó G: Phase transitions for rock-scissors-paper game on different networks, PHYS. REV. E, 70, 037102 (2004)
156. Szolnoki A, Szabó G: Vertex dynamics during domain growth in three-state models, PHYS. REV. E, 70, 027101 (2004)

157. Szucs B, Hajnal Z, Scholz R, Sanna S, Frauenheim T: Theoretical study of the adsorption of a PTCDA monolayer on S-passivated GaAs(100), APPLIED SURFACE SCIENCE, 234, 173-177 (2004)
158. Trimaille I, Ganem JJ, Vickridge IC, Rigo S, Battistig G, Szilagyi E, Baumvol IJ, Radtke C, Stedle FC: Thermal oxidation of 6H SiC studied by oxygen isotopic tracing and naroee nuclear resonance profiling, NUCLEAR INSTRUMENTS AND METHODS, B219-220, 914 (2004)
159. Ujvári T, Tóth A, Kovács G, Sáfrán G, Geszti O, Radnóczi G, Bertóti I: Composition, Structure and Mechanical Property Analysis of DC Sputtered C-Ni and CNx-Ni Nanocomposite Layers, SURFACE AND INTERFACE ANALYSIS, 36(8), 760-764 (2004)
160. Vázsonyi E, Vértesy Z, Tóth A, Szlufcik J: Anisotropic etching of silicon in a two component alkaline solution, JOURNAL OF MICROMECHANICS AND MICROENGINEERING, 13, 165-169 (2004)
161. Vázsonyi E, Ádám M, Dücső C, Vízváry Z, Tóth AL, Bársony I: Three-dimensional force sensor by novel alkaline etching technique Eurosensors XVIII, In: Eurosensors XVIII, (Ed. Di Natale C), 2004, pp 568-569
162. Veisz B, Pécz B: Polarity dependent Al-Ti contacts to 6H-SiC, APPLIED SURFACE SCIENCE, 233, 360 (2004)
163. Végso B, Balázs G, Kozmann g: Intelligens Kardiológiai Távmonitorozó Rendszer, IME, III, 8 (2004)
164. Vértesy G, Mészáros I, Tomáš I: Non-destructive indication of plastic deformation of cold-rolled stainless steel by magnetic minor loops measurement, J. MAGN. MAGN. MATER. 285(3), 335-342 (2004)
165. Vértesy G, Tomáš I: Coercive properties of epitaxial magnetic garnet films after heat treatment in reducing atmosphere, PHYS. STAT. SOL. (A), 1, 1800-1804 (2004)
166. Vértesy Z, Bálint Z, Kertész K, Méhn D, Kiricsi I, Lousse V, Vigneron JP, Biró LP: Modifications of wing scale microstructures in lycaenid butterflies, MICROSCOPY AND ANALYSIS, 18(4), 25-27 (2004)
167. Vértesy Z, Veress E, Mihailescu G, Pruneanu S, Biró LP: Scanning Electron Microscopy study of undoped and metal doped anodic porous alumina membranes, STUDIA UNIVERSITATIS BABES-BOLYAI CHEMIA, XLIX,(1), 149-154 (2004)
168. Vízváry, Z, Volk J, Dücső C: Elasticity modulus measurement of silicon-nitride, In: Proceedings of Fourth Conference on Mechanical Engineering, (Eds Penninger A, Kullmann L, Vörös G), BMGE, ISBN 963 214 748 0, 2004, pp 215-219
169. Volk J, Balázs, J, Tóth AL, Bársony i: Porous silicon multilayers for sensing by tuneable IR-transmission filtering, SENSORS & ACTUATORS: B, 100, 163 (2004)
170. Volk J, Fried M, Tóth AL, Bársony I: The ideal vehicle for optical model development: porous silicon multilayers, THIN SOLID FILMS, 455-456, 535 (2004)
171. Weishart H, Heera V, Eichhorn F, Pécz B, Toth L, Skorupa W: Diamond formation by carbon implantation into cubic silicon carbide, DIAMOND AND RELATED MATERIALS, 13, 627-632 (2004)
172. Wrotek, S, Morawski A, Tkaczyk Z, Mąkosa A, Wosiński T, Dybko K, Łusakowska E, Story T, Yu. Sipatov A, Pecz B, Grasza K, Szczerbakow A, Wróbel J: Fabrication and Electrical Characterisation of PbS--EuS Ferromagnetic Semiconductor Microstructure, ACTA PHYSICA POLONICA A, 105, 615-620 (2004)

173. Yastrubchak O, Wosinski T, Domagata JZ, Lusakowska E, Figielski T, Pecz B, Toth AL: Misfit strain anisotropy in partially relaxed lattice-mismatched InGaAs/GaAs heterostructures, J.OF PHYSICS-CONDENSED MATTER, 16(2), S1-S8 (2004)
174. Yastrubchak O, Wosinski T, Lusakowska E, Figielski T, Toth AL: Misfit-dislocation induced surface morphology of InGaAs/GaAs heterostructures, MICROCHIMICA ACTA, 145(1-4), 267-270 (2004)
175. Zelenáková A, Kollár P, Kuźminski M, Vértesy Z, Rieheman W: Magnetic properties and domain structure investigation of laser treated Finemet, J. MAGN. MAGN. MAT. 254-255, 152-154 (2004)
176. Zolnai Z, Son NT, Hallin C: Annealing behavior of the carbon vacancy in electron-irradiated 4H-SiC, JOURNAL OF APPLIED PHYSICS, 96(4), 2406-2408 (2004)
177. Zolnai Z, Son NT, Magnusson B, Hallin BC, Janzén E: Annealing behaviour of vacancy- and antisite-related defects in electron-irradiated 4H-SiC, MATERIALS SCIENCE FORUM, 457-760, 473-476 (2004)
178. Zolnai Z, Ster A, Khánh NQ, Kótai E, Posselt M, Battistig G, Lohner T, Gyulai J: Ion Beam Analysis and Computer Simulation of Damage Accumulation in Nitrogen Implanted 6H-SiC: Effects of Channeling, MATERIALS SCIENCE FORUM, 483-485, 637-640 (2004)
179. Ódor G: Critical behavior of the two-dimensional 2A -> 3A, 4A -> 0 binary system. PHYS. REV. E, 70, 026119 (2004)
180. Ódor G: Phase transitions of the binary production 2A->3A, 4A->0 model, PHYS. REV. E, 69, 036112 (2004)
181. Ódor G: Role of diffusion in branching and annihilation random walk models, PHYS. REV. E, 70, 066122 (2004)
182. Ódor G: Universality classes in nonequilibrium lattice systems, REV. MOD. PHYS. 76, 663 (2004)