
ISI
ASCR
Institute
of Scientific
Instruments
AS CR, v.v.i.

Institute of Scientific Instruments of the ASCR, v.v.i.

Academy of Sciences of the Czech Republic

ISI ASCR
Institute of Scientific Instruments AS CR, v. v. i.

MISSION

To carry out scientific research on physical methods of the study of matter, special technologies and new instrumentation principles, to contribute to the utilization of its research results, and to provide infrastructure for research.

PRINCIPAL ACTIVITIES

Scientific research in the field of methodology of physical properties of matter, in particular in the field of nuclear magnetic resonance, electron microscopy and microanalysis, quantum light generation, measurement and processing of biosignals, research and construction of scientific instruments and their components, and research of special technologies and methods of data processing.

– Contribution to raising the level of knowledge and education and to utilising the results of scientific research in practice
– Acquisition, processing and dissemination of scientific information and issuing scientific publications (monographs, journals, proceedings, etc.)
– Carrying out doctoral study programmes in cooperation with universities
– Training of young scientists
– Promoting of international cooperation within the scope of ISI activities
– Organization of scientific meetings, conferences and seminars at national and international level
– Providing infrastructure for research
– Pursuing ISI aims both independently and in cooperation with universities, other research and professional institutions and private companies

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A view of ISI ASCR, v. v. i. in the year 2013 (on the left) and the same infrastructure in the year 1967

STATISTICS 2012

- **Financial resources in thousands CZK**
- Resources for expensive equipment and construction: 130 351
- from Academy of Sciences of the Czech Republic: 4 705
- from infrastructural project ALISI: 125 646
- **Operating resources**: 113 363
- from Academy of Sciences of the Czech Republic: 44 201
- from Czech projects (incl. ALISI): 68 675
- from foreign projects: 487
- **Revenue from contractual research:** 7 012
- **Number of employees:** 138 (full time equivalent FTE)
- **Number of researchers:** 75 FTE
- **Number of PhD students:** 15 FTE
- **Number of papers in scientific journals with impact factor:** 42
- **Number of filed patents:** 2

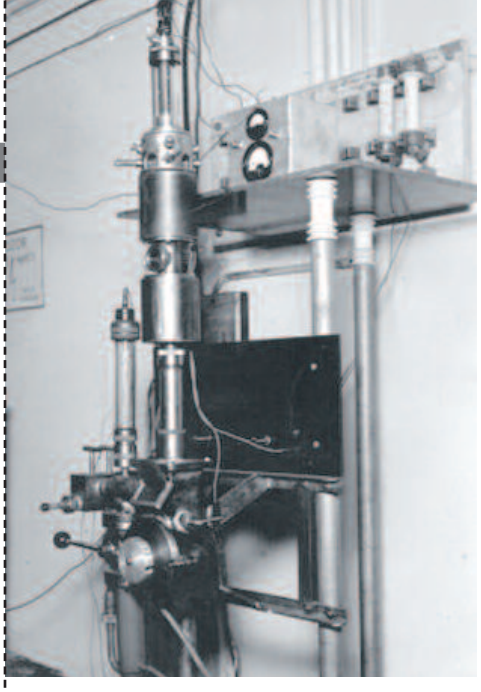
BRIEF HISTORY & RECENT ACHIEVEMENTS

HISTORY OF ISI

1953 – Establishment of the Development Workshop of the Czechoslovak Academy of Sciences (DWCAS)
1957 – DWCAS renamed to Institute of Scientific Instruments (ISI)
1960 – Laboratory of Electron Optics and Laboratory of Industrial Electronics joined ISI in a new building
1961 – 1990 Armin Delong appointed the director of ISI
1993 – Academy of Sciences of the Czech Republic established as the Czech descendant of the former Czechoslovak Academy of Sciences
2007 – ISI transformed to public research body (v.v.i.)

REMARKABLE ACHIEVEMENTS IN THE PAST

1950 – The first Czechoslovak transmission electron microscope (TEM) developed at the Laboratory of Electron Optics (LEO)
1951 – Tesla BS 241 – the first Czechoslovak commercial TEM developed at LEO and TESLA company
1954 – The world's first table-top TEM developed at LEO



The first Czechoslovak transmission electron microscope at ISI in 1950

Table-top transmission electron microscope – Gold medal at the Brussels World's Fair EXPO58 (1958)

New infrastructure – ALISI, front view

New infrastructure – ALISI

1958 – Gold medal at the Brussels World's Fair EXPO58 for the table-top TEM
1959 – TEM with resolution below 1 nm
1960 – The first Czechoslovak nuclear magnetic resonance (NMR) spectrometer (30 MHz) developed at ISI
1963 – The first Czechoslovak HeNe laser developed at ISI
1965 – The first Czechoslovak ruby laser developed at ISI
1966 – NMR spectrometers commercially produced by the TESLA company
1971 – Gold medal at the International Brno Fair for laser interferometric system LA3000 developed at ISI and produced by the Metra Blansko company
1972 – The first Czechoslovak superconducting magnet for NMR developed at ISI
1976 – Scanning electron microscope with a cold field emission gun
1978 – The first Czechoslovak Fourier NMR spectrometer
1985 – The first electron beam lithograph in Eastern Bloc developed at ISI and commercialized by the TESLA company
1987 – Original setup of iodine-stabilized HeNe laser for metrological purposes
1987 – The first Czechoslovak ultra-low loss cryostat for NMR magnets developed at ISI
1990 – The first Czechoslovak ESEM, AQUASEM I, was developed at ISI

RECENT IMPORTANT ACHIEVEMENTS AND AWARDS

2000 – New type of electron microscope using very slow electrons was demonstrated
2004 – New method of length measurement using optical cavity with sub-nanometer resolution
2004 – New environmental scanning electron microscope AQUASEM II was developed at ISI
2004 – Development of various nanocomposite coatings used as hard solid lubricants in cooperation with Masaryk University, Aarhus university Denmark, University of West Bohemia Pilsen, Czech Technical University in Prague, Brno University of Technology, Euroconsult and the Institute of Electrical Engineering of the Slovak Academy of Sciences
2004 – Development of a new experimental apparatus for the measurement of low temperature radiative properties of materials used in cryogenics
2005 – prof. Armin Delong was awarded the national prize Czech Head
2005 – The world's first concept of optical conveyor belt was presented and demonstrated in cooperation with University of St. Andrews (UK)
2005 – Discovery of the injected charge contrast in very low energy electron microscopy
2005 – New method of analysis and optimization of broadband, high dynamic range acquisition systems

The first Czechoslovak HeNe laser (1963)


La technique au service de la paix et du progrès

Le jury du concours pour l'appréciation des meilleurs produits exposés à la Foire Internationale de l'Industrie Mécanique de Brno, ayant lieu du 11 au 20 septembre 1971, a attribué au produit

Interféromètre á laser universel LA 3000

fabriqué par

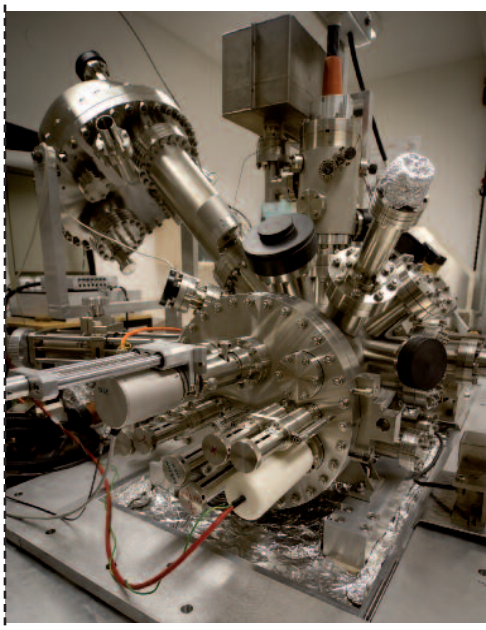
METRA Blansko n. p., Blansko, ČSSR
Ústav přístrojové techniky ČSAV, Brno, ČSSR

la médaille d'or

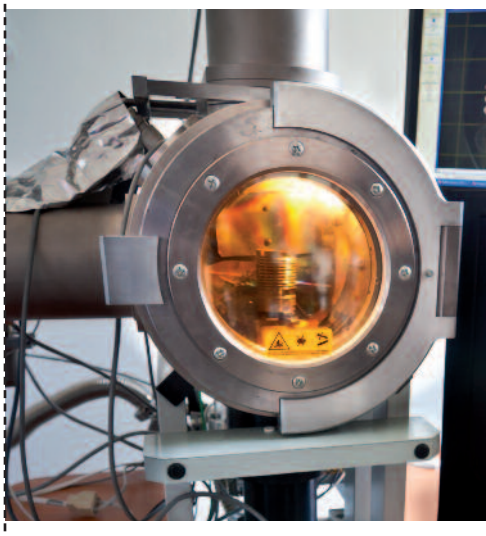
aux termes des Règlements pour l'appréciation des produits

Gold medal for laser interferometric system (1971)

2006 – New knowledge in event-related desynchronization/synchronization from intracerebral recordings
2006 – Original concept of optical sorting of sub-micrometer objects in movable optical fringes
2006 – New method of electron microscopy of water-containing samples
2006 – Electron beam pattern generator BS601M for diffractive optical elements is installed at the Optaglio company
2007 – Original model of estimation of sudden heart arrest using QT intervals and heartbeat rate
2007 – Prototype of an original electron beam welding machine for Focus GmbH
2007 – Demonstration of a narrowband power laser based on a laser diode array for the preparation of hyperpolarized xenon
2008 – Description and experimental study of optical binding of microparticles in cooperation with University of St. Andrews
2008 – Novel laser nanocomparator for the calibration of length sensors, in cooperation with the Mesing company and Czech Metrology Institute
2008 – Unique compact system for laser micromanipulation or microdissection in cooperation with Meopta-Optika company
2009 – New algorithm (QuaM-EPG) has been developed for computer simulation of the evolution of coupled spin systems during cyclic excitation in fast proton MR spectroscopic imaging in high magnetic field
2009 – Original approach for the calculation of aberration coefficients using the results of accurate electron ray tracing
2009 – Novel sample nanopositioning system for nanometrology AFM using interferometric measurement in all six degrees of freedom (axial motions and angle deviations) was developed and tested at ISI
2009 – Application Laboratories of Microtechnologies and Nanotechnologies (ALISI) were founded and funded from EC and CR
2010 – New method of graphene investigation using very slow electrons
2010 – Description of self-organization of microparticles caused by their mutual optical interaction
2010 – Minimization of QT hysteresis by a transfer function description of the QT/RR coupling in cooperation with Mayo Clinic, Rochester
2011 – Verification of MR-based perfusion imaging for biomedical research and cancer diagnostics
2011 – New system of biological automated radiotracking system of flying small vertebrates (BAARA)
2011 – New method for calculation and optimization of optical properties of ion or electron systems with perturbed axial symmetry
2011 – Experimental determination of heat transfer efficiency in natural turbulent convection at high Rayleigh numbers in cold helium gas
2012 – Original theoretical and experimental study of near field heat transfer at low temperatures
2012 – Identification of the local crystallographic orientation from the reflectance of very slow electrons
2012 – Interferometer with compensation of the fluctuations of the refractive index of air
2012 – Measure of the QT–RR dynamic coupling in patients with the long QT syndrome
2012 – Original ionisation detector of secondary electrons with electrostatic separator was patented
2012 – New methods for magnetic resonance and ultrasound quantitative perfusion measurement
2012 – Novel system for contactless calibration of gauge blocks, in cooperation with the Mesing company (gold medal at the 54th International Engineering Fair, Werner von Siemens Award for the best innovation in 2012)
2013 – Experimental demonstration of optical tractor beam and its applications



Ultrahigh vacuum scanning low energy electron microscope



Electron beam welder MEBW-60/2

Group of Electron Optics
Department of Electron Microscopy

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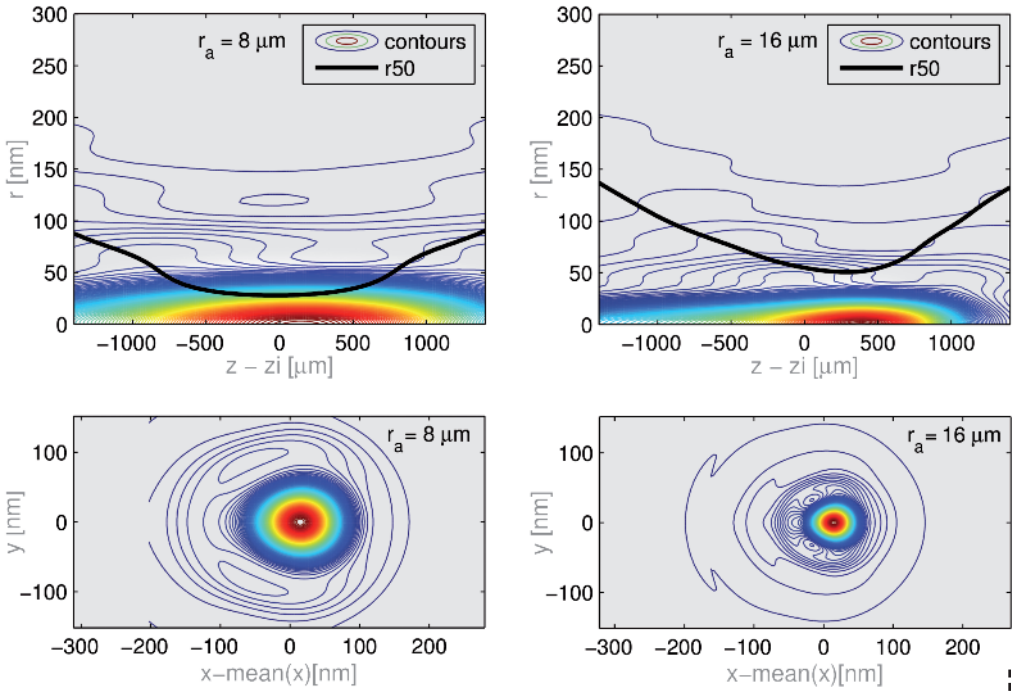
THEMATIC RESEARCH FOCUS

Research area
– Electron and ion optics
– Electron optical design and simulation
– Design of detection systems
– Simulation of ion and electron sources

Excellence
– Electron and ion optical simulation of nonstandard systems

Mission
– Development of new simulation methods in electron and ion optical systems
– Simulation and design of nonstandard electron and ion optical systems



Beam profiles with diffraction

DEVELOPED TECHNOLOGIES

Content of research
– Calculations of higher-order aberrations and current density profiles
– Space charge and stochastic Coulomb interactions
– Simulation of interaction of electrons with gas molecules

Main capabilities

Basic research

– exploring the resolution limits of electron and ion optical systems due to aberrations, Coulomb interactions and diffraction
– simulation of the electron and ion source properties

Applied research

– Design of electron and ion optical instruments
– Development of software for simulation of non-standard electron and ion optical systems

Fields of research results application

– Charge particle optics
– Ion mass spectroscopy
– Materials science

KEY RESEARCH EQUIPMENT

Software for simulation of electron and ion optical systems developed at the ISI

ACHIEVEMENTS

- **Simulation of Coulomb interactions in electron and ion optical systems including the region in the vicinity of emitting surfaces and their influence on beam properties and resolution of the system.**

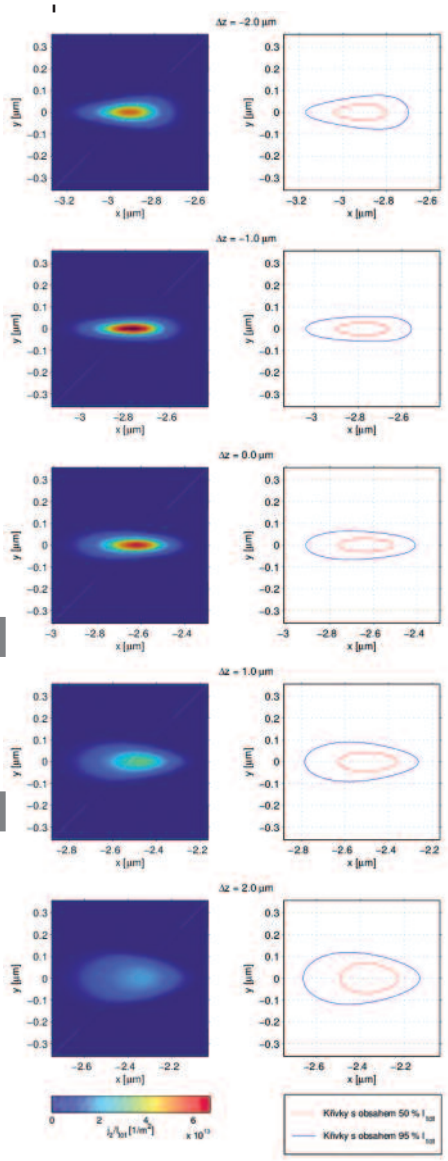
– Radlička, T., Lencová, B., *Coulomb interactions in GaLMIS*. Ultramicroscopy 108, (2008), p. 445–454
– Jansky, P., Zlámal, J., Lencová, B., Zobač, M., Vlček, I., Radlička, T., *Numerical simulations of the thermionic electron gun for electron-beam welding and micromachining*. Vacuum 84, (2009), p. 357–362
– Radlička, T., Lencová, B., *Influence of clusters on BiLMIS properties.* Nucl. Instrum. Meth. A, 645, (2011), p. 124–129

- **Calculation of higher-order aberrations of electron and ion optical systems, calculation of current density beam profiles**

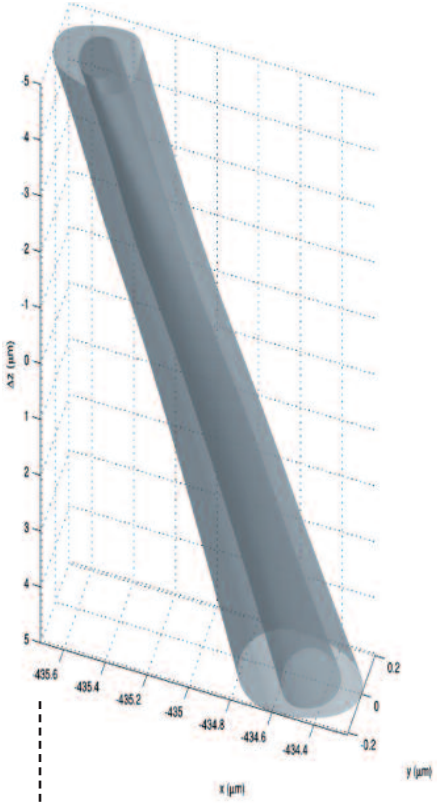
– Radlička, T., *Lie Algebraic Methods in Charged Particle Optics.* Adv. in Imagin. Electr. Phys. 151, (2008), p. 241–362
– Radlička, T., Lencová, B., *Determination of analytical expansion from numerical field data.* Ultramicroscopy 110, (2010), p. 1198–1204
– Oral, M., Lencová, B., *Calculation of aberration coefficients by ray tracing*. Ultramicroscopy 109, (2009), p. 1365–1373

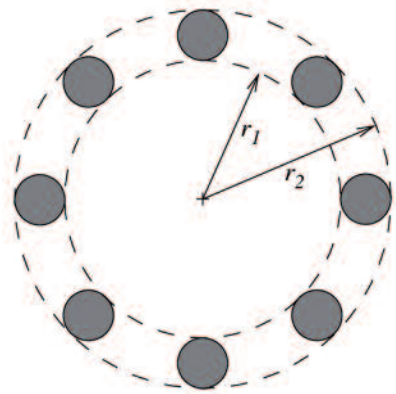
- **Simulation of nonstandard electron and ion optical systems (electron mirror, extraction optics of Time-of-Flight detectors, Wien Filter with permanent magnets, general 3D optical systems), correctors and misalignment aberrations**

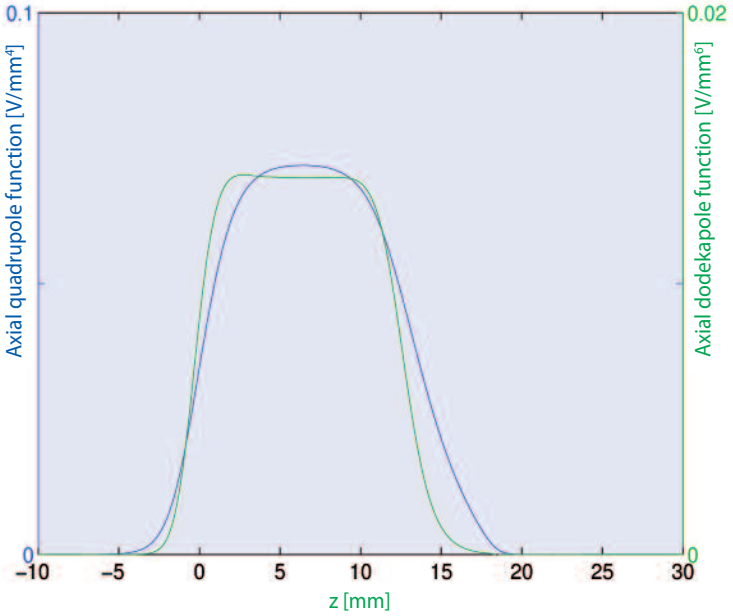
– Oral, M., Radlička, T., Lencová, B., *Effect of sample tilt on Photo Emission Electron Microscopy resolution.* Ultramicroscopy 119, (2012), p. 45–50
– Oral, M., Lencová, B., *Correction of sample tilt in FIB instruments.* Nucl. Instrum. Meth. A 645, (2011), p. 130–135



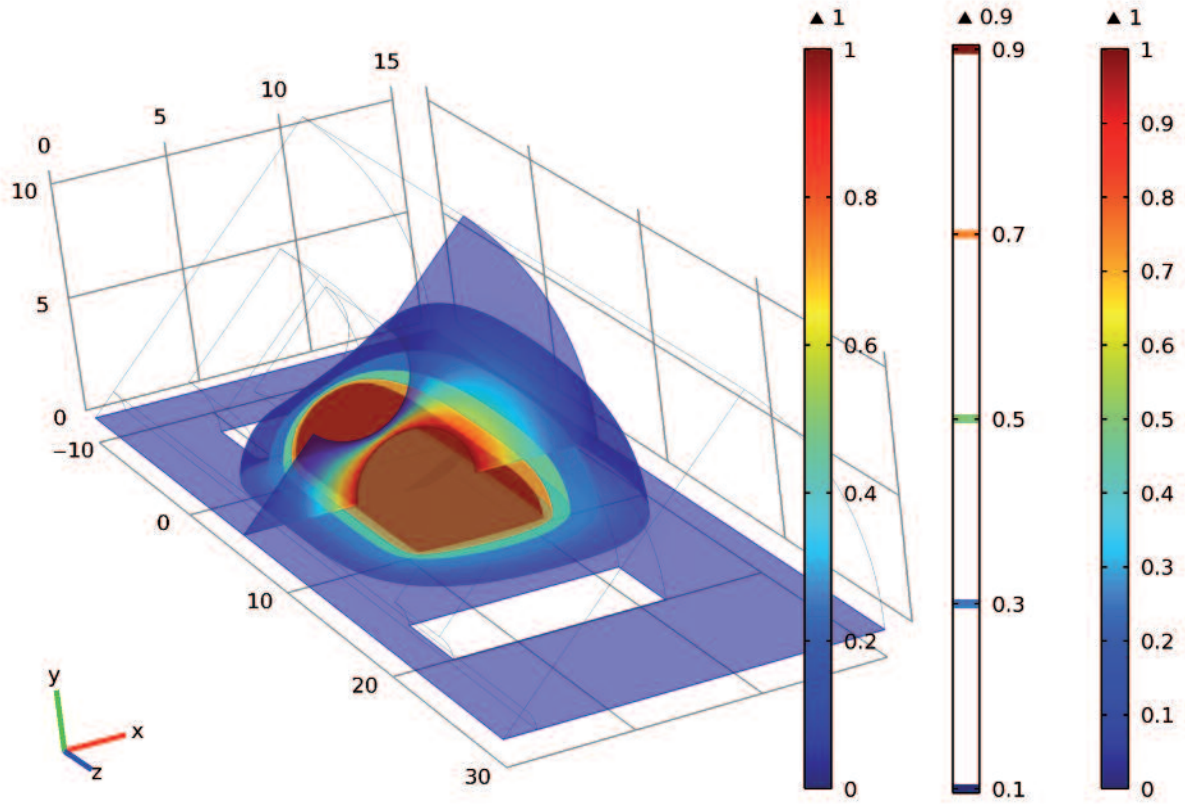
Beam profiles of a deflected beam







Slice: Electric potential (V) Isosurface: Electric potential (V)
Slice: Electric potential (V)



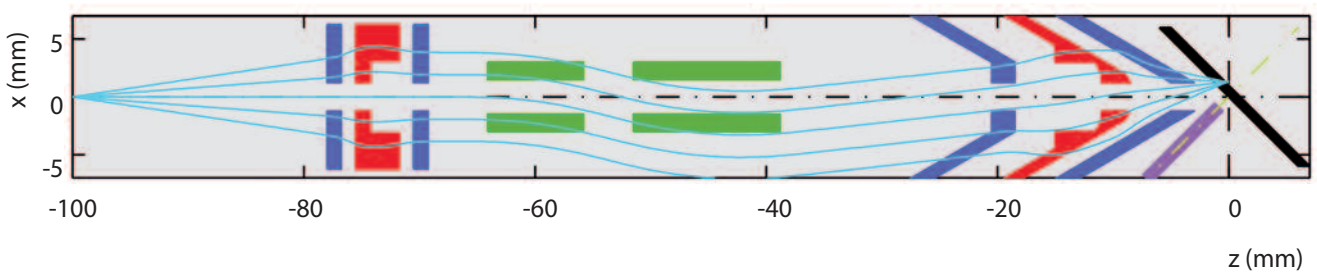
3D field of a stigmator

MAIN COLLABORATING PARTNERS

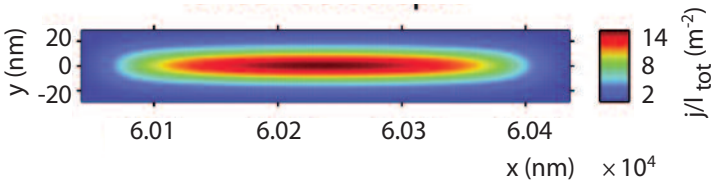
Collaboration with academic partners
Brno University of Technology (Brno, CZ)

Collaboration with companies
ION-TOF, GmbH (Muenster, D)
FEI Czech Republic (Brno, CZ)

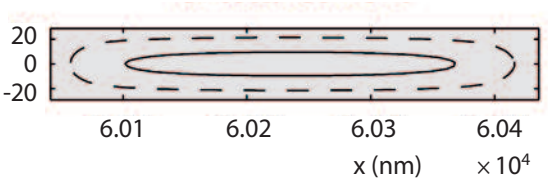
Optical system, selected trajektories (15× vertically magnified)



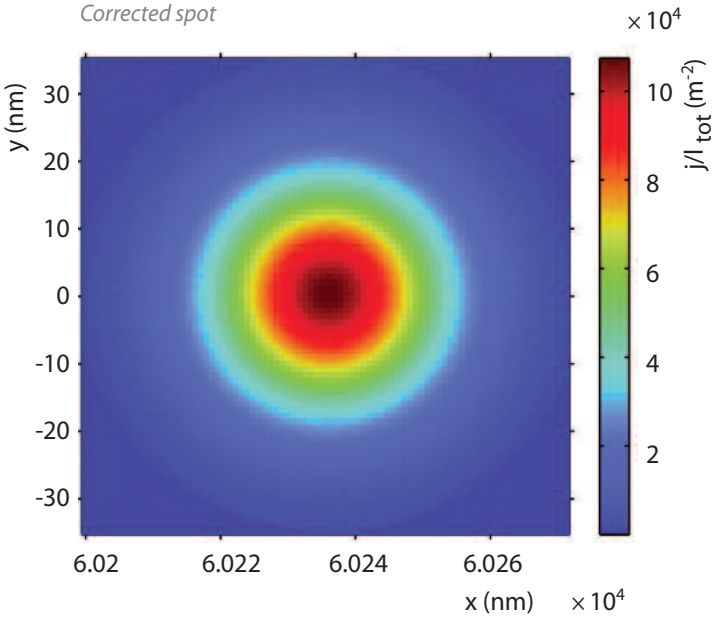
Uncorrected spot



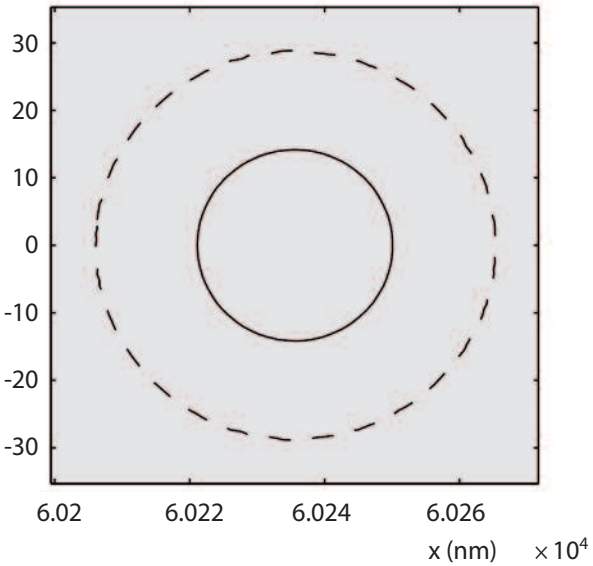
Contours for 50 %, 95 % of total current



Corrected spot



Contours for 50 %, 95 % of total current



Offers

– Partnership in international projects
– Design of electron and ion optical systems
– Simulation and design of electron and ion sources
– Consultation in charged particle optics

Requirements

– Collaboration with industrial partners in projects in applied science
– Collaboration with academic partners in development of custom instruments using charged particles

Correction of sample tilt in a SIMS

Group of Microscopy and Spectroscopy of Surfaces

Department of Electron Microscopy

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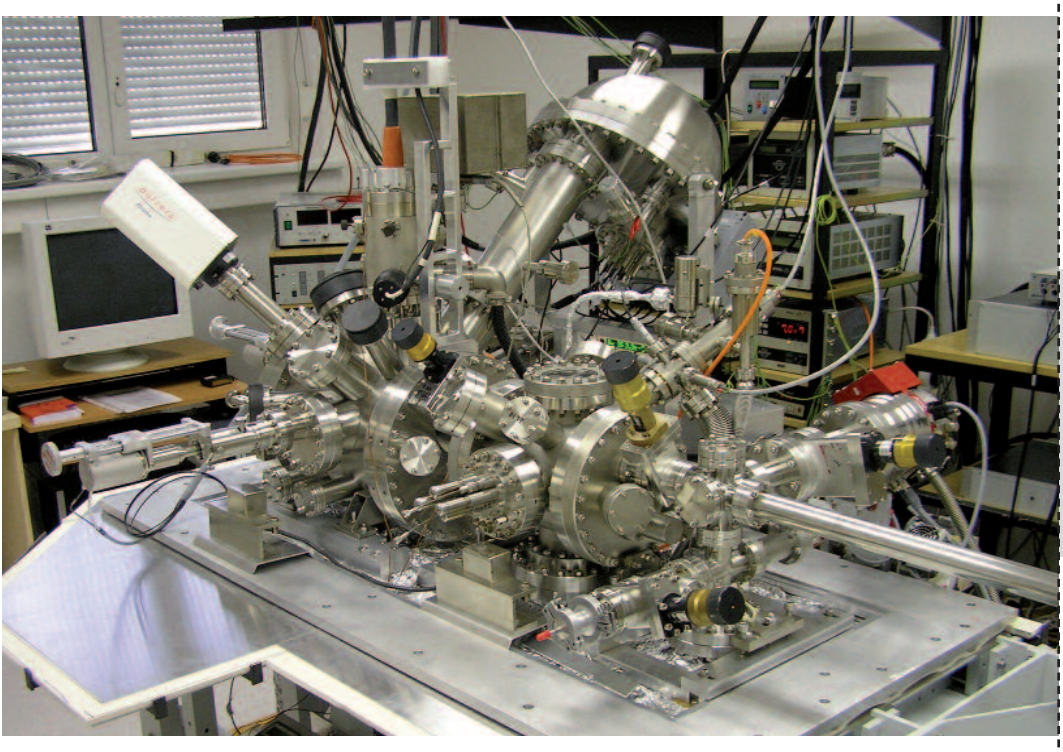

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Ultrahigh vacuum apparatus for scanning microscopy with very slow electrons and for Auger electron spectromicroscopy of atomically clean or in-situ prepared surfaces

THEMATIC RESEARCH FOCUS

Research area

– Low energy scanning electron microscopy, Auger electron spectroscopy and spectromicroscopy, surface physics
– Micro- and nanostructure of advanced materials, thin films

Excellence

Contrast formation at low and very low energies in the scanning electron microscopy (SEM) both in the reflection and transmission mode with lateral resolution of units of nm, with an application to the study of advanced materials and biostructures

Mission

Development of advanced methods of scanning electron microscopy and their application in materials and biomedical sciences and technologies

DEVELOPED TECHNOLOGIES

Content of research

– Methodology for the formation of beams of very slow electrons and their manipulation aimed at the illumination of solid surfaces or free-standing films, including vortex electron beams

– Theory of interaction of slow electrons with matter, generation of signals released under impact of electrons, analysis of information carried by species emitted under electron bombardment
– Detection of electrons emitted from surfaces or transmitted through films, including multichannel detection of angular and energy distribution of emitted electrons in SEM, aiming at ultimate angular, energy and lateral resolution
– Interpretation of scanned electron beam micrographs and Auger electron spectromicrographs
– Quantitative scanning electron microscopy, especially at low energies

Main capabilities

Basic research

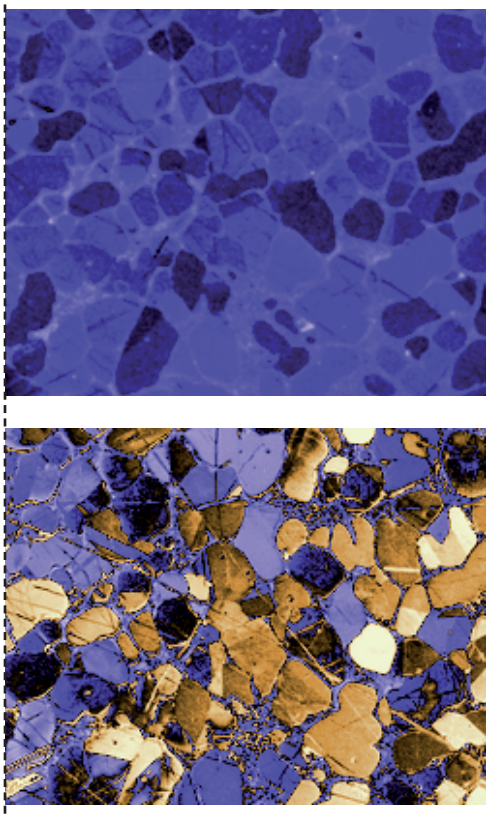
– Interaction of slow electrons with matter
– Reflectance and transmittance of slow and very slow electrons
– Generation of Auger electrons
– Theory of contrast mechanisms in scanning electron microscopy
– Relations between the state of surface and its response to electron bombardment
– Principles of detection of low energy electrons
– 3D distribution of electromagnetic fields and motion of charged particles in them

Applied research

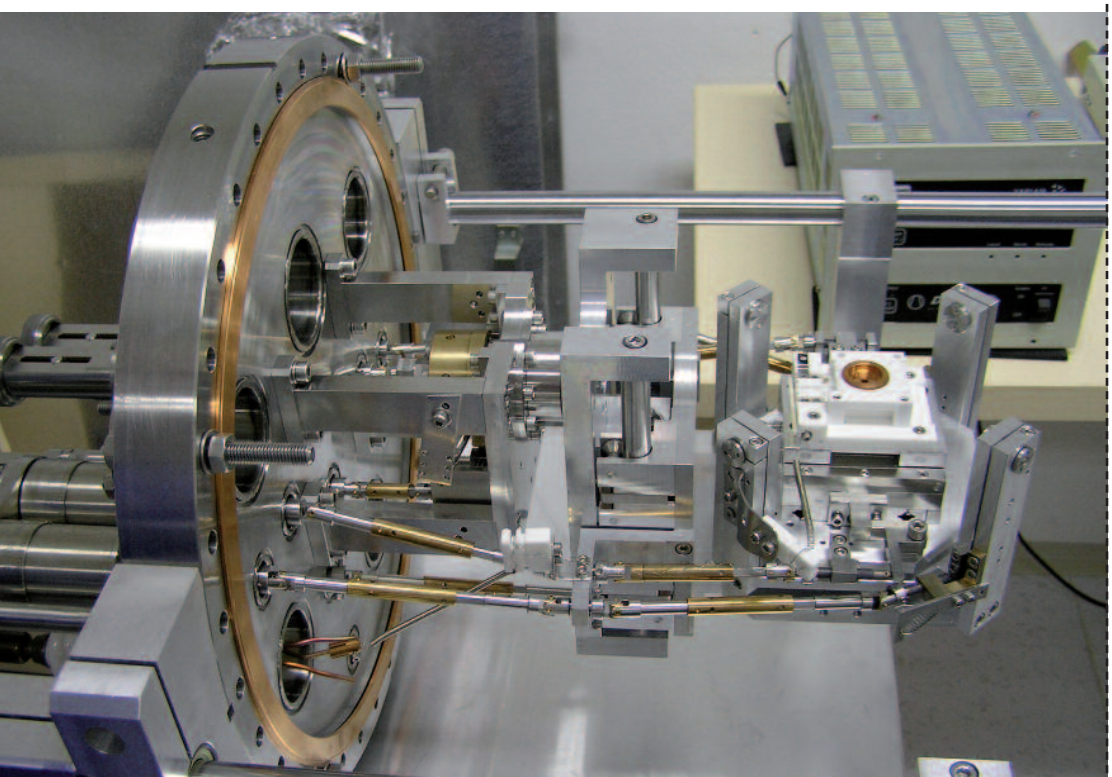
– Ultrahigh vacuum scanning low energy electron microscopy
– Analysis of phases in complex materials, e.g. steels
– Analysis of surface coatings and thin films, Auger electron spectromicroscopy
– Analysis of ultrathin tissue sections and free-standing films or 2D crystals
– Simulation of electron trajectories in electron optical elements and systems
– Design of multichannel electron detectors

Fields of research results application

– Materials science (micro- and nanostructure of materials)
– Life sciences (ultrathin tissue sections, biological crystals)
– Nanotechnologies
– Industry of scientific instrumentation
– Metallurgy
– Industry of polymers, composites, surface coatings, etc.
– Medicine



Structure of X210Cr12 stainless steel with the grain contrast enhanced due to a decrease of the incident electron energy: original micrograph taken at 6 keV (top), and at 500 eV using the cathode lens with a biased sample (bottom); pseudo-color images



Specimen stage of the ultrahigh vacuum scanning low energy electron microscope

KEY RESEARCH EQUIPMENT

– Ultrahigh vacuum scanning low energy electron microscope of in-house design consisting of the observation and preparation chambers, equipped with in-situ technologies for specimen treatment, namely ion beam cleaning, heating and deposition of thin films, and auxiliary techniques, namely Auger electron spectrometry and mass spectroscopy of released gases
– Attachments for several commercial scanning electron microscopes allowing sample observation with low and very low energy electrons
– Equipment for the preparation of clean, smooth or coated specimens

ACHIEVEMENTS

Study of transmissivity of ultrathin free standing foils at very low energies in scanning electron microscope with a high contrast and a high lateral resolution in the nm scale.

– Müllerová, I.; Hovorka, M.; Frank, F.; *A method of imaging ultrathin foils with very low energy electrons.* Ultramicroscopy 119, (2012), p. 7881

Characterisation of crystal orientation with a high lateral resolution from the reflectivity of electrons at impact electron energies between 50 eV and 1 eV. The information is proportional to the local density of electron states.

– Pokorná, Z.; Mikmeková, Š.; Müllerová, I.; Frank, L.; *Characterization of the local crystallinity via reflectance of very slow electrons.* Appl. Phys. Lett. 100, (2012), 261602, p. 1–4

Applications of low energy SEM in nanotechnology.

– Müllerová, I.; Hovorka, M.; Mika, F.; Mikmeková, E.; Mikmeková, Š.; Pokorná, Z.; Frank, L.; *Very low energy scanning electron microscopy in nanotechnology.* International Journal of Nanotechnology 9, (2012), p. 695–716

Development of new highly sensitive method for the determination of crystallographic orientation of grains from maximum anisotropy of reflected electrons. Tiny changes in the lattice constant caused by local deformations are made visible. The method has a very high sensitivity to the local 3D inner potential.

– Mikmeková, Š.; Hovorka, M.; Müllerová, I.; Man, O.; Pantělejev, L.; Frank, L.; *Grain contrast imaging in UHV SLEEM.* Materials Trans. 51, (2010), p. 292–296

A method for quantitative measurements of dopant level in semiconductors using the secondary electron yield at optimum primary beam energy.

– Frank, L.; Müllerová, I.; Valdaitsev, D.; Gloskovskii, A.; Nepijko, S.; Elmers, H.; Schönhense, G.; *The origin of contrast in the imaging of doped areas in silicon by slow electrons.* J. Appl. Phys. 100, (2006), 093712, p. 1–5
– Müllerová, I.; El Gomati, M. M.; Frank, L.; *Imaging of the boron doping in silicon using low energy SEM.* Ultramicroscopy 93, (2002), p. 223–243

An overview about the development of the scanning low energy electron microscopy.

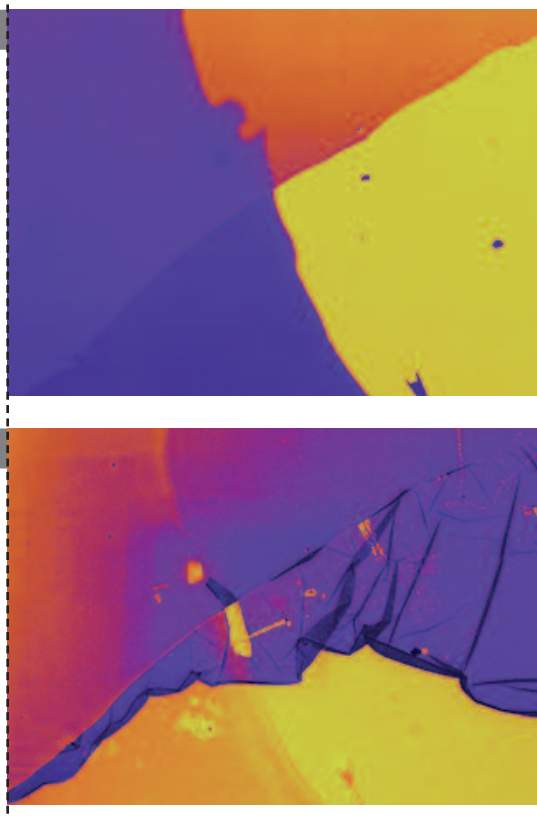
– Müllerová, I.; Frank, L.; *Scanning low energy electron microscopy.* Advances in imaging and electron physics 128, (2003), p. 309–443

An automatic method for the imaging of uncoated and nonconductive specimens by fine-tuning the primary beam energy so that the number of incoming and outgoing electrons from the specimen is equal.

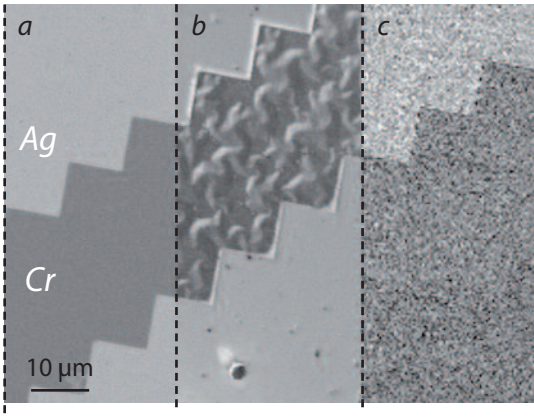
– Frank, L.; Zadražil, M.; Müllerová, I.; *Scanning electron microscopy of nonconductive specimens at critical energies in a cathode lens system.* Scanning 23, (2001), p. 36–50

Mini scanning low energy electron microscope with the total length of 10 cm was designed and tested for the in situ observation of surfaces by Auger electrons and by low energy electrons. Six channel detectors were designed for the collection of Auger and low energy electrons.

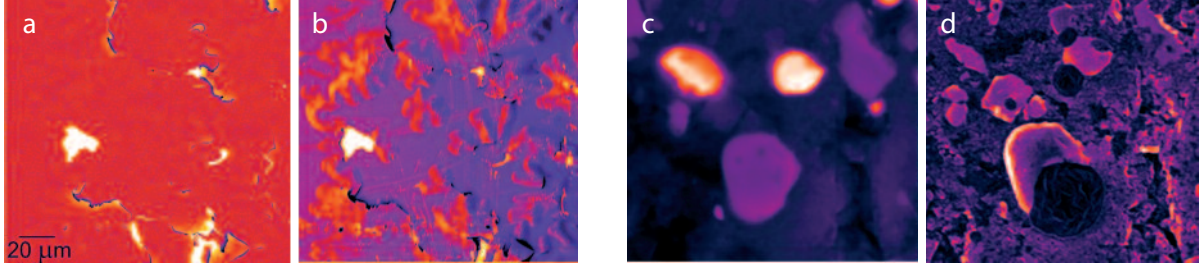
– Frank, F.; Müllerová, I.; El Gomati, M. M.; *A novel in-lens detector for electrostatic scanning LEEM mini-column.* Ultramicroscopy 81, (2000), p. 99–110



Structure composed of mutually overlapped thin layers of Au and GeSi on a silicon substrate, imaged with 9800 eV electrons (top) and with 850 eV electrons (bottom), showing the high surface sensitivity of low energy electrons



Surface analysis tools demonstrated on a 100 nm microcrystalline chromium foil, electron beam lithograph patterned on a silver-coated silicon wafer: a) scanning electron microscopy, image taken at 6 keV; b) scanning low energy electron microscope, image taken at 1 keV, surface crystallinity is clearly visible; c) elemental mapping using Auger electron spectroscopy, chromium LMM peak at 482 eV



Delaminated 200 nm CN_x layer on Si imaged with 4 keV electrons (a) and with 500 eV electrons (b) emitted from the sample biased to 4 kV

Composite of AlB_2, MgB_2, TiB_2 and ZrB_2 particles embedded in an Al matrix and imaged using 20 keV electrons (c) and 1 keV (d) with the sample biased to 10 kV

Pseudo-color images

First experiments showing the diffraction contrast in SEM and surface crystal orientation of clean Si were performed.

– Frank, F.; Müllerová, I.; Faulian, K.; Bauer, E.; *The scanning low-energy electron microscope: first attainment of diffraction contrast in the scanning electron microscope.* Scanning 21, (1999), p. 1–13

European and US patent

– El Gomati, M. M.; Frank, L.; Müllerová, I.; Electron detectors, EP1012867 (2006), US 6,570,163 (2003)

Applied result

– Müllerová, I.; Frank, L.; Klein, P.; Sýkora, J.; Detector of transmitted very low energy electrons for the ultra high vacuum scanning low energy electron microscope, functional module, (2012)

MAIN COLLABORATING PARTNERS

Collaboration with academic partners

– University of Toyama (Toyama, Japan)
– University of York (York, UK)
– University of Zürich (Zürich, CH)
– University of West Bohemia (Plzeň, CZ)
– Biology Centre of the ASCR (CZ)
– Institute of Macromolecular Chemistry of the ASCR (CZ)
– Brno University of Technology (Brno, CZ)
– Masaryk University (Brno, CZ)

Collaboration with companies

– JFE Steel Corporation (Tokyo, Japan)
– Voestalpine Stahl (Wien, Austria)
– Research and Testing Institute (Plzeň, CZ)
– Delong Instruments (Brno, CZ)
– FEI Czech Republic (Brno, CZ)
– FEI Company (Hillsboro, OR, USA)
– Crytur (Turnov, CZ)

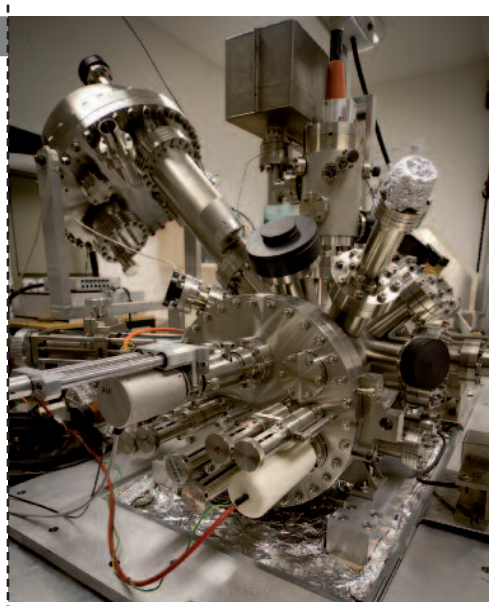
EXPECTATIONS

Offers

– Partnership in international projects
– Analysis of samples of advanced materials (imaging of various types of precipitates even under the sample surface, contrast measurement of graphene and other thin foils in reflected and transmitted signal; study of clean surfaces, crystallographic orientation of ultrafine grains; measurement of dopant concentration)
– Cooperation on nanostructure tasks difficult to solve with traditional electron microscopic methods (e.g. biological samples, polymers etc.)
– Design of detection systems for instruments using charged particles (electron and ion microscopes and lithographs)
– Contrast formation in electron and ion microscopes and lithographs, study of signal trajectories and interaction of charged particles with matter
– Design and manufacture of ultrahigh vacuum components and systems

Requirements

– Provision of samples of advanced materials
– Cooperation on nanostructure tasks difficult to solve with traditional electron microscopic methods
– Collaboration with industrial and academic partners
– Cooperation on vortex electron beams



Manipulators and feedthroughs controlling the specimen stage of the ultrahigh vacuum scanning low energy electron microscope

Group of Microscopy and Microanalysis
Department of Electron Microscopy

ISI ASCR
Institute of Scientific Instruments AS CR, v. v. i.

THEMATIC RESEARCH FOCUS

Research area
– High resolution scanning electron microscopy (SEM)
– Imaging of nonconductors in SEM
– Low energy SEM
– Scanning transmission electron microscopy (STEM)
– Energy dispersive X-ray analysis (EDX)
– Electron backscatter diffraction analysis (EBSD)

Excellence
– Imaging of nonconductors (biological specimens) without conductive coating in standard vacuum high resolution SEM.
– Imaging of materials at low energies of incident electrons.

Mission
Development of new high-resolution SEM imaging methods for various kinds of materials at low energies.

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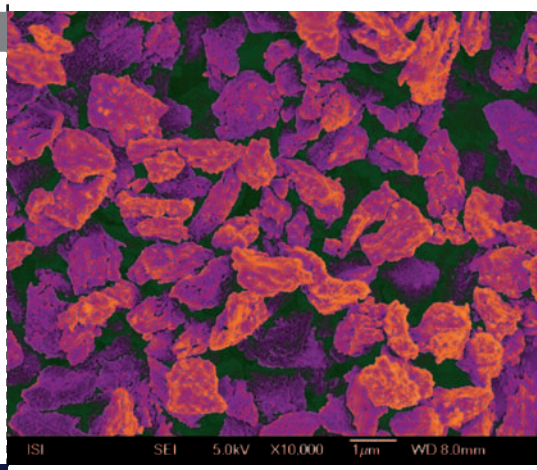
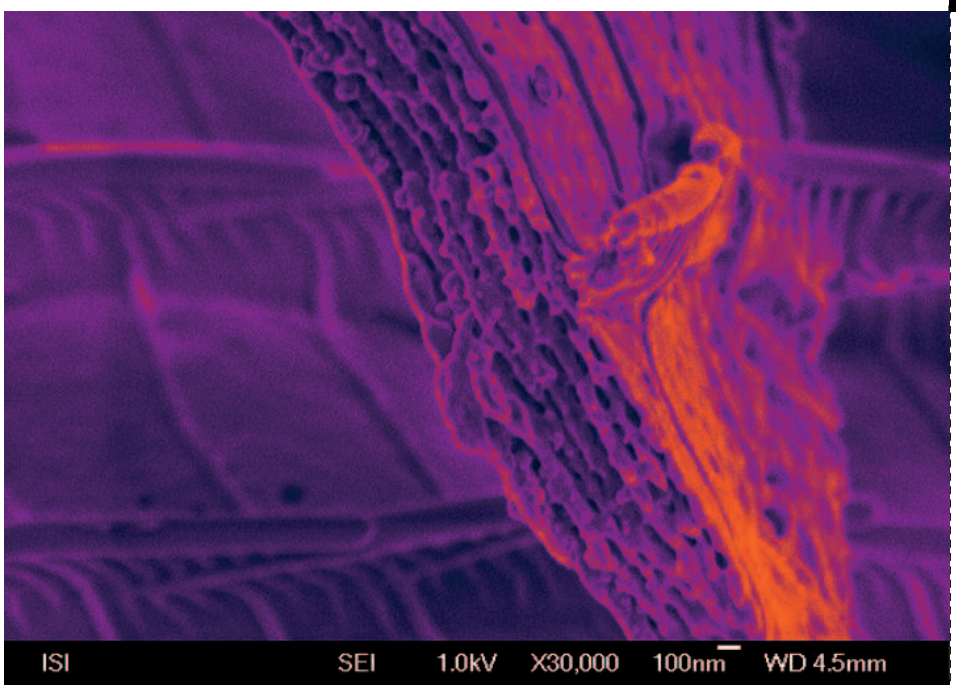
DEVELOPED TECHNOLOGIES

Content of research
– Experimental and theoretical activities aimed at the imaging of specimens by electrons with energy below 1000 eV, suitable for high-resolution imaging of nonconductors without conductive coating. Imaging in reflection and transmission mode.
– Elemental analysis of the sample by means of Energy Dispersive X-ray (EDX) spectroscopy.
– Determination of crystallographic orientation, defect studies, phase and grain boundary identification by means of Electron Backscatter Diffraction (EBSD).



Synthetic diamond powder



Butterfly wing structure

High resolution SEM Jeol 6700F

Main capabilities

Basic research

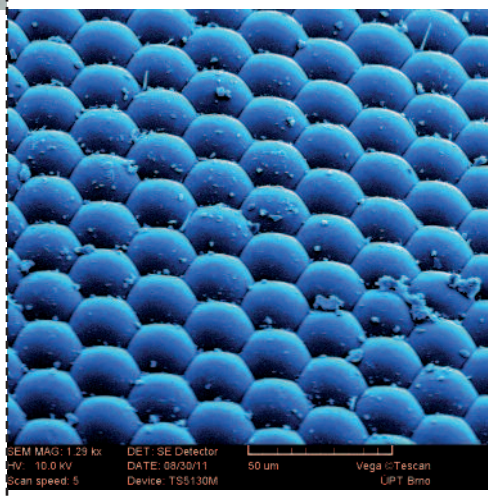
– Generation of signal electrons and their detection mechanisms in SEM

Applied research

– Imaging of metals, alloys, composite materials, polymers, electronics materials, ceramic materials, organic compounds and biological materials
– Complex sample analysis

Fields of research results application

– Materials engineering
– Life-sciences (especially molecular biology, biochemistry)
– Measuring instruments
– Plastics, polymers
– Glass, ceramics



Eye of a flies

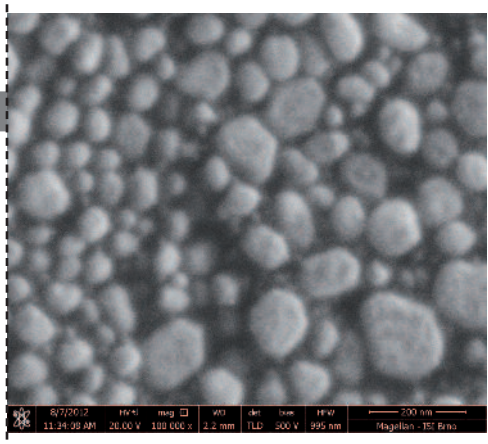


Image of gold on carbon test specimen at the lending energy of 20 eV

KEY RESEARCH EQUIPMENT

Scanning electron microscopes:

FEI MAGELLAN 400
JEOL JSM 6700F
TESCAN VEGA 5130

Analysers:

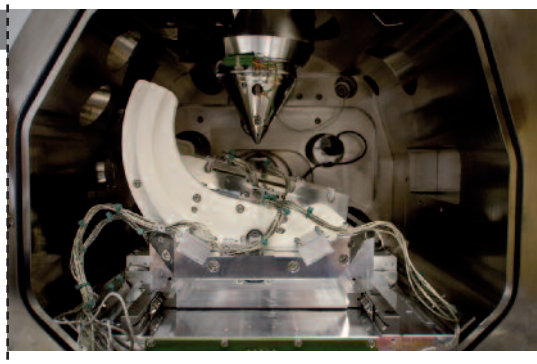
Energy Dispersive X-ray (EDX) analyzer (INCA 350 and EDAX Apollo X)
Electron Backscatter Diffraction (EBSD) Analyzer (Hikari)

Other:

Equipment for vacuum evaporation
Equipment for sputter deposition
Cutting machine

ACHIEVEMENTS

- **Mastering of original methods of biological specimen imaging without conductive coating.** This method reveals the real nanostructure and microstructure of the studied sample without coating artifacts. Recently we have focused on natural photonic crystals with interesting optical properties present in butterfly wings.
  - Mika, F.; Matějková-Plšková, J.; Jiwajinda, S. et al.; *Photonic Crystal Structure and Coloration of Wing Scales of Butterflies Exhibiting Selective Wavelength Iridescence.* Materials, 5, (2012), p. 754–771
  - Matějková-Plšková, J.; Mika, F.; Shiojiri, S. et al.; *Fine Structure of Wing Scales in Chrysozephyrus Ataxus Butterflies.* Materials Transactions 52, (2011), p. 297–303
- **Imaging of doped structures using SEM to reveal the distribution of dopants in semiconductor devices to improve the control of the manufacturing process and reduce the production costs.**
  - Hovorka, M.; Mika, F.; Mikulík, P. et al.; *Profiling N-Type Dopants in Silicon.* Materials Transactions 51, (2010), p. 237–242
  - Mika, F.; Frank, L.; *Two-dimensional dopant profiling with low-energy SEM.* Journal of Microscopy – Oxford 230, (2008), p. 76–83



Arrangement in the chamber of Magellan 400 SEM

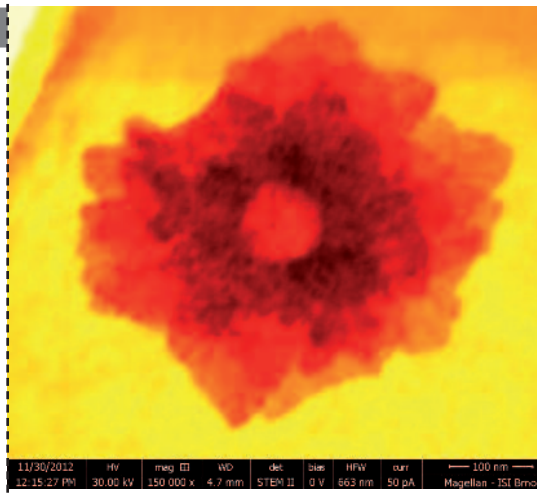
MAIN COLLABORATING PARTNERS

Collaboration with academic partners

Brno University of Technology (Brno, CZ)
Masaryk University (Brno, CZ)
University of Veterinary and Pharmaceutical Sciences (Brno, CZ)
Tomas Bata University (Zlin, CZ)
University of Toyama (Toyama, Japan)
Institute of Inorganic Chemistry ASCR, v. v. i. (Praha, CZ)
Institute of Analytical Chemistry ASCR, v. v. i. (Praha, CZ)
Institute of Physics of Materials ASCR, v. v. i. (Brno, CZ)

Collaboration with companies

Contipro (Dolní Dobrouč, CZ)
Synthesia (Pardubice, CZ)
EID Industrial Diamonds (London, GB)
BVT Technologies, a. s. (Brno, CZ)
Solartec, s. r. o. (Rožnov pod Radhoštěm, CZ)
SURO, s. r. o. (Praha, CZ)
AVX CZECH REPUBLIC, s.r.o. (Uherské hradiště, CZ)
Koito (Žatec, CZ)
Autopal (Uherské Hradiště, CZ)
SHM, s. r. o. (Šumperk, CZ)
Rohde & Schwarz International (Praha, CZ)



Carbon monolayers in STEM mode

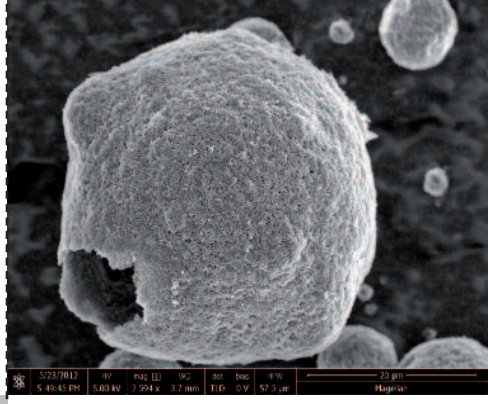
EXPECTATIONS

Offers

- Know-how in the field of scanning electron microscopy imaging and interpretation of results of different detection modes
- Know-how in the field of Energy Dispersive X-ray analysis
- Know-how in the field of Electron Backscatter Diffraction analysis

Requirements

– Collaboration with industrial partners in common projects dedicated to applied science
– Knowledge and technologies for materials analysis
– New complementary technologies



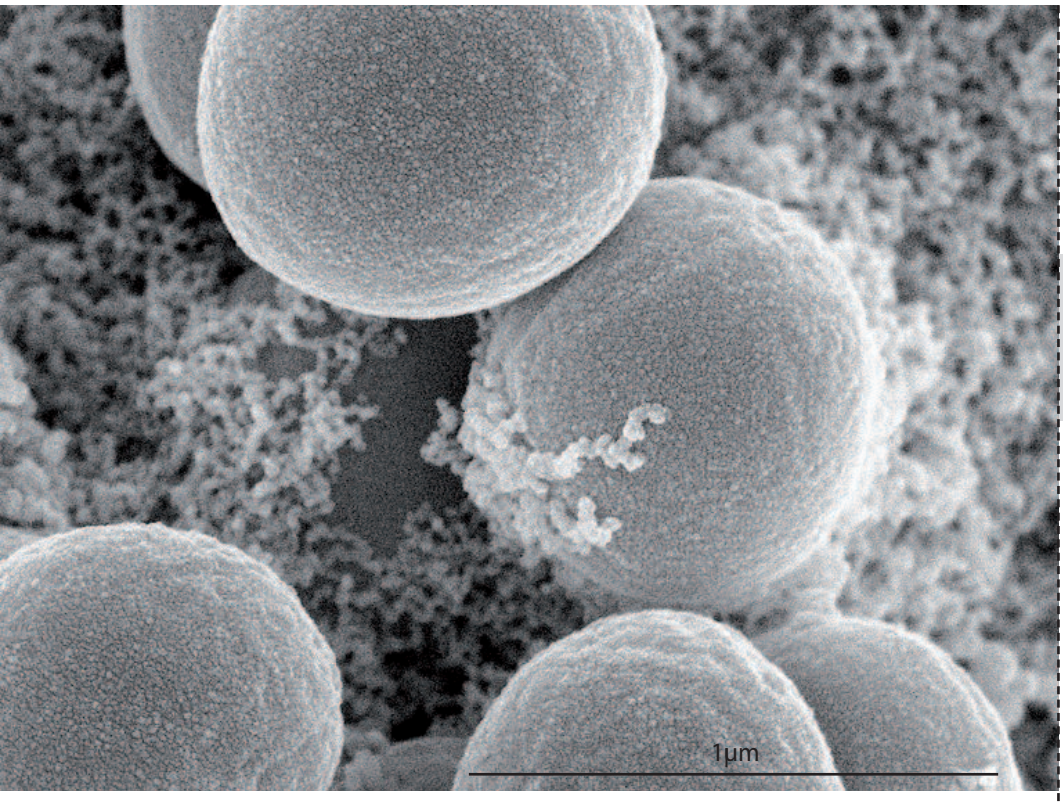
Organic pigment without coating

Extreme high-resolution SEM Magellan 400

Group of Microscopy for Biomedicine

Department of Electron Microscopy

ISI ASCR Institute of Scientific Instruments AS CR, v. v. i.



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SEM micrograph of Staphylococcus epidermidis and its biofilm (combined chemical and physical sample preparation)

THEMATIC RESEARCH FOCUS

Research area

– Scanning electron microscopy (SEM)
– Scanning transmission electron microscopy (STEM)
– Quantitative imaging
– Cryo-electron microscopy
– Cathodoluminiscence

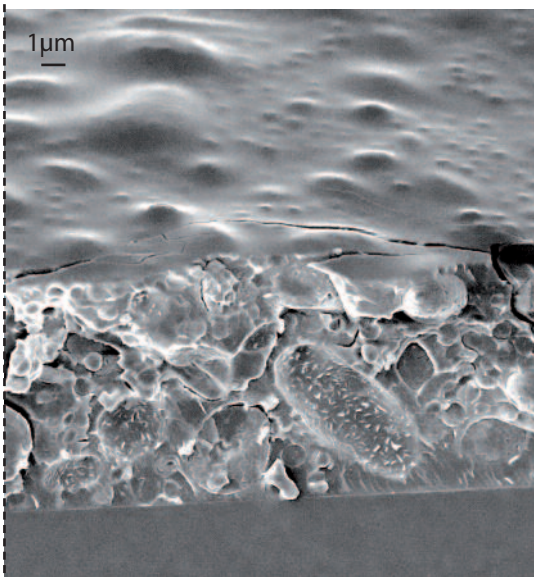
Excellence

– Quantitative imaging using annular dark-field mode in SEM, detection of very low signals in S(T)EM for quantitative imaging, mass measurement of macromolecular complexes
– Cathodoluminescence and photon collection in scintillators and screens for image formation in electron microscopy

Mission

– Development of quantitative imaging using SEM/STEM including hardware and software developments and specific sample preparation of biomedical and soft matter samples
– Improving the performance of imaging systems in electron microscopy and in other electron beam instruments

Freeze-fracture of microbial biofilm (Staphylococcus epidermidis, Candida parapsilosis)



Content of research

– Theoretical and experimental activities related to quantitative imaging using SEM/STEM of very thin samples, nanoparticles and macromolecular complexes
– Cryo-techniques in SEM/STEM
– Novel techniques in correlative microscopy
– Imaging of biomedical and soft-matter samples using SEM/STEM
– Cathodoluminescence kinetics of fast single crystal scintillators
– Design of scintillation detection systems with high efficiency of signal photon collection

Main capabilities

Basic research

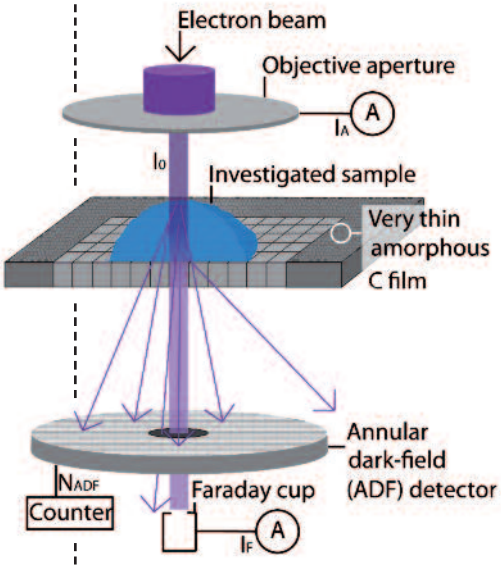
– Theoretical simulations of electron scattering for quantitative imaging
– Study of sample preparation in relation to quantitative imaging
– Efficiency and kinetics of cathodoluminescence using time-resolved spectroscopy in a large temperature range
– Study of very weak cathodoluminescence using Time Correlated Single Photon Counting (TCSPC)

Applied research

– New detectors for SEM/STEM of very low signals for quantitative imaging
– Cryo-preparation techniques
– Applications in quantitative imaging like mass-thickness mapping and molecular mass measurements
– Applications in cryo-SEM

Fields of research results application

– Electron microscopy
– Cryo-electron microscopy
– Measuring instruments
– Materials sciences (polymers, soft matter, etc.)
– Life sciences (molecular biology, tumor biology, biochemistry, etc.)
– Nanotechnology
– Microbiology
– Nuclear radiation detection



Principle of quantitative imaging in SEM using an annular dark-field detector

KEY RESEARCH EQUIPMENT

– Electron beam excitation unit with an electrostatic deflection system and a blanking diaphragm
– UV light collection and transmission system with a Horiba Jobin Yvon iHR320 spectrometer
– Utilization of equipment of the Group of Microscopy and Microanalysis
– Cryo-equipment extending the SEM Magellan 400 (FEI) to cryo-SEM

ACHIEVEMENTS

We started employing new methods of S(T)EM microscopy at ISI focused especially on the observation of biological objects. Related results from the Institute of Medical Physics and Biophysics at the University of Münster where the group leader worked are also included in the following list:

Quantitative electron microscopy

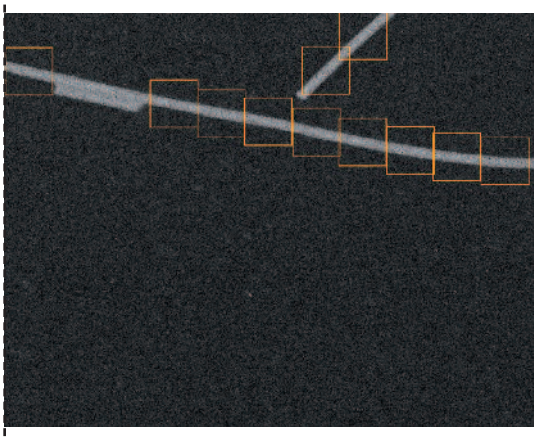
- Kouyianou, K.; De Bock, P.–J.; Müller, S. A.; Nikolaki, A.; Rizos, A.; Krzyžánek, V.; Aktoudianaki, A.; Vandekerckhove, J.; Engel, A.; Gevaert, K.; Tsiotis, G.; *The Chlorosome of Chlorobaculum tepidum: size, mass and protein composition revealed by electron microscopy, dynamic light scattering and mass spectrometry-driven proteomics.* Proteomics 11, (2011), p. 2867–2880
- Pfaff, M.; Miller, E.; Klein, M. F. G.; Colsmann, A.; Lemmer, U.; Krzyžánek, V.; Reichelt, R.; Gerthsen, D.; *Low-energy electron scattering in carbon-based materials analyzed by scanning transmission electron microscopy and its application to sample thickness determination.* Journal of Microscopy 243, (2011), p. 31–39
- Krzyžánek, V.; Müller, S. A.; Engel, A.; Reichelt, R.; *MASDET–A fast and user-friendly multiplatform software for mass determination by dark-field electron microscopy.* Journal of Structural Biology 165, (2009), p. 78–87
- Krzyžánek, V.; Reichelt, R.; *High-Resolution Scanning Electron Microscope for Mass Determination: Progress in the Development of a New Nanoanalytical Tool.* Microscopy & Microanalysis 13 (Suppl. 3), (2007), p. 80–81

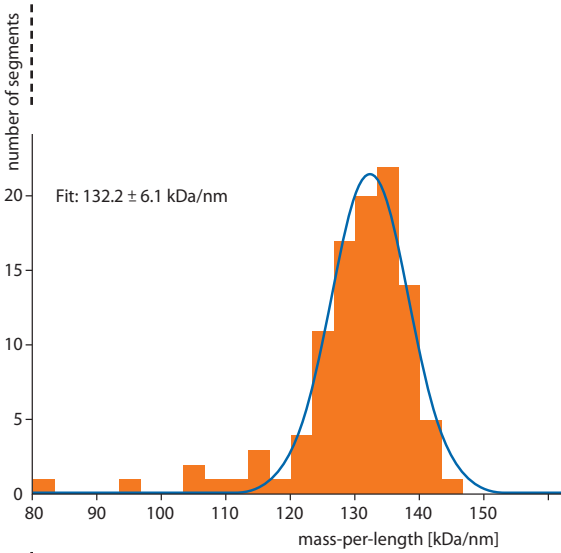
Characterisation of biological, biomedical and soft-matter samples using SEM and TEM techniques

- Groscurth, S.; Müller, B.; Schwan, S.; Diekstall, F.; Senft, M.; Kendall, A.; Kommor, B. A.; Neumann, U.; Kalischuk, M.; Kawchuk, L. M.; Krzyžánek, V.; Heilmann, A.; Stubbs, G.; Twyman, R. M.; Prüfer, D.; Noll, G. A.; *Artificial Forisomes Are Ideal Models of Forisome Assembly and Activity That Allow the Development of Technical Devices.* BioMacromolecules 13, (2012), p. 3076–3086
- Hillebrand, A.; Post, J. J.; Wurbs, D.; Wahler, D.; Lenders, M.; Krzyžánek, V.; Prüfer, D.; Schulze Gronover, C.; *Down-Regulation of Small Rubber Particle Protein Expression Affects Integrity of Rubber Particles and Rubber Content in Taraxacum brevicorniculatum.* PLoS ONE 7, (2012), e41874
- Ernst, A. M.; Jekat, S. B.; Zielonka, S.; Müller, B.; Neumann, U.; Rüping, B.; Twyman, R. M.; Krzyžánek, V.; Prüfer, D.; Noll, G. A.; *Sieve element occlusion (SEO) genes encode structural phloem proteins involved in wound sealing of the phloem.* PNAS 109, (2012), E1980–E1989
- Eissenberg, J. C.; Ilvarsonn, A. M.; Sly, W. S.; Waheed, A.; Krzyžánek, V.; Pohlmann, R.; Waschkau, D.; Kretzschmar, D.; Dennes, A. C.; *Drosophila GGA model: an ultimate gateway to GGA analysis.* Traffic 12, (2011), p. 1821–1838
- Krzyžánek, V.; Sporenberg, N.; Keller, U.; Guddorf, J.; Reichelt, R.; Schönhoff, M.; *Polyelectrolyte multilayer capsules: Nanostructure and visualisation of nanopores in the wall.* Soft Matter 7, (2011), p. 7034–7041.
- Edlmayr, J.; Niespodziana, K.; Popow-Kraupp, T.; Krzyžánek, V.; Focke-Tejkl, M.; Blaze, D.; Grote, M.; Valenta, R.; *Antibodies induced with recombinant VP1 from Human Rhinovirus exhibit cross-neutralization.* European Respiratory Journal 37, (2011), p. 44–52
- Grote, M.; Krzyžánek, V.; Reichelt, R.; *Bundles of hexagonally arranged tubules in timothy grass pollen: Detection of a novel pollen component using anhydrous fixation and image analysis techniques in transmission electron microscopy.* Journal of Microscopy 228, (2007), p. 34–39

We are engaged in the preparation and observation of hydrated samples by SEM, cryo-SEM, FIB-SEM and correlative microscopy.

- Dobranská, K.; Růžička, F.; Nebesářová, J.; Wepf, R. A.; Samek, O.; Krzyžánek, V.; *Characterisation of bacterial/yeast biofilms by scanning electron microscopy.* In: Proc. 15th European Microscopy Congress EMC2012, 16–21. September 2012, Vol. 1 Physical Sciences Applications, p. 671–672





Annular dark-field micrograph of Tobacco mosaic virus (TMV) and the mass distribution within 104 segments

We are the pioneers of algorithms of Computer Optimized Design of scintillation detectors for electron microscopy.

- Schauer, P.; *Extended Algorithm for Simulation of Light Transport in Single Crystal Scintillation Detectors for S(T)EM.* Scanning, 29, (2007), p. 249–253

We have developed and introduced into practice unique methods for the characterization of solids using cathodoluminescence.

- Schauer, P.; *Optimization of decay kinetics of YAG:Ce single crystal scintillators for S(T)EM electron detectors.* Nucl. Instr. Meth. B 269, (2011), p. 2572–2577
- Bok, J.; Schauer, P.; *LabVIEW-based control and data acquisition system for cathodoluminescence experiments.* Rev. Sci. Instrum. 82, (2011), p. 113109.
- Schauer, F.; Schauer, P.; Kuřitka, I.; Bao, H.; *Conjugated Silicon–Based Polymer Resists for Nanotechnologies: EB and UV Meditated Degradation Processes in Polysilanes.* Materials Transactions, 51, (2010), p. 197–201
- Horák, P.; Schauer, P.; *Cathodoluminescence as a method for the study of degradation of polysilanes.* Nucl. Instrum. Methods Phys. Res. Sect. B – Beam Interact. Mater. Atoms 252, (2006), p. 303–307

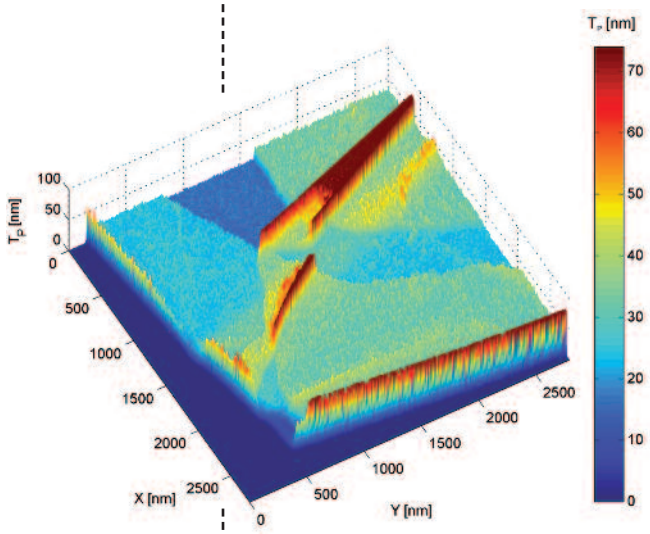
MAIN COLLABORATING PARTNERS

Collaboration with academic partners

University of Münster (Münster, DE)
University of Basel (Basel, CH)
ETH (Zurich, CH)
National Institute of Health (Bethesda, USA)
Physikalisch-Technische Bundesanstalt (Braunschweig, DE)
University of Manchester (Manchester, GB)
Brno University of Technology (Brno, CZ)
Masaryk University (Brno, CZ)
St. Anne's University Hospital (Brno, CZ)
Biology Centre of the ASCR (České Budějovice, CZ)
Institute of Physiology of the ASCR (Praha, CZ)
Institute of Macromolecular Chemistry of the ASCR (Praha, CZ)
Institute of Physics of the ASCR (Praha, CZ)
Tomáš Baťa University in Zlín (Zlín, CZ)

Collaboration with companies

Hitachi High-Tech (Tokyo, JPN)
TESCAN (Brno, CZ)
Crytur (Turnov, CZ)



Randomly folded very thin carbon film: annular dark-field image (bottom) and projected thickness map (upper)

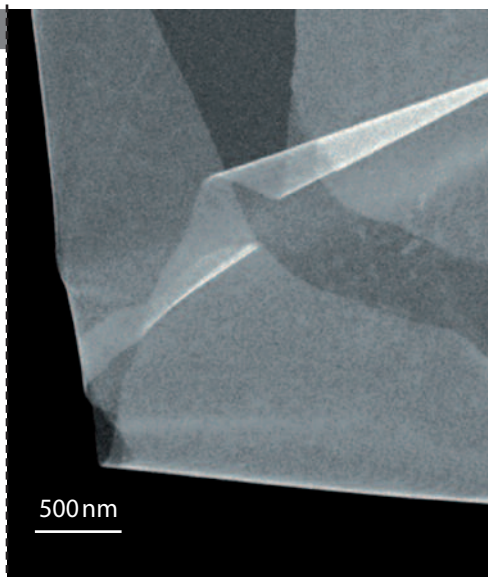
EXPECTATIONS

Offers

We offer our know-how in the areas of our expertise.

Requirements

We look for cooperation with academic partners as well as companies in the fields of electron microscopy, nanotechnologies, applications of SEM/STEM techniques including cryo-techniques to biological, medical and soft matter research, material characteristics, applications of scintillators and imaging screens.



Group of Environmental Electron Microscopy

Department of Electron Microscopy

ISI ASCR Institute of Scientific Instruments AS CR, v. v. i.

THEMATIC RESEARCH FOCUS

Research area

– Environmental scanning electron microscopy (ESEM)

Excellence

– Design and manufacturing of scintillation single crystal detectors of backscattered and secondary electrons
– Design and manufacturing of ionisation detectors for environmental scanning electron microscopes (ESEM)
– Study of sensitive samples of various nature (electrically non-conductive, wet, biological, living cells and animals)
– Morphological, chemical and structural changes of samples studied in conditions of dynamical in-situ experiments in ESEM

Mission

Excellence in understanding of the influence of electron-liquid and electron-gas interactions on signal detection and imaging in ESEM, development of new detection and experimental techniques for SEM and ESEM.

DEVELOPED TECHNOLOGIES

Content of research

– Theoretical and experimental research of electron-gas interactions in ESEM (Monte Carlo simulations and theoretical models of electron-gas interactions and signal amplification, electron beam scattering in gas environment, electron-gas ionisation and excitation phenomena, charge recombination processes in gas, Monte Carlo simulations of electron-water interactions and study of electron energy losses in thin water layer).
– Gas flow computations in ESEM and detection systems for ESEM (design of optimum geometry of differentially pumped chambers and ESEM equipment as detectors, hydration systems, etc.)

Live dust mite in water vapor conditions of ESEM

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Head: Dr. Vilém Neděla
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– Scintillation single crystals for the detection of signal electrons in SEM, ESEM (Theoretical and experimental study of electron losses in thin conductive layers on scintillators, design of new scintillation detectors working in high pressure environment, experimental study of combined scintillation and ionisation detectors)

Main capabilities

Basic research

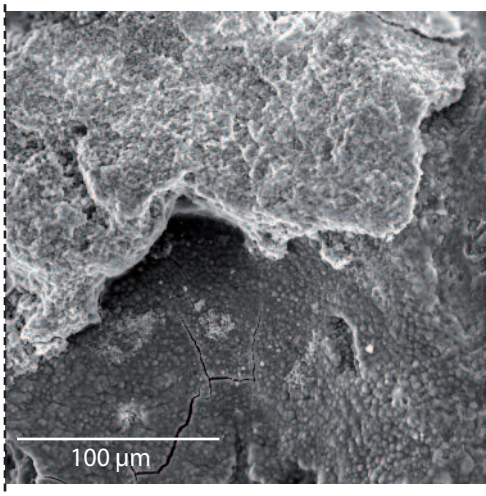
– Understanding of mechanisms of generation and multiplying of signal electrons in an environment of high pressure gas and simulation of these phenomena
– Methods of observation of samples in terms of dynamic in-situ experiments in ESEM
– Imaging methods of special or sensitive biological samples in SEM and ESEM
– Understanding of gas flow phenomena in ESEM and detection systems

Applied research

– New types and features of detectors for SEM and ESEM
– The study of morphology and elemental analysis of electrochemical sensors with sputtered thin diamond-like carbon layers doped with boron using electron beam analytical methods
– Morphological study of solar cell surfaces and of deep holes created, modified or machined by various types of laser technologies, using own patented detector of secondary electrons in ESEM
– Methods for observation of stem cells and other wet biological samples in their native state as well as of live animals in ESEM

Fields of research results application

– Life sciences (medicine, biochemistry, pharmacy, food industry, etc.)
– Materials science (study of some special non-conductive samples)
– Measuring instruments
– Renewable energy
– Plastics, polymers
– Glass, ceramics
– Textile industry
– Chemistry



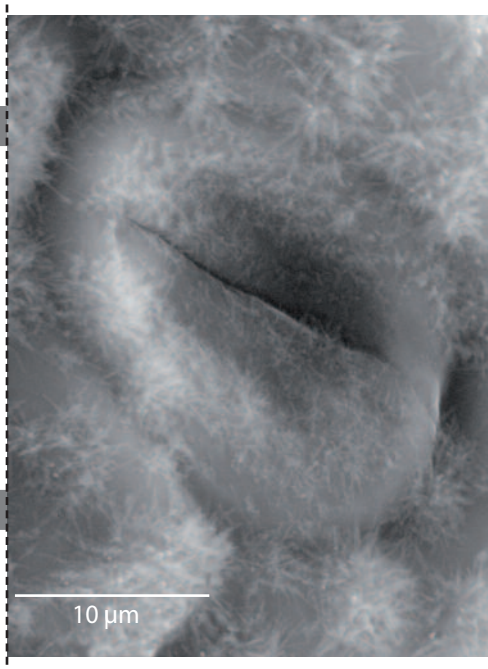
Human tooth with tartar in native state treeted by laser

KEY RESEARCH EQUIPMENT

– Environmental scanning electron microscope AQUASEM I and AQUASEM II
– Uniquely designed hydration system for ESEM
– Ionization secondary electron detector with electrostatic separator (ISEDS)
– Peltier stage for sample cooling in ESEM
– Scintillation BSE detector with integrated ionization detector of SEM for ESEM
– New multichannel pre-amplifier for multi-segmental ionization detector for ESEM
– ISEDS with combined electrostatic and magnetic fields

ACHIEVEMENTS

We are deeply focused on theoretical and experimental research in the field of signal detection, new methods and instrumentation for the study of various types of samples in high pressure conditions of ESEM. We led this topic in Czech Republic. Our tradition was started over twenty years ago when the first ESEM in Czech Republic was designed in cooperation with the Tescan Company. We published over two hundred papers in scientific journals and conference proceedings.

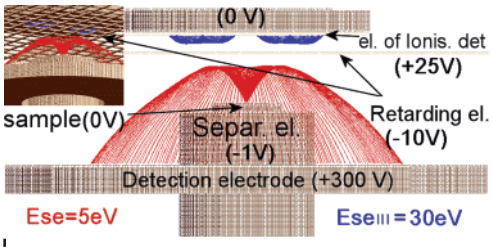


Stomata on somatic embryo of cotyledon in native state

European patent

- **The world's first high efficiency secondary electron detector for ESEM allows the energy separation of detected electrons and simultaneous work with the original BSE-YAG detector and ionisation detector. Suitable for working pressures from units to thousands of Pa.**

– Neděla, V.; Jirák, J.; Ionisation detector of an environmental scanning electron microscope. Institute of Scientific Instruments, Academy of Sciences of the Czech Republic, EP2195822 (A2), (2010)

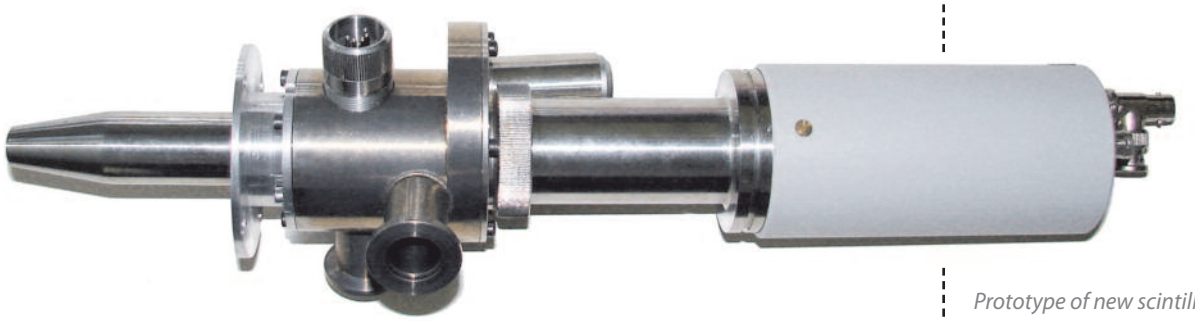


Ionization secondary electron detector with electrostatic separator

Scientific results of team members are regularly published in high profile scientific journals

- **The world's first high efficiency secondary electron detector suitable for SEM or ESEM. Detector based on a scintillator-photomultiplier working principle can be used for the study of samples in the pressure range from a thousandth to a thousand Pa.**

– Jirák, J.; Neděla, V.; Černoch, P.; Čudek, P.; Runštuk, J.; *Scintillation SE detector for variable pressure scanning electron microscopes.* Journal of Microscopy, 239, 3, (2010), p. 233–238



Prototype of new scintillation SE detector for SEM and ESEM

- **Various types of sample hydration methods for long time observation in ESEM were tested. A new method for additional sample hydration from agar substrate was described.**

– Neděla, V.; *Methods for Additive Hydration Allowing Observation of Fully Hydrated State of Wet Samples in Environmental SEM.* Microscopy research and technique, Vol.70, p. 95–100

- **The evaluation of morphological changes of biological sample surface during the dynamical insitu experiment in the specimen chamber of ESEM.**

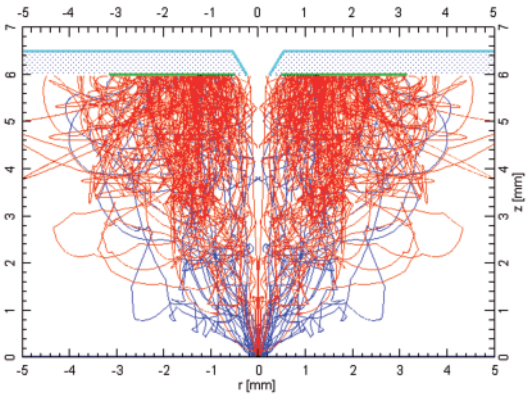
– Neděla, V.; *Controlled dehydration of a biological sample using an alternative form of environmental SEM.* Journal of Microscopy, 237(1), (2010), p. 7–11

- **New results of Monte Carlo simulations of electron-gas interactions and signal amplification for selected energies of signal electrons in high pressure conditions of ESEM were introduced.**

– Neděla, V.; Konvalina, I.; Lencová, B.; Zlámal, J.; *Comparison of calculated, simulated and measured signal amplification in variable pressure SEM.* Nucl. Instrum. Meth A, 645 (1), (2011), p. 79–83

- **New method for observation of native plant sample in ESEM was introduced. The world's first images of early conifer embryonic tissues in their native state were shown using ESEM.**

– Neděla, V.; Hrib, J.; Vooková, B.; *Imaging of early conifer embryonic tissues with the environmental scanning electron microscope.* Biologia Plantarum, 56 (3), (2012), p. 595–598



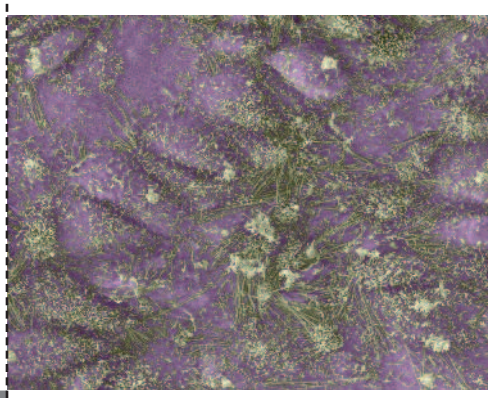
Monte Carlo simulation of electron trajectories in water vapor environment (50 Pa) inside the specimen chamber of ESEM

- **The morphological study of undifferentiated human embryonic stem cells in different state of preparation was realized using ESEM and SEM.**

– Neděla, V.; Tihlaříková, E.; Hampl, A.; Sedláčková, M.; *SEM and ESEM Observation of Stem Cells.* G.I.T. Imaging and Microscopy, 4, (2012), p. 32–34

- **New system of pressure-limiting apertures for scintillation secondary electron detector was introduced.**

– Maxa, J.; Neděla, V.; Jirák, J.; *Analysis of gas flow in the new system of apertures in the secondary electron scintillation detector for ESEM.* Microscopy and Microanalysis, 18, Suppl 2, (2012), p. 1264–1265



A false colored SEM image of the undifferentiated human embryonic stem cells surface

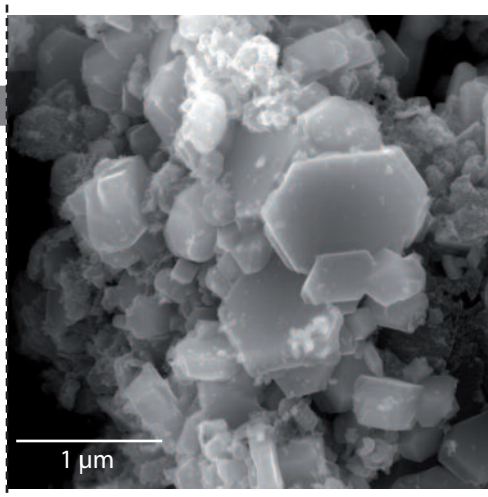
MAIN COLLABORATING PARTNERS

Collaboration with academic partners

– University of Cambridge (Cambridge, GB)
– ESEM Research Laboratory (Sydney, AU)
– University at Albany (New York, USA)
– Masaryk University (Brno, CZ)
– Brno University of Technology (Brno, CZ)

Collaboration with companies

– Delong Instruments (Brno, CZ)
– BVT Technologies, a.s. (Brno, CZ)
– Solartec s.r.o. (Rožnov pod Radhoštěm, CZ)
– Hitachi (Tokyo, JP)
– JEOL(Tokyo, JP)
– Crytur s.r.o (Turnov, CZ)



Portlandite crystals in $Ca(OH)_2$, observed in wet state

EXPECTATIONS

Offers

– Licensing of the patented detection systems for electron microscopes
– Testing of functional properties of detection systems for SEM and ESEM
– Partnership in international projects
– Morphological study of different cell cultures and impact of growing parameters on their structure, preparation methods for study in SEM and ESEM
– Morphological study of wet biological or pharmaceutical samples
– Study of microstructure and functional properties of building materials, plastics, rubbers, wood and paper
– Microstructure of wet materials and liquids
– Materials properties and their changes in dynamical experiments (battery mass, samples in acids, heated and cooled materials, food chemical reactions, etc.)
– Study of specific properties of sensitive or chemically active samples

Requirements

We look for cooperation with academic partners as well as companies in the fields of instrumentation for SEM and ESEM, microtechnologies, nanotechnologies, building materials, pharmacy, food science, plant science, chemistry, medicine, etc.

– Partners for FP7 research project in the field of instrumentation of electron microscopes, materials science, biology, pharmacy, food science, etc.
– Collaboration with industrial partners in common projects dedicated to applied science
– New complementary technologies

Group of Thin Layers
Department of New Technologies

ISI ASCR
Institute of Scientific Instruments AS CR, v. v. i.

THEMATIC RESEARCH FOCUS

Research area
Deposition of thin films by magnetron sputtering and their dynamic impact testing, microfluidic field-flow fractionation

Excellence
– Multilayer X-ray and EUV optics
– Self-organized growth of nanocrystals
– Dynamic impact testing of thin films
– Microfluidic field-flow fractionation

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Computer contgrolled magnetron sputtering system Aurion

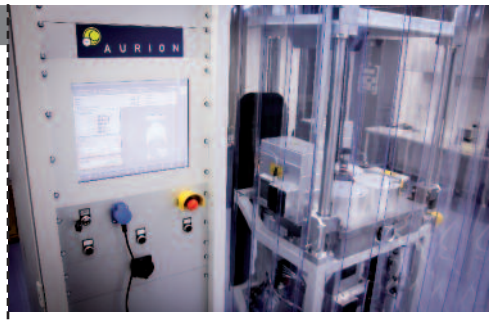
Mission

Search for new practical applications of technologies we excel in, e.g. deposition of x-ray and EUV optics, in particular in new branches of industry (space research), development of unique instruments, and last but not least, the technological support of teams at ISI.

DEVELOPED TECHNOLOGIES

Content of research

– Creation and characterization of nanolayers used in soft X-ray lasers
– Deposition of thermally stable nanostructured DLC coatings
– Coating technology of thin passivation and antireflection layers, production of crystalline solar cells
– Deposition of multilayer X-ray and EUV optics
– Dynamic impact testing of thin films
– Microfluidic apparatus for the separation, analysis and characterisation of nano- and microparticles



Computer contgrolled magnetron sputtering system Aurion

Main capabilities

Basic research

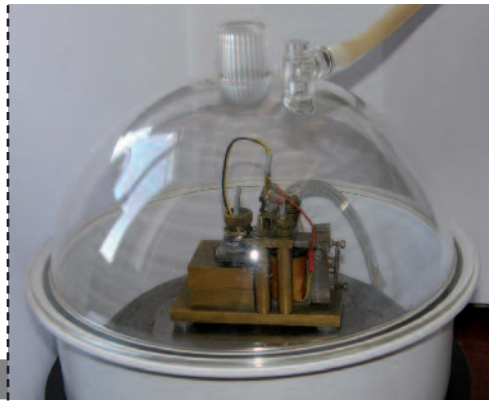
– Study of self-organized growth of nanocrystals
– Study of mechanisms of dynamic impact wear of films / substrate systems
– Study of thermal diffusion of macromolecules, nano- and microparticles by microthermal field-flow fractionation

Applied research

– New types and features of the multilayer X-ray and EUV optics
– Electrochemical sensors
– Solar cells
– Wear-resistant coatings in automotive industry
– Development of microfluidic apparatus for the separation, analysis and characterisation of nano- and microparticles

Fields of research results application

– Materials science (study of the coating/substrate system under dynamical load)
– Measuring instruments (construction of impact testers and microfluidic apparatus)
– Renewable energy (solar cells)
– Automotive industry (wear-resistant coatings in automotive industry)
– Optics (multilayer X-ray and EUV optics)



Impact tester in chamber with controlled atmosphere

KEY RESEARCH EQUIPMENT

List of devices

– Computer controlled magnetron sputtering system Aurion equipped with two RF and one DC magnetrons with a diameter of 150 mm for the development and production of multilayer X-ray and EUV optics
– Magnetron sputtering system Leybold Heraeus- Z550 equipped with three RF magnetrons with a diameter of 150 mm for the development and production of the wear resistant coatings
– Magnetron sputtering system equipped with one RF. magnetron with a diameter of 75 mm for the development and production of electrochemical detectors
– Confocal microscope Olympus 3100 (magnification max. 14 400 ×)
– Calotest – CSM Instruments

– Impact tester for the evaluation of impact resistance of the coating/substrate system
– Microfluidic apparatus for the separation, analysis and characterisation of nano- and microparticles
– Disc polishing and grinding machine MTH kompakt 1031 + head APX010

ACHIEVEMENTS

Production of multilayered systems with an exactly defined individual layer thickness which can be used for x-ray or EUV optics. The repeatability of the bilayer thickness of the Mo/Si multilayer is better than 0,1 nm. We master also the deposition of x-ray or EUV optical elements composed of different materials, such as Sc/Si, Ni/C or C/Si with the same repeatability.

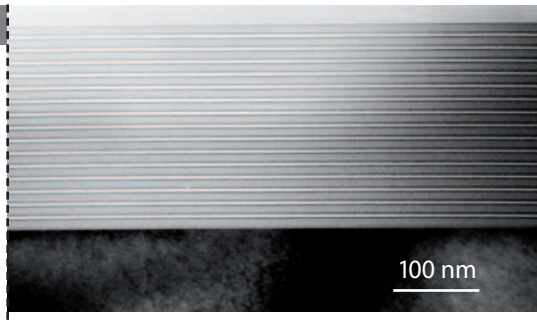
– Protopov, V. V.; Sobota, J.; *X-ray dark-field refraction-contrast imaging of micro-objects.* Optics Communications, Vol. 213, Issue 4–6, p. 267–279
– Kolacek, K.; Straus, J.; Schmidt, J.; Frolov, O.; Prukner, V.; Shukurov, A.; Holý, V.; Sobota, J.; Fořt, T.; *Nano-structuring of solid surface by extreme ultraviolet Ar8+ laser.* Laser and Particle Beams, Vol. 30, Issue 1, p. 57–63
– Jakubczak, K.; Mocek, T.; Rus, B.; Polan, J.; Hřebiček, J.; Sasická, M.; Sikocinski, P.; Sobota, J.; Fořt, T.; Pina, L.; *Beam properties of fully optimized, table-top, coherent source at 30 nm.* Opto-electronics Review, Vol. 19, Issue 2, p. 169–175
– Krčmář, J.; Holý, V.; Horák, L.; Metzger, TH.; Sobota, J.; *Standing-wave effects in grazing-incidence x-ray diffraction from polycrystalline multilayers.* Journal of Applied Physics, Vol. 103, Issue 3

Our group is one of the few laboratories in Europe capable to evaluate the impact resistance of the coating/substrate system using an impact tester developed in our laboratory in collaboration with Brno University of Technology.

– Sobota, J.; Grossman, J.; Bursiková, V.; Dupák, L.;Vyskočil, J.; *Evaluation of hardness, tribological behaviour and impact load of carbon-based hard composite coatings exposed to the influence of humidity.* Diamond and Related Materials, Vol. 20, Issue 4, p. 596–599
– Fořt, T.; Vitu, T.; Novák, R.; Grossman, J.; Sobota, J.; Vyskočil, J.; *Testing of the Impact Load and Tribological Behaviour of W–C: H Hard Composite Coatings.* Chemické listy, Vol. 105, Special Issue SI, p. S102–S104

Our group was one of a few laboratories discovering nanocomposite principle applied on thin films. We find it possible to use this principle in practice and at present we participate in this field in industry-oriented research.

– Vorlíček, V.; Široký, P.; Sobota, J.; Peřina, V.; Železný, V.; Hrdina, J.; *C:N and C:N:O films: Preparation and properties.* Diamond and Related Materials, Vol. 5, Issue 3–5, (1996), p. 570–574
– Jensen, H.; Sobota, J.; Sorensen, G.; *A study on film growth and tribological characterization of nanostructured C–N/TiNx multilayer coatings.* Surface & Coatings Technology, Vol. 94–5, Issue 1–3, (1997), p. 174–178
– Sobota, J.; Sorensen, G.; Jensen, H.; Kuběna, J.; Holý, V.; *Temperature stability of C-N/NbN nanocomposite multilayers.* Diamond and Related Materials, Vol. 9, Issue 3–6, (2000), p. 587–591
– Sobota, J.; Bochníček, Z.; Holý, V.; *Friction and wear properties of C–N/MeNx nanolayer composites.* Thin Solid Films, Vol. 433, Issue 1–2, (2003), p. 155–159
– Sobota, J.; Grossman, J.; Bursiková, V.; Dupák, L.; Vyskočil, J.; *Evaluation of hardness, tribological behaviour and impact load of carbon-based hard composite coatings exposed to the influence of humidity.* Diamond and Related Materials, Vol. 20, Issue 4, (2011), p. 596–599



Cross section of the Si/C multilayer on silicon substrate

Our group is one of the few laboratories in Europe developing microfluidic apparatuses for the separation, analysis and characterisation of nano- and microparticles.

- Janča, J.; Ananieva, I. A.; Sobota, J.; Dupák, J.; *Ultra-micro-thermal field-flow fractionation.* International journal of Polymer Analysis and Characterization, Vol. 13, Issue 3, p. 232–239
- Janča, J.; Berneron, J. F.; Stejskal, J.; *Effect of Particle-Particle Attractive and Repulsive Interactions on the Retention in Field-Flow Fractionation.* International Journal of Polymer Analysis and Characterization, Vol. 15, Issue 8, p. 536–543
- Janča, J.; Stejskal, J.; *On the retention mechanisms and secondary effects in microthermal field-flow fractionation of particles.* Journal of Chromatography A, Vol. 1216, Issue 52, p. 9071–9080

Microfluidic apparatus

MAIN COLLABORATING PARTNERS

Collaboration with academic partners

- Masaryk University (Brno, CZ)
- Institute of Physics of Materials of the ASCR, v. v. i. (Brno, CZ)
- University of West Bohemia (Plzeň, CZ)
- Institute of Physics of the ASCR, v. v. i. (Praha, CZ)
- Czech Technical University in Prague (Praha, CZ)
- Charles University (Praha, CZ)
- Institute of Plasma Physics (Praha, CZ)
- Tomas Bata University (Zlín, CZ)
- PALS – Prague Asterix Laser System (Praha, CZ)
- The University of Sheffield (Sheffield, UK)
- Aristoteles University of Thessaloniki, (Thessaloniki, GR)

Collaboration with companies

- Solartec s. r. o. (Rožnov pod Radhoštěm, CZ)
- HVM Plasma Ltd. (Praha, CZ)
- Rigaku Innovative Technologies Europe, s. r. o. (Praha, CZ)
- Czech Metrology Institute (Brno, CZ)
- VUHZ a. s. (Dobrá, CZ)
- Research and Testing Institute (Plzeň,CZ)
- Watrex Praha s. r.o. (Praha, CZ)

EXPECTATIONS

Offers

- We offer testing of functional properties of thin coatings under dynamic load, development and deposition of new types and features of multilayer X-ray and EUV optics, coatings used in photovoltaic solar cells, etc.
- Partnership in international projects

Requirements

We look for cooperation with academic partners as well as companies in the fields of EUV and X-ray optics, photovoltaic solar cells, testing of thin films, study of thermal diffusion of macromolecules, nano- and microparticles by microthermal field-flow fractionation.

Group of Electron Beam Technology
Department of New Technologies

ISI ASCR
Institute of Scientific Instruments AS CR, v. v. i.

THEMATIC RESEARCH FOCUS

Research area
– Electron beam welding
– Vacuum brazing and vacuum feedthroughs
– Special electronics

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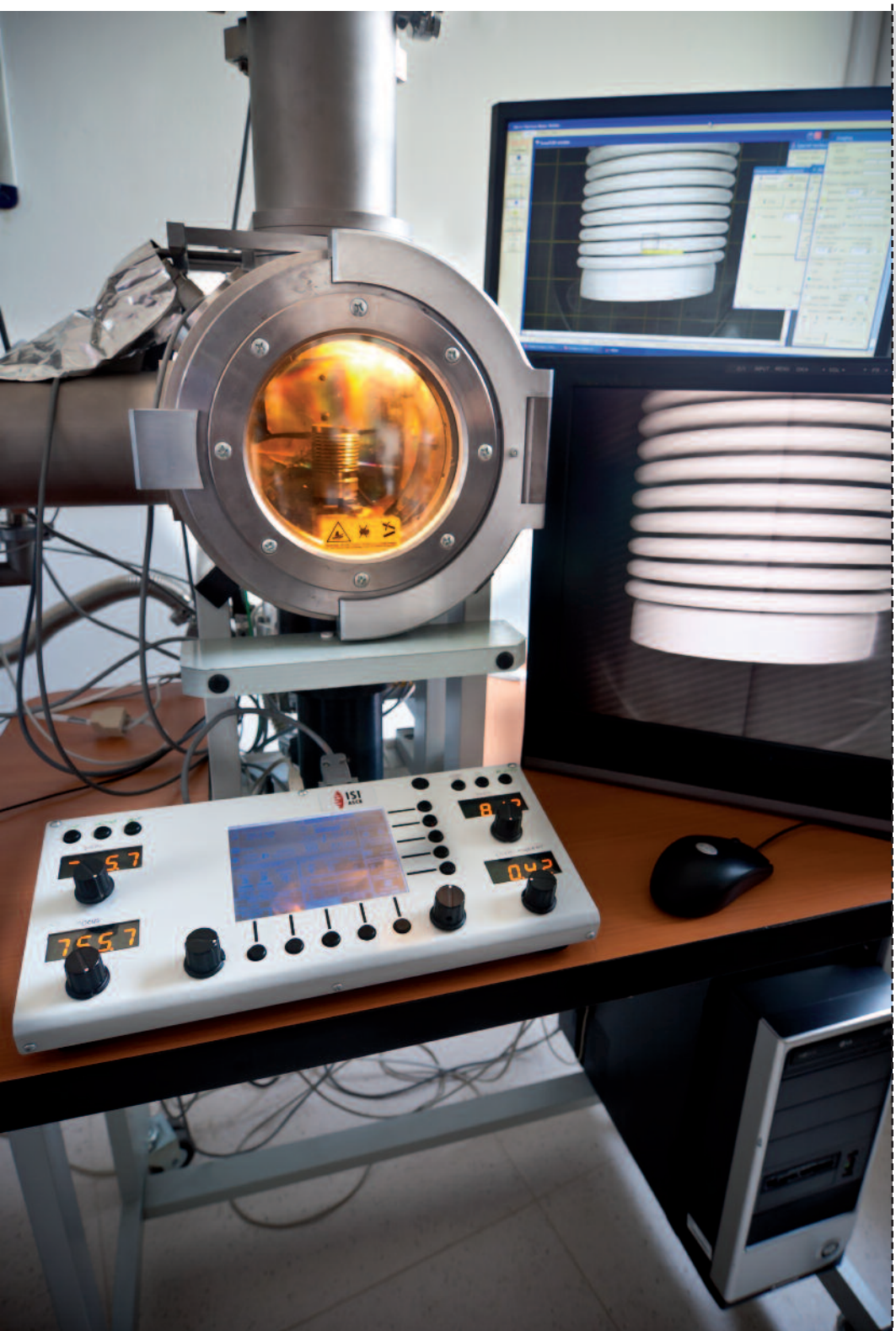


Electron beam welder MEBW-60/2 at ISI Brno

Excellence

Electron beam welding of dissimilar metals, custom-made vacuum feedthroughs, precise high voltage supplies

Mission

Development of new joining techniques of various metals, as well as design of the necessary equipment, such as electron beam welders and vacuum furnaces

DEVELOPED TECHNOLOGIES

Content of research

– Electron beam welding of dissimilar metals
– Development of electron beam welders including high voltage power supplies
– Brazing of metals with brittle non-metallic materials using pliable active filler metals
– Development of vacuum feedthroughs based on glass-to-metal seal

Main capabilities

Basic research

– Study of homogenous and heterogeneous joints of various metals

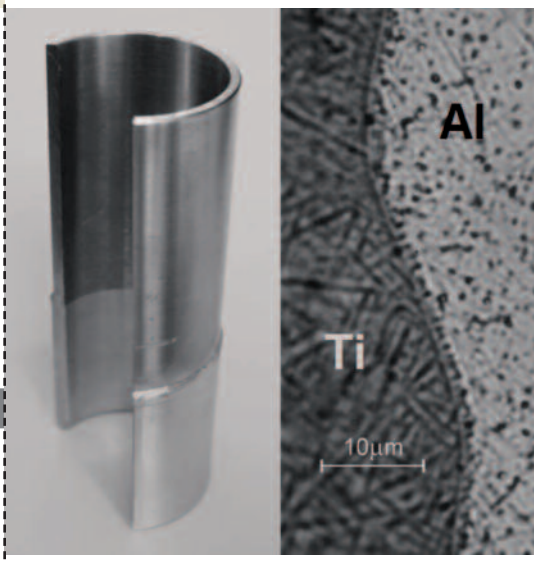
Applied research

– Design of technological devices such as electron beam welders, vacuum furnaces, etc.
– Development of high voltage power supplies
– Various types of vacuum feedthroughs based on glass-to-metal seal (matched kovar-glass or compression seal) both standard types (e.g. D-sub) or custom made

Heat exchanger welded by electron beam

Various components welded by electron beam

Custom-made vacuum feedthroughs



Detail of heterogeneous joint of Ti and Al

Fields of research results application

– Precision engineering
– Automotive and aerospace industry
– Nuclear industry
– Vacuum technology
– Scientific instruments

KEY RESEARCH EQUIPMENT

– Three electron beam welders (up to 60 kV, up to 2kW) developed and produced at ISI with two different types of vacuum chambers. The newest EB welder is currently produced by Focus GmbH (Germany) under licence agreement as MEBW-60/2.
– Upgraded vacuum furnace PZ-810 produced by former Czech company Tesla Roznov
– Laboratory vacuum furnace of in-house design for brazing and heat treatment of smaller parts
– Helium leak detector QualyTest™Dry HLT 270 by Pfeiffer Vacuum

ACHIEVEMENTS

– Electron beam welder with power up to 2 kW with acceleration voltage up to 60 kV. The welder is nowadays produced and marketed as MEBW-60/2 by German company Focus GmbH under licence agreement.
– Electron beam welding of dissimilar metals (e.g. Ti-Al) for applications in cryogenics
– Electron beam welding along requested trajectory
– Standard and custom-made vacuum feedthroughs suitable for nuclear industry from single-pin up to 24 pin feedthroughs

MAIN COLLABORATING PARTNERS

Collaboration with academic partners

– Brno University of Technology (Brno, CZ)
– University of West Bohemia in Pilsen (Plzeň, CZ)
– Masaryk University (Brno, CZ)
– Institute of Physics of Materials ASCR, v. v. i. (Brno, CZ)

Collaboration with companies

– Focus GmbH (Hünstetten, Germany)
– Tescan, a. s. (Brno, CZ)
– První brněnská strojírna, a. s. (Brno, CZ)
– PBS ENERGO, a. s. (Třebíč, CZ)
– Honeywell Turbo Technologies (Brno, CZ)
– KOMO mark, s. r. o. (Ostrava, CZ)
– Lavat, a. s. (Chotutice, CZ)
– MESIT přístroje spol. s r. o. (Uherské Hradiště, CZ)
– Rigaku Innovative Technologies Europe, s. r. o. (Praha, CZ)
– ŠKODA JS, a. s. (Plzeň, CZ)
– Strojírny Bohdalice, a. s. (Bohdalice, CZ)
– Glatt – Pharma, spol. s r.o. (Hradec Králové, CZ)
– VÚHŽ a. s. (Dobrá, CZ)
– UJP PRAHA, a. s. (Praha, CZ)
– Siemens, s. r. o., odštěpný závod Industrial Turbomachinery (Brno, CZ)
– FEI Czech Republic (Brno, CZ)
– DELONG INSTRUMENTS, s. r. o. (Brno, CZ)
– Visteon-Autopal, s. r. o. (Nový Jičín, CZ)
– ČKD KOMPRESORY, a. s. (Praha, CZ)
– ÚJV Řež, a. s. (Husinec, CZ)
– Tecpa s. r. o. (Brno, CZ)

Dual 9-pin D-sub vacuum feedthrough

EXPECTATIONS

Offers

– Know-how in the field of electron beam welding and vacuum brazing
– Welding and brazing equipment capacities for job shop production
– Development and small-lot production of vacuum feedthroughs

Requirements

– Collaboration with industrial partners on common projects dedicated to applied science
– Knowledge and technologies for materials analysis
– New complementary technologies

Electron beam welder MEBW-60/2

Group of Electron Beam Lithography
Department of New Technologies

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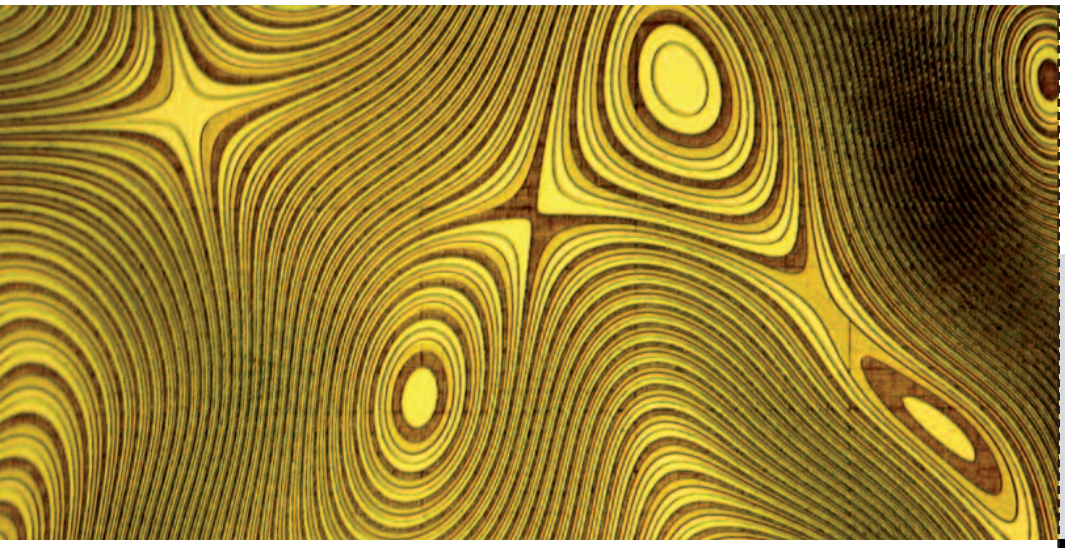


Example of a general Fresnel structure

THEMATIC RESEARCH FOCUS

Research area
Electron beam lithography

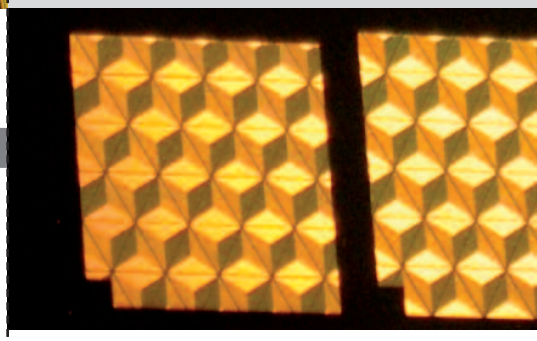
Excellence
Variable-shaped e-beam writer
Diffractive optically variable image devices (DOVIDs)

Mission
Planar micro- and nano-structures prepared by e-beam lithography

DEVELOPED TECHNOLOGIES

Content of research
– Variable-shaped e-beam pattern generator
– E-beam lithography using shaped beam writer and Gaussian beam writer
– Electron emitter preparation and characterization
– Optical diffractive, Fourier and Fresnel structures, DOVIDs
– Micro-sensors and calibration specimens

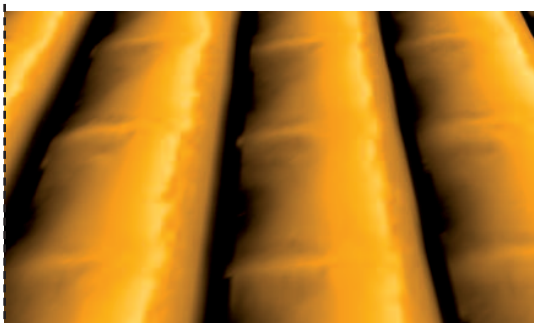
Main capabilities
Basic research
– Study and evaluation of electron scattering effects
– Electron emitter preparation and characterisation
– Calculation and optimization of computer generated holograms (CGH)

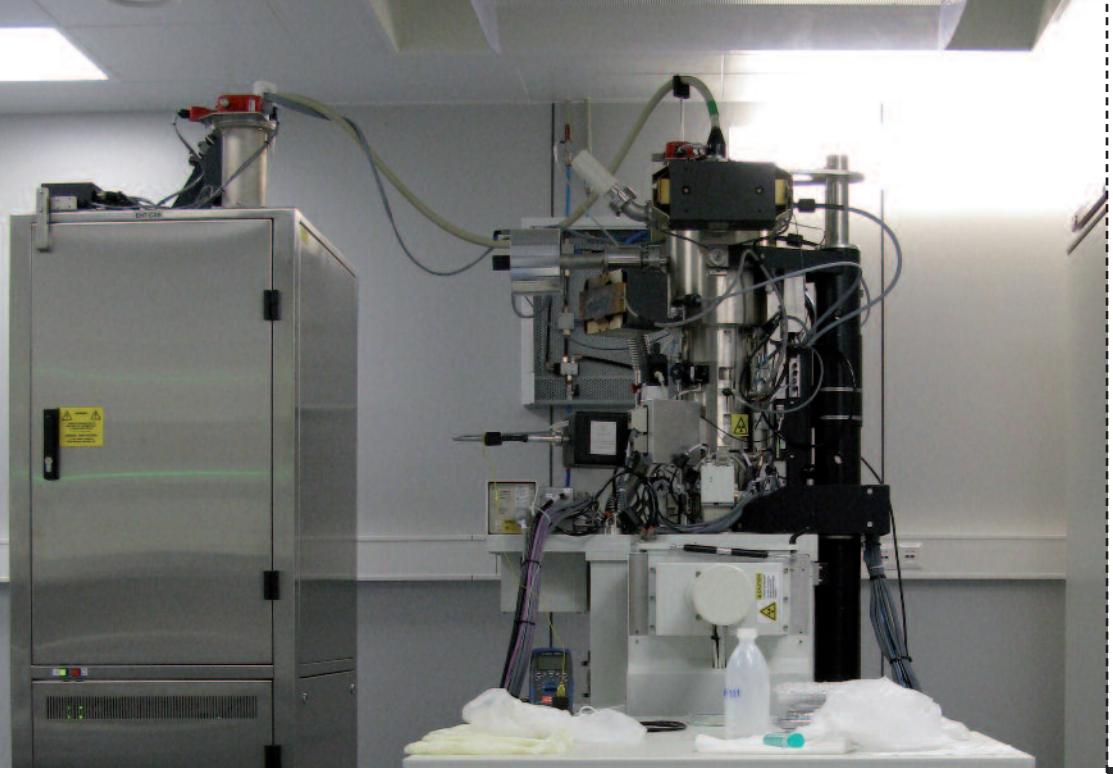


General Fresnel structure 20 x 20 mm²

Part of a Fresnel lens

Blazed grating (detail)

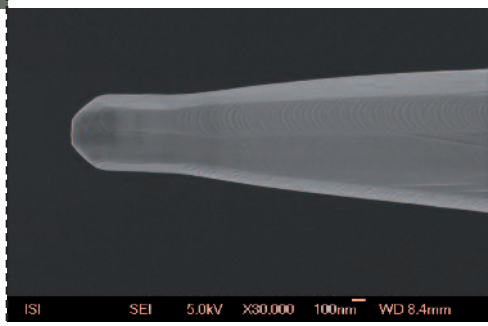




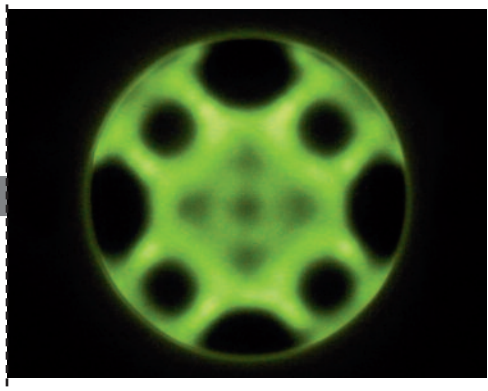
E-beam writer Vistec EBPG5000plusES

Applied research
– Phase and amplitude computer generated hologram structures
– Diffractive optically variable image devices
– Electrochemical and biological sensors

Fields of research results application
– Life sciences
– Materials science
– Measuring instruments
– Renewable energy
– Plastics, polymers
– Glass, ceramics



Electron emitter tip



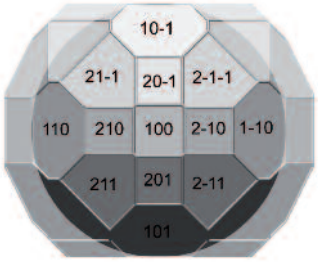
Emission pattern of the emitter tip

KEY RESEARCH EQUIPMENT

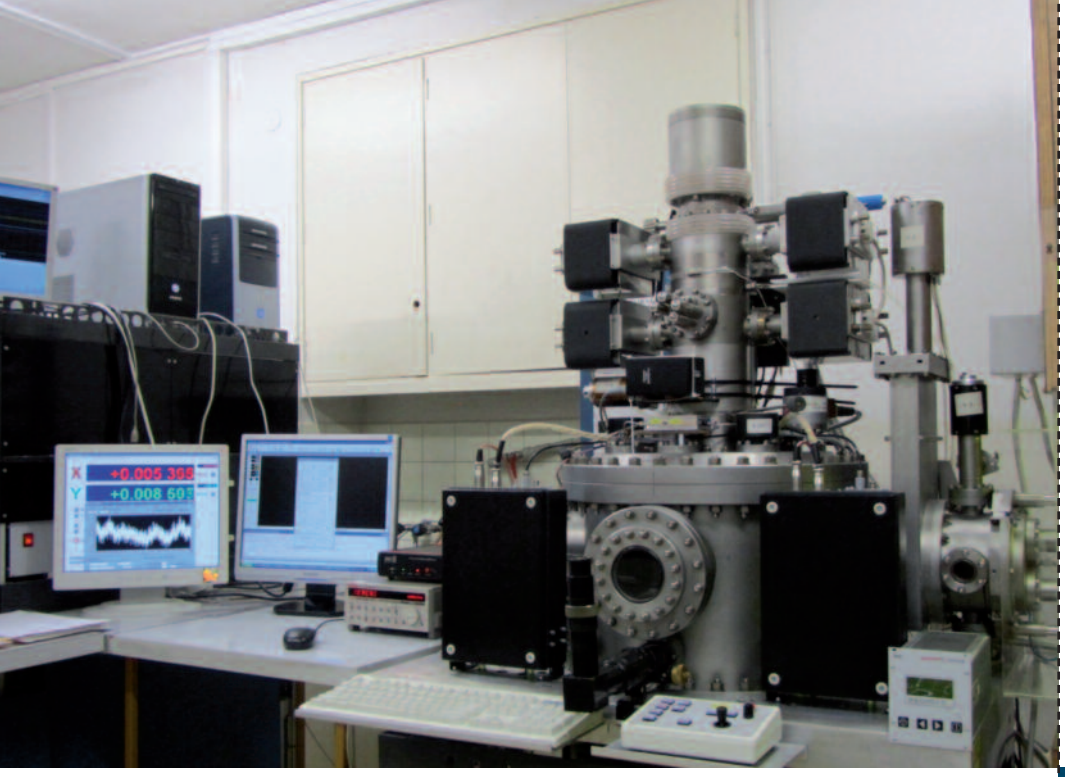
– E-beam writer (pattern generator) with shaped beam Tesla BS600
– E-beam writer with Gaussian beam Vistec EBPG5000plusES
– Atomic Force Microscope (AFM) Pacific Nanotechnology Nano-R

ACHIEVEMENTS

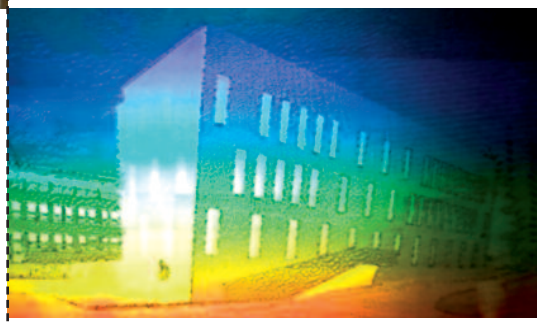
Electron–beam lithography group has been focused on the technological principles and the preparation of planar submicron-sized structures prepared in different solid state materials. Both the e-beam writer and the lithography technology was gradually developed. E-beam writer BS600 issues concern the improvement of resolution, writing speed, stability and appropriate source of electrons and proximity effect correction. Developed technologies led to very interesting results e.g. large-area diffractive structures, computer generated holograms, Fresnel structures, dimension calibration specimens, micro-sensors, special photolithographic masks and other structures used both for academic and industrial applications.



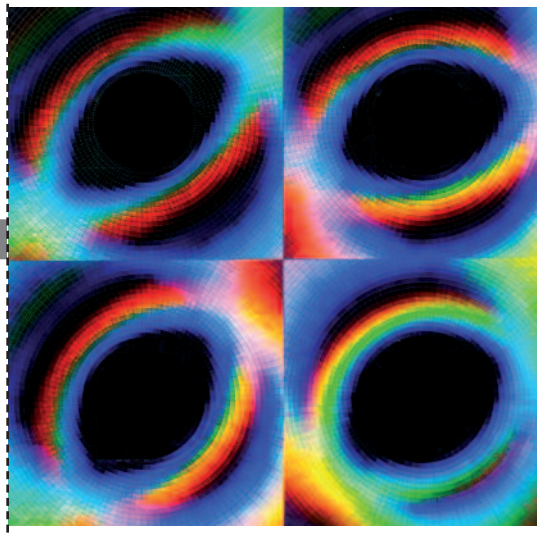
Model of the end form shape of the emitter tip



E-beam writer Tesla BS600



Simple diffractive image (ALISI building)



Diffraction grating sampler aranged as a segmented Fresnel lens

Scientific results

- Kolařík, V.; Horáček, M.; Matějka, F.; *Temperature monitoring of the EBL facility.* Electronic devices and systems 02 – proceedings, Brno, (2002), p. 207–210
- Daněk, L.; Matějka, F.; Kolařík, V.; Kokrhel, S.; Matějková, J.; *Non-diffractive submicron structures forming on electron beam lithograph BS601*. Proceedings – 7th Multinational Congress on Microscopy (MCM 2005), Ljubljana, (2005), p. 383–384
- Matějka, F.; Horáček, M.; Lencová, B.; Kolařík, V.; *Reducing the Size of a Rectangular-Shaped Electron Beam in E-Beam Writing System*. Proceedings of the 8th Multinational Congress on Microscopy, Prague, (2007), p. 87–88
- Matějka, F.; Horáček, M.; Kolařík, V.; Král, S.; *Modification of the Schottky Fe ZrO/W electron emitter.* Proceedings of the 12th International Seminar on Recent Trends in Charged Particle Optics and Surface Physics Instrumentation, Brno, (2010), p. 13–14

Application results

- Horáček, M.; Matějka, F.; Kolařík, V.; *Electron-Beam Writing System for Diffractive Optical Elements.* Pilot plant, (2006)
- Kolařík, V.; Matějka, F.; Horáček, M.; Lencová, B.; Matějka, M.; Král, S.; Urbánek, M.; Mikšík, P.; Vašina, J.; Horák, R.; *E-Beam Writing Technology with Variable Beam Size of 66–2100 nm*. Technology, (2009)

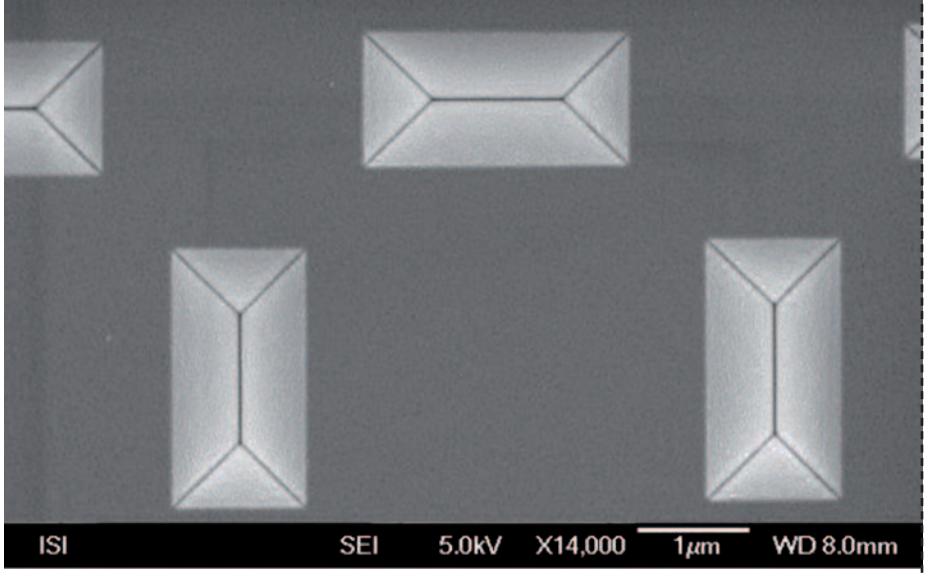
MAIN COLLABORATING PARTNERS

Collaboration with academic partners

- Brno University of Technology (Brno, CZ)
- Masaryk University (Brno, CZ)
- Czech Metrology Institute (Brno, CZ)

Collaboration with companies

- Tescan (Brno, CZ)
- Optaglio (Řež u Prahy, CZ)
- FEI Czech Republic (Brno, CZ)
- Delong Instruments (Brno, CZ)



Grooves of a dimension calibration sample

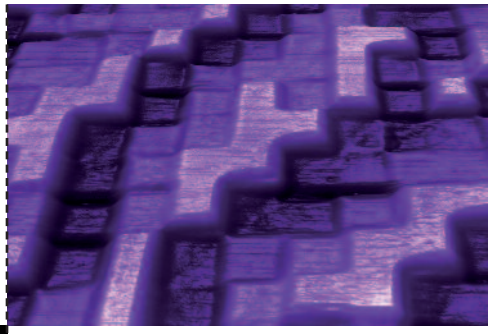
EXPECTATIONS

Offers

– Diffractive image structures
– Optical focusing elements
– Optical beam splitters, computer generated holograms (CGH)
– Photolithography masks
– Direct write lithography
– Dimension and material calibration samples

Requirements

– Collaboration with industrial partners on common projects dedicated to applied science
– New complementary technologies



Multilevel CGH structure

Laser beam forming on computer generated hologram (CGH) structures

Group of Magnetic Resonance
Department of Magnetic Resonance and Cryogenics

ISI ASCR Institute of Scientific Instruments AS CR, v. v. i.

THEMATIC RESEARCH FOCUS

Research area
Nuclear magnetic resonance imaging
Nuclear magnetic resonance spectroscopy in vivo
MR for preclinical research with small laboratory animal models
MR imaging for medical diagnostics
MR for material research and development

Excellence
MR spectroscopy in vivo – spin system simulation, pulse sequence development.
MR measurement of perfusion – pharmacokinetic modeling.

Mission
1. Research into the biological, chemical and physical background of modern MR techniques, incl. MR in ultra-high fields, fast steady-state techniques, computer simulation of spin systems as a tool for method design and quantitation.
2. Development of measurement techniques and advanced physical and physiological data modeling, incl. uncertainty assessment for robust quantitative MR imaging of relaxation, diffusion and perfusion, MR spectroscopy and spectroscopic imaging, and their application to study dynamics. The focus is on in vivo applications in preclinical imaging and human diagnostics, particularly on metabolite quantitation and pharmacokinetic modeling of perfusion.
3. Development of applications of MR techniques for specific biomedical research and medical diagnostics of neurologic, cerebrovascular, oncologic diseases, incl. application of exogeneous contrast nanoparticles, and data mining from multiparametric MR images.
4. Support of biomedical research by providing complex MR services with laboratory animals.
5. MR measurements for plant biology and industrial material research and development.

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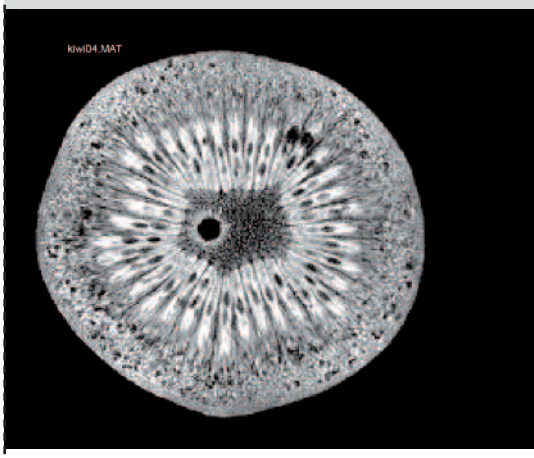


Kiwi fruit cross-section, MRI at 4.7 T

Preclinical 9.4T MR scanner equipped for mouse/rat imaging

DEVELOPED TECHNOLOGIES

Content of research

1a. Behaviour of coherence in coupled spin systems in fast multipulse excitation and its computer simulation

1b. Computer simulation of coupled spin system as a tool for pulse sequence design, development of MR spectroscopic data analysis and metabolite quantitation, and for education. The goal is to provide a comprehensive and practical analytical tool covering multiple relevant phenomena (chemical shift, spin-spin coupling, relaxation, magnetization transfer, chemical exchange, field inhomogeneity, motion)

2a. Pharmacokinetic modeling in MR imaging of perfusion – model development, algorithm implementation, experimental verification, application

2b. Metabolite quantitation in MR single voxel spectroscopy and spectroscopic imaging – model development, algorithm implementation, experimental verification, application

2c. Assessment of model parameter uncertainty, its reduction by MR measurement optimization

3a. Multiparametric MR including relaxometry, diffusion tensor imaging and fibre tractography, perfusion measurement, functional MR imaging, spectroscopy – optimized protocols for biomedical research and medical diagnostics, research into efficient data fusion, presentation, and classification

3b. Research into experiment parameters and biological, chemical and physical factors affecting MR measurements in animal models

4a. Development of standard operation procedures for animal MR measurements

5a. Water transport – diffusion and perfusion in plants

5b. MR characterization of gels and porous materials

Main capabilities

Core competence

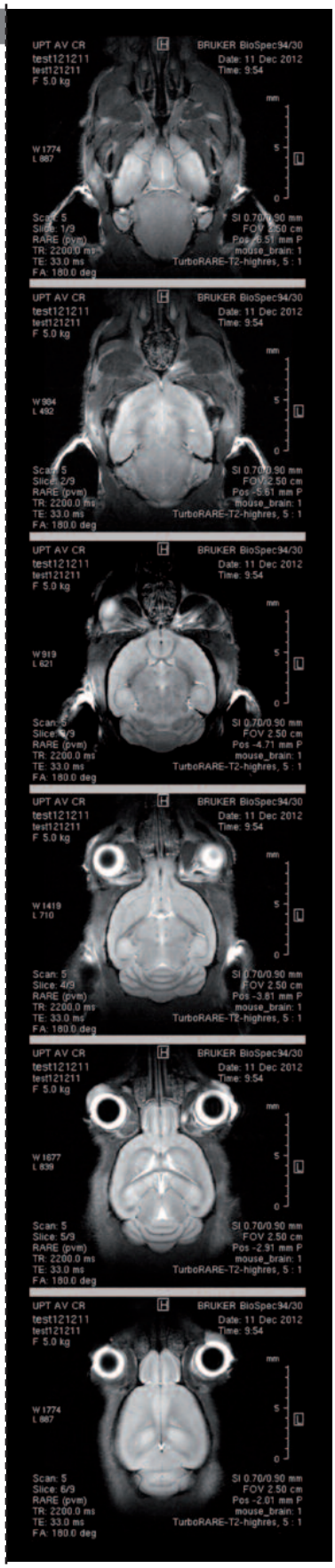
– Pulse sequence design and analysis by computer simulation of spin system evolution
– MR data analysis for the measurement of relaxation, diffusion, perfusion, spectroscopy
– Verification of measurement protocols and analytics by phantom studies
– Development of customized MR protocols

Application areas

– Phenotyping of murine animal models by multiparametric MR examination
– Research into etiology and pathophysiology of diseases in animal models
– Development of therapeutical procedures and drugs: efficiency, targeting, toxicity
– Animal model based development of diagnostics for medical use
– Testing nanoparticle carriers for targeted markers and drugs
– Plant development, genomics
– Study of properties of technical gels
– Characterization of porous materials

Fields of research results application

– Life-sciences (animal model based research into neurodegeneration, psychiatric, cerebrovascular, cardiovascular, oncologic diseases, drug targeting tests, nanoparticle deposition for toxicity assessment)
– Electrotechnics and power storage (characterization of specific gels)
– Construction industry (characterization of specific gels – concrete, and porous materials – wood, foams)
– Food and drug industry (structure, water/fat/air content and its dynamics, deterioration processes)
– Magnetic resonance education for university students and MR professionals (virtual scanner)



Anatomical T2 weighted MR images of a mouse brain at 9.4 T

KEY RESEARCH EQUIPMENT

– MR scanner 9.4T/30cm Bruker BioSpec Avance III 94/30 (^{1}H 400 MHz), 300 mT/m gradients, 660 mT/m gradient insert for microimaging, multinuclear (^{31}P, ^{13}C, ^{19}F, ^{129}Xe), RF coils for mouse/rat/rabbit measurement, 2 transmit, 4 receive channels
– isoflurane anesthesia, vital function monitor SAII 1030, artificial ventilation, animal bed heating, minisurgery room
– animal facility for 200 mice and 100 rats with overpressure and EU14 filtration, animals in individually ventilated cages, hygienic loop, autoclave, UV sterilization chamber, laminar flow boxes
– wet lab with fume chamber, deep freezer (-80 °C), cadaver freezer
– MR scanner 4.7T/20cm with magnet Magnex Sci. Ltd., console MR Solutions MR6000, 1kW RF amplifier CPCAmps 5T1000M, gradients 180 mT/m, Gz insert 1000 mT/m

ACHIEVEMENTS

Ultra-short echo-time spectroscopic techniques exhibiting particularly robust water suppression and low contamination have become a worldwide standard and make it possible to reliably determine up to 20 metabolites in brain MR spectra.

– Tkáč, I.; Starčuk, Z.; Choi, I.–Y.; Gruetter, R.; *In Vivo 1H NMR Spectroscopy of Rat Brain at 1 ms Echo Time.* Magnetic Resonance in Medicine 41, (1999), p. 649–656.
– Mlynárik, V.; Gruber, S.; Starčuk, Z.; Starčuk Jr., Z.; Moser, E.; *Very Short Echo Time Proton MR Spectroscopy of Human Brain With a Standard Transmit/Receive Surface Coil.* Magnetic Resonance in Medicine 44, (2000), p. 964–967.
– Starčuk, Z.; Mlynárik, V.; Roden, M.; Horký, J.; Moser, E.; *Low-Power Water Suppression by Hyperbolic Secant Pulses with Controlled Offsets and Delays (WASHCODE).* Journal of Magnetic Resonance 152, (2001), p. 168–178. DOI: 10.1006/jmre.2001.2392.

A simulator of coupled spin systems undergoing relaxation and spatially--frequentially-inhomogeneous excitation (NMRScopeB) has been developed and integrated into jMRUI software, used at over 2000 institutions worldwide.

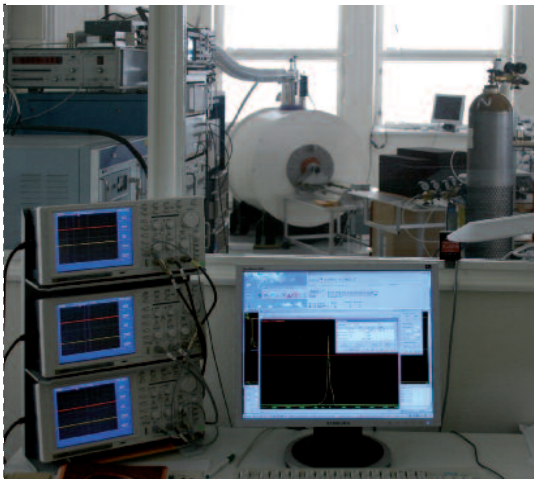
– Stefan, D.; Di Cesare, F.; Andrasescu, A.; Popa, E.; Lazariev, A.; Vescovo, E.; Strbak, O.; Williams, S.; Starčuk, Z.; Cabanas, M.; van Ormondt, D.; Graveron-Demilly, D.; *Quantitation of magnetic resonance spectroscopy signals: the jMRUI software package.* Meas. Sci. Technol. 20, (2009), 104035, 9p. DOI:10.1088/0957-0233/20/10/104035.

Techniques for accurate measurement of material properties (relaxation, magnetic susceptibility) have been developed and applied in practical studies.

– Starčuková, J.; Starčuk Jr., Z.; Hubálková, H.; Linetskiy, I.; *Magnetic susceptibility and electrical conductivity of metallic dental materials and their impact on MR imaging artifacts.* Dental materials 24, (2008), p. 715–723. DOI: 10.1016/j.dental.2007.07.002.
– Kořínek, R.; Vondrák, J.; Bartušek, K.; Sedlaříková, M.; *Experimental investigations of relaxation times of gel electrolytes during polymerization by MR methods.* J Solid State Electrochem, (2012). DOI 10.1007/s10008-012-1715-6.

Models and algorithms have been developed for pharmacokinetic analysis of perfusion based on MR measurement of contrast agent bolus dynamics in the animal and human body. Perfusion is an important process in cancer, brain injuries, neurodegenerative diseases and drug targeting – this development aids the diagnostics, therapy development, and basic research of pathophysiology.

– Taxt, T.; Jiřík, R.; Rygh C. B. Grüner, R.; Bartoš, M.; Andersen, E.; Curry F.-R.; Reed, R. K.; *Single-Channel Blind Estimation of Arterial Input Function and Tissue Impulse Response in DCE-MRI.* IEEE Transactions on Biomedical Engineering 59, 4, (2012), p. 1012–1021. DOI 10.1109/TBME.2011.2182195.



4.7 T MR laboratory

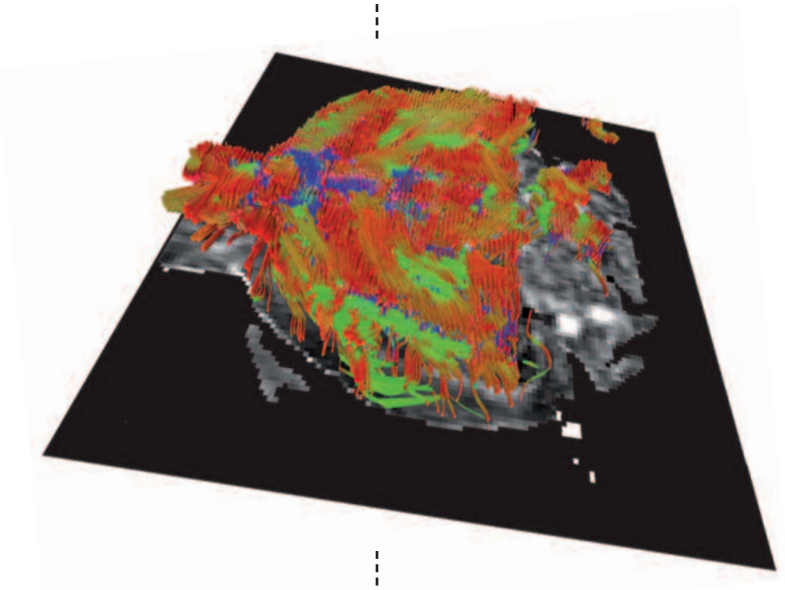
MAIN COLLABORATING PARTNERS

Collaboration with academic partners

Katholieke Universiteit Leuven (Leuven, BE)
Ecole Polytechnique Fédérale de Lausanne (Lausanne, CH)
University of Manchester (Manchester, UK)
Max Planck Institute for Human Cognitive and Brain Sciences (Leipzig, DE)
Radboud University Nijmegen Medical Centre (Nijmegen, NL)
Universitat Autonoma de Barcelona (Barcelona, ES)
University of Bern (Bern, CH)
Université Claude Bernard Lyon 1 (Lyon, FR)
Delft University of Technology (Delft, NL)
Instytut Fizyky Jadrowej PAN (Kraków, PL)
Masarykova univerzita (Brno, CZ)
Vysoké učení technické (Brno, CZ)
Fakultní nemocnice u sv. Anny – ICRC (Brno, CZ)
Výzkumný ústav veterinárního lékařství (Brno, CZ)

Collaboration with companies

Philips Healthcare (Nijmegen, NL)
Siemens Healthcare (Erlangen, DE)
Bruker Biospin (Ettlingen, DE)
AlterSystems (Lyon, FR)
icoMetrix (Leuven, BE)



Neuronal fiber tracking based on diffusion tensor imaging in mouse brain

EXPECTATIONS

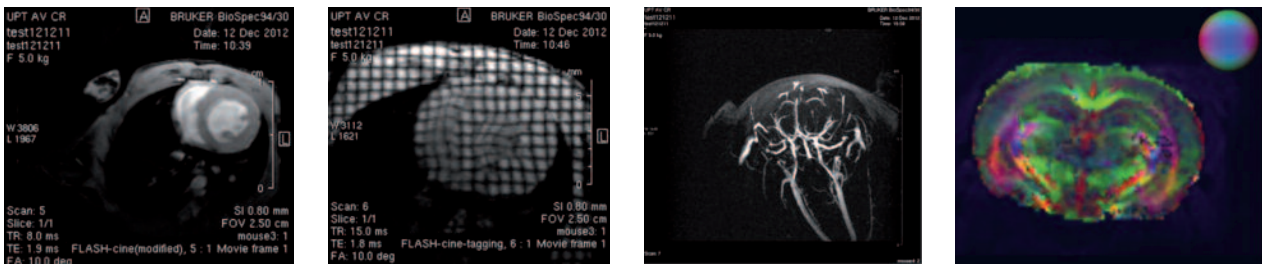
Offers

– Development of MR measurement protocols for specific applications
– Development of MR data analysis methods (measurement of relaxation, diffusion, perfusion, spectroscopy)
– Multiparametric testing of animal models by MR methods
– Multiparametric testing of disease markers, drugs, therapeutic procedures in animal models
– Characterization of gels or porous materials
– MR imaging of small diamagnetic objects, MR data analysis
– Nanoparticles in animals

Requirements

– Biomedical research and development using small laboratory animals (mouse, rat) by methods of magnetic resonance, behavioural testing possible upon request, complementary imaging modalities welcome.

Mouse cardiac real time MR imaging without and with tagging, angiography, diffusion tensor imaging (left to right)



Group of Cryogenics & Superconductivity

Department of Magnetic Resonance & Cryogenics

ISI ASCR Institute of Scientific Instruments AS CR, v. v. i.

THEMATIC RESEARCH FOCUS

Research area

– Cryogenics
– Low temperature physics
– Fluid dynamics, turbulence
– Applied superconductivity

Excellence

– Characterization of thermal-radiative properties of materials at low temperatures
– Experimental study of near-field effect at low temperatures
– Basic research in fluid dynamics – Rayleigh-Bénard convection
– Design and optimization of cryogenic systems

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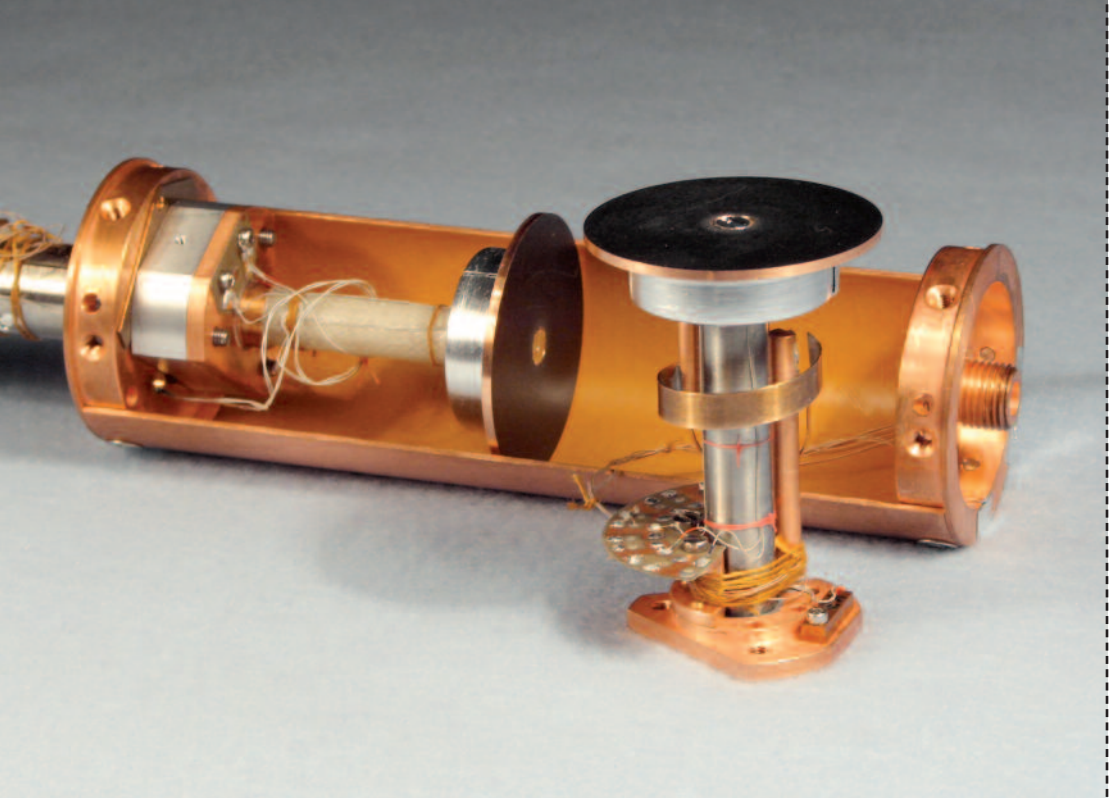
Cryostat for study of natural convection in cold helium gas



Apparatus for measurement of thermal radiative properties

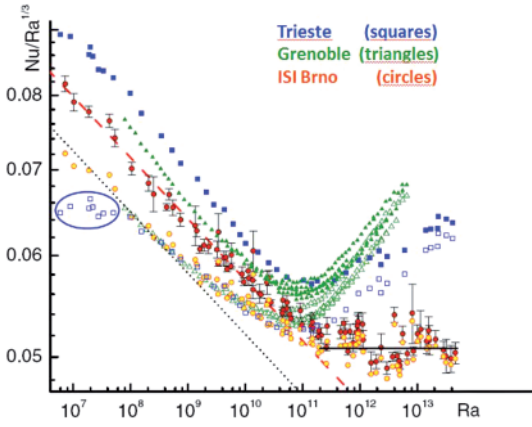
Mission

– Elucidation of natural turbulent convection in cryogenic experiments considering the fact that a general theory of turbulence is still absent
– Broadening of our unique database of thermal-radiative properties of materials used in cryogenics
– Validation of theoretical model of the near-field effect at low temperatures for different materials

DEVELOPED TECHNOLOGIES

Content of research

– Experimental study of the dependence of the Nusselt number (Nu) on the Rayleigh number (Ra) up to Ra ≈ 10^{15}
– Experimental study of large scale circulation and coherent structures in cryogenic helium gas
– Study of near-field effect at low temperatures over 6 orders of magnitude of heat transfer
– Characterization of materials and multilayer insulation (MLI) from the viewpoint of reduction of parasitic heat transfer at low temperatures
– Experimental study of ultra-clean pumping using helium cryopump and elimination of cryogenic liquids losses
– Design of sample cooling for low temperature scanning probe microscope (SPM)
– Vacuum instrumentation for cryogenic systems
– Low temperature thermometry



Different results for Ra over 10^{11}

Main capabilities

Basic research

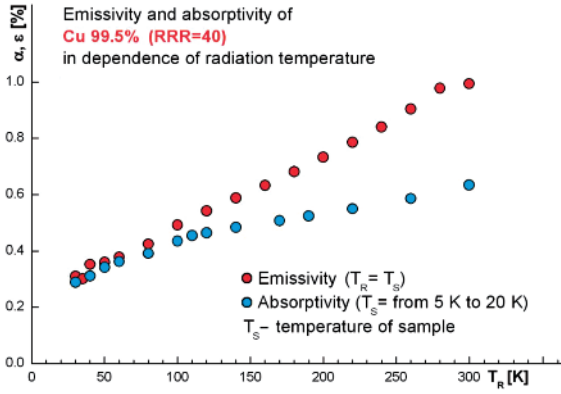
– Study of Rayleigh-Bénard convection using cold helium gas
– Methods of loss reduction in cryogenic systems
– Study of material surfaces used in cryogenics
– Study of near-field effect at low temperatures

Applied research

– Measurement of thermal-radiative properties of materials
– Advanced microscopy and spectroscopy platform for research and development in nano- and microtechnologies: UHV SEM/SPM modular system for in situ fabrication and characterization of nanostructures and surface analysis at variable substrate temperatures (5–700 K)
– Design of cryogenic systems by the KRYOM 3.1 program developed in the Group of Cryogenics & Superconductivity
– Design of superconducting magnet systems with a defined shape of magnetic field

Fields of research results application

Materials science (study of materials used in cryogenics)
Special measuring instruments
Space research
Nuclear magnetic resonance and imaging



Emissivity and absorptivity of Copper

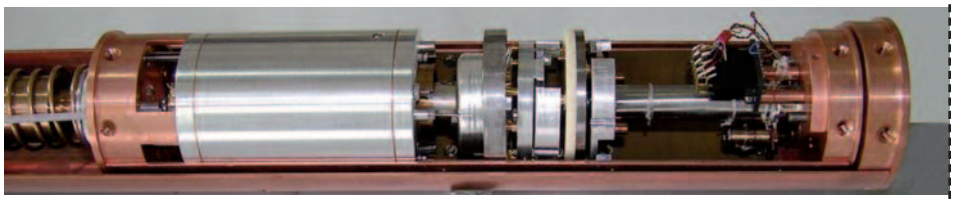
KEY RESEARCH EQUIPMENT

– Helium liquefier L1410 (Linde Process Plants), 18 l of liquid helium per hour, complete helium recovery system for helium gas savings.
– Helium Dewars with neck diameter up to 50 mm and volumes from 30 l to 100 l of liquid helium
– Precise NMR magnetometer PT 2025 (Metrolab Instruments), measurement range from 0.7 to 13.7 Tesla
– Low temperature controllers (3 pcs) Model 340 (LakeShore) for precise measurement of (low) temperature with different types of sensors
– Helium leak detector ASM 310 (Adixen Vacuum Products)
– Mass spectrometer PrismaPlus (Pfeiffer Vacuum) up to mass number A=100
– Container (500 l) for liquid nitrogen storage (Chart Ferox)

ACHIEVEMENTS

Development of unique experimental system for observation of near-field effect at low temperatures and pilot experimental measurements

– Králík, T.; Musilová, V.; Hanzelka, P.; Zobač, M.; Fořt, T. and Horák, M.; *Strong Near-Field Enhancement of Radiative Heat Transfer between Metallic Surfaces.* Phys. Rev. Lett. 109, (2012) 224302



Apparatus for the measurement of the radiative heat transfer by the near field

Elucidation of natural turbulent convection using our original experimental apparatus

– Urban, P.; Hanzelka, P.; Králík, T.; Musilová, V.; Srnka, A. and Skrbek, L.; *Effect of boundary layers asymmetry on heat transfer efficiency in turbulent Rayleigh-Bénard convection at very high Rayleigh Numbers.* Phys. Rev. Lett. 109, (2012), 154301
– Urban, P.; Musilová, V.; Skrbek, L.; *Efficiency of heat transfer in turbulent Rayleigh-Bénard convection.* Phys. Rev. Lett. 107, (2011), 014302

Characterization of thermal-radiative properties of materials at low temperatures using original measurement system of in-house design

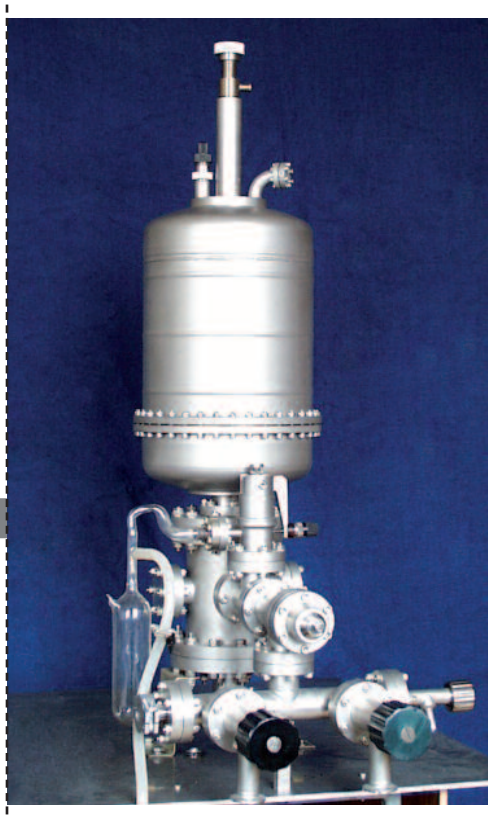
– Musilová, V.; Hanzelka, P.; Králík, T.; Srnka, A.; *Low temperature radiative properties of materials used in cryogenics.* Cryogenics 45, (2005), 529–536

Design and manufacturing of wiggle-free helium bath cryopump suitable for electron optical devices

– Musilová, V.; Dupák, J.; Hanzelka, P.; Králík, T.; Urban, P.; *Economical helium bath cryopump: design and testing.* Vacuum 74, (2004), 77–83

Design of unique custom-made cryogenic systems

– Urban, P.; Hanzelka, P.; Králík, T.; Musilová, V.; Skrbek, L.; Srnka, A.; *Helium cryostat for experimental study of natural turbulent convection.* Review of Scientific Instruments. 81, n. 8, (2010), 085103



Ultra high vacuum helium bath cryopump

MAIN COLLABORATING PARTNERS

Collaboration with academic partners

– Charles University (Praha, CZ)
– Brno University of Technology (Brno, CZ)
– CERN (Geneva, Switzerland)
– Polytechnic Institute of New York University (New York, USA)
– University of Vienna (Vienna, Austria)
– International Centre for Theoretical Physics (Trieste, Italy)

Collaboration with companies

– RUAG Space (Vienna, Austria)
– Acktar (Kyriat-Gat, Israel)
– Delong Instruments (Brno, CZ)
– SHM Plasma (Brno, CZ)
– První brněnská strojírna Velká Bíteš, a.s. (Velká Bíteš, CZ)

EXPECTATIONS

Offers

– Properties of materials at low temperatures
– Thermal shielding of cryogenic systems
– Calculation of cooling capacities of different liquid gases
– Design of special cryogenic systems for physics experiments
– Low temperature measurement and its accuracy
– Vacuum in cryogenic systems
– Calculation of parasitic heat flows at cryogenic temperatures
– Measurement of parasitic heat flows at cryogenic temperatures
– Expertise in cryogenic safety, training in cryogenic safety

Requirements

– Partners for EU research projects in the field of cryogenic helium turbulence
– Co-operative research and development of new materials for the thermal insulation of cryogenic systems
– Collaboration with industrial partners on common projects dedicated to applied science in the field of cryogenics (e.g. special cryogenic devices)

Measurement of thermal dependence of the emissivity and absorptivity of materials at low temperatures.

Group of Medical Signals
Department of Medical Signals

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THEMATIC RESEARCH FOCUS

Research area
– Non-invasive cardiology
– Scalp and intracerebral neurology
– Medical signal processing
– Medical acquisition systems
– Experimental devices – ECG monitors, amplifiers, whole body plethysmography
– Testing and verification of new diagnostics procedures

Excellence
Analysis and statistical evaluation of EEG recordings from deep brain structures, circulation control and hemodynamics, cardio electrophysiology

Mission
Development of new measurement techniques and analytical procedures for brain activity mapping and treatment of epileptic patients. Diagnostic procedures for non-invasive, cheap, comfortable and early diagnosis of cardiovascular system diseases.

DEVELOPED TECHNOLOGIES

Content of research
– Research based on the interpretation of experimental repeated stimulations related to description of brain structure connectivity
– Experimental research in cardiology leading to the interpretation of pathological patterns and couplings in ECG signals
– Development of new methods for dynamic description of hemodynamic parameter coupling during different excitations and states

Multi-channel whole-body impedance cardio-plethysmograph system ISI MBM

Main capabilities

Basic research

– Deep brain structure cross-connectivity, description of involvement of brain structures in decision-making processes
– Experimental procedures related to the description of basic heart electrophysiology behaviour during different excitations
– Genetically dependent coupling between heart rate and ventricular repolarisation

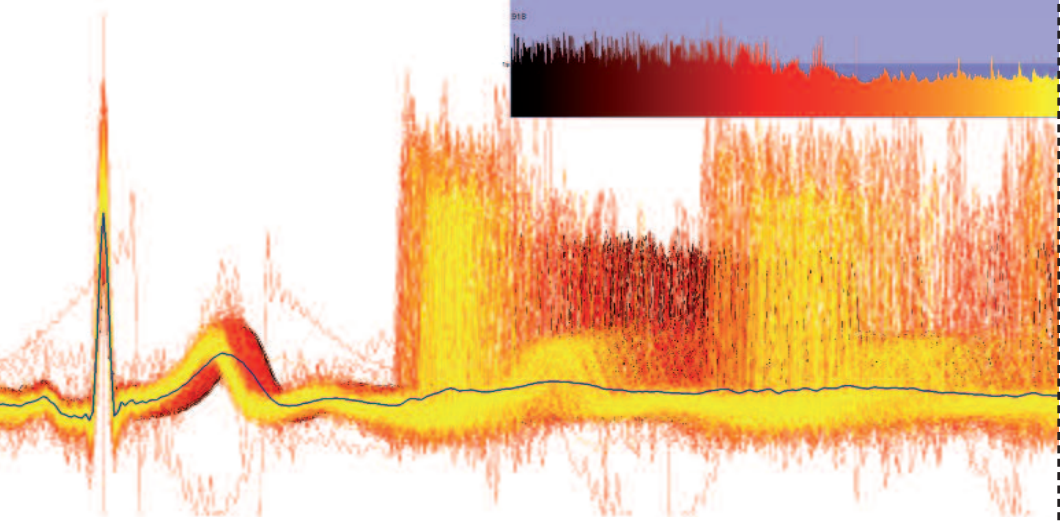
Applied research

– Deep brain structure epileptic foci detection and localization
– High frequency EEG identification, detection of pathological deep brain EEG oscillations
– Non-invasive diagnostics of heart and cardiovascular diseases

Blood circulation control measurement, experimental laboratory located in St. Anne's University Hospital, Brno

Fields of research results application

– Neurology in general
– Epileptic patient treatment
– Dementia diseases
– Cardiology in general
– Heart failure, arrhythmia, heart attack, ischemic disease
– Blood vessel stiffness and properties of blood circulation
– Cardiac output and heart efficiency
– Non-invasive preventive cardiology



ECG signal during rest and exercise

KEY RESEARCH EQUIPMENT

- Data acquisition systems for neuro-cardio electrophysiology – ISI PAS II.
- Data acquisition software and software for signal visualisation and pre-processing – ScopeWin, EEGVisual
- Multi-channel whole-body impedance cardiograph-plethysmograph system – ISI MBM
- Experimental syringe mixing pump for ultrasound contrast agents – ISI MSP
- Microneurography amplifier – ISI FARIO
- Experimental 12 lead electrocardiographs – ISI ECG 12
- Detector of vagus nerve stimulation – ISI VAG 1
- Respiration control device – ISI RECO 2
- Strain gauge plethysmograph – ISI SGP

Detector of vagus nerve stimulation ISI VAG 1

ACHIEVEMENTS

New methodology for description of dynamic properties of heart repolarisation

- Halámek, J.; Couderc, JP.; Jurák, P.; Vondra, V.; Zareba, W.; Viščor, I.; Leinveber, P.; *Measure of the QT–RR Dynamic Coupling in Patients with the Long QT Syndrome.* Ann Noninvasive Electrocardiol, 17(4), (2012), p. 323–330
- Halámek, J.; Jurák, P.; Bunch, T.; Lipoldová, J.; Novák, M.; Vondra, V.; Leinveber, P.; Plachý, M.; Kára, T.; Villa, M.; Fráňa, P.; Souček, M.; Somers, V.; Asirvatham, S.; *Use of a novel transfer function to reduce repolarization interval hysteresis.* J Interv Card Electrophysiol, 29, (2010), p. 23–32

European patent

- Halámek, J.; Jurák, P.; *Method of Ventricular Repolarization Analysis.* Institute of Scientific Instruments, Academy of Sciences of the Czech Republic, PCT/IB2008/002198, priority 30. 5. 2007, granted 15. 2. 2012

Detection and analysis of ECG parameters and blood circulation

- Lanfranchi, P. A.; Ackerman, M. J.; Kára, T.; Shamsuzzaman, A. S.; Wolk, R.; Jurák, P.; Amin, R.; Somers, V. K.; *Gene-specific paradoxical QT responses during rapid eye movement sleep in women with congenital long QT syndrome.* Heart Rhythm, 7, n. 8, (2010), p. 1067–1074
- Lanfranchi, P. A.; Gosselin, N.; Kára, T.; Jurák, P. et al.; *Menopause, hormone replacement and RR and QT modulation during sleep.* Sleep Medicine, Vol. 6, Issue 6, (2005), p. 561–566
- Halámek J.; Kára T.; Jurák P. et al.; *Variability of phase shift between blood pressure and heart rate fluctuations – A marker of short-term circulation control.* Circulation, Vol.108, Issue 3, (2003), p. 292–297

Respiration control and stimulation

Interictal high-frequency oscillations indicating seizure onset zone

- Brázdil, M.; Halámek, J.; Jurák, P.; Daniel, P.; Kuba, R.; Chrastina, J.; Novák, Z.; Rektor, I.; *Interictal high-frequency oscillations indicate seizure onset zone in patients with focal cortical dysplasia.* Epilepsy Research, 90, 1–2, (2010), p. 28–32

Deep brain structure cognitive, memory and emotion properties

- Bočková, M.; Chládek, J.; Šímová, L.; Jurák, P.; Halámek, J.; Rektor, I.; *Oscillatory changes in cognitive networks activated during a three-stimulus visual paradigm.* An intracerebral study. Clinical Neurophysiology, in press
- Štillová, K.; Jurák, P.; Chládek, J.; Halámek, J.; Telecká, S.; Rektor, I.; *The Posterior Medial Cortex is Involved in Visual but not in Verbal Memory Encoding Processing.* An Intraceribral Recording Study, Intracerebral Recording Study, J Neural Transm, (2012), DOI 10.1007/s00702-012-0890-z, in press
- Bočková, M.; Chládek, J.; Jurák, P.; Halámek, J.; Baláž, M.; Rektor, I.; *Involvement of the subthalamic nucleus and globus pallidus internus in attention.* Journal of Neural Transmission, (2011), 118, n. 8, p. 1235–1245
- Brázdil M.; Roman R.; Urbánek T.; Chládek J.; Spok D.; Mareček R.; Mikl M.; Jurák P.; Halámek J.; Daniel P.; Rektor I.; *Neural correlates of affective picture processing – A depth ERP study*. NEUROIMAGE, Vol. 47, Issue 1, p. 376–383

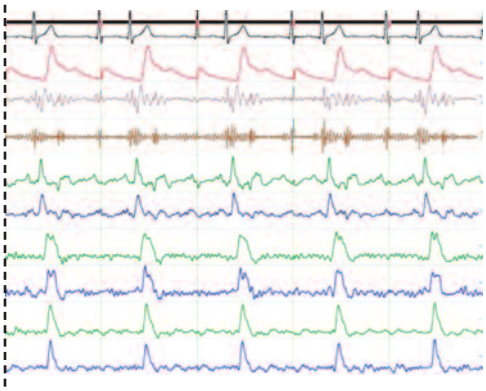
MAIN COLLABORATING PARTNERS

Collaboration with academic partners

St. Anne's University Hospital (Brno, CZ)
University Hospital (Brno, CZ)
Mayo Clinic (Rochester, MN, USA)
Masaryk University (Brno, CZ)
International Clinical Research Center (Brno, CZ)
Central European Institute of Technology (Brno, CZ)
University of Rochester Medical Center (Rochester, NY, USA)
Université de la Méditerranée, (Marseille, France)
University of Veterinary and Pharmaceutical Sciences (Brno, CZ)
Universita degli Studi di Milano (Milano, Italy)
Université de Montréal (Montreal, Canada)
Medical University of Gdansk (Gdansk, Poland)

Collaboration with companies

M&I, s.r.o. (Praha, CZ)
Unimedis, s.r.o. (Praha, CZ)



Multi-Channel Impedance Cardiography, ECG, blood pressure, heart sounds

EXPECTATIONS

Offers

- Sharing experience with experimental medical device design and construction
- Offering experience with experimental protocols design, data acquisition and processing
- Providing a professional background for the implementation of medical experimental measurement in cardiology and neurology
- Partnership in international projects
- Custom manufacturing of medical devices

Requirements

We welcome collaboration with academic partners especially from human health area as well as medical companies in the fields of cardiology and neurology.

Group of Optical Micromanipulation Techniques

Department of Optical Micromanipulation Techniques

ISI ASCR Institute of Scientific Instruments AS CR, v. v. i.

THEMATIC RESEARCH FOCUS

Research area

– Biophotonics and nanophotonics

Excellence

– Force interaction between light and objects (theoretical and experimental aspects)
– Applications of focused laser beams (laser microdissection, optical tweezers, optical cell sorters, long-range optical delivery of micro(nano)objects, polymerization of micro-structures)
– Laser beam shaping by spatial light modulators
– Design and manufacturing of custom-made laser beam systems

Mission

To be at the forefront in looking for new optical methods appropriate for contactless, nondestructive investigation of living or inanimate parts of the microworld.

DEVELOPED TECHNOLOGIES

Content of research

– Theoretical and experimental activities related to optical micromanipulations with microobjects and nanoobjects (light scattering, optical tweezers, optical sorters, optical scalpel, optical delivery, optical binding, localized plasmons, photonic force microscope, force spectroscopy, microfluidics)
– Raman microspectroscopy, Raman tweezers
– Photopolymerization, soft-lithography, lab-on-a-chip

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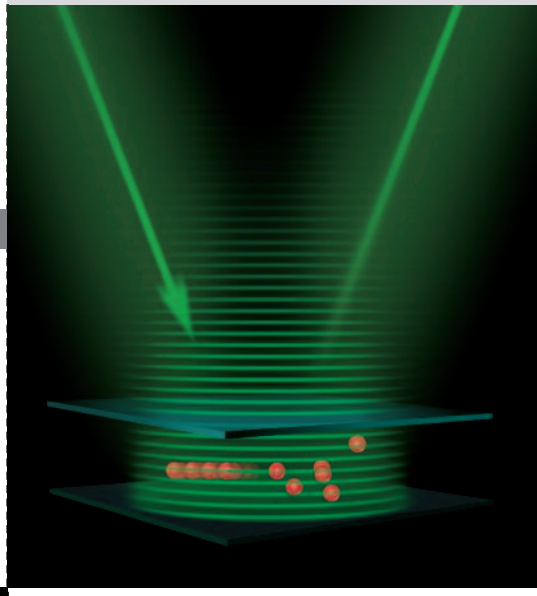
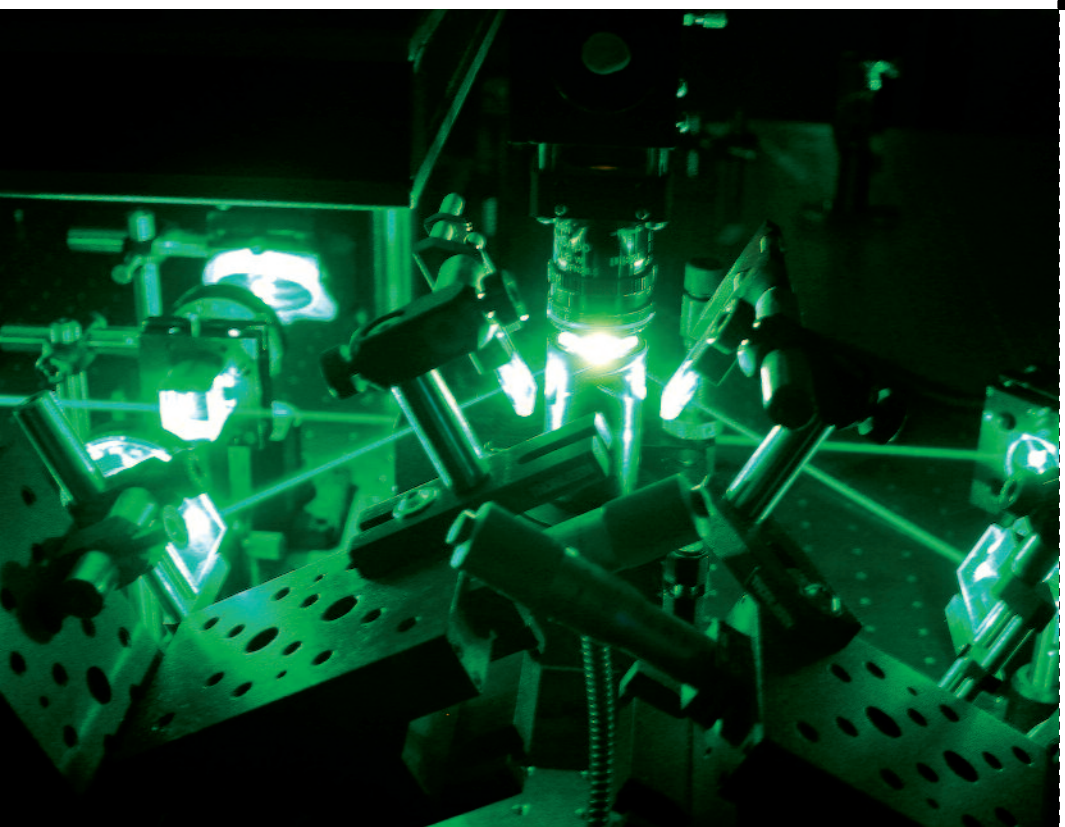
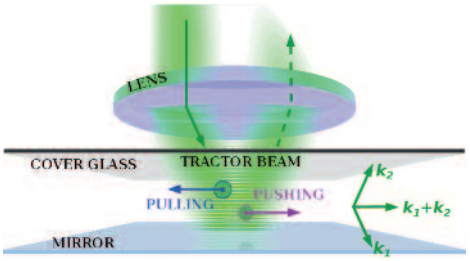
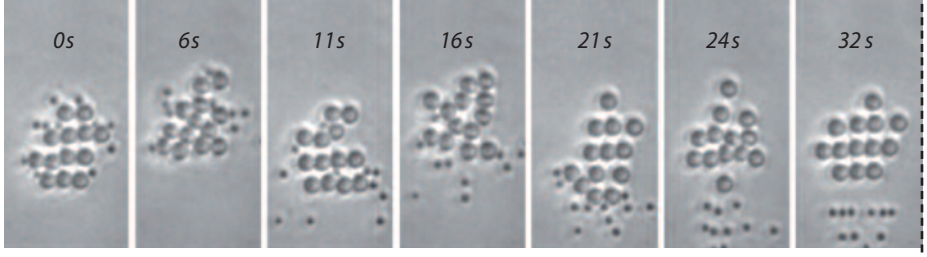






Geometrical configuration of the optical tractor beam setup and visualization of the pulling and pushing optical force acting upon particles of different sizes

Example of experimental set-up.



Example of optical sorting of suspension of polystyrene particles of sizes 800 nm and 1600 nm in travelling interference fringes

Main capabilities

Basic research

– Theoretical simulations of light scattering and optical forces acting on microparticles and nanoparticles illuminated by spatially structured laser beams
– Experimental activities related to micromanipulation with microparticles or nanoparticles using laser beams (sample preparation, laser beam shaping and positioning, microobjects position measurement in nm resolution, pN force measurement, optical sorters)
– Spatially resolved Raman spectroscopy combined with optical micromanipulation techniques

Applied research

– Manufacturing of custom-made opto-mechanical laser beam systems
– Design and manufacturing of microfluidic chips by soft-lithography
– Photopolymerization of microstructures
– Optical sorters of microobjects or living microorganisms

Fields of research results application

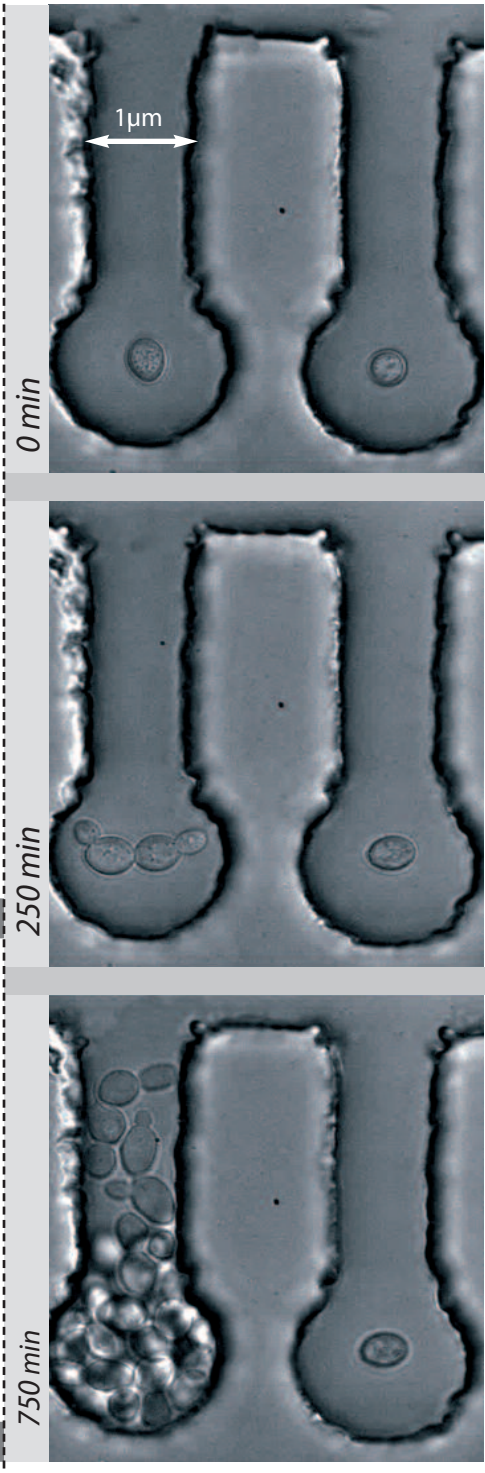
– Optical microscopy
– Microtechnology, nanotechnology
– Cell biology
– Colloidal chemistry
– Laser spectroscopy
– Microfluidics
– Lab-on-a-chip systems
– Microbiology (algae, bacteria)

KEY RESEARCH EQUIPMENT

– Various CW high power lasers working at 1064 nm, 980 nm, 785 nm, 532 nm, 680–1000 nm (Coherent, Spectra Physics, IPG, Sacher)
– Femtosecond laser systems Mira 800 HP, Mai Tai HP Deep See
– Renishaw inVia Raman microscope
– Raman tweezers made by the research team
– Photonic force microscope made by the research team
– Optical cell sorters made by the research team
– Several different flexible systems for advanced optical micromanipulation experiments (holographic tweezers, dual-beam holographic traps)
– Fast CCD cameras (thousands fps)
– Ion etching system (Plasmalab System 100)

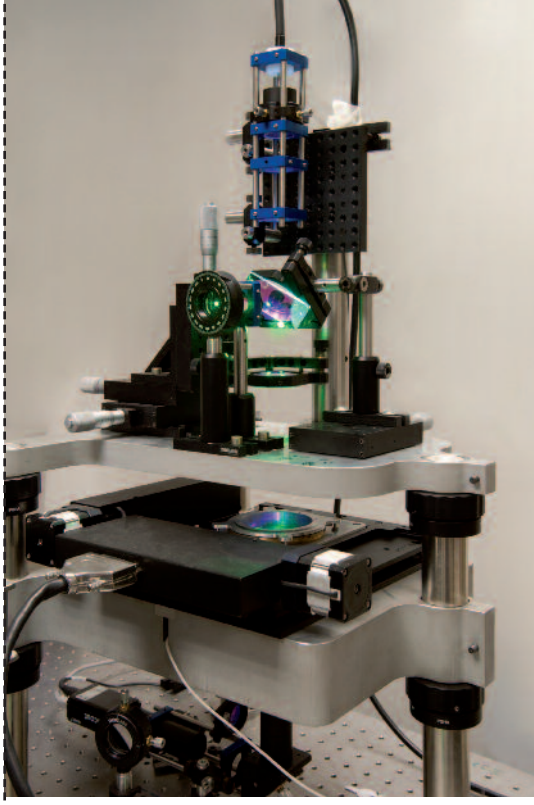
ACHIEVEMENTS

We deepened the understanding of the force interaction between light and micro/nanoparticles and developed original methods how to manipulate with individual particles or even thousands of particles, how to sort and self-arrange them. We published about 50 papers in impacted journals with very good citation response and about 70 longer contributions in conference proceedings or local journals.

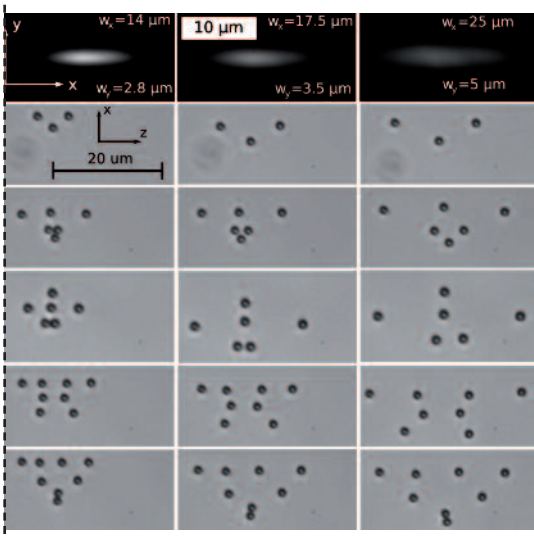


Example of a small part of a microfluidic chip enabling cultivation of individual cells in separated micro-compartments under different conditions (right illuminated by a laser beam)

- **Experimental demonstration of optical "tractor" beam and its utilization in optical sorting and self-arrangement of microobjects.** This result attracted strong interest of media all over the world.
  - Brzobohatý, O.; Karásek, V.; Šiler, M.; Chvátal, L.; Čižmár, T. & Zemánek, P.; *Experimental demonstration of optical transport, sorting and self-arrangement using a 'tractor beam'.* Nature Photonics 7, (2013), p. 123–127
- **Microparticles illuminated by wide laser beams tend to self-organize into structures bound together by light (optically bound matter).** We developed methods to study such behaviour and performed pioneering experiments to understand it.
  - Karásek, V.; Čižmár, T.; Brzobohatý, O.; Zemánek, P.; Garcés-Chávez, V.; Dholakia, K.; *Long-range one dimensional longitudinal optical binding.* Physical Review Letters 101, (2008), 143601:1–4
  - Dholakia, K. and Zemánek, P.; *Colloquium: Gripped by light: Optical binding.* Reviews of Modern Physics 82, (2010), p. 1767–1791
  - Brzobohatý, O.; Čižmár, T.; Karásek, V.; Šiler, M.; Dholakia, K. and Zemánek, P.; *Experimental and theoretical determination of optical binding forces.* Optics Express 18, (2010), p. 25389–25402
  - Brzobohatý, O.; Karásek, V.; Čižmár, T. and Zemánek, P.; *Dynamic size tuning of multidimensional optically bound matter.* Applied Physics Letters 99, (2011), 101105
  - Čižmár, T.; Brzobohatý, O.; Dholakia, K. and Zemánek, P.; *The holographic optical micro-manipulation system based on counter-propagating beams.* Laser Physics Letters 8, (2011), p. 50–56
  - Šiler, M.; Čižmár, T. and Zemánek, P.; *Speed enhancement of multi-particle chain in a traveling standing wave.* Applied Physics Letters 100, (2012), 051103
- **Simultaneous optical trapping and delivery of thousands of sub-micrometer particles in non-diffracting laser beams or evanescent waves – so called Optical conveyor belt.** This tool attracted attention all over the world in 2005.
  - Čižmár, T.; Garcés-Chávez, V.; Dholakia, K.; Zemánek, P.; *Optical conveyor belt for delivery of submicron objects.* Appl Phys Lett 86, (2005), 174101-1
  - Čižmár, T.; Kollárová, V.; Bouchal, Z.; Zemánek, P.; *Sub-micron particle organization by self-imaging of non-diffracting beams.* New Journal of Physics 8, (2006), 43:1–23
  - Čižmár, T.; Šiler, M.; Zemánek, P.; *An optical nanotrap array movable over a milimetre range.* Applied Physics, (2006), B 84, p. 197–203
  - Šiler, M.; Čižmár, T.; Šerý, M.; Zemánek, P.; *Optical forces generated by evanescent standing waves and their usage for sub-micron particle delivery.* Applied Physics, (2006), B 84, p. 157–165
  - Šiler, M.; Čižmár, T.; Jonáš, A.; Zemánek, P.; *Surface delivery of a single nanoparticle under moving evanescent standing-wave illumination.* New Journal of Physics 10, (2008), 1130101:1–16
- **Discovery of several original methods of spontaneous optical sorting of polydisperse sample of sub-micron size objects according to their sizes in interfering laser beams (optical sorter).** Up to now the smallest difference in the sizes of sorted objects was 60 nm for polystyrene beads of diameters 350 a 410 nm.
  - Čižmár, T.; Šiler, M.; Šerý, M.; Zemánek, P.; Garcés-Chávez, V.; Dholakia, K.; *Optical sorting and detection of submicrometer objects in a motional standing wave.* Physical Review B 74, (2006), 035105:1–6
  - Jákl, P.; Čižmár, T.; Šerý, M.; Zemánek, P.; *Static optical sorting in a laser interference field.* Applied Physics Letters 92, (2008), 161110:1–3
  - Dholakia, K.; MacDonald, M. P.; Zemánek, P.; Čižmár, T.; *Cellular and colloidal separation using optical forces.* Methods in Cell Biology 82, (2007), p. 467–495
  - Jonáš, A.; Zemánek, P.; *Light at work: The use of optical forces for particle manipulation, sorting, and analysis.* Electrophoresis 29, (2008), p. 4813–4851
- **Optical cell-sorter based on fluorescences or Raman spectra of microorganisms (in cooperation with Photon Systems Instruments).**



Experimental setup of the optical tractor beam



Optical self-arrangement of microparticles into 2D optically bound structures tunable by the width of the laser beam

- **Combination of Raman microspectroscopy and optical tweezers** offers a unique tool that provides contactless and nondestructive manipulation and information about the chemical bonds inside mobile living microobjects including living microorganisms.
  - Samek, O.; Jonáš, A.; Pilát, Z.; Zemánek, P.; Nedbal, L.; Tříska, J.; Kotas, P. and Trtílek, M.; Raman microspectroscopy of individual algal cells: Sensing unsaturation of storage lipids in vivo. Sensors 10, (2010), 8635–8651
  - Samek, O.; Zemánek, Z.; Jonáš, A. and Telle, H. H.; Characterization of oil-producing microalgae using Raman spectroscopy. Laser Physics Letters 8, (2011), p. 701–709
  - Pilát, Z.; Bernatová, S.; Ježek, J.; Šerý, M.; Samek, O.; Zemánek, P.; Nedbal, L. and Trtílek, M.; Raman microspectroscopy of algal lipid bodies: beta-carotene quantification. Journal of Applied Phycology 24, (2012), p. 541–546
- **Manufacturing of polymer fibres of diameters in units of micrometers and length in centimetres by non-diffracting beams.**
  - Ježek, J.; Čižmár, T.; Neděla, V.; Zemánek, P.; Formation of long and thin polymer fiber using nondiffracting beam. Optics Express 14, (2006), p. 8506–8515
- **Manufacturing of microfluidic chips combined with optical trapping and diagnostics for microfluidic cell-sorters, cell cultivation and droplets generators for discrete microfluidics or droplet lasers**
- **Compact optical tweezers modules compatible with majority of optical microscopes (utility model awarded, in cooperation with Meopta-Optika)**

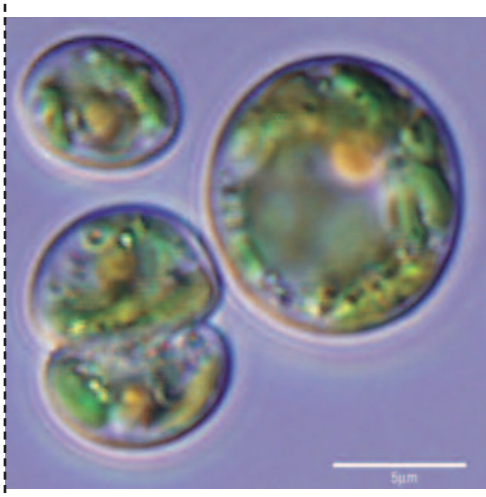


Image of Trachydiscus Minutus from optical microscope

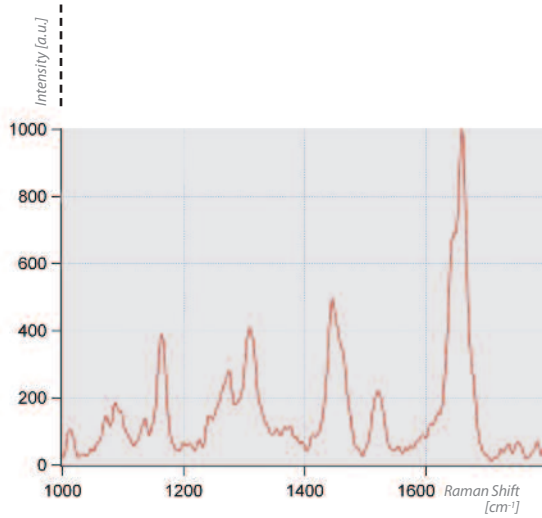
MAIN COLLABORATING PARTNERS

Collaboration with academic partners

- University of St. Andrews (St. Andrews, GB)
- University of Naples Frederico II (Naple, IT)
- University of Texas (Austin, US)
- Universidad Nacional Autonoma de Mexico (Mexico City, MX)
- Koc University (Istanbul, TR)
- Max Planck Institute of Molecular Cell Biology and Genetics (Dresden, DE)
- Lehigh University (Bethlehem, USA)
- Palacky University (Olomouc, CZ)
- Brno University of Technology (Brno, CZ)
- Masaryk University (Brno, CZ)
- Institute of Experimental Physics, Slovak Academy of Sciences (Košice, SK)

Collaboration with companies

- Photon Systems Instruments (Drasov, CZ)
- Meopta-Optika (Přerov, CZ)
- Measurement Technic Moravia Ltd. (Omice, CZ)



Example of Raman spectrum of an optically trapped single living alga Trachydiscus Minutus enabling determination of fatty acid saturation

EXPECTATIONS

Offers

- We offer collaboration in the areas of our expertise
- Partnership in international projects
- Manufacturing of custom-made opto-mechanical laser beam systems
- Theoretical studies based on Mie light scattering, coupled dipoles method, COMSOL multiphysics software

Requirements

We look for cooperation with academic partners as well as companies in the fields of optics, biophotonics, microtechnologies, nanotechnologies, applications of optical methods.

Group of Coherent Lasers and Interferometry
Department of Coherence Optics

ISI ASCR Institute of Scientific Instruments AS CR, v. v. i.

THEMATIC RESEARCH FOCUS

Research area

– Optical frequency laser length standards
– Laser interferometers and refractive index of air measurement
– Absorption gas cells for laser spectroscopy
– Femtosecond laser based optical frequency synthesis
– Special optical sensing in industrial processes
– Laser induced fluorescence for body fluid level measurement and tissue necrosis detection
– Electronics for process control and measurement
– Design, fabrication and employment of Fibre Bragg Grating (FBG) elements for length measurement

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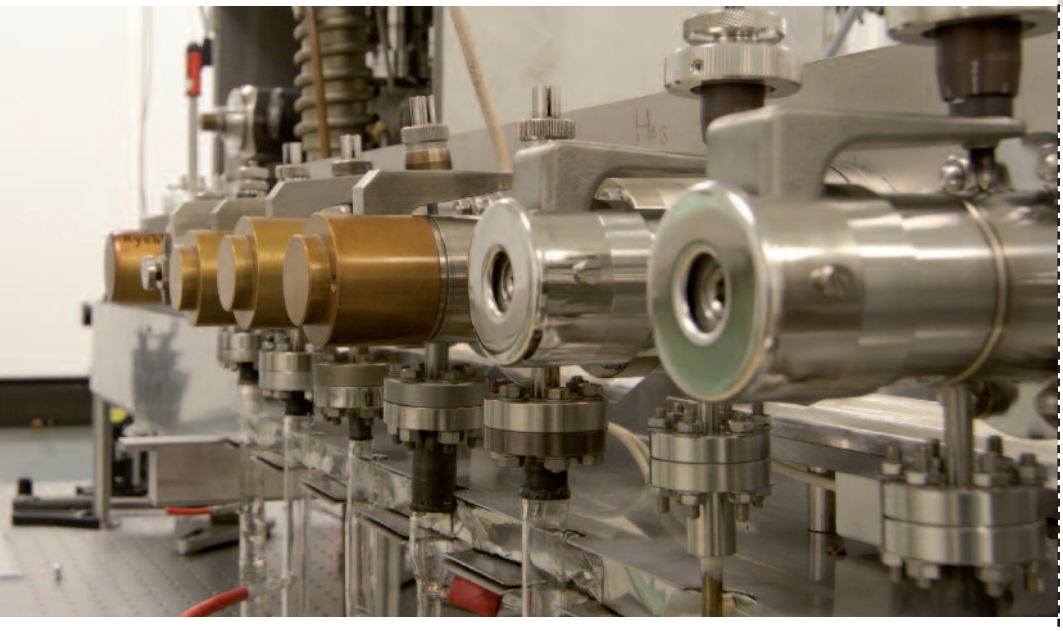


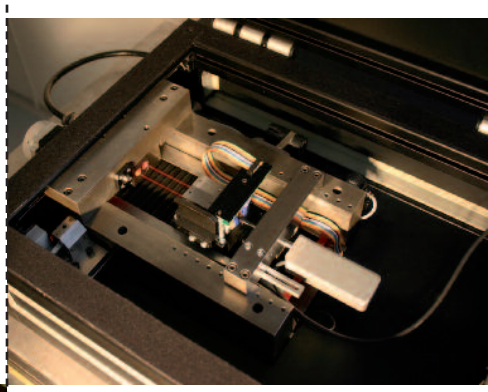
Vacuum system for filling of absorption cells with highly pure gases

Excellence

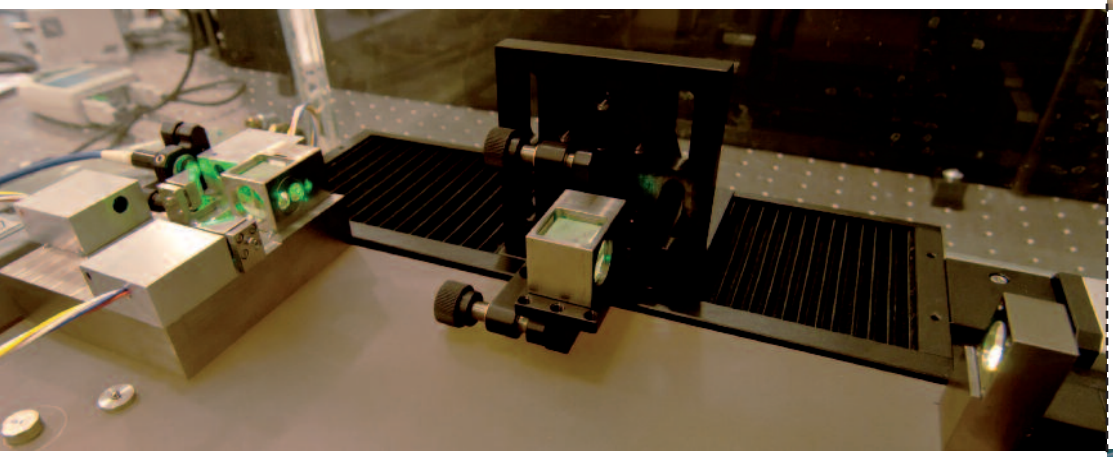
– Laser length measurement with sub-nanometer resolution for scale-linearity testing of length sensors
– Measurement of coefficient of thermal expansion of ultra-stable optical glass or ceramics (ULE, Zerodur)
– High purity absorption gas cell for frequency locking of laser wavelength with stability at the level of 10^{-14}
– Techniques for the measurement of refractive index of air with 10^{-8} accuracy
– Contactless laser interferometry for gauge block length calibration
– Real-time dissemination of process values via industrial networks (CANbus and Ethernet)

Mission

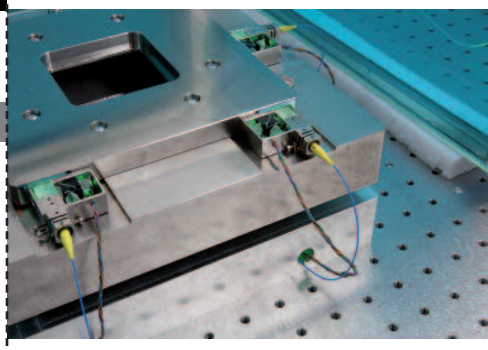
Our mission is to stay in the wider world top in the field of methodology of laser interferometers and optical sensing of lengths in vacuum and in the air. Our aim is the development of laser spectroscopy methods for gas concentration measurement, measurement of body fluid level and tissue quality, research of methods for long-distance measurement with the suppression of refractive index of air fluctuation, FBG gratings for mechanical stability testing of concrete blocks in nuclear power plants, design and control of X-Y positioning system with position sensing by laser interferometers.



Laser interferometer for length sensors calibration



Refractive index of air measurement with special configuration of laser interferometer



Example of the multiaxis interferometer for the 3D positioning of the sample for AFMmicroscopy

DEVELOPED TECHNOLOGIES

Content of research

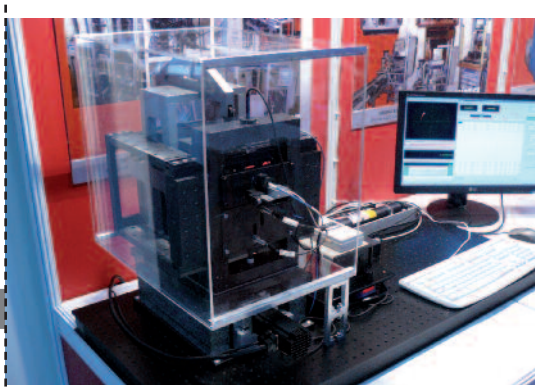
- Optical frequency laser length standards
- Laser interferometers and refractive index of air measurement
- Absorption gas cells for laser spectroscopy
- Femtosecond laser based optical frequency synthesis
- Special optical sensing in industrial processes
- Laser induced fluorescence for body fluid level measurement and tissue necrosis detection
- Electronics for process control and measurement
- Design, fabrication and employment of Fibre Bragg Grating (FBG) elements for length measurement

Main capabilities

- Technology of ultra-precise measurement of lengths with stable, tuneable and femtosecond lasers
- Methods of suppression of fluctuation of the refractive index of air for length measurement in the air
- Techniques for the stabilization of the angle of reflecting mirrors in laser interferometry
- Method for scale linearization of interference fringe for ultra-precise laser interferometry
- Techniques of locking tuneable lasers to optical frequency components of femtosecond laser spectrum
- Technology of high purity absorption gas cell production (also custom-made) and high purity gas production
- Methods for real-time dissemination of process values through network (CANbus and Ethernet)

Fields of research results application

– Optics
– Medical Technology
– Automotive industry
– Software
– Telecommunications



System for automated calibration of length sensors

KEY RESEARCH EQUIPMENT

– Optical frequency synthesizers (optical "combs") based on femtosecond lasers
– Set of optical frequency standards working at 532 nm, 633 nm and 1550 nm wavelength
– Active H-maser – highly stable radiofrequency generator
– Laboratory instrumentation for methodology experiments with optics, vacuum technology and electronics

ACHIEVEMENTS

- **A method for non-linearity compensation of interference fringes in homodyne laser interferometer**

– Číp, O.; Petrů, P.; *A scale-linearization method for precise laser interferometry.* Measurement Science & Technology, 11, (2000), p. 133–141

- **A method for the suppression of refractive index of air fluctuation in interferometric measurement of precise length**

– Lazar, J.; Holá, M.; Číp, O.; Čížek, M.; Hrabina, J.; Buchta, Z.; *Displacement interferometry with stabilization of wavelength in air.* Optics Express, 20, (2012), p. 27830–27837

- **Tunable extended cavity laser (ECL) as an optical frequency standard**

– Lazar, J.; Číp, O.; Jedlička, P.; *Tunable extended cavity laser (ECL) as an optical frequency standard working at 633 nm*. Applied Optics, 39, (2000), p. 3085–3088

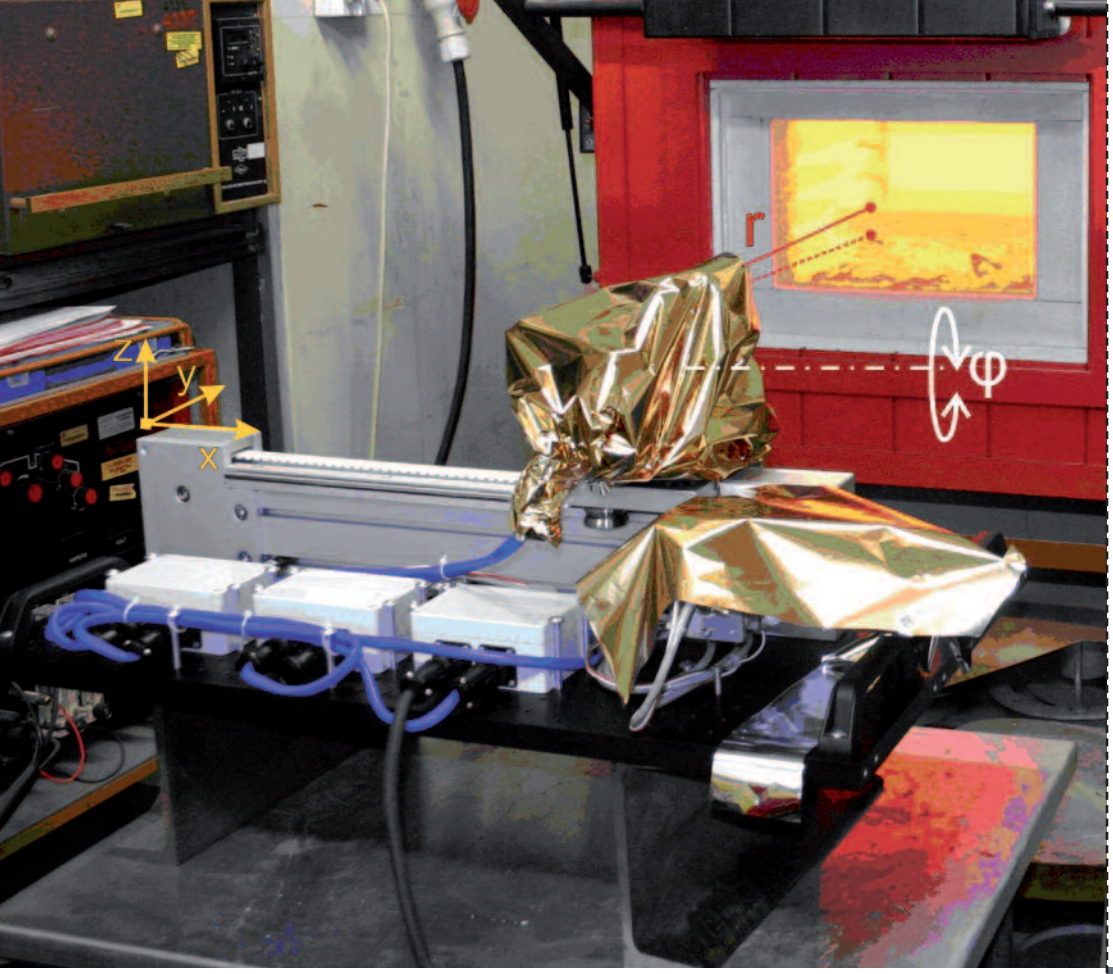
- **A method for the measurement of coefficient of thermal expansion of stable materials (Zerodur, ULE)**

– Číp, O.; Šmíd, R.; Čížek, M.; Lazar, J.; *Study of the thermal stability of Zerodur glass ceramics suitable for a scanning probe microscope*. Central European Journal of Physics, 10, (2012), p. 447–453

- **A novel method of contactless gauge block calibration by combination of coherent light and white light produced by mode-locked laser**

– Buchta, Z.; Řeřucha, Š.; Mikel, B.; Čížek, M.; Lazar, J.; Číp, O.; *Novel Principle of Contactless Gauge Block Calibration.* Sensors, 12, (2012), 3350–3358

- **Gold medal of 54th International Engineering Fair in Brno (2012)** for Contactless laser interferometer system for gauge block calibration by combination of coherent light and white light produced by picosecond laser (in cooperation with an industrial partner – the Mesing company).
- **Werner von Siemens Excellence Award (2012)** for Novel method of contactless gauge block calibration by combination of coherent light and white light produced by mode-locked laser.
- **Prize at the 50th International Engineering Fair in Brno (2008)** Prize was awarded by the editors of the Technický týdeník and of the periodical Automatizace for development the Laser nano-comparator. The research group for the first time presented a unique method for the active stabilization of the laser beam position which improves the reproducibility of the calibration process at the nanometer level.
- In the past ten years, **three scientists from the group were awarded by the international community URSI**, **IMEKO** and **SPIE** for their work in the field of precise measurement of lengths and methods of laser optical frequency stabilization.



Laser tracking detection of shape deviations of objects with high surface temperature

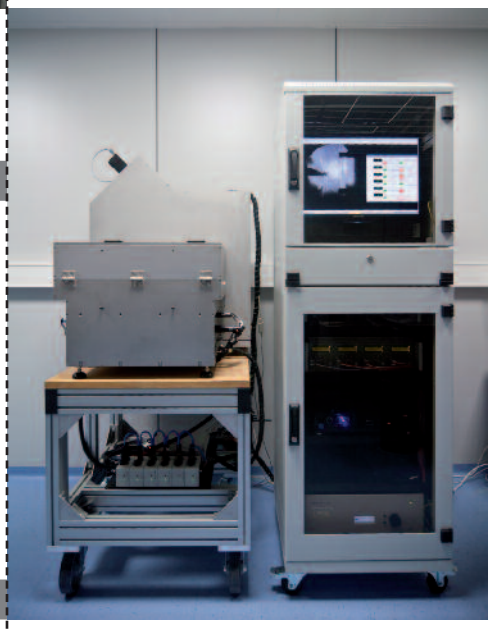
MAIN COLLABORATING PARTNERS

Collaboration with academic partners

Czech Metrology Institute (Brno, CZ)
Brno University of Technology (Brno, CZ)
Palacky University in Olomouc (Olomouc, CZ)
PTB Braunschweig (Braunschweig, D)
VSL Delft (Delft, NL)
CESNET (Prague, CZ)
BEV Vienna (Wien, AT)

Collaboration with companies

MESING (Brno, CZ)
Delong Instruments (Brno, CZ)
Meopta-Optika (Přerov, CZ)
PROFIcomms (Brno, CZ)
NETWORK GROUP (Brno, CZ)
ÚJV Řež (Prague, CZ)



Contactless calibration of gauge blocks

EXPECTATIONS

Offers

Many quality basic research results in these fields:
– High-resolution laser interferometry for length measurement in vacuum and air
– Optical measurement of concentration of various gases
– Detection of stress and length changes by Fibre Bragg Grating technology
– Scientific instruments for real-time processing of signals in laser interferometers and length measurement

Requirements

Cooperation in joint projects where the partner solves technical and technological aspects of the research subject while our group focuses at the development of new methods or at the adaptation of state-of-the-art methods to solve the topic.

Group of Laser Technology
Department of Coherent Optics

ISI ASCR Institute of Scientific Instruments AS CR, v. v. i.

THEMATIC RESEARCH FOCUS

Research area
– Laser welding
– Laser 2D/3D cutting
– Laser surface hardening
– Process diagnostic
– High power beam shaping

Excellence
– Diagnostics of laser welding process

Mission
– Theoretical and experimental study of the laser welding process
– Control of the laser welding process
– Application of the laser welding technology for the manufacturing of heat exchangers and solar absorbers
– Thin optical coatings for high-power laser optics

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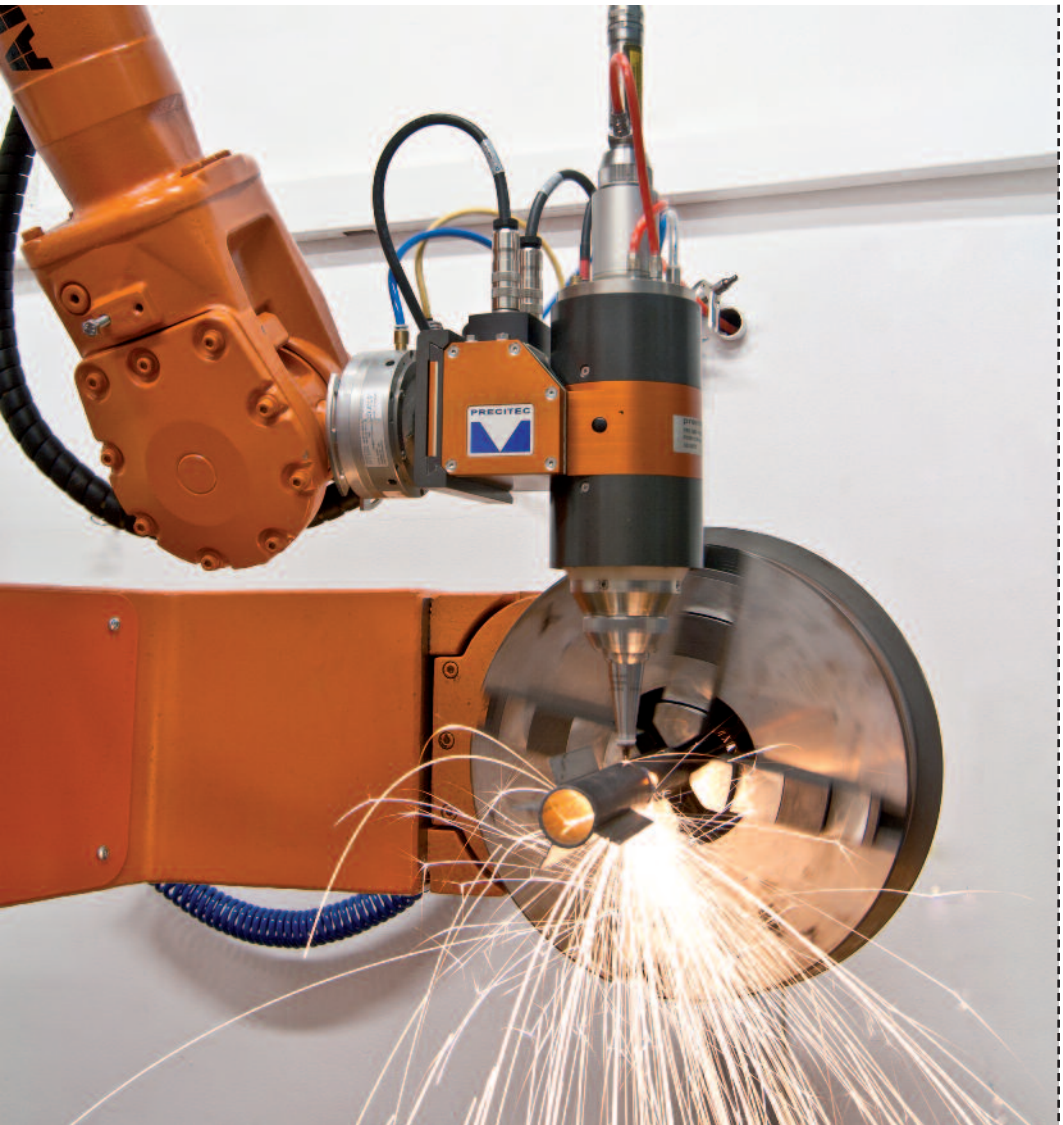


Laser cutting in action

Laser processing facility: six-axis robot with absolute accuracy precision

Content of research

– Correlation of the penetration depth and the frequency characteristics of the light emissions produced during the welding process
– Numeric modeling of the laser welding process
– Analysis of the welding process dynamics by means of image processing
– Analysis of the laser weld microstructure by means of electron microscopy
– Development of optical components adjusting the intensity distribution and the focal geometry of the laser beam
– Theoretical and experimental study of laser induced damage threshold of thin film optical coatings

Main capabilities

Basic research

– Study of the welding process using a method based on frequency analysis of the light oscillations produced during the process
– Numeric modeling of the welding process depending on the welding parameters and the focal geometry of the laser beam

Applied research

– New type of a sensor monitoring the quality of the laser welding process
– System for continuous control and optimization of the laser beam geometry during the welding process
– Heat exchangers and solar absorbers with controlled circulation
– Laser induced damage threshold test station

Fields of research results application

– Engineering industry related to modern methods of material processing
– Renewable energy
– Materials science
– Optics for high-power lasers

Laser welded solar collectors

KEY RESEARCH EQUIPMENT

– Laser YLS2000 (IPG photonics), welding head YW30 (Precitec), cutting head YRC100 (Precitec), robotic arm IRB2400 and 2-axis rotary positioner IRBP250 (ABB)
– PIAD Electron beam evaporation coating system SYRUSpro 710 by Leybold Optics
– Electron beam evaporation coating system Balzers BAK550
– Spectrophotometer Varian CARY 5E

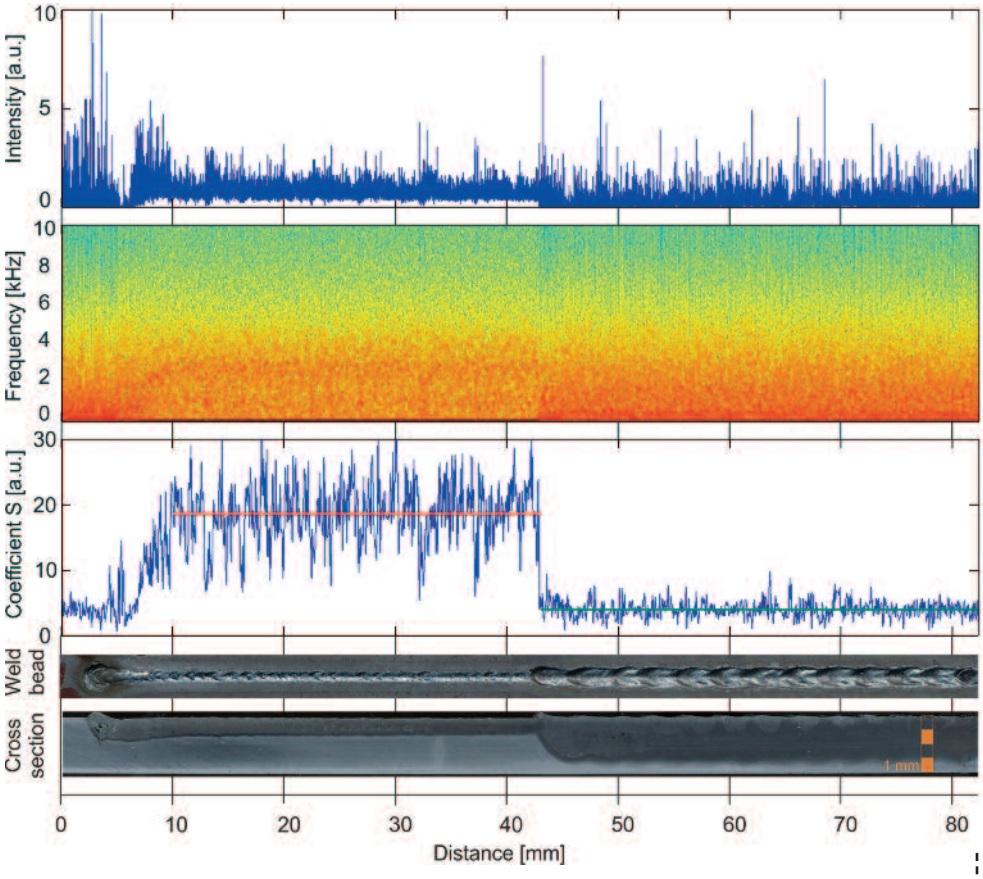
ACHIEVEMENTS

– Feedback control of laser welding based on the frequency analysis of light emissions, adaptive beam shaping
– Correlation Between Keyhole Depth and the Frequency Characteristics of Light Emissions in Laser Welding

MAIN COLLABORATING PARTNERS

Collaboration with academic partners

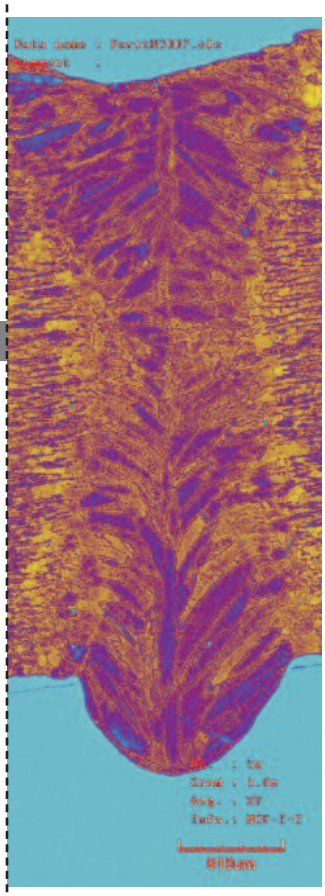
Brno University of Technology (Brno, Czech republic)
Technical Unversity of Liberec (Liberec, Czech Republic)



Sample output of the laser welding diagnostics

Collaboration with companies

Aquadem (Brno, CZ)
Fermat CZ (Brno, CZ)
AB KOMPONENTY (Brno,CZ)
LAO - Lasers and Optics (Praha,CZ)
TMT (Chrudim,CZ)
Matex PM (Plzeň, CZ)



laser weld microstructure shown on a cross-section

EXPECTATIONS

Offers

– Licensing of the patent for automatic optimization of the laser beam geometry in laser welding
– Partnership in international projects
– Long term collaboration with industry partners (contract research)
– Contractual research in laser welding, cutting, surface hardening etc.
– Consulting in the field of laser welding, cutting, surface hardening etc.
– Cooperation in the development of solar absorbers and heat exchangers
– Design and production of custom thin film optical coatings
– Consulting in the field of optical coating deposition

Requirements

– Real interest in applied research and innovation
– Knowledge of grant projects
– Collaboration with industrial partners in common projects dedicated to applied science
– New complementary technologies