Institute of Scientific Instruments

ISI ASCR

Academy of Sciences of the Czech Republic

1999–2003

ISBN 80-239-3103-2

I.

Preface

It has become something of a tradition for voluntarily assembled human communities to summarize the experience of their common lives in yearbooks issued in a periodicity proportional to their viability. This does not just concern clubs engaged in amateur and hobby activities – many scientific societies and even scientific institutions produce such yearbooks – though they do not seem to have become so popular in the Czech Republic. Czech scientists, preoccupied with a continual hunt for scientometric trophies, would rather avoid compiling brochures restricted to a horizon not exceeding one institution. In any case, in the course of writing proposals for tiny grants and reports about them, they hardly get round to doing the proper scientific work. Reporting on results strongly dominates their achievement, and each additional penny coming into science brings with it a new version of a bureaucratic machine dealing with the distribution of funds and requiring scientists to write further scientometrically worthless texts. Still, the pamphlet is here as a by-product of evaluation of the institute.

It should be left to science historians to discover the origins and roots of the evaluation of scientists (being, unlike any other profession, performed even when no promotion is at question) and their groups, and perhaps to sociologists to explain why this phenomenon has spread so widely. In the background one might even feel distrust and suspicion from subjects unable to understand what is happening within the scientific community and believing that scientists should be forced to explain in detail what they are going to explore and how they are going to proceed. In this way the danger of the uncontrolled word-supremacy of some maniacal scientist or other is meant to be eliminated, though more realistically scientists will be prevented from becoming too much for the politicians. Intelligence used to be defined as the ability to adapt oneself to varying environments, and who should be intelligent if not scientists. So we write proposals and reports, pass certification procedures and, along with our entire institutes, invest huge efforts into assembling piles of materials summarizing every important activity within the period of evaluation. Fortunately enough, this period has recently been set as no less than six years. And when all these data have been collected and processed, it really is worth while preparing a reasonably detailed extract from them and adding a few short abstracts, as understandable as possible, describing individual interesting results achieved within the period in question.

The institute's evaluation will be performed by a board nominated for this purpose and equipped with extremely serious rules of procedure and criteria of assessment. For those going to be evaluated it remains only to wait for the verdict. Still, it is surely the right of the institute's director to have and communicate his personal opinion in this respect. And this opinion is that the Institute of Scientific Instruments of the Academy of Sciences of the Czech Republic is sound, vivid, creative and has good prospects. The evidence for this is collected hereinafter, and one should not overlook the high rate of success in grant tenders, the extremely high number of postgraduate students, intensive collaboration with renowned foreign figures and institutions, engagement in all relevant national programmes, projects and activities, and plenty of various items of recognition from international as well as national scientific communities. And, of course, a respectable set of noteworthy results. This brochure is being finished only days before the country enters the European Union. For many this step will bring significant changes and stresses. Scientists entered Europe and the whole world immediately after the iron curtain disappeared, and have nothing to fear. Access to scientific programmes supported by the EU was also granted to Czech scientists years ago. Still, with the position of a full EU member we will acquire closer contacts and broader possibilities to participate in common European efforts. Indeed, quite recently ISI scientists have joined multiple European projects, including those of the Sixth Research Framework Programme, and the overall success rate is clearly growing.

This brochure represents a review of the institute's past life, although the materials submitted to the evaluation also represent the research plan for the next six years. I am fully convinced that this plan is ambitious but feasible, and wish all of us at ISI much success in fulfilling this plan, or even better, in achieving goals still more glorious than those, which can only be seriously anticipated from the present status of knowledge.

18 April 2004

Luděk Frank
Director of ISI ASCR

Contents

I

History

The Institute of Scientific Instruments (ISI) was established in 1957 as an institution providing instrumental equipment for other institutes of the Academy of Sciences in many areas. In the beginning the institute had 83 employees, though this number gradually increased to 240. During the process of transformation of the Academy of Sciences, which began in 1989, only the most promising branches of scientific research were supported at the institute. Consequently, the number of employees was reduced to 95 working full time. The structure of the scientific departments of the institute was also changed, so that it gained from the research activities of the projects solved by the research teams. The teams dealing with related problems are organised into departments.

The Department of Electron Optics

The history of electron optics (ELO) at the Institute of Scientific Instruments was shaped by personalities, whose scientific career had begun during their studies. The students of Prof. A. Bláha – A. Delong, V. Drahoš and L. Zobač – built the first prototype electron microscope in this country, and followed this with the first serially produced instrument (the BS 241). At that time electron microscopes were built in only three countries in the world. In 1954 a functional model of a desktop electron microscope (the Tesla BS 242) was built and it won the Gold Medal at EXPO 1958. Over 1000 of these instruments were produced over a period of 20 years and exported to 20 countries.

The branch electron microscopy developed significantly in the sixties thanks to the then director Prof. A. Delong and the head of the department of electron optics Prof. V. Drahoš. Unique transmission, emission and scanning electron microscopes were built and, at the same time, the problems of highly stabile current and high voltage sources, problems of vacuum and, subsequently, ultra-high vacuum and analysis of residual gases were resolved. In 1962 the first experiments with electron interferences anywhere in the world were carried out at ISI and were soon applied to various cases. The development and realization of an instrument for electron beam welding was necessary for the construction of ultra-high vacuum devices, and such a device was first realized at the Institute of Scientific Instruments in 1968. The technology of membrane (welded) bellows subsequently proved to be an interesting application. One of the successful transmission microscopes developed in ELO was the TEM TESLA BS 413 microscope with a resolution of up to 0.6 nm and accelerating voltage up to 100 kV, of which 400 were produced by the company TESLA Brno to the end of 1975. At that time non-conventional forms of electron microscopy were also developed, e.g. interference, shadow, Lorentz and tunnel emission microscopy, as well as diffraction under small angles. The first experiments in the world and application possibilities of low-energy electron diffraction were demonstrated with the newly developed ISI electron microscope and were published by A. Delong and V. Drahoš in the journal Nature (1971). The end of the sixties was significant for the achievement of an ultra-high vacuum of 10^{-6} Pa in the specimen chamber of the emission microscope, which was preceded by the development of a vacuum technique and technology of electron beam welding.

This department also focused on calculations of the magnetic field of lenses and computation of electrons trajectories. Since 1973 the method of finite elements has been exploited for computation of electrostatic and magnetic rotation symmetric lenses. At that time more complex computations were very problematic, as ISI did not own a computer. Computing possibilities did not improve until the nineteen eighties. Regular visits by Professor T. Mulvey from the University of Aston, Birmingham, contributed significantly to the development of this branch and contacts with foreign laboratories.

In the middle of the nineteen seventies a team was established, which produced an Auger electron spectrometer in connection with a newly developed scanning electron microscope with a field-emission gun, subsequently produced as the TESLA BS 350. The development of an electron lithograph working with a field-emission gun began at the end of the nineteen seventies. A small series of this instrument was produced by the company TESLA Brno. The device is presently used for research into lithographical techniques in the production of holographic and diffraction structures and for testing preparations for the purposes of microscopy and micro-analysis. The development of new scintillation and cathodoluminescence screens began in the seventies. The introduction of a single crystal of YAG (Yttrium-aluminium-garnet) proved to be a particularly significant success within the scope of these efforts. The detectors based on this principle have become established around the world. In the area of thin layers a world first was achieved by the creation of a multi-layer x-ray mirror with resonance absorption, serving as an analyser during x-ray imaging of biological preparations by phase contrast in the dark field. Unique results in microscopy and diffraction by very slow electrons in scanning electron microscope have recently been presented. Software for electron optics is now improving at an extraordinary rate thanks to the development of information technology. Work in the field of environmental electron microscopy is also proving extremely successful, especially in the area of electron detection in the environment of higher gas pressure.

The Department of Nuclear Magnetic Resonance

The Nuclear Magnetic Resonance (NMR) Department at ISI was founded in 1960 by J. Dadok, the constructor of the first ISI spectrometer working at a frequency of 30 MHz. The industrial production of spectrometers at TESLA Brno began in 1966. This was the only production of its kind in any of the Eastern European countries and continued for 25 years. These spectrometers were an extremely successful export article and several hundred of various types were produced, based on the R&D provided by ISI.

In 1967 a laboratory for low-temperature technology oriented towards the R&D of super-conducting magnets for NMR was established by J. Jelínek. After J. Dadok's emigration the department was led by K. Švéda and later (until 1990) by Z. Starčuk. In the 1970s the department began to deal with more methodological problems, for example Fourier pulse spectrometry, under the supervision of Z. Starčuk and V. Sklenář. The most significant achievements included a number of firsts in the field of NMR experiment methodology. The institute's specialists also achieved many original results in the fields of design and generation of magnetic fields in general, data processing and experiment control, spectrometer electronics, etc.

After 1990, when the production of NMR spectrometers at Tesla Brno ceased, the department was led by M. Kasal until 2002. The ongoing work has been carried out by several teams, focusing on the development of progressive electronic modules, radiofrequency and gradient coils for NMR spectrometers and tomographs, solving the problems related to NMR experiment control, data acquisition and processing in both spectroscopy and imaging, and on further methodological development, mainly oriented towards in vivo spectroscopy. Non-negligible research capacity was devoted to problems in cryogenics and the processing of biomedical signals.

The Department of Coherence Optics

The Department of Coherence Optics (former Quantum Generators of Light) was founded on the basis of the former Section of Infrared Spectroscopy at ISI shortly after the invention of lasers. F. Petrů was its head until 1999. At the beginning of 1960s the department was still focused on the field of infrared spectrophotometry, but had already started work on manufacturing the first lasers in both solid and gaseous states. The department's staff was successful in both directions. A pulse laser was put into operation in 1964 and a machine for drilling diamonds was developed on its basis. This direction was subsequently abandoned, and the technology of He-Ne lasers and related problems of reaching population inversion in neon became the focus of the department's effort. Results came extremely quickly, as no longer than six months after this work began in 1963 a stimulated emission at a wavelength of 1.15 nm was recorded, and shortly afterwards emissions at 3.39 mm and 633 nm obtained. An He-Ne laser working at a wavelength of 633 nm had already existed for two years and the technology of its production had not been published at that time. After being quickly put into production three types of lasers of different powers were displayed at the Brno Trade Fair in 1964 by their producer Meopta Přerov. Since 1967 the exact measurement of geometrical quantities by means of interference methods has been the main focus of the department. A frequency stabilized single-mode He-Ne laser was developed and formed the basis for the Czechoslovak laser sub-normal of lengths which was used by the metrological institutions of this country in the 1970s. Another achievement was the compact transferable and modular interferometric system (LIMS) that was designed for mechanical engineering and had several new functional possibilities – length measurement up to three axes, measurement of speeds, flatness, small angles with the possibility of correction to the air refractive index. In 1981–1982 a precise laser interferometric system was constructed. It measured the position in two coordinates with an accuracy of 40 nm as well as speed. From 1984 the department focused on the development of He-Ne lasers stabilized by the use of saturated absorption in iodine vapours, increasing the accuracy of interferometric systems, two-colour and absolute interferometry.

In 1995 J. Lazar, P. Zemánek and O. Číp focused on the use of semiconductor diodes in metrology, and in particular on increasing their coherence, frequency stabilization, and interferometric systems with a tuneable laser source. These results were recently used by F. Petrů for a new type of laser refractometre. In 1995 P. Zemánek established a new direction for the department exploiting focused laser beams for manipulation with nano- and micro-objects or microablation. Gradually new types of optical traps were developed, together with methods of measurement of pN forces, micro-particle sorting and laser induced fusion of living cells.

II
About the Institute

Director:	**Luděk Frank, M.Sc., Ph.D., D.Sc. (2001–present)** Professor Rudolf Autrata, M.Eng, Ph.D., D.Sc. (1999–2001)
Deputy Director:	**Assoc. Professor Pavel Zemánek, M.Sc., Ph.D. (2001–present)**
Deputy Director for Science:	Luděk Frank, M.Sc., Ph.D., D.Sc. (1999–2001)
Deputy Director for Economics:	Jan Slaměník, M.Eng., Ph.D. (1999–2001)

Heads of the Departments

Department of Electron Optics:	**Ilona Müllerová, M.Eng., Ph.D., D.Sc. (1999–present)**
Department of Coherence Optics:	**Josef Lazar, M.Eng., Ph.D. (2003–present)** Assoc. Professor Pavel Zemánek, M.Sc., Ph.D. (1999–2003)
Department of Nuclear Magnetic Resonance:	**Zenon Starčuk, jr., M.Eng., Ph.D. (2002–present)** Assoc. Professor Miroslav Kasal, M.Eng., Ph.D. (1999–2002)
Economic Administration:	**Pavel Furch, M.Eng (2001–present)** Jan Slaměník, M.Eng., Ph.D. (1999–2001)
Information System:	**Miroslav Lýčka, M.Sc. (2003–present)** Jan Slaměník, M.Eng., Ph.D. (1999–2003)
Library:	**Miluše Lángová (2002–present)** Jan Slaměník, M.Eng., Ph.D. (1999–2002)

Centre of Technical Services

Workshop:	**Václav Novák (1999–present)**
Housekeeping:	**Bedřich Coufal (1999–present)**

Scientific Council

Chairman:	**Josef Lazar, M.Eng., Ph.D. (2003–present)** Jaroslav Sobota, M.Eng., Ph.D. (2000–2003) Aleš Gottvald, M.Eng., Ph.D. (1999–2000)
Deputy Chairman:	**Jaroslav Sobota, M.Eng., Ph.D. (2003–present)** Josef Lazar, M.Eng, Ph.D. (2001–2003) Assoc. Professor Pavel Zemánek, M.Sc, Ph.D. (2000–2001) Jaroslav Sobota, M.Eng., Ph.D. (1999–2000)
Secretary:	**Zenon Starčuk, jr., M.Eng., Ph.D. (2001–present)** Josef Lazar, M.Eng, Ph.D. (1999–2001)

Internal members:	**Ondřej Číp, M.Eng., Ph.D. (2003–present)** **Miroslav Horáček, M.Eng., Ph.D. (2003–present)** **Pavel Jurák, M.Eng., Ph.D. (2001–present)** **Josef Lazar, M.Eng., Ph.D. (2000–present)** **Assoc. Professor Bohumila Lencová, M.Sc., Ph.D. (2000–present)** **Ilona Müllerová, M.Eng., Ph.D., D.Sc. (2000–present)** **Jaroslav Sobota, M.Eng., Ph.D. (2000–present)** **Aleš Srnka, M.Eng., Ph.D. (1999–present)** **Zenon Starčuk, jr., M.Eng., Ph.D. (2000–present)** **Assoc. Professor Pavel Zemánek, M.Sc., Ph.D. (1999–present)** Karel Bartušek, M.Eng., Ph.D., D.Sc. (1999–2000) Jan Dupák, M.Eng., Ph.D. (1999–2003) Luděk Frank, M.Sc., Ph.D., D.Sc. (1999–2001) Assoc. Professor Miroslav Kasal, M.Eng., Ph.D. (1999–2003) Petr Schauer, M.Sc., Ph.D. (1999–2000)
External members:	**Assoc. Professor Radim Chmelík, M.Sc., Ph.D. (2003–present)** **Professor Jiří Jan, M.Eng., Ph.D. (1999–present)** **Professor Jan Janča, M.Sc., Ph.D., D.Sc. (1999–present)** **Vladimír Kolařík, M.Sc., Ph.D. (2000–present)** **Professor Radimír Vrba, M.Eng., Ph.D. (2003–present)** Professor Miroslav Liška, M.Sc., Ph.D., D.Sc. (1999–2003) Professor Jiří Pospíšil, M.Eng, Ph.D., D.Sc. (2000–2003) Professor Eduard Schmidt, M.Sc., Ph.D. (1999–2000) Professor Vladimír Sklenář, M.Sc., Ph.D., D.Sc. (1999–2000)

Scientific Departments

Department of Electron Optics

Ilona Müllerová, M.Eng., Ph.D., D.Sc.
43 employees, adjusted work capacity 26.09
Scientific teams:
- Environmental microscopy and detection of signal electrons
  Professor Rudolf Autrata, M.Eng., Ph.D., D.Sc.
- Scintillation and cathodoluminescent systems
  Petr Schauer, M.Sc., Ph.D.
- Electron-optical computer simulations
  Assoc. Professor Bohumila Lencová, M.Sc., Ph.D.
- Low energy electron microscopy
  Ilona Müllerová, M.Eng., Ph.D., D.Sc.
- New technologies
  Jan Dupák, M.Eng., Ph.D.
- Microlithographical technologies
  Vladimír Kolařík, M.Eng., Ph.D.
- Thin film and multilayer preparation and characterization
  Jaroslav Sobota, M.Eng., Ph.D.

Department of Coherence Optics

Josef Lazar, M.Eng., Ph.D.
20 employees, adjusted work capacity 14.00
Scientific teams:
- Gas lasers and laser interferometry
  František Petrů, M.Eng., Ph.D. D.Sc.
- Coherent semiconductor lasers and their application
  Josef Lazar, M.Eng., Ph.D.
- Optical micro-manipulation techniques
  Assoc. Professor Pavel Zemánek, M.Sc., Ph.D.

Department of Nuclear Magnetic Resonance

Zenon Starčuk, M.Eng., Ph.D.
29 employees, adjusted work capacity 22.24
Scientific teams:
- NMR methodology
  Zenon Starčuk, M.Eng., Ph.D., D.Sc.
- Computer simulation, processing, visualization and analysis of NMR data
  Zenon Starčuk, jr., M.Eng., Ph.D.,
- Generation of gradient magnetic fields
  Karel Bartušek, M.Eng., Ph.D., D.Sc.
- Electronics
  Assoc. Professor Miroslav Kasal, M.Eng., Ph.D.
- Data processing
  Josef Halámek, M.Eng., Ph.D.
- Measurement and data processing in medicine
  Pavel Jurák, M.Eng., Ph.D.
- Magnetic fields and superconductivity
  Aleš Srnka, M.Eng., Ph.D.
- Cryogenics
  Pavel Hanzelka M.Eng.
- Inverse and optimization methodologies
  Aleš Gottvald, M.Eng., Ph.D..

Notes:
- Scientific teams are functional but not organisational units – some members of staff participate in more than one team
- Important differences between numbers of employees and the adjusted work capacity in scientific departments follow from numerous partial jobs of postgraduate students and scientists emeriti.

Institute in Numbers

The research and development budget (in thousands of CZK)

Indicator	1999	2000	2001	2002	2003
Institutional support from the state budget[1]	25 627	28 412	30 376	37 468	42 155
Targeted support from the state budget[2]	14 128	17 515	22 437	15 323	12 788*
Other domestic and foreign sources[3]	2 719	4 954	5 167	5 493	4 379
Total	**42 474**	**50 881**	**57 980**	**58 284**	**59 322**

[1] *Total amount of funds the institution has received from the state budget of the Czech Republic as an institutional subsidy for its Institutional Research Plan.*
[2] *Total amount of funds the institution has received from the state budget of the Czech Republic in the form of research grants, targeted research programmes, etc.*
[3] *Income from contracts related to the principal activity of the institution, grants supported by industry, foreign grants.*
* *Including financial support from the Grant Agency of the Czech Republic which was not provided directly from the state budget in 2003.*

Personnel capacity engaged in research and development

Indicator	1999	2000	2001	2002	2003
Total number of employees	114.0	119.3	118.2	125.1	130.5
Total adjusted work capacity (FTE)*	91.1	95.0	93.6	96.9	98.5
Number of university graduates	66.1	67.8	69.5	73.8	79.6
University graduates (FTE)	46.2	48.7	50.3	51.7	53.7
Number of Scientists	31.6	33.7	34.8	37.1	35.2
Scientists (FTE)	24.1	26.1	26.0	28.6	27.7

* *FTE – full-time-employee capacity*
The figures correspond to the time-averaged values over each year.

Educational activities

Number of	1999	2000	2001	2002	2003
PhD students	21	20	32	39	46
awarded PhD degrees	1	2	3	2	1
diploma students	19	36	20	14	7
student assistants	19	22	22	15	11
employees engaged in teaching at universities	18	16	6	9	29
lectures given at domestic universities (in hours)	423	537	738	722	762
trainings given at domestic universities (in hours)	267	451	1412	1520	1548
lecturers having courses at foreign universitites	0	0	1	2	1

Publishing and dissemination activities

Indicator	1999	2000	2001	2002	2003
Monographs	2	0	1	6	3
Papers in reviewed journals	35	28	20	20	26
Papers in proceedings	39	49	36	44	25
Edition and translation of monographs and proceedings	0	3	1	3	0
Number of lectures at conferences	46	60	14	38	15
Number of invited lectures	5	9	3	4	5

Number of grant and R&D programmes projects carried out in the years 1999–2003

Provider	1999	2000	2001	2002	2003
Academy of Sciences of the Czech Republic	3	8	11	12	8
Grant Agency of the Academy of Sciences of the Czech Republic	5	7	6	6	6
Grant Agency of the Czech Republic	10	13	12	13	12
Ministry of Education, Youth and Sports of the Czech Republic	4	5	3	3	4
Ministry of Industry and Trade of the Czech Republic	2	2	3	1	2
European Commission	0	0	0	1	1
NATO	0	1	0	0	1
Other	1	1	0	0	0
Total	25	37	35	36	34

III
Research Reports

Department of Electron Optics

Environmental scanning electron microscopy for the observation of natural samples
Rudolf Autrata, Josef Jirák, Jiří Špinka, Vilém Neděla, Petr Wandrol, and Jiří Runštuk

Study of hydration methods of native samples in ESEM
Rudolf Autrata, Vilém Neděla, Petr Wandrol, Jiří Runštuk, Josef Jirák, and Jiří Špinka

New single crystal scintillators in scanning electron microscopy
Rudolf Autrata, Josef Jirák, Jiří Špinka, Petr Schauer, Petr Wandrol, and Vilém Neděla

High-resolution backscattered electron imaging
Rudolf Autrata, Petr Schauer, Jiřina Matějková, Antonín Rek, Petr Wandrol, Vilém Neděla, and Jiří Runštuk

Soldering with ductile active solders
Jan Dupák and Vladimír Ustohal

Cryostat for optical measurement in the temperature range 80–300 K
Jan Dupák and Pavel Hanzelka

Mapping the local density of states by means of very low energy electrons
Luděk Frank and Ilona Müllerová

Quantification of the detection quantum efficiency of electron detectors
Luděk Frank, Ivo Konvalina, Miroslav Horáček, Libor Novák, and Ilona Müllerová

Examination of aluminium based alloys and composites with slow electrons
Luděk Frank, Petr Hrnčiřík, and Ilona Müllerová

Charge-coupled device area detector for low energy electrons
Miroslav Horáček, Ivan Vlček, and Bohumila Lencová

Progress in computations in electron optics
Pavel Jánský, Bohumila Lencová, and Martin Oral,

Anisotropic etching of monocrystalline tungsten wire
Svatopluk Kokrhel and Jiřina Matějková

Accurate computations of electrostatic and magnetic lenses
Bohumila Lencová

Observation and study of nanometer scale materials
Jiřina Matějková, Antonín Rek, František Matějka, and Jan Grossman

Material contrast at very low electron energies
Ilona Müllerová and Luděk Frank

Ultrahigh vacuum scanning low energy electron microscope
Ilona Műllerová, Pavel Klein, Petr Čižmár, and Luděk Frank

Imaging of the dopant distribution in a semiconductor by secondary electrons
Ilona Müllerová, Filip Mika, and Luděk Frank

The ultimate resolution of scanned electron micrographs at very low energies
Ilona Müllerová and Luděk Frank

Cathodoluminescence degradation in organo-silicon structures
Petr Schauer, Petr Horák, Rudolf Autrata, Jan Dupák, Jaroslav Sobota, and Jiří Runštuk

Optimization of a scintillation detector for a scanning electron microscope
Petr Schauer, Rudolf Autrata, Ilona Müllerová, Jan Dupák, Jaroslav Sobota, and Ivan Vlček

Carbon based nanolayer and nanocomposite coatings
Jaroslav Sobota, Jan Grossman

X-ray imaging of micro-objects using the dark field refraction-contrast method with a resonantly absorbing multilayer mirror
Jaroslav Sobota

Department of Coherence Optics

A laser interferometer for absolute distance measurement based on a VCSEL laser
Ondřej Číp, Břetislav Mikel, Josef Lazar and František Petrů

A laser refractometer for determination of the refractive index of air
Ondřej Číp, František Petrů, Zdeněk Buchta, Vít Matoušek, Josef Lazar, and Pavel Pokorný

The measurement of surface profiles using an optically held probe
Petr Jákl, Mojmír Šerý, Jan Ježek, and Pavel Zemánek

A semiconductor frequency stabilized laser as a master oscillator for the Prague Asterix Laser System (PALS)
Petr Jedlička, Ondřej Číp, and Josef Lazar

Laser induced fusion of living cells
Jan Ježek, Petr Jákl, Mojmír Šerý, and Pavel Zemánek

Study of laser induced damage in living protozoa cells
Jan Ježek, Petr Jákl, Mojmír Šerý, and Pavel Zemánek

Semiconductor external cavity lasers for surface property measurements
Josef Lazar, Ondřej Číp, and Bohdan Růžička

Helium-Neon etalon of wavelength with prolonged discharge tube lifetime
František Petrů, Ondřej Číp, and Josef Lazar

Measurement of lengths in the nanometer region
František Petrů, Ondřej Číp, Břetislav Mikel, and Zdeněk Buchta

The behaviour of nanoobjects and microobjects in an optical standing wave
Pavel Zemánek, Alexandr Jonáš, Petr Jákl, Jan Ježek, and Mojmír Šerý

Department of Nuclear Magnetic Resonance

Bayesian and Entropic Methods Applied to NMR
Aleš Gottvald

Laplace's Demon vs Maxwell's Demon: A View of Information Physics
Aleš Gottvald

Accumulation of phase non-coherent signal
Josef Halámek, Pavel Jurák, and Miroslav Kasal

Estimation of the relationship between variables
Josef Halámek and Pavel Jurák

Small Helium Bath Cryopump
Pavel Hanzelka, Věra Musilová, Jan Dupák, Tomáš Králík, and Pavel Urban

Coherent Clock Signals Unit
Vladimír Húsek, Josef Halámek, and Miroslav Kasal

Impedance cardiography method for relative stroke volume change measurement
Pavel Jurák, Josef Halámek, Vlastimil Vondra, Jan Chládek, Milan Samek and Jiří Kališ

Evaluation of short-time circulation control parameters in human medicine.
Pavel Jurák, Josef Halámek, Vlastimil Vondra, Jan Chládek, Milan Samek, and Jiří Kališ

A device for measurement of thermal emissivity at cryogenic temperatures
Tomáš Králík, Pavel Hanzelka, Věra Musilová, and Aleš Srnka

Monte Carlo simulation of radiative heat transfer and molecular flow
Věra Musilová, Jan Dupák, Pavel Hanzelka, Tomáš Králík, and Pavel Urban

A Small Superconducting Magnet for Low-Temperature Nuclear Orientation
Aleš Srnka, Jan Dupák and Miloš Rotter

Robust pulse sequences for the observation of metabolite and macromolecule signals in short echo-time in vivo 1H NMR spectroscopy of the brain
Zenon Starčuk, Jr., Zenon Starčuk and Jaroslav Horký

Processing, visualization and quantitative analysis of multidimensional data acquired by NMR imaging, spectroscopy and spectroscopic imaging
Jana Starčuková and Zenon Starčuk Jr.

A two-channel digital measurement system
Ivo Viščor, Josef Halámek and Vladimír Húsek

Close-in spurs in a digital receiver
Ivo Viščor and Josef Halámek

Specification of the principal research and development activity

In general it can be said that specialists of Institute of Scientific Instruments have has developed physical methods, special technologies and instrumentation principles and used them to investigate living and non-living matter. Wave-corpuscular and statistic phenomena in interactions of atomic, molecular and cellular structures with electromagnetic fields, electrons and ions have been studied at the micro- and macro-level. New methods for the acquisition of image, spectral and metrology information have been developed and focused on biomedical applications. Beams of electrons have been generated, controlled and detected using advanced methods, and used for excitation of phenomena in solids that enabled study of their composition and structure in a vacuum or in a diluted gas, together with investigation of holographic phenomena and the joining, processing and development of special materials. Coherent light emitted by highly stable lasers was used to develop methods of metrology of lengths and for non-destructive manipulation of micro- and nanoobjects.

In more detail, in the field of study of the structure of matter by using electron microscopy, our research activity has been directed towards development of methods of detection of signal electrons, microscopy with low and very low energy electrons and microscopy with increased gas pressure, and towards its use in the investigation of biological samples and materials. In particular we have concentrated on the original design of ionization and scintillation detectors of electrons, on research into single-crystal imaging screens for transmission electron microscopy, and on the study of cathodoluminescence in organo-silicon hybrid structures with variable dimensionality. Attention has been paid to detection methods for the observation of wet biological specimens at a pressure of up to 1000 Pa in various contrast modes in environmental scanning electron microscopy. The methodology of microscopy with low energy electrons and the necessary instrument parts have been developed in order to apply new principles of imaging with high sensitivity to the details of the crystalline and electronic structure of the sample and its chemical composition. The interaction of low energy electrons with matter has been studied and selected applications in important fields of materials science, biology and medicine have been mapped. A great deal of effort has been devoted to the additional development of methods and programs for electron optical computations used in the study and design of lenses and detectors for a number of electron optical devices. Particular attention has been paid to increasing the accuracy of the finite element method in order to diminish the computation inaccuracy of fields, to determine the aberrations of imaging systems, and to analyse the properties of non-standard elements.

In the field of vacuum technologies, intensive research has been directed towards the use of a focused electron beam for welding and machining, and towards the development of new techniques for joining heterogeneous materials. In micro- and nano-lithographic technologies the research has focused on the production of microstructures with controlled geometry in thin films of polymer organic resists and in thin films of metallic and dielectric materials. The technology of high-frequency magnetron sputtering has been improved and optimized in order to obtain unique parameters of thin-film, multi-layered and nano-structured coatings for use as multi-layer elements of X-ray optics and nano-composite surface films for engineering applications.

In the field of highly coherent quantum light generation, new laser sources have been introduced with wavelengths ranging from 633 nm up to the telecommunications band at 1550 nm. The newly designed devices have been used for metrological purposes as fundamental etalons of length and optical frequency. They have allowed further development of methods in interferometry and measuring technology, leading to an increase in the precision of measurements of lengths and indices of refraction.

Study of focused laser beam interaction with microobjects and nanoobjects has led to better understanding and has thrown more light upon some observed phenomena. The results achieved have been further exploited for the development of optical micromanipulation methods and their biological, physical and technical application.

Research in the area of nuclear magnetic resonance (NMR) methodology focused principally on the improvement of existing techniques and the development of new techniques for spatially localized in-vivo 1H NMR spectroscopy (MRS) and spectroscopic imaging (MRSI) of the human brain. Experimental methods have been developed simultaneously with data processing, aimed at reliable quantification of the measured NMR spectra as the basic prerequisite for the application of these techniques in clinical practice – in medical research, diagnostics and therapy monitoring. Attention has also been paid to data acquisition and signal analysis, focusing on direct digital synthesis and digital processing of NMR signals in order to achieve high dynamic and frequency ranges with minimal instrumental artefacts – minimal harmonic distortion, phase noise and dynamic nonlinearities. The results achieved have also been utilized for measurement and signal processing in medicine, especially in cardiology and neurology, where new measurement techniques involving non-invasive excitation and recording of interactions between biosignals have been applied. The informational-theoretical aspects of NMR spectroscopy were another research topic, in which a probabilistic approach to the problems of spectroscopic data analysis and concepts of modern information theory (Bayesian, entropic, inversion, and optimization methodologies) were employed.

Technological research into magnetic field generation and cryogenics has also been carried out in relationship to the methodological development of NMR. In the field of magnetic field generation, attention has been devoted to the development and generalization of procedures for the design of systems efficiently generating magnetic fields with defined spatial configuration and/or prescribed waveforms. Particular emphasis has been devoted to the generation of homogeneous magnetic fields for NMR imaging and spectroscopy (generated by superconducting magnets) and magnetic fields of shim and gradient coils for MR imaging with reduced power dissipation and inductance. Methods for magnetic field mapping and appropriate data processing have also been developed. In the area of cryogenics, the research was oriented towards the reduction of radiative heat flows at low temperatures, reduction of heat conduction in construction materials, and final optimization of the entire cryogenic system.

The following summary presents the most important results achieved by the applicant within the last five years and published in scientific journals, presented at reputable international conferences (which is an accepted method of publication in the field of scientific instruments), or implemented in unique instrumentation components for usage together with domestic and foreign partners.

The results are split into three parts according to the applicant's three main research fields. Cross-references to the list of major implemented R&D results are given for each result.

Environmental scanning electron microscopy for the observation of natural samples

Rudolf Autrata, Josef Jirák, Jiří Špinka, Vilém Neděla, Petr Wandrol and Jiří Runštuk

Environmental scanning electron microscopy (ESEM) allows the examination of the surfaces of practically any samples, wet or dry, insulating or conducting, since it allows the introduction of a gaseous environment into the specimen chamber. Gaseous pressures above 609 Pa allow the maintenance of a saturated vapour pressure at temperatures above freezing point and, therefore, the presence of liquid water. The presence of positive ions supplied from the ionised gas ensures the suppression of negative charge build-up on insulating specimens. ESEM operation is made possible by separating the microscope column containing electron optics from the space of the specimen chamber by using pressure limiting apertures and a system for differential pumping of the individual pressure regions. There are two possibilities for how to ensure differential pumping in ESEM. Either the pumping system is integrated with the objective lens or a differential pumped chamber is built under the pole piece of the objective. The differential chamber is pumped separately and two pressure limiting apertures separate it from the specimen chamber and the microscope column, respectively.

Within the framework of the above project, a combined detection system of an original design has been realized, in which the scintillation and ionisation methods of detection are integrated and which enables separation of the vacuum from the pressure regions of the specimen chamber. The detection system (Fig. 1) is based on a single crystal of yttrium aluminium garnet (YAG) split into two optically independent halves for the recording of the backscattered electron (BSE) signals A+B (material contrast of the sample) or A-B (topographical contrast of the sample). The YAG is provided with a pressure-limiting aperture. From the side of impact of BSEs, a system of three circular thin-layer electrodes is deposited on the single YAG crystal. These electrodes are supplied with a positive and negative potential of hundreds of volts. The positive electric field accelerates secondary electrons (SEs) to sufficient energies that cause multiple ionisations as they cross the gas between the sample and the bias electrodes. The outer ring electrode is supplied positively for suppressing the influence of the BSE signal. SE emission initiates an ionisation cascade that amplifies the measured signal by a factor of 100 or more. The ionisation detector amplifies both the SE and BSE signals, though to different degrees.

BSE detection using YAG scintillation detectors can be provided simultaneously with SE ionisation detection. One YAG-BSE detector divided onto two halves is located in the specimen chamber (tight to the differential chamber) and a second YAG-BSE detector is located in the differential chamber where a higher vacuum is achieved. This detector is intended for work with an extremely high pressure in the specimen chamber (around 2000 Pa). A very low working distance (less than 1 mm) must be used [1, 125, 183, 337, 376,].

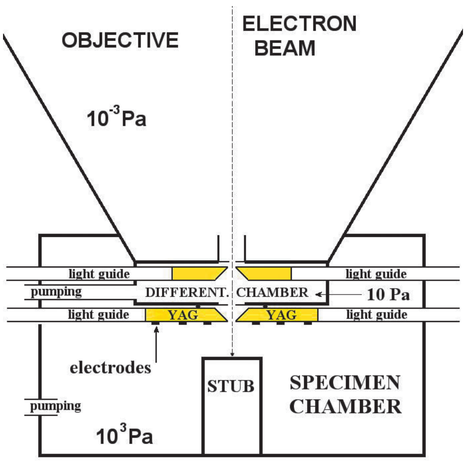


Fig. 1. Detection system of the adapted AQUASEM.

Within the scope of the above project, the AQUASEM scanning electron microscope of our own construction has been adapted to incorporate a new column (VEGA), new software, a device for sample freezing, a water reservoir for sample hydration and a modified pumping system (Fig. 2). Methods for the hydration of water-containing samples during the pumping process have been developed. Two images (Fig. 3, Fig. 4) of samples in their natural state are shown.

Fig. 2. Adapted AQUASEM.

Fig. 3. Soft tissues on human stomach, mag. 1000x, 900 Pa.

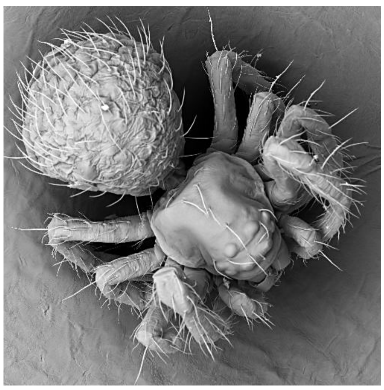


Fig. 4. Spider after hatching. BSE image, mag. 200x, 300 Pa.

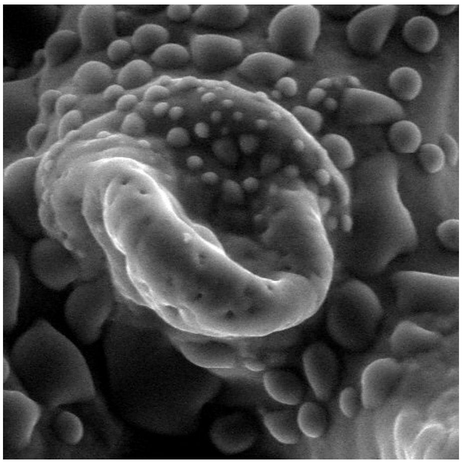
Study of hydration methods of native samples in ESEM

Rudolf Autrata, Vilém Neděla, Petr Wandrol, Jiří Runštuk, Josef Jirák and Jiří Špinka

It is known that study of samples containing a large amount of water, e.g. soft biological tissues, can be realised by the technique of environmental scanning electron microscopy (ESEM). This technique enables one to use a high pressure of water vapour in the specimen chamber (10^3 Pa), which creates the right conditions for the minimization of water evaporation from the sample, the detection of signal electrons with sufficient efficiency and neutralization of the charge originating on the surface of insulation samples. Studying biological samples of soft tissues with a fine or very fine hydrated structure still remains a big problem, because this structure can be easily damaged by dehydration during the initiating phase of vacuum pumping of the microscope. Attention is, therefore, being focused on setting up the right conditions for the complete dehydration of samples, ensuring the nature state of a sample during the critical phase of pumping of the microscope. Such conditions can be created by respecting the physical dependence of the pressure of saturated water vapours on temperature.

Violation of these conditions leads to dehydration of the sample or to the coating of the surface topography of the specimen by water. These states are presented in Fig. 1., which presents a partially dried specimen of small intestine tissue, on which forming water drops are visible as a consequence of the condensation process and the specimen beginning to be coated with water.

Fig. 1. Water drops as a consequence of violation of physical conditions.

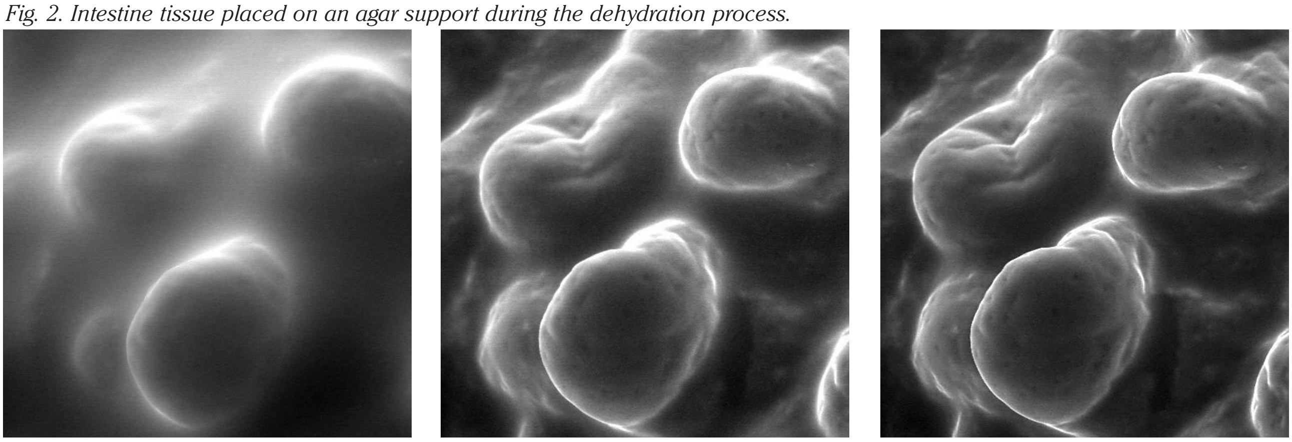


0 °C / 800 Pa / 90 min

The method of cyclical irrigation of the specimen chamber is one of the methods, which preserve prolongation of a relatively natural state of a soft tissue sample. An experimentally determined amount of distilled water (approx. 0.5 ml) is inserted into the specimen chamber before the beginning of the pumping process. The pumping of the specimen chamber goes through the pressure limiting aperture, which separates the chamber of differential pumping from the specimen chamber. This pumping is accompanied by a decrease in pressure down to the value of the pressure of saturated water vapours (2062 Pa) corresponding to the temperature of distilled water in the specimen chamber (18 °C). A further decrease in the pressure in the specimen chamber occurs after evaporation of distilled water. At that moment filling-in of water vapour must start from the external reservoir of water, regulated by a valve. In order to achieve stable high relative wetness in the specimen chamber, it is necessary to repeat the irrigation process several times.

Another method is based on observation of wet tissues placed on a special support made of agar, whose area represents a sufficient supplier of water, which gradually evaporates and thus hydrates the specimen. The agar successfully minimizes the influence of dehydration deviations on the observed specimen and, in connection with the method of cyclical irrigation of the specimen chamber, creates a very good means of observation of biological tissues in ESEM. It is demonstrated in Fig. 2, in which samples of small intestine tissue observed at equal temperatures and pressures in the ESEM chamber are presented [182, 189, 192, 271].

Fig. 2. Intestine tissue placed on an agar support during the dehydration process.



5 °C / 1250 Pa / 45 min | 3 °C / 1000 Pa / 60 min | 2 °C / 800 Pa / 75 min

New single crystal scintillators in scanning electron microscopy

Rudolf Autrata, Josef Jirák, Jiří Špinka, Petr Schauer, Petr Wandrol and Vilém Neděla

The properties of the scintillation – PMT detection system in a scanning electron microscope (SEM) depend on the properties of the scintillator and the light guide. The decisive properties for an efficient detection system are an efficient energy transfer electron-photon, a very short decay time of luminescence and the loss-avoiding transfer of photons in the light guide to the photomultiplier. A variety of scintillation materials have been proposed for the detection of signal electrons in SEM. Nevertheless, the range of suitable scintillators is restricted to powder phosphor of yttrium silicate (phosphor P47), plastic scintillators (NE 102 A) and single crystal scintillator based on yttrium aluminium garnet (YAG) and perovskite (YAP). YAP single crystals (Fig. 1) have not been used for the detection of signal electrons until recently. The relatively short light emission maximum wavelength of 370 nm was an extremely serious limitation to the use of YAP because the light transmission of 370 nm wavelength is very low in the organic glass light guide. An additional problem was the extremely high self-absorption of the generated light emission itself. (20 % in a 5 mm thick single crystal). All these problems have, however, been resolved.

A special light guide material, which transmits light at the wavelength 370 nm, has been developed. This organic glass contains special organic dopants for increasing light transmission in the short wavelength region of spectra (Fig. 3). The light from YAP is transmitted to 95 % in the light guide rod 150 mm in length and 20 mm in diameter. The colour centres in the YAP or YAG crystal lattice have been suppressed thanks to additional treatment of the YAP single crystal discs in an oxygen and hydrogen atmosphere at an extremely high temperature. Self-absorption of the generated light has been decreased by one half to approx. 10 % in YAP. The decay time 1/e has been shortened from the previous value of 30 ns to the new value of 17 ns, for an incident electron energy of 10 keV, thanks to a modified technological process for growing YAP single crystals and the additional treatment of the YAP discs (Fig. 2). It has been found that the surface of YAP is contaminated after the polishing process. Microparticles of the polishing material are embedded into micro-cracks of a depth of a few micron units. These impurities can only be removed by a washing process in a special mixture of acids at a suitable temperature. The smoothness of the YAP surface is decreased by this treatment, but the relative efficiency of the electron-photon transfer is increased (Fig. 4) [147, 188, 191, 402, 405].

New YAP is now an extremely efficient single crystal scintillator, suitable for all types of detectors in SEM.

Fig. 1. YAP single crystal scintillators.

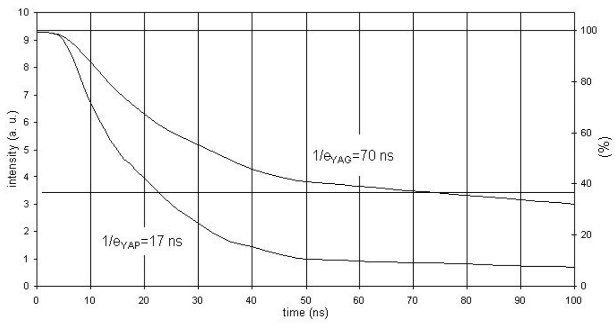


Fig. 2. Time characteristics of YAP and YAG (1/eYAP = 17 ns, 1/eYAG = 70 ns).

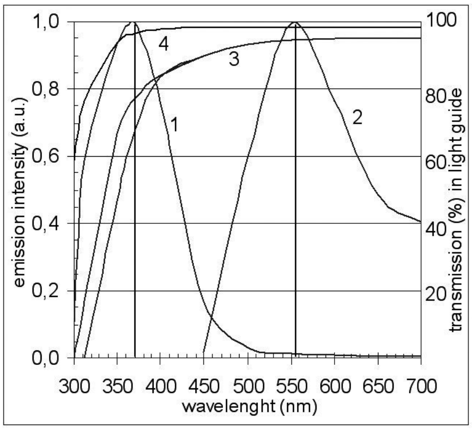


Fig. 3. Emission spectra of YAP (1) and YAG (2) and transmission spectra of standard organic glass (3) and modified organic glass (4).

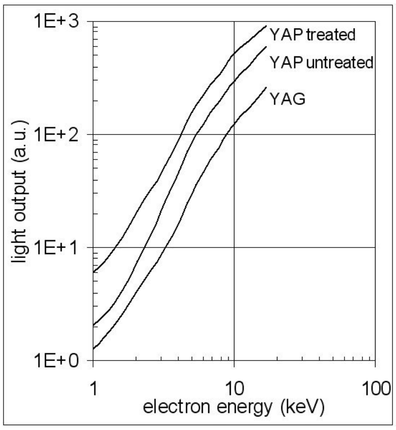


Fig. 4. Relative efficiency of single crystals versus energy of incident electrons.

High-resolution backscattered electron imaging

Rudolf Autrata, Petr Schauer, Jiřina Matějková, Antonín Rek, Petr Wandrol, Vilém Neděla and Jiří Runštuk

The detection of backscattered electrons (BSEs) in scanning electron microscopy (SEM) seems to be an auxiliary method in the study of surfaces and composition materials. BSEs have properties that are different from those of the secondary electrons (SEs) usually used. The achievement of the theoretical limit of resolution (0.6–0.8 nm for SEs and 0.9 nm for BSEs) depends not only on the properties of the electron source, the properties of electron optics, the specimen preparation technique and the type of electrons, but also on the detection system efficiency.

The features of a BSE image originate partly from the continuously increasing dependence of the BSE signal coefficient on the atomic number of the investigated specimen (which causes the material contrast of the image) and partly from the deeper penetration of BSEs into the specimen (which decreases the image resolution in comparison with an SE image). Nevertheless, the lateral resolution of a BSE image can be comparable with an SE image if the specimen contains components of different atomic numbers, the energy of the electron beam is sufficiently low and a BSE scintillation photomultiplier (PMT) detector with a high detective quantum efficiency is used.

The efficiency of the BSE detector depends not only on the optical properties of the whole detector system, but also on the efficiency of the electron-photon transfer in the scintillator. An yttrium aluminium garnet (YAG) treated with a special method for achieving the best physical properties has been used as the scintillator in a BSE detector. Additional treatment of the YAG discs in an oxygen or hydrogen atmosphere increases the efficiency of the light output and decreases time characteristics, namely the decay time. Treatment of the YAG discs in a special mixture of acids at a high temperature removes the polishing microparticles from the surfaced microcracks and makes the YAG surface more sensitive to the low energy incident electrons. The scintillator and the light guide are provided with various optical layers ensuring efficient transfer of photons upwards to the PMT.

A YAG-BSE detector with DQE=0.8 at a BSE energy of 12 kV (Fig. 1) has been designed thanks to these modifications (Fig. 2). This detector was inserted into the JSM-6700F SEM and its function tested. Fig. 3 documents that SE and BSE images of gold-coated magnetic tape may be at least comparable. Fig. 4 represents gold particles on carbon at a magnification of 200,000x. A BSE image resolution of 3 nm at an electron beam energy of 10 keV can be achieved [181, 188, 346].

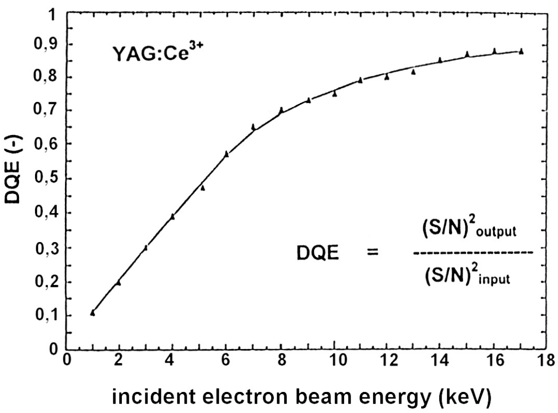


Fig. 1. Detective quantum efficiency of a YAG-BSE detector.

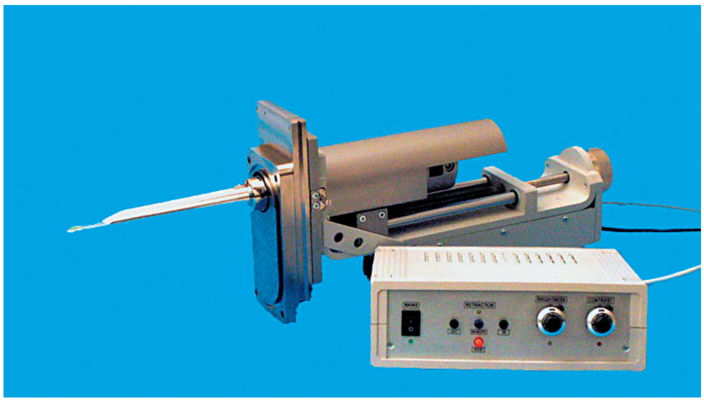


Fig. 2. Design of a YAG-BSE detector with motorized shifting of scintillator.

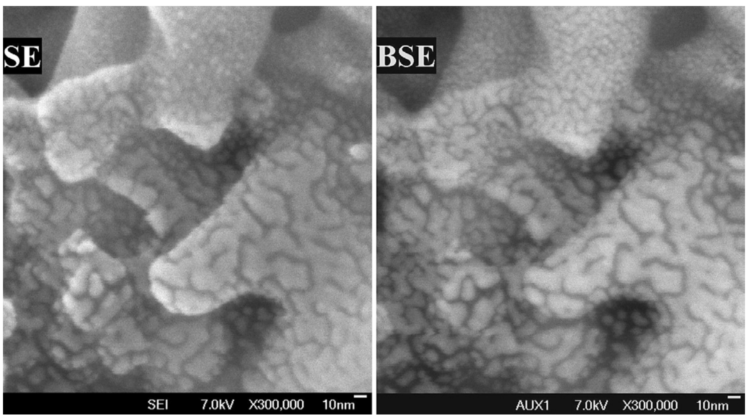


Fig. 3. SE and BSE images of gold-coated magnetic tape. Mag. 300,000x, 7 kV.

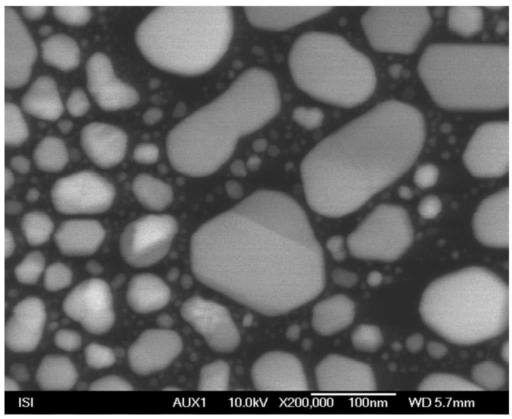


Fig. 4. BSE image of gold particles on carbon substrate.

Soldering with ductile active solders

Jan Dupák and Vladimír Ustohal

The term “active solders” means solders containing an active element, such as titanium or zirconium, which are characterised by the high wettability of the surface of metallic as well as many non-metallic materials. Silver solders containing a certain amount of titanium are most often used for the creation of the joints of ceramics – metal. They are made in the form of a wire with a titanium core or in the form of foils prepared by the rapid cooling method. Active solders based on silver alloys, or on copper and gold, are very hard and have a relatively high coefficient of thermal expansion. These properties hamper their use for the joining of various metals with brittle non-metallic materials, such as silica, sapphire, silicon, carbon, etc.

Ductile active solders go a considerable way towards solving such problems. The solder is formed by a ductile metal (indium, lead or tin) enriched with an active element – titanium or zirconium. Due to its plastic deformation the ductile solder is able to compensate differences in the thermal expansion of joined materials and the presence of an active element ensures good wettability of the surface of the joined parts.

The aim of this work was to create the joins of some metals with non-metallic materials by means of ductile active solders and to verify their practical applicability for cryogenic and vacuum devices. Greatest attention was paid to the joining of steels with silicon glass and ceramics [43, 160].

Examples of the practical application of ductile active solders:

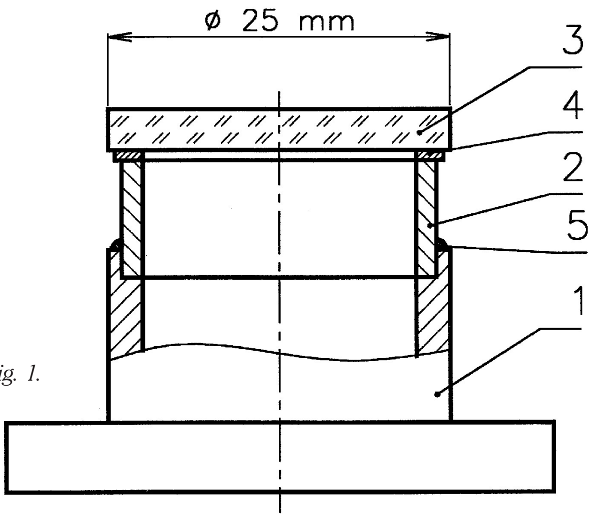


Fig. 1.

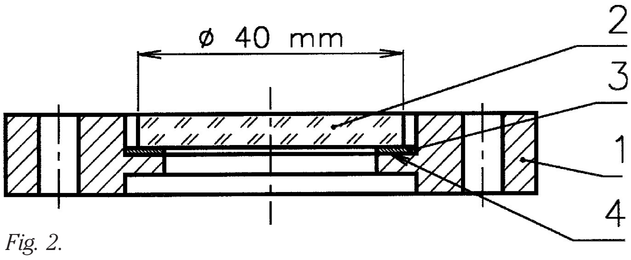


Fig. 2.

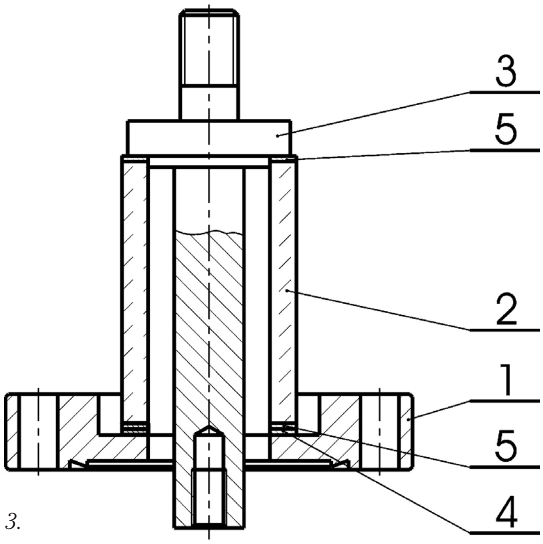


Fig. 3.

Fig. 1. The viewport for UHV apparatus. 1 – stainless steel, 2 – titanium, 3 – quartz, 4 – lead foil, 5 – Ag72Cu solder.

Fig. 2. The viewport of helium cryostat. 1 – stainless steel, 2 – quartz, 3 – indium foil, 4 – sputtered titanium layer.

Fig. 3. Ceramic electrical feedthrough. 1 – flange made of stainless steel, 2 – aluminium, 3 – titanium plug, 4 – sputtered titanium layer, 5 – tin foil.

Cryostat for optical measurement in the temperature range 80–300 K

Jan Dupák and Pavel Hanzelka

The cryostat described was designed in accordance with the requirements of the optical measurements intended to be performed. As most of the measurements will be done at a range of specimen temperatures nearing that of liquid nitrogen (LN2) and with a relatively low speed of changes of this temperature, a cryostat of a traditional construction with a vacuum-insulated LN2 vessel suspended on a thin-wall filling neck was chosen (Fig 1.). Simplicity and undemanding operation are the virtues of this type.

The inner LN2 vessel (1) of a cylindrical shape made of copper has a capacity of 0.4 litres. The specimen holder (2) with a temperature sensor and heating winding is connected to the bottom of the LN2 container by means of a thermal link (3) consisting of a thin-wall stainless steel tube and two replaceable copper strips. It is possible to tune the thermal resistance over a wide range by modification of the cross-sectional area of the strips. The speed of specimen cooling and the lower temperature limit are adjusted in this way. There are four openings (4) on the outer shell of the cryostat. Three of them are occupied by electrical connections. The last opening is used for pumping of the cryostat after specimen exchange. In the lower part of the cryostat there are two quartz windows (5) placed opposite each other. It is possible to fit the measured sample to the windows axes.

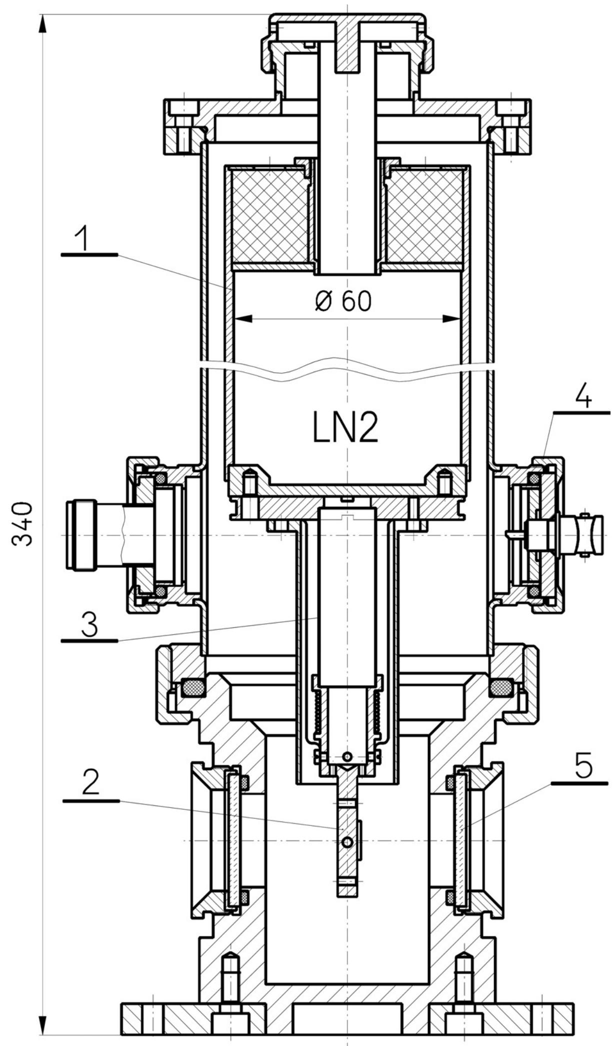


Fig. 1. Structure of the cryostat.

The compromise value of the thermal resistance connecting the specimen holder with the LN2 vessel was to be found in order to achieve both an acceptable LN2 consumption and a satisfactory specimen temperature response. That is why the parameters of the cryostat were simulated numerically before manufacturing. A new numerical procedure for the modelling of the cryostat transient states was applied. Spontaneous cooling of the specimen holder and holder warming by the heater are the most significant effects simulated by the calculating procedure. Non-linear temperature dependence of the specific heat and that of the thermal conductivity of materials used is taken into account. In addition to heat conduction, the heat radiation also affects the temperature changes of the holder.

The optimal dimensions of the copper strips were found and verified in experiments. Several steady states of the cryostat with different specimen temperatures were simulated and tested (Fig. 2.). The measured LN2 evaporation rate value was in good agreement with the calculated value. The cryostat enables the performance of a series of optical measurements in a temperature range of 80 K to 300 K with one charge of LN2 [221, 377].

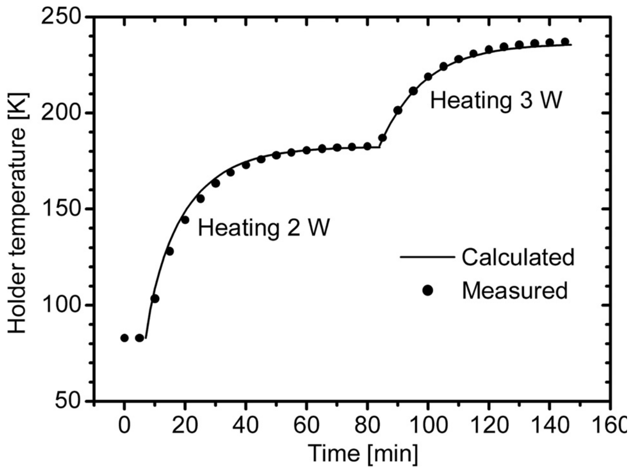


Fig. 2. Stepwise increase in the holder temperature.

Holder temp. [K]	Evaporation [ml/h]	LN2 hold time [h]
83	20	18.4
183	61	6.1
237	81	4.5
289	104	3.5

Table 1. Cryostat parameters at steady states.

Mapping the local density of states by means of very low energy electrons

Luděk Frank and Ilona Müllerová

Inside any solid the energies of electrons are subject to the laws of the quantum mechanics, so the allowed energy states depend on the wave vector, i.e. the momentum of the electron, and the bands of allowed states are separated by forbidden gaps appearing, for example, where the wave vector touches the boundary of the Brillouin zone. This also holds true for energies close above the vacuum level, i.e. for so called hot electrons injected from outside. If the incident electron hits the gap, it does not enter allowed states and should be reflected. Nevertheless, total reflection is not obtained because the electron can pass an inelastic collision and lose energy, or changes its wave vector owing to scattering on a phonon or some crystal imperfection – in both cases a shift to allowed states may occur.

In the range of units of eV elastic reflection of electrons is strongly enhanced, so it can be utilized in the VLEED (Very Low Energy Electron Diffraction) method. Its users know the energy band structure region existing on the intensity vs. energy (I-V) curve for the specularly reflected (00) spot below the threshold where the first non-specular diffracted beam appears. It is important to note that the incident electron wave has to couple to the energy states into which it is to penetrate. This means those Bloch states inside the specimen that have dominant Fourier components resembling the incident wave (the coupling bands). A further crucial condition is low absorption of electrons, which is met below landing energies of 25 to 30 eV. Simulations show that any local features on the reflectivity curve are washed out at even moderate absorption (appearing for the imaginary part of the crystal potential exceeding 1 eV) and that the model better fits the experimental data when the non-isotropic situation is considered with absorption reduced in directions along the surface.

A scanning low energy electron microscope (SLEEM) mode for a scanning electron microscope (SEM) has been developed at ISI so that high image resolution is preserved down to the lowest landing electron energies in units or even fractions of eV. This feature is achieved by forming and focusing the primary electron beam at high energy and decelerating it to low energy just in front of the specimen surface. Apparatus of this kind enables one to map the electron reflectivity (or the local density of states to which the reflectivity is inversely proportional) at high lateral resolution. Variations of this kind appear between different orientations of the same crystal, e.g. between crystal grains, though an attractive application is to map the local doping of semiconductor structures, intended to alter the energy band structure merely locally.

The electron-optical image contrast, corresponding to the local density of states, has not been demonstrated yet, as the electron energy desired is not available in commercial devices. The experiment requires not only lowering the electron energy sufficiently, but also keeping the specimen surface very clean under ultrahigh vacuum conditions free of oil contamination. The required apparatus has been built at ISI, as described elsewhere in this volume, and the desired contrast observed in the plan view of a specimen consisting of doped patterns on a semiconductor substrate [11, 116, 118, 229].

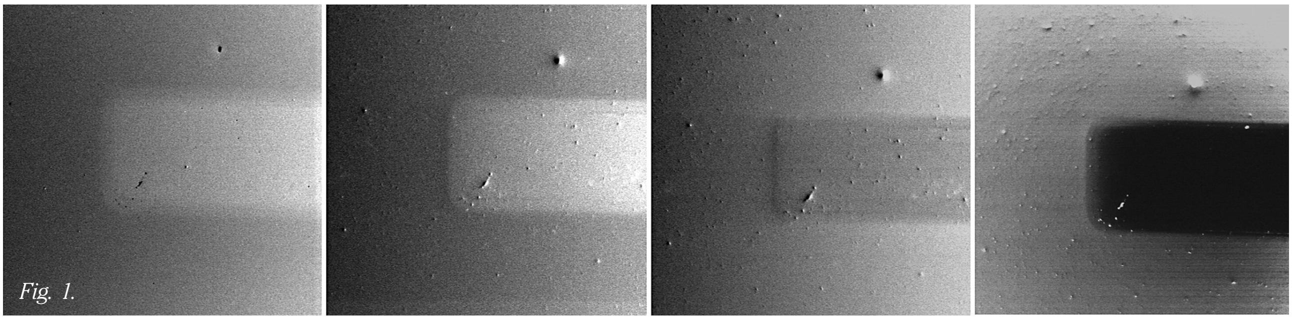


Fig. 1.

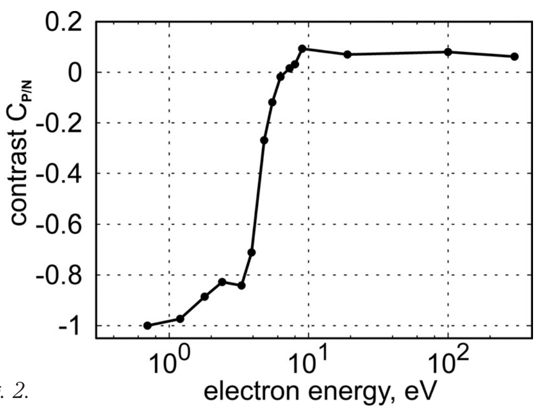


Fig. 2.

Fig. 1. The SLEEM mode micrographs of a P^+ type area formed by boron diffusion into N type Si (111) substrate; electron energies from the left: 300, 9, 6.3 and 1.2 eV, width of the field of view 50 µm.

Fig. 2. The doping/substrate contrast, calculated as $C_{P/N} = (S_P - S_N) / S_N$, where S_P and S_N are mean signal levels in appropriate areas. A drop in the image signal from the doped area indicates the presence of additional allowed energy states connected with the doping.

Quantification of the detection quantum efficiency of electron detectors

Luděk Frank, Ivo Konvalina, Miroslav Horáček, Libor Novák and Ilona Müllerová

Traditionally the detection quantum efficiency (DQE) is measured by the ratio of squared signal-to-noise ratios (SNR) at the input and output of the detector or the part of it in question. This approach is based on the usual definition of SNR as the ratio of the actual image signal to its rms noise. In terms of the random variable calculus, it is the ratio of the mean value to the standard deviation of a pixel signal taken from scenery with no true image contrast. If the image signal is governed by Poisson statistics, SNR is equal to the square root of the mean signal and hence the ratio of squared SNRs simply expresses the loss of events in the detection process, which is the optimal measure of DQE. The validity of the Poisson statistics is, however, restricted to random processes with only two complementary phenomena as their outputs, such as when the incident electron is backscattered or not, while secondary electrons (SE) can be emitted multiple per one impact. Detailed analysis of SNR was performed for a low yield case, when the non-Poisson contribution comes mainly from SE released by scattered electrons returning back to the surface, and for the signal digitised by rounding to a limited number of discrete values. Calculation showed that, for example, for a carbon specimen, 10 keV electrons, 8 bit digitisation and a few thousand primary electrons per pixel, the non-Poisson factor remains negligible so that the "squared SNR" method can be applied under conditions defined according to this analysis.

DQE quantification is performed in practice by calculating the mean value and standard deviation from the SE image of a fine-grained graphite surface, acquired by a defocused primary beam. Their ratio gives the output SNR, while the input value is calculated from measured primary current and tabulated emission yield data. With the conventional side-attached Everhart-Thornley type of SE detectors (Fig. 1), the most important loss of events in the detection process concerns the initial collection of signal species. The collection was computer-simulated (Fig. 2, 3) and the loss of events compared with that found in final digital images. The good fit of both sets of data (Fig. 4) demonstrates the correctness of the quantification method. The project was implemented in collaboration with, and with the support of, FEI Czech Republic, Ltd. [94].

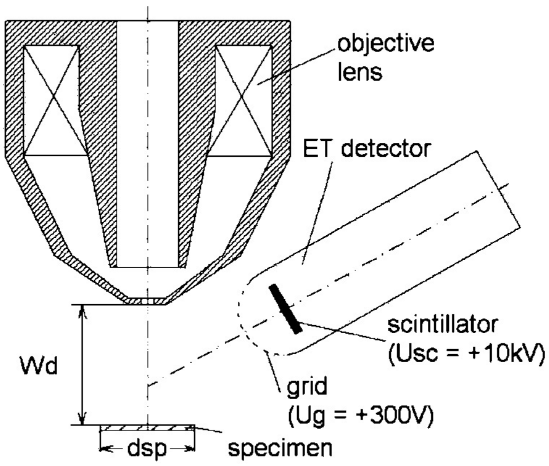


Fig. 1. Scheme of the Everhart-Thornley detector extracting slow SE from around the specimen by means of the front grid bias.

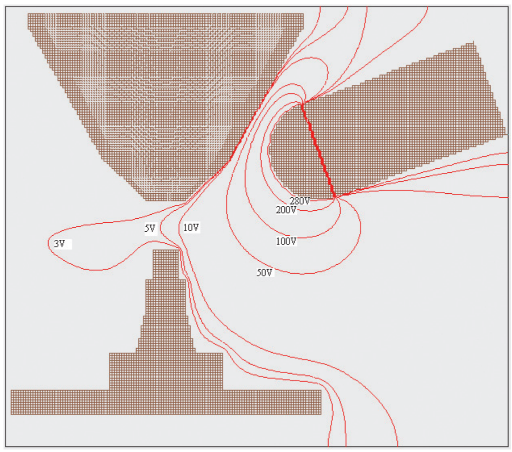


Fig. 2: Equipotentials of the front-grid field for extraction of SE.

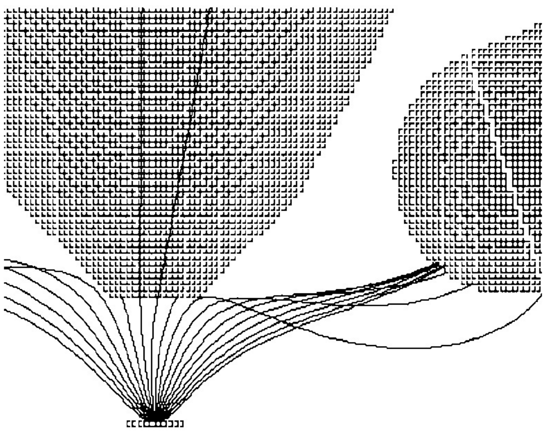


Fig. 3. Simulated trajectories of SE emitted under various polar angles within the front view plane.

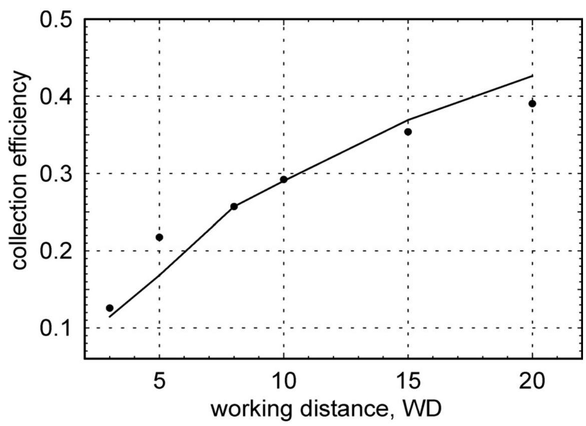


Fig. 4. Comparison of the simulated (solid line) and measured (points) values of the collection efficiency.

Examination of aluminium based alloys and composites with slow electrons

Luděk Frank, Petr Hrnčiřík and Ilona Müllerová

Activities covered by the agreement on co-operation in research and education with the Faculty of Engineering of the University of Toyama in Japan mostly concern aluminium based alloys and metal matrix composites, which the partner studies for industrial applications. A feasibility study of the prospective use of low energy electron microscopy in this field confirmed that important structural features in these materials are difficult to observe with conventional scanning (SEM) or transmission (TEM) electron microscopes. These features exhibit sufficient heterogeneity with respect to the surrounding matrix, but only a small difference in the mean atomic number, and their dimensions are much smaller than those of the interaction volume of electrons at energies normally used. When lowering the electron energy in SEM and collecting a certain combination of secondary (SE) and backscattered (BSE) electrons, as is done in a cathode lens equipped SEM in its SLEEM mode (see elsewhere in this brochure), important features are visualized at a high resolution and contrast [48].

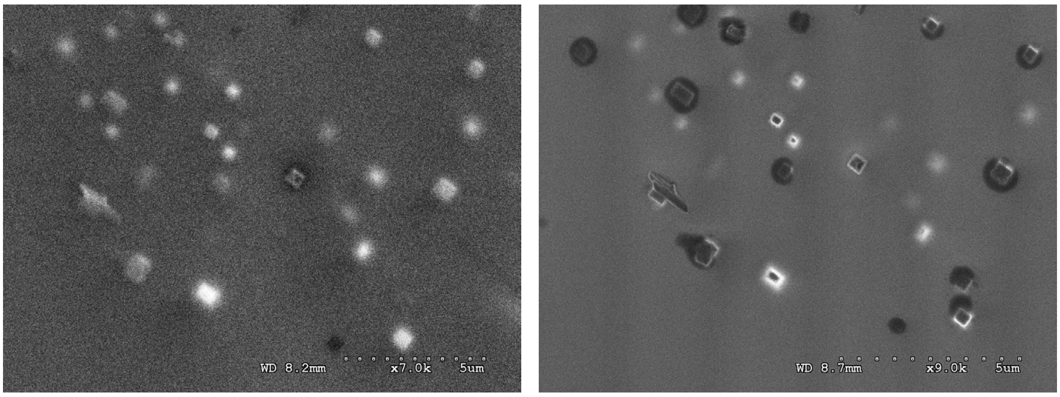


Fig. 1. Cross-sections of precipitates in the Al-1.0 mass % Mg_2Si alloy: SE mode at 20 keV (left) and SLEEM mode at 1600 eV (right) – see better signal-to-noise ratio and much more detail in the SLEEM image.

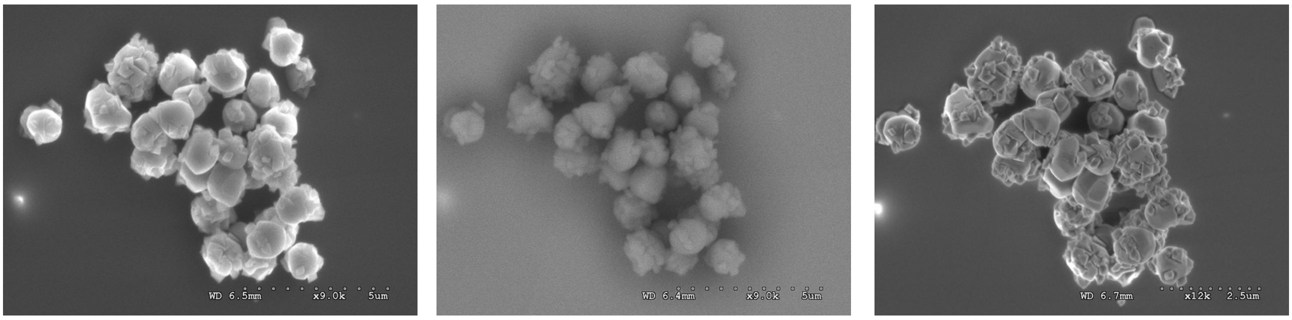


Fig. 2. Spinel ($MgAl_2O_4$) crystals on Al_2O_3 particles in the Al-Mg-Si alloy based metal-matrix-composite (MMC) (from the left): SE mode at 10 keV, BSE mode at 13 keV, SLEEM mode at 3 keV (with the crystal shapes best reproduced).

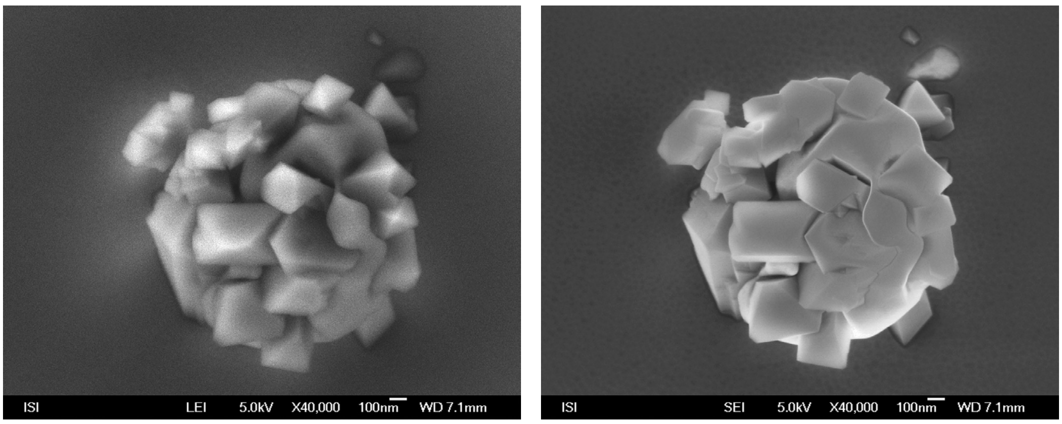


Fig. 3. Spinel crystals on a ceramic particle in MMC (see Fig. 2), SE mode at 5 keV: "lower" detector (left) acquiring a part of high angle SE and "upper" detector (right) extracting virtually all SE emitted and producing high signal-to-noise ratio, though bad reproduction of sub-micrometer shapes.

Charge-coupled device area detector for low energy electrons

Miroslav Horáček, Ivan Vlček and Bohumila Lencová

Progress in low-energy electron microscopy includes enhancement of the surface sensitivity of the information as well as the reduction of the local charging of low conductivity specimens. The range of very low energy electrons with energies below 50 eV is particularly interesting. Micrographs in this mode bring new types of contrast due to the wave nature of the electron. The wave-optical phenomena appear in the backscattered electron signal only when the electron wavelength becomes comparable with the inter-atomic distance, i.e. in the range of 10^0–10^1 eV. An anisotropic angular distribution exhibiting maxima and minima is typical for the interaction of very slow electrons with a crystalline surface or thin multilayer. In the low-energy scanning electron microscope (LESEM) the diffraction pattern is formed in the back-focal plane, and can be directed toward the area detector and recorded separately for every image pixel.

A fast position-sensitive detector was designed for the angle- and energy-selective detection of signal electrons in a low-energy scanning electron microscope, based on a thinned back-side directly electron-bombarded CCD sensor (EBCCD) CCD39-02. The electronics of the detector are based on a digital signal processor (DSP). The DSP generates clock signals to operate the image-area, store-area and serial-register gates of the frame-transfer operation CCD image sensor and a synchronous clock signal for the analog-to-digital converter. The analogue output signal from CCD is synchronously converted by the 12-bit converter pixel by pixel. Correlated double sampling is realized by on-line digital subtraction of signal level voltage and reset level voltage for each pixel. The EBCCD-gain of 565 for electron energy 5 keV and dynamic range 59 dB for short integration time up to 10 ms at room temperature were obtained.

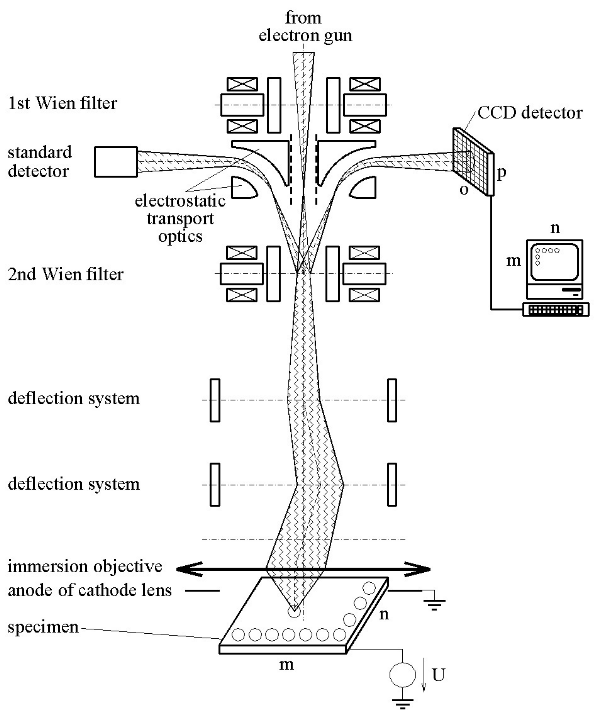


Fig. 1. Low-energy scanning electron microscope (LESEM) with electron-bombarded CCD detector (EBCCD).

The detector was designed for the LESEM arrangement shown in Fig. 1. The column works with a primary beam of several keV, decelerated close to the specimen surface to the desired very low energy in the cathode lens. The combination of a cathode lens with a focusing magnetic or electrostatic lens (a so-called immersion objective lens) ensures significantly lower aberrations at very low energies than the focusing lens alone.

The signal electrons passing backwards through the immersion objective lens are accelerated by the cathode lens and collimated toward the optical axis so that their angular distribution is preserved. Behind the objective lens the diffraction spots are focused in the back-focal plane. The signal and primary electron beams move in the vicinity of the optical axis in opposite directions, so that they can be separated using the Wien filter that directs the signal beam toward a side-attached detector. A two-dimensional image of the specimen can be composed from the four-dimensional data by various methods employing local differences in the diffraction patterns.

In a SLEEM the elastically backscattered electrons strongly dominate the total emission. These electrons preserve their energy during interaction with the specimen and are re-accelerated in the cathode lens back to the primary energy controlled by the high-voltage power supply of the electron gun (up to 5 keV in our case). The electrons also arrive at the detector with this energy, but their landing energy in the specimen plane (10^0–10^1 eV) is independently adjusted by the high voltage bias of the specimen. With knowledge of the energy dependence of EBCCD-gain we can set the optimum gain. Hence the energy of the electrons in the EBCCD detector plane can be tailored to achieve a reasonable dynamic range. From the point of view of dynamic range, brightness resolution and integration time we have an optimum incident electron energy at 4.2 keV [11, 67, 104, 180, 266, 267, 268, 269, 315].

Progress in computations in electron optics

Pavel Jánský, Bohumila Lencová and Martin Oral

The software used at the institute for electron optical design is based mostly on fields computed by the first order finite element method (FOFEM). This software allows fast and accurate computation of electrostatic and magnetic lenses and deflectors. It consists of four separate packages, each equipped with a graphical user interface, allowing both the interactive input of data and graphical presentation of the output results, and another interface for the input of data for evaluation of optical properties. These interfaces were written for DOS in Borland Pascal, now obsolete, and the graphical display of the output of results becomes slow. The computation programs themselves are “console” applications for 32-bit Windows written in the latest Visual Fortran. They do not use any graphics. The fifth package is for ray tracing in fields computed by FOFEM, but the computation programs are difficult to use, partly due to their obsolete interface and the use of off-line 2D graphics. The programs also do not allow the computation of space charge limited systems such as electron guns.

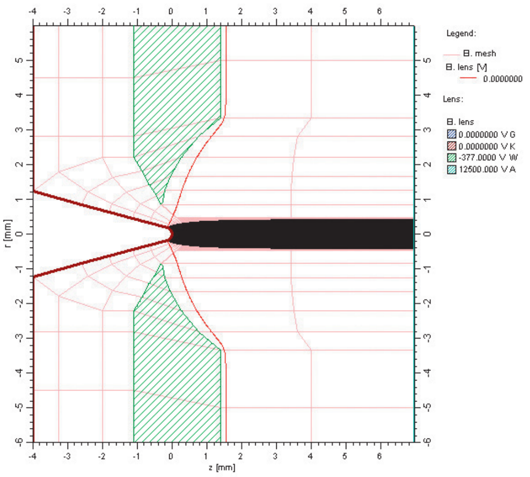


Fig. 1. An example of the computation of a space charge limited electron gun for an electron-beam welding machine. The cathode on the axis is held at zero potential, the Wehnelt electrode, shown by hatching, is at a negative potential, which focuses the beam and limits the area from which the beam (dark lines) can leave the cathode.

In the standard way of evaluating optical properties we obtain focal properties from paraxial trajectories and aberration coefficients from aberration integrals containing paraxial trajectories and fields. With high-accuracy ray tracing it is possible to evaluate focusing properties and aberrations by fitting the results of ray tracing by the least-squares method. In this way we can obtain aberration coefficients of any order even for systems for which the theory is not fully implemented. Knowledge of the numerical values of aberration coefficients does not allow easy estimation of image properties. For known optical parameters (paraxial properties, aberrations of a given order, chromatic and diffraction effects) it is possible to estimate the imaging properties from a “spot profile”, not only in the Gaussian image plane, but also in any arbitrary plane close to a given image position.

We have developed a new program called EOD (Electron Optical Design), a 32-bit Windows program written entirely in Visual Fortran, which combines graphical interfaces for FEM and all FEM programs for the computations of fields with ray tracing and its graphical presentation. This program was written by Jakub Zlámal from the Faculty of Mechanical Engineering of Brno University of Technology, but began within his PhD project at ISI. Many improvements have recently been made, including the option of analysing space charge limited beams and electron and ion sources. The computation of space charge requires very precise ray tracing , which is possible only if the field is computed with sufficient accuracy. The electron gun of an electron-beam welding machine shown in Fig. 1 is a typical example, where the emission current and optical properties of the gun are limited by space charge [71, 120, 316, 317, 394].

Anisotropic etching of monocrystalline tungsten wire

Svatopluk Kokrhel and Jiřina Matějková

Sharpened single-crystal tungsten wires with a tip radius of less than 1000 nm are used as an electron source in focused electron beam technology equipment. Cold-field emission cathodes in particular require a tip radius of less than 100 nm. Another possible use is in scanning probe microscopy equipment.

Single-crystal tungsten wires with a diameter of 100–130 mm were formed in computer-controlled equipment for anodic etching. A microcontroller unit was designed and realised in co-operation with the Department of Microelectronics, Faculty of Electrical Engineering and Communication Technology, Brno University of Technology. Anisotropic etching conditions were optimised for a set of polycrystalline and single-crystal wires.

Two kinds of single-crystal wire – with crystallographic orientation (100) and (111) – were used (see Fig. 1 and 2). The sharpness and crystallography of the tip were studied in a Field Emission Scanning Electron Microscope – JSM 6700F JEOL. A tip diameter of less than 50 nm in the case of the (100) orientation was achieved. Such a formed tip can be used for manufacturing electron beam sources both in an e-beam microscopy and e-beam lithography. The crystallographic data acquired corresponded well with appropriate crystal models. Modifications of sharpening conditions allow control of the tip geometry, which is expressed by the ratio of the tip length and the tungsten wire diameter. Experimental results with finalized cold-field emission cathodes show that better parameters are achieved when the ratio is greater than one.

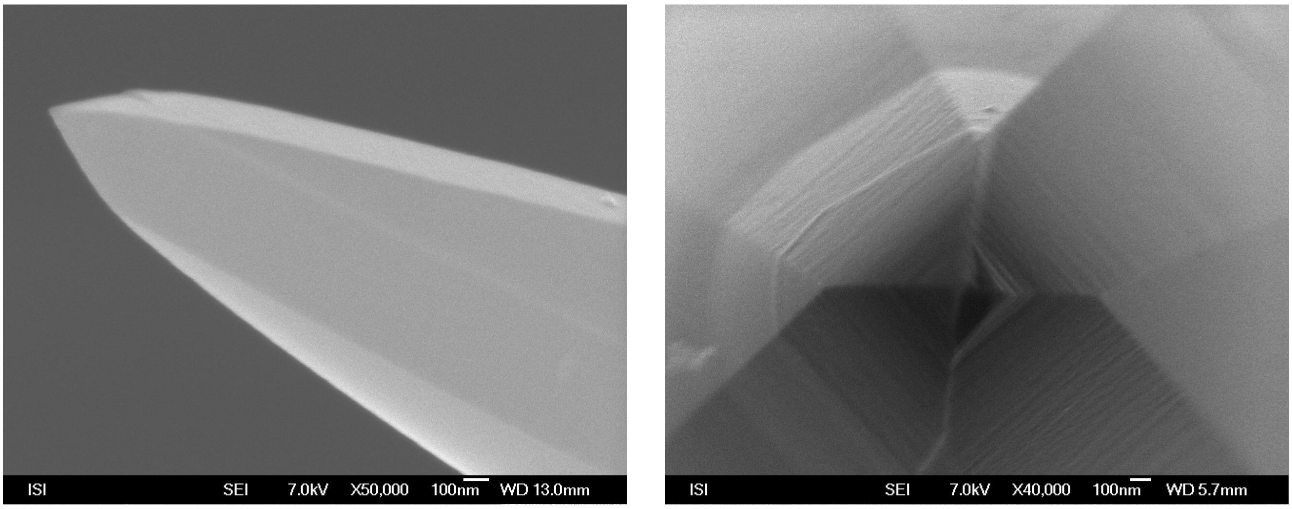


Fig. 1. Anisotropically etched crystal (100). Left: side view, right: front view.

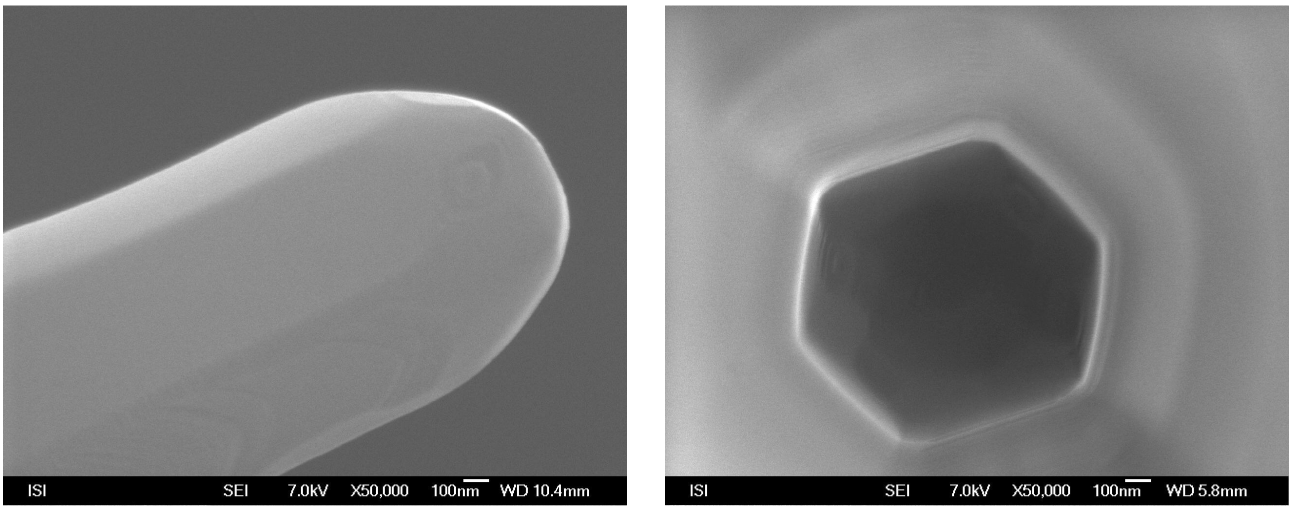


Fig. 2. Anisotropically etched crystal (111). Left: side view, right: front view.

Accurate computations of electrostatic and magnetic lenses

Bohumila Lencová

In every practical computation it is desirable to have an easy way of estimating the accuracy of the computed result and an indication of the zones where sources of inaccuracy occur. A natural option is to compare the computation results obtained in several meshes of different density and geometry. Such an analysis of the computation error is not straightforward even if we compare only the axial values of fields, and is almost impossible in two dimensions, unless the potential is available at the same points. Recently we have shown that the FOFEM mesh can use up to one million points without running into problems with round-off errors, and that computation on a personal computer takes just a few minutes. This is a much larger number than the 200,000 points that can be generated and displayed by the current user interface.

We have introduced a new accuracy estimate method, which is in principle extremely simple and provides the computation error for a given FOFEM mesh. Using this method we first calculate the potential in the given mesh and then, by inserting a new line between each two neighbouring mesh lines, we get the potential at the same mesh points with higher accuracy, as the new mesh has almost four times as many points as the original mesh. Such a computation is only about 8 times longer. The difference between the two potentials gives an estimate of the error. The error of potential or flux is known at every point of the lower density mesh; on the axis we have the error of potential, field or axial flux density. Analysis of the result is then much easier. It is well known in theory how the computation error behaves in rectangular meshes, where the local error is proportional to the fourth power of the mesh step, and the "global" error, the integral effect on the potential on axis, is proportional to the second power of the mesh step. The error in non-rectangular meshes or meshes with varying mesh step or the error caused by the corners of electrodes depends on the mesh step in a more complicated way. In most cases we have to check merely the behaviour of the error on the axis, which should have the same shape as the second derivative of the axial function. Any deviation from this behaviour can be analysed by checking the equipotentials of the "error potential", which can be easily displayed with the existing interface.

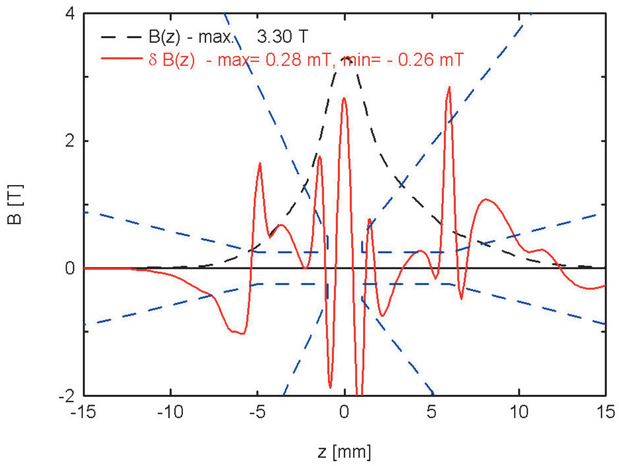


Fig. 1. The full line shows the error of the axial flux density (multiplied by 10000). The dashed curve shows the axial flux density, reaching 3.30 T for 16000 AT lens excitation (the outline of the polepieces is given by the straight dashed lines). The accuracy of the result is below 0.01 % of the maximum flux density on axis.

The example below shows the accuracy of the axial flux density in a saturated objective lens of a 200 keV transmission electron microscope. The dashed curve shows the axial flux density, reaching 3.30 T for 16000 AT lens excitation (the outline of the polepieces is given by the straight dashed lines). The computation in a mesh with almost 80000 points takes only around 30 seconds on a 1 GHz PC. The full line showing the error of the axial flux density is multiplied by 10000. It demonstrates that the accuracy of the computed result is below 0.01 % of the maximum flux density on axis. The peaks on this curve can be related to the geometry of the lens, to the changes of the step in the mesh and to the uneven saturation of the magnetic material. The optical properties (focal distance, axial aberrations) computed in both the less and the more accurate axial fields differ by less than 0.005 % [31, 104, 105, 389, 390].

Observation and study of nanometer scale materials

Jiřina Matějková, Antonín Rek, František Matějka and Jan Grossman

Accurate observation of nanostructures can be one of the starting points in understanding substances. High-resolution scanning microscopy has proven to be a versatile tool for characterizing nanomaterials and nanostructures. The cold field emission cathode of the Field Emission Scanning Electron Microscope (FE SEM) JSM-6700F JEOL generates electrons with a small energy spread. This microscope, suitable for obtaining a high resolution at a wide range of acceleration voltages, has been operating at ISI since the year 2002. Because of its resolution of 1.0 nm for an accelerating voltage of 15 kV and working distance of 3 mm, resolution of 2.2 nm for an accelerating voltage of 1 kV and working distance of 1.5 mm, this instrument is highly suitable for observation of fine structures such as multilayered films, reliefs and nanoparticles (see Fig. 1). Research into single-crystal tungsten materials has been carried out in order to manufacture a powerful E-beam Writer electron source (see Fig. 2). Nanocarbon materials have been an important topic over the past ten years. Various applications of these innovative materials, such as electronics and energy, are under development. Plasma deposited carbon nanostructures such as carbon nanotubes have been studied in co-operation with the Department of Physical Electronics, Faculty of Science, Masaryk University in Brno (see Figs. 3, 4). In 2003 the JSM 6700F microscope was fitted with an INCA energy dispersive X-ray analyser system from Oxford Instruments, which represents a vital combination for the study of nanomaterials and nanostructures.

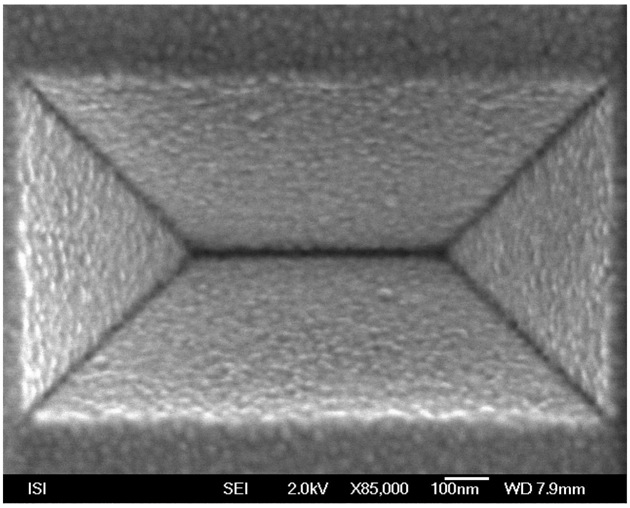


Fig.1. Secondary electron image of a gold-coated surface of an anisotropically etched silicon single crystal.

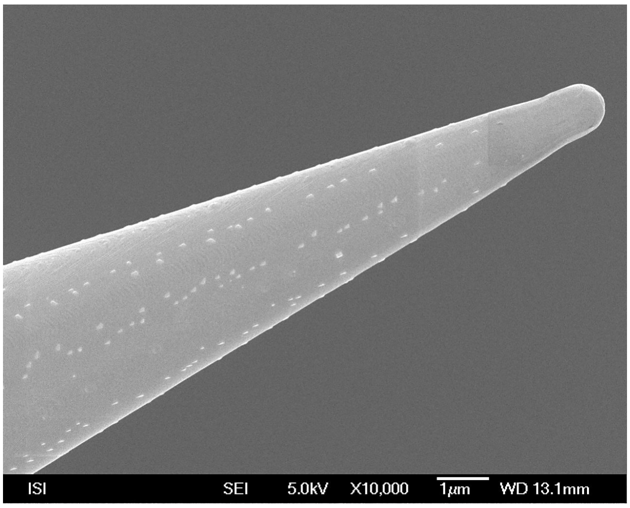


Fig.2. Secondary electron image of the zircon nanocrystals grown on the surface of a tungsten single crystal.

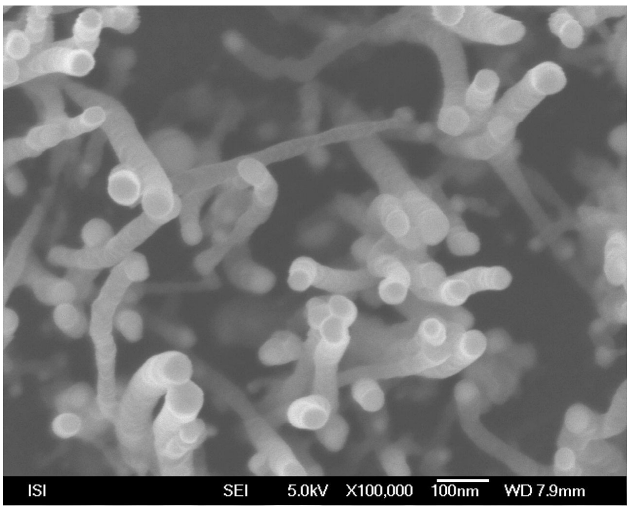


Fig.3. Secondary electron image of the plasma-deposited carbon nanostructure - nanotubes.

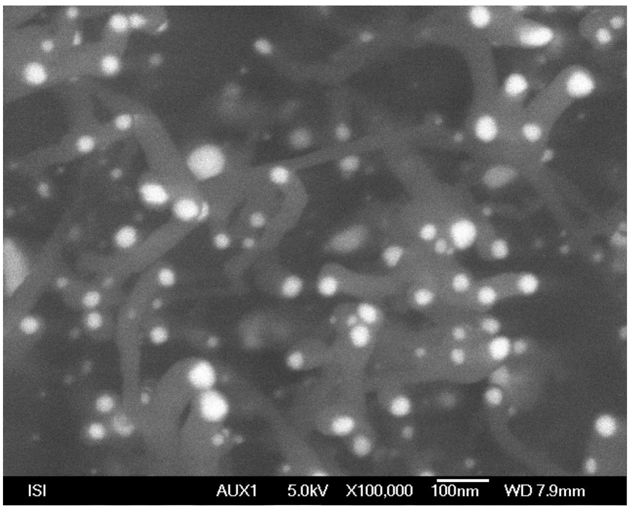


Fig.4. Backscattered electron image of grow nuclei for carbon nanotubes.

Material contrast at very low electron energies

Ilona Müllerová and Luděk Frank

A standard commercially available gold/carbon (Au/C) test specimen is normally used for testing the image resolution in a Scanning Electron Microscope (SEM). The specimen is manufactured by evaporating very small gold particles on a carbon substrate. The large difference in the atomic numbers of these materials causes both the secondary (SE) and backscattered (BSE) emissions to be sufficiently different between the particles and substrate, so that a high image contrast is available. This behaviour of contrast formation is well known for primary electron (PE) beam energies above several keV.

We examined the development of this contrast down to low (hundreds of eV) and very low (tens of eV) energies. Measurements were taken under varying vacuum conditions and magnitude of the electrostatic and magnetic fields in a specimen region [119]. In order to achieve a high resolution at low and very low energies, the SEMs used were equipped with the cathode lens (CL) reducing the landing energy of PE by a negative specimen bias. Even more important was the fact that the CL assembly acts to accelerate all emitted electrons, so that the energies of SE and BSE strongly increase and subsequently both fall to the same order of magnitude.

The experiments were conducted in an SEM JEOL 6700F, with the specimen immersed in a strong electrostatic field of CL and strong magnetic field of the focusing objective lens. The vacuum in the specimen region was 2×10^{-4} Pa. The same experiments were conducted in an ultrahigh vacuum scanning low-energy electron microscope (UHV SLEEM) system developed at ISI with an electrostatic column; here the specimen was immersed merely in the strong electrostatic field of the CL and the vacuum in the specimen vicinity was 10^{-8} Pa. Fig. 1 shows the development of the contrast at various energies in both instruments. Finally, the experiment was repeated in a Vega TS5130 SEM (Tescan Brno) with standard vacuum and negligible magnetic field on the specimen.

The experiments performed reveal the Au/C contrast strongly decreasing at the low order of hundreds of eV. In the very low energy range, the contrast can either disappear or invert its sign. This behaviour has been analysed and the contrast mechanism explained with a model [119] taking into account, in addition to the CL electrostatic field, the magnetic field in the specimen vicinity as well as the vacuum conditions projecting themselves into the rate of creation of graphitic contamination on the surface under observation.

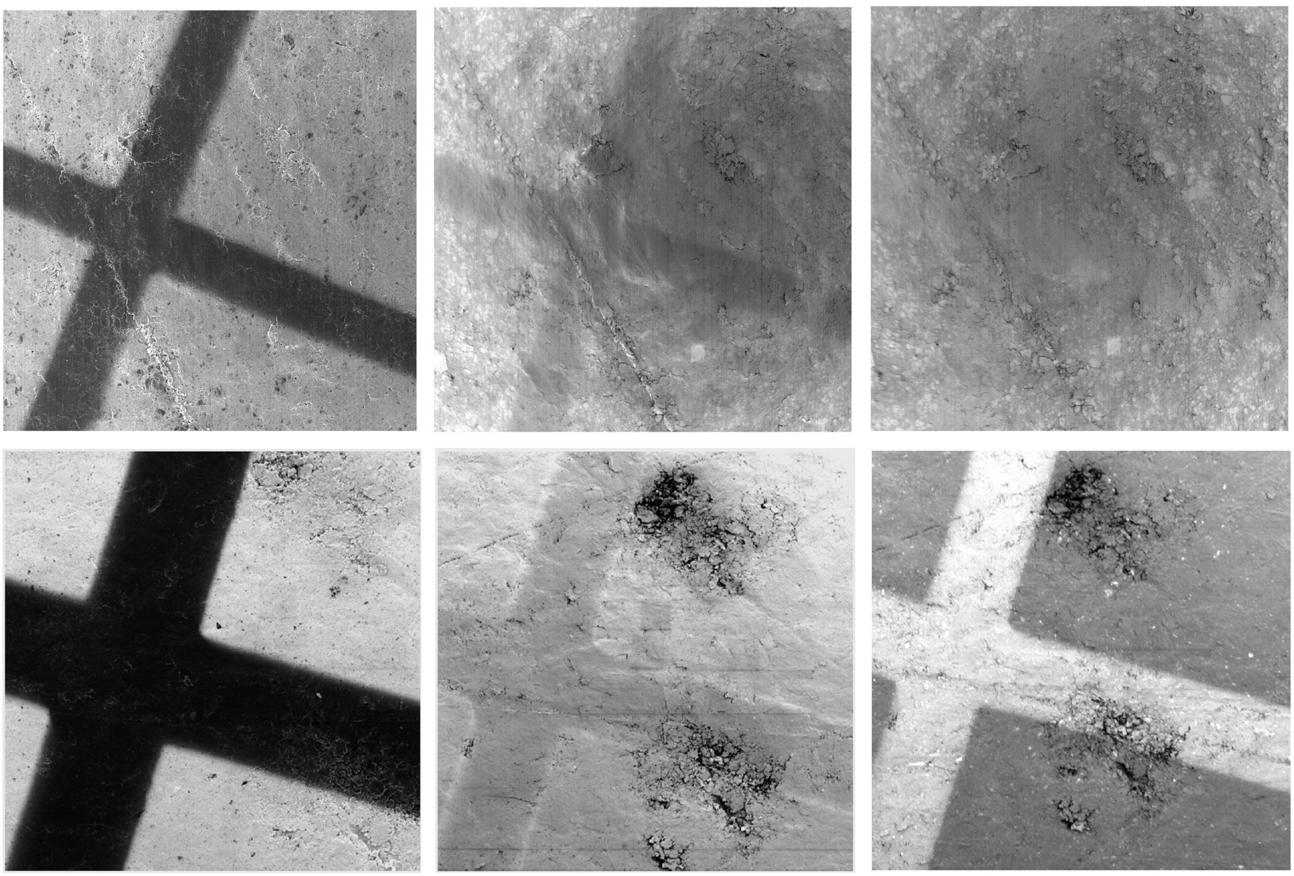


Fig. 1. The Au/C resolution-testing specimen, from the left: 3020, 320 and 20 eV. Top: JEOL 6700F adapted to SLEEM, bottom: UHV SLEEM of ISI Brno, the width of the field of view 200 µm (top) and 100 µm (bottom).

Ultrahigh vacuum scanning low energy electron microscope

Ilona Műllerová, Pavel Klein, Petr Čižmár, and Luděk Frank

An ultrahigh vacuum scanning low energy electron microscope (UHV SLEEM) has been developed for the purpose of studying clean and well-defined surfaces via imaging at high spatial resolution with electrons of energies from 0 to 25 keV. While at 10 keV the image resolution reaches 11.5 nm, at 10 eV it has been proved to deteriorate only very moderately to 26 nm. The whole system is fully bakeable up to 180 °C and hence the residual pressure is 1×10^{-10} mbar.

The instrument (Fig. 1a) consists of three vacuum chambers: one is intended for observation of the specimen, the second for in-situ preparations and the third is the loading chamber of the air lock.

The observation chamber is equipped with the two-lens field emission electrostatic column (FEI Corp.). To preserve high resolution down to very low energies, we incorporated a cathode lens into the specimen region (Fig. 1b). Negatively biased specimen forms the cathode of the lens while co-axial scintillator disc of the detector, positioned just above the specimen, serves as the anode at ground potential. Signal electrons are collimated onto the detector by the cathode lens field so that high detection efficiency is available down to lowest energies [11]. The central scintillator bore, allowing the primary beam to pass, is 0.3 mm in diameter only. Fluent movements of the specimen stage are available within intervals X=±5 mm, Y=±5 mm, and Z=±10.5 mm, and two mutually perpendicular tilts ±5° and rotation ±8° are available, too. The observation chamber is equipped with a quadrupole mass spectrometer (QMS 200 of Balzers) operating in the mass ranges 1 to 200 amu under pressure down to 10^{-11} mbar. Under development is electron spectrometer based upon the hyperbolic field parallel energy analyser. The microscope is connected to a PC based electronic console with dedicated software package (Tescan Ltd. Brno), securing primary beam control and data acquisition and processing.

The preparation chamber contains a differentially pumped scanning ion beam gun for surface cleaning (IQE 12/38 of Specs), the heating facility for the specimen and an evaporation attachment for deposition of thin metal layers. The air-lock chamber is equipped with a specimen loading mechanism and the specimen transport from the air-lock chamber into the preparation chamber and further to the observation chamber is performed by means of a manipulator driven by magnets from outside (Delong Instruments, Brno).

First experiments concentrate on observation of the doping patterns in semiconductors and on demonstration of wave-optical contrasts, e.g. interferences, diffraction and contrast of the local density of states.

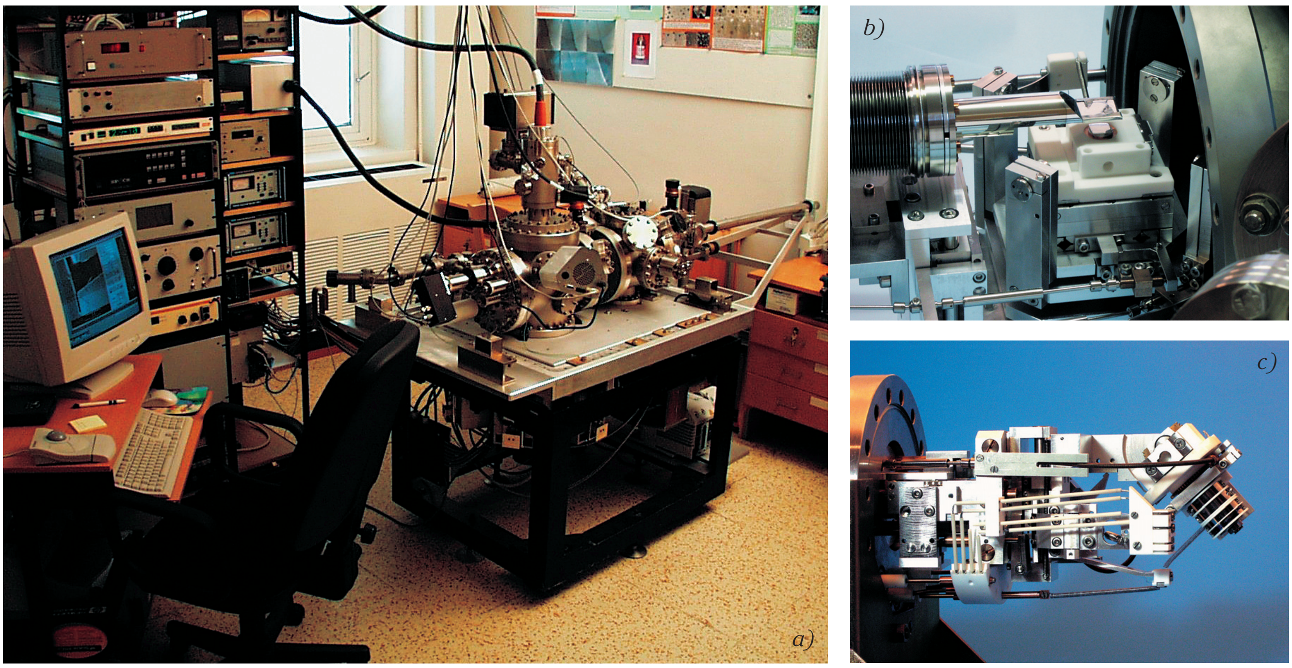


Fig. 1. (a) UHV SLEEM, (b) specimen stage of the observation chamber with the SLEEM detector, (c) specimen stage of the preparation chamber.

Imaging of the dopant distribution in semiconductor by secondary electrons

Ilona Müllerová, Filip Mika, and Luděk Frank

Along with the continuous growth in the scale of integration, in the number of technological layers in semiconductor heterostructures and in the size of substrates (and therefore also in need for timely detection of any significant imperfections), increasing demand arises for methods capable of direct observation of local differences in critical structure parameters. Most important is the necessity for visualization of both compositional and doping contrast between layers or between elements of the patterned layout of an individual layer. The scanning electron microscope (SEM) stands as one of the most important examination methods capable of being applied even in a non-destructive inter-operational check.

The usual doping concentrations in the order of 10^{17} to 10^{19} cm^{-3}, i.e. the relative contents between 0.02 and 0.0002 at%, do not produce any observable material contrast normally carried by backscattered electrons (BSE). Since mid 1990s the dopant contrast in the secondary electron (SE) emission was successfully observed. Leading groups in this problematic agreed about a model explaining the contrast (e.g. the p-type regions being brighter than the n-type ones) by means of local differences in the ionization energy, balanced to a constant ground level potential via so-called patch fields above the specimen surface, generated by different densities of surface dipoles. This model considers the specimen absolutely clean and its electron bands flat up to the very surface, while band bending caused by surface states should eliminate the contrast.

Our study, made in cooperation with the Department of Electronics of the University of York, UK, verified the basic properties of the contrast mechanism and revealed the p/n contrast strongly enhanced with the specimen immersed in electrostatic field (Fig. 1) [115]. The field was applied in the cathode lens securing high image resolution at low electron energies (the SLEEM mode). The p/n contrast reaches its maximum at or below 1 keV and its magnitude strongly depends on the vacuum conditions (Fig. 2). Finally, when the specimen is coated with a thin metal layer, the p/n contrast is obtained with both signs in dependence on relation of the work function of metal to that of silicon.

New experimental data enabled us to formulate a contrast model (Figure 3) [45] relying upon electric fields located solely below the surface and explaining the contrast dependence on the work function of an overlayer, including the ever-present graphitic contamination, as well as the contrast preservation after removal of the overlayer and re-activation of surface states.

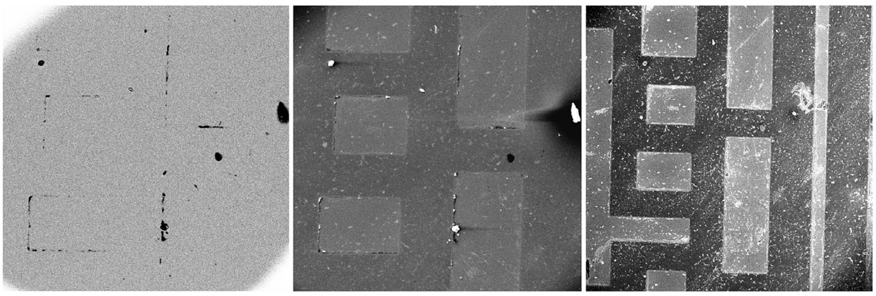


Fig. 1. The boron doped p-type patterns on an n-type Si (111): (from the left) the BSE image at 10 keV, the SE image at 10 keV, and the SLEEM image with 10 keV electrons decelerated to 1 keV (the width of the field of view 350 μm).

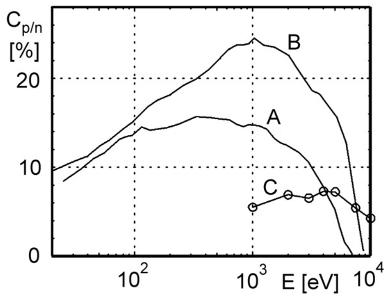


Fig. 2. The contrast level obtained in an ultrahigh vacuum (UHV) SLEEM (A), standard SLEEM (B) and in the SE mode (C).

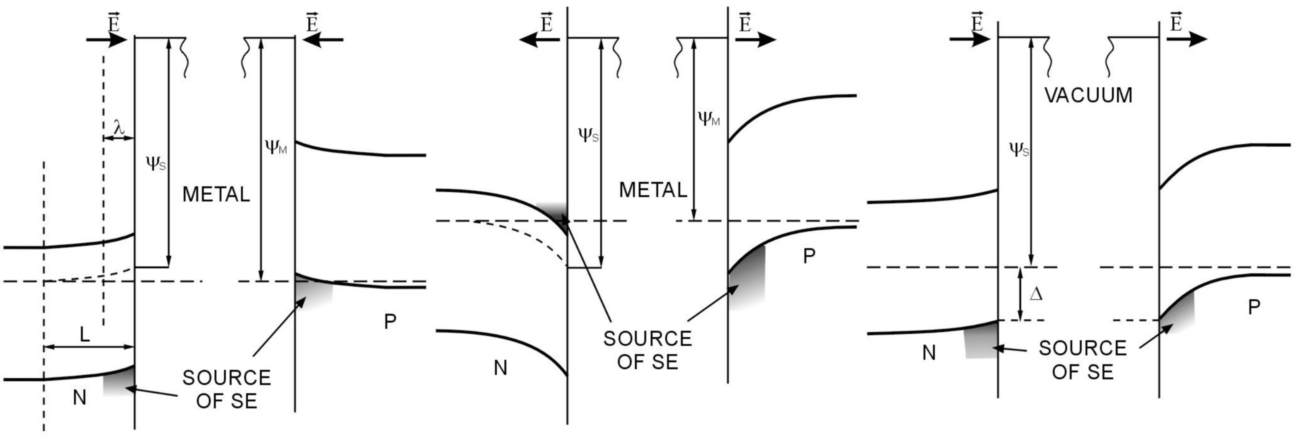


Fig. 3. From the left: The junction below the metal-coated structure for a high work function of the metal (or for carbon), the same for the low work function, and the in-situ cleaned surface with re-activated surface states. The contrast is connected with ionization energies of SE and orientation of the subsurface fields.

34

The ultimate resolution of scanned electron micrographs at very low energies

Ilona Müllerová and Luděk Frank

In a scanning electron microscope (SEM) the image resolution is governed by the spotsize of the illuminating beam, enlarged by the lateral diffusion of primary electrons inside the specimen. The spotsize dimension is contributed by demagnified crossover of the electron gun and by confusion discs of the optical aberrations inherent to the demagnification. Two of the three main aberrations, the chromatic and diffraction aberrations, increase with decreasing electron energy and hence the same holds true for the spotsize (see Fig. 1). Obviously, when lowering the beam energy down to units of eV, the resolution drops from the nanometer to the micrometer range. This adverse circumstance can be avoided when forming and focusing the beam at high energy and retarding it just in front of the specimen surface within the cathode lens [49] (so called scanning low-energy electron microscope or SLEEM mode). In this case the specimen is negatively biased and serves as the cathode of the cathode lens (CL) while the anode can be combined with the detector (see Fig. 2).

Adaptation to the SLEEM mode can be performed on virtually any conventional SEM provided the CL/detector assembly is fitted into the specimen chamber and high-voltage biasing of the specimen is ensured. This task has been performed on a highest-class microscope (see Fig. 3) capable of achieving unrivalled resolution values at very low energies. The image resolution of 9.3 nm at 10 eV (see Fig. 4) is the best value ever demonstrated [11, 330].

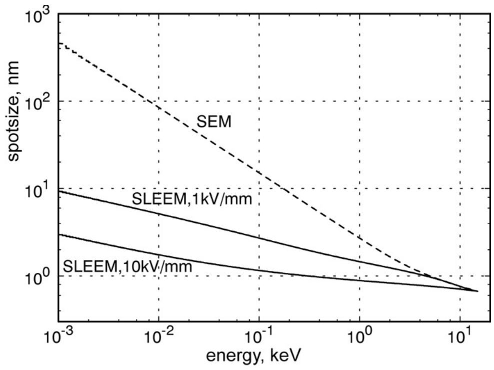


Fig. 1. The ultimate spotsize at an optimum beam aperture calculated for typical parameters of a cold field emission SEM and for the same SEM adapted to the SLEEM mode (labelled with the CL field strength).

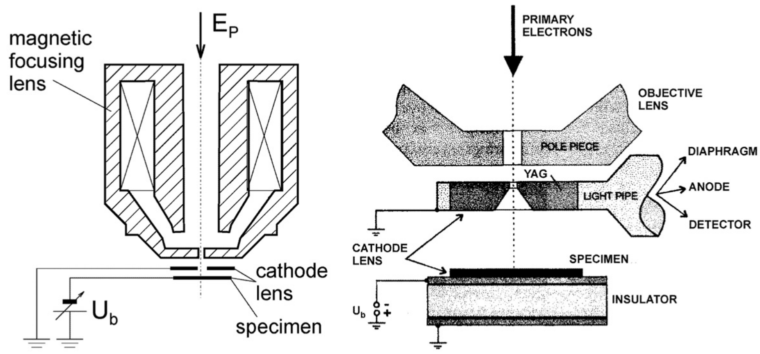


Fig. 2. The principle of the cathode lens inserted below the standard objective lens (left), configuration of the cathode lens with the anode consisting of a coaxial bored single-crystal scintillator disc serving as the detector (right).

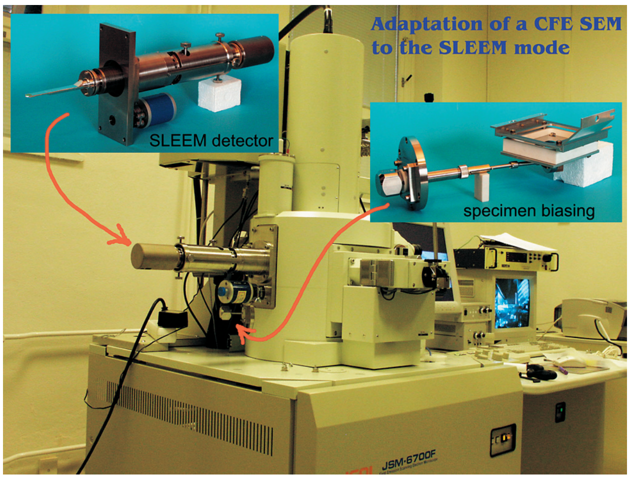


Fig. 3: A cold field emission gun equipped SEM (with nominal resolution of 1 nm at 15 keV) adapted to the SLEEM mode by entering the cathode lens.

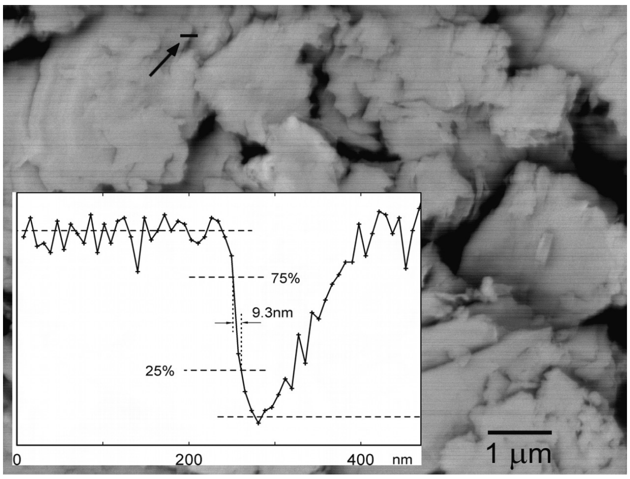


Fig. 4: Gold particles sputtered onto a carbon substrate, imaged in the SLEEM mode at 10 eV; the inset shows linescan along the arrow-indicated abscissa, demonstrating the edge resolution of 9.3 nm.

Cathodoluminescence degradation in organo-silicon structures

Petr Schauer, Petr Horák, Rudolf Autrata, Jan Dupák, Jaroslav Sobota and Jiří Runštuk

The synthesis, characterization and study of unique properties, as well as the application of optically active synthetic polymers, are of great interest in the field of modern polymer science. The reason for this is that optically active polymers are promising materials in such areas as liquid crystals, switch and memory, non-linear optics and luminescence. Furthermore, knowledge and understanding of optically active polymers are necessary for further progress in the given areas and other new areas. The structure of these materials (the structural formula is shown in Fig. 1a) is very similar to the structure of biological materials, for which reason the study of optically active polymers enables us to understand the most important molecular building blocks of natural biopolymers such as DNA, polysaccharides and proteins.

The subject of our research is a group of optically active poly[alkyl(phenyl)silylene]. Within these series the research focused on poly[methyl(phenyl)silylene], i.e. PMPhSi, whose structural formula is shown in Fig. 1b. Excitations of PMPhSi lead to both irreversible degradation and metastable state formation that decisively influence its physical properties. The main aim of our investigation was to study all the steps that can lead to the formation of metastable states in PMPhSi. A cathodoluminescence (CL) study of metastable states in the material chosen has been conducted. In addition to the construction of the experimental set-up, attention has also been paid to specimen optimization.

The PMPhSi studied was prepared by Wurtz coupling polymerization. The layers for the CL measurements were prepared from a toluene solution by casting on quartz disk substrates. The low-molecular weight fractions were extracted with boiling diethyl ether. For electron beam experiments the PMPhSi was covered with Al sputtered film of 50 nm, possessing an optical reflection of 89 % and an electron energy yield of 96 % for 10 keV electrons. The given conductive film is important to protect the sample from charging during electron beam impact. The coating must be thin enough so as not to absorb excitation electrons, and at the same time thick enough to be conductive and to show a high optical reflectivity for photon collection. Monte Carlo (MC) simulation was used to estimate the electron energy losses in the Al film, and matrix method calculations of the internal optical reflection were carried out to ensure high optical reflection for photon collection. Before Al deposition the PMPhSi was purified by precipitation in a methanol and toluene solution and centrifuged.

It has been verified that PMPhSi is a low-density material possessing high transmission for fast electrons. An MC simulation of its interaction volume for 10 keV primary electrons is given in Fig. 2. The thickness of the PMPhSi must be at least 3 μm to ensure no excitation losses during CL measurements. On the other hand, the PMPhSi layer must be thin enough to avoid the losses resulting from photon self-absorption. The degradation of the CL emission of the thickness-optimised PMPhSi (2 μm) sample is plotted in Fig. 2. It can be found out from this semi-logarithmic plot that the material forms metastable states approximately after 7, 27 and 60 minutes of 10 keV electron beam exposure [128, 177, 348, 417].

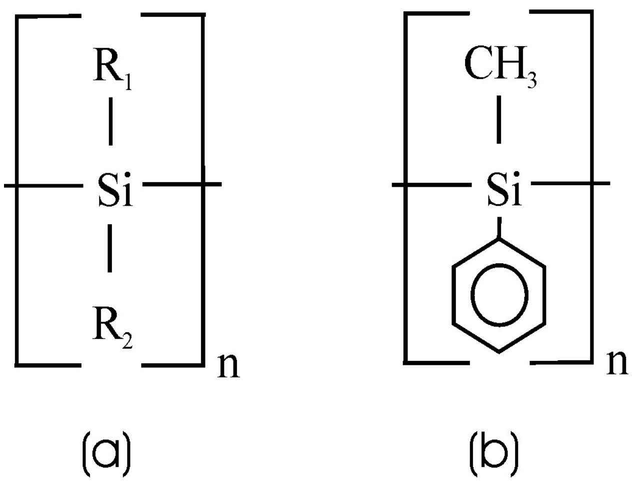


Fig. 1. Typical structural formula (a) of an optically active polysilylene (R1 and R2 are chiral groups) and (b) of the studied PMPhSi.

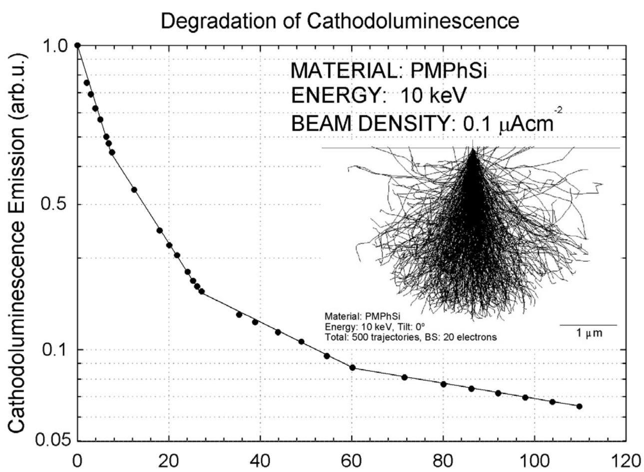


Fig. 2. Experimental results of CL emission degradation measurement in PMPhSi (10 keV, 0.1 μAcm^{-2}). MC simulation of 3D trajectories in the material is also shown.

Optimization of a scintillation detector for a scanning electron microscope

Petr Schauer, Rudolf Autrata, Ilona Müllerová, Jan Dupák, Jaroslav Sobota and Ivan Vlček

In a scanning electron microscope (SEM) and/or scanning transmission electron microscope (STEM) an image is formed by a focussed electron beam, which scans across a very small part of the specimen surface. The point-by-point imaging system processes only one pixel of the image at any given moment. The quality of the resulting image is dependent to a considerable extent on the type of electron detector used. This is the main reason why semiconductor detectors are not used on a wider scale in S(T)EM. A scintillation detection system utilising a scintillator, light-guide and photomultiplier tube is the most widely used assembly for performing the given scanning mode of imaging. The system utilises optical coupling, since separation of the accelerating electric potential at the scintillator from follow-up electronics is necessary. In simple terms, the whole detection system must have a high detective quantum efficiency. Various scintillation detectors show a noticeable difference in detection efficiency due to poor electron-photon energy conversion and/or light losses in the optical part of the detector. The main component of such a detector is the scintillator. This has to be extremely fast, possess a high efficiency of electron-photon conversion, and has to emit light in the spectral region of high photomultiplier sensitivity. The contribution made by our laboratory regarding this important part of the detector was the introduction of single crystal scintillators YAG:Ce and YAP:Ce, which are currently used by nearly all microscope producers all over the world. To date certain optimization of the given single crystal scintillators has been achieved by our laboratory.

The light guide (including the optical coupling) is an often underrated component of the S(T)EM scintillation detector. It has to transport the signal from the scintillator to the photomultiplier with minimum losses. It is often complexly shaped in order to fit the space available in the microscope chamber. As for the arrangement of the light guide, two different modes of scintillation detectors are used in S(T)EMs. The first one (basic) makes use of the Everhart-Thornley detector, i.e. a base guided signal rotationally symmetric system, intended for the detection of secondary electrons. The other mode makes use of an edge guided signal scintillation system, and is intended for the detection of backscattered electrons (BSEs). A computer optimized design method for photon transport optimization in nearly any S(T)EM scintillation detection system has been developed at our laboratory. The extended version 3.0 of our SCIUNI program possesses an algorithm for the interaction of a photon with the scintillator and light-guide surfaces, and thus the detector systems may comprise almost all actual surfaces. Some results of photon transport simulation are demonstrated by presenting the step-by-step improvement of the BSE scintillation detector S 4000 Hitachi SEM in Fig. 1 and Table 1. The final optimized design (e) has been accomplished by integrating low angle widening planes and a conical light guiding ring close to the scintillator. The resulting photon collection efficiency is about 400 %, compared with the initial efficiency calculated for design (a) [176, 346, 416].

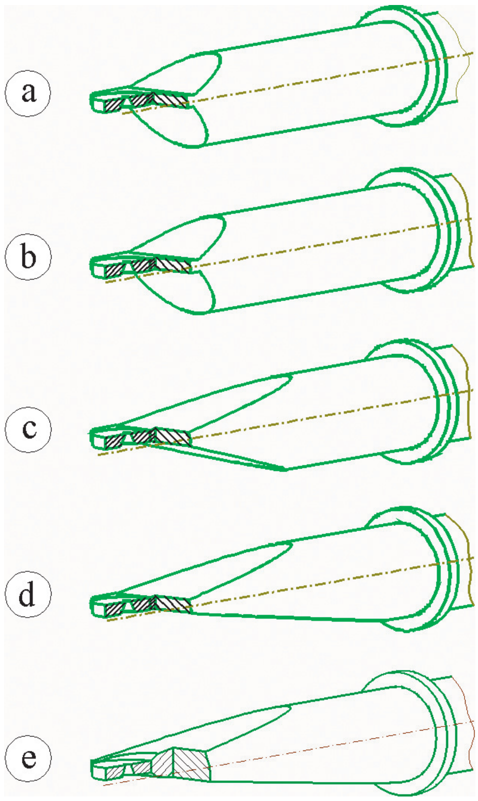


Fig. 1. Design of S 4000 BSE scintillation detection systems. It is improving from the basic (a) geometry to the final (e) geometry.

Geometry[1]	Light-Guiding Efficiency		
	Mean[2]	Total improvement[3]	Relative improvement[4]
(a)	0.043	1.00x	–
(b)	0.054	1.26x	1.26x
(c)	0.110	2.56x	2.04x
(d)	0.153	3.56x	1.39x
(e)	0.176	4.09x	1.15x

Table 1. Light-guiding efficiency of the S 4000 BSE scintillation detector in dependence on different light-guide geometries (see Fig. 1).

[1] *See Fig. 1.*

[2] *Over the electron impact surface.*

[3] *Related to the starting geometry.*

[4] *Related to the previous geometry*

Carbon based nanolayer and nanocomposite coatings

Jaroslav Sobota and Jan Grossman

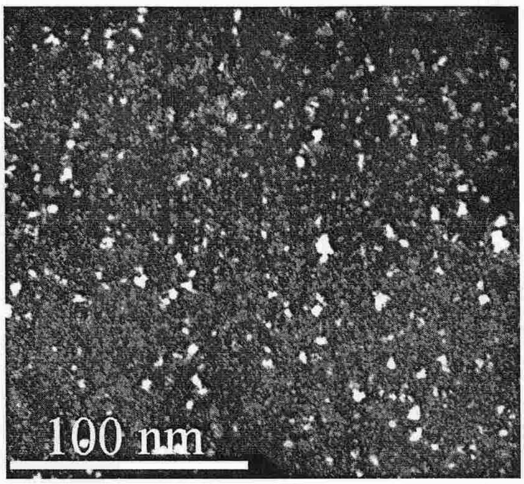
Carbon-based nanolayer and nanocomposite coatings are hard, low-friction and wear-resistant coatings for engineering applications that enable the creation of a stable structure with unique physical properties and, most importantly, a combination of properties conventionally considered as mutually exclusive, such as high hardness and high toughness.

The idea of creating nanocomposite coatings as the next generation of hard coatings for tools originated in the nineties at several laboratories at the same time. At ISI we utilise our experience acquired in the preparation and characterisation of multilayered systems with a bilayer thickness in the nanometer range applicable in x-ray optics. We worked on the project in collaboration with the Institute of Physics ASCR and with HVM Plasma Ltd. in the field of evaluation of microhardness and adhesion of DLC and CNx coatings. Managing these technologies led to the idea of applying the knowledge acquired in the implementation of x-ray mirrors in the field of coatings for tools. In 1994 we established contact with the group of surface modification and tribology at the Institute of Physics and Astronomy in Aarhus, where a sputtering system suitable for the deposition of nanocomposite multilayers was available. Following its undemanding reconstruction we began experiments here, which in 1996 led to the verification of the possibility of realising the nanostructured systems designed. At that time the first papers on nanostructured multilayers from several other laboratories (Wright Laboratory – Materials Directorate, Wright-Patterson Air Force Base, Ohio USA; BIRL, Northwestern University Illinois USA and Institute for Chemistry of Inorganic Materials, Technical University Munich, Germany) began to appear. In 1996 we managed to establish contact with these laboratories. In 1996–1997 the investigator of the project worked on nanocomposite coatings at the Tribology Laboratory at Aarhus University. Since 2000 a project for carbon based nanolayers and nanocomposite coatings has been running at ISI and has been supported by COST as project no. OC523.30. The entire coating a few micrometers thick is deposited by magnetron sputtering during substrate rotation in front of carbon and metal targets in a reactive atmosphere composed of argon and nitrogen.

An impact test based on successive impacts of a cemented carbide ball onto coated specimen has been used to evaluate the impact resistance of carbon-based nanolayer and nanocomposite coatings deposited by reactive r.f. magnetron sputtering. These impact tests were carried out using a tester developed in collaboration with Brno University of Technology.

These coatings are useful for a wide spectrum of machine tools products, from cutting tools to the bearings of compressors and pumps. The aim is not only to prolong the lifetime of these products, but in many cases also incorporates ecological aspects, such as the elimination or limitation of cutting fluids, which play an important role here. This is enabled by the use of carbon containing nanocomposite coatings, where the friction coefficient without lubrication is lower than typical friction values for the system steel – high quality lubricant – steel [73,129-131].

These results were obtained in co-operation with Z. Bochníček, V. Holý and V. Buršíková (Masaryk University, Brno), G. Sorensen (Euroconsult, Aarhus, Denmark), I. Vávra and K. Sedláčková (Institute of Electrical Engineering SAV, Slovakia), Z. Soukup (University of West Bohemia, Pilsen), R. Novák, T. Polcar and T. Kubart (Czech Technical University in Prague, Faculty of Mechanical Engineering), J. Boušek, T. Fořt and M. Fibich (Brno University of Technology, Faculty of Electrical Engineering and Communication).



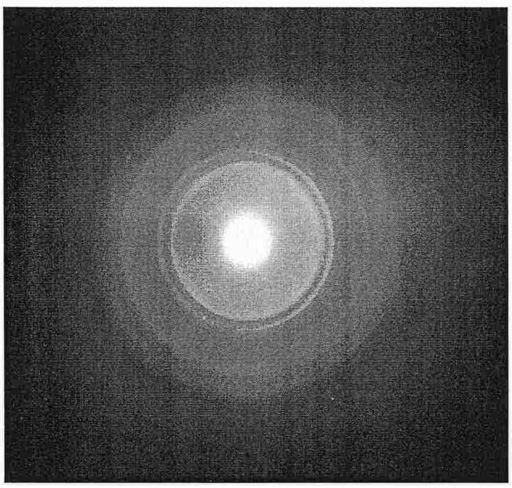


Fig. 1. The image of a cross-sectional TEM micrograph shown represents an example of the nanocomposite structure of niobium nitride and carbon nitride. The upper part represents a dark field TEM micrograph of NbN / C-N – the NbN nanocrystallites (size up to 4 nm). On the lower picture we can see the electron diffraction on an NbN / C-N nanocomposite where the nanocrystalline cubic NbN phase is identified. The diffusion halo comes from the amorphous C-Nx matrix.

X-ray imaging of micro-objects using the dark field refraction-contrast method with a resonantly absorbing multilayer mirror

Jaroslav Sobota

Until now three essentially different methods for refraction-contrast X-ray imaging have been known: the method based on the sharp angular response of crystal analyzers for selecting the refracted waves, the method that uses the coherence property of the probe X-ray beam, and the dark field method that uses resonantly absorbing multilayer mirrors for simultaneous selection of the refracted waves and suppression of the direct beam. While the first two methods have already been experimentally proven to be viable, the dark field method had not yet been experimentally validated, and there was no clear understanding of the physical mechanism for resonant absorption in X-ray multilayer mirrors. The present work forms a theoretical basis for the X-ray dark field method of imaging, and shows its practical feasibility for laboratory-based applications.

An X-ray multilayer mirror (see Fig. 2.), consisting of two periodical reflecting structures separated by a quarter-wave spacer, can be designed to have a very sharp and deep resonant absorption at a definite angle of incidence. Such a mirror may be used as an angular dispersive element for refractive X-ray radiography. In this method, which can be referred to as dark-field refraction contrast imaging, the image contrast is obtained not due to the variation of absorption, but due to the variation of the refractive index of the object inner structure. The signal-to-noise ratio in the image can be significantly enhanced, and the dynamical range of the detector reduced due to suppression of the shot noise produced by the direct beam.

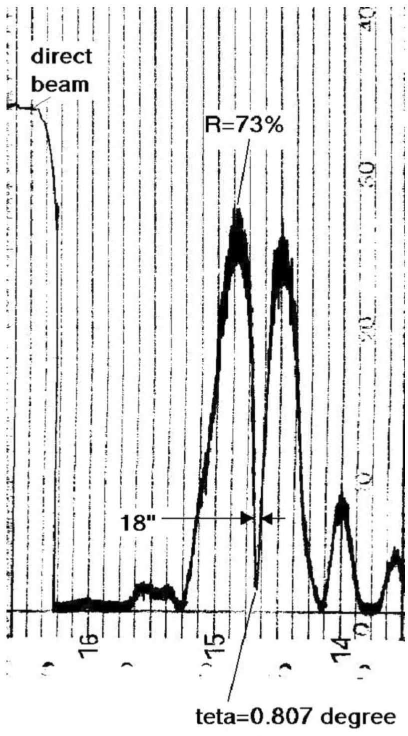


Fig. 1. Reflection curve of the mirror measured in the angular region around the resonance. The angular axis is directed from right to left.

A theoretical basis for this method has been developed, providing definite rules for designing a mirror with resonant absorption, and explaining the limitations on the detector spatial resolution. The refraction contrast images of a copper wire 75 mm in diameter and a human hair were experimentally observed using an Ni/C multilayer mirror with resonant absorption at CuK_{α} radiation (1.5Å). The multilayer structure consisting of 30 bilayers was designed for CuK_{α} radiation so as to have absorbing resonance of the width of about several arc seconds at a grazing angle of 0.8°. A monochromatic probe X-ray beam with a divergence of approximately 5 arc seconds was obtained from a conventional X-ray tube and a double crystal monochromator set in a strongly dispersive configuration [122, 335, 336].

These results were obtained in co-operation with A. S. Tremsin and O. H. W. Siegmund (Space Sciences Laboratory, UC Berkeley, Berkeley), Vladimir V. Protopopov (The Institute of Physics and Technology, Moscow, Russia), Yuriy Ya. Platonov (OSMIC Inc., Troy MI, USA), Z. Bochníček and V. Holý (Masaryk University Brno, Czech Republic).

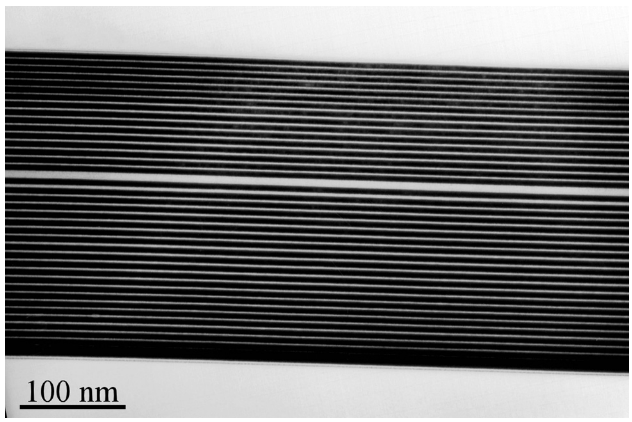


Fig. 2. X-ray multilayer mirror.

A laser interferometer for absolute distance measurement based on a VCSEL laser

Ondřej Číp, Břetislav Mikel, Josef Lazar and František Petrů

Laser interferometers based on He-Ne lasers working at a wavelength of 633 nm are some of the most precise instruments for measurements of changes of length. They work in a tracking (incremental) regime where the interference phase between the measuring and reference beam of the Michelson interferometer is monitored and the passing interference fringes are counted at the same time. The value of the instantaneous interference phase will be lost if the geometrical quantity to be measured does not allow positioning of the reflecting mirror without beam interruption. In these cases conventional interferometers cannot be used.

We have worked on a project in which the aim was research and development of methods for laser interferometry capable of measuring non-incremental absolute values of distance. We solved the problem of relative measurement by a conventional interferometer by introducing a tuneable semiconductor laser into the Michelson interferometer set-up. The trick performed by this method is based on replacement of the movement of the reflecting mirror of the interferometer by tuning the wavelength of the laser. We used a special spectroscopic laser diode with a vertical structure of the semiconductor chip as the primary laser source for the interferometer. The diode is known as a Vertical Cavity Surface Emitting Laser (VCSEL) and works at a wavelength of 760 nm. The diode can be tuned across a 1.2 nm wavelength difference by changes of the injection current. We developed a low-noise injection-current controller for the experiment, which supplies the laser diode and at the same time protects the diode against electromagnetic spikes and ripples. Since the lasing wavelength of the VCSEL laser is extremely sensitive to temperature changes on the semiconductor chip, we designed a temperature controller with high resolution and digital control. To monitor the tuning range of the VCSEL laser – the resulting resolution of the absolute distance measurement is limited by the reproducibility of the tuning interval – we applied a technique of frequency stabilization of the lasing wavelength of VCSEL to a selected resonance mode of the Fabry-Perot resonator (etalon). We developed a detection chain using the first harmonics detection technique based on digital signal processing. The electronic system provides the possibility of periodical tuning of the wavelength within a fixed wavelength interval with a triangle waveform. We improved the resolution of the method by means of a quadrature detection technique that helps sub-divide each interference fringe and determine the direction of movement of the reflecting mirror of the interferometer.

We compared this absolute interferometer experimentally with an interferometer using conventional incremental detection. We used a motorized stage for moving a pair of reflecting mirrors for both interferometers as a nano-comparator. We achieved the resolution 3 mm approximately of the absolute distance measurement for a stage travel of up to 80 mm [107, 170, 324].

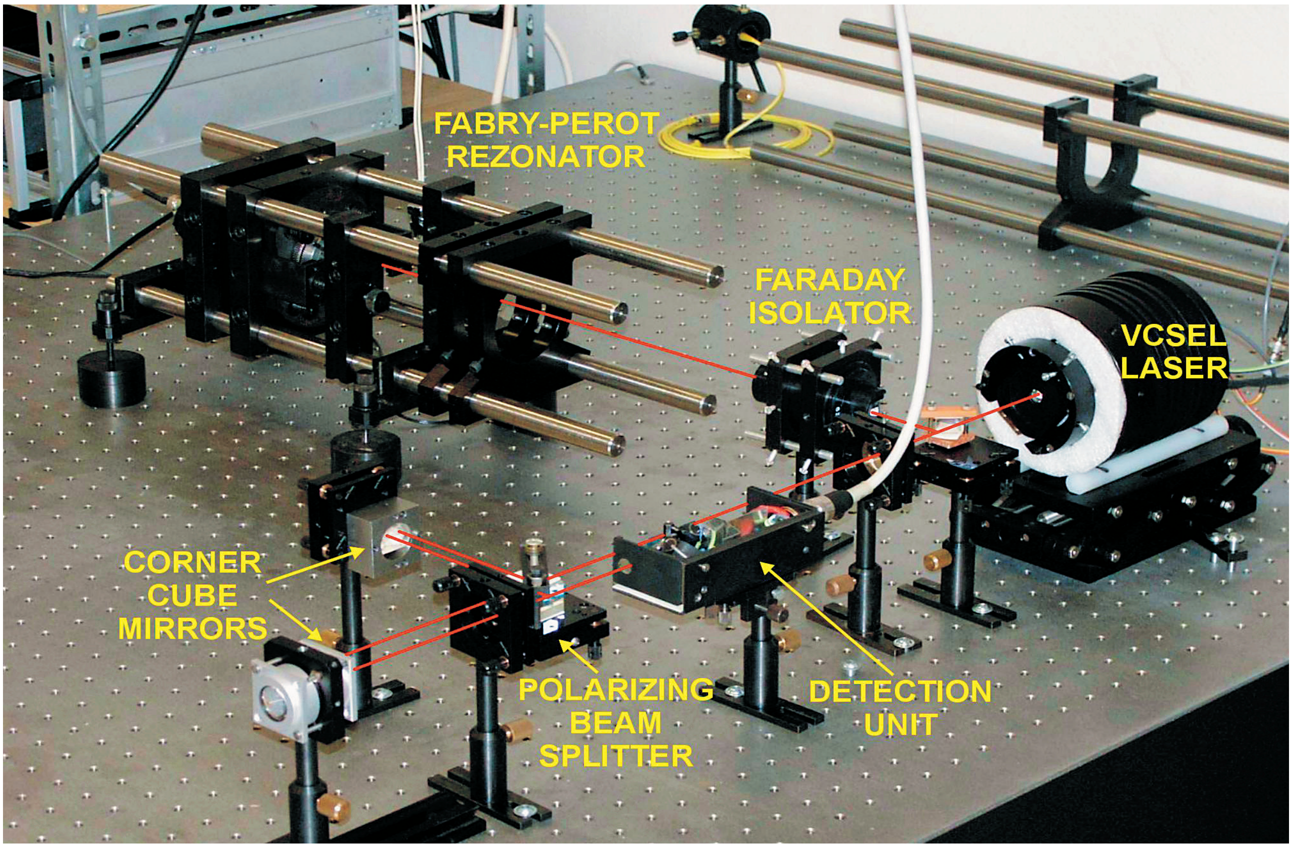


Fig. 1. Laboratory interferometer set-up.

A laser refractometer for determination of the refractive index of air

Ondřej Číp, František Petrů, Zdeněk Buchta, Vít Matoušek, Josef Lazar and Pavel Pokorný

The well-being of highly developed industrial nations relies on the manufacturing of sophisticated and advanced products. Rapid progress in the development of new microelectronic components with large-scale integration allows great advances in broadband high-dense optic communications, information technology, the automobile industry, and other fields of micro and nanotechnology. Laser interferometers are useful and highly precise measurement devices for the microelectronics industry that provide an accurate and convenient way of measuring lengths or displacements in the scale of the wavelength of light.

A Michelson interferometer controlling the displacement of the 2-D micro positioning stage of lithographic systems is a typical example of this application. With this laser technology and servo-loop control systems, the controlled stage of the lithograph can be positioned with a reproducibility and precision of within a few nanometers in the environment of air, though fluctuations in the index of refraction of air limits the achievable accuracy and reproducibility. In this case the surrounding environment in the beam path, close to the axes of measurement of the position of the stage or positioning system, must be monitored with respect to variations of the index of refraction, or the fluctuations of the environment would be a source of poor reproducibility and lower production efficiency.

We have worked on a project in which the aim was to study and develop new methods for direct measurement of the refractive index of air. We designed an innovative and sophisticated optical set-up for a laser refractometer with two independent Fabry-Perot interferometers that makes it possible to improve the accuracy of measurements in nanotechnology.

The arrangement of the experimental set-up relies on building one resonant cavity placed in the air and another equipped with a permanently evacuated cell. A pair of external lasers, frequency locked to selected resonant modes of both cavities, helps to measure optical frequency changes of the resonant mode of the cavity in the air. Thanks to the direct relationship between optical frequency and changes of the optical length of the cavity in the air, we were able to produce an instrument for measurement of the refractive index of air with an unparalleled accuracy of better than 10^{-8}. We compared this refractometer with indirect measurement of the refractive index of air. This method measured the local air pressure, temperature, humidity and CO_2 concentration with a set of atmospheric sensors collected in a “weather bureau” unit. We were then able to calculate the refractive index of air on the basis of these values with respect to the Edlen formula.

We anticipate that these results will lead to an improvement to the accuracy of the calibration process of industrial etalons calibrated by means of nanocomparators under atmospheric conditions [208, 210].

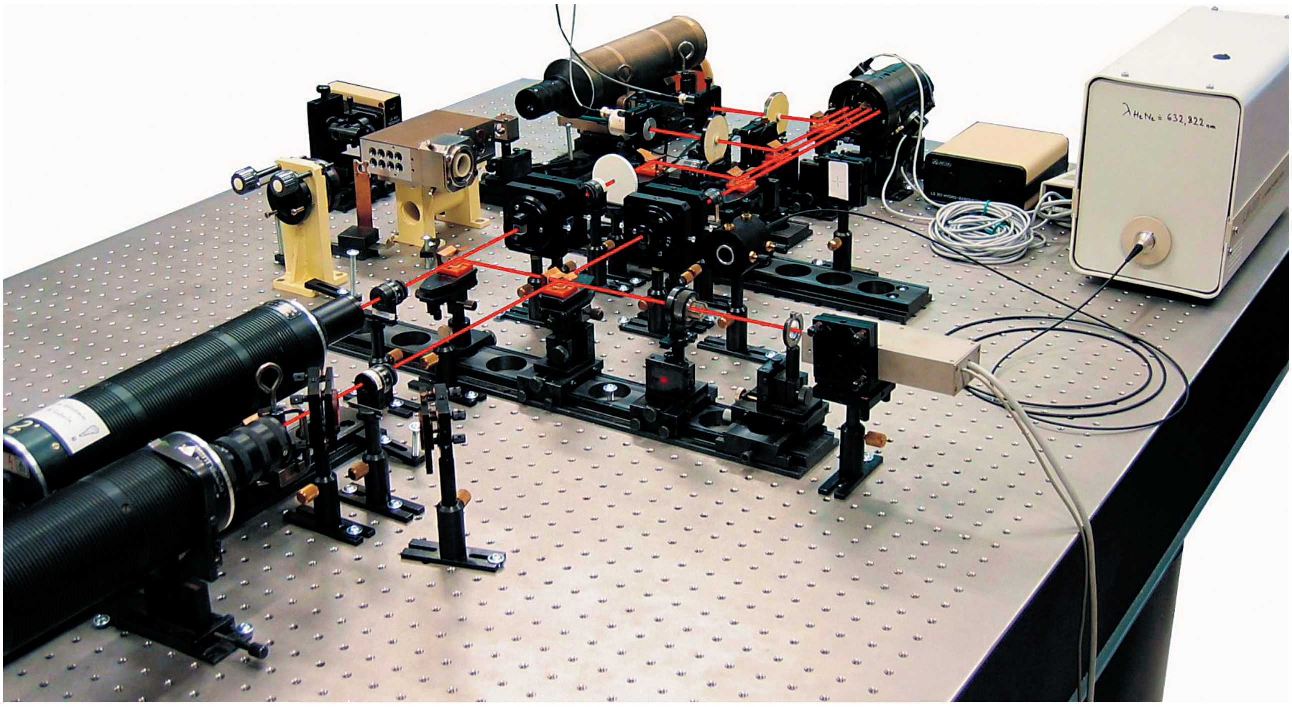


Fig. 1. Laboratory interferometer set-up.

The measurement of surface profiles using an optically held probe

Petr Jákl, Mojmír Šerý, Jan Ježek and Pavel Zemánek

Local-probe microscopy of this type employs a probe that is softly confined by a focused laser beam. This method of optical manipulation with micro- and nano-objects is known as optical tweezers and was developed in 1986 by A. Ashkin. It is based on the momentum transfer from the incident light to the particle – probe. The number of photons involved must be extremely high to obtain noticeable movement of the particle, and so the single laser beam is strongly focused by an objective with a high numerical aperture onto a spot of a diameter comparable to the laser wavelength. If the particle has a refractive index higher than that of the surrounding liquid medium, it is pushed towards places of higher optical intensity – the focus of the beam.

In co-operation with M. Liška (Faculty of Mechanical Engineering, Brno University of Technology) we combined optical tweezers with sensitive detection of the trapped probe, and obtained what is known as a photonic force microscope. We used a polystyrene bead labelled with fluorescent dye so that two-photon fluorescence exciting by the trapping beam occurs. Such an optically trapped probe is dragged along the measured surface and deflections of the probe from its equilibrium position are recorded via detection of the fluorescence intensity. This weak signal measured by the photomultiplier is extremely sensitive to the distance of the bead from the beam focus. Unfortunately due to the irreversible photochemical changes in the dye this signal also suffers from exponential decay in time known as photobleaching. We developed a sophisticated method consisting of several steps to enable the surface profile to be measured along with vertical calibration and photobleaching suppression.

Since the probe is only softly confined, each movement of the probe is accompanied by a deviation of the probe from its equilibrium position caused by the hydrodynamic Stoke's force. For this reason we had to halt scanning for a while in order to collect enough data to analyse the equilibrium probe position precisely. To speed up the whole procedure of surface scanning we increased the number of optical traps and consequently the number of trapped probes. We employed acousto-optical modulators that redirected the incident beam in several directions and was able to switch between them extremely rapidly, which meant that the probe that was not illuminated by the beam did not have enough time to escape far from the trap and could be retrapped.

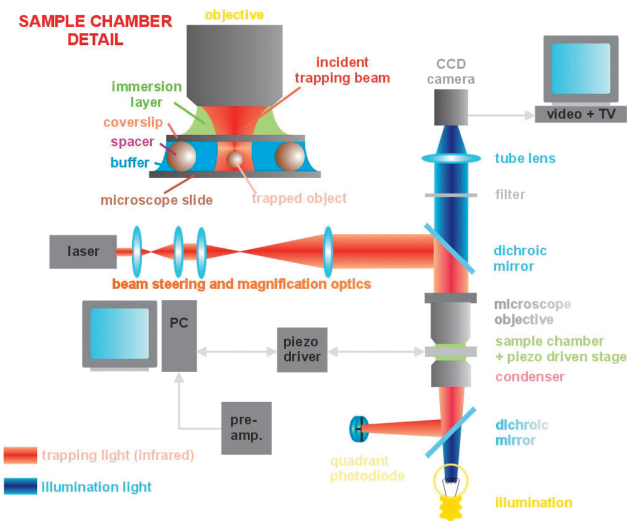


Fig. 1. Experimental set-up of optical tweezers.

We tested this microscope on a glass surface with a system of grooves and stuck polystyrene spheres of diameters of 200 nm and 65 nm. We obtained a vertical resolution better than 25 nm. An example of a surface profile with spheres of a diameter of 65 nm is shown in Fig. 2 for two simultaneously trapped probes [178, 283].

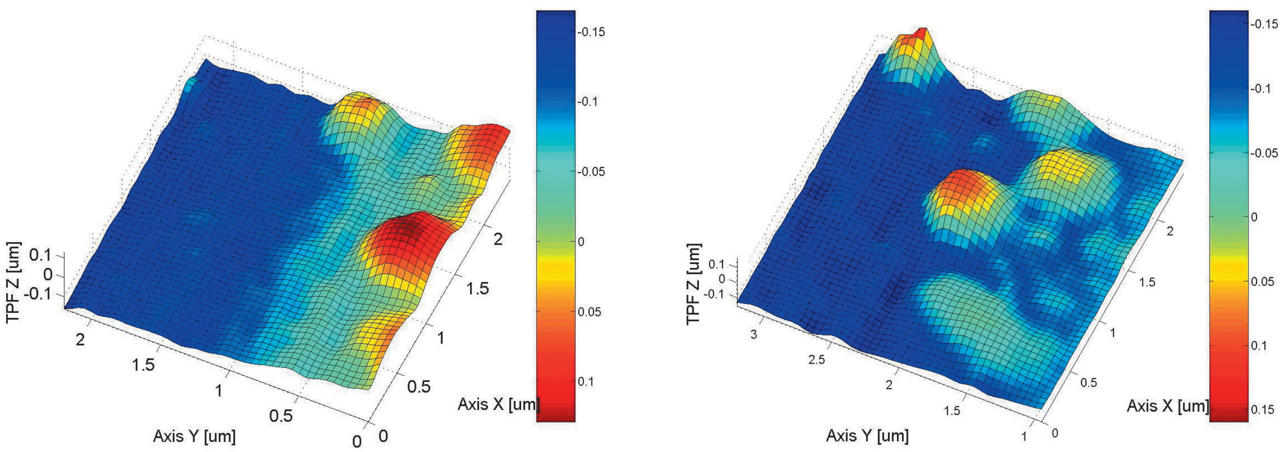


Fig. 2. Surface relief with stuck polystyrene spheres of a diameter of 65 mn scanned with two independent probes of a diameter of 850 nm.

A semiconductor frequency stabilized laser as a master oscillator for the Prague Asterix Laser System (PALS)

Petr Jedlička, Ondřej Číp and Josef Lazar

The design of a new laser master oscillator is a result of co-operation with the PALS Research Centre in Prague, Czech Republic. The principal experimental resource at PALS is the Asterix IV high-power iodine laser system. This instrument was developed at the Max Planck Institute for Quantum Optics in Garching, Germany, and with the latest upgrade in 1991 provided an irradiation facility at the 1 kJ energy level until May 1997. It has been exploited by the wide international research community within the European Large-Scale Facilities scheme.

A large-scale reconstruction of the power laser is now underway, which aims to increase the peak optical power output from the present 2 TW to 5 PW. This can be achieved by implementation of the technique known as OPCPA (Optical Parametric Chirped Pulse Amplification). This became possible when ultrashort pulse generating mode-locked lasers appeared. The final duration of the laser pulses will be reduced by several orders and the peak power increased dramatically by means of non-linear optical mixing of femtosecond pulses generated by a Titanium:Sapphire laser and power pulses from the iodine laser.

Our part of this project was to assemble a new “seed laser”, the first low-power, high-stability continuously working laser that will stand at the front end of the entire power laser system, a cascade of optical amplifiers. The pulses will be generated by an electro-optic shutter.

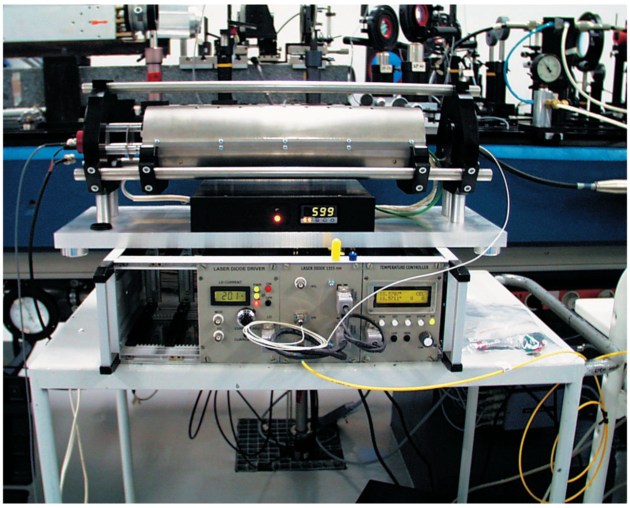


Fig. 1. The thermostatized iodine cell (top) with electronics covering the temperature stabilization, laser diode drivers and closed -loops for frequency locking to selected absorption lines.

The key demand for optical stability arises from the relatively narrow spectral profile of the iodine amplifying media of the optical amplifiers, which had to be kept within a range of tens of MHz of the optical frequency. From the viewpoint of fundamental laser metrology this is not such a strict requirement, but the laser here had to be a fully autonomous system, completely maintenance-free and capable of operating in the harsh environment of the power pulsed laser full of strong electromagnetic interference arising from the huge discharging capacitors and pumping flashlamps. It can be considered extremely lucky that the desired wavelength of 1315 nm falls within the range of optical telecommunication bands, which allowed us to use a commercially available laser diode with a DFB (Distributed FeedBack) structure featuring single-frequency operation, narrow linewidth and easy current and temperature tunability of the emission wavelength.

The set of subsequent optical amplifiers is intended to begin with fibre-coupled amplifiers, so the design of our optical set-up was fibreoptic from the very beginning. Output light from a laser diode with an integrated Faraday optical isolator was split by a fibre coupler by a ratio of 90 % to 10 %. The smaller part of the output power was used for frequency stabilization of the laser, while the larger part comprised the useful output. The 10 % of the light from the coupler was collimated into an absorption cell filled with pure iodine. We used the same transition in the dissociated iodine that drives the power amplifiers to derive the signal for frequency stabilization. The dissociation of iodine molecules into atomic iodine was achieved in our cell by thermal dissociation. The cell was heated and thermostatized at 600 °C.

The control electronics are fully digital and based on powerful microcontrollers that calculate the derivative signal of the absorption lines, generate modulation signal, perform some digital filtering and produce a control signal for the servo-loop of the laser frequency. With a narrow “locking range” of the absorption lines we proposed a system of two servo-loops, where the laser itself is locked by thermal tuning to a certain temperature and a slow frequency drift is controlled with respect to the dispersion signal of the detected absorption line. An autonomous algorithm for self-diagnostics and selection of the proper absorption line to lock the laser is applied.

The laser system has already been successfully tested several times at the PALS laboratory under real conditions and is now prepared for final implementation [460].

Laser induced fusion of living cells

Jan Ježek, Petr Jákl, Mojmír Šerý and Pavel Zemánek

There are three known methods of cell fusion. The first one uses the immersion of cells in a chemical solution; the second employs an external electric field for cell perforation. Unfortunately neither of these methods can be easily used for the fusion of individually selected cells. The third method of cell fusion uses focused laser beams that evaporate a tiny volume of the cell membrane at the place where the cells contact (see Fig. 2). This laser induced cell fusion takes place under the objective of a microscope (see Fig. 1) and, therefore, makes it easy to study the fusion dynamics.

In co-operation with S. Kozubek and E. Lukášová (Institute of Biophysics ASCR) and M. Kozubek (Faculty of Informatics, Masaryk University in Brno) we studied the behaviour of MCF7, HL 60 cell nuclei and selected parts of the chromatin after fusion using fluorescent microscopy, an automated high-resolution cytometer and computer image analyses. The fusion itself was performed in an inverted optical microscope by bringing the selected cells into contact using either a mechanical or laser-light-based micro-manipulator (optical tweezers) and subsequent perforation of their touching membranes by an optical scalpel (see Fig. 3) [289, 290].

We studied the position of fluorescently labelled centromers in cells fixed at certain time periods after fusion and found that the nuclei fused after 48 hours, probably due to mitotic changes in the cell.

We also studied the fusion of two living cells. The entire process was recorded, but without fluorescent dying of the cells it was not possible to properly recognize the boundaries of each cell nucleus. For this reason we are developing a method in which each cell nucleus in the living cell will be coloured with a different dye, so that the origin of each nucleus can be easily determined after cell fusion.

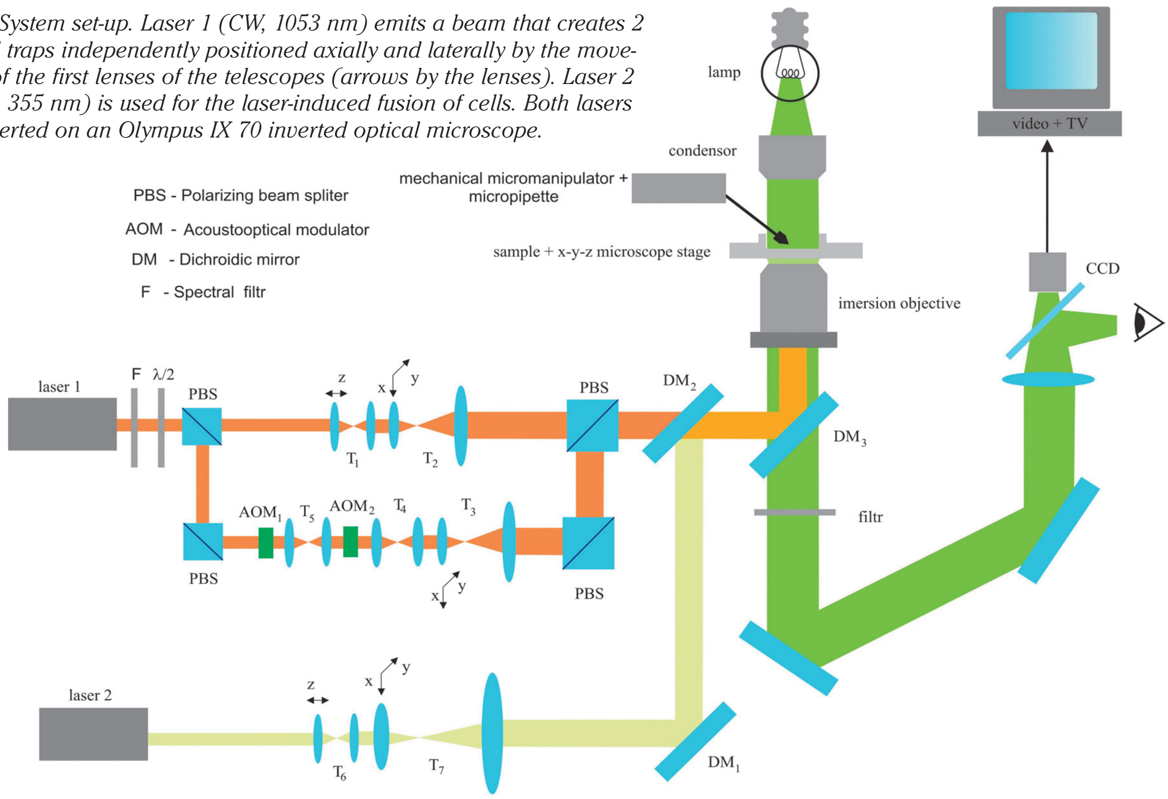


Fig. 1. System set-up. Laser 1 (CW, 1053 nm) emits a beam that creates 2 optical traps independently positioned axially and laterally by the movement of the first lenses of the telescopes (arrows by the lenses). Laser 2 (pulse, 355 nm) is used for the laser-induced fusion of cells. Both lasers are inserted on an Olympus IX 70 inverted optical microscope.

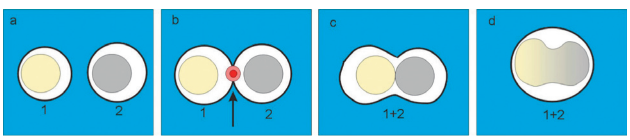


Fig. 2. The principle of laser induced fusion (a) Two cells (denoted as 1, 2) are brought into contact using optical tweezers. (b) Laser pulses are applied to perforate the cell membrane at the point of contact (denoted by the arrow). (c) The cytoplasm of both cells is mixed. (d) The nuclei fuse together and the fusion product takes on a round shape again.

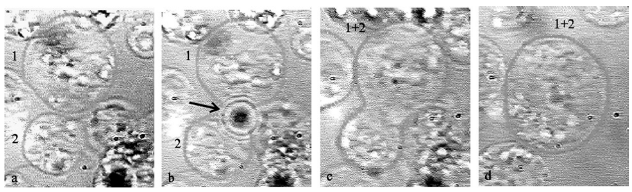


Fig. 3. a) Two HL60 cells (denoted as 1, 2) are brought into contact using optical tweezers. b) A series of 4-5 UV laser pulses (the average energy per pulse was equal to 8 μJ) perforates the cell membrane at the point of contact (denoted by the circle). c) The cytoplasm of both cells is mixed. d) 180 seconds later the fusion product takes on a round shape again.

Study of laser induced damage in living protozoa cells

Jan Ježek, Petr Jákl, Mojmír Šerý and Pavel Zemánek

The influence of an ultra-violet laser microbeam pulse on the cortex of Paramecium caudatum and Blepharisma undulans undulans was studied in co-operation with R. Janisch and Z. Moravčík from the Institute of Biology, Faculty of Medicine, Masaryk University in Brno. The character and extent of cortical injury was video recorded and subsequently analyzed. Destruction of the cytoskeleton by laser irradiation was detected by immunofluorescence staining. A difference between Paramecium and Blepharisma cells was observed in the development and healing of the wound. A more immediate reaction was recorded in Blepharisma cells containing blepharismin, a red pigment known to absorb light energy. The damage to the infusorian's cortex caused by the laser irradiation was compared with that produced by mechanical devices.

For irradiation by a pulse laser, a single infusorian cell was drawn into a micromanipulation capillary and thus immobilized. This procedure was performed in a drop of water on a microscopic slide. We used a TransferMan NK mechanical micromanipulator with a CellTram Air micropipette.

Laser Minilite II (Continuum) was used to generate a UV laser pulse with the following properties: wavelength λ=355 nm, maximal pulse energy 8 mJ, pulse length 5 ns. Specific areas of the surface or selected structures close beneath the surface of immobilized cells were irradiated by a single laser pulse of energy from 4 μJ to 15 μJ, according to the type of cell and sample (see Fig. 1).

A laser beam targeted close beneath the cortex had a more destructive effect (see Fig. 2). Within a fraction of a second, due to the sudden rise in temperature at the irradiated site, organic molecules turned into gas molecules and produced gas bubbles of about 3 μm in diameter, which in turn caused the cytoplasm with organelles, mitochondria and trichocysts to "explode" out of the cell. The exploded cytoplasm was destroyed to such an extent that it produced no membrane-bound bodies. The cell itself reacted with a sudden contraction along its longitudinal axis, which moved it away from the viewing field. The wound in the cortex had a necrotic appearance and was free of the plasma membrane; a sharp, protruding rim of the wound was formed by the plasma membrane. Exploded trichocysts were visible as rod-shaped bodies (arrows) in the close vicinity of the cell (see Fig. 3). After 20 seconds, the wound edge shrunk concentrically and the cortex preserved around it retracted towards the cell centre. This crater-like appearance was characteristic of wounds produced by a laser beam and was easily distinguished from injuries caused by a mechanical microscalpel [112].

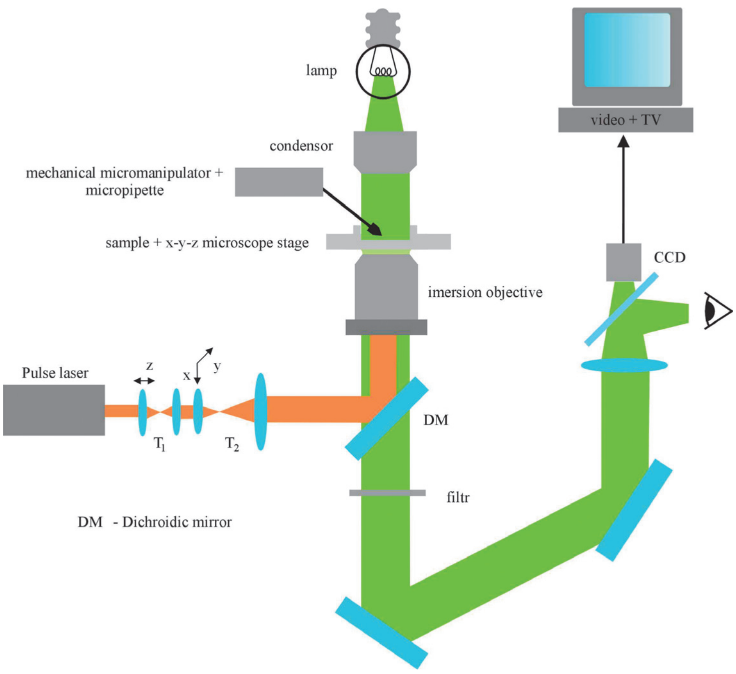


Fig. 1. System set-up. A pulse laser (355 nm) is used for laser-induced damage to cells. This laser beam can be independently positioned axially and laterally by movement of the first lenses of the telescopes (arrows near the lenses). The lasers are inserted on an Olympus IX 70 inverted optical microscope.

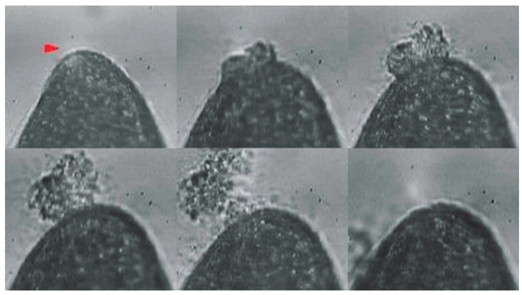


Fig. 2. Exposure of the Blepharisma cortex to a laser beam in the front part of the cell.

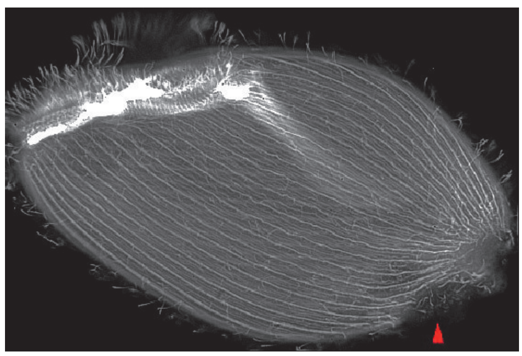


Fig. 3. Laser-induced wound in the Blepharisma cortex visualized by immunofluorescence staining.

Semiconductor external cavity lasers for surface property measurements

Josef Lazar, Ondřej Číp and Bohdan Růžička

The technology of improvement of the spectral properties of semiconductor lasers by an external cavity has been successfully tested in many applications. This technique is capable of fully exploiting the great potential of semiconductor lasers even when single-frequency operation, narrow linewidth and frequency stability are needed. Semiconductor lasers are the most common lasers these days, being mass-produced in huge numbers. They are also available in a great variety of wavelengths. Along with their small size and low price it is no wonder that we also encounter them in many everyday gadgets.

High demands posed by such applications as spectroscopy, interferometry, etc. cannot be met by most of the commercially available laser diodes. The more advanced laser diode designs with spectrally selective elements such as distributed feedback or Bragg reflectors are unfortunately available only on a handful of wavelengths mainly in the near-infrared telecommunication band. The parameters of ordinary Fabry-Perot laser diodes may be improved significantly by using the diode merely as an amplifying media and adding selective elements to the laser resonator. This technique was introduced when the first broad-range tuneable lasers – dye lasers – emerged, and was reinvented and perfected with semiconductor lasers of various wavelengths. The external cavity consists of collimating optics, a spectrally selective reflecting element – an optical grating and finally a mirror. By ganging the resonator length and the angle of the beam incident on the grating the optical feedback into the laser diode is forced to operate on a single optical frequency and can be tuned over a certain range. The resulting linewidth is reduced significantly, even below the MHz range.

We participated on a joint project with the Institute of Physical Engineering at the Faculty of Mechanical Engineering of Brno University of Technology, in which the aim was to design an interferometric profilometer for detection of surface topography and roughness. When an exposition of an interferogram with multiple – at least two – wavelengths is possible, the precision and resolution of the interferometer can also be combined with a large dynamic range. The first experiments with a tuneable argon laser were successful, and the decision was taken to put together a pair of independently tuneable and stable semiconductor lasers with a coupling of the output light into one fibre to make simultaneous exposition possible.

The result was a set-up comprised of two extended-cavity lasers operating on the wavelength 633 nm, close to the wavelength of common He-Ne lasers. This allows the use of optical elements readily available for most interferometric applications. The lasers are of a compact and robust design, the cavity body is milled from a single piece of hard Aluminium alloy ensuring mechanical stability and easy thermostatization. The external cavities are of the Littmann configuration with a grating and a tuning mirror pushed by a micrometer screw for coarse adjustment and a PZT (Piezoelectric Transducer) for fine-tuning. The configuration keeps the output laser beam at a fixed position during wavelength tuning, which is crucial for the subsequent fibre coupling.

Both lasers are fixed to one board and controlled from a single set of electronics containing two laser diode current controllers and fully digital temperature controllers. The design of the controllers ensures a high level of protection against electromagnetic interference and feature high stability of the drive current and temperature [101, 102, 311].

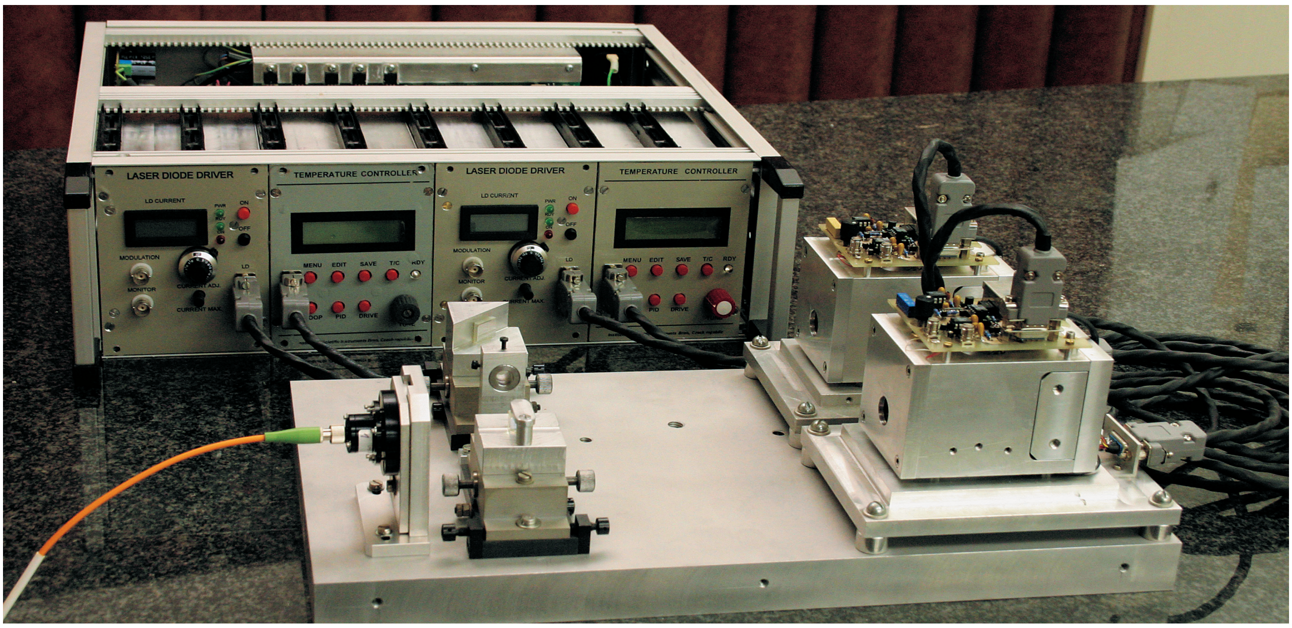


Fig. 1. A pair of tuneable semiconductor lasers with control electronics.

Helium-Neon etalon of wavelength with prolonged discharge tube lifetime

František Petrů, Ondřej Číp and Josef Lazar

Helium-Neon (He-Ne) lasers were among the first quantum light generators developed after the discovery of stimulated emission of coherent light. They soon proved to have some important features, such as low noise, high frequency stability, very narrow linewidth and, under certain conditions, single-frequency operation. These parameters increased in importance when interferometry became the dominant technique in the most precise dimensional metrology. He-Ne lasers emitting red light at the 633 nm wavelength became the best choice for laboratory and industrial interferometers. With the definition of the unit of length by means of a physical constant – the vacuum speed of light – a source of optical radiation with a precise and stable wavelength became the representation of the etalon of length. In the case of vacuum interferometry the precision is limited by the precision of the laser wavelength. High-stability laser sources can be built on the basis of various lasers, although direct radio-frequency comparison and calibration is easy only between lasers of very close wavelengths. In practice this means that the most common laser etalon of wavelength is a system employing an He-Ne laser.

At the department of Coherence Optics the technology of He-Ne lasers and their application has been studied for a long time and has been brought to perfection. The development of He-Ne lasers here was oriented towards achieving not merely low-noise and stability, but also such technical parameters of the discharge tube as its long lifetime. The first He-Ne laser with a frequency stabilization to saturated absorptions in molecular iodine was assembled here about 15 years ago. Laser etalons of this design have participated in regular international calibrating comparisons under the supervision of the BIPM (Bureau International des Poids et Mesures) in Paris, France.

The new He-Ne laser etalon developed at our laboratory has been built within the framework of a project for targeted research, with the end-user being the Czech Metrology Institute in Prague. The aim was to design and put together a stabilized laser system not merely fulfilling all the requirements of precision, but also technically advanced and with simple operation and maintenance. The laser head with a short resonator is made of a single piece of invar – a steel with ultra-low thermal expansion. Even this small dilatation is compensated for by PZT (Piezo-Transducer) elements that also serve as mirror holders allowing electronically controlled tuning and modulation. To achieve the homogeneous transfer of heat from its main source – the discharge tube – the resonator body is fitted with copper rails attached longwise. As a result the laser is ready for operation shortly after being switched on, with a significantly reduced warm-up time. The discharge tube itself is the main component of lasers with a limited lifetime due to the leakage of Helium through the quartz-glass walls. We were able to eliminate this problem by means of a double-wall design, with the whole tube being placed in a second vacuum-tight housing made of stainless steel by the technique of electron-beam welding with the necessary high-voltage feedthroughs for supplying the laser.

The control electronics of the entire laser system are fully computer-controlled, with the monitoring of all parameters and the locking of the laser frequency to various spectral components of the hyperfine spectrum of molecular iodine being performed by a PC computer. The software package written especially for the operation of the laser has a user-friendly fully graphic interface, allowing the iodine spectrum to be recorded and the proper spectral line selected. Communication between the computer and the control electronics is performed over an industrial serial CAN bus [173, 311, 461].

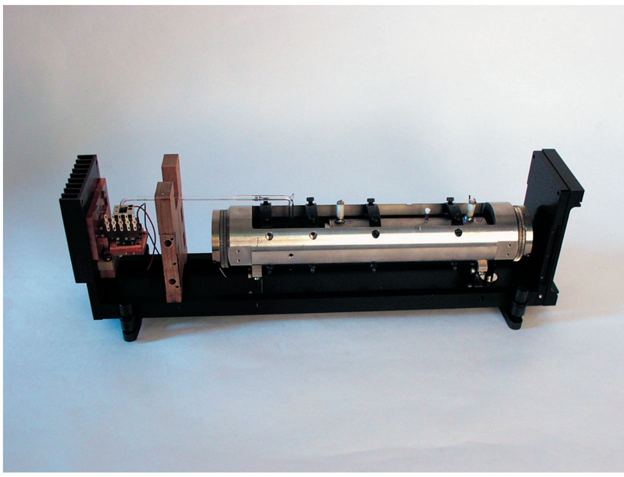


Fig. 1. The entire laser head with its cover removed.

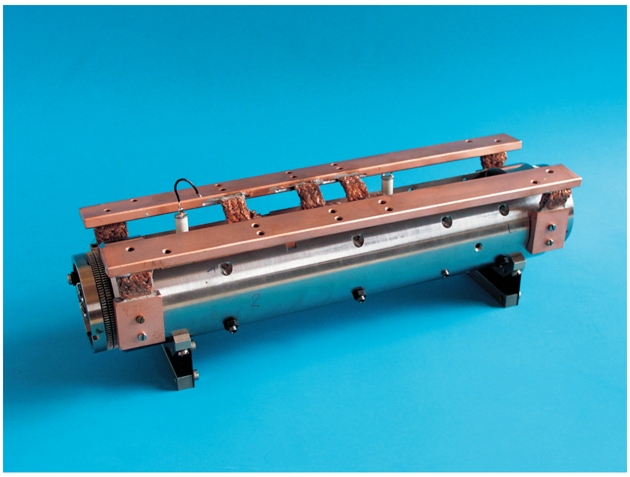


Fig. 2. The resonator body with heat-conducting rails.

Measurement of lengths in the nanometer region

František Petrů, Ondřej Číp, Břetislav Mikel and Zdeněk Buchta

The dimensions of microelectronic, optoelectronic and many other components are presently being shifted into the nanometer domain. This fact is placing ever-greater demands on measurement technology. The predominate measuring method remains laser interferometry, with its considerable measuring range and a resolution as small as one nanometer. The advantage of this measuring technique is its flexibility, large measuring range and a digital output with computer processing of the measured data. In view of the fact that in the majority of cases a 633 nm He-Ne laser is used as the light source, the interference unit is relatively long and an increase in resolution must be achieved by the electronic subdivision of this interference fringe spacing into fractions. This further subdivision is, however, a source of non-linearity that usually ranges from several units to several tenths of nanometers.

For these reasons a computer compensation for this non-linearity has been developed. Even in a special type of a differential interferometer with a resolution of 0.3 nm this does, however, limit the practical and usable resolution and linearity to a range of several tenths of nanometers.

For this reason a new measuring method has been developed that, rather than an interference method, uses transformation of the optical length into a change of the resonance frequency of an optical resonator. The change of the resonance frequency of an optical resonator is directly proportional to the length change, and this frequency change then serves to determine the measured length directly. The resolution achieved by this method is about one hundred times better than that of the interferometric method, and its most important parameter is high linearity.

To prove this method we designed an optical resonator using the material ZERODUR, which has a thermal coefficient of expansion in the region of 10^{-8} which ensures its high stability. The greater part of the optical path inside the optical resonator is permanently evacuated, which makes it possible to considerably reduce the effect of the refraction index of air in the resonator. The moving mirror of the resonator is controlled by a piezoelectric transducer that can make shifts ca. 2 mm. The resolution given by the linewidth of the resonator, together with the stabilizing electronic servo-system, results in a resolution down to approx. 0.01 nm.

The arrangement with an optical resonator with direct coupling to the interferometer makes it possible to compare interference measuring methods with the method of the transformation of length changes into the frequency domain.

The set-up consists of a differential interferometer with a resolution of 0.3 nm fitted with a separate single-frequency laser and a detection unit with computer processing of the measured results. The electronic system enables additional non-linearity correction. The differential interferometer has a measuring optical part directly coupled with the moving mirror of the optical resonator, so that the length change (shift) of the interferometer is simultaneous with the moving mirror of the optical resonator. The measured values of interferometer shift can be directly compared with the change in the resonant frequency of the optical resonator. A tuneable laser is always locked to it by means of an electronic servo-system. The evaluation of the mirror shift of the optical resonator is performed from the change of the resonant frequency of a laser etalon that is represented by an iodine-stabilized laser. In this way it is possible to test the electronic interferometer linearization and, therefore, to eliminate periodical errors of interferometer linearity.

This piece equipment is also proposed for testing inductive and capacitive position transducers. The accuracy of these transducers with a calibrated non-linearity correction may be substantially increased [34, 121, 208-211].

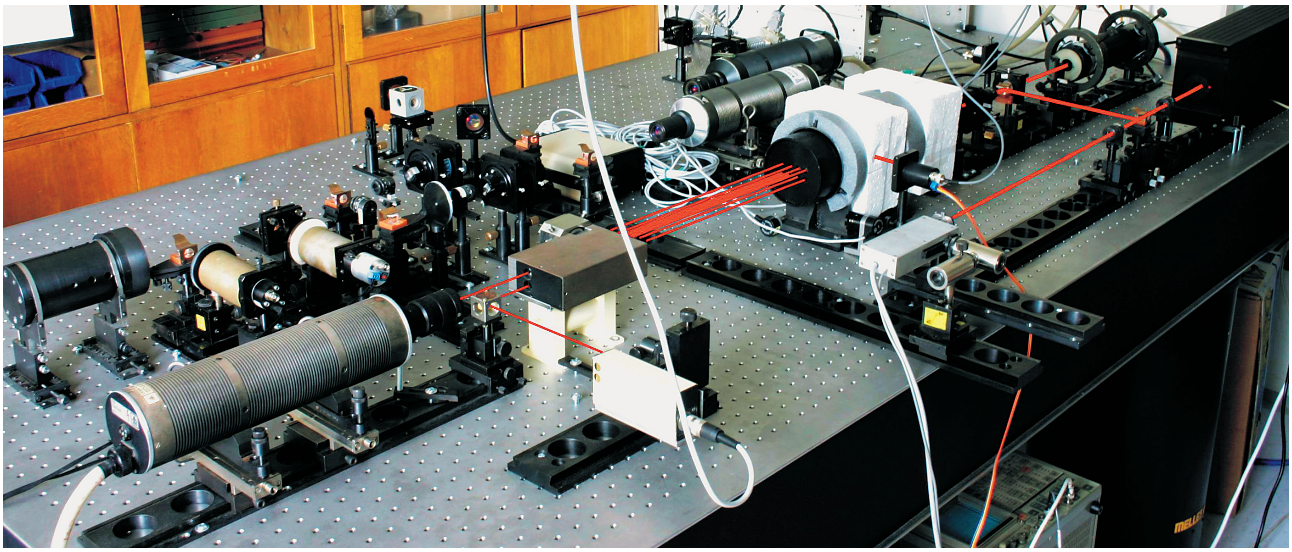


Fig. 1. The experimental set-up.

The behaviour of nanoobjects and microobjects in an optical standing wave

Pavel Zemánek, Alexandr Jonáš, Petr Jákl, Jan Ježek and Mojmír Šerý

It has been known for a long time that light can influence the behaviour of tiny objects and is even able to confine them in space. In other words, properly prepared light can create a trap for dielectric nano- and micro-objects placed in a liquid medium. A single focused laser beam is usually used to create a single optical trap near the intensity maximum of the beam focus. This apparatus is usually referred to as optical or laser tweezers thanks to the analogy with its mechanical counterpart. Over the last twenty years optical tweezers have found numerous applications in physics, colloid chemistry and cellular and molecular biology.

We studied the properties of an innovative type of optical trap created by the interference of counter-propagating laser beams. In this way a standing wave along the propagation axis of both beams is created and each intensity maximum (antinode) or minimum (node) can serve as an optical trap. It was originally believed that an object with a refractive index higher that the surrounding medium can be trapped at the intensity maximum. We found that this is true in standing wave (or other types of periodically changing fields) only for certain sizes of objects. Objects are trapped at the intensity maximum if their size is smaller than about 0.7 of the laser wavelength λ. In this case the trapping forces are usually ten times stronger than those of a single beam trap. Slightly bigger objects (between 0.7 λ and 1.2 λ) place their centre at the intensity minimum. These properties are periodically repeated even for larger objects, and the boundary values also depend on the refractive indices of the object and medium and on the focusing of the laser beams. If the diameter of the spherical object is close to the boundary "non-trapping" diameter, the force of light is small and usually does not influence the behaviour of such an object. These properties are quite new and might be used in light-controlled systems that sort colloids according to their size or refractive index.

We tested these properties experimentally using a standing wave created by retro-reflection of the trapping beam from a plane interface. We measured the amplitudes of trapped object jumps between neighbouring optical traps. The amplitudes of these jumps are proportional to the strength of the force produced by the standing wave. We used spherical polystyrene micro-beads of various diameters and found that there are smaller or bigger jump amplitudes with respect to the difference of the actual bead diameter from the "non-trapping" diameter [70, 74, 149-151, 164, 284, 285, 291, 294, 359, 372].

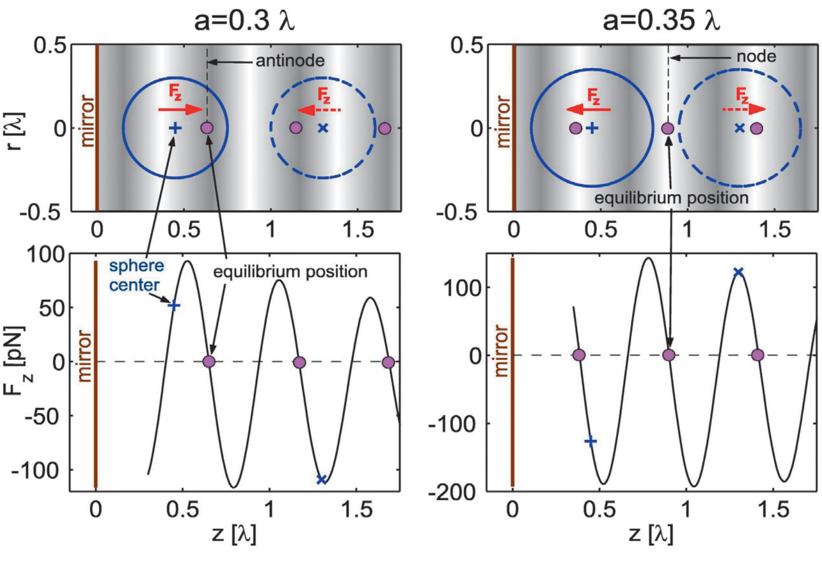


Fig. 1. The behaviour of two polystyrene spheres of slightly different radii (a = 0.3λ, 0.35λ) placed symmetrically with respect to the standing wave node. The centre of the smaller sphere is pushed by force F_z to the intensity maximum (see "equilibrium position"), while the bigger sphere is pushed to the intensity minimum. Therefore, the equilibrium positions of the two spheres are separated by λ/4.

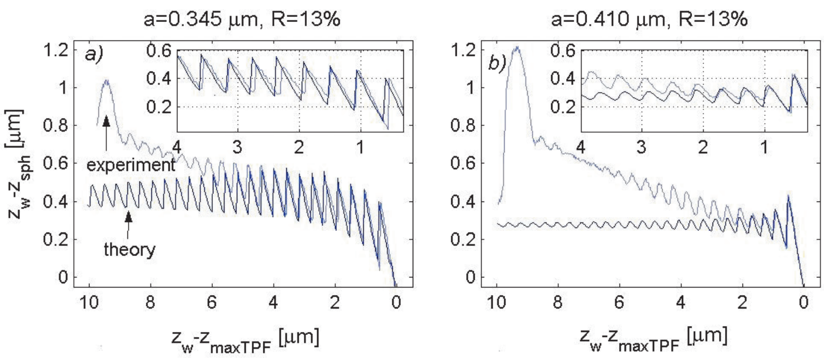


Fig. 2. An example of the comparison of the calculated and measured amplitudes of polystyrene sphere jumps between neighbouring optical traps in a standing wave created by retro-reflection from a mirror with reflectivity R = 13 %. The radius a of the larger sphere is close to the "non-trapping" condition and so the amplitudes of the jumps are smaller compared to the smaller sphere, which should be strongly influenced by the standing wave.

Bayesian and Entropic Methods Applied to NMR

Aleš Gottvald

As recognized already by Laplace, probability theory occupies a very special and central place among all scientific theories. It is the unique methodology for coding and processing incomplete (or partial) information in a logically consistent way. Moreover, the probability theory interlocks some particularly special algebraic, geometrical and topological features into a calculus for which many fundamental optimality theorems hold true with mathematical certainty. And because in real-world applications we practically never work with complete information about the system in question, the probability theory is of paramount importance. It should be emphasized that the role of modern probability theory is by far not restricted to its conventional statistical applications, but (as discussed in more detail elsewhere [57, 3]) in fact underlies virtually all aspects of our physical laws, data representations and information processing tools. No wonder that in NMR spectroscopy or imaging, the quest for some optimality in coding, processing and extracting information naturally leads to probabilistic and information-theoretic tools.

The Bayes Theorem and Maximum Entropy Principle are two central concepts of the probability theory and, consequently, of any optimized information processing methodology. These days there are many heuristic techniques in NMR in which these probabilistic concepts are still dormant or hidden, but there can hardly be any aspect of NMR in which these tools would be irrelevant for modern improvements. Let us list some examples from our recent work:

(1) Quantification of highly non-ideal signals and spectra of NMR for biomedical applications: The Bayes' Theorem allows us to incorporate various forms of prior information in a theoretically consistent and computationally effective way. Consequently, a much higher accuracy of parameter estimation may often be achieved. The model to be quantified may also incorporate convolutionary phenomena describing magnetic field inhomogeneity, instability and other common distortions. Moreover, even uncertainties of parameter values may be estimated. These methods are particular modules of our "Bayesian-Evolutionary MR Tools" (implemented in the MATLAB environment).

(2) Spectral lineshape analysis: We can interpret NMR spectra as the "most entropic" probability distributions and, consequently, take advantage of all the benefits of the powerful MaxEnt methodology by E. T. Jaynes. For example, the spectral lineshapes in real-world experiments (not just Lorentz, Voigt, etc.) may be classified and parametrized in a physically meaningful way by the fundamental exponential formula, analogically to Gibbs' method of statistical physics. This provides both physical and computational advantages. In particular, Fisher's concept of sufficient statistics may be employed (a new MaxEnt view on an important Pitmann-Koopman Theorem of statistics).

(3) Fourier analysis interpreted as a probabilistic method: The normalizing factors in the exponential MaxEnt formula or Bayes Theorem are actually Fourier-Laplace transforms of a structural function and, at the same time, the partition functions of statistical physics. These functions incorporate all information about the "most entropic" probability distributions and associated thermodynamic relationships in a concise way. All theorems of Fourier-Laplace analysis possess a certain straightforward probabilistic or entropic meaning, a new insight that is also of educational value. Consequently, one can offer a new rationale to various spectral phenomena and relationships. It also encompasses other areas of spectroscopy, as can be demonstrated on a Planck's black-body radiation spectrum.

Many other emergent applications of probabilistic methods in NMR are currently being developed. For example:

(4) Cepstral Deconvolution as a new way of separating chirp signals from instrumental smearing factors in NMR.

(5) A new rationale for sensitivity and resolution formulae, including a refutal of the celebrated Ernst's sensitivity formula for pulsed Fourier NMR spectroscopy.

(6) Entropic uncertainty relationships as a more adequate view of time-frequency duality theorems.

(7) A new rationale for NMR quantum computing as an application of exponential mapping, generating functionology and analytic number theory.

In conclusion, these and other examples show that the probabilistic methodology is an extremely promising key component of some more effective information processing tools in NMR and, consequently, should be given much more emphasis in the future.

Laplace's Demon vs Maxwell's Demon: A View of Information Physics

Aleš Gottvald

Information Physics (IP) is a modern scientific theory that investigates the possibility that our physical laws might merely be consequences of some more fundamental conceptual structure – information theory and probabilistic laws. Two classical thought experiments (Gedanken experiments), usually nicknamed "Maxwell's Demon" and "Laplace's Demon", are extremely important in this context [241]. Laplace's Demon challenges our (mis)understanding of evolutionary laws and their limitations. IP shows that evolutionary laws for deterministic chaos or quantum systems are merely special cases of a properly defined probabilistic law (topological evolution) [241, 6]. Maxwell's Demon challenges our (mis)understanding of probability theory and certain tricky points behind the hidden usage of various information levels (parasitic information flows). Moreover, IP shows that these concepts challenge our very (mis)understanding of two fundamental physical laws. The concept of Laplace's Demon is closely related to the First Law of Thermodynamics (the principle of energy conservation). The concept of Maxwell's Demon is closely related to the Second Law of Thermodynamics (the maximum entropy principle). Actually, the concepts of both Demons may be grasped from a unified perspective: The Laplace Demon is about the physical consequences of information conservation laws, whilst the Maxwell Demon is about the physical consequences of certain parasitic or hidden information flows [241].

For a classical example, let us define the state of a gas using some thermodynamic parameters (e.g. temperature, pressure and volume). Now suppose that a hypothetical being ("Demon") is equipped with some additional information about the velocities of the individual particles of the gas. In this case, the Demon could filter the particles in such a way that a strange heat flow might appear from a colder to a warmer place, which contradicts our sacred Second Law of Thermodynamics. A physical puzzle of this type was formulated for the first time by J. C. Maxwell at around 1871. Only after Szilard's inspiring paper (1929), however, and some insightful articles by E. T. Jaynes (from 1957 onwards) has it been gradually perceived that the Gedanken experiment of Maxwell's Demon is after much bigger issues. Most fundamentally, it demonstrates an intimate and surprising link between the concepts of entropy and information. Consequently, entropy is recognized as a quantity that depends on a level of description defining the system in question. When the level of description is prescribed, the entropy value is unique. However, when different description levels are mixed, the entropy value is not unique and a conflict with the Second Law may occur. How does Information Physics clarify the situation?

Suppose that one observer (call him "Maxwell") makes his probabilistic predictions using some macroscopic information M (e.g. the mean values of some thermodynamic quantities). Mathematically this leads to maximizing an entropic functional, subject to constraints defining the macroscopic information M. Technical details of this task are now relatively well understood: one general MaxEnt-solution is a structure called the exponential family that possesses many important information-theoretic interpretations [3]. Let another observer (call him "Demon") make his probabilistic predictions using some more detailed microscopic information D (e.g. degrees of freedom of the individual particles). In this case, the Demon can filter the particles in such a way that – from the point of view of Maxwell – it bypasses the Second Law and gives rise to a perpetuum mobile of the second kind. And it doesn't stop there. When we want to understand the transition from a microscopic to a macroscopic description of physics, whilst being unaware of the Maxwell Demon phenomenon, some fundamental conceptual difficulties arise (just think of Boltzmann's scientific struggle with the so-called ergodic hypothesis of statistical mechanics, or Planck's famous black-body radiation problem). Obviously, the observer with all the information (M + D) can also be interpreted as Laplace's Demon; such a being could compute probabilities of all events associated with the information (M + D).

When two observers maximize their entropies for two different levels of information about a system, they inevitably obtain two different probability distributions with two different entropy values. The observer with more detailed information D obtains a lower value of entropy, which also gives him the possibility of extracting more work from the system. For the observer with less detailed information M, the situation may erroneously be interpreted as a limitation of the Second Law of Thermodynamics (a perpetuum mobile of the second kind).

Thus, IP makes it possible to clarify the situation regarding many physical experiments, where some authors of unquestioned competence (from J. C. Maxwell to a series of recent articles in Nature) have speculated about the limitations of the Second Law. The ideas lying behind both Demons are universal and encompass many physical problems: (1) all applications of the First and Second Laws of Thermodynamics; (2) ergodic hypotheses of statistical mechanics; (3) chaos theory and quantum theory as an integral part of a unified probabilistic description of physics. In more specific domains, such as NMR spectroscopy, one can also show many situations in which both Demons are instrumental in clarifying the underlying physics; e.g. (4) spin-echo experiments; (5) the sensitivity myth of the pulsed Fourier spectroscopy; (6) NMR quantum computing. Note finally that Laplace's Demon also addresses some common historical, philosophical and physical myths about the legacy of Pierre-Simon

Accumulation of phase non-coherent signal

Josef Halámek, Pavel Jurák and Miroslav Kasal

Accumulation has already been used for about 50 years to increase signal-to-noise ratio. The first commercial systems were analogue systems and were used in NMR spectroscopy. Summing is a linear function and if the input, repetitive signal, is coherent, at signal the amplitude is added and at noise the power is added. As a result, after N accumulations the output SNR is $\sqrt{N}$ times higher than the input SNR. This holds true for any N and input SNR as long as the input signal is coherent. In some areas, for example in neurology, we may encounter signals that are time locked (i.e. the signal is repetitive) on some events, but their phase and frequency is not locked to these events. In this case the classical accumulation does not increase the SNR and cannot be used to detect the signal. The accumulation of instantaneous power, given by digital quadrature detection and digital filtering, is the best way. The coherent signals, together with the non-coherent signals, are detected in this case. An example from neurology is given in Fig. 1 a-d.

There is significant non-linearity in data processing if the instantaneous power is computed. This is why there is no simple relation between input and output SNR. Moreover, if the input SNR in the analyzed frequency band is below 0.1, the accumulation is pointless, since it does not increase the output SNR. The same is true if instantaneous amplitude is used for accumulation.

Another possibility is the accumulation of instantaneous phase; to detect event locked changes of phase or frequency. This is, however, possible only in areas in which a carrier signal exists, for example in communications. The instantaneous phase is extremely sensitive to noise and the SNR is not good enough for neurology [250, 251].

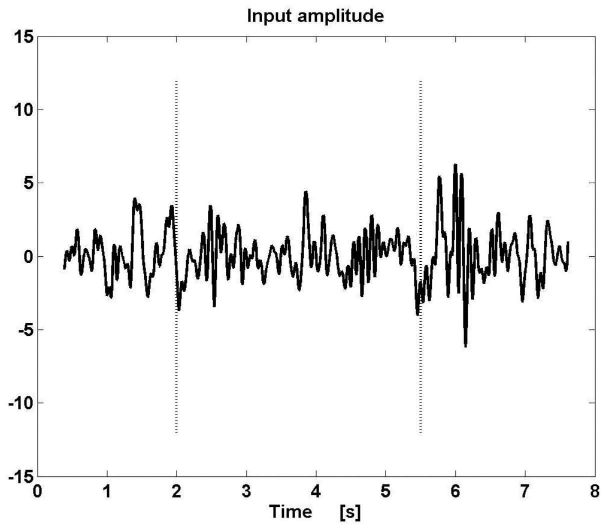


Fig. 1a) One segment with two stimuli (dotted lines), warning (2 s), executive (5.5 s).

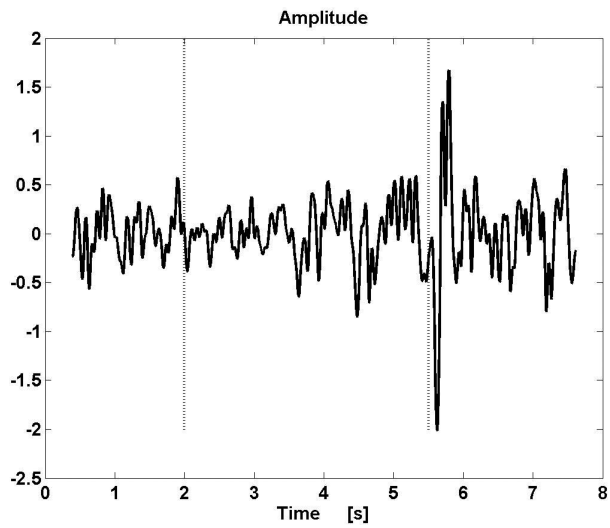


Fig. 1b) Accumulated amplitude (N=32), detection of coherent signals.

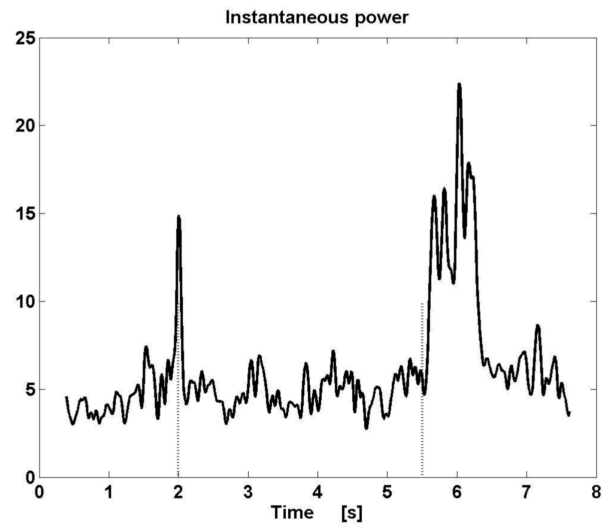


Fig. 1c) Accumulated instantaneous power (N=32), detection of coherent and non-coherent signals.

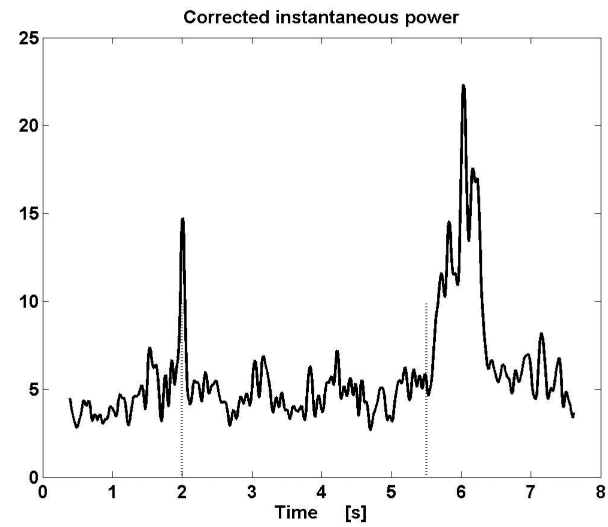


Fig. 1d) Accumulated instantaneous power with corrected background, detection of non-coherent signals only.

Estimation of the relationship between variables

Josef Halámek and Pavel Jurák

One of the basic tasks of any science is to determine whether an association between two or more variables exists and, if it exists, to determine the simplest model for it. Pearson's correlation coefficients are commonly used to quantify the strength of the linear association between two variables x and y. Its value between 0 and 1 depends not only on the real level of association, but also on the reproducibility of measurement, the distribution of measured points, outliers and slopes and the validity of the linear model. Some other parameters used include: p coefficients, parameters of a linear model with standard deviations and scatter plots. The scatter plot with confidence ellipses is the best option. The scatter plot is a simple plot of one variable against another. When more than one independent variables are involved, the experimental and calculated data can be used as two vectors of variables. The calculation can be also based on Principal Component analysis. The confidence ellipse, drawn about the points, expresses, for example, a 95 % confidence interval for both variables. The centre of the ellipse is the centre of gravity of the group. The longer half axis coincides with the orthogonal regression line; its direction represents the deterministic behaviour. The shorter half axis represents the stochastic behaviour. The ratio of the longer axis to the shorter axis (with respect to scales and the angle of the longer axis) expresses the strength of association between the variables. The higher this ratio is, the stronger the association. Variables without association have the ellipse approaching a circle. From such a plot the outliers may be simply detected and eliminated; the distribution of variables is noticeable, the validity of the suggested linear model and its parameters are observable. An example from cardiology is given in Fig. 1 [65, 246-249].

A deeper analysis may be performed from this picture as follows: all the shorter axes are relatively the same, i.e. the random errors (given principally by the reproducibility of BRS) are about the same; the decreased correlation coefficient is caused by the limited length of the longer axis, i.e. by the limited distributed area of HR.

The scatter plot with confidence ellipse gives a fast and exhaustive overview of the association between variables. The ratio of longer to shorter axis may be used as a numerical parameter that describes the strength of association. This parameter can be used to simply explain and imagine in contrast to commonly used parameters and its numerical values (from 1 to infinity) also describe the dependency well.

We co-operated on this topic with M. Holík from the Faculty of Sciences at Masaryk University in Brno.

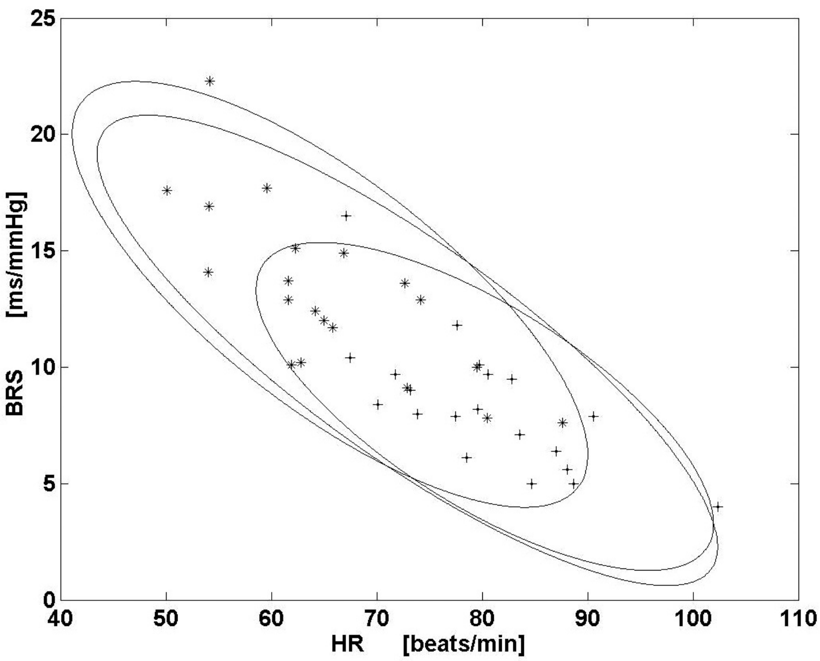


*Fig. 1. The association between heart rate (HR) and baroreflex sensitivity (BRS) measured at two groups (marks * and +). Ellipses give the confidence interval for groups and over both groups. The corresponding correlation coefficients for *, +, and both groups together are -0.75, -0.72, and -0.84. Analogous scaled ratios of longer to shorter axis are (2.1, 1.9 and 2.6). The corresponding p coefficients are (0.0002, 0.0004, 2e-11).*

Small Helium Bath Cryopump

Pavel Hanzelka, Věra Musilová, Jan Dupák, Tomáš Králík and Pavel Urban

The aim of our project was to design and realize a small economical helium bath cryopump maintaining an ultra-high vacuum (UHV) in an preliminarily evacuated and well-degassed specimen chamber in an electron-optic device used for studying surfaces by means of low energy electrons. The ion pumps usually used for this purpose generate a stray magnetic field that represents a drawback of this type of pump. Cryopumping overcomes this problem and takes advantage of extreme cleanness, high pumping speed and the very low ultimate pressure attainable by cryopumps. Miniaturized closed-cycle refrigerators are used for cooling the cryopumps, though appropriate construction measures need to be performed to reduce the vibrations induced by the mechanical refrigerator in the electron optic instrument. A low level of vibration is an important advantage of bath cryopumps.

Condensation and sorption of gases are the main principles of cryopumps. To achieve the desired value of UHV, the active surface and the sorbent in the pump are to be cooled below 10 K. Liquid helium (LHe) with a boiling point of 4.2 K is the most suitable medium for cooling. On the other hand, the LHe losses due to evaporation and the necessity of LHe refilling are the significant problems of bath cryopumps. An additional bath of liquid nitrogen (LN2) at 77 K is ordinarily used for LHe bath protection against parasitic heat flows from the surroundings. As the heat radiation is the significant constituent of the heat flows in the pump, the shielding baffles that obstruct this radiation but enable the particles of the pumped gas to reach the active surface are the critical component of every pump.

Advanced cryogenic technology and numerical calculation and optimization procedures that take into account all types of heat flows and the non-linear thermophysical properties of materials at low temperatures enabled us to design and realize a small low-loss bath cryopump, with a volume of the external shell of about 15 litres. The pump is transportable in its operating state and possesses parameters suitable for electron microscopy. In comparison with the pumps presented by other authors, a thermal shield protecting the LN2 vessel is included and a longer LN2 refill interval is thus achieved. Monte Carlo (MC) simulations of molecular flow and thermal radiation heat transfer were performed to support the pump design and to study the influence of the baffle system on the pump characteristics in particular.

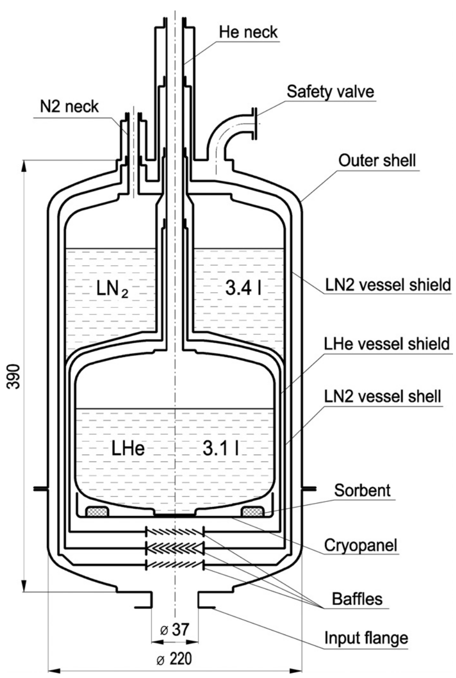


Fig. 1. Scheme of the cryopump.

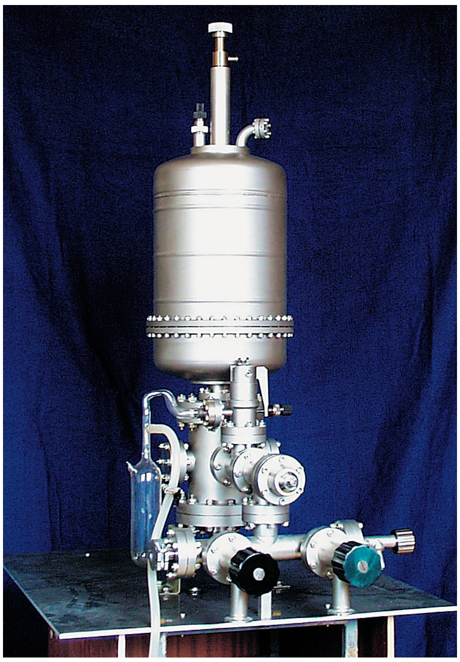


Fig. 2. Tested cryopump.

LHe refill interval	35 days
LN2 refill interval	6 days
Ultimate pressure	1.5×10^{-7} Pa
Pumping speed for He gas	25 litres/s

Tab. 1. Main cryopump parameters.

The pump is designed to be resistant against degassing temperatures of up to 170°C. All the internal parts of the cryopump are closed in a vacuum outer shell made of stainless steel and are suspended on a central LHe vessel neck. The bottom of the outer shell is demountable and an aluminium wire ring seals its flange. Both the LHe and LN2 vessels are made of aluminium. The LN2 vessel is protected against thermal radiation by an aluminium shield, whereas copper was used for the LHe vessel radiation shield. The sufficient wall thickness of all vessels and thermal shields guarantees the isothermal state of these parts. A cryopanel made of pure aluminium plate is used for the deposition of condensable gases. Boxes with charcoal sorbent for H2 and He sorption are attached to its upper side.

The finished pump was connected to a UHV chamber and tested. The main parameters were found satisfactory for the intended application. The ultimate pressure is supposed to be reduced after proper degassing of the UHV chamber [62, 165, 222, 265, 473].

Coherent Clock Signals Unit

Vladimír Húsek, Josef Halámek and Miroslav Kasal

The clock signals coherency is extremely important in Radio Frequency Spectroscopy, especially for current Digital Signal Processing (DSP) applications. Together with the phase noise and jitter it determines the system properties. The described unit has been developed for a two-channel DSP vector analyser with a high dynamic range and extremely precise frequency and phase processing.

Thermal stability is also required in addition to the properties mentioned above . All VCXO are temperature compensated voltage controlled crystal oscillators. In 'free run' mode the first 10 MHz VCXO controls all output signal frequencies and phases. For special applications an external ultrastable oscillator can be utilized as a frequency standard – 'locked to standard mode'. All output signals are obtained by Phase Lock Loops (PLL) designed extremely carefully from the viewpoint of phase noise and loop stability at four frequencies. PLLs are 2nd order loops to achieve defined phase relationships between output signals. The PLL's reference signals are provided by a chain of precise analogue multipliers. Phase adjustment allows phase control within the range 0–360 deg at 120 MHz output. A block diagram of the coherent clock signals unit is shown in Fig. 1.

The achieved results confirm the theoretically predicted parameters. The jitter of the whole vector analyser is better than 0.4 ps, which is given, first and foremost by clock signals and their distribution. The achieved spectral purity of the output signals is shown in Fig. 2 and Fig. 3 [60, 257, 259].

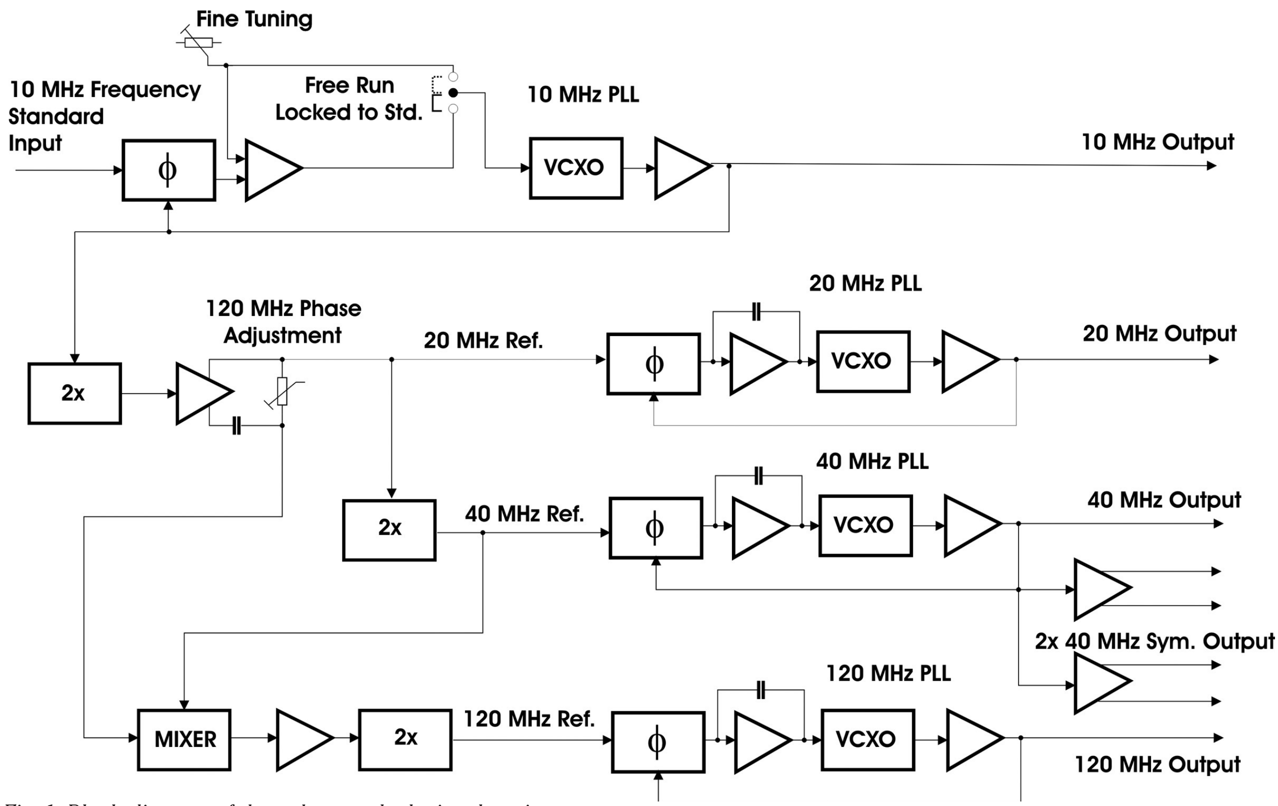


Fig. 1. Block diagram of the coherent clock signals unit.

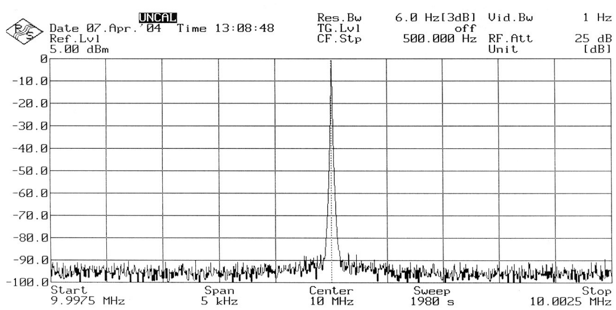


Fig. 2. Power spectral density of 10 MHz signal.

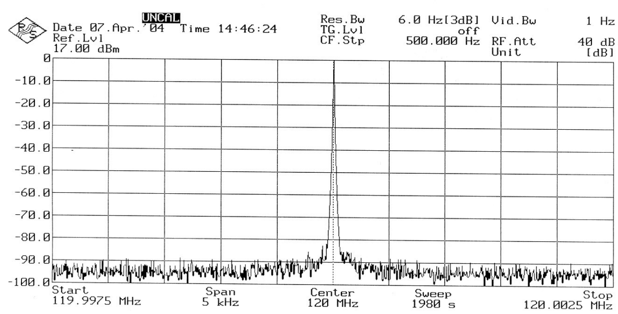


Fig. 3. Power spectral density of 120 MHz signal.

Impedance cardiography method for relative stroke volume change measurement

Pavel Jurák, Josef Halámek, Vlastimil Vondra, Jan Chládek, Milan Samek and Jiří Kališ

The impedance cardiograph (IC) is an electronic system for measurement of impedance changes across the thorax that reflect cardiac function and the blood flow from the heart's left ventricle into the aorta. The basic parameters analyzed are stroke volume (SV) – the amount of blood flowing through the heart during a single beat, and cardiac output (CO) – blood output per minute. The SV and CO provided by commercial IC monitors are sensitive to the quality of the measured signal and the patient's subjective parameters (weight, sex, etc.). Low reproducibility and high distortion of numerical values motivate us to design and test new methods for precise SV change detection in clinical practice. We use interactive graphical methods for raw bioimpedance signal preprocessing, such as segmentation, artefact elimination, averaging, etc.

IC is a method that can provide good results, first and foremost, during the analysis of relative blood flow changes. Absolute flow values in millilitres can also be obtained, although this is difficult and often tainted by a large degree of error. In co-operation with St. Anne's University Hospital in Brno we realized a system for IC measurement simultaneously with other physiological signals (ECG, blood pressure, SpO2, respiration) and consequential off-line SV and CO analysis. The off-line processing methods we use allow extremely precise artefact selection and the combination of various SV computational algorithms. There are many possibilities for the application of IC in medicine.

IC is incorporated, for example, into investigation of the control mechanisms of the Autonomic Nervous System (ANS) and Blood Circulatory System (haemodynamics). IC is an appropriate method for non-invasive measurement of stroke volume (SV) change during the setting of dual-chamber pacemakers (DCHP). DCHPs are used increasingly for patients with varying degrees of heart block, dysrhythmias and cardiomyopathy. The clinical benefits of DCHP include, first and foremost, the promotion of forward blood flow. After introducing a stimulator the flow of blood through the heart can be optimized by adjusting the atrial-ventricular (AV) and ventricular-ventricular (VV) time delays. The fact that these are relative changes to a stable system (the patient lying down at rest, all conditions remaining unchanged, with merely the AV and VV delays changing) makes IC a suitable method. The section of data processed is usually 2–3 minutes long and contains as many as 200 heartbeats. Such a quantity allows for precise analysis and the elimination of artefacts. Aortic Doppler echocardiography and an invasive thermodillutation technique are currently used to determine the flow. These methods are time-consuming and costly. IC has been introduced as a supplementary method, and allows a comparison of all three techniques. IC provides a simple, repeatable and non-invasive way of assessing cardiac function at a dramatically reduced cost. IC clearly has a broad potential for hospital applications [7, 77, 397].

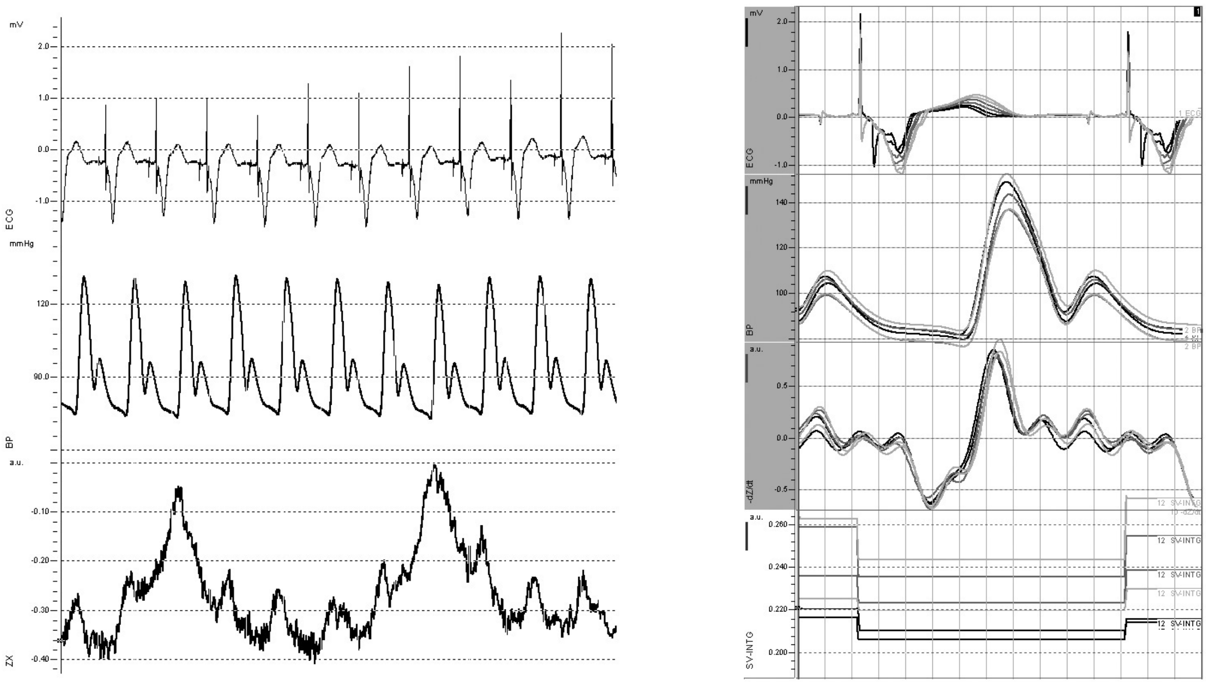


Fig. 1. Left: from top – ECG, blood pressure, raw bioimpedance signal. Right: filtered and averaged signals from 3 minutes intervals. Different shade – different venticular-venticular stimulation conditions.

Evaluation of short-time circulation control parameters in human medicine

Pavel Jurák, Josef Halámek, Vlastimil Vondra, Jan Chládek, Milan Samek and Jiří Kališ

ISI Brno has been co-operating for 7 years with medical teams from St. Anne's University Hospital, 1st Internal Department, Brno and the Mayo Clinic, Rochester, MN, USA on basic research into the behaviour of haemodynamics – the Blood Circulatory System in healthy and ill subjects and the differentiation of these subjects into diagnostic groups according to the properties of the parameters obtained.

Disorders in the regulation of blood circulation and the autonomous nervous system (ANS) are playing an ever-greater part in the inception of cardiovascular diseases, in particular essential hypertension, chronic heart failure, ischemic heart disease, syncopal state and heart rhythm failure. They are also among the principal factors in the high risk of sudden cardiac death among after-stroke patients. In current clinical medicine the ECG is generally measured, with the blood pressure (BP) being continually measured in rare cases by the Peňáz method. These measurements are accompanied, according to the type of examination, by non-invasive impedance cardiography (IC) and the Doppler ECHO cardiography technique or invasive catheter methods, oxygen saturation (SpO2) and measurement of the depth and frequency of breathing.

It is now becoming ever more obvious that it is extremely difficult to obtain “pure” parameters uninfluenced by other effects. These effects being ignored may, however, lead to distorted results and continually altering interpretations. Determination of the behaviour of haemodynamics needs stable conditions during the whole measurement and recording, and a signals set necessary for analysis (ECG, BP, respiration, IC). Methods of data processing and analysis are closely associated with measurement protocols. The results they provide may very often differ. To respect all possible influences we designed non-invasive measurement protocols for the characterization of basic functions in the behaviour of haemodynamics, instruments to include the precise measurement of haemodynamic changes, and off-line processing methods that consider the mutual relations between the measured quantities. A simultaneous analysis of ECG, BP and blood flow allows the considerably more reliable formulation of a hypothesis on changes to the peripheral blood vessel resistance, the causes of loss of consciousness, reactions of the organism to load and mental stress, and so on. An important part of the data analysis is statistics. It is absolutely fundamental from the viewpoint of the reliability of the results obtained and their reputable publication [36, 88, 59, 75].

As an example we can mention a protocol which seems to us an appropriate compromise between the load imposed on the measured subject and the amount of information acquired. This protocol includes rest in supine position, paced breathing at different frequencies and depth, a tilted table test, count test and load – cycling test. In the figures below a measured subject can be seen during the load-test and computed signals obtained from this test.

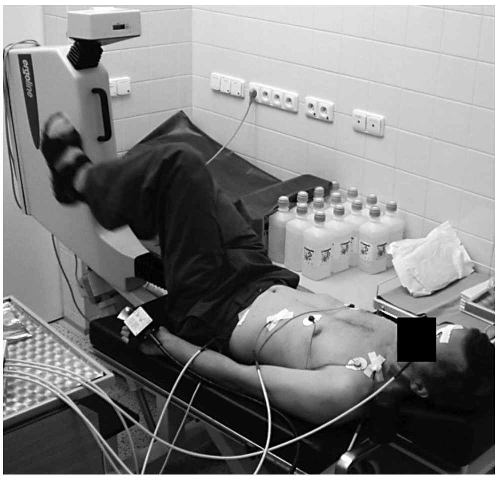


Fig. 1. Load test - cycling part, 1st Internal Department, St. Anne's University Hospital in Brno. Measured signals: ECG, BP, IC, ANNAlab ScopeWin 16-bit ADC, 500 Hz sampling.

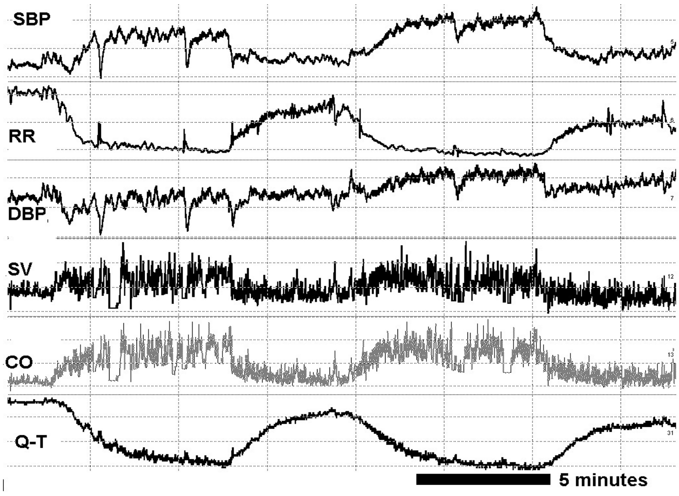


Fig. 2. Example of measured-computed signals, load test: 3 minutes rest - 5 min load - 5 min rest - 5 min load - 3 min rest, signals from top: systolic BP (SBP), heart beat intervals (RR), diastolic BP (DBP), stroke volume (SV), cardiac output (CO) and Q-T interval (Q-T).

A device for measurement of thermal emissivity at cryogenic temperatures

Tomáš Králík, Pavel Hanzelka, Věra Musilová and Aleš Srnka

The basic problem in designing low-temperature devices is the estimation of the heat input into the cold part of the device. The choice of a refrigerator or the volume of the cryoliquid bath is associated with this problem. Thermal radiation is one of the significant mechanisms of heat transfer in cryogenics. Exact evaluation of the radiative heat flow in cryogenic devices requires a good knowledge of the radiative properties of surfaces (emissivity and absorbtivity). This is important for better modelling and design of cryogenics apparatus such as cryostats, Dewar cans, superconducting magnets and other low-temperature devices. Radiative properties are unfortunately usually difficult to measure and are in many cases not well known.

The usage of the published data is limited. The processing of the material and its surface treatment are often not sufficiently specified. Furthermore, the emissivity depends on the temperature of the radiating surface and the absorbtivity depends on the temperature of both the absorbing surface and the radiating surface (radiator). Very little experimental data exists on this dependency.

A device for the measurement of total hemispherical emissivity and absorbtivity of heat radiation at cryogenic temperatures was built and successfully tested by our cryogenics team (Fig. 1, 2).

In the device developed, the radiative properties are evaluated from the measurement of heat flow, which is transported by thermal radiation between two parallel surfaces (the absorber and radiator in Fig. 1). This heat sinks into the LHe bath through a thermal resistor supporting the absorber. The radiative heat flow is stated by measuring the temperature gradient T_A–T_K on this resistor.

Calibration of the device is performed by using an electrical heater mounted on the absorber and substituting the radiative heat flow during calibration. A sample surface can be used as a radiator or an absorber. This is a 1 mm thick circular sheet with a diameter of 40 mm, made from a measured material (e.g. polished aluminium) or coated with a measured layer (e.g. a superinsulation foil).

Fast measurement of radiative properties within the range of the radiating surface temperature T_R = 25 K÷150 K is possible. The temperature of the absorbing surface TA is held between 5 K and 10 K.

The desired measurement precisions are ±1 mK for the relative temperatures (temp. gradient) and 0.1 μW for heat power respectively. The sensitivity of the device enables the measurement of an absorbtivity value of 0.3 % and higher when the sample is irradiated from a black surface at 25 K. The diameter of the whole device is only 50 mm and so it is possible to place it in a commercial Dewar can for cooling. The radiative properties and their temperature dependency for various surface treatments can be checked immediately before application in a cryogenic system.

New experimental low-temperature data of absorptivity were obtained within the wavelength range 25 μm–100 μm. The temperature of the radiator T_R is converted to the wavelength λ by means of Wien's displacement law. In Fig. 3 our measurements (filled dots) are compared with published data measured at shorter wavelengths. An evident continuation of the anticipated trend can be seen. Systematic measurements of the radiative properties of various materials and treatments have been performed continuously since the beginning of the year 2003 [469].

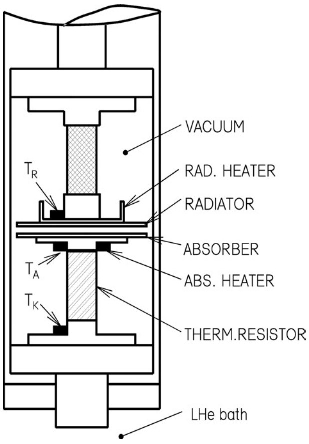


Fig. 1. Scheme of the apparatus.

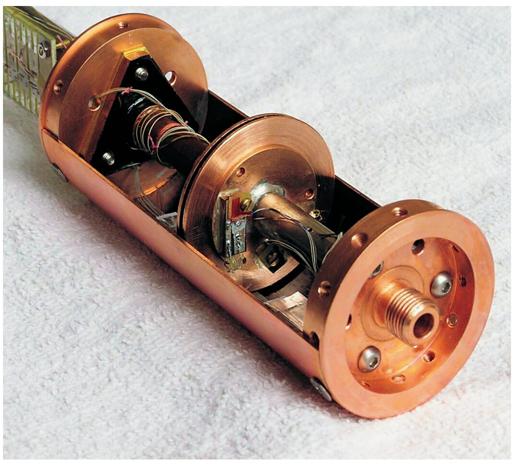


Fig. 2. Detail of the open measuring chamber.

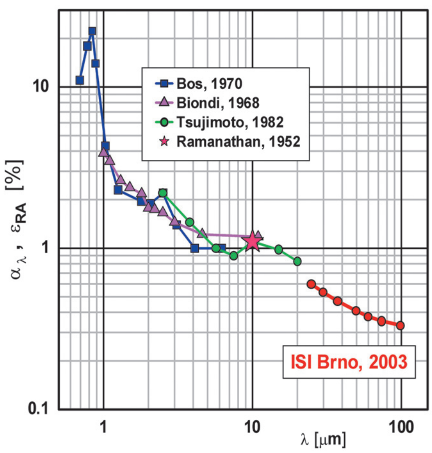


Fig. 3. Comparison of published data with our measurements (pure Al at 5 K).

Monte Carlo simulation of radiative heat transfer and molecular flow

Věra Musilová, Jan Dupák, Pavel Hanzelka, Tomáš Králík and Pavel Urban

We used Monte Carlo simulation of radiative heat transfer and molecular flow for the simulation of a small helium bath cryopump, which we designed to maintain a very clean and high vacuum in an electron microscope. The cryopump design optimizes two competing parameters: pumping speed, which should be as high as possible, and thermal heat input to the cryopanel, which should be minimized. The transfer of thermal radiation is reduced by a system of optical baffles positioned between the pump inlet and the cryopanel. These baffles, however, also impede molecule movement, thereby reducing the pumping speed.

Pumping speed depends on the probability that a pumped gas molecule entering the cryopump inlet "finds" the cryopanel, cooled by liquid helium to 4 K in our case, and condenses or is sorbed on it. At low pressures the gas molecules collide with the walls of the cryopump structure without colliding into each other. Knowing the law of molecule interaction with the walls, i.e. the probability of reflection and probabilities of movement in different directions after molecule reflection, the trajectories of individual molecules can be calculated independently. Thus cryopumping is performed virtually on computer.

It is also possible to use this method for the simulation of a beam of far infrared radiation. Knowledge of the optical properties of cryopump walls in far infrared enables us to simulate the heat transferred by thermal radiation.

In our computer code the particles or rays propagate in a 3D body constructed of thin walls of a planar triangular or tetragonal shape and collide with its surfaces. The surface properties of the walls depend on their material and temperature and on the impact angle. Molecules, according to the experiment, are reflected uniformly in all directions, independently of the impact angle (diffuse reflection). Bi-directional reflectivity data would be more appropriate for the definition of a surface in the case of heat radiation, but this data is rarely known. In view of the lack of data we simulated two limiting cases of surface behaviour, i.e. diffuse and specular reflections. The polarization of radiation was not fully simulated.

The Monte Carlo computer experiment for cryopumping by a small cryopump (Fig 1) proved the degree of accuracy of the analytical models represented by curves a) and b) in Fig. 2, and their applicability to pump optimization. We measured the pumping speed of two versions of the cryopump for helium gas. The results agreed with the computer experiment performed.

Simulation of thermal radiative heat transfer helped us to determine the influence of the optical baffles of cryopump on heat loads of low temperature parts, which is important for cryogenic design. Thanks to the flexibility of this type of Monte Carlo simulation, we can also use our PC code to simulate thermal heat transfer in other cryogenic devices designed by our cryogenics team [62, 223, 333, 396].

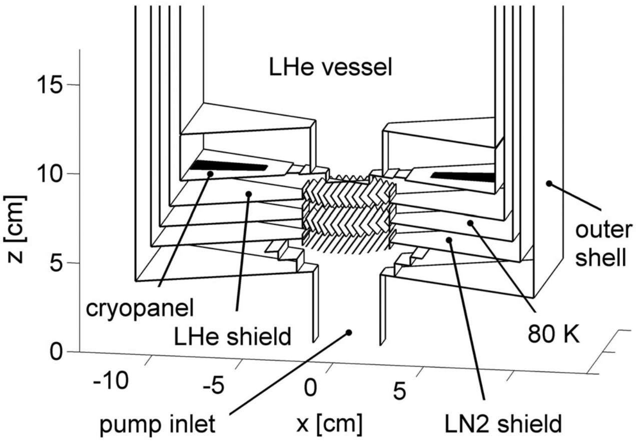


Fig. 1. Internal structure of the lower part of the cryopump. 3D model used in Monte Carlo simulations. Two segments of octagonal prisms, which represent the cylindrical pump parts, and the whole chevron baffles are shown.

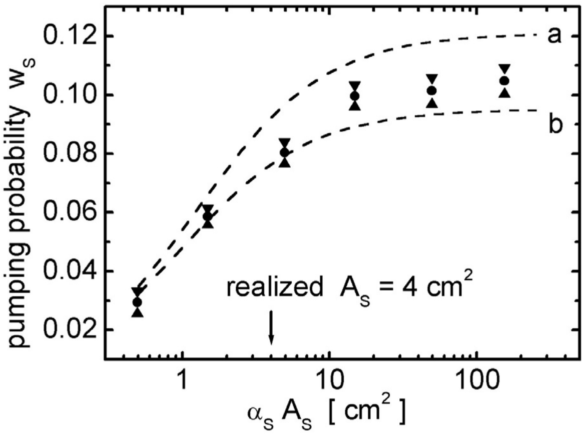


Fig. 2. Dependence of pumping probability by sorption on the "effective sorbent area" aS AS. Circles are Monte Carlo calculated values and their accuracy is marked by triangles. About 10,000 molecular paths were simulated in each configuration.

Type of pump baffles	LHe vessel[mW]	LN2 vessel[mW]
Simple	0.7; 0.7	460; 490
Chevron	0.9; 1.3	780; 840

Table 1. Thermal radiation heat loads of cryopump vessels with cryoliquids simulated by Monte Carlo in two versions of the cryopump. The lower value of each pair of numbers was obtained for a pump model with diffusively reflecting surfaces, whereas the higher one corresponds to mirror-like surfaces.

A Small Superconducting Magnet for Low-Temperature Nuclear Orientation

Aleš Srnka and Jan Dupák

A new low-temperature nuclear orientation facility has been installed at the Faculty of Mathematics and Physics at Charles University in Prague. The facility is based on a small dilution refrigerator ^3He–^4He of the French type and is principally used for solid state physics research. The refrigerator allows the cooling of radioactive samples down to 10 mK in the magnetic field of a superconducting solenoid up to 4 T. Gamma-ray anisotropy is observed exclusively in the direction of the applied vertical magnetic field, which is generally sufficient for solid-state studies.

Nuclear physics research frequently needs overall information on the gamma-ray anisotropy pattern. It is necessary for this purpose to use a horizontal magnetic field, which allows anisotropy measurements along, as well as perpendicular to, the direction of the magnetic field. Simultaneous information on the gamma-ray anisotropy in two or more directions is a principal condition for some nuclear physics studies, e.g. the mixing ratio of nuclear transition. The above-mentioned study is devoted to the systematic experimental research into rare earths radionuclides prepared in at Joint Institute for Nuclear Research in Dubna, Russia.

A new insert to the helium cryostat which holds a horizontal superconducting magnet with a double-coil configuration (Fig. 1) allowing measurements in two directions has been designed at our institute. Both magnet coils are wound from a single piece of NbTi single-core superconducting wire on a titanium former. The former is made of a single piece of Ti material (type Poldi Titan 110). Homogeneous titanium was chosen to reduce the Compton phenomenon – interaction between gamma-ray and atomic lattice of the former material. A superconducting thermal switch and two superconducting joints allow work in a persistent mode with a magnetic field of up to 1.9 T in the sample area. A map of the magnetic field in axial plane z, r (calculated by elliptic integrals) is shown in Fig. 2. Important magnet parameters are summarized in Tab. 1. These results were obtained in co-operation with M. Rotter (Charles University, Prague).

The main goal in magnet design was to achieve the highest magnetic field possible with the given type of superconductor and given dimensions of cryostat and dilution refrigerator. The viewpoint of the low cost of the magnetic system was also taken into account [224, 471].

Mechanical parameters		Electromagnetic parameters	
Outer diameter	64 mm	Critical current	> 70 A
Length	67 mm	Max. magnetic field at the centre	1.9 T
Diameter of both bores	20 mm	Inductivity of coils	0.12 H
Weight	0.87 kg	Current of thermal switch	45 mA
Superconductor length	417 m	Winding protection	2 power diodes

Table 1. Important magnet parameters

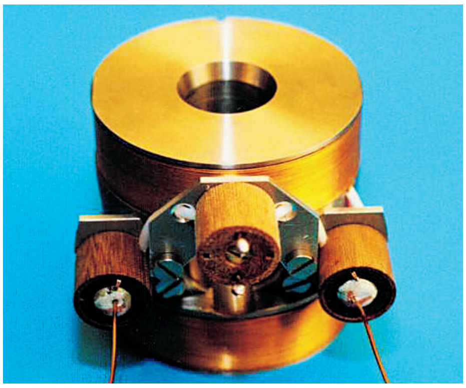


Fig. 1. Magnet view (sc switch and sc joints with current leads are clearly visible).

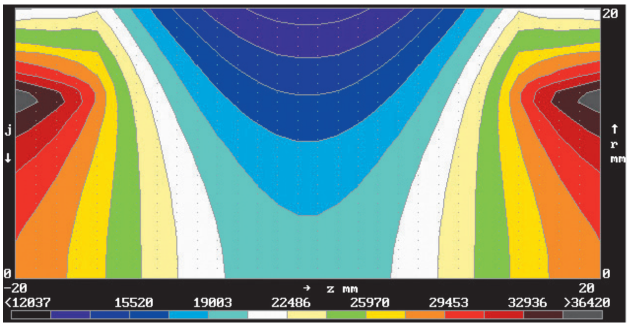


Fig. 1. Magnet view (sc switch and sc joints with current leads are clearly visible).

Robust pulse sequences for the observation of metabolite and macromolecule signals in short echo-time in vivo 1H NMR spectroscopy of the brain

Zenon Starčuk, Jr., Zenon Starčuk and Jaroslav Horký

Nuclear magnetic resonance (NMR) is a physical phenomenon based on the interaction between the angular momentum of atomic nuclei with magnetic fields, ranging from the nanoscale of a molecule to the macroscopic scale of the NMR instrument. By applying suitable sequences of pulses of radiofrequency (RF) magnetic fields and of static-field gradients to nuclei placed in a homogeneous static magnetic field (B_0), specific information can be encoded in the frequency and the intensity of the oscillating magnetization detected by electromagnetic induction. Neurosciences and brain disease diagnostics have benefited a lot from the recent development of in vivo proton (^{1}H) magnetic resonance imaging (MRI), spectroscopy (MRS) and spectroscopic imaging (MRSI). As a complement to high-spatial-resolution MRI, providing information primarily on water in the tissues examined, MRS(I) is capable of delivering specific biochemical information on several low-molecular-weight metabolites (N-acetyl aspartate, creatines, cholines, glutamines, myo-inositol) and certain macromolecules (proteins or polypeptides) and lipids. Pathological conditions are often indicated by a specific change of the detectable metabolic profile. Thanks to its non-invasive nature and improving data quality, MRS(I) is becoming an attractive substitute to a biopsy in diagnosis, therapeutic planning and response monitoring of brain diseases, such as cerebral tumours, stroke, Alzheimer's disease, multiple sclerosis, epilepsy and psychiatric diseases.

The detection of these compounds is hampered by the low signal-to-noise ratio corresponding to their low concentrations (<10 mM) and by the huge signals of the abundant protons of water (80 M) and, in some tissues, lipids, which can mask the signals of metabolites and/or become the source of various systematic or random artefacts, mostly caused by contamination from distant volumes, local field inhomogeneities and the resulting motion sensitivity [351]. Quantitative interpretation of the spectra is then difficult and unreliable. Short echo-time (TE<25–35 ms) measurements are attractive for the higher signal-to-noise ratio achievable due to the shorter relaxation. However, such measurements run into instrumental problems, such as dynamic B_0 variation due to pulse-sequence related mechanical vibration. Avoidance of artefacts for which no model exists is a major task addressed by the new pulse sequences designed [110, 111, 138, 139, 141, 146, 327]. Efficient water, macromolecule and lipid suppression is a clear goal if low-molecular-weight metabolites are the only subject of interest. On the other hand, such signals, if properly localized, may themselves be valuable: partially suppressed, artefact-free water may serve as an internal reference for signal correction, intracerebral lipids and changes in the spectra of macromolecules, detectable at short TE only, may indicate pathological processes (infection, inflammation, necrosis, stroke, trauma, hypoxia). Reliable detection of such signals was another goal of the pulse sequences designed [142, 355, 356, 438].

Several problems have been solved in the pulse sequences designed: improvement of localization purity (by optimized slice-selection RF pulses), signal suppression insensitivity to the RF field inhomogeneity (by adiabatic pulses or optimized RF power), compensation of T_1 relaxation (by optimized sequence timing, power or frequency shift of RF-pulses), distinguishing metabolites and macromolecules (by inversion-recovery schemes optimized to suppress components with fast or slow T_1-relaxation), insensitivity to B_0 inhomogeneity (employing T_1 selectivity and outer-volume saturation). The function of these sequences has been demonstrated on 1.5, 3.0 and 9.4 Tesla NMR systems from co-operating institutions.

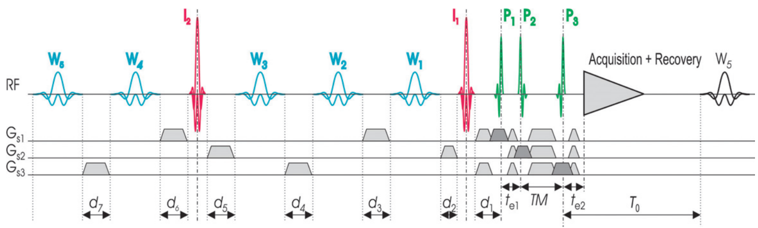


Fig. 1. Depiction of a pulse sequence for macromolecule suppression. A double inversion framework (I_1, I_2) includes water saturation by adiabatic pulses (W_i), asymmetric slice selection pulses (P_i) ensure proper volume selection. Gradient pulses (G_{sk}) are used for dephasing undesired signals and for slice definition.

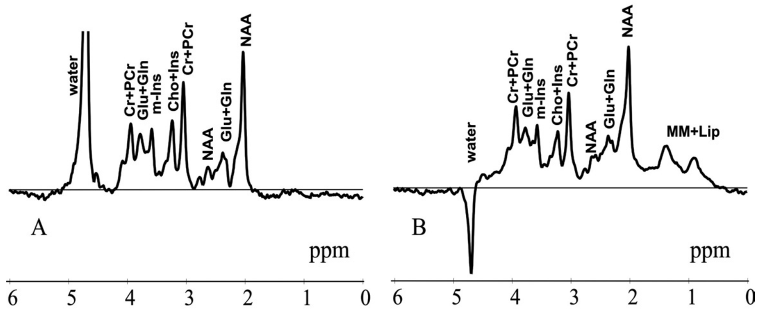


Fig. 2. In vivo ^{1}H MR spectra measured (A) with an optimized double-inversion macromolecule-nulling sequence, in comparison with (B) a standard sequence. Measured in 3.0 T, with echo time TE=10 ms, from 8 cm^3 volume localized by STEAM in the occipital lobe of a healthy volunteer. Broad macromolecule background is eliminated in (A).

Processing, visualization and quantitative analysis of multidimensional data acquired by NMR imaging, spectroscopy and spectroscopic imaging

Jana Starčuková and Zenon Starčuk Jr.

Contemporary in vivo nuclear magnetic resonance (NMR) measurements often produce large 2- or more-dimensional data sets. The dimensions may correspond to spatial dimensions in 2D or 3D imaging (MRI) or spectroscopic imaging (MRSI), to chemical shift in spectroscopy (MRS) or MRSI, or to the various levels of the nested-cycle structure of a complex experiment (e.g. index of a slice, echo, repetition, diffusion encoding step, inversion time, detection coil, etc.). A single data set may represent a 2D slice, a 3D volume, a 1D or 2D spectrum, a 2D or 3D matrix of 1D spectra, a set of spectroscopic or parametric images, etc. The size of a data set may easily reach tens or even hundreds of megabytes. For human-understandable interpretation, considerable processing of the raw data is needed. In most cases the processing steps may operate along 1D vectors only. For example, data points that sample spatial frequencies or spectroscopic evolution time may have to undergo Fourier-transform (or similar) processing to generate spatially and metabolite specific information. Some of the indexed dimensions may be intended to provide data vectors (relaxation curves, spectra) to be fitted by suitable parametric model functions. Occasionally, more-dimensional processing steps may be required (e.g. for fastacquisition or projection reconstruction, image segmentation). The parameters derived from data models may themselves become regular data objects, typically smaller though retaining the dimensions not entering in the model. In some types of experiments, separate data sets are acquired between which spatial relationships exist, such as between a 2D anatomic high-definition image and a 1+2D spectroscopic image, or between a navigator image and an oblique slice. No standard software provided by the major NMR system producers provides enough flexibility and functionality for efficient handling of all such types of data, nor does it support the data formats of other producers. Graphical interfaces to the data sets are typically designed to support mainstream applications, while measurement protocol development and research pose specific requirements on data processing and visualization, and their availability on a standalone computer, avoiding wastage of precious system console time.

For these reasons, the software system Marevisi® providing the necessary infrastructure for NMR research has been developed in co-operation with Inst. for Biodiagnostics, NRC Canada. It is used at many research institutes around the world. The processing, analysis and visualization of multidimensional MRI and MRS(I) data are supported by specialized browser modes in which standard NMR data processing, including Fourier transforms, filtering, interpolation, phase correction, offset correction, etc., are applicable to multidimensional data in an interactive or automated mode. Mechanisms for the geometric planning of experiments based on navigation images have been implemented for integration into a measurement system, and an application program interface (API) prepared for software automation or specialized calculations. Several specialized analytical tools have been implemented, such as tools for the definition and statistical evaluation of regions of interest, or for parametric modelling of mono- and bi-exponential relaxation and diffusion. These tools, as prototypes for quantitative MRI and MRS, are being further developed with the aim of providing reliable quantitative results characterized by their confidence regions. The unified processing of data from the various systems of the co-operating institutions has been made possible by the development of appropriate conversion modules. Several data export methods are supported for publication and research purposes [437].

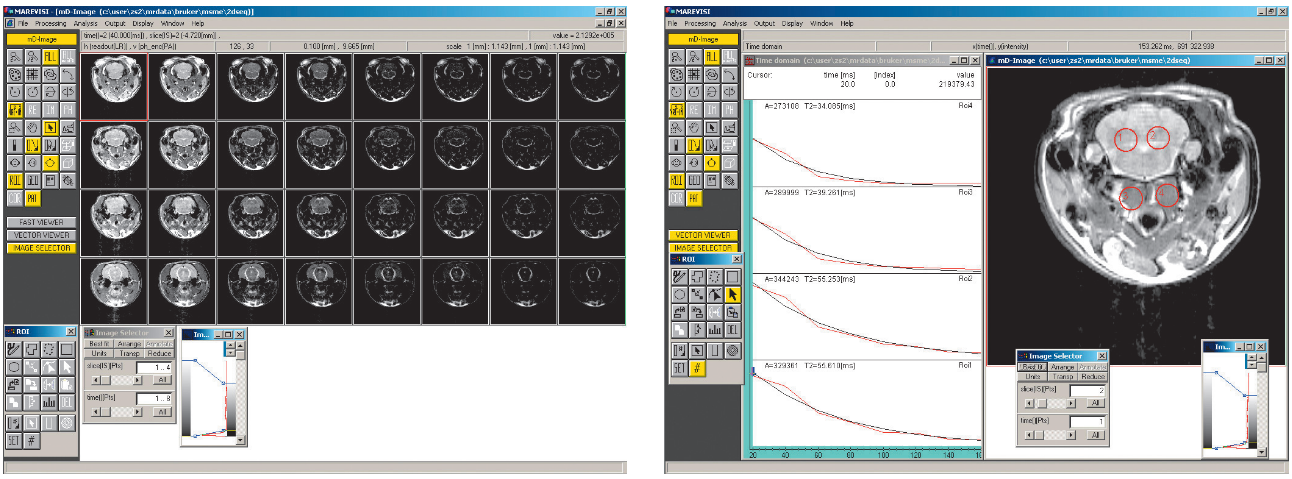


Fig. 1. Example of a 4D data set acquired in an animal study in which 8 echoes from 8 slices were measured; each of them was used to generate a 2D image of 128×256 pixels. Left: all echoes of slices 1–4 are selected for display. Right: in 4 selected regions, total image intensities of slice 2 were used for T_2 relaxation analysis.*

A two-channel digital measurement system

Ivo Viščor, Josef Halámek and Vladimír Húsek

Narrow band radio-frequency analysis is mostly based on a network analyser. Phase information is often necessary in addition to the magnitude of the analysed signal. In this case a vector analyser is used. Both types of analysers usually use frequency sweep techniques. Newer devices – Fourier transformation-based analysers dramatically shorten the time of measurement. For example, measurement with an FFT-based analyser takes much less time (20 s) than swept measurement with a spectrum analyser (500 s). In addition to this they also preserve the time and frequency domain information compact. FFT-based devices generally use digitalisation of the signal at the end of the receiver chain. The goal is to convert the signal to digital domain as near as possible to the beginning of the receiver chain. This assures the simplicity of the measurement system and the versatility and stability of the system parameters. Preserving the system parameters as maximal dynamic range and high passband is not, however, a simple task. The main demands for the measurement system are maximal dynamic range, high passband, high frequency range, parallel acquisition of two bands, preservation of phase coherence and system compactness. Phase coherence means assuring a reproducible phase relation between the transmitted and received carrier, between both channels, and between the transmitter pattern modulation and receiver acquisition boundary.

The basic parameters of the transmitter are a frequency range up to 120 MHz, and wide-band and narrow-band spurious-free-dynamic-range of 65 dB and 85 dB respectively. The frequency range of the receiver is 0.11 MHz to 130 MHz, the dynamic range is 148 dBFS/√Hz and jitter is as low as 0.4 ps necessary for the acquisition of high frequency signals.

The measurement unit can be used for a variety of measurements, including a simple NMR experiment, phase noise measurement and network analyser functions [60, 262, 263, 363, 367, 368].

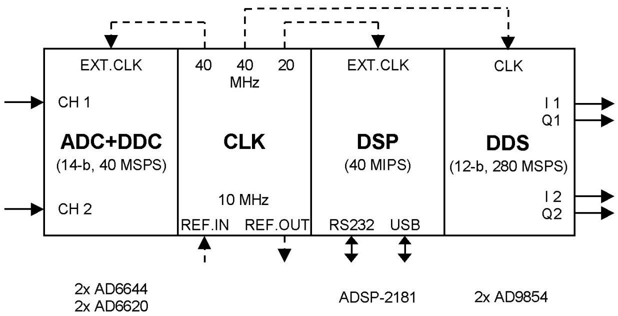


Fig. 1. Digital measurement system architecture: Receiver part (analogue-to-digital converter and digital down converter), clock generation unit, digital signal processor unit and transmitter part (direct digital synthesis).

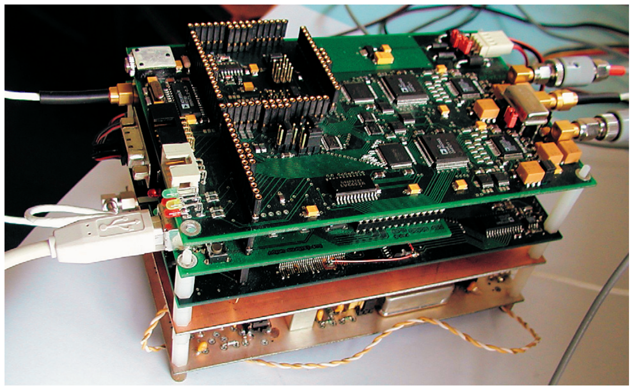


Fig. 2. Modular realisation of digital measurement system. Boards from the top: receiver part, DSP part, transmitter part and clock unit.

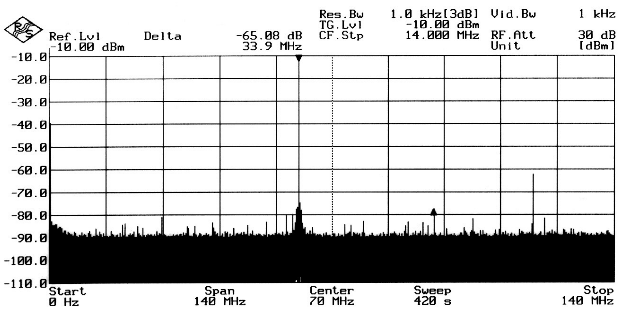


Fig. 3. Wide-band spurious-free-dynamic-range of transceiver measured by spectral analyser (clock frequency 7 x 40 MHz, output frequency 61.504 MHz, tuning word 0x383B80000000).

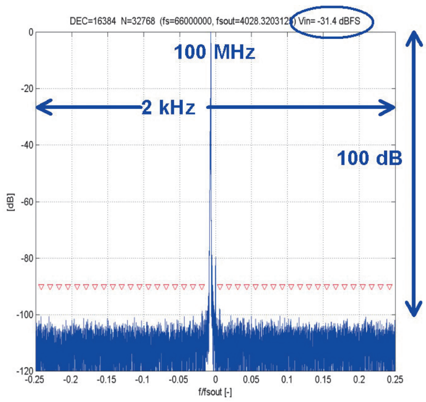
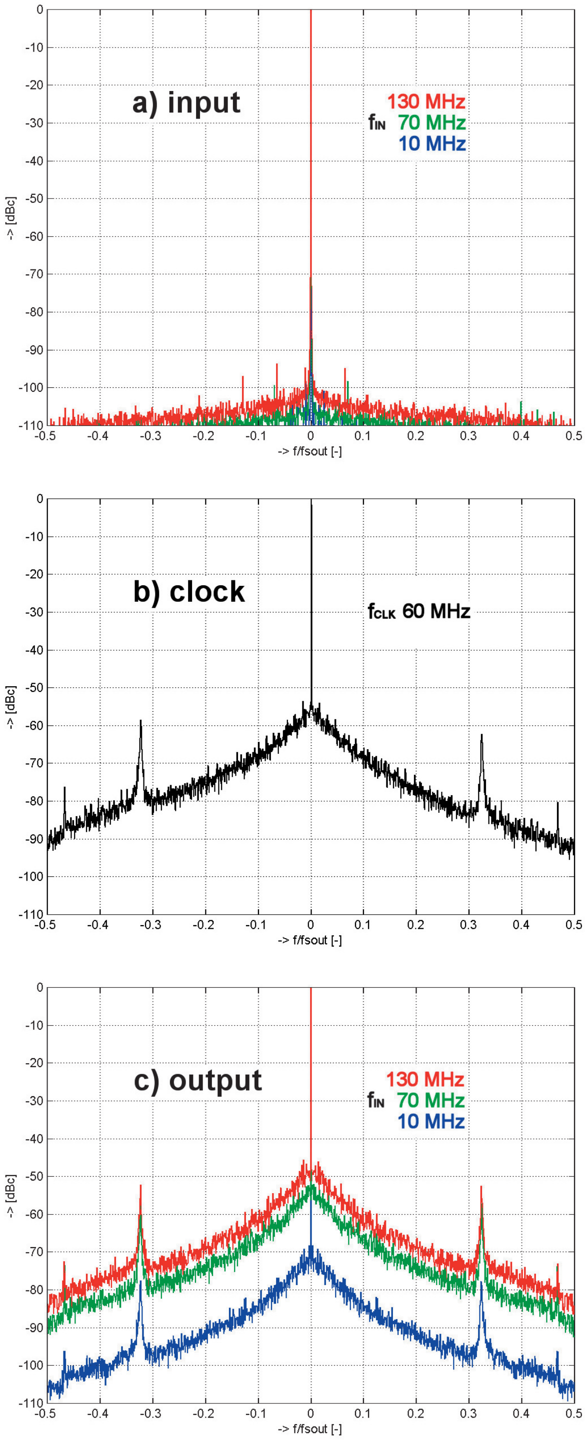


Fig. 4. Narrow-band spurious-free-dynamic-range of receiver (input frequency 100 MHz, input amplitude 31 dB below full-scale).

Close-in spurs in a digital receiver

Ivo Viščor and Josef Halámek

The parameters of digital receivers have become quite competitive to the traditional analogue radio architecture in the past few years, as A/D converters (ADC) have been considerably improved. Until now the dynamic range of ADC was the limiting factor of the digital receiver. Now, the dynamic range of the front-end amplifier, the quality of the sample-clock source and distribution and proper system design are becoming increasingly important. The digital receiver substitutes traditional radio parts as mixers and filters by ADC and digital signal processor (DSP). It is important to know how the acquired signal is affected by imperfections to the ADC sample clock. The importance of sample clock purity increases with the acquired signal frequency. This is particularly the case in under-sampling applications. In a digital receiver all the frequencies of the analogue signals are quite distant from low-frequency interference, such as 50 Hz (or 60 Hz) power-net signals. This can cause designers to tend to neglect its impact. If, however, the goal of the digital receiver is to acquire a narrow-band signal with high dynamic range (100 dB), then 50 Hz related close-in interference may significantly contaminate the digitised signal. Another serious close-in interference is phase noise. Both these types of imperfection are transferred from the ADC clock signal to the resulting (acquired) signal. Moreover, imperfections are amplified by input-to-sampling-clock ratio, so the demand on ADC clock purity can be higher than the demand on the oscillator in the mixer [361, 362, 366, 367].



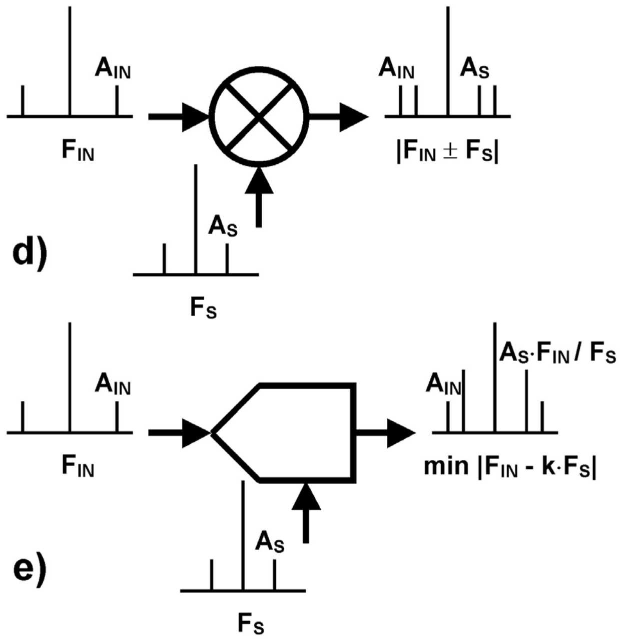


Fig. 1. a), b), c) Experimental demonstration of phase noise translation from clock to output signal: a) harmonic signals 10 MHz, 70 MHz and 130 MHz measured by a digital receiver with good sample clock signal; b) sample clock signal 60 MHz with excessive phase noise measured by a digital receiver with good clock signal; c) harmonic signals the same as a), but measured by a digital receiver with noisy clock signal b). (FFT 32 k, bandwidth 'fsout' 1.5 MHz)
d), e) Analogue mixer versus analogue-to-digital converter: Sensitivity of mixer d) and ADC e) to parasitic argument modulation of local oscillator/sample clock (FS). FIN is the frequency of the input signal, AIN and AS are relative amplitudes of parasitic side-bands. Clock side-bands are amplified by input-to-sampling-clock ratio in ADC.

IV

Scientific Co-operation, Activities and Results

Co-operation with universities

List of accredited PhD study programs based on an agreement

University	PhD study program	Study specialisation
FEEC BUT	Electrotechnology, electronics, communication and control technology	Biomedicine electronics and biocybernetics
FEEC BUT	Electrotechnology, electronics, communication and control technology	Electronics and communication technology
FEEC BUT	Electrotechnology, electronics, communication and control technology	Cybernetics, automatization and measurements
FEEC BUT	Electrotechnology, electronics, communication and control technology	Microelectronics and technology
FEEC BUT	Electrotechnology, electronics, communication and control technology	Teleinformatics
FME BUT	Physical and material engineering	Physical and material engineering
FS MU Brno	Physics	Wave and particle optics

BUT – Brno University of Technology
MU – Masaryk University
FEEC – Faculty of Electrical Engineering and Communication (acronym before 2001 was FEI)
FME – Faculty of Mechanical Engineering
FS – Faculty of Science
FCH – Faculty of Chemistry

Scientific co-operation between ISI and universities is being conducted by means of joint laboratories and by means of common grant projects involving cooperation between a principal investigator and a co-investigator. The activities of these joint laboratories are described in this paragraph. These laboratories exist on the basis of agreements between the universities and ISI which are not limited in terms of their duration. Their existence is informal and no further administration is involved. The institute and its partners understand the term "joint laboratory" merely as a declaration of their willingness to co-operate on the selected topics within the research orientation of both partners. Within this framework gradually emerged:

Name of the joint laboratory	Co-operating university
Laboratory of the physics of environmental scanning electron microscopy (ESEM)	FEEC BUT
ESEM demonstration and application laboratory	FEEC BUT
Laboratory for the study of detection systems	FEEC BUT
Laboratory for the study of the physical properties of polysilylene	FCH BUT
Laboratory of optoelectronics and electron lithography	FEEC BUT
Laboratory of electron microscopy and special technologies	FS MU Brno
Laboratory of digital signal processing (DSP)	FEEC BUT
Laboratory of nanotechnologies	FME BUT
Laboratory of experimental satellite communications	FEEC BUT

In the years 1999–2002 the structure of the yearly report included a special chapter describing the results of research achieved within these laboratories. The most important of these results are now summarized here. In the year 2003 the results achieved by institute staff are not summarized in this way, although some of them are the result of this kind of cooperation with universities.

Laboratory of the physics of environmental scanning electron microscopy (FEEC BUT)

- An ESEM was assembled and the effect of magnetic field on extending the path-length of electrons was studied, computer simulation of electron trajectories was undertaken for high-pressure conditions in the vacuum chamber, investigations of the possibility of using electrostatic fields for higher energies in ESEM conditions and of using x-ray analysis in ESEM were undertaken (1999).
- We studied the effect of magnetic fields on trajectories of signal electrons in a wet environment in the ESEM chamber. We performed experimental verification of this effect on the detection of secondary and back-scattered electrons (2000).

ESEM demonstration and application laboratory (FEEC BUT)

- We studied the surfaces of non-conductive and wet samples in order to optimize detection conditions for obtaining higher resolutions (1999).
- We investigated methods of cooling, introduction of water and the effects of various gases on imaging soft biological tissues (1999).
- We researched the possibilities of imaging wet biological samples with high resolution using a new ionization detector for secondary electrons (2000).
- We determined optimal physical conditions (gaseous environment, ionization cross-sections, pressure, working distance, wetness, the path length and energy of electrons) and modified the ionization detection system in order to obtain high resolution for wet biological samples in ESEM (2001).

Laboratory for the study of the physical properties of polysilylene (FCH BUT)

- Within the framework of cathodoluminescence (CL) study of polysilylenes we performed CL measurements and analyzed degradation curves of polysilylenes, the effect of electric field on the CL of polysilylenes and determination of their metastable states (1999).
- We applied CL methods within the framework of study of metastability in organic-silicon hybrid structures with variable dimensionality (2000).
- We determined the thickness and structure of plasma deposited polymer layers of polysilane (2000).
- Metastable states of polysilylenes were studied theoretically and experimentally (2002).

Laboratory for the study of detection systems (FEEC BUT)

- We adapted an ionization detector of secondary electrons in ESEM with reduced effect of back-scattered electrons and confirmed the advantages of this adaptation (1999).
- We studied a new detector of back-scattered electrons in conventional scanning electron microscope working with low energy of electrons (1999).
- We designed and experimentally verified an ionization detector of secondary electrons in an experimental scanning electron microscope. The detector is based on separation of secondary and back-scattered electrons by an electrostatic field (2000).
- For an environmental scanning electron microscope (ESEM) we produced a two-stage detector of back-scattered electrons and ionization detector placed under the plane of the sample, and began development of a new type of detector of secondary electrons (2002).

Laboratory of optoelectronics and electron lithography (FEEC BUT)

- We evaluated the properties of thin films deposited by ion beam technologies, utilizing ion beam etching, and developed and produced phase diffraction filters (1999).
- We produced a test structure for study of the dimensions of a focused ion beam (1999) and studied microelectronic conductive sensors (1999).
- We measured the thickness of a large series of deposits and performed microscopic evaluation of layers after thermal annealing within the range 450–700 °C (1999).
- We produced large-area diffractive structures (2000).
- We developed technology allowing the production of very thin nitride silicon for use as an intelligent pressure sensor (2001).

Laboratory of DSP (FEEC BUT)

- Simulation tests were carried out on a linear digital filter with zero phase characteristics by applying an IIF filter and its DSP implementation. Its properties were tested with respect to application in NMR (1999).
- A hardware DSP set for adjusting matrix shims for the NMR system MIDI was prepared and experimentally tested (1999).
- Simulation tests were carried out on a digital filter with a nonsymmetric impulse response and implemented on a DSP. Its properties were tested with respect to application in NMR spectroscopy and for gradient magnetic field measurement in MR systems (2000).
- A new more accurate method of measurement of the time-spatial characteristics of gradient magnetic fields was developed (2002).

Laboratory of nanotechnologies (FME BUT)

- By means of a combined system of optical tweezers and scalpel an induced fusion of living cells HL60 was performed, as well as manipulation of artificial objects inside Amoeba, and the resistance of protozoa against UV pulses was investigated (1999).
- An experiment involving the induced breakdown of a cell at a suitable phase of the cell cycle was performed. This was performed by a shock wave resulting in the ejection of chromosomes, which were later trapped and manipulated with the optical tweezers (1999).
- A calculation of optical forces effecting nanoobjects and microobjects placed in a convergent Gaussian beam and in a standing wave created by the interference of incident and reflected electromagnetic waves was performed (1999).
- Experiments involving the trapping of objects by means of a standing wave were performed (2000).
- The apparatus for the optical manipulation of microparticles was modified so that two independently positioned traps were obtained, while other traps were generated by means of acousto-optic deflectors. A high-precision digitally controlled stage with micropositioning was put into operation (2000).
- Experimental conditions for optical tweezers and an optical scalpel have been found that allowed contact of two selected living cells, burning of their separating cell membrane and subsequent fusion of the cells. Subsequently they were mechanically picked, fixed after various periods following fusion and studied by means of the FISH method at the Institute of Biophysics of the ACSR (2001).
- An experimental set-up allowing optical trapping of objects into several optical traps was completed. The objects can be spatially moved and may be subjects of ablation interventions on the micrometer scale on free or trapped objects. Selected objects may also be mechanically picked, moved or removed (2001).
- An improved set-up of optical tweezers and an optical scalpel was used for study of the process of laser induced fusion of living cells MCL7, and the distribution of chromatin in the resulting hybrid cells was studied by the FISH method (Institute of Biophysics ASCR, Faculty of Informatics MU Brno, FME BUT) (2002).
- A pair of two independently tuneable semiconductor lasers with an external resonator was designed and constructed for the generation of a synthetic wavelength in the interferometric profilometer (FME BUT, FS MU Brno) (2002).
- A method using detection of the position of the optically trapped probe for mapping the profiles of inaccessible surfaces was completed. The vertical resolution achieved was 25 nm (2002).

Laboratory of experimental satellite communications (FEEC BUT)

- Participation in launching satellite P3D (2000).

Collaboration with St. Anne's University Hospital Brno and the Faculty of Medicine, MU Brno

- Analysis and diagnostics of the autonomic neurovegetative system were extended to include respiration measurement, and correlation between the examined vascular characteristics was studied (1999).
- Invoked biopotentials affected by various external events were measured and analyzed (1999).
- Data transfer from the tomograph to a personal computer for further processing was designed and experimentally tested (2000).
- Statistical evaluation of the influence of various algorithms and computation parameters on the resulting value of the estimate of the standard parameter of baroreflex sensitivity was carried out; the applicability of the standard baroreflex sensitivity parameter for diagnostics was analyzed, including terminological analysis; mechanical components for a mercury plethysmograph were designed and manufactured (2000).
- Measurements and analyses of the influence of vagus stimulator activity on systemic blood pressure and the heart rate revealed zero correlation between them, which is in surprising contradiction to the generally accepted assumptions (2001).

- Various parts of mechanically trapped live infusoria of Paramecium and Blepharisma were exposed to UV irradiation, whose energy caused local damage, which was studied by optical and electron microscopy (2001).
- Measurements of proton NMR spectra of the human brain in healthy volunteers and patients with neurological, psychiatric and oncological conditions were begun (2002).
- A procedure for processing the results of intracerebral ERP and ERD/ERS signal measurements with deep intracerebral electrodes was developed (2002).
- The dependence of the heart rate and baroreflex sensitivity (BRS) was studied in young healthy subjects using the method of confidence ellipses and an algorithm for classification of the studied subject groups was developed (2002).

Collaboration with the Faculty of Medicine, Charles University in Plzeň

- Special samples of diffractive lenses were designed and manufactured for a confocal microscope used in laser operations in ophthalmology (1999).

The results of the following one-off projects are also worth mentioning, in addition to the results of the systematic cooperation projects given above:

- In cooperation with MU, within the framework of a joint project, we performed analysis of the structural properties of multi-layer nanocomposite coatings prepared at ISI by means of x-ray diffraction and low-angle x-ray reflection (1999).
- In cooperation with the FCH BUT we evaluated methods for measurement of the thickness and structure of plasma deposited polymer layers (1999).
- In cooperation with the FCH BUT we performed checks and optimization of the operation of a BS 687 (80 MHz) spectrometer used for research and teaching purposes (1999).
- We evaluated the properties of thin layers of materials deposited by ion beam technologies; utilizing ion-beam etching we performed the development and production of phase diffraction filters (2000).
- A modification of an electrometric device for the measurement of ions by means of an aspiration capacitor was developed, tested and applied in the measurement of the spectral characteristics of aerial ion concentration in an enclosed space (2000).
- In collaboration with MU and FEEC BUT, the ion field in buildings was mapped and the effect of buildings on ion concentration in workplaces was studied (1999).
- In cooperation with the department of low-temperature physics, Faculty of Mathematics and Physics, Charles University, Prague, a superconducting magnet for nuclear orientation was designed and its specifications experimentally tested (1999).
- In collaboration with the Faculty of Mathematics and Physics, Charles University, Prague, a device for low-temperature nuclear orientation from the department of low-temperature physics was put into operation with a new magnet developed and manufactured at ISI (2000).
- A chip for calibration of SEM magnification was prepared for the West-Bohemian University in Plzeň (2000).
- A simple method of measurement of electrostatic charges produced by friction on dielectrics surfaces was proposed and experimentally proven (2000).
- A new method for optimizing various types of measurements and processing based on statistical evaluation of results was developed and tested (MU Brno) (2001).

Co-operation with targeted and applied research

Co-operative projects in research and development considered as grants

Collaboration with První brněnská strojírna, Velká Bíteš, a. s.
FB-C2/40/99 (Investigator. A. Srnka, provider: *Ministry of Industry and Trade of the Czech Republic (MITCR)*, investigation period: *1. 1. 1999–31. 12. 2001*)
Cryogenic turbine and compressor research and development centre

- An experimentally verified model of heat transfer from the room-temperature part of a cryogenic turbine of a compressor in the operating gas was developed. Based on the model, a concrete turbine was proposed so that the total heat transfer could be reduced by 30 %.
- A testing site for research and development tests of cryogenic turbines and (in part) cryogenic compressors at low temperatures was established.

FF-P2/058 (A. Srnka, *MITCR, 1. 1. 2003–31. 12. 2005*)
Research and development of cryogenic turbines and compressors

- Goals were focused on research and development of cryogenic high-speed turbines and compressors; experimental research of problems of vibration, dynamics, heat, thermodynamics and hydrodynamics of existing helium turbines and compressors, development of innovation measures and their implementation. A turbine of a new typical size will be constructed, manufactured and tested.

Collaboration with Vakuum Praha, spol. s r. o
FB-C2/45 (J. Dupák, *MITCR, 1. 1. 1999–31. 12. 2001*)
Ultra-high vacuum (UHV) technological and production centre

- The main project goal is the establishment of an UHV technological and production centre equipped with complete technologies for efficient and ecologically friendly production of vacuum systems and components.

Cooperation with BD SENSORS, s. r. o.
FD-K/104 (K. Bartušek, *MITCR, 1. 7. 2001–31. 12. 2003*)
SENSVISION – internet access to processes

- Applied research on intelligent sensors in the system SENSVISIONR for the measurement of non-electrical quantities with direct data access to information system of local Ethernet network via web server connected to Internet/intranet with additional open data protocols and services of ICT.

Results of R&D for the economic sphere (or achieved in collaboration with it) based on controllable agreements.

Czech Holography, s. r. o. – since 2000: **Optaglio, s. r. o.**
Shaping of thin polymer layers with electron beams into area microstructures suitable for basic and applied research of optically active structures and for industrial application of holography (1999–2002).

- We prepared large-area holographic structures from provided software outputs (1999).
- We prepared samples of large-area holographic structures from provided software outputs (2000).
- 22 different large-area diffractive structures were made in films of polymer electron resists (2001).
- Large-area diffractive structures were made in films of polymer electron resists with the help of an electron lithograph (2002).
- In the field of holography the work focused on setting the conditions for lithography of holographic gratings with defined depth and profile of surface relief. We significantly increased the diffraction efficiency of the diffractive-optical-element-type of holograms (2003).
- We developed lithographic technologies for general achromatic diffractive optical elements with defined profiles of the relief. We produced a program tool for the computations and input of calibration constants for the suppression of deflection field distortions based on detection of calibration marks when the electron-beam lithograph is operating in the scanning electron microscope regime (2003).
- In the field of lithography for nanotechnologies the work was directed at improvements of resolution of the device by changing the apertures of the probe-shaping system (original Pt for anisotropically etched Si), changing the control software of the lithograph (removing 10 D/A converter for table position control) and changing the wiring from the control PC to beam deflection in order to suppress the disturbing fields (2003).

FEI Czech Republic, s. r. o., Brno

A method for objective quantification of the detection efficiency of the secondary electron detector

- In the project for the development of a method for objective quantification of the detection efficiency of the standard detector of secondary electrons the first phase was devoted to a detailed literature search (2002).
- In the second project phase a theoretical model of the entire detection channel and its efficiency was developed and methods were proposed for assessment of the quality of the information transfer rate and for the time response to an abrupt change in the input signal (2003).
- At the beginning of the third project phase the theoretical model and the quantification method were successfully verified by static measurements of statistical properties of the image signal (2003).

Czech Metrology Institute

Research and development of an etalon of a frequency (wavelength) for optical communications (2002)

- A suitable semiconductor laser was chosen and purchased for the etalon of the optical frequency in the C band and its control electronics were assembled.

Tescan, s. r. o. Brno

Electron microscopy of specimens under critical conditions (1999-2001)

- Environmental conditions were determined and implemented for observation of the surfaces of biological samples with high water content with image resolution of 8–9 nm (1999).
- The design and realization of the environmental scanning electron microscope were completed and its production begun under the trademark AQUASEM (2000).
- Optimum physical conditions for the ionization detection system were determined and the system was modified in order to achieve a high resolving power with biological specimens in ESEM (2001).

Scanning electron microscopy of non-conductive specimens (2002)

- A prototype of a scanning electron microscope was equipped with an imaging mode with very low-energy electrons.

VEGA scanning electron microscope (2002)

- The microscope was adapted for operation under increased gas pressure and equipped with a new projection lens.

PALS research centre

- A laser stabilized on the absorption in the vapour of dissociated iodine was designed and realized (1315.24 nm), which will be a part of the master oscillator of the pulsed laser system ASTERIX.
- With reactive magnetron sputtering we prepared multi-layer coatings with high efficiency and low roughness of the boundary that were used as mirrors in experiments with an extremely high-power pulsed x-ray laser based on the laser system ASTERIX.

Preciosa, Turnov

- Technology and preparations of wear and corrosion resistant coatings (2002).

Delong Instruments, s. r. o.

- Implementation of Schottky cathodes in an electron lithograph (2002).

Veterinary and Pharmaceutical University in Brno (CR); Pharmaceutical Research Institute in Modra (Slovakia); Institute of Physics ASCR in Prague (CR)

- A considerably less expensive and faster method was developed for the pumping of the helium gas penetrating into the isolation space of superconducting magnets, with no requirement for heating and deenergizing the magnet (2002).

International co-operation in research and development

Participation in international research and development co-operation implemented on the basis of international contracts concluded by the Czech Republic with foreign entities

ME 134 (Investigator J. Dupák, provider: *Ministry of Education, Youth and Sports of the Czech Republic (MEYSCR)*, Investigation period: *1. 1. 1997–31. 12. 2000*)
Collaboration between the CR and the Joint Institute of Nuclear Research in Dubna in the application of methods of theoretical and nuclear physics in other subject fields.

- Methods were clarified that describe the usage of gadolinium matrix for the measurement of hafnium isotopes by nuclear orientation (1999),
- a plasma ion source was reconstructed so that radioactive isotopes of hard melting elements were emitted (1999),
- experiments with oriented nuclei were run within the project SPIN (2000).

30/66 (M. Kasal, *MEYSCR, 1. 1. 1998–31. 12. 2000*)
Advanced Instruments and Methodology for NMR Spectroscopy and Tomography. A joint project between INFM (Italy), University of Pavia (Italy) and MŠMT (CR) within the friendship agreement concluded between the CR and Italy, project no. 30/66.

ME 181 (A. Gottvald, *MEYSCR, 1. 1. 1998–31. 12. 2001*)
Japanese-Czech-Slovak seminar on applied electromagnetism, entitled “The 4th Japan-Central Europe Symposium on Energy and Information in Nonlinear Systems”, organized within the framework of co-operation with the Japanese Society of Applied Electromagnetics and Mechanics (JSAEM) and supported by the Science and Technology Agency, Japan (1999),

- Aleš Gottvald was awarded the JSAEM diploma for the best book published by JSAEM in 1999 (together with Dr. J. Pavó, HU).

AKTION 24P15 (Z. Starčuk, *MEYSCR, 1. 1. 1999–31. 12. 1999*)
Implementation of effective suppression of water and environmental influences into localized in-vivo NMR spectroscopy of low molecular weight metabolites at 3T.

- Simulation, optimization and testing of new pulse sequence modules and single shaped pulses (1999).

PST.CLG.97082 (L. Frank, *NATO, 1. 1. 2000–31. 12. 2000*)
Scanning very low energy electron microscopy in ultrahigh vacuum conditions (NATO project).

KONTAKT 2000/9 (Z. Starčuk, *MEYSCR, 1. 1. 2000–31. 12. 2001*)
Quantitative problems of single-voxel ultra-short echo-time in-vivo proton NMR spectroscopy of the human brain in a 3 T magnetic field.

- New methods for localized in-vivo spectroscopy developed at ISI were implemented on a whole-body 3 T MR scanner at Universität Wien (Austria) (1999),
- simulation, optimization and testing of new pulse sequence modules and individual shaped pulses on the NMR scanners at ISI and Institut für Medizinische Physik, Universität Wien (2000),
- a new class of pulse sequences for the suppression of water signals in in-vivo NMR spectroscopy of the human brain was developed and applied at AKH Wien, (2000),
- together with Universität Wien and AKH several inversion-recovery methods were analyzed to distinguish MR resonances of low-molecular-weight metabolites and macromolecules in the human brain using the differences in their spin-lattice relaxation (2001).

OC 523.30 (J. Sobota, *MEYSCR, 1. 1. 2000–31. 12. 2003*)
Coatings used as hard solid lubricants.

- Carbon nitride coatings prepared under various conditions by radio-frequency reactive magnetron sputtering were analyzed in cooperation with the Institute of Physics (ASCR), University of Kassel (Germany), University of Brussels (Belgium), Charles University (CR) (1999),
- a very stable dynamic impact wear tester of hard coatings was developed in cooperation with the Institute of Physics and Astronomy, University of Aarhus (Denmark),
- in cooperation with Universität Wien a number of nano(multi) layer and nano-structured C-N/MeN coatings were prepared. They have a low friction coefficient, high wear resistance and microhardness, and suitable temperature stability (2002).

KONTAKT 2002-13 (Z. Starčuk, *MEYSCR, 1. 1. 2002–31. 12. 2003*)
Quantitative in-vivo MR spectroscopy of the human brain in a 3 T magnetic field with improved information content.
- A method of proton in-vivo MR spectroscopy of the human brain with a suppressed water signal was clinically tested at Algemeines Krankenhaus in Vienna (2002).

ME 526 (A. Gottvald, *MEYSCR, 1. 1. 2002–31. 12. 2004*)
Information physics as a unified point of view on physical theories and complex systems.
- A concept of an exponential family was elaborated from theoretical and practical aspects and applied as a systematic tool for the definition and solution of NMR problems (University of Kyoto, Japan) (2002).

LST.CLG.979869 (P. Jurák, *NATO, 1. 1. 2003–31. 12. 2004*)
Sudden cardiac death risk stratification.

G5RD-CT-2000-00344 (B. Lencová, *European Commission, 1. 5. 2002–31. 12. 2003*)
Nanofabrication with focused ion beams.

ME 492 (A. Srnka, *MEYSCR, 1. 1. 2003–31. 12. 2006*)
This COMPASS project focused on CERN experiment NA58 dealing with the study of the interaction of high-energy particles scattered onto a low temperature target.

Contracts or joint projects of the applicant with foreign organisations engaged in research and development

- Contract on collaboration in research and education between the Technical Faculty of Toyama University (Japan) and ISI (since 2003),
- agreement on collaboration with the University of York, UK (since 1999),
- contract on electron optics software dissemination by the Delft Particle Optics Foundation and the Technical University of Delft (the Netherlands),
- contract on collaboration in the development of imaging software, scientific instruments and methodology in NMR between the Institute for Biodiagnostics (NRC) in Winnipeg (Canada) and ISI (since 1999),
- project No. 7987, Jubiläums fond ONB, Austria, Quantification of intro-cellular hypoglycemic metabolites (1999–2000),
- contract for KRYOM 3.3 software dissemination by the company CRYODATA (Louisville, USA).

Informal collaboration with foreign partners:

- CEMES-LOE, CNRS, Toulouse (France) – Calculation of the optical properties of ion lenses (2003),
- BIPM, Sevres (France) – Participation in the international comparison of frequency stabilized semiconductor laser systems (1999),
- PTB Braunschweig (Germany) – Collaboration in the development of semiconductor lasers with external cavity (1999),
- DFM Copenhagen (Denmark), HUT Helsinki (Finland) and CNAM Paris (France) – Collaboration in the development of iodine cells for absorption spectroscopy (1999),
- Technical University of Tampere (Finland) – Development of technology for antireflection coating of high-power laser diode facets (2001),
- Laserlabs (France) – Collaboration in the development of technology for high-reflection coating of mirrors for iodine stabilized lasers (2000),
- Laboratoire de Spectroscopie Atomique et Ionique. C. N. R. S. (France) – Special laser mirrors (2000),
- Technical University of Helsinki, Finnish National Metrology Institute – Mutual comparison of frequency stabilized semiconductor laser systems of all partners (2000),
- European Molecular Biology Laboratory – Heidelberg (Germany) – Theoretical determination of optical forces (1999) and experimental usage of two-photon fluorescence for study of the behaviour of objects confined in optical traps (2000),
- NIST Gaithersburg (USA) – Collaboration in the field of absolute laser interferometry and methods of precise measurement of the refractive index of the air (1999–2000),
- University of Minnesota (USA) – Detection of backscattered electrons in a high resolution SEM (1999),
- University of Nagoya (Japan) – Single-crystal screens for TEM with electron energy from 100 keV to 1 MeV (1999) and image acquisition through high-energy electrons by YAG screens (2000),

- Jeol Ltd. Tokyo (Japan) – Detection of signal electrons in TEM and SEM (1999),
- Applied Materials, Nes-Ziona (Israel) – Ultrafast scintillators and detection systems for detection of secondary electrons (1999),
- University of Minnesota, Medical School (USA) – Collaboration with the Center for Magnetic Resonance Research (1999),
- Dérer Hospital of, Bratislava (Slovakia) – Collaboration with MR Center (1999),
- University of Pavia (Italy) – Implementation and initiation of a digital receiver unit in an NMR system (2001).

The organization of international conferences

- 12th European Congress on Electron Microscopy (Brno, 9th–14th July 2000), organised by the Czechoslovak Society for Electron Microscopy and ISI, congress president and organising committee chairman L. Frank, secretary of the congress and organising committee I. Müllerová, vice-chairman of programme committee R. Autrata, vice-chairman of organising committee P. Schauer, treasurer of organising committee P. Furch, 1248 participants.
- The 4th Japan-Central Europe Joint Workshop on Energy and Information in Non-Linear Systems (Brno, 10th–12th November 2000), organised by ISI, the Japanese Society of Applied Electromagnetics and Mechanics and the Japanese International Science and Technology Exchange Center, chairmen of the program committee A. Gottvald and M. Uesaka, 80 participants from 5 countries.
- 7th International Seminar on Recent Trends in Charged Particle Optics and Surface Physics Instrumentation (Brno, 15th–19th July 2000), chairperson I. Müllerová, 39 participants from 9 countries.
- 8th International Seminar on Recent Trends in Charged Particle Optics and Surface Physics Instrumentation (Brno, 8th–12th July 2002), chairperson I. Müllerová, 48 participants from 9 countries.

Publicity and public promotion of science

Press:

- Publication and broad distribution of the proceedings "Institute of Scientific Instruments 1995–1999",
- newspaper articles about electron microscopy and EUREM 12 organized by ISI: Rovnost Jul. 10, 2000, Rovnost Jul. 11, 2000, Dnes Jul. 20, 2000, Technical Weekly (Technický týdeník) Jul. 18, 2000, Právo Jul. 10, 2000, Czech Press Office news Jul. 9, 2000,
- articles in the specialized press about EUREM 12: Fine Mechanics and Optics (Jemná mechanika a optika), 10/2000, G.I.T. Imaging and Microscopy, Vol. 2, no. 2 (2000), Bulletin of the ASCR (Akademický Bulletin), no. 10 (2000), Bulletin SIME (Italian Society for EM), Microscopy and Analysis, no. 67 (September 2000),
- post-congress summary of EUREM 12: Microscopy and Analysis, no. 67 (September 2000), article by I. Watt,
- Preciosa News (Preciosa Noviny), October 2000,
- Bulletin of the ASCR (Akademický bulletin) no. 10 (ESEM - AQUASEM put into practice),
- Autrata R.: Czech science at the crossroads, EKONOM 45, no. 6, pp. 10–12 (2001),
- Jurák P.: Scientists from Brno have developed a unique medical device..., Den – Rovnost – Právo, Jul. 19, 2001,
- two articles in the Japanese press about cooperation between ISI and the University in Toyama, Japan: Metal and Technology (specialized journal) Oct. 23, 2002, Toyama Press (regional daily) Oct. 31, 2002,
- two articles about the Visitor's Days at ISI in the regional daily Rovnost (Oct. 18 and 19, 2002),
- Mother has a microscope – interview with I. Müllerová, magazine supplement of the daily Lidové noviny, Sept. 26, 2003.

Popularization seminars/lectures:

- Popularization seminar for the medical public, held in cooperation with the Institute of Oncology, MU Brno (Brno, May 1999),
- Zemánek P.: The use of an optically trapped probe for the study of very weak interactions, for the seminar Optical Measurements in Laboratory Practice organized by the Czech Association of Scientific and Technical Societies, Oct. 16, 2001,
- active participation at the popularization seminars of the Czech Association of Scientific and Technical Societies in 2001,
- Horký J.: NMR tomographs, Faculty Hospital, Olomouc, Oct. 22, 2002,
- Frank L.: Science and education in Brno, Czech Republic. Lecture for students of material engineering at the University of Toyama, Japan, Dec. 16, 2002,
- Frank L. and Müllerová I.: The Czech Republic and Brno, history, science, education. Lectures for students of material engineering at the University of Toyama, Japan, Jul. 3 and Jul. 8, 2003.

Press conferences:

- Press conference, Brno Town Hall, Sept. 4, 1999 (L. Frank),
- press conference, Brno Town Hall, Jun. 20, 2000 (L. Frank),
- Sympathetic Physics, participation in the press conference and presentation of a book, office of the BUT chancellor and Aula Q, FME BUT, Nov. 24, 2001 (Bohumila Lencová),
- press conference, Brno Town Hall, 2002 (Jan Chládek),
- press conference, Brno Town Hall, 2003 (Jan Chládek).

TV:

- 6-minute contribution to the TV programme Vědník (no. 9), Thu. Nov. 2, 9 and 10 1999 (Pavel Zemánek),
- TV programme about electron microscopy and EUREM 12: TV Prima, Regional News, Jul. 10, 2000, Thu. 1, South-Moravian Evening News, Jul. 11, 2000,
- 8-minute contribution about a detector of activity of the vagus nerve stimulator for the programme Vědník, Czech TV2 Sept. 4, 2002. (Pavel Jurák).

Radio:

- Programme about electron microscopy and EUREM 12: Czech Radio 1 Radiožurnál, Great and Small News Jul. 7, 2000, Czech Radio 1 Radiožurnál, Heuréka Jul. 15, 2000,
- post-congress summary of EUREM 12: Czech Radio 2, Meteor Nov. 4, 2000, interview with prof. Zahradník,
- Czech Radio, Meteor – 5 min. interview, Jun. 28, 2003 (Pavel Zemánek).

Visitor's Days at the ASCR:

- Visitor's days at ISI 1999 (151 visitors),
- visitor's days at ISI 2000 (184 visitors),
- visitor's days at ISI 2001 (254 visitors),
- visitor's days at ISI 2002 (368 visitors),
- visitor's days at ISI 2003 (546 visitors).

V

List of major implemented R&D results within the period of 1999–2003

A. Authorship of monographs and parts of monographs

[1] Autrata Rudolf, Jirák Josef: Environmentální rastrovací elektronová mikroskopie (in Czech). In: Metody analýzy povrchů. Iontové, sondové a speciální metody (2002). – (Frank, L. – Král, J.). – Praha, Academia. – p. 459–484

[2] Frank Luděk: Advances in scanning electron microscopy. In: Advances in imaging and electron physics Vol. 123 (2002). – New York, Elsevier science. – p. 327–373

[3] Gottvald Aleš: Exponential family and inverse problems. In: Optimization and Inverse Problems in Electromagnetism (2003). – (Rudnicki, M. – Wiak, S.). – Dordrecht, Kluwer Academic Publishers.

[4] Gottvald Aleš: Sec. 3.1 – Optimizing Axisymmetric Coils Systems for NMR. In: Electromagnetic Phenomena and Inverse Problems (1999). – Tokyo, Yokendo. – p. 58–73

[5] Gottvald Aleš: Sec. 5.2 – Meta–Evolutionary Optimization and Inverse Problems. In: Electromagnetic Phenomena and Inverse Problems (1999). – Tokyo, Yokendo. – p. 125–139

[6] Gottvald Aleš: Topological evolution and inverse problems. In: Optimization and Inverse Problems in Electromagnetism (2003). – (Rudnicki, M. – Wiak, S.). – Dordrecht, Kluwer Academic Publishers.

[7] Kára T, Souček M, Jurák P, Halámek J: Regulační mechanizmy krevního tlaku (in Czech). In: Klinická patofyziologie hypertenze (2002).– (Souček, M. – Kára, T.). – Praha, Grada Publishing. – p. 235–289

[8] Lencová Bohumila, Lenc M.: Optika iontových svazků (in Czech). In: Metody analýzy povrchů. Iontové, sondové a speciální metody (2002). – (Frank, L. – Král, J.). – Praha, Academia. – p. 67–103

[9] Matějka František, Matějková Jiřina, Vrba R., Beneš P.: Means of Pressure Analysis using Nitride Silicon Diaphragm. In: Advances in Systems Science: Measurement, Circuits and Control (2001). – Piraeus, WSES Press. – p. 70–73

[10] Müllerová Ilona: Mikroskopie pomalými elektrony (in Czech). In: Metody analýzy povrchů. Iontové, sondové a speciální metody (2002). – (Frank, L. – Král, J.). – Praha, Academia. – p. 383–448

[11] Müllerová Ilona, Frank Luděk: Scanning low energy electron microscopy. In: Advances in imaging and electron physics Vol. 128 (2003). – (Hawkes, P.). – New York, Elsevier Science. – p. 309–443

[12] Vondra Vlastimil: Parasympatický nervový systém (in Czech). In: Klinická patofyziologie hypertenze (2002). – (Souček, M. – Kára, T.). – Praha, Grada. – p. 65–68

B. Edition and translation of monographs and proceedings

[13] Frank Luděk: Microscopy 2002 (Proceedings of the 2nd annual meeting of the Czechoslovak microscopy society) – Brno, Czechoslovak Society for Electron Microscopy. – 108 pages

[14] Frank Luděk: Recent trends in charged particle optics and surgace physics instrumentation (Proceedings of the 8th international seminar) – Brno, Czechoslovak Society for Electron Microscopy. – 96 pages

[15] Frank Luděk, Čiampor F.: Proceedings of the 12th European Congress on Electron Microscopy (2000) – Volume 1 to 4. – Brno, Czechoslovak Society for Electron Microscopy. – 1998 pages

[16] Frank Luděk, Král J.: Metody analýzy povrchů. Iontové, sondové a speciální metody (in Czech). Praha, Academia 2002.

[17] Gottvald Aleš: Proceedings of the 4rd Japan–Central Europe Joint Workshop on Energy and Information in Non-linear Systems.

[18] Lencová Bohumila: Moderní fyzika (in Czech). In: Fyzika. – Brno, Vutium 2000.

[19] Lencová Bohumila: Fotony a de Broglieho vlny (39) (in Czech). In: Fyzika (2000). – Brno, Vutium. – p. 1034–1054 (translation)

C. Papers in reviewed international journals

[20] Souček M., Kára T., Kuba R., Jurák Pavel, Halámek Josef, Seménka J., Toman J.: Autoregulation of brain circulation in patients with vasodepressoric type of vasovagal syncope. Journal of Hypertension 18 [4-Suppl.] (2000)

[21] Autrata Rudolf, Jirák J., Schneider L.: Usage of Segmental Ionization Detector in Environmental Conditions. Microscopy and Microanalysis 9 [Sup. 3] – p. 142–143 (2003)

[22] Autrata Rudolf, Roubalíková L., Wandrol Petr, Jirák Josef: Study of Surface Tooth Treatment using Low–Vacuum Scanning Electron Microscopy. Microscopy and Microanalysis 9 [Sup. 3] – p. 428–429 (2003)

[23] Bareš M., Brázdil M., Kaňovský P., Jurák Pavel, Daniel P., Kukleta M., Rektor I.: The effect of apomorphine administration on smooth pursuit ocular movements in early Parkinsonian patients. Parkinsonism and Related Disorders 9 [3] – p. 139–144 (2003)

[24] Bartušek Karel, Dokoupil Zdeněk: Automatic Device for Ion Fields Measurement. Measurement Science Review 3 [3] – p. 75–78 (2003)

[25] Bartušek Karel, Dokoupil Zdeněk, Gescheidtová E.: Applications of digital signal processors in a gradient controller for MR tomography. www.electronicsletters.com (2002)

[26] Brázdil M., Rektor I., Daniel P., Dufek M., Jurák Pavel: Unconscious processing of visual stimuli (evidence from intracerebral ERP recordings). Clinical Neurophysiology 111 [1–Suppl.] – p. 152–153 (2000)

[27] Brázdil M., Rektor I., Daniel P., Dufek M., Jurák Pavel: Intracerebral Event–related Potentials to Subthreshold Target Stimuli. Clinical Neurophysiology 112 [4] – p. 650–661 (2001)

[28] Brázdil M., Rektor I., Dufek M., Daniel P., Jurák Pavel, Kuba R.: The role of frontal and temporal lobes in visual discrimination task – depth ERP studies. Neurophysiologie Clinique/Clinical Neurophysiology 29 [4] – p. 339–350 (1999)

[29] Brázdil M., Roman R., Falkenstein M., Daniel P., Jurák Pavel, Rektor I.: Error processing – evidence from intracerebral ERP recordings. Experimental Brain Research 146 [4] (2002)

[30] Brázdil M., Roman R., Rektor I., Jurák Pavel: Intracerebral Recordings of Visual Event–related Potentials on Reaction Errors. Clinical Neurophysiology 112 [1–Suppl.] – p. 41 (2001)

[31] Cubric D., Lencová Bohumila, Read F. H., Zlámal Jakub: Comparison of FDM, FEM and BEM for electrostatic charged particle optics. Nuclear Instruments and Methods in Physics Research 427 [1] – p. 357–362 (1999)

[32] Čech V., Horváth P., Trchová M., Zemek Josef, Matějková Jiřina: Analysis of annealed thin polymer films prepared from dichloro(methyl)phenylsilane by plasma polymerization. Journal of Applied Polymer Science 82 – p. 2106–2112 (2001)

[33] Čech V., Horváth P., Zemek J., Trchová M., Matějková Jiřina: The plasma–polymerized films of dichloro(methyl)phenylsilane. Czechoslovak Journal of Physics 50 [Supp. S3] – p. 356–364 (2000)

[34] Číp Ondřej, Petrů František: A scale–linearization method for precise laser interferometry. Measurement Science and Technology 11 – p. 133–141 (2000)

[35] Čižmár Petr, Müllerová Ilona: New Multichannel Electron Energy Analyzer with Cylindrically Symetrical Electrostatic Field. Microscopy and Microanalysis 9 [Sup. 3] – p. 18–19 (2003)

[36] Davies C. L., Francis D., Jurák Pavel, Kára T., Piepoli M., Coats A. J.: Reproducibility of methods for assessing baroreflex sensitivity in normal controls and in patients with chronic heart failure. Clinical Science 97 [4] – p. 515–522 (1999)

[37] Deineka Alexander, Tarasenko A. A., Jastrabík Lubomír, Chvostová Dagmar, Boušek Jaroslav: An ellipsometric study of W thin films deposited on Si. Thin Solid Films 339 – p. 216–219 (1999)

[38] Delyagin N. N., Erzinkyan A. L., Parfenova V. P., Reiman S. I., Gurevich G. M., Dupák Jan: Thermal destruction of antiferromagnetic Fe–Fe exchange bonds and mechanism of the transition to spin-glass state in (Fe0.65NI0.35)1-xMnx systems with antiferromagnetic competing exchange interactions. Journal of Experimental and Theoretical Physics [1] – p. 70–76 (1999)

[39] Delyagin N. N., Erzinkyan A. L., Parfenova V. P., Reiman S. I., Gurevich G. M., Dupák Jan: Teplovaia destrukcia antiferomagnitnych obmennych sviazei Fe-Fe i mechanizm perechoda v sostoianie spinovovo stekla v sisteme s konkuriruiuschimi obmennymi vzaimodeistviami (Fe0.65NI0.35)1-xMnx (in Russian). Zhurnal experimentalnoi i teoreticheskoi fiziki [1(7)] – p. 130–140 (1999)

[40] Dokoupil Zdeněk: Personal Computer Debug Port. Journal of Electrical Engineering 50 [3–4] – p. 102–105 (1999)

[41] Dupák Jan, Finger jr M., Janata A., Jolos R. V., Kracíková T. I., Slunečka M.: Atomic Nucleus as the Laboratory for Symmetry Tests. The SPIN Program. Czechoslovak Journal of Physics 51 [Supp. A] (2001)

[42] Dupák Jan, Finger M., Finger jr M., Janata A., Kracíková T. I., Lebedev N. A., Nováková D., Ota J., Rotter M., Slunečka M., Slunečková V., Virus M., Yushkevich Y. V.: Nuclear orientation of radioactive nuclei the spin program. Czechoslovak Journal of Physics 50 [Supp. S1] – p. 253–268 (2000)

[43] Dupák Jan, Ustohal V.: Soldering with ductile active solders. Materials and manufacturing processes 16 [6] – p. 855–861 (2001)

[44] Dupák Jan, Vlček Ivan, Zobač Martin: Electron Gun for Computer–controlled Welding of Small Components. Vacuum 62 [2–3] – p. 159–164 (2001)

[45] El–Gomati, M. M. T. C. R. Wells, I. Müllerová, L. Frank, and H. Jayakody: Why is it that differently doped regions in semiconductors are visible in low voltage SEM? IEEE Trans Electron Devices (2004) – in print

[46] Fráňa P., Kára T., Souček M., Halámek Josef, Řiháček I., Orban O., Toman J., Bartosikova L., Nečas J., Dzurova J.: Changes of heart rate variability and baroreflex sensitivity in patients soon after orthotopic heart transplantation. Journal of Hypertension 20 [4] – p. S293 (2002)

[47] Fráňa P., Souček M., Kára T., Sitar J., Groch L., Jurák Pavel, Řiháček I., Toman J., Bartosikova L., Dzurova J.: Can short isometric contraction influence coronary, systemic and pulmonary hemodynamics in patients with chronic heart failure? Journal of Hypertension 20 [4] – p. S17 (2002)

[48] Frank Luděk, Matsuda K., Hrnčiřík Petr, Müllerová Ilona: Low Energy Contrast of Metal Matrix Composite in SEM. Microscopy and Microanalysis 9 [Sup. 3] – p. 328–329 (2003)

[49] Frank Luděk, Müllerová Ilona: Strategies for low- and very-low-energy SEM. Journal of Electron Microscopy 48 [3] – p. 205–219 (1999)

[50] Frank Luděk, Müllerová Ilona, El Gomati M. M.: A novel in–lens detector for electrostatic scanning LEEM mini-column. Ultramicroscopy 81 [2] – p. 99–110 (2000)

[51] Frank Luděk, Müllerová Ilona, Faulian K., Bauer E.: The Scanning Low–Energy Electron Microscope: First Attainment of Diffraction Contrast in the Scanning Electron Microscope. Scanning 21 [1] – p. 1–13 (1999)

[52] Frank Luděk, Müllerová Ilona, Káňová Jitka: Imaging of Unstained and Uncoated Specimens in the Scanning Electron Microscope at Optimum Electron Energy. Scanning 23 [6] – p. 116 (2001)

[53] Frank Luděk, Steklý Richard, Zadražil Martin, El Gomati M. M., Müllerová Ilona: Electron Backscattering from Real and In–Situ Treated Surfaces. Mikrochimica Acta 132 [2–4] – p. 179–188 (2000)

[54] Frank Luděk, Zadražil Martin, Müllerová Ilona: Scanning Electron Microscopy of Nonconductive Specimens at Critical Energies in a Cathode Lens System. Scanning 23 [1] – p. 36–50 (2001)

[55] Franta D., Ohlídal I., Klapetek P., Pokorný Pavel: Characterization of the boundaries of thin films of TiO_2 by atomic force microscopy and optical methods. Surface and interface analysis 34 – p. 759–762 (2002)

[56] Franta D., Ohlídal I., Klapetek P., Pokorný Pavel, Ohlídal M.: Analysis of Inhomogeneous Thin Films of ZrO2 by the Combined Optical Method and Atomic Force Microscopy. Surface and interface analysis 23 [1] – p. 91–94 (2001)

[57] Gottvald Aleš: Bayesian Evolutionary Inversions in Computational Electromagnetics. IEEE Transactions on Magnetics 36 [4] – p. 1098–1101 (2000)

[58] Halámek Josef, Jurák Pavel, Kára T., Souček M.: Transfer Function and Biosignal Analysis. Measurement Science Review 1 [1] – p. 51–54 (2001)

[59] Halámek Josef, Kára T., Jurák Pavel, Souček M., Francis D., Davies L. C., Shen W. K., Coats A. J., Novák M., Nováková Z., Panovský R., Toman J., Šumbera J., Somers V. K.: Variability of Phase Shift Between Blood Pressure and Heart Rate Fluctuations – A Marker of Short–Term Circulation Control. Circulation 108 [3] – p. 292–297 (2003)

[60] Halámek Josef, Viščor Ivo, Kasal Miroslav: Dynamic Range and Acquisition System. Measurement Science Review 1 [1] – p. 71–74 (2001)

[61] Hanzelka Pavel: Current leads in vacuum space of cryogenic systems. Cryogenics 39 [11] – p. 955–961 (1999)

[62] Hanzelka Pavel, Dupák Jan, Musilová Věra: Small helium bath cryopump for electron optical devices. Cryogenics 42 – p. 39–44 (2002)

[63] Hanzelka Pavel, Horký Jaroslav: Problems of measurement of the helium boil off rate of tomographic magnets. Cryogenics 39 [7] – p. 647–649 (1999)

[64] Hawkes P. W., Lencová Bohumila: Studies on the asymptotic cardinal elements and aberration coefficients of symmetric unipotential electrostatic lenses. Optik 113 [2] – p. 78–82 (2002)

[65] Holík M., Halámek Josef: Calculation of the tilts of curved lines. Chemometrics and Intelligent Laboratory Systems 67 [1] – p. 59–67 (2003)

[66] Holík M., Halámek Josef: Transformation of a Free–Wilson matrix into Fourier coefficients. Quantitative structure activity relationship 20 – p. 422–428 (2002)

[67] Horáček Miroslav: Charge–coupled device area detector for low energy electrons. Review of Scientific Instruments 74 [7] – p. 3379–3384 (2003)

[68] Horáček Miroslav, Dupák Jan: Temperature Controlled Cathode Heating in Electron Beam Welding Machine. Vacuum 62 [2–3] – p. 165–169 (2001)

[69] Chládek Jan, Konzbul Pavel, Ošmera P., Gottvald Aleš: Evolutionary and Genetic Optimization of NMR Gradient and Shim Coils. IEEE Transactions on Magnetics 36 [4] – p. 1102–1105 (2000)

[70] Jákl Petr, Šerý Mojmír, Ježek Jan, Jonáš Alexandr, Liška M., Zemánek Pavel: Behaviour of an optically trapped probe approaching a dielectric interface. Journal of Modern Optics 50 [10] – p. 1615–1625 (2003)

[71] Jánský Pavel, Lencová Bohumila, Zlámal J.: Calculations of Intensive Electron Source for Electron Beam Welding. Microscopy and Microanalysis 9 [Sup. 3] – p. 22–23 (2003)

[72] Jelínek Miroslav, Kulisch W., Delplancke–Ogletree M. P., Vorlíček Vladimír, Studnička Václav, Chvostová Dagmar, Trchová M., Sobota Jaroslav: Applications–relevant characterization of magnetron–sputtered carbon nitride films. Diamond and Related Materials 8 – p. 1857–1862 (1999)

[73] Jensen H., Sorensen G., Mannike I., Muktepavela F., Sobota Jaroslav: Reactive sputtering of nanostructured multilayer coatings and their tribological properties. Surface and Coatings Technology 116–119 [1–3] – p. 1070–1075 (1999)

[74] Jonáš Alexandr, Zemánek Pavel, Florin E. L.: Single–beam Trapping in Front of Reflective Surfaces. Optics Letters 26 [19] – p. 1466–1468 (2001)

[75] Jurák Pavel, Halámek Josef, Kára T., Davies C. L., Francis D., Souček M., Toman J., Šumbera J.: Immediate baroreflex sensitivity – new approach to this parameter. Medical & Biological Engineering & Computing 37 [Supplement] – p. 496–497 (1999)

[76] Jurák Pavel, Kára T., Halámek Josef, Souček M., Francis D., Davies C. L., Toman J.: Breathing and Testing of Autonomic Nervous System. Journal of Hypertension 18 [1–Suppl.] (2000)

[77] Kára T, Souček M, Jurák P, Novák M, Halámek J, Frana P, Toman J; The Influence of Sympathetic Cholinergic System in Pathophysiology of Vasodepressoric Type of Vasovagal Syncope. Awarded Honorable Mention in Clinical Research. Pace – Pacing and Clinical Electrophysiology 23 [4 part II], S. 615 (2000)

[78] Kára T., Jurák Pavel, Halámek Josef, Souček M., Francis D., Davies C. L., Toman J., Samek Milan: Frequency and depth of breathing – important signals at autonomic nervous system analysis. Medical & Biological Engineering & Computing 37 [Supplement] – p. 1310–1311 (1999)

[79] Kára T., Jurák Pavel, Halámek Josef, Souček M., Šumbera J., Novák M., Toman J.: A Spirometre ANNA 1, Depth of Breathing and Autonomic Nervous System. Pacing and Clinical Electrophysiology 22 [6-Part II] (1999)

[80] Kára T., Jurák Pavel, Novák M., Souček M., Nováková Z., Halámek Josef, Šumbera J., Toman J., Štejfa M., Řiháček I.: Sudden Cardiac Death Risk Stratification Based on Phase Shift and XYt Graph Methods. Pacing and Clinical Electrophysiology 22 [6-Part II] (1999)

[81] Kára T., Jurák Pavel, Souček M., Davies C. L., Francis D., Toman J., Halámek Josef: Spirometric system anna 1, breathing and baroreflex sensitivity. Journal of Hypertension 18 [4-Suppl.] (2000)

[82] Kára T., Jurák Pavel, Souček M., Halámek Josef, Francis D., Davies C. L., Řiháček I., Toman J.: Low risk of sudden cardiac death at the low value of baroreflex sensitivity: Unexplained clinical paradox. Journal of Hypertension 18 [4-Suppl.] (2000)

[83] Kára T., Jurák Pavel, Souček M., Halámek Josef, Francis D., Davies C. L., Toman J., Novák M., Pinarová L., Řiháček I.: Stability of baroreflex feedback system: new parameter in testing of autonomic nervous system? European Heart Journal 21 [Supplement] – p. 550 (2000)

[84] Kára T., Jurák Pavel, Souček M., Halámek Josef, Novák M., Šumbera J., Toman J., Štejfa M., Nováková Z., Řiháček I.: Depth of Breathing and Baroreflex Sensitivity. American Journal of Hypertension 12 [4-P2] (1999)

[85] Kára T., Jurák Pavel, Souček M., Halámek Josef, Novák M., Šumbera J., Toman J., Štejfa M., Nováková Z., Řiháček I.: Evaluation of Autonomic Nervous System Dysfunction by Phase Shift and XYt Graph Methods. American Journal of Hypertension 12 [4-P2] (1999)

[86] Kára T., Jurák Pavel, Souček M., Novák M., Nováková Z., Halámek Josef, Šumbera J., Toman J., Štejfa M., Řiháček I.: Time delay stability of baroreflex feedback system and autonomic nervous system dysfunction. Journal of Hypertension 17 [3-Suppl.] (1999)

[87] Kára T., Jurák Pavel, Souček M., Novák M., Nováková Z., Halámek Josef, Šumbera J., Toman J., Štejfa M., Řiháček I.: Time delay stability of baroreflex feedback system and autonomic nervous system dysfunction. European Heart Journal 20 [Supplement] – p. 443 (1999)

[88] Kára T., Jurák Pavel, Souček M., Novák M., Nováková Z., Halámek Josef, Šumbera J., Toman J.: Assesment of baroreflex feedback system. Physiologist 43 [4] (2000)

[89] Kára T., Jurák Pavel, Souček M., Toman J., Halámek Josef, Špinarová I., Novák M., Šumbera J., Štejfa M., Nováková Z., Řiháček I.: The Influence of Atrial Mechanisms on Heart Rate of Patients with Essential Hypertension. American Journal of Hypertension 12 [4-P2] (1999)

[90] Kára T., Jurák Pavel, Vondra Vlastimil, Kuba R., Nykodým J., Brázdil M., Souček M., Cífková R., Halámek Josef, Winnicki M., Fráňa P., Somers V. K.: The effects of direct vagus nerve stimulation on heart rate and blood pressure in humans. Journal of Hypertension 20 [4] – p. S135 (2002)

[91] Kára T., Souček M., Jurák Pavel, Halámek Josef, Hofírek I., Řiháček I., Toman J.: The Influence of Sympathetic Cholinergic System on Blood Pressure Regulation. Journal of Hypertension 18 [1-Suppl.] (2000)

[92] Kára T., Souček M., Jurák Pavel, Novák M., Halámek Josef, Fráňa P., Toman J.: The Influence of Sympathetic Cholinergic System in Pathophysilogy of Vasodepressoric Type of Vasovagal Syncope. Pacing and Clinical Electrophysiology 23 [4-Part II] – p. 615 (2000)

[93] Klapetek P., Ohlídal I., Franta D., Pokorný Pavel: Analysis of the boundaries of ZrO2 and HfO2 thin films by atomic force microscopy and the combined optical method. Surface and interface analysis 34 – p. 559–564 (2002)

[94] Konvalina Ivo, Müllerová Ilona: Efficiency of Collection of the Secondary Electrons in SEM. Microscopy and Microanalysis 9 [Sup. 3] – p. 108–109 (2003)

[95] Konzbul Pavel, Švéda Karel, Fiala P.: Influence of eddy currents on checking gradient and shim magnetic field configurations for MRI. Journal of Electrical Engineering 50 [8/S] – p. 14–16 (1999)

[96] Konzbul Pavel, Švéda Karel, Srnka Aleš: Design of Matrix Shim Coils System for Nuclear magnetic resonance. IEEE Transactions on Magnetics 36 [4] – p. 1732–1735 (2000)

[97] Kracíková T. I., Dupák Jan, Finger M., Finger jr M., Janata A., Krmar M., Kumar K., Kavsil J., Lebedev N. A., Pavlov V. N., Slunečka M., Slunečková V., Šimečková Eva, Yushkevich Y. V.: Low–temperature nuclear orientation: possibilities, results, perspectives. Czechoslovak Journal of Physics 49 [Supp. S2] – p. 205–214 (1999)

[98] Kracíková T. I., Dupák Jan, Finger M., Finger jr M., Janata A., Kotovski N. Y., Krmar M., Kumar K., Lebedev N. A., Pavlov V. N., Slunečka M., Slunečková V., Šimečková Eva, Yushkevich Y. V.: Particularities in the properties of 166Er, 160Dy and 148Gd. Czechoslovak Journal of Physics 49 [Supp. S2] – p. 215–228 (1999)

[99] Kracíková T. I., Dupák Jan, Finger M., Janata A., Kumar K., Lebedev N. A., Pavlov V. N., Tlustý P., Shchus A. F., Slunečka M.: Nuclear orientation of the 60 min 148TbGd. Czechoslovak Journal of Physics 50 [Supp. S1] – p. 279–284 (2000)

[100] Lanfranchi P., Shamsuzzaman A. S., Ackerman M. J., Kára T., Jurák Pavel, Wolk R., Somers V. K.: Sex–selective QT prolongation during rapid eye movement sleep. Circulation 106 [12] – p. 1488–1492 (2002)

[101] Lazar Josef, Číp Ondřej, Jedlička Petr: Tunable extended–cavity diode laser stabilized on iodine at lambda=633nm. Applied Optics 39 [18] – p. 3085–3088 (2000)
[102] Lazar Josef, Číp Ondřej, Růžička Bohdan: The design of a compact and tunable extended–cavity semiconductor laser. Measurement Science and Technology 15 [1] – p. N6–N9 (2004) – in print
[103] Lazar Josef, Jedlička Petr, Číp Ondřej, Růžička Bohdan: Laser diode current controller with a high level of protection against electromagnetic interference. Review of Scientific Instruments 74 [8] – p. 3816–3819 (2003)
[104] Lencová Bohumila: Accuracy of electrostatic lens computations with FOFEM. Ultramicroscopy 93 [3/4] – p. 263–270 (2002)
[105] Lencová Bohumila: Accurate computation of magnetic lenses with FOFEM. Nuclear Instruments and Methods in Physics Research 427 [1] – p. 329–337 (1999)
[106] Lopour F., Kalousek R., Škoda D., Spousta J., Matějka František, Šikola T.: Application of AFM in microscopy and fabrication of micro/nanostructures. Surface and interface analysis 34 [1] – p. 352–355 (2002)
[107] Matoušek Vít, Číp Ondřej: Temperature stabilization of VCSEL laser diode. www.electronicsletters.com [3/6] (2003)
[108] Mika Filip, Ryšávka J., Lopour F., Zadražil M., Müllerová Ilona, Frank Luděk: Computer Controlled Low Energy SEM. Microscopy and Microanalysis 9 [Sup. 3] – p. 116–117 (2003)
[109] Mlynárik V., Gruber S., Stadlbauer A., Starčuk Zenon, Moser E.: Anatomically matched short–echo time spectroscopy of human brain at 3T. Magnetic resonance materials in physics, biology, and medicine 16 [Sup. 1] – p. S205 (2003)
[110] Mlynárik V., Gruber S., Starčuk Zenon, Starčuk jr Zenon, Moser E.: Short echo time MR spectroscopy of human brain at 3 Tesla using asymmetric pulses. Magnetic resonance materials in physics, biology, and medicine 8 [1–Suppl.] – p. 231–232 (1999)
[111] Mlynárik V., Gruber S., Starčuk Zenon, Starčuk jr Zenon, Moser E.: Very Short Echo Time Proton MR Spectroscopy of Human Brain With a Standard Transmit/Receive Surface Coil. Magnetic Resonance in Medicine 44 [6] – p. 964–967 (2000)
[112] Moravčík Z., Janisch R., Ježek Jan, Zemánek Pavel: Response of infusorian cells to injury caused by a laser microbeam. Scripta Medica 76 [3] – p. 149–161 (2003)
[113] Müllerová Ilona: Imaging of specimens at optimized low and very low energies in scanning electron microscopy. Scanning Microscopy 13 [1] – p. 7–22 (1999)
[114] Müllerová Ilona: Imaging of Specimens at Optimized Low and Very Low Energies in Scanning Electron Microscopes. Scanning 23 [6] – p. 379–394 (2001)
[115] Müllerová Ilona, El–Gomati M., Frank Luděk: Imaging of the boron doping in silicon using low energy SEM. Ultramicroscopy 93 [3/4] – p. 223–243 (2002)
[116] Müllerová Ilona, Frank Luděk: Contrast Mechanisms in the Scanning Low Energy Electron Microscopy. Microscopy and Microanalysis 9 [Sup. 3] – p. 120–121 (2003)
[117] Müllerová Ilona, Frank Luděk: Multidimensionality of the Scanned Imaging with Very low Energy Electrons. G.I.T. Imaging and Microscopy 2 [2] – p. 20–23 (2000)
[118] Müllerová Ilona, Frank Luděk, Hutař Otakar: Visualization of the Energy Band Contrast in SEM Scanning Electron Microscopy Through Low–energy Electron Reflectance. Scanning 23 [6] – p. 115 (2001)
[119] Müllerová, Frank: Contrast at very low energies of the gold/carbon specimen for resolution testing, Scanning 26 (2004) no. 1 (in print)
[120] Oral Martin, Lencová Bohumila: Calculation of Aberration Coefficients by Ray Tracing. Microscopy and Microanalysis 9 [Sup. 3] – p. 26–27 (2003)
[121] Petrů František, Číp Ondřej: Problems regarding linearity of data of a laser interferometer with a single–frequency laser. Precision Engineering 23 [1] – p. 39–50 (1999)
[122] Protopopov V. V., Sobota Jaroslav: X–ray dark–field refraction–contrast imaging of micro–objects. Optics communications 213 [4/6] – p. 267–279 (2002)
[123] Roman R., Brázdil M., Jurák Pavel, Dufek M., Kukleta M.: EEG and Motor Reponses to Target Stimuli in an Oddball Paradigm: SEEG Recordings in Epileptic Patients. Homeostasis 40 [3–4] – p. 96–98 (2000)
[124] Roman R., Brázdil M., Jurák Pavel, Kukletal M., Rektor I.: Is the potential evoked by visual stimulus dependent on verbal instruction, which determined the stimulus significance? Homeostasis 41 [5] – p. 224–226 (2001)
[125] Romanovský Vladimír, Autrata Rudolf: Scintillation and Ionisation Detectors for Environmental SEM. European Microscopy and Analysis [59] – p. 19 (1999)
[126] Rotter M., Trhlík M., Hubalovský S., Srnka Aleš, Dupák Jan, Ota J., Pari P.: Nuclear orientation facility at Charles University in Prague. Czechoslovak Journal of Physics 50 [Supp. S1] – p. 381–384 (2000)
[127] Sadovský P., Bartušek Karel: Optimisation of the Transient Response of a Digital Filter. Radioengineering 9 [2] – p. 14–17 (2000)
[128] Schauer Petr, Nešpůrek Stanislav, Schauer F., Autrata Rudolf: Optimization of Poly–(Methylphenylsilylene) Specimen for Cathodoluminiscence Measurement.Microscopy and Microanalysis 9 [Sup. 3] – p. 156–157 (2003)

[129] Sobota Jaroslav, Bochníček Z., Holý V.: Friction and wear properties of C–N/MeNx nanolayer composites. Thin Solid Films 433 [1–2] – p. 155–159 (2003)
[130] Sobota Jaroslav, Sorensen G., Jensen H., Bochnicek Z.: C–N/Men Nanocomposite Coatings, Deposition and Testing of Performance. Surface and Coatings Technology 142–144 – p. 590–595 (2001)
[131] Sobota Jaroslav, Sorensen G., Jensen H., Kubina J., Holý V.: Temperature stability of C-N/NbN nanocomposite multilayers. Diamond and Related Materials 9 [3–6] – p. 587–591 (2000)
[132] Sochůrková D., Brázdil M., Jurák Pavel, Rektor I.: Intracerebral Recordings of ER–ERS and P3 in Visual Oddball Paradigm. Clinical Neurophysiology 112 [1-Suppl.] – p. 51 (2001)
[133] Souček M., Kára T., Jurák Pavel, Halámek Josef, Řiháček I., Toman J.: “Normotension” in patients with Reaven's syndrome: What is the fundamental cause? Journal of Hypertension 18 [4-Suppl.] (2000)
[134] Souček M., Kára T., Jurák Pavel, Halámek Josef, Špinarová L., Meluzín J., Toman J., Řiháček I., Šumbera J., Fráňa P.: Heart Rate and Increased Intravascular Volume. Physiological Research 52 – p. 137–140 (2003)
[135] Souček M., Kára T., Jurák Pavel, Halámek Josef, Špinarová L., Meluzín J., Toman J., Řiháček I., Šumbera J., Fráňa P.: Heart Rate and Increased Intravascular Volume. Physiological Research 52 – p. 137–140 (2003)
[136] Souček M., Kára T., Jurák Pavel, Toman J., Halámek Josef, Špinarová L., Šumbera J., Štejfa M., Řiháček I., Meluzín J.: The influence of atrial mechanisms on heart rate in patients with essential hypertension. Journal of Hypertension 17 [3-Suppl.] (1999)
[137] Souček M., Kára T., Novák M., Jurák Pavel, Halámek Josef, Nováková Z., Šumbera J., Homolka P., Toman J., Štejfa M., Řiháček I.: Changes in autonomic regulation of blood pressure in patients with vasodepresoric type of vasovagal syncope. Journal of Hypertension 17 [3-Suppl.] (1999)
[138] Starčuk jr Zenon, Starčuk Zenon, Mlynárik V., Gruber S., Horký Jaroslav: Low power “adiabatic” T1 and B1 insensitive water suppression for in vivo localised 1H MR spectroscopy. Magnetic resonance materials in physics, biology, and medicine 11 [1-Suppl.] –
[139] Starčuk jr Zenon, Starčuk Zenon, Mlynárik V., Roden M., Horký Jaroslav, Moser E.: Low–Power Water Suppression by Hyperbolic Secant Pulses with Controlled Offsets and Delays (WASHCODE). Journal of magnetic resonance 152 [1] – p. 168–178 (2001)
[140] Starčuk jr. Zenon, Krupa P., Horký Jaroslav, Starčuk Zenon: Short TE in vivo proton MRS of the brain: the problem of separating the signals of metabolites, macromolecules, and lipids. Magnetic resonance materials in physics, biology, and medicine 15 [1] – p. 155 (2002)
[141] Starčuk jr. Zenon, Starčuková Jana, Horký Jaroslav, Starčuk Zenon: Water suppression for short–TE MRSI in 1,5 T using trains of hyperbolic secant RF pulses. Magnetic resonance materials in physics, biology, and medicine 16 [Sup. 1] – p. S39–S40 (2003)
[142] Starčuk Zenon, Starčuk jr Zenon, Mlynárik V., Gruber S., Horký Jaroslav: Macromolecule or metabolite nulled very short TE 1H MR spedtra of the human brain at 3T. Magnetic resonance materials in physics, biology, and medicine 11 [1-Suppl.] – p. 179–180 (2000)
[143] Stone J., Ohya S., Rikovska J., Woehr A., Betts P., Dupák Jan, Fogelberg B., Jacobsson L.: Attenuation of nuclear orientation of 127In in GD and the InGD Korringa spin–lattice relaxation time constant. Hyperfine Interactions [133] – p. 111–115 (2001)
[144] Stone J., Stejskal Alois, Howard L. P.: Absolute Interferometry with a 670 nm External Cavity Diode Laser. Applied Optics 38 [28] – p. 5981–5994 (1999)
[145] Svoboda R., Bartušek Karel: Digital filtration in NMR measurement of gradient magnetic field. Magnetic resonance materials in physics, biology, and medicine 11 [1-Suppl.] – p. 39–40 (2000)
[146] Tkáč I., Starčuk Zenon, Choi I. Y., Gruetter R.: In Vivo 1H NMR Spectroscopy of Rat Brain at 1ms Echo Time. Magnetic Resonance in Medicine 41 [4] – p. 649–656 (1999)
[147] Yamamoto K., Tanji T., Hibino M., Schauer Petr, Autrata Rudolf: Improvement of Light Collection Efficiency of Lens-Coupled YAG Screen TV System for a High–Voltage Electron Microscope. Microscopy Research and Technique 49 [6] – p. 596–604 (2000)
[148] Zarka A., Abou-Zeid A., Chagniot D., Chartier J. M., Číp Ondřej, Cliche J. F., Edwards C. S., Imkenberg F., Jedlička Petr, Kabel B., Lassila A., Lazar Josef, Merimaa M., Millerioux Y., Simonsen H., Tetu M., Wallerand J. P.: Instrumentation comparison of eight semiconductor lasers stabilized on 127I2 at lambda=633 nm. Metrologia 37 [4] – p. 329–339 (2000)
[149] Zemánek Pavel, Jonáš Alexandr, Jákl Petr, Ježek Jan, Šerý Mojmír, Liška M.: Theoretical comparison of optical traps created by standing wave and single beam. Optics communications 220 [4–6] – p. 401–412 (2003)
[150] Zemánek Pavel, Jonáš Alexandr, Liška M.: Simplified description of optical forces acting on a nanoparticle in the Gaussian standing wave. Journal of the optical society of America. A – Optics and image science and vision 19 [5] – p. 1025–1034 (2002)
[151] Zemánek Pavel, Jonáš Alexandr, Šrámek Libor, Liška M.: Optical trapping of nanoparticles and microparticles by a Gaussian standing wave. Optics Letters 24 [21] – p. 1448–1450 (1999)
[152] Zobačová Jitka, Frank Luděk: Specimen Charging and Detection ofSignal from Non–conductors in a Cathode Lens–Equipped Scanning Electron Microscope. Scanning 25 [3] – p. 150–156 (2003)

D. Papers in national journals

[153] Bartušek Karel: Měření spektrálních charakteristik iontových polí (in Czech). Elektrorevue [38] (2001)

[154] Bartušek Karel: Stanovení vlastností gradientních magnetických polí měřením okamžitého kmitočtu NMR signálu (in Czech). Elektrorevue [16] (2000)

[155] Bartušek Karel: Wavelet and adaptive filtration of the nuclear magnetic resonance signal. Folia Facultatis Scientiarum Naturalium Universitatis Masarykianae Brunensis, Mathematica 11 – p. 13–18 (2002)

[156] Bartušek Karel, Gescheidtová E.: Měření indukce magnetického pole metodou okamžitého kmitočtu spinového echa (in Czech). Elektrorevue (2002)

[157] Bartušek Karel, Gescheidtová E.: Měření vlastností gradientních magnetických polí v tomografii magnetické resonance metodou okamžitého kmitočtu (in Czech). Elektrorevue (2002)

[158] Bartušek Karel, Gescheidtová E.: Instantaneous frequency of spin echo method for gradient megnetic fields measurement in MR systems. Journal of Electrical Engineering – Elektrotechnický časopis 53 [10/s] – p. 49–52 (2002)

[159] Dupák Jan, Hanzelka Pavel, Michalička Petr, Tuček L., Ustohal V.: Nová konstrukce rotoru heliové expanzní turbiny (in Czech). Jemná mechanika a optika [9] – p. 275–276 (2002)

[160] Dupák Jan, Klíčník Martin, Ustohal V.: Pájení tvárnými aktivními pájkami (in Czech). Zváranie–Svařování 48 [6] – p. 130–132 (1999)

[161] Dupák Jan, Vlček Ivan: Elektronové dělo pro svařování v přístrojové technice. Jemná mechanika a optika 44 [7–8] – p. 239–241 (1999)

[162] Hanzelka Pavel, Dupák Jan: Studie heliové kryovývěvy pro elektronově optické přístroje (in Czech). Jemná mechanika a optika 44 [4] – p. 108–110 (1999)

[163] Hutař Otakar, Oral Martin, Müllerová Ilona, Romanovský Vladimír: Application of low–energy backscattered electron detection in the inspection of semiconductor devices technology. Jemná mechanika a optika 45 [10] – p. 271–272 (2000)

[164] Jonáš Alexandr, Šrámek Libor, Zemánek Pavel, Liška M.: Elektromagnetické záření jako nástroj pro manipulaci s mikroskopickými objekty (in Czech). Jemná mechanika a optika 44 [11–12] – p. 344–347 (1999)

[165] Jura P., Hanzelka Pavel: Stabilizátor tlaku helia s fuzzy regulátorem (in Czech). Jemná mechanika a optika [11/12] – p. 361–363 (2002)

[166] Konečný Pavel, Vlček Ivan: Dělení wolframového monokrystalického drátku při výrobě hrotových katod (in Czech). Jemná mechanika a optika 46 [6] – p. 195–197 (2001)

[167] Matějka František: Příprava víceúrovňových difraktivních optických elementů elektronovou litografií (in Czech). Jemná mechanika a optika 48 [5] – p. 138–141 (2003)

[168] Matějka František, Matějková Jiřina, Lopour F.: Možnosti testování metriky přístrojů STM a AFM (in Czech). Československý časopis pro fyziku 5 [1] – p. 38–42 (2001)

[169] Matoušek Vít, Číp Ondřej: Stabilizace teploty laserové diody typu VCSEL (in Czech). Elektrorevue [34] (2003)

[170] Mikel Břetislav, Růžička Bohdan, Číp Ondřej, Lazar Josef, Jedlička Petr: Stabilní polovodičové lasery v metrologii délek (in Czech). Jemná mechanika a optika [11/12] – p. 341–344 (2002)

[171] Musilová Věra, Hanzelka Pavel, Jelínek Josef: Dosahování nízkých teplot odčerpáváním par. Héliový kryostat 1,5K (in Czech). Jemná mechanika a optika 44 [4] – p. 111–115 (1999)

[172] Petrů František, Veselá Zdenka: Principles and Some Properties of Laser Interferometers With Plane Reflective Systems. Jemná mechanika a optika 44 [11–12] – p. 359–364 (1999)

[173] Petrů František, Zemánek Pavel, Lazar Josef, Číp Ondřej: Iodine–stabilized He–Ne lasers at 633 nm for testing the vacuum wavelength of laser interferometers. Jemná mechanika a optika 48 [1] – p. 10–16 (2003)

[174] Romanovský Vladimír, Autrata Rudolf: Combined scintillation and ionisation detectors for environmental scanning electron microscopes. Jemná mechanika a optika 45 [10] – p. 273–274 (2000)

[175] Romanovský Vladimír, Hutař Otakar: Imaging of semiconductor structures in environmental SEM. Jemná mechanika a optika 45 [10] – p. 274–275 (2000)

[176] Schauer Petr, Autrata Rudolf: Performance of detector elements for electron microscopes. Jemná mechanika a optika 45 [10] – p. 268–270 (2000)

[177] Schauer Petr, Nešpůrek Stanislav, Schauer F., Autrata Rudolf: Cathodoluminescence study of silicon polymers. Jemná mechanika a optika 48 [5] – p. 156–157 (2003)

[178] Šerý Mojmír, Jákl Petr, Ježek Jan, Liška M., Zemánek Pavel: Využití více opticky zachycených sond pro měření profilů nepřístupných průhledných povrchů (in Czech). Jemná mechanika a optika 48 [6] – p. 170–173 (2003)

[179] Škoda D., Lopour F., Kalousek R., Burian D., Spousta J., Šikola T., Matějka František: Aplikace AFM v oblasti přípravy a studia nanostruktur (in Czech). Československý časopis pro fyziku 53 [2] – p. 105–108 (2003)

[180] Vlček Ivan, Lencová Bohumila: Rastrovací elektronový mikroskop s velmi nízkou energií elektronů (in Czech). Jemná mechanika a optika 45 [10] – p. 276–280 (2000)

E. Contributions to proceedings of prominent international conferences

[181] Autrata Rudolf: Detection of low energy backscattered electrons for the study of material contrast in SEM. In: Proceedings of 3rd Japanese.Polish Joint Seminar on Material Analysis (2000). – Krakow, Institute of Metallurgy and Material Sciences Polish Academy of Sciences. – p. 17–18

[182] Autrata Rudolf, Horký D., Ilkovics L., Procházka V., Skřička T.: Studies of biological specimens by environmental scanning electron microscopy. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. I231–I232

[183] Autrata Rudolf, Jirák Josef: Scanning electron microscopy at low vacuum in specimen chamber. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. I211–I212

[184] Autrata Rudolf, Jirák Josef, Špinka Jiří: Detection of SEs and BSEs at Higher Pressure. In: Proceedings of the 4th Multinational Congress on Electron Microscopy (1999). – Veszprém, University of Veszprém. – p. 285–286

[185] Autrata Rudolf, Jirák Josef, Špinka Jiří: Effect of the electron beam accelerating voltage and of specimen coating on the image in the microscope operating at higher pressures. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. I245–I246

[186] Autrata Rudolf, Jirák Josef, Špinka Jiří, Romanovský Vladimír: Environmental scanning electron microscopy for the study of wet specimens. In: Proceedings of the 4th Multinational Congress on Electron Microscopy (1999). – Veszprém, University of Veszprém. – p. 105–111

[187] Autrata Rudolf, Jirák Josef, Wandrol Petr, Špinka Jiří: Detection of backscattered electrons in environmental scanning electron microscope. In: Proceedings of the 6th Multinational Congress on Microscopy – European Extension (2003). – (Milat, O. – Ježek, D.). – Zagreb, Croatian Society for Electron Microscopy. – p. 489–490

[188] Autrata Rudolf, Matějková Jiřina: Backscattered electron imaging using the improved YAG scintilation detector. In: Proceedings of the 6th Multinational Congress on Microscopy – European Extension (2003). – (Milat, O. – Ježek, D.). – Zagreb, Croatian Society for Electron Microscopy. – p. 450–451

[189] Autrata Rudolf, Neděla Vilém, Horký D.: Influence of water environment on biological specimens imaging in ESEM. In: Proceedings of the 6th Multinational Congress on Microscopy – European Extension (2003). – (Milat, O. – Ježek, D.). – Zagreb, Croatian Society for Electron Microscopy. – p. 497–498

[190] Autrata Rudolf, Neděla Vilém, Horký D., Schauer Petr: Comparison of imaging with SE ionization and BSE scintillation detector in ESEM. In: Proceedings of the 6th Multinational Congress on Microscopy – European Extension (2003). – (Milat, O. – Ježek, D.). – Zagreb, Croatian Society for Electron Microscopy. – p. 487–488

[191] Autrata Rudolf, Schauer Petr: New fast and efficient YAP scintillator for the detection in SEM. In: Proceedings of 15th international congress on electron microscopy (2002). – (Engelbrecht, J. – Sewell, T. – Witcomb, M. – Cross, R. – Richards, P.). – Durban, Microscopy society of Southern Africa. – p. 347–348

[192] Autrata Rudolf, Schauer Petr, Jirák Josef: Detection of Backscattered Electrons for Biological Specimens Study. In: Proceedings of 5th Multinational Congress on Electron Microscopy (2001). – Lecce, Rinton Press. – p. 519–520

[193] Bartušek Karel, Buřival Z., Hanáková D.: Methodology of Measurement of Air Ions in Moist Environment for Speleotherapy. In: Proceedings of the 2nd International Conference on Measurement – Measurement '99 (1999). – Bratislava, Institute of Measurement Science, Slovak Academy of Sciences. – p. 262–265

[194] Bartušek Karel, Dokoupil Zdeněk: Automatic Device for Ion Fields Measurement. In: Proceedings of the 4th International Conference on Measurement (2003). – Smolenice, Institute of Measurement Science SAS. – p. 427–430

[195] Bartušek Karel, Gescheidtová E.: Adaptive digital filter for gradient magnetic fields measurement in MR tomography. In: Proceedings – APCCAS 2002 (2003). – Denpasar, IEEE. – p. 79–82

[196] Bartušek Karel, Gescheidtová E.: Adaptive digital filter for gradient magnetic fields measurement in MR tomography. In: Proceedings of Asia–pacific conference on circuits and systems (2001). – Piscataway, IEEE. – p. 79–82

[197] Bartušek Karel, Gescheidtová E.: Spin echo series MR technique for gradient measurement. In: Proceedings of the 4th International Conference on Measurement (2003). – Smolenice, Institute of Measurement Science SAS. – p. 371–374

[198] Bartušek Karel, Geschneidtová E.: Magnetic resonance technique of gradient magnetic field measurement. In: 25th Annual (Silver Anniversary) International Conference on Engineering in Medicine and Biology Society: A New Beginning for Human Health (2003). – Cancun, IEEE. – p. 3282–3285

[199] Bartušek Karel, Geschneidtová E.: MR Measurement Technique of the Rapidly Switched Gradient Magnetic Fields in MR Tomograph. In: 3rd International Conference on International Conference Advanced Engineering Design – AED 2003 (2003). – Praha, Czech Technical University in Prague. – p. P34

[200] Bartušek Karel, Svoboda R.: Filtration of the signal with time–variable instantaneous frequency in the gradient magnetic field measurement. In: 2nd Krakow–Winnipeg Workshop on Biomedical Application of MRI and MRS (2000). – Krakow, Komitet Badaň Naukovych. – p. P06

[201] Bělohrad D., Švéda Karel, Kasal Miroslav: Optimalized magnetic field homogeneity for MR coils. In: RADIOELEKTRONIKA 2002 – Conference proceedings (2002). – Bratislava, FEI SUT.

[202] Bělohrad David, Húsek Vladimír, Kasal Miroslav: RF power switch for MRI. In: Conference Proceedings of the 10th International Scientific Conference Radioelektronika 2000 (2000). – Bratislava, Department of Radio and Electronics, FEI SUT. – p. II.101–II.104

[203] Bělohrad David, Kasal Miroslav: Saddle coil for MRI. In: Conference Proceedings of the 10th International Scientific Conference Radioelektronika 2000 (2000). – Bratislava, Department of Radio and Electronics, FEI SUT. – p. IV.46–IV.49

[204] Bělohrad David, Kasal Miroslav: Saddle Coil Magnetic Field Calculations. In: 11th International Czech – Slovak Scientific Conference Radioelektronika 2001 Conference Proceedings (2001). – Brno, Brno University of Technology. – p. 262–265

[205] Beneš P., Matějka František, Vrba R., Kolařík V.: Optoelectronic pressure sensor with Si_3N_4 diaphragm. In: 16th international conference on production research (2001). – (Hanus, D. – Talácko, J.). – Praha, ČSVTS.

[206] Beneš P., Matějka František, Vrba R., Kolařík V.: Pressure sensor with SI3N4 diaphragm and optoelectronic sensing. In: TEMI 2001 – 11th IMEKO TC-4 Symposium on Trends in Electrical Measurement and Instrumentation (2001). – (Serra, A. C. – Girao, P. S.). – Lisabon, Instituto de Telecomunicacoes. – p. 327–329

[207] Buršíková V., Sobota Jaroslav, Buršík J.: Study of Mechanical Properties of Nanostructured Multilayer NbN/C–N Coatings by Reactive Sputtering. In: Proceedings of SAPP XIV (Post Deadline Papers – Supplement of Proceedings) (2003). – (Šutta, P. – Müllerová, J. – Brunner, R.). – Liptovský Mikuláš, Military Academy. – p. 199–200

[208] Číp Ondřej, Lazar Josef, Petrů František: Frequency method of sub–nanometer distance measurement using the optical resonator and tunable semiconductor laser. In: Proceedings of the general assembly of the international union of radio science (2002). – Maastricht, –.

[209] Číp Ondřej, Petrů František: Determination of Scale Nonlinearity in a Laser Interferometer. In: Proceedings of the 12th Czech–Slovak–Polish Optical Conference on Wave and Quantum Aspects of Contemporary Optics (Proc. SPIE 4356) (2001). – Washington, SPIE – The International Society for Optical Engineering. – p. 139–146

[210] Číp Ondřej, Petrů František: Set of experimental methods for scale–linearity verification in laser interferometers with nanometer resolution. In: Proceedings of SPIE – The International society for optical engineering. Seventh international symposium on laser metrology applied to science, industry, and everyday life (2002). – Novosibirsk, SPIE. – p. 290–297

[211] Číp Ondřej, Petrů František: The compensation method for the scale linearization of the high precision laser interferometer. In: Proceedings of the Wave and Quantum Aspects of Contemporary Optics (Proc. SPIE 3820) – 11th Slovak-Czech-Polish Optical Conference (1999). – Washington, SPIE – The International Society for Optical Engineering. – p. 144–153

[212] Číp Ondřej, Václavík V., Jurák Pavel: New concept of plethysmography instrumentation by means of bioelectrical impedance technology. In: Proceedings of 2nd European medical and biological engineering conference (2002). – (Hutten, H. – Krösl, P.). – Vídeň, Verlag der Technischen Universität Graz. – p. 90–91

[213] Drnovský Radek, Jirák Josef: Conditions of study of electrode masses structures in environmental scanning electron microscope. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. I235–I236

[214] Drnovský Radek, Michálek Martin: Conditions of observation of electrode masses in environmental scanning electron microscope. In: Proceedings EMAS 2000 – 4th Regional Workshop on Electron Probe Microanalysis Today – Practical Aspects (2000). – Prague, Czech Technical University in Prague, Faculty of Mechanical Engineering. – p. 200

[215] Dupák Jan, Hanzelka Pavel, Michalička Petr, Tuček L., Ustohal V.: A new construction of rotor of helium expansion turbine. In: Proceedings of 7th Cryogenics IIR international conference (2002). – Praha, ICARIS. – p. 29–32

[216] Dupák J., Michalička Petr, Ustohal V., Kuchyňka R.: Electron beam welding of stainless steel with tungsten, tantalum and molybdenum. In: Proceedings of the 7th International Conference on Electron Beam Technologies (EBT 2003) (2003). – Varna, Institute of Electronics BAS. – p. 198–201

[217] Dupák Jan, Finger M., Finger jr M., Janata A., Kracíková T. I., Krmar M., Kumar K., Kvasil J., Lebedev N. A., Pavlov V. N., Slunečka M., Yushkevich Y. V.: Low Temperature Nuclear Orientation. Some results. In: Proceedings of the Conference on Nuclear Structure – Bologna 2000 (2001). – New Jersey, World Scientific Publishing. – p. 478–481

[218] Dupák Jan, Finger M., Finger jr M., Janata A., Kracíková T. I., Krmar M., Kumar K., Kvasil J., Slunečka M.: Low–Temperature Nuclear Orientation: Possibilities, Results, Perspectives. In: Application of Lasers in Atomic Nuclei Research (2000). – Dubna, Joint Institute for Nuclear Research. – p. 193–212

[219] Dupák Jan, Finger M., Finger jr M., Janata A., Kracíková T. I., Krmar M., Kumar K., Lebedev N. A., Pavlov V. N., Slunečka M., Slunečková V., Yushkevich Y. V.: Particularities in the Properties of 166 Er and 160 Dy. In: Proceedings of the Conference on Nuclear Structure – Bologna 2000 (2001). – New Jersey, World Scientific Publishing. – p. 253–256

[220] Dupák Jan, Finger M., Finger jr M., Janata A., Kracíková T. I., Lebedev N. A., Nováková D., Ota J., Rotter M., Slunečka M., Slunečková V., Srnka Aleš, Virius M., Yushkevich Y. V.: Nuclear Orientation of Radioactive Nuclei – The SPIN project. In: Proceedings of the Conference on Nuclear Structure – Bologna 2000 (2001). – New Jersey, World Scientific Publishing.

[221] Dupák Jan, Hanzelka Pavel: Cryostat for optical measurements in temperature range 80–300 K. In: Proceedings of the 6th Cryogenics 2000 IIR International Conference – Refrigeration Science and Technology (2000). – Praha, Czech Committee for co–operation with IIR. – p. 80–83
[222] Dupák Jan, Hanzelka Pavel, Musilová Věra: Helium cryopump for electron optical devices design and preliminary cryogenic testing. In: Proceedings of the 6th Cryogenics 2000 IIR International Conference – Refrigeration Science and Technology (2000). – Praha, Czech Committee for co–operation with IIR. – p. 73–76
[223] Dupák Jan, Hanzelka Pavel, Musilová Věra: Simulation of chevron baffle system for small helium bath cryopump. In: Proceedings of the 6th Cryogenics 2000 IIR International Conference – Refrigeration Science and Technology (2000). – Praha, Czech Committee for co–operation with IIR. – p. 77–79
[224] Dupák Jan, Rotter M., Srnka Aleš: Small Superconducting Magnet for Low Temperature Nuclear Orientation. In: Proceedings of the 4rd Japan-Central Europe Joint Workshop on Energy and Information in Non–linear Systems (2000). – Brno, ISI. – p. 66
[225] El–Gomati M. M., Wells T. C. R., Frank Luděk, Müllerová Ilona: On the imaging of semiconductor doping using low energy electron microscopy. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. P635–P636
[226] El–Gomati M., Romanovský V., Frank Luděk, Müllerová I.: A very low energy scanning electron column for surface studies. In: Proceedings of 15th international congress on electron microscopy (2002). – (Engelbrecht, J. – Sewell, T. – Witcomb, M. – Cross, R. – Richards, P.). – Durban, Microscopy society of Southern Africa. – p. 323–324
[227] El–Gomati M., Romanovský V., Frank Luděk, Müllerová Ilona: A very low energy electron column for surface studies. In: Proceedings of the Institute of Physics electron microscopy and analysis group conference (2001). – (Aindow, M. – Kiely, C. J.). – Bristol, Institute of Physics Publishing. – p. 111–114
[228] Frank Luděk, Müllerová Ilona: Advances in SEM Instrumentation. In: Proceedings of 5th Multinational Congress on Electron Microscopy (2001). – Lecce, Rinton Press. – p. 503–514
[229] Frank Luděk, Müllerová Ilona, El-Gomati M.: SEM visualization of doping in semiconductors. In: Proceedings of 15th international congress on electron microscopy (2002). – (Engelbrecht, J. – Sewell, T. – Witcomb, M. – Cross, R. – Richards, P.). – Durban, Microscopy society of Southern Africa. – p. 39–40
[230] Frank Luděk, Müllerová Ilona, El-Gomati M., Jayakody H.: SEM acquired electronic contrast of doped areas in semiconductors and its interpretation. In: Proceedings of seminar on nanotechnology for fabrication of hybrid materials (2002). – Toyama, JPJSMA. – p. 9–12
[231] Frank Luděk, Steklý Richard, Zadražil Martin, El Gomati M. M., Müllerová Ilona: To the information depth of the backscattered electron signal. In: Proceedings of the 4th Multinational Congress on Electron Microscopy (1999). – Veszprém, University of Veszprém. – p. 315–316
[232] Gottvald Aleš: Aharonov–Bohm Effect and Vector Potential: How Weird for Bayesians? In: Studies in Applied Electromagnetics and Mechanics – Vol. 18 (2000). – Amsterdam, IOS Press. – p. 447–450
[233] Gottvald Aleš: Bayesian Entropic Evolution. In: Mendel 2000 – 6th International Conference on Soft Computing (2000). – Brno, Brno University of Technology, Faculty of Mechanical Engineering. – p. 58–65
[234] Gottvald Aleš: Bayesian Evolutionary Inversions in Biomedical NMR-Spectroscopy. In: Studies in Applied Electromagnetics and Mechanics – Vol. 18 (2000). – Amsterdam, IOS Press. – p. 435–438
[235] Gottvald Aleš: Bayesian Evolutionary Inversions in Computational Electromagnetics. In: Proceedings of the 12th Conference on the Computation of Electromagnetic Fields – COMPUMAG (1999). – Sapporo, Hokkaido University. – p. 302–303
[236] Gottvald Aleš: Bayesian Evolutionary Optimization. In: Mendel '99 – 5th International Conference on Soft Computing (1999). – Brno, Brno University of Technology, Faculty of Mechanical Engineering. – p. 30–35
[237] Gottvald Aleš: Beyond the MaxEnt Principle: Bayes, Fourier, Zipf and Spirals in Metamorphoses. In: Proceedings of the 4rd Japan-Central Europe Joint Workshop on Energy and Information in Non–linear Systems (2000). – Brno, ISI. – p. 48–51
[238] Gottvald Aleš: Beyond the MaxEnt Principle: from Fourier to Spirals, Zipf's Law, Golden Ratio ... In: JSAEM Studies Vol. 10: Proceedings of the 10th International Symposium on Applied Electromagnetics and Mechanics (2001). – Tokyo, Japan Society of Applied Electromagnetics and Mechanics. – p. 625–626
[239] Gottvald Aleš: Exponential family and inverse problems. In: Proceedings of OIPE – optimisation and inverse problems in electromagnetism (2002). – Lodz, IMET. – p. 13
[240] Gottvald Aleš: Inverse Problems and Statistical Physics. In: JSAEM Studies Vol. 10: Proceedings of the 10th International Symposium on Applied Electromagnetics and Mechanics (2001). – Tokyo, Japan Society of Applied Electromagnetics and Mechanics. – p. 599–600
[241] Gottvald Aleš: Laplace's Demon vs Maxwell's Demon: From historical myths to topological evolution. In: Mendel 2002 (2002). – (Matoušek, R. – Ošmera, P.). – Brno, VUT. – p. 139–145
[242] Gottvald Aleš: On Bayesian Spectral Electromagnetics – I. In: Digests of the Joint Seminar '99 (1999). – Sapporo, Hokkaido University. – p. 101–102
[243] Gottvald Aleš: On Bayesian Spectral Electromagnetics – II. In: Digests of the Joint Seminar '99 (1999). – Sapporo, Hokkaido University. – p. 103–104

[244] Gottvald Aleš: Planck's Law and the Rise of Information Physics. In: Proceedings of the 4rd Japan–Central Europe Joint Workshop on Energy and Information in Non–linear Systems (2000). – Brno, ISI. – p. 44–47

[245] Gottvald Aleš: Topological evolution and inverse problems. In: Proceedings of OIPE – optimisation and inverse problems in electromagnetism (2002). – Lodz, IMET. – p. 12

[246] Halámek Josef, Holík M., Jurák Pavel: Scatter plot and confidence interval. In: Analysis of biomedical signals and images (2002). – (Kozumplík, J. – Provazník, I. – Jan, J.). – Brno, University of Technology VUTIUM Press. – p. 135–137

[247] Halámek Josef, Holík M., Jurák Pavel: Scatter plots and the choice of an optimal method. In: Proceedings of 2nd European medical and biological engineering conference (2002). – (Hutten, H. – Krösl, P.). – Vídeň, Verlag der Technischen Universität Graz. – p. 498–499

[248] Halámek Josef, Holík M., Jurák Pavel: The Estimation of the Relationship between Variables. In: Proceedings of the 4th International Conference on Measurement (2003). – Smolenice, Institute of Measurement Science SAS. – p. 91–93

[249] Halámek Josef, Holík M., Jurák Pavel, Kasal Miroslav: Statistical analysis and optimization methods. In: Nové smery v spracovaní signálov (2002). – (Puttera, J.). – Liptovský Mikuláš, Vojenská Akadémia – FZV. – p. 286–289

[250] Halámek Josef, Jurák Pavel, Chládek Jan, Roman R., Sochůrková D., Kasal Miroslav: Accumulation of non-coherent signal. In: Radioelektronika 2002 – Conference proceedings (2002). – Bratislava, FEI SUT.

[251] Halámek Josef, Jurák Pavel, Chládek Jan, Sochůrková D., Roman R., Nestrašil I.: Event related synchronization and desynchronization in intracerebral recordings. In: Proceedings of 2nd European medical and biological engineering conference (2002). – (Hutten, H. – Krösl, P.). – Vídeň, Verlag der Technischen Universität Graz. – p. 610–611

[252] Halámek Josef, Jurák Pavel, Kára T., Davies C. L., Francis D.: Baroreflex sensitivity and signal processing. In: Analysis of Biomedical Signals and Images. Proceedings of the 15th International EURASIP Conference EuroConference Biosignal 2000 (2000). – Brno, Brno University of Technology. – p. 47–49

[253] Halámek Josef, Jurák Pavel, Kára T., Souček M.: Transfer Function and Biosignal Analysis. In: Proceedings of the 3nd International Conference on Measurement – Measurement 2001 (2001). – Bratislava, Institute of Measurement Science, Slovak Academy of Sciences. – p. 321–324

[254] Halámek Josef, Jurák Pavel, Kára T., Souček M., Eisenberger M., Nykodým J.: Heart rate variability and breathing. In: Proceedings of 2nd European medical and biological engineering conference (2002). – (Hutten, H. – Krösl, P.). – Vídeň, Verlag der Technischen Universität Graz. – p. 586–587

[255] Halámek Josef, Jurák Pavel, Swenne C. A., Kára T., Souček M., Eisenberg M., Nykodým J.: Baroreflex sensitivity and heart rate. In: Analysis of biomedical signals and images (2002). – (Kozumplík, J. – Provazník, I. – Jan, J.). – Brno, University of Technology VUTIUM Press. – p. 72–74

[256] Halámek Josef, Kasal Miroslav, Húsek Vladimír: Intercept points and ADC. In: Conference Proceedings of the 10th International Scientific Conference Radioelektronika 2000 (2000). – Bratislava, Department of Radio and Electronics, FEI SUT. – p. II.62–III.64

[257] Halámek Josef, Kasal Miroslav, Húsek Vladimír: Maximal Dynamic Range – Its Limitation. In: Conference Proceedings of the 9th International Czech–Slovak Scientific Conference Radioelektronika '99 (1999). – Brno, Brno University of Technology, Institute of Radio Electronics. – p. 229–232

[258] Halámek Josef, Kasal Miroslav, Húsek Vladimír, Villa M., Cofrancesco P.: Phase Coherence and Digital Receiver. In: 11th International Czech – Slovak Scientific Conference Radioelektronika 2001 Conference Proceedings (2001). – Brno, Brno University of Technology. – p. 86–89

[259] Halámek Josef, Kasal Miroslav, Jurák Pavel, Villa M., Cofrancesco P.: The ADC and maximal dynamic range. In: Proceedings of the 4th International Workshop on ADC Modelling and Testing – IWADC '99 (1999). – Bordeaux, IMEKO TC–4. – p. 227–231

[260] Halámek Josef, Kasal Miroslav, Serra A. C., Villa M.: Harmonic distortion and ADC. In: XVI. World Congress IMEKO 2000 – Proceedings Vol. X (2000). – Vienna, Austrian Society for Measurements and Automation. – p. 147–152

[261] Halámek Josef, Kasal Miroslav, Villa M., Cofrancesco P.: Reproducibility of the jitter measurement. In: XVI. World Congress IMEKO 2000 – Proceedings Vol. X (2000). – Vienna, Austrian Society for Measurements and Automation. – p. 153–157

[262] Halámek Josef, Viščor Ivo, Kasal Miroslav: Dynamic Range and Acquisition System. In: Proceedings of the 3nd International Conference on Measurement – Measurement 2001 (2001). – Bratislava, Institute of Measurement Science, Slovak Academy of Sciences. – p. 45–48

[263] Halámek Josef, Viščor Ivo, Kasal Miroslav, Villa M., Cofrancesco P.: Dynamic Nonlinearity at Undersampling, Fast ADC. In: Proceedings of the 8th International Workshop on ADC Modelling and Testing (2003). – (Moschitta, A. – Macii, D. – Nunzi, E. – Carbone, P.). – Perugia, Universita degli Studi di Perugia. – p. 105–108

[264] Halámek Josef, Viščor Ivo, Kasal Miroslav, Villa M., Cofrancesco P.: Harmonic distortion and statistical analysis. In: ADDA & EWADC 2002 (2002). – Praha, CVUT. – p. 91–94

[265] Hanzelka Pavel, Jura P.: Fuzzy pressure controller for helium bath cryostats. In: Proceedings of 7th Cryogenics IIR international conference (2002). – Praha, ICARIS. – p. 53–56

[266] Horáček Miroslav: Area selective detector of low energy electrons. In: Proceedings of 15th international congress on electron microscopy (2002). – (Engelbrecht, J. – Sewell, T. – Witcomb, M. – Cross, R. – Richards, P.). – Durban, Microscopy society of Southern Africa. – p. 111–112
[267] Horáček Miroslav: Detection of angular distribution of the signal electrons in VLESEM. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. I477–I478
[268] Horáček Miroslav: Direct Detection of Electrons by Area Array CCD. In: Conference Proceedings of the 9th International Czech-Slovak Scientific Conference Radioelektronika '99 (1999). – Brno, Brno University of Technology, Institute of Radio Electronics. – p. 78–81
[269] Horáček Miroslav: Charge–coupled device area detector for low energy electrons. In: Proceedings of the 6th Multinational Congress on Microscopy – European Extension (2003). – (Milat, O. – Ježek, D.). – Zagreb, Croatian Society for Electron Microscopy. – p. 476–477
[270] Horáček Miroslav, Müllerová Ilona, Frank Luděk: Acquisition of Angular Distribution of Signal Electrons in VLESEM. In: Proceedings of 5th Multinational Congress on Electron Microscopy (2001). – Lecce, Rinton Press. – p. 521–522
[271] Horký D., Autrata Rudolf, Ilkovics L., Procházka V.: Electron Microscopy of Biological Specimens at Their Natural State. In: Proceedings of 5th Multinational Congress on Electron Microscopy (2001). – Lecce, Rinton Press. – p. 63–64
[272] Hutař Otakar: The imaging using a cathode lens in LVSEM. In: Proceedings of the 4th Multinational Congress on Electron Microscopy (1999). – Veszprém, University of Veszprém. – p. 169–170
[273] Hutař Otakar, Autrata Rudolf, Romanovský Vladimír: Simple BSE detector for LVSEM. In: Proceedings of the 4th Multinational Congress on Electron Microscopy (1999). – Veszprém, University of Veszprém. – p. 325–326
[274] Hutař Otakar, Müllerová Ilona, Romanovský Vladimír, Káňová Jitka: Recent trends in low voltage scanning electron microscopy for the imaging of semiconductor devices. In: Proceedings EMAS 2000 – 4th Regional Workshop on Electron Probe Microanalysis Today – Practical Aspects (2000). – Prague, Czech Technical University in Prague, Faculty of Mechanical Engineering. – p. 205
[275] Hutař Otakar, Oral Martin, Müllerová Ilona, Frank Luděk: Dimension measurement in a cathode lens equipped low-energy SEM. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. I199–I200
[276] Hutař Otakar, Oral Martin, Müllerová Ilona, Romanovský Vladimír: Application of low-energy backscattered electron detection in the inspection of semiconductor devices technology. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. I201–I202
[277] Chládek Jan, Halámek Josef, Jurák Pavel, Roman R., Sochůrková D.: EEG event-related signals evaluation. In: Nové smery v spracovaní signálov (2002). – (Puttera, J.). – Liptovský Mikuláš, Vojenská Akadémia – FZV. – p. 92–95
[278] Chládek Jan, Konzbul Pavel, Ošmera P.: Evolution and Genetic Optimization of Higher-Order Shim Coils for NMR. In: Mendel 2000 – 6th International Conference on Soft Computing (2000). – Brno, Brno University of Technology, Faculty of Mechanical Engineering. – p. 39–44
[279] Chládek Jan, Konzbul Pavel, Ošmera P., Gottvald Aleš: Evolutionary and Genetic Optimization of NMR Gradient and Shim Coils. In: Proceedings of the 12th Conference on the Computation of Electromagnetic Fields – COMPUMAG (1999). – Sapporo, Hokkaido University. – p. 840–841
[280] Chládek Jan, Konzbul Pavel, Ošmera P., Gottvald Aleš: Optimization of NMR Gradient and Shim Coils Using Evolutionary Algorithms. In: Digests of the Joint Seminar '99 (1999). – Sapporo, Hokkaido University. – p. 22–23
[281] Chládek Jan, Konzbul Pavel, Ošmera P., Gottvald Aleš: Optimization of NMR Coils using Evolutionary and Genetic Algorithms. In: Mendel '99 – 5th International Conference on Soft Computing (1999). – Brno, Brno University of Technology, Faculty of Mechanical Engineering. – p. 15–17
[282] Chládek Jan, Nestrašil I., Jurák Pavel, Halámek Josef: Different Ways of EEG Data Analysis. In: Proceedings of the 4th International Conference on Measurement (2003). – Smolenice, Institute of Measurement Science SAS. – p. 208–210
[283] Jákl Petr, Ježek Jan, Šerý Mojmír, Jonáš Alexandr, Zemánek Pavel: The use of a microprobe held by a laser beam for the study of the surface reliefs. In: Proceedings of SPIE – The International society for optical engineering. Seventh international symposium on laser metrology applied to science, industry, and everyday life (2002). – Novosibirsk, SPIE. – p. 777–783
[284] Jákl Petr, Jonáš Alexandr, Florin E. L., Zemánek Pavel: Comparsion of the Single Beam and the Standing Wave Trap Stiffnesses. In: Proceedings of the 12th Czech-Slovak-Polish Optical Conference on Wave and Quantum Aspects of Contemporary Optics (Proc. SPIE 4356) (2001). – Washington, SPIE – The International Society for Optical Engineering. – p. 347–352
[285] Jákl Petr, Jonáš Alexandr, Lazar Josef, Číp Ondřej, Harna Z., Liška M., Tománek P., Zemánek Pavel: Measurement of submicron laser beam profiles using nanoprobes. In: Proceedings of the Photonics, Devices, and Systems (Proc. SPIE 4016) – Photonics Prague '99 (2000). – Washington, SPIE – The International Society for Optical Engineering. – p. 309–314

[286] Jedlička Petr: Instrumentation for narrow linewidth semiconductor laser. In: Proceedings of the Wave and Quantum Aspects of Contemporary Optics (Proc. SPIE 3820) – 11th Slovak-Czech-Polish Optical Conference (1999). – Washington, SPIE – The International Society for Optical Engineering. – p. 298–301

[287] Jedlička Petr, Lazar Josef: Frequency Noise Analysis of Semiconductor Lasers. In: Proceedings of the 12th Czech–Slovak–Polish Optical Conference on Wave and Quantum Aspects of Contemporary Optics (Proc. SPIE 4356) (2001). – Washington, SPIE – The International Society for Optical Engineering. – p. 277–282

[288] Jelínek Josef: Electromagnetic fields effects on biological and other objects. In: Proceedings of the 6th Cryogenics 2000 IIR International Conference – Refrigeration Science and Technology (2000). – Praha, Czech Committee for co–operation with IIR. – p. 42–47

[289] Ježek Jan, Jonáš Alexandr, Liška M., Jedlička P., Lukášová Emilie, Kozubek Stanislav, Zemánek Pavel: Combined system for optical cutting and multiple-beam optical trapping. In: Proceedings of the Photonics, Devices, and Systems (Proc. SPIE 4016) – Photonics Prague '99 (2000). – Washington, SPIE – The International Society for Optical Engineering. – p. 303–308

[290] Ježek Jan, Palša S., Lukášová E., Kozubek S., Jákl Petr, Šerý Mojmír, Jonáš Alexandr, Liška M., Zemánek Pavel: Spatial structure of chromatin in hybrid cells produced by laser induced fusion studied by optical microscopy. In: Proceedings of SPIE – The International society for optical engineering. Photonic, devices, and systems II (2002). – Prague, SPIE. – p. 630–634

[291] Ježek Jan, Zemánek Pavel, Jonáš Alexandr, Šerý Mojmír, Pokorný Pavel, Liška M.: Study of the Behavior of Nanoparticle and Micropatricle in the Standing Wave Trap. In: Proceedings of the 12th Czech-Slovak-Polish Optical Conference on Wave and Quantum Aspects of Contemporary Optics (Proc. SPIE 4356) (2001). – Washington, SPIE – The International Society for Optical Engineering. – p. 318–325

[292] Jirák Josef, Autrata Rudolf, Drnovský Radek: Influence of Size of Ionization Detector Electrode on Signal Detection in Environmental Conditions. In: Proceedings of 5th Multinational Congress on Electron Microscopy (2001). – Lecce, Rinton Press. – p. 523–524

[293] Jirák Josef, Autrata Rudolf, Schneider L.: Influence of Primary Electron Energy on Signal Detection in Environmental Conditions. In: Proceedings of 5th Multinational Congress on Electron Microscopy (2001). – Lecce, Rinton Press. – p. 525–526

[294] Jonáš Alexandr, Šrámek Libor, Liška M., Zemánek Pavel: Theoretical study of the optical forces and other characteristical parameters in the standing wave trap. In: Proceedings of the Wave and Quantum Aspects of Contemporary Optics (Proc. SPIE 3820) – 11th Slovak-Czech-Polish Optical Conference (1999). – Washington, SPIE – The International Society for Optical Engineering. – p. 70–76

[295] Jurák Pavel, Halámek Josef, Bareš M., Brázdil M., Daniel P., Rektor I.: The Eye Movements Analysis and Parkinson's Disease. In: Proceedings of the 4th International Conference on Measurement (2003). – Smolenice, Institute of Measurement Science SAS. – p. 211–214

[296] Jurák Pavel, Halámek Josef, Kára T.: Coupling between breathing and heart rate and breathing and systolic blood pressure – two new parameters for autonomic nervous system analysis. In: Analysis of Biomedical Signals and Images. Proceedings of the 15th International EURASIP Conference EuroConference Biosignal 2000 (2000). – Brno, Brno University of Technology. – p. 12–14

[297] Jurák Pavel, Halámek Josef, Kára T., Lanfranchi P., Souček M.: Short and long time blood pressure, heart beat and respiratory oscillation control analysed by XYt graphs. In: Analysis of biomedical signals and images (2002). – (Kozumplík, J. – Provazník, I. – Jan, J.). – Brno, University of Technology VUTIUM Press. – p. 226–229

[298] Jurák Pavel, Halámek Josef, Kára T., Souček M.: Blood Pressure and Heart Beat Short Time Oscillation Coherency Analysis by XYt Graphs. In: Proceedings of the 3nd International Conference on Measurement – Measurement 2001 (2001). – Bratislava, Institute of Measurement Science, Slovak Academy of Sciences. – p. 243–246

[299] Jurák Pavel, Kára T., Halámek Josef, Kuba R., Chládek Jan, Vondra Vlastimil: Influence of vagus nerve stimulator to systemic blood pressure and heart rate measurement. In: Nové smery v spracovaní signálov (2002). – (Puttera, J.). – Liptovský Mikuláš, Vojenská Akadémia – FZV. – p. 96–99

[300] Káňová Jitka, Frank Luděk: Signal detection near the critical energy of non–charging illumination in low-energy SEM equipped with a cathode lens. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. I203–I204

[301] Káňová Jitka, Müllerová Ilona, Frank Luděk: Imaging of Uncoated Biostructures in a Conventional SEM Adapted to Very Low Energy Microscopy. In: Proceedings of 5th Multinational Congress on Electron Microscopy (2001). – Lecce, Rinton Press. – p. 527–528

[302] Klvač Martin, Jirák J.: Detector for Backscattered Electrons in Environmental SEM. In: Proceedings of the 4th Multinational Congress on Electron Microscopy (1999). – Veszprém, University of Veszprém. – p. 335–336

[303] Konzbul Pavel: Practical Aspects of Some Designing Methods for NMR Shim Coils. In: Digests of the Joint Seminar '99 (1999). – Sapporo, Hokkaido University. – p. 16–17

[304] Konzbul Pavel, Švéda Karel: Design and Optimisation of Matrix Shim Coils for NMR and MRI. In: Proceedings of the 12th Conference on the Computation of Electromagnetic Fields – COMPUMAG (1999). – Sapporo, Hokkaido University. – p. 860–861

[305] Konzbul Pavel, Švéda Karel: Measurement of Magnetic Field of Matrix Shim Systems for MRI. In: Proceedings of the 2nd International Conference on Measurement – Measurement '99 (1999). – Bratislava, Institute of Measurement Science, Slovak Academy of Sciences. – p. 76–78
[306] Konzbul Pavel, Švéda Karel: Modified Matrix Inversion Design Method for Cylindrical NMR Coils. In: Proceedings of the 12th Conference on the Computation of Electromagnetic Fields – COMPUMAG (1999). – Sapporo, Hokkaido University. – p. 68–69
[307] Konzbul Pavel, Švéda Karel, Chládek Jan: Optimum Design of Axial Matrix Shim Coils for NMR. In: Mendel '99 – 5th International Conference on Soft Computing (1999). – Brno, Brno University of Technology, Faculty of Mechanical Engineering. – p. 162–164
[308] Konzbul Pavel, Švéda Karel, Chládek Jan, Srnka Aleš: Axial Super Shim Coils System for MRI. In: Digests of the Joint Seminar '99 (1999). – Sapporo, Hokkaido University. – p. 18–19
[309] Lazar Josef: Design and stability measurement of 543 nm He-Ne-I2 laser system. In: Proceedings of the Wave and Quantum Aspects of Contemporary Optics (Proc. SPIE 3820) – 11th Slovak–Czech–Polish Optical Conference (1999). – Washington, SPIE – The International Society for Optical Engineering. – p. 294–297
[310] Lazar Josef, Číp Ondřej, Jedlička Petr: Design and Stabilization of the Extended–cavity Semiconductor Laser. In: Proceedings of the 12th Czech-Slovak-Polish Optical Conference on Wave and Quantum Aspects of Contemporary Optics (Proc. SPIE 4356) (2001). – Washington, SPIE – The International Society for Optical Engineering. – p. 303–308
[311] Lazar Josef, Číp Ondřej, Jedlička Petr, Růžička Bohdan: Extended cavity semiconductor lasers in fundamental metrology. In: Proceedings of SPIE – The International society for optical engineering. Seventh international symposium on laser metrology applied to science, industry, and everyday life (2002). – Novosibirsk, SPIE. – p. 132–138
[312] Lazar Josef, Pokorný Pavel: Deposition and Measurements of Antireflection Coatings for Semiconductor Lasers. In: Proceedings of the 12th Czech-Slovak-Polish Optical Conference on Wave and Quantum Aspects of Contemporary Optics (Proc. SPIE 4356) (2001). – Washington, SPIE – The International Society for Optical Engineering. – p. 297–302
[313] Lencová Bohumila: Electron sources and beam formation for X–ray microanalysis. In: Proceedings EMAS 2000 – 4th Regional Workshop on Electron Probe Microanalysis Today – Practical Aspects (2000). – Prague, Czech Technical University in Prague, Faculty of Mechanical Engineering. – p. 111–120
[314] Lencová Bohumila: Recent Development in Methods for Electron Optical Computations. In: Microscopy, Barcelona 2001 (2001). – Barcelona, Universitat de Barcelona. – p. 29–30
[315] Lencová Bohumila, Vlček Ivan: Computations of Wien Filter Properties and Aberrations. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. I87–I88
[316] Lencová Bohumila, Zlámal J.: New CAD program for design in electron optics. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. I101–I102
[317] Lencová Bohumila, Zlámal J., Jánský P.: Programs for design of systems in particle optics. In: International summer school: Role of physics in future applications: from nanotechnology to macroelectronics (2002). – Tři Studně, VUT.
[318] Man Jiří, Polák Vladimír, Vičar M., Obrtlík Karel, Matějková Jiřina, Rek Antonín: AFM study of slip localization and surface relief evolution in fatigued ferritic X10CrAl24 stainless steel. In: Fatigue Damage of Materials: Experiment and Analysis (2003). – (Varvani–Farahani, A. – Brebbia, C. A.). – Toronto, Wessex Institute of Technology. – p. 193–203
[319] Matějka František: Fabrication of Multilevel Diffractive Optical Elements using Electron Beam Lithography. In: Proceedings of the 9th International Workshop on Applied Physics of Condensed Matter (2003). – Žilina, FEE University of Žilina. – p. 241–244
[320] Matějka František, Ryzí Z.: Test Specimens for SEM. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. I445–I446
[321] Matys K., Gottvald Aleš: On Wavelet Transform in Generalized NMR Spectroscopy. In: Digests of the Joint Seminar '99 (1999). – Sapporo, Hokkaido University. – p. 105–106
[322] Michálek Martin, Jirák Josef: Modified Configuration of Ionization Detector for Environmental SEM. In: Proceedings of 5th Multinational Congress on Electron Microscopy (2001). – Lecce, Rinton Press. – p. 529–530
[323] Michálek Martin, Jirák Josef: Possibilities of evaluation of the influence of conditions in the specimen chamber on the quality of imaging in environmental SEM. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. I217–I218
[324] Mikel Břetislav, Číp Ondřej: Stabilization of VCSEL laser source for absolute laser interferometry. In: Proceedings of SPIE – The International society for optical engineering. Seventh international symposium on laser metrology applied to science, industry, and everyday life (2002). – Novosibirsk, SPIE. – p. 918–923

[325] Mikel Břetislav, Číp Ondřej, Harna Z.: Two Axis Micropositioning System with Piezoelectric Actuators and Digital Control. In: Proceedings of the 12th Czech-Slovak-Polish Optical Conference on Wave and Quantum Aspects of Contemporary Optics (Proc. SPIE 4356) (2001). – Washington, SPIE – The International Society for Optical Engineering. – p. 333–338

[326] Mikel Břetislav, Růžička Bohdan, Číp Ondřej, Lazar Josef, Jedlička Petr: Highly coherent tunable semiconductor lasers in metrology of lenght. In: Proceedings of SPIE – The International society for optical engineering. Photonic, devices, and systems II (2002). – Prague, SPIE. – p. 8–13

[327] Mlynárik V., Gruber S., Starčuk Zenon, Starčuk jr Zenon, Roden M., Moser E.: Single-Voxel Short-Echo Time Proton Spectroscopy of Human Brain with Standard Surface Coils. In: Proceedings of 8th Scientific Meeting and Exhibition Magnetic Resonance in Medicine (2000). – Denver, ISMRM. – p. 1857

[328] Müllerová Ilona: Low Voltage Electron Microscopy. In: Proceedings of the 4th Multinational Congress on Electron Microscopy (1999). – Veszprém, University of Veszprém. – p. 99–104

[329] Müllerová Ilona, Frank Luděk: Current trends in scanning low energy electron microscopy (SLEEM). In: Proceedings of the 6th Multinational Congress on Microscopy – European Extension (2003). – (Milat, O. – Ježek, D.). – Zagreb, Croatian Society for Electron Microscopy. – p. 85–86

[330] Müllerová Ilona, Frank Luděk: Practical resolution limit in the scanning low energy electron microscope. In: Proceedings of 15th international congress on electron microscopy (2002). – (Engelbrecht, J. – Sewell, T. – Witcomb, M. – Cross, R. – Richards, P.). – Durban, Microscopy society of Southern Africa. – p. 99–100

[331] Müllerová Ilona, Frank Luděk: Scanning low and very low energy electron microscopy. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. I177–I178

[332] Müllerová Ilona, Frank Luděk, El Gomati M. M.: SLEEM Imaging of Doping Patterns in Semiconductors. In: Proceedings of 5th Multinational Congress on Electron Microscopy (2001). – Lecce, Rinton Press. – p. 317–318

[333] Musilová Věra, Hanzelka Pavel, Srnka Aleš: Monte Carlo simulation of molecular flow and radiative heat transfer in He bath cryopump. In: Proceedings of 7th Cryogenics IIR international conference (2002). – Praha, ICARIS. – p. 11–14

[334] Mynář M., Vašina R., Kolařík Robert, Lencová Bohumila: Electron Ray-Tracing for Numerical Determination of Aberrations. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. I99–I100

[335] Protopopov V. V., Sobota Jaroslav, Tremsin A. S., Siegmund O. H., Platonov Y. Y.: X-ray imaging of microobjects using dark field refraction–contrast method with resonantly absorbing multilayer mirrors. In: Proceedings of SPIE – The International society for optical engineering. Medical imaging 2002: Physics of medical imaging (2002). – San Diego, SPIE. – p. 277–285

[336] Protopopov V.V., Sobota Jaroslav, Tremsin A.S., Siegmund O H. W.: X-ray Dark Field Refraction-Constrast Imaging – a New Tool for Medical Imaging, IEEE Nuclear Science Symposium and Medical Imaging Conference, Norfolk, Virginia, USA, November 10–16, 2002

[337] Romanovský Vladimír, Autrata Rudolf: Combined scintillation and ionisation detectors for environmental scanning electron microscopes. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. I241–I242

[338] Romanovský Vladimír, Autrata Rudolf: Use of ionisation detectors in environmental SEM. In: Proceedings of the 4th Multinational Congress on Electron Microscopy (1999). – Veszprém, University of Veszprém. – p. 359–360

[339] Romanovský Vladimír, Autrata Rudolf, Hutař Otakar: Voltage contrast imaging in environmental SEM. In: Proceedings of the 4th Multinational Congress on Electron Microscopy (1999). – Veszprém, University of Veszprém. – p. 357–358

[340] Romanovský Vladimír, Hutař Otakar: Imaging of semiconductor structures in environmental SEM. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. I243–I244

[341] Růžička Bohdan, Lazar Josef, Číp Ondřej, Wilfert O.: Workplace for demonstration of frequency stabilization of laser using personal computer. In: Proceedings – Region 8 EUROCON 2003 – The International Conference on Computer as a Tool (2003). – (Zajc, B. – Tkalcic, M.). – Ljubljana, IEEE.

[342] Růžička Bohdan, Lazar Josef, Wilfert O.: Measurements of Residual Reflectivity and Wavelength of Coated Laser Diodes. In: 11th International Czech – Slovak Scientific Conference Radioelektronika 2001 Conference Proceedings (2001). – Brno, Brno University of Technology. – p. 286–289

[343] Růžička Bohdan, Wilfert O., Lazar Josef, Číp Ondřej: Single Frequency Semiconductor Laser at 635 nm Stabilized by Means of Linear Absorption of Molecular Iodine with Spectral Analyser. In: Conference Proceedings ICECom 2003 – 17th International Conference on Applied Electromagentic and Communications (2003). – (Bonefacic, D.). – Dubrovnik, IEEE. – p. 282–285

[344] Ryzí Z., Fiala P., Matějka František: Blazed diffractive structures produced by scanning methods. In: EOS Topical Meetings Digest Series Vol. 22: Diffractive Optics – Jena '99 (1999). – Jena, Electron Optical Society. – p. 193–194

[345] Schauer Petr, Autrata Rudolf: Experimental setup for cathodoluminescence spectra measurement. In: Proceedings of 15th international congress on electron microscopy (2002). – (Engelbrecht, J. – Sewell, T. – Witcomb, M. – Cross, R. – Richards, P.). – Durban, Microscopy society of Southern Africa. – p. 337–338

[346] Schauer Petr, Autrata Rudolf: Performance of detector elements for electron microscopes. In: Proceedings of the 12th European Congress on Electron Microscopy (2000). – Brno, Czechoslovak Society for Electron Microscopy. – p. I455–I456

[347] Schauer Petr, Autrata Rudolf: Study of TEM fluorescent screens. In: Proceedings of the 4th Multinational Congress on Electron Microscopy (1999). – Veszprém, University of Veszprém. – p. 167–168

[348] Schauer Petr, Nešpůrek Stanislav, Schauer F., Autrata Rudolf: Electron beam degradation study of silicon polymers. In: Proceedings of the 6th Multinational Congress on Microscopy – European Extension (2003). – (Milat, O. – Ježek, D.). – Zagreb, Croatian Society for Electron Microscopy. – p. 205–206

[349] Schauer Petr, Vlček Ivan, Autrata Rudolf: Improved Recording System for the Study of Single Crystal Imaging Screens. In: Proceedings of 5th Multinational Congress on Electron Microscopy (2001). – Lecce, Rinton Press. – p. 533–534

[350] Starčuk jr Zenon, Starčuk Zenon, Mlynárik V., Gruber S., Horký Jaroslav, Moser E.: Robust, Efficient, and Flexible Water Suppression for In Vivo Proton MRS. In: 2nd Krakow–Winnipeg Workshop on Biomedical Application of MRI and MRS (2000). – Krakow, Komitet Badaň Naukovych. – p. 36

[351] Starčuk jr. Zenon, Krupa P., Horký Jaroslav, Starčuk Zenon: Reproducibility of short TE STEAM ^{1}H MR spectra from frontal, occipital and parietal brain regions acquired without outer volume suppression. In: Proceedings of the International Sociaty for Magnetic Resonance in Medicine – 10th Scientific Meeting and Exhibition (2002). – Honolulu, ISMRM. – p. 966

[352] Starčuk jr. Zenon, Starčuk Zenon, Mlynárik V., Horký Jaroslav, Moser E.: Water-inversion based difference techniques for localized proton spectroscopy without water suppression. In: Proceedings of the International Sociaty for Magnetic Resonance in Medicine – 10th Scientific Meeting and Exhibition (2002). – Honolulu, ISMRM. – p. 2511

[353] Starčuk jr. Zenon, Starčuková Jana: Determination of confidence regions of model parameters in mono– and biexponential fitting of relaxation curves. In: Proceedings of the International Sociaty for Magnetic Resonance in Medicine – 11th Scientific Meeting and Exhibition (2003). – Toronto, ISMRM. – p. 1102

[354] Starčuk Zenon, Starčuk jr Zenon, Horký Jaroslav: “Baseline” Problems in Very Short Echo–time Proton MR Spectroscopy of Low Molecular Weight Metabolites in the Brain. In: Proceedings of the 3nd International Conference on Measurement – Measurement 2001 (2001). – Bratislava, Institute of Measurement Science, Slovak Academy of Sciences. – p. 89–92

[355] Starčuk Zenon, Starčuk jr Zenon, Mlynárik V., Gruber S., Horký Jaroslav, Moser E.: T1–Based Differentiation Between Basic Components in In Vivo Proton MRS. In: 2nd Krakow-Winnipeg Workshop on Biomedical Application of MRI and MRS (2000). – Krakow, Komitet Badaň Naukovych. – p. P04

[356] Starčuk Zenon, Tkáč I., Starčuk jr Zenon, Horký Jaroslav, Gruetter R.: Measurement of macromolecule or metabolite nulled in vivo proton NMR spectra of the rat brain. In: ISMRM – 7th Scientific Meeting and Exhibition (1999). – Philadelphia, International Society for Magnetic Resonance in Medicine. – p. 1582

[357] Stone J., Stejskal Alois, Howard L. P.: Diode Lasers in Length Metrology: Application to Absolute Distance Interferometry. In: Proceedings of Measurement Science Conference 1999 (1999). – Anaheim, MSC. – p. 328–339

[358] Stone J., Stejskal Alois, Howard L. P.: Sources of error in absloute distance interferometry. In: Proceedings of International Symposium on Laser Metrology for Precision Measurement and Inspection in Industry 1999 (1999). – Santa Catarina, Brazilian Society for Metrology. – p. 1.45–1.53

[359] Šerý Mojmír, Jákl Petr, Ježek Jan, Jonáš Alexandr, Liška M., Zemánek Pavel: Influence of weak reflections from dielectric interfaces on properties of optical trap. In: Proceedings of SPIE – The International society for optical engineering. Photonic, devices, and systems II (2002). – Prague, SPIE. – p. 624–629

[360] Václavík V., Rozman J., Číp Ondřej, Mikel Břetislav: Digital Controlled Electronics for Three–dimension Hydrophone Position System. In: 11th International Czech – Slovak Scientific Conference Radioelektronika 2001 Conference Proceedings (2001). – Brno, Brno University of Technology. – p. 78–81

[361] Viščor Ivo, Halámek Josef: Acquisition system with low jitter. In: ADDA & EWADC 2002 (2002). – Praha, CVUT. – p. 83–86

[362] Viščor Ivo, Halámek Josef: Close–in spurs in digital receiver. In: Proceedings of the 8th International Workshop on ADC Modelling and Testing (2003). – (Moschitta, A. – Macii, D. – Nunzi, E. – Carbone, P.). – Perugia, Universita degli Studi di Perugia. – p. 125–128

[363] Viščor Ivo, Halámek Josef: Digital transceiver with high dynamic range. In: Nové smery v spracovaní signálov (2002). – (Puttera, J.). – Liptovský Mikuláš, Vojenská Akadémia – FZV. – p. 122–125

[364] Viščor Ivo, Halámek Josef: DSP and Digital Down Conversion. In: Conference Proceedings of the 9th International Czech–Slovak Scientific Conference Radioelektronika '99 (1999). – Brno, Brno University of Technology, Institute of Radio Electronics. – p. 225–228

[365] Viščor Ivo, Halámek Josef: Phase noise measured by digital receiver. In: Nové smery v spracovaní signálov (2002). – (Puttera, J.). – Liptovský Mikuláš, Vojenská Akadémia – FZV. – p. 126–129

[366] Viščor Ivo, Halámek Josef: Phase Noise Measurement. In: 11th International Czech-Slovak Scientific Conference Radioelektronika 2001 Conference Proceedings (2001). – Brno, Brno University of Technology. – p. 131–134

[367] Viščor Ivo, Halámek Josef: Two-channel digital measurement system. In: Radioelektronika 2002 – Conference proceedings (2002). – Bratislava, FEI SUT.

[368] Viščor Ivo, Halámek Josef: Two-channel digital receiver as a measurement unit. In: Conference Proceedings of the 10th International Scientific Conference Radioelektronika 2000 (2000). – Bratislava, Department of Radio and Electronics, FEI SUT. – p. III.32–III.35

[369] Vondra Vlastimil, Halámek Josef, Kasal Miroslav: Spectral artefacts in DDS aplication. In: Conference Proceedings of the 10th International Scientific Conference Radioelektronika 2000 (2000). – Bratislava, Department of Radio and Electronics, FEI SUT. – p. II.81–II.84

[370] Vondra Vlastimil, Jurák Pavel, Kára T.: The detector of vagus nerve stimulation. In: Analysis of biomedical signals and images (2002). – (Kozumplík, J. – Provazník, I. – Jan, J.). – Brno, University of Technology VUTIUM Press. – p. 230–232

[371] Zemánek Pavel, Jonáš Alexandr: Employment of Gaussian standing wave for optical trapping of nanoparticles and microparticles. In: Digests of the Joint Seminar '99 (1999). – Sapporo, Hokkaido University. – p. 20–21

[372] Zemánek Pavel, Šrámek Libor, Jonáš Alexandr, Moravčík Z., Janisch R., Liška M.: Standing wave trap and single beam gradient optical trap – experiments and biological applications. In: Proceedings of the Wave and Quantum Aspects of Contemporary Optics (Proc. SPIE 3820) – 11th Slovak-Czech-Polish Optical Conference (1999). – Washington, SPIE – The International Society for Optical Engineering. – p. 401–410

[373] Zobač Martin: Marking of welded pieces using continuous or pulse electron beam. In: Proceedings of the 7th International Conference on Electron Beam Technologies (EBT 2003) (2003). – Varna, Institute of Electronics BAS. – p. 191–197

F. Internal publications of foreign partners

[374] Dupák Jan, Finger M., Finger jr M., Janata A., Kracíková T. I., Krmar M., Kumar K., Kvasil J., Lebedev N. A., Pavlov V. N., Slunečka M., Slunečková V., Šimečková Eva, Yushkevich Y. V.: Low-Temperature Nuclear Orientation. In: Research Program of the Laboratory of High Energies of Joint Institute for Nuclear Research (1999). – Dubna, JINR. – p. 130–132

[375] Kracíková T. I., Finger M., Janata A., Krmar M., Kumar K., Kvasil J., Procházka I., Dupák Jan, Finger jr M., Lebedev N. A., Pavlov V. N., Slunečka M., Šimečková Eva, Yushkevich Y. V.: Low-Temperature Nuclear Orientation. In: Laboratory of Nuclear Problems of Joint Institute for Nuclear Research in 1996–2000 (1999). – Dubna, JINR. – p. 192–195

G. Patents

[376] Autrata R., Jirák J., Špinka J., Blažek K.: Detection system of a scanning electron microscope. Patent No. 284 288

H. Realizations

[377] Cryostat for optical measurements in the temperature range from -190°C to +20°C (partner: Brno University of Technology, Faculty of Civil Engineering), J. Dupák, 1999

[378] Cryostat and furnace for Mössbauer measurements (partner: Palacký University Olomouc, Faculty of Science), J. Dupák, 2000

[379] Vacuum furnace for soldering diamond machine tools (partner: Gatto Diamond Tools Oriolo Romano, Itálie), J. Dupák, 2002

[380] Set of electrical feedthroughs for reactors (partner: Škoda JS a.s., Plzeň), J. Dupák, 2003

[381] Cryostat for cooling germanium diodes (partner: PESO – Ing. Petr Souček), J. Dupák, 2003

[382] Detector of low-energy electrons for field-emission scanning electron microscope JEOL 6700F (for our own use), I. Müllerová, 2002

[383] Ultra-high vacuum scanning electron microscope with preparation chamber for imaging clean and well-defined surfaces with the help of low-energy electrons (for our own use), I. Müllerová, 2002

[384] Program modul extending the control software of microscope Vega of Tescan to microscopy with very-low energy electrons using a cathode lens (partner: Tescan s.r.o., Brno), F. Mika, 2002

[385] Detector of very-low energy electrons for scanning electron microscope Hitachi 3500 (partner: University of Toyama, Japonsko), I. Müllerová, 2003

[386] Ultra-high vacuum compatible sample manipulator with two independent precise tilts, movement in three axes and limited rotation, allowing the input of five independent high voltages on the sample (for our own use), P. Klein, 2003

[387] Ultra-high vacuum compatible sample manipulator with large tilt, continuous rotation and movement in three axes, allowing the input of five independent intermediate voltages on the sample (for our own use), P. Klein, 2003

[388] Miniature scanning electron microscope with built-in detector of very-low energy electrons (partner: University of York, UK), I. Müllerová, 2003
[389] Version 3.7. of program package MLD for the computation of magnetic fields with axial symmetry (for our own use), B. Lencová, 2002
[390] Version 3.7. of program package ELD for the computation of electrostatic fields with axial symmetry (for our own use), B. Lencová, 2002
[391] Version 3.7. of program package MMD for the computation of magnetic fields of multipole elements (for our own use), B. Lencová, 2002
[392] Version 3.7. of program package TRC for the computation of trajectories of charged particles in electromagnetic fields (for our own use), B. Lencová, 2002
[393] Version 3.7. of program package EMD for the computation of electrostatic fields of multipole elements (for our own use), B. Lencová, 2002
[394] Beta version of program EOD for computer-aided design of electron optical systems with space-charge effects in the Windows operating system (for our own use), B. Lencová, 2003
[395] A set of elements of multi-layer x-ray optics for pulsed x-ray lasers (partner CNRS; PALS), J. Sobota, 2003
[396] Program RHTMF for Monte Carlo simulation of molecular flow and radiative heat transfer (developed for own use), V. Musilová, 2001
[397] Measurement system ScopeWin NI for recording biological signals (partner: FN u sv. Anny, Brno), P. Jurák, 2000
[398] Program ScopeWin ANS 2000 for the analysis of the properties of the autonomic nervous system (partner: St. Anne's Univ. Hospital, Brno, Mayo Clinic, Rochester, MN, USA), P. Jurák, 2001
[399] Program ScopeWin EEG for processing of surface and intracerebral EEG signal (partner: Faculty of Medicine, Masaryk Univ. Brno, St. Anne's Univ. Hospital, Brno), P. Jurák, 2002
[400] Program ScopeWin QT 2002 for automatic detection and analysis of the QT interval in ECG signals (partner: Mayo Clinic, Rochester, MN, USA, St. Anne's Univ. Hospital, Brno), P. Jurák, 2003
[401] Environmental scanning electron microscope AQUASEM (partner: Preciosa, a. s., Tescan, s. r. o), R. Autrata, 2001
[402] YAG detector of back-scattered electrons for JSM-6700F (for our own use), R. Autrata, 2003
[403] Television system with YAG screen for image recording in a high-voltage transmission electron microscope (partner: Nagoya University), R. Autrata, 2000
[404] YAG detector for image recording in the dark field of a transmission electron microscope with suppression of the effect of back-scattered electrons (partner: Research and Developement Div. Jeol), R. Autrata, 2003
[405] Low-voltage YAG detector of back-scattered electrons (partner: Jeol ltd.), R. Autrata, 2000
[406] Combined scintillation and ionization detection system for environmental scanning electron microscope (partner: Preciosa, a. s., Tescan, s. r. o.), R. Autrata, 2001
[407] Adapter for connection of digital camera Nikon Coolpix 4500 to stereomicroscope Nikon SMZ 1500 (for our own use), I. Vlček, 2003
[408] Telescope for observation of welding position in table-top electron beam weldin machine (for our own use), I. Vlček, 2002
[409] Tool for controlled cutting of single-crystal wire for the production of field emission cathodes (for our own use), I. Vlček, 2001
[410] Spot-welder for welding thin wires for the production of field emission cathodes (for our own use), I. Vlček, 2000
[411] An integrated software package based on evolutionary optimization algorithms (1+1)–Evolution strategy, (μ+λ)–ES, meta (1+1)–ES, meta-ES-GA (developed for own use), J. Chládek, 1998–2001
[412] Software package for the optimization of NMR shim coils of types X, XZ2 a XZ4 in MATLAB (developed for own use), J. Chládek, 1998–2001
[413] Program for the analysis of magnetic field configuration in 2D and 3D space (developed for own use), J. Chládek, 2001
[414] Program for the evaluation of statistical data generated by software ScopeWin, EEG data analysis (partner: St. Anne's Univ. Hospital), J. Chládek, 2003
[415] Imaging unit for a transmission electron microscope using single-crystal YAG screen and CCD camera (for our own use), P. Schauer, 2000
[416] Version 3.5 of program SCIUNI for optimization of photon collection in scintillation detection systems by Monte Carlo methods (for our own use), P. Schauer, 2001
[417] Version 2.3 of program TRANZIT and version 2.1 of program VRSTVA for Monte Carlo simulations of interaction of electrons with solids (for our own use), P. Schauer, 2003
[418] Chip for callibration of magnification in a scanning electron microscope (partner: University of West Bohemia, Plzeň), F. Matějka, 2000
[419] Structure of diffraction filter on glass substrate (partner: Institute of Physical Engineering of the Faculty of Mechanical Engineering, Brno University of Technology), F. Matějka, 2000
[420] Metallized reflex phase structures prepared by electron-beam lithography on three Si substrates (partner: Military technology institute of defence Brno), F. Matějka, 2000

[421] Lithographic mask in Cr on glass with slit structures prepared by electron-beam lithography (partner: Delong Instruments s.r.o), F. Matějka, 2000
[422] Test object for confocal microscope with reliefs of variable height on Si substrate prepared by electron-beam lithography (partner: Institute of Physical Engineering of the Faculty of Mechanical Engineering, Brno University of Technology), F. Matějka, 2000
[423] Set of binary phase diffractive structures on Si substrates (partner: Czech Holography s. r. o.), F. Matějka, 2000
[424] Set of test phase diffractive structures on glass (partner: Institute of Physical Engineering of the Faculty of Mechanical Engineering, Brno University of Technology), F. Matějka, 2001
[425] Set of reflex phase diffraction structures on Si substrates (partner: Military technology institute of defence Brno), F. Matějka, 2001
[426] Set of test samples for a scanning electron microscope on Si substrate (partner: TESCAN, s. r. o.) F. Matějka, 2001
[427] Set of binary phase diffractive structures on Si substrates (partner: Optaglio, s. r. o.), F. Matějka, 2001–3
[428] Software for analysis of optical efficiency of diffractive structures (for our own use), M. Halíček, 2000
[429] Program for subdividing large-area rotationally symmetric DOE type lenses on individual exposure sections (for our own use), R. Gavenda, 2001
[430] Device for continuous temperature control of electron-beam lithograph BS600 with the help of a PC (for our own use), M. Horáček, 2001
[431] Software for correction of exposure time of multi–level diffractive structures (for our own use), L. Daněk. 2002
[432] Chip of anisotropically etched test structures "REM–test" for testing magnification of an electron microscope (partner: On Semiconductor a.s), F. Matějka, 2003
[433] NMR spectrotomograph 4.7 T – realization of electronics and control and data processing software, integration with commercial modules (magnet and shielded gradient coils Magnex, power amplifiers Techron, RF amplifier Kalmus), (developed for own use), odd. NMR, 2002
[434] Software for the design of flat coils generating spatially defined magnetic fields in NMR systems with a permanent magnet (partner: Institute for Biodiagnostics, NRC, Kanada), Z. Starčuk jr., 1999
[435] Software for the simulation of spin evolution in NMR experiments for the development and optimization of pulse sequences for in vivo measurements (developed for own use), Z. Starčuk jr., 1999
[436] Software for the design of shielded systems of flat coils generating spatially defined magnetic field in NMR systems with a permanent magnet (partner: Institute for Biodiagnostics, NRC, Kanada), Z. Starčuk jr., 2001
[437] Software modules extending software Marevisi for NMR data processing and visualization by functions for image-based experiment navigation and for software integration (developed for own use and with partner: Inst. for Biodiagnostics, NRC, Kanada), J. Starčuková, 2002
[438] Optimized pulse sequences for localized in vivo NMR spectroscopy of the brain (partner: Univ. Hospital Brno – Bohunice), Z. Starčuk jr., 2002
[439] Mercury plethysmograph – 1st generation (partner: St. Anne's Univ. Hospital, Brno), V. Vondra, J. Kališ, 2000
[440] Detector of the activity of a vagus nerve stimulator – prototype (partner: St. Anne's Univ. Hospital, Brno), V. Vondra, 2000
[441] Detector of the activity of a vagus nerve stimulator and a universal biosignal amplifier (partner: St. Anne's Univ. Hospital, Brno), V. Vondra, 2001
[442] Device for paced breathing (partner: St. Anne's Univ. Hospital, Brno), V. Vondra, 2002
[443] Amplifier for microneurography (partner: St. Anne's Univ. Hospital, Brno), V. Vondra, 2002
[444] Preamplifier for microneurography (2 types), (partner: St. Anne's Univ. Hospital, Brno), V. Vondra, 2002
[445] Mercury plethysmograph – 2nd generation (partner: St. Anne's Univ. Hospital, Brno), V. Vondra, 2003
[446] Clock frequency module – 10/20/40 MHz (partner: INFM Pavia, Italy), V. Húsek, 2001
[447] Clock frequency module – 10/20/40/120 MHz (developed for own use), V. Húsek, 2003
[448] Numerically controlled device for sample positioning in the NMR magnet for coil inner diameter 135 mm (developed for own use), J. Kališ, 2000
[449] Numerically controlled device for sample positioning in the NMR magnet for coil inner diameter 92 mm (developed for own use), J. Kališ, 2002
[450] Radiofrequency shielding of gradient and shim coils in the NMR magnet (developed for own use), J. Kališ, 2003
[451] NMR console software for multiple acquisition during one pulse sequence (developed for own use), J. Halámek, 2002
[452] RF resonator 200 MHz, for the nonshielded gradient system (developed for own use), M. Samek, J. Kališ, 2000
[453] RF resonator 200 MHz, for the actively shielded gradient system (developed for own use), M. Samek, J. Kališ, 2002
[454] Transmit/receive switch module and selective preamplifier for the NMR spectrotomograph (developed for own use), M. Samek, 2002
[455] Universal signal processor module ADSP–2181 with USB communicationand memory 1M×16 bits (developed for own use), I. Viščor, I. Krejčí, 2000
[456] Single-channel digital receiver A2DDC module (developed for own use), I. Viščor, J. Halámek, 2000
[457] Two-channel digital receiver RX2A2D module (developed for own use), I. Viščor, J. Halámek, 2002

[458] Digital receiver with software in the Matlab environment for educational use (partner: Dept. of Radioelectronics, Univ. of Technology Brno), I. Viščor, J. Halámek, 2002
[459] Software toolbox for the communication with universal ports (IOPORT), with a GPIB port (GPORT) and an USB port (UPORT) from the Matlab environment (developed for own use), I. Viščor, 2000–2002
[460] Stabilized semiconductor laser operating at 1315 nm as a master oscillator for pulsed high power laser (partner: PALS), J. Lazar, 2002–2003
[461] Absorption cells filled with superpure iodine manufactured as an optical frequency reference for frequency stabilized lasers (partner: Bureau National des Poids et Mesures, Paris, Niels Bohr Institute, Copenhagen, Humbolt-Universitaet zu Berlin, Max Planc Institute Fuer Quantenoptik, Muenchen, Physikalish-Technische Bundesanstalt Braunschweig, aj.), F. Petrů, 1999–2003
[462] Software for laser tuning and absorption spectra recording (developed for own use), O. Číp, 2001
[463] Implementation of a couple of tunable semiconductor lasers with external resonator for interferometric profilemeter. (partner: FME BUT), J. Lazar, 2001–2002
[464] Temperature controller – digital selflearning termostat and laser diode wavelength regulator. (developed for own use), O. Číp, 2001–2002
[465] Laser diode current controller with high level of protection against EMI (developed for own use), J. Lazar, 2001–2002
[466] Universal system of analog modules for absorption spectroscopy and frequency stabilization of lasers. (developed for own use), J. Lazar, 1999–2002
[467] Confocal Fabry-Perot scanning interferometers for spectral analyses of lasers operating at several different wavelengths (developed for own use), J. Lazar, 2002–2003
[468] Special optical filters, dichroic splitters and mirrors, and antireflection coatings for optical elements (partner: Institute of Landscape Ecology ASCR, Institute of Analytical Chemistry ASCR, Institute of Biophysics ASCR, etc.), P. Pokorný, 1999–2003
[469] Device for the measurement of thermal radiation emissivity at cryogenic temperatures (developed for own use), P. Hanzelka, 2003
[470] Computer controlled system of optical tweezers and laser scalpel. (developed for own use), P. Zemánek, 2001
[471] Superconducting magnet for low-temperature nuclear orientation of radioactive samples with a possibility of measurement in two orthogonal directions (partner: Dept. of low-temperature physics, Fac. of mathematics and physics, Charles Univ. Praha), A. Srnka, 1999
[472] Testing device for the measurement of parasitic heat flows into low-temperature parts of helium expasion turbines and compressors under conditions very close to their real-life arrangement (partner: PBS, a. s. Velká Bíteš), A. Srnka, 2001
[473] Helium bath cryopump for ultra-high vacuum, employing gas condensation on a 4.2 K cryopanel and attaining very low liquid helium consumption (developed for own use), P. Hanzelka 2002
[474] Cryogenic part of a scanning microscope with vector Hall probe (partner: ELÚ SAV Bratislava), P. Hanzelka, 2003
[475] Device for rapid experimental determination of thermal conductivity of the shafts of cryogenic machines in the temperature range of 4.2 K to 350 K (partner: PBS, a. s. Velká Bíteš), P. Hanzelka, 2003

Institute of Scientific Instrument

Academy of Sciences of the Czech Republic

1999–2003

Project editor: Pavel Zemánek
Editorial co-ordinator: Petr Jedlička

Cover design: Hana Bartošková
Prepress and Print: CCB, s. r. o.

Number of copies: 500
Publish: ISI ASCR, Královopolská 147, Brno, Czech Republic, 2004
ISBN 80-239-3103-2