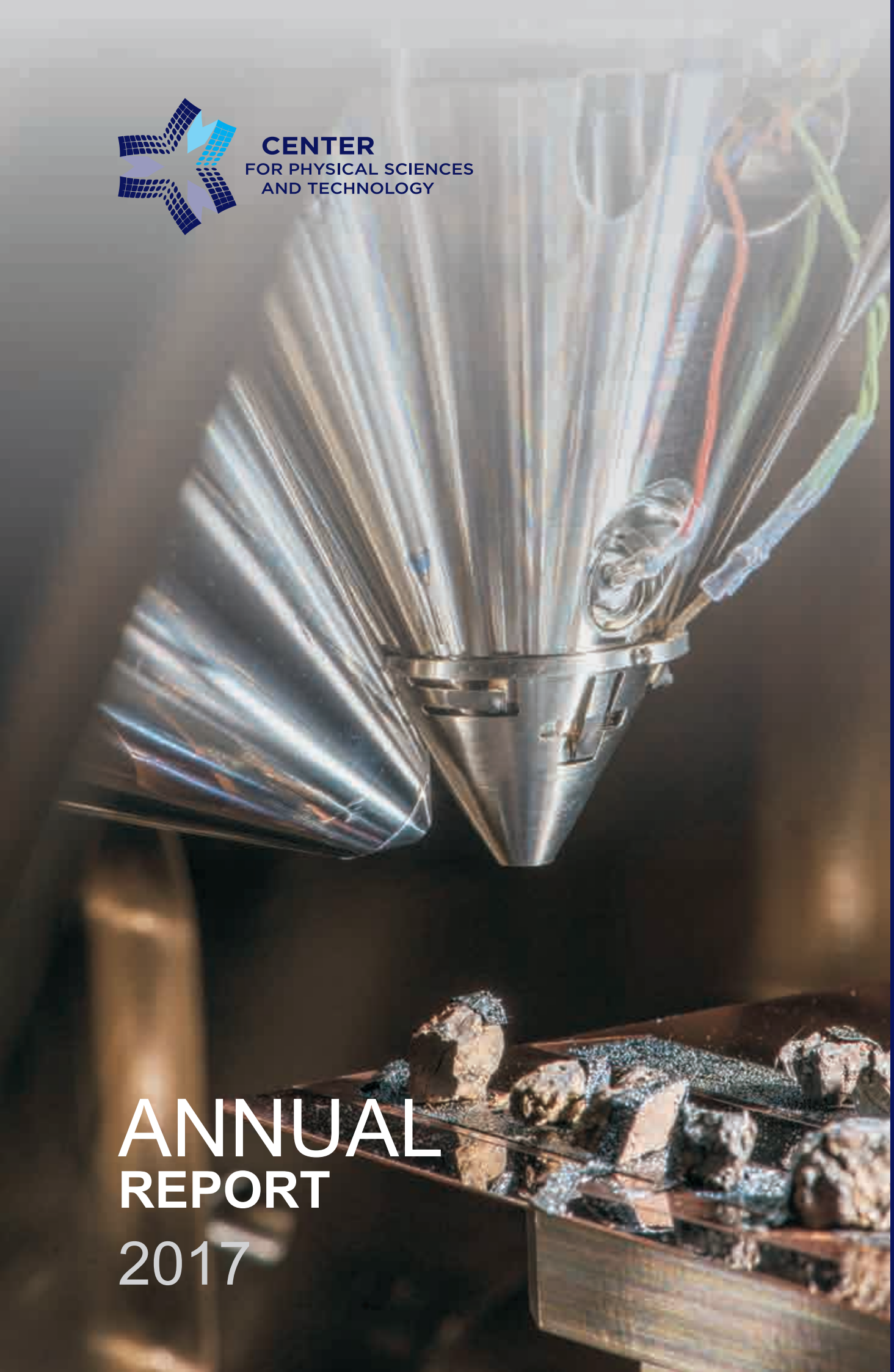

CENTER
FOR PHYSICAL SCIENCES
AND TECHNOLOGY

ANNUAL REPORT 2017

MODERN PATHS TO INNOVATIONS

Message from Director: new period towards innovations and excellence

Every year at this time we have an obligation to look back in time scale of 365 days to estimate and evaluate, to reconsider and analyse our scientific events and publications, projects and innovations, aiming to highlight the most important achievements and progressive ideas.

2017 has been quite a year for the Center. We have completed the final stage of the movement to the Sunrise (Saulėtekis) Valley and finally aligned the geography of the Center. It is not only because all the technological and processing laboratories in the new building are already operating in full power – the important fact was that we left at last the old buildings located at A. Goštauto street in Vilnius. They were given over for further needs of the State. Hence, the Center has accomplished the geographic redistribution of its divisions. Currently, the Center is dispersed in 6 different places: Savanorių ave. 231 in Vilnius (Departments of Laser Technologies, Nanoengineering, part of Nuclear Physics, Science and Technology Park of Institute of Physics, Sunrise Valley Technology and Innovation Center, LITEK cluster); Saulėtekio ave. 3 in Vilnius (Departments of Optoelectronics, Molecular Compound Physics, Characterization of Materials Structure, Catalysis, part of Organic Chemistry, Physical Technologies, part of Nuclear Physics, Environmental Research, Electrochemical Materials Science, Electronics, Materials Science and Electrical Engineering, Fundamental Research as well as Administration and its services); Akademijos str. 7 in Vilnius (Department of Chemical Technologies, part of Organic Chemistry, Industrial Laboratory of Chemical Coatings); Lukiškių str. 9 in Vilnius (Department of Metrology acting as National Institute of Metrology); Demokratų str. 53 in Kaunas (Department of Textile Technologies, Textile Technological Development and Accredited Department of Textiles Physical – Chemical Testing) and in Preila, Neringa City, Klaipėda region (Atmospheric Monitoring Station).

2017 has been a year of intensive (and quite fruitful) national and international projects preparation. We are happy that scientific applications were positively evaluated by the Lithuanian Research Council, European Commission, European Space Agency and other institutions. The Center has acted as an efficient provider of high-tech services for international business and high-tech industry, developer of new prototypes and novel technologies.

This Annual Report is more than just a catalog of important events and enlightening achievements – it is a survey of phenomenal occurrences that take place across of our Departments, and we highly appreciate photographer Marius Jovaiša for adding them elegant photodocumentation. The Annual Report manifests a new period and breakpoint towards innovations and scientific excellence in a qualitatively new technological environment. We will support this way stimulating creativity and culture that embrace discovery; we will encourage talented and agile individuals who are making great science and breakthrough innovations possible.

Gintaras Valušis
Director of the Center

Fizinių ir technologijos mokslų centras (FTMC)

Center for Physical Sciences and Technology

Contents

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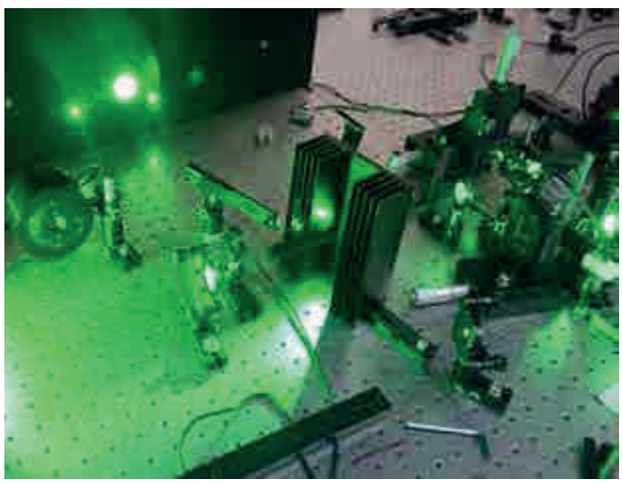
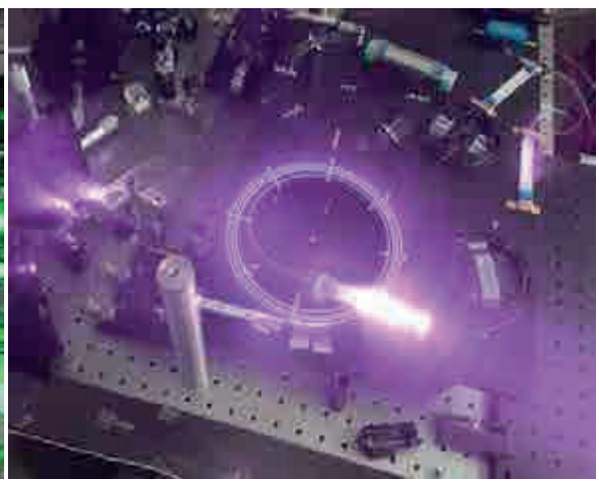
Laser technologies





Optical coatings, solid-state and fibre lasers, laser material processing and nanophotonics

Laser technologies are becoming a commodity in many areas of production as well as installed into consumer products. The Department of Laser Technologies with its six laboratories covers a significant part of the photonics related activities, ranging from newly discovered optical effects to laser machines, and stepping through all technology readiness levels. The smart optical coatings developed in the Laboratory of Optical Coatings convert the pieces of glass into valuable products able to control spectral and temporal properties of the light. New laser sources, under development in the Fiber Laser and Solid-State Laser Laboratories, that are based on tiny but smart fibres or active bulk crystals, provide not only new wavelengths of coherent radiation, but high peak power, ultra-short pulses and controlled wavefront as well. Combining of the coherent beams makes the lasers even more powerful.

The scope in the material processing using ultrashort pulse lasers includes the investigations of the laser-matter interaction as well as hardware development in a new Laboratory of 3D Technologies and Robotics. Thin film scribing for photovoltaics, efficient surface texturing utilizing laser beam interference, glass processing with lasers, nano-textures decorated by nanoparticles, 3D metal sculpturing by subtractive and additive technologies, novel processes for electroless plating of laser modified polymers, laser-induced transformations in graphene-like materials make up the main working topics of the Laboratories of Laser Microfabrication Technologies and 3D technologies and Robotics in 2017.

When the structure dimensions are smaller than light wavelength, new effects arise. The Laboratory of Nanophotonics deals with sub-wavelength structures, in this way enhancing interaction of photon propagating in microring resonators with the environment. That allows constructing sensitive tools for sensing applications.

A large group of scientist, PhD students and engineers work together in laser-related fields. The Department keeps close collaboration with colleagues from other departments of FTMC (Optoelectronics, Physical Technologies, Nanoengineering, Organic Chemistry, Catalysis, Electrochemical Material Science, Characterization of Material Structure) gaining new ideas for joint projects and applications.

Combining laser and chemical technologies

Fabrication of circuit traces is the most challenging task in moulded interconnect devices (MID) production. The selective surface activation induced by laser (SSAIL), a new technology for writing electronic circuits directly onto the dielectric material by modifying surface properties with a laser, has been developed as a part of the European APPOLO project.

Lasers can write the circuits directly by modifying the surface of polymers followed by an electroless metal plating. The SSAIL is a three-step process: (i) surface modification by laser; (ii) chemical activation of modified areas, and (iii) metal deposition by electroless plating. The new technology offers laser writing speeds of up to 4 m/s, and therefore spatial plating pitch is kept narrow at 25 µm. Moreover, the SSAIL is capable to metalise not only polymers, but glass also.

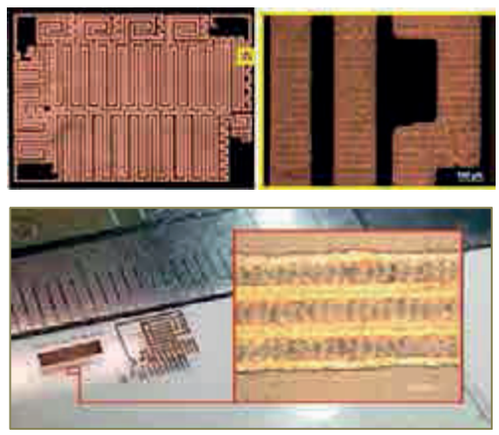


Fig. 1. Copper plated circuit on PA 6 (top) and glass (bottom).

Efficient dicing of sapphire wafers

The evidence of a multi-photon absorption enhancement by the dual-wavelength double-pulse laser irradiation in a transparent sapphire was demonstrated experimentally and explained theoretically. Two collinearly combined laser beams with the wavelengths of 1064 nm and 355 nm, inter-pulse delay of 0.1 ns, and pulse duration of 10 ps were used to induce intra-volume modifications in sapphire.

The new effect of a multi-photon absorption enhancement allowed utilisation of the laser energy up to four times more efficiently for initiation of internal modifications in sapphire. This effect has been used for efficient intra-volume dicing and singulation of transparent sapphire wafers. This method opens new opportunities for the manufacturers of the GaN-based light-emitting diodes for fast and precise separation of sapphire substrates.

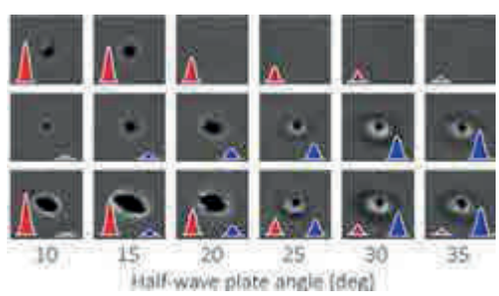


Fig. 2. Laser-induced intra-volume modifications in sapphire.

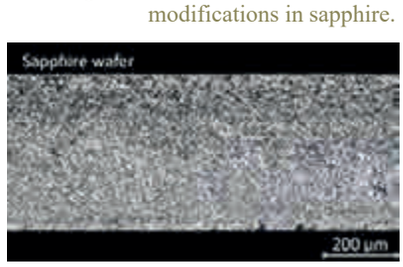


Fig. 3. Image of the sapphire fracture plane.

Structuring of surfaces with gold nanoparticles by using Bessel-like beam

The structuring of surfaces with gold nanoparticles by using Bessel-like beam array is demonstrated. The experimental results show that the fabricated microring structures containing gold nanoparticles have a surface plasmon resonance in the spectral range of 520-540 nm, which can be tuned by selecting the laser treatment parameters. Fabricated microring structures exhibit a lower light transmittance comparing with the randomly distributed gold nanoparticles for wavelengths 500-570 nm due to the growth in the size of nanoparticles. The demonstrated method enables easy fabrication of microring structures with tunable plasmonic properties.

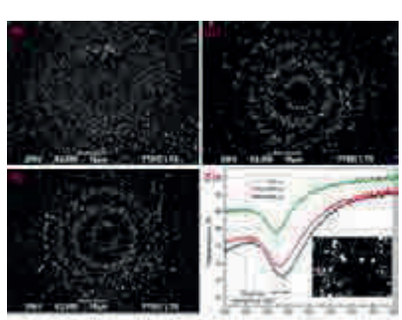


Fig. 4. SEM micrographs of microring structures made from arranged Au nanoparticles fabricated using various laser pulse energies and transmission spectra of Au nanoparticles structures on the glass fabricated using 140 µJ, 350 µJ and 490 µJ energy pulses.

Laser patterning of thin-film solar cells at different pulse durations

The transition to full sized solar modules requires additional three-step laser structuring process to preserve the small-scale cell efficiencies over the large areas. New results were achieved on the P2 and P3 laser scribing, utilising the lift-off processing of the $Cu_2ZnSn(S,Se_4)$ (CZTSe) thin-film solar cells covering the pulse duration range from 300 fs to 60 ps. During the lift-off process, the laser radiation has to penetrate through the layer stack down to the CZTSe/Mo interface. At sub-ps pulses, the nonlinear effects triggered absorption of the laser radiation in the bulk of the material, resulting in increased damage to the CZTSe layer. The shorter pulses also induced higher electrical conductivity of a scribe, resulting in lower photo-electrical efficiency due to shunt formation. In the case of the P3 lift-off scribing, the 10 ps pulses were found to be optimal for P3 lift-off patterning.

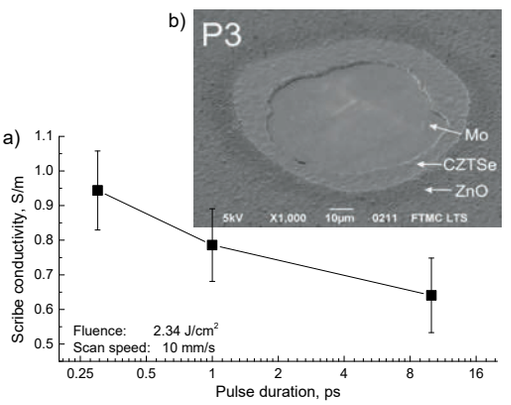


Fig. 5. (a) Extracted P3 scribe conductivity versus laser pulse duration and (b) the example of ablation of complete CZTSe structure to expose the Mo back-contact, 3.1 J/cm^2, single shot, 10 ps pulse duration.

Correlation between stoichiometry and properties of scandium oxide films prepared by reactive magnetron sputtering

Stoichiometric scandium oxide can be used in various optical applications as high refractive index and wide bandgap material. Comprehensive investigations of dependence between stoichiometry, phase composition and roughness, density, wetting and optical properties of scandium oxide deposited by reactive magnetron sputtering were performed. As a result, new procedures were developed for a high-rate deposition at low substrate temperatures (<90°C) of a material with high refractive index, wide bandgap and low compressive stress.

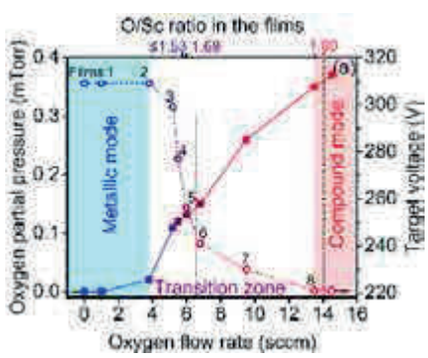


Fig. 6. Oxygen partial pressure, target voltage and O/Sc ratio of scandium oxide films as a function of the oxygen flow rate.

Enhanced sensitivity SOI microring resonator with integrated one-dimensional photonic crystal

A silicon-on-insulator (SOI) microring resonator-based refractive index sensor with enhanced sensitivity and measurement range was fabricated. Both improvements were achieved by integrating a 1D photonic crystal inside the microring waveguide. A photonic crystal was formed by periodically patterning, partially etching the rectangular perforations.

Our findings show that, while deeper perforations result in a larger bulk refractive index sensitivity, the optimal design exhibiting the smallest limit of detection can be obtained at some intermediate value, depending on the leading term in sensor resolution. In addition to theoretical analysis, we present an experimental demonstration of a fabricated microring resonator with the 120 nm deep perforations.

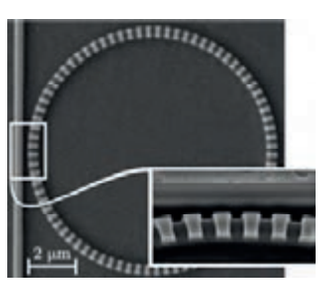


Fig. 7.Scanning electron microscopy image of the fabricated microring resonator.

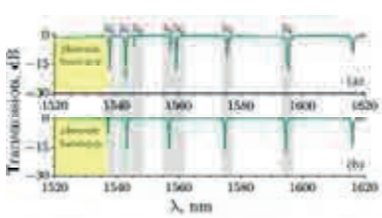


Fig. 8. Transmission spectra of the microring resonator embedded in methanol: (a) experiment, (b) simulation.

Argon plasma etching of fused silica substrates for manufacturing high laser damage resistance optical interference coatings

The laser damage resistance of an optical element in high power laser systems depends significantly on the surface quality of the optical substrate. In our experiments, commercially polished fused silica substrates were etched in argon plasma generated by an RF source, and their surface roughness, flatness and optical properties were investigated. This method can be applied in a vacuum chamber before deposition of the multilayer coatings without breaking the vacuum. It was shown that the damage resistance to the 355 nm laser radiation could be improved more than 8 times depending on a primary substrate quality.

As an example of an application of our technology, antireflective and polarising optical interference coatings were deposited on etched substrates, and the increase of their resistance to laser radiation was measured.

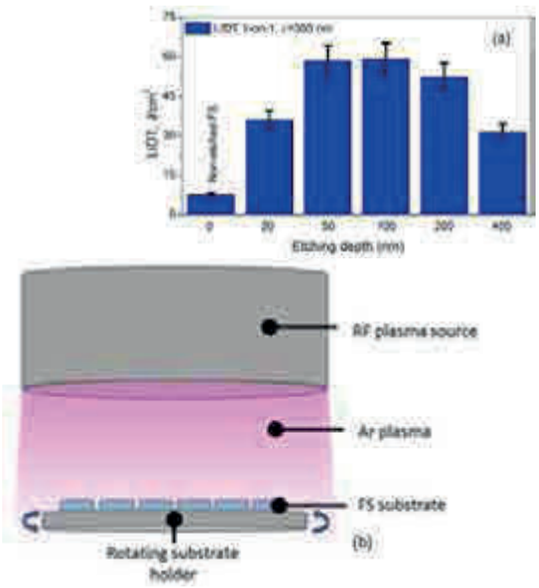


Fig. 9 (a) Laser-induced damage threshold comparison of non-etched and etched fused silica substrates. (b) Side view of the plasma etching procedure.

Self-starting operation of optical pulse generators (OPGs) based on non-linear spectral reshaping

Pulse forming mechanism based on self-phase modulation and alternating spectral filtering can be successfully implemented for generation of ultrashort pulses. Further development of such ultrashort pulse laser sources allowed to explore different operation regimes and determine conditions for self-starting operation, which is very important for practical applications of such lasers. Self-starting was achieved in two experimental pulse generator setups with Yb-doped gain fibre and two different bandwidth and technology filters (Narrowband Fiber Bragg Grating (FBG) and Broadband free-space interference (FSI)). The most reliable self-starting was achieved for FSI setup, in which material dispersion influences pulse generation. According to numerical calculations, material dispersion stabilises pulse generation for a broader range of gain values providing more reliable self-starting.

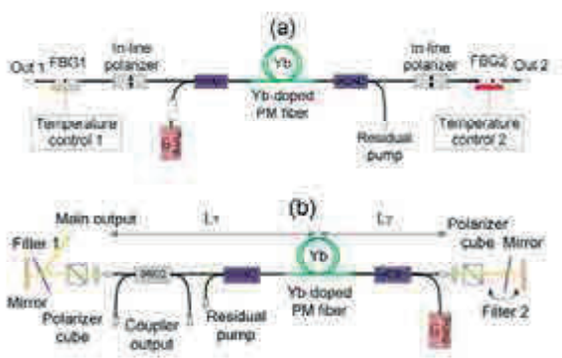


Fig. 10. Schematic diagrams of OPG setups: (a) all-in-fibre setup with FBG filters, (b) FSI setup.

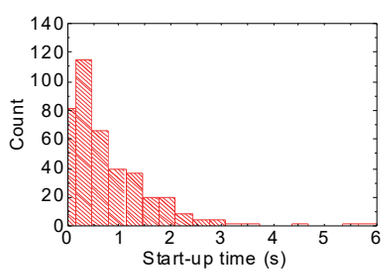


Fig. 11. Measured distribution of start-up time for the FSI setup.

Optoelectronics

Semiconductors for the light technologies

Optoelectronics is widely recognized as one of the Key Enabling Technologies of the future. At Optoelectronics Department this field of research is developed in two main directions: (i) epitaxial growth technology of semiconductor structures and devices for mid- and far-infrared spectral ranges and (ii) THz frequency range components, systems, and applications. Moreover, the Department operates a most comprehensive set of standard optical characterization techniques that is intensely exploited also by other Lithuanian research groups and companies.

Terahertz (THz) radiation, which lies in the frequency gap between the infrared and microwaves, referred to as the frequencies from 100 GHz to 30 THz, has long been studied in fields such as astronomy and analytical science. THz imaging holds promise for a multitude of applications from biomedical imaging to the inspection of semiconductor devices. At the Optoelectronics Department we are active in investigating different THz spectroscopy and THz imaging applications, in developing novel optoelectronic THz frequency range components and systems. These are commercialized by two companies that have been started by the researchers of the Department. During the year under reference the researchers of the Department were investigating the physical origin of THz emission from the surfaces of various semiconductors illuminated by femtosecond laser pulses. It has been demonstrated that this emission from narrow gap semiconductors such as InAs or InSb, which are most efficient THz emitters at the moment, is caused by the electron energy bandgap anisotropy and lateral photocurrents appearing due to this anisotropy.

The ultrafast measurement facilities of the Department are becoming increasingly attractive for the scientist from abroad, who are performing their investigations in Vilnius. One of them, Dr. Carlito Ponseca from the Linköping University (Sweden) together with the colleagues from the FTMC discovered intense THz emission from hybrid organic-inorganic perovskite layers – a material which is actively investigated presently for photovoltaic applications. Researchers from UK, Belarus, Poland, and Estonia were also working in the laboratories of the Optoelectronic Department. The photo on top shows Dr. C. Ponseca and Prof. R. J. Shiller, member of the FTMC International Advisory Board, with a group of researchers from the Optoelectronics Department.

Plasmonic THz emitters

THz radiation of electrically driven 2DEG plasmons in AlGaN/AlN/GaN structures at temperature 110K was observed. The plasmonic sample is shown in Fig. 1. Metal periodic grating was used to couple electromagnetic radiation out from the sample excited in a pulsed regime. The peak power radiated from ungated 2DEG plasmons at a frequency of 5.0 THz under an electric field of 450 V/cm was up to 940 nW. This intensity was sufficient to measure THz spectra with a conventional far-infrared Fourier transform spectrometer. The analysis of the data revealed that the 2DEG plasmon radiation was superimposed with the black-body radiation of the sample and electroluminescence of the impurities. The research aims to develop the strategy to reach higher powers of THz emission necessary for practical applications.

Fig. 1. Scanning electron microscopy image of the plasmonic sample.

Bismides on germanium substrates

One of the important fields in which the new GaAsBi layers could be applied are multi-junction solar cells with enhanced solar spectrum harvesting. It has been shown that, by inserting of an additional p-n junction from the material with 1 eV energy bandgap, the overall cell efficiency could be increased up to 40% and more. The researchers from the Optoelectronic technology laboratory working on the contract with the European Space Agency were the first to grow bismides with such a bandgap on Ge, which is the main substrate for multi-junction solar cells for the space applications. The solution of this challenging task became possible after a careful selection of the technological conditions of both MBE growth technology and after-growth thermal annealing. The X-ray Reciprocal Space Map (RSM) shown in Fig. 2 evidences that the bismide layer grown on Ge substrate remains strained even when its thickness is close to 1 micrometer.

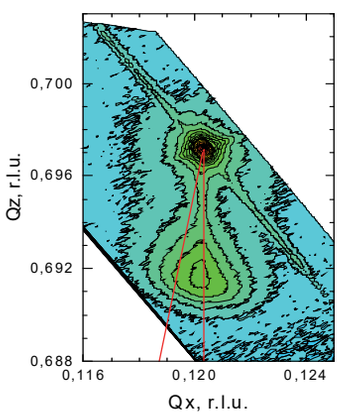


Fig. 2. The X-Ray RSM map of GaAsBi layer grown on 6° off-cut (100) Ge substrate.

Excitation of surface phonon polariton modes in nitride structures

The excitation of surface phonon polariton modes in the AlGaN/GaN HEMT structures grown on GaN and SiC substrate was investigated. Depending on the sample structure and the period of the metallic grating, weak and strong resonant couplings of the plasmons to the underlying semiconductor layers were observed across the Reststrahlen band.

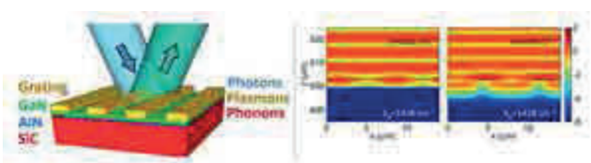


Fig. 3. Illustration of the interacting photons, plasmons, and phonons (left). Field plots calculated for the case of TM-polarized light (right).

Fresnel lenses for 0.6 THz frequency

Two consistent series of the multilevel phase Fresnel lenses (MPFLs) with phase quantization levels varying between 2 and the continuous kinoform shape for the focal lengths of 5 and 10 mm have been developed. The focusing performance was studied at the optimal 0.58 THz frequency using a Gaussian beam and scanning 2D intensity distribution along the optical axis. The efficiency was found to be dependent on the number of subzones. The position and orientation angles of the patterned plane of the silicon wafer were also considered to reduce the effect of standing waves formation in the experiment.

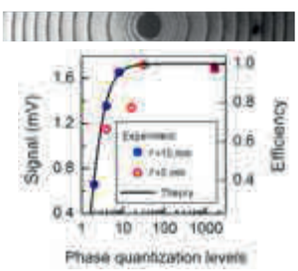
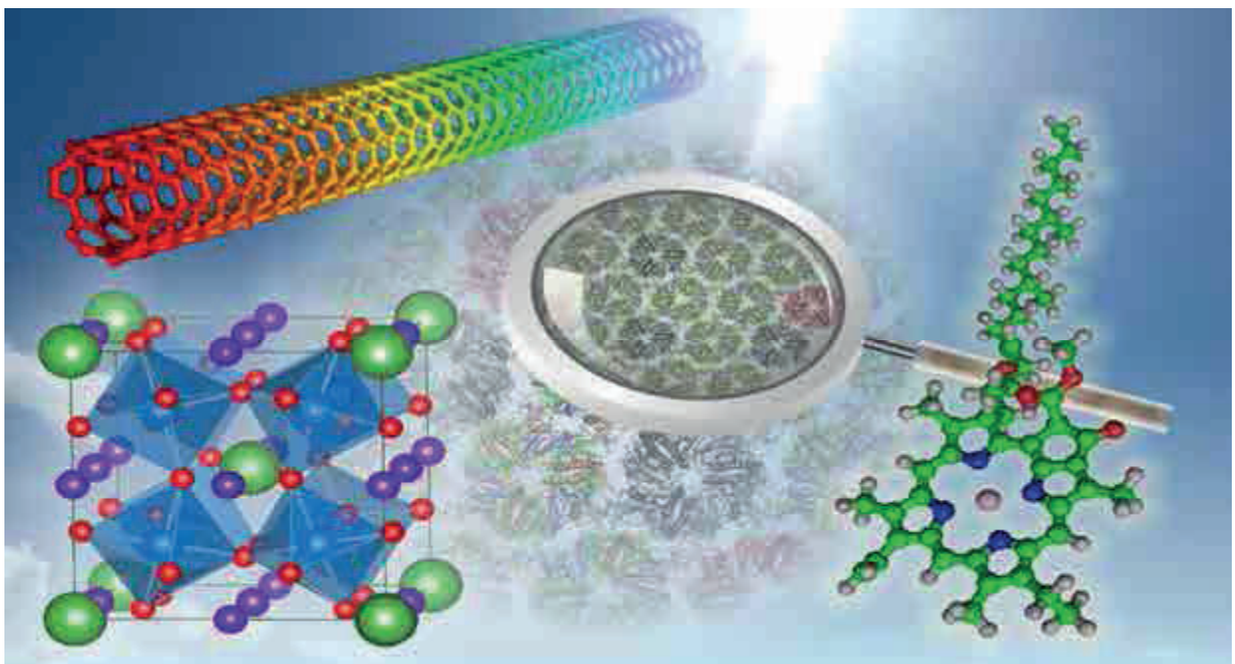


Fig. 4. Microscope image of the 0.6 THz MPFL (top) and peak signal of the THz detector versus the phase quantization number (bottom).

Molecular physics



Excitation dynamics and dissipation in natural and artificial molecular systems

Molecular systems, mostly studied due to their biological relevance, recently started to show a strong potential for applications in technology and industry. Organic materials increasingly penetrate into electronics – the field that used to be totally dominated by the inorganic semiconductors in the past.

Electronic devices such as organic light-emitting diodes, organic solar cells, or organic field effect transistors are often cheaper and more flexible, with quantitatively different properties. Unlimited variety of organic molecules as well as a broad range of technological fabrication abilities promise a wide spectrum of device characteristics. On the other hand, applications require a detailed understanding of molecular properties determining characteristics of molecular-based materials. Amazing functional characteristics and reliability of molecular systems created by Nature suggest operational principles that might be adapted for various man-made devices. Nonetheless, because of the complexity of natural systems, a blind mimicking usually does not work. Operational principles and device fabrication techniques, developed for inorganic materials, also cannot be directly transferred to molecular devices. Molecular systems necessarily involve a significant amount of nuclear dynamics, ranging from coherent nuclear vibrations at high frequencies to Brownian fluctuations or even proton transfer reactions in the molecular complexes. In addition, the molecular aggregates have multiple electronic excited states (excitonic states) that are responsible for the spectral properties and are involved in the photoinduced processes and reactions. All such complexity of the energetic arrangement has to be taken into consideration in order to enhance the efficiency of the molecular devices. The possibility to achieve this aim is well exhibited in natural molecular complexes. For instance, in photosynthesis the flexibility of the protein structure is a fundamental feature that probably has been utilized by Nature to select and optimize biologically relevant structural configurations. Studies of this type are carried out in the Department of Molecular Compounds Physics. Experience in experimental and theoretical approaches, obtained by studying numerous molecular systems, allows us to expect novel practical applications of the systems under consideration.

Oxide layer enhances gain of planar methylammonium lead iodide photodetector

Organic-inorganic hybrid perovskites belong to a new class of semiconducting materials currently yielding high-performance solar cells. They are also attractive for fabrication of photodetectors, which are based on similar operating principles. We fabricated an easily producible perovskite photodetector with lateral architecture by one-step solution processing technique on planar interdigitated electrodes. Despite the simple structure, the planar photodetector demonstrates comparable, or even some superior characteristics to photodetectors based on a more complex architecture.

We demonstrate that a hole blocking oxide layer between metal electrodes and perovskite may enhance the device responsivity and gain by an order of magnitude. Application of Cr electrodes with naturally formed oxide layer enabled to reach external gain of more than 350 and maintaining response time of about 10 milliseconds.

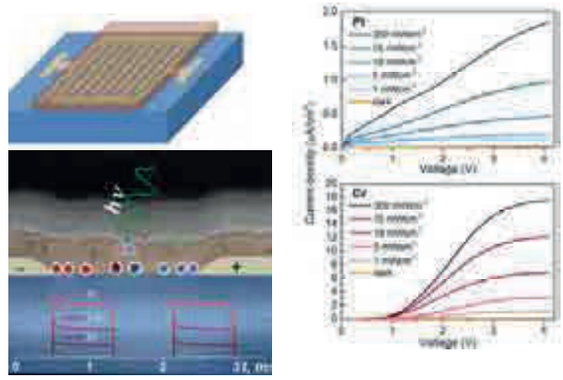


Fig. 1. Shematic layout of the planar photodetector formed on interdigitated electrodes (top, left) and its sectional vew (botom, left). The right picture illustrates performace of the photodetector on Pt electrodes and Cr electrodes covered with oxide layer.

Transfer tensors can speed up calculations of excitation dynamics in molecular systems

Accurate simulations of excitation dynamics is a long standing issue in the field of chemical physics. Recently a new black-box type method, called transfer tensor method (TTM), was proposed. We investigated the parameter regimes where an application of TTM would be most beneficial in terms of computational time. We identify several promising parameter regimes. We propose that TTM should be applied whenever system evolution is expected to be long and accuracy of perturbative methods cannot be ensured, or in cases when the system under consideration does not correspond to any single perturbative regime.

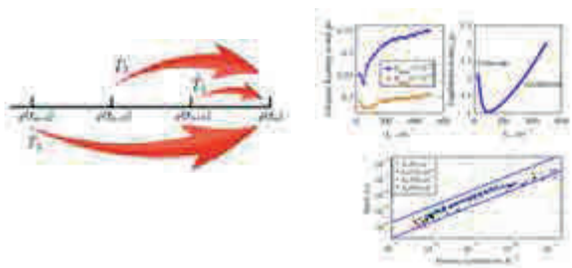


Fig. 2. Schematic illustration of the TTM method idea (left). Calculations of adequate learning period and equilibration time (top, right) for a dimer system with different reorganization energy values. The dependence of the error of the calculated dynamics using TTM on the memory kernel norm (bottom, right). The error was calculated with respect to calculations of exact hierarchical equations of motion.

Single-molecule fluorescence microscopy unravels the intricacies of DNA-protein interactions

A new approach to study the real-time dynamics of DNA-protein interactions at a single-molecule level has been devised. Förster resonance energy transfer (FRET) allows to monitor intra- and inter-molecular dynamics of FRET dye pair-labelled bio-molecules. We extended this method by monitoring the fluorescence intensity changes of a fluorophore label in the evanescent excitation field. This provided additional means to detect the protein-induced DNA looping. In combination with FRET, the new experimental modality allowed us to decipher different DNA loop conformations that could not be detected with other methods before.

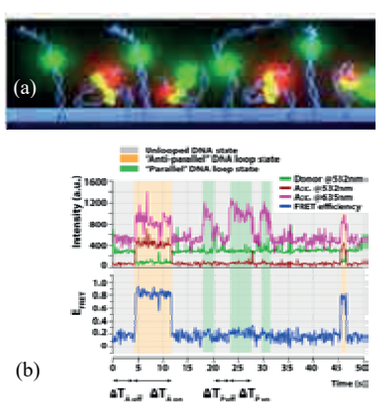
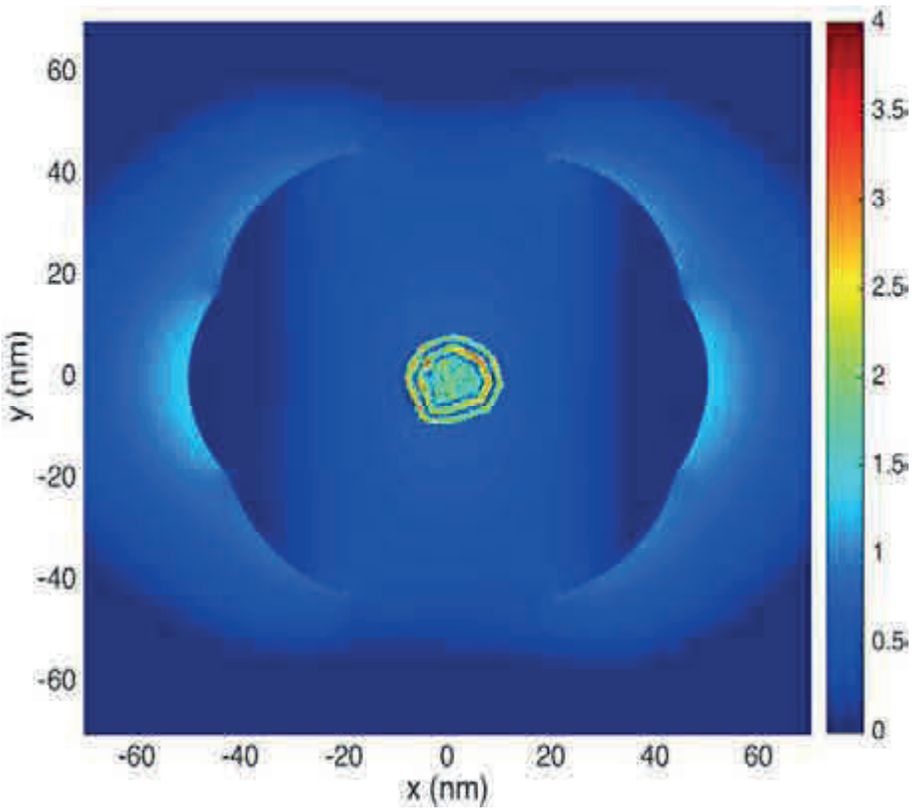


Fig. 3. Single-molecule fluorescence microscopy of DNA-restriction endo nuclease interactions. (a) Artistic representation of different possible DNA loop conformations and corresponding fluorescence of the FRET labels upon DNA interaction with Ecl18kI restrictase. (b) An example of measured donor and acceptor intensity and calculated FRET efficiency traces of an individual DNA fragment interacting with Ecl18kI.

Nanoengineering



Fabrication and applications of nanostructures

Mission – new tools and processes for on-chip fabrication and integration of physical, chemical and biological nanoarchitectures. Aims – establishment of reliable experimental platforms for biophysical studies of desired complexity: proteins, single cells and tissues, miniaturized sensor arrays. Tasks – High speed nanolithography of functional patterning of soft (molecular) and solid surfaces, cell membrane-mimetic assemblies, nanobiochips for single cell analysis, micro/nanofabrication of hydrogel interfaces for tissue engineering, electrochemical and optical micro/nanosensors.

The activities of the Department of Nanoengineering are divided into three major subgroups:

Alternative nanofabrication. We are investigating nanometer-scale transport and assembly of molecules at interfaces to identify the physical principles for formation of molecular and hybrid architectures with controlled physical and chemical properties. Based on that, we are developing fabrication processes for rapid prototyping and small batch production. Recent examples include nanochips for single-cell level analysis of cytoskeleton, probing of cellular metabolism, or plasmonic sensing of protein-protein interactions.

Synthesis and functional modification of nanomaterials. We are employing organic synthesis for designing bi/multifunctional compounds that are used as building blocks of self-assembling structures. We are investigating in situ synthesis of nanostructures, e.g., by click-chemistry or electrochemical polymerization of conductive compounds.

Sensing and miniaturized analytics. We are developing localized surface plasmon resonance-active structures for on-chip detection of specific biomarkers (proteins). We have strong expertise in miniaturized electrochemical sensor systems for cell analysis, diagnostics and biosafety: from fabrication and characterization of microelectrode arrays to a complete portable device. We are pushing forward scanning probe technologies for characterization of molecular assemblies, soft materials and biointerfaces.

Polyriboflavin – a new conducting polymer for electrochemical sensing

New conducting polymer composed of natural monomer riboflavin (vitamin B_2) was synthesised electrochemically. This polymer has been applied for fabrication of the biosensors for hypoxanthine and glutamate. The latter was particularly stable in comparison to those reported in the literature. The biosensors were successfully tested in natural samples: for detection of glutamate in tomato products and in fresh cheese, and for hypoxanthine in fish after different storage times. Finally, a microbio-sensor device prototype for glutamate was constructed.

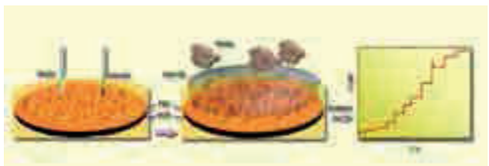


Fig. 1. Biosensor assembly from electrochemically synthesised polyriboflavin modified with graphene chitosan composite film and glutamate oxidase.

Rotational scanning atomic force microscopy

Atomic force microscope (AFM) has become an essential tool in nanoscience and nanotechnology. However, depending on resolution and the mode of operation, producing an image can take up to several tens of minutes. Seeking to address this limitation, a rotational scanning technique for AFM has been developed. Taking an inspiration from the rotating platters of the hard drives, the experimental scanning system was based on rotational–translational motion instead of the usual orthogonal piezoelectric scanner. The control and data reconstruction algorithms were the essential part, since in the new non-raster platform the AFM probe moved following a spiral or a concentric circle trajectory. During the experiments, the sample under the probe was rotated at frequencies up to 100 Hz, with probe-surface velocities reaching more than 45 mm/s and an image diameter of 142 micrometres. Even at such high speeds, the features of the surface were well resolved. It is expected that the reported technique will open new possibilities in characterization of precision optical components, composite materials and semiconductor nanodevices.

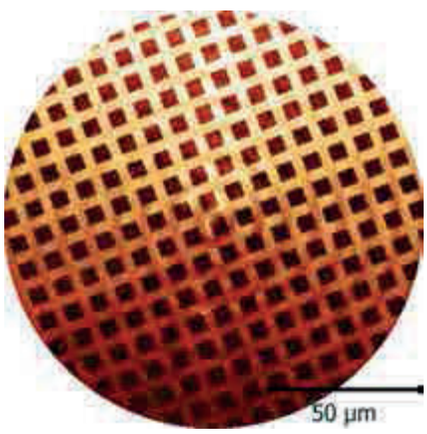


Fig. 2. Rotational scanning AFM readings: 141.9 µm diameter calibration grating image acquired in 12s.

Golden cups as nanoplasmonic sensors

Light energy manipulation by metallic nanostructures, known as the field of plasmonics, offers promising applications ranging from medical diagnostics to photovoltaics and IT. However, the challenging task is to establish scalable and cost-effective fabrication of plasmonic components and devices, especially those containing three-dimensional nanoarchitectures. Therefore, directed self-assembly of particles and molecules has been explored as an alternative fabrication platform for producing sensor chips consisting of ordered arrays of gold nanoantennas. The developed desktop process proved to be efficient for obtaining unique cup-shaped features with sub-50 nm bowls and rims, a nanostructure that provided a “test tube” volume of tens of zeptoliters and supported localized surface plasmon resonance. By adjusting the cup shape, the resonance was tuned into the visible/near-infrared spectral range for miniaturized optical detection of biomolecular interactions by regular instrumentation. These nanoantennas are attractive for further plasmonic engineering as well as for different nanobiotechnological applications.

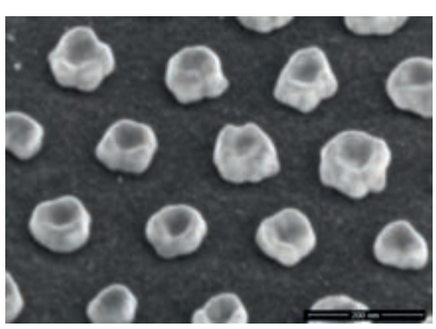
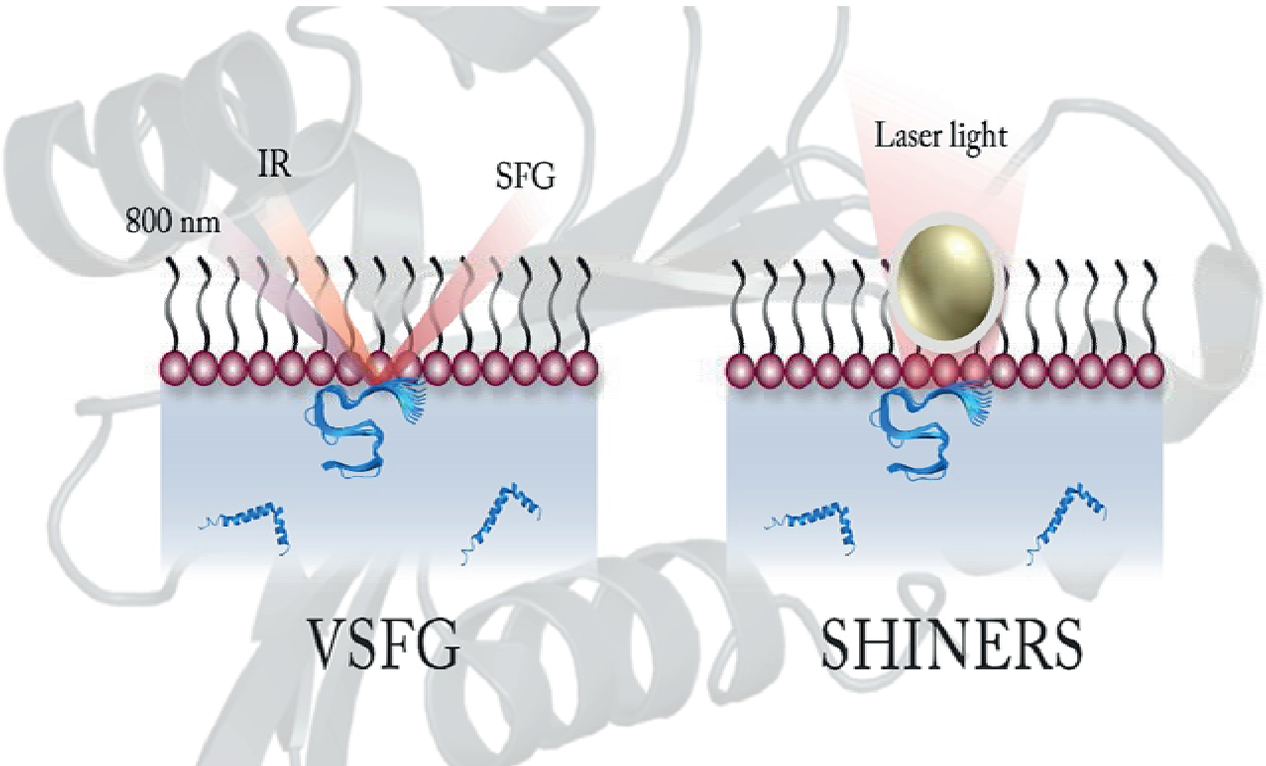


Fig. 3. Morphological characterization of the fabricated plasmonic Au nanocup arrays. Zoomed-in SEM images (scale bar is 200 nm).

Spectroelectrochemistry



Spectroscopy of adsorption and electrochemical processes at a metal-solution interface

Electron transfer reactions, electrocatalysis, function of biomolecules, and corrosion processes critically depend on adsorption of organic molecules at metal surfaces. Bifunctional self-assembled monolayers (SAMs) are widely used for construction of surfaces with desirable properties. To predict and control the function of SAMs, molecular level understanding of monolayer architecture is required. We have used one of the most sensitive vibrational spectroscopic tools, surface-enhanced Raman spectroscopy (SERS) for in-situ probing the bonding, structure, and orientation of adsorbed molecules at Au, Ag, and Cu surfaces. In addition, reflection absorption infrared spectroscopy and sum frequency generation spectroscopy were used for analysis of electrochemical interface. The spectroscopic methods were coupled with first principle calculations and isotopic substitution approach. Spectroscopic experiments were conducted in-situ at controlled electrode potential. We have synthesized bifunctional thiols and provided spectroscopic evidence for the interaction of biomolecules at electrodes modified with positive charge bearing self-assembled monolayers. Electrochemical SERS studies of gold electrode modified by copper hexacyanoferrate have revealed that the rate of some redox processes of solute species, like the anodic oxidation of ascorbate and cathodic reduction of H_2O_2, appears to be limited by the slow electrochemical redox transformations within the modifier layer.

Electrical activity of cellobiose dehydrogenase adsorbed on thiols: influence of charge and hydrophobicity

The interface between protein and material surface is of great research interest in applications varying from implants, tissue engineering to bioelectronics. Maintaining functionality of bioelements depends greatly on the immobilization process. In the present study direct electron transfer of cellobiose dehydrogenase from *Humicola insolens* (*Hi*CDH), adsorbed on four different self-assembled monolayers (SAMs) formed by 5-6 chain length carbon thiols varying in terminal group structure, was investigated (Fig. 1). It was found that the presence of charged pyridinium groups was needed to successfully establish direct electron transfer between the enzyme and electrode (Fig. 2). SAMs formed on hydrophilic charged thiols achieved nearly two time higher current densities compared to hydrophobic charged thiols. Additionally, the results also indicated proportionality between *Hi*CDH catalytic constant and water content of the enzyme film. Enzyme films on charged pyridine thiols had smaller variations in water content and viscoelastic properties than films adsorbed on the more hydrophobic thiols.

Fig. 1. Structures of studied thiols.

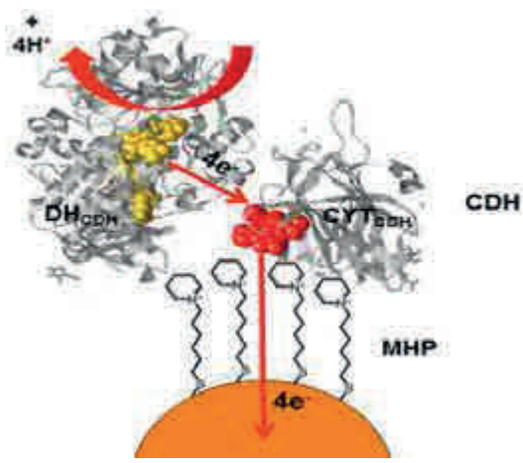


Fig. 2. Schematic representation of the studied interfacial structure.

Electrochemical SERS of interfacial processes at copper hexacyanoferrate modified electrode

Electrochemical redox processes taking place at copper hexacyanoferrate (CuHCF) modified Au electrode have been investigated by surface-enhanced Raman spectroscopy (SERS). The most characteristic Raman bands, related to triple CN bond vibrations and centered at 2187 and 2127 cm^{-1} were assigned to the oxidized and reduced forms of CuHCF, respectively. Time-resolved Raman spectroelectrochemical study shows that the electrochemical redox interconversions between these two forms proceed relatively slow, thus resembling the behavior of structurally related cobalt hexacyanoferrate, and differing essentially from that of Prussian blue layer studied previously. It has been shown that the rate of some redox processes of solute species, like the anodic oxidation of ascorbate or cathodic reduction of hydrogen peroxide at CuHCF modified electrode, appears to be limited by the slow electrochemical redox transformations within the modifier layer itself rather than by the redox interactions of a modifier with the solute species (Fig. 3).

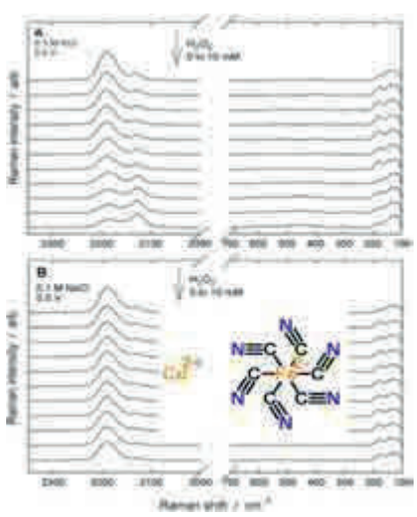
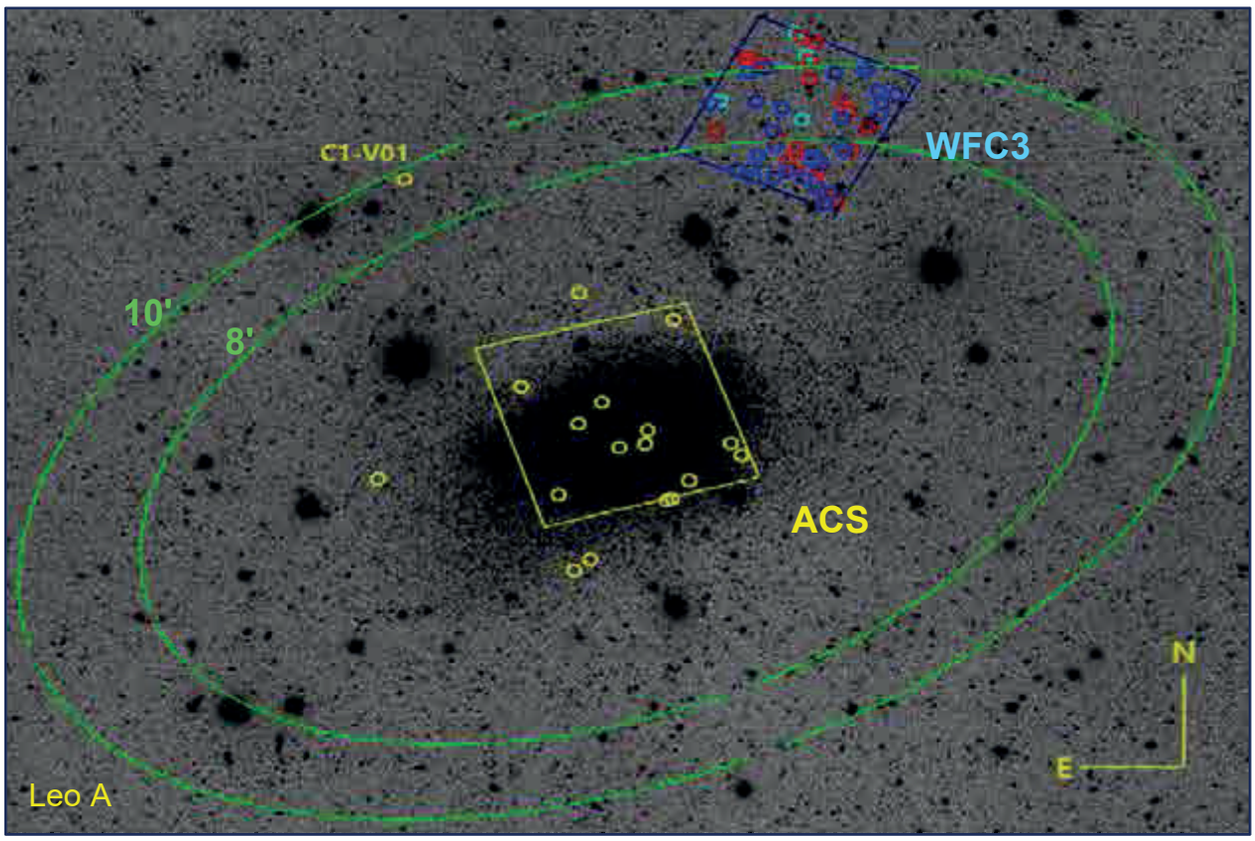


Fig. 3. SERS spectra from copper hexacyanoferrate modified gold electrode in two different electrolytes under electrolysis conditions at controlled potential of 0.0 V with different concentrations of hydrogen peroxide.

Astrophysics



We study complex systems, from star clusters to galaxies, by employing ground- and space-based observations, as well as computer simulations.

Leo A is bigger yet again!

Dwarf irregular galaxies are supposed to be simple gas-rich stellar systems, presumably "building blocks" of large galaxies. Analysis of these systems, which are likely built up only via self-enrichment, could provide insight into the early star formation history in the Universe. Leo A is an isolated gas-rich nearby (800 kpc) dwarf irregular galaxy of low stellar mass and metallicity, residing at the outskirts of the Local Group. We have discovered its stellar halo extending far beyond the previously known limits and found old >7 Gyr stellar populations of extremely low metallicity $Z \sim 0.0001$. Moreover, the discovered stellar halo is extending beyond the limits of the neutral hydrogen envelope (8'), which suggests a very complex evolutionary scenario of such a small and isolated galaxy.

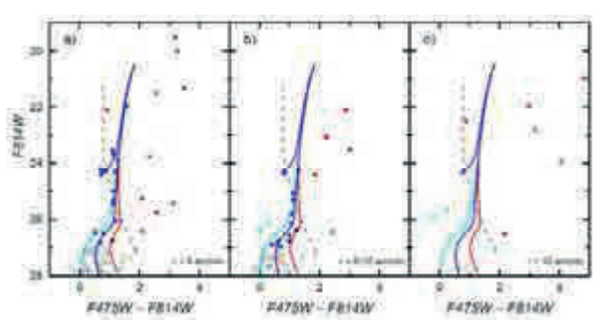


Fig. 1. In the image of the Leo A galaxy (top) the green ellipses mark previously known (8') and newly established (10'–2.3 kpc) Leo A sizes. The square regions marked in yellow and in blue were observed with the HST ACS and WFC3 cameras, respectively. Filled colour circles in the colour magnitude diagrams (CMDs) (above) mark the following objects: probable Leo A stars (blue), probable MW stars (red), probable compact faint blue galaxies, Leo A blue stragglers or Milky Way (MW) white dwarfs (cyan). Stars plotted in the CMDs are shown in the WFC3 region. A 7 Gyr age and Z=0.0001 metallicity isochrone (a blue line), photometric scatter limits (cyan and red lines), and the limit of MW stars (a grey dashed line) are plotted in all CMDs.

Modeling

Electronic structure calculations of processes at defects in semiconductors

The laboratory of Electronic Structure Theory investigates the electronic structure of point defects in semiconductors for quantum information processing and quantum metrology applications. In recent few years, bright single-photon emitters in hexagonal boron nitride (h-BN) have been discovered. The laboratory is actively engaged in research of these new colour centres, via both first-principles calculations and active collaboration with experimental colleagues from the US and Australia. In collaboration with the group from the University of Pennsylvania, we have discovered weak lattice locking of colour centres in h-BN responsible for quantum emission. This could potentially point to the origin of these as yet unidentified defects. On the theoretical front, we have performed systematic investigations of point defects that could potentially lead to the observed emission. We have discovered that all defects with electronic states derived from nitrogen dangling bonds (e.g., boron vacancies and their complexes) lead to strong electron-phonon coupling. This is in disagreement with experiment and points to a much more exotic nature of the experimentally observed emitters.

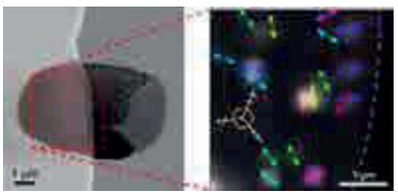


Fig. 1. Left: scanning electron microscope image of hexagonal boron nitride on top of silicon substrate. Right: single photon emitters and their polarization in h-BN as seen in confocal microscope images.

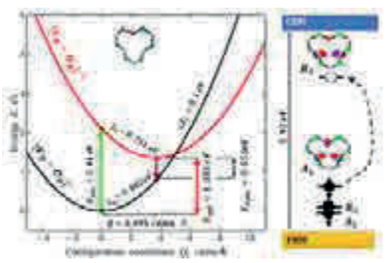


Fig. 2. First-principles modeling associated to non-radiative process pertaining to the $B_1 > A_1$ transition at boron vacancy-oxygen complex in h-BN.

Exploring the antipolar nature of methylammonium lead halides

The high power conversion efficiency of the hybrid $CH_3NH_3PbX_3$ (X = I, Br, Cl) solar cells is believed to be tightly related to the dynamics and arrangement of the methylammonium (MA) cations. We propose a statistical phase transition model which accurately describes the ordering of the MA^+ cations and the whole phase transition sequence of the $CH_3NH_3PbI_3$ perovskite. The model is based on the available structural information and involves the short-range strain-mediated and long-range dipolar interactions between the cations. It is solved using Monte Carlo (MC) simulations on a 3D lattice allowing us to study the heat capacity and electric polarization of the MA^+ cations. The temperature dependence of the polarization indicates the antiferroelectric nature of these perovskites. We support this result by performing pyrocurrent measurements of $CH_3NH_3PbX_3$ single crystals.

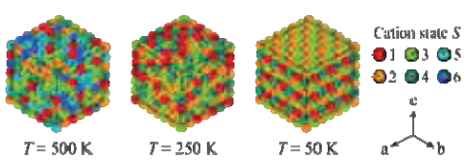


Fig. 3. Snapshots of MC simulations at different temperatures corresponding to the cubic (left), tetragonal (middle) and orthorhombic (right) phases. The MA^+ cation states are color-coded, and the dipole moments are indicated by the arrows. The presented cubes were cut from a larger simulation.

Resonances in a system of three dielectrics with one metalized interface

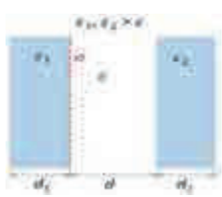


Fig. 4. Cross sectional view of a system (ε is a relative dielectric constant of the particular dielectric).

We considered a system of three dielectrics with one thin metal layer covered interface characterised by a surface conductivity σ (Fig. 4). Resonances in such a system were investigated at microwave frequencies trying to find the conditions at which the maximum or the minimum of shielding effectiveness (SE=10 log(1/T), where T is a transmittance) can be observed. We performed the calculations of SE as a function of t, t_1 and t_2 using dimensionless coordinates $t = d\sqrt{\varepsilon}/\lambda$, where λ is a wavelength of microwave radiation. As shown in Fig. 5 the SE is a periodic function in both directions with a period 0.5 characteristic to Fabry-Perot resonance. We found conditions at which the maximum or the minimum of the SE can be realized. The largest difference between these values is 24 dB. These calculations were confirmed by the experiments.

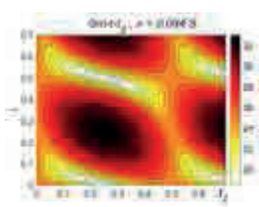
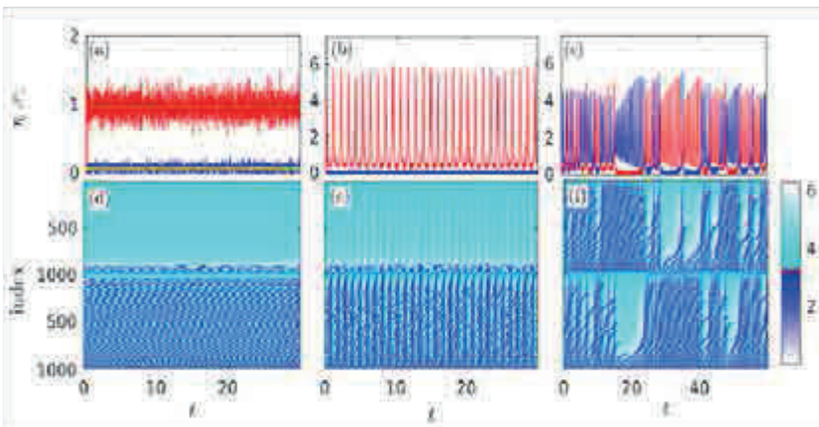


Fig. 5. Dependence of SE (in dB) on t and t_2 for $t_1 = 0$.

Nonlinear dynamics and chaos



Modeling of two inhibitory coupled populations of QIF neurons consisting of 1000 neurons in each population. (a)-(c) Dynamics of spiking rates of different populations shown by different colors. (d)-(f) Microscopic dynamics of the phases of neurons in both populations. Three columns of the figure correspond to three different states observed at different coupling strengths: [(a) and (d)] a splay state, [(b) and (e)] a chimera state and [(c) and (f)] a chaotic chimera state.

Symmetry breaking in two interacting populations of quadratic integrate-and-fire neurons

Studies of collective motion in networks of nonlocally or globally coupled oscillators or excitable elements are the focus of current research in diverse fields from physics to neuroscience. One of the most striking effects observed in such systems is so called chimera state. The simplest setup that supports chimera states is a pair of oscillator populations in which each oscillator is coupled equally to all the others in its group, and with different strength to those in the other group. Though such a system is symmetric with respect to exchange of populations, it may possess a symmetry broken (chimera state) solution so that the oscillators in one of populations are synchronized while in other population they are desynchronized. Chimera states are of particular interest in neural models. Many creatures like birds, reptiles and sea mammals sleep with only half their brain at a time. In such a unihemispheric sleep, the awake side of the brain shows desynchronized electrical activity, whereas the sleeping side is highly synchronized. An asymmetric brain activity has been also observed in human sleep apnea patients. Thus, the study of neural chimera states have clinical relevance as well.

We analyzed two globally coupled populations of quadratic integrate-and-fire (QIF) neurons. Unlike typical models, which consider chimera states in systems of identical oscillators, here we analyzed two populations of heterogeneous neurons. Each population contains both excitable and spiking neurons interacting via synaptic coupling. Our model admits an analytical treatment in the thermodynamic limit of infinity number of neurons. We derived an *exact macroscopic model* described by a simple system of ordinary differential equations, which enabled us to perform a thorough bifurcation analysis of the system.

We were convinced that the macroscopic model predicts well the behavior of a finite-size network consisting of only thousand neurons in each population. Thus, the macroscopic models of the type considered here are natural candidates for use in future large-scale brain simulations. They may be a good alternative to neural mass models, which are currently used to understand brain rhythms. The neural mass models are phenomenological in nature, while the approach discussed here provides an exact macroscopic description of an underlying microscopic neurodynamics.

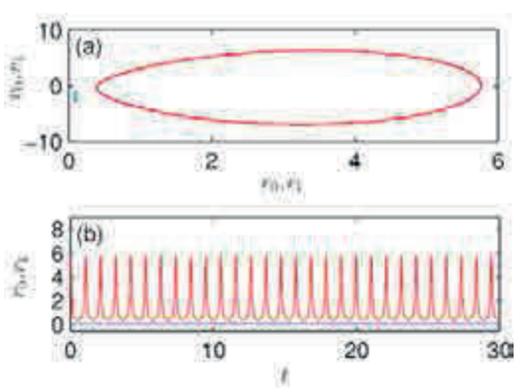


Fig. 1. Chimera solution derived from the macroscopic model. (a) Dependence of the mean membrane potential on the spiking rate for different populations are presented by different colors. (b) Dynamics of the spiking rates in different populations also shown by different colors.

Nanostructures for applications

2D material technology for gas and photo-sensitive systems

Recent progress in growth technologies of the two-dimensional (2D) materials and promising proofs of concepts in development of electronic devices had stimulated a great interest in the applied studies of the 2D materials. In our research and development strategy we had focused on the combined autonomous detecting modules that include several parts of the core functions, namely renewable power supply, conversion of a response to an external factor, e.g. chemicals, light, temperature, into an electronic output, signal pre-procesing, database generation and an external control of the functions. We are developing vertically stacked up multi-layered structures with the 2D materials (graphene, molybdenum disulfide) and ultra-thin films (metal and metal oxides). The van der Waals interaction between the stacked up films play an essential role in functioning of the multilayered structures. In this report we illustrate our experimental results obtained for the model structures that reveal an influence of the device working temperature on the electron transport in a solid insulator supported graphene sheets and the metal-graphene sandwich-like contacts. Typical results are represented graphically in Fig. 1. The I_{C0} and σ_{sh0} are the magnitudes of the corresponding parameters measured at the room temperature. Based on the patterned maps of the Raman shift spectra of the graphene monolayer (Fig. 1 (b)), we proposed a grain boundary scattering controlled electron transport model that explains a decrease of the graphene conductivity with temperature. Although the Raman maps of graphene on the metallic contacts clearly proves a diversity in the interaction between the graphene sheets and Au and Ni metal films, the electron transport across these metal junctions is surprisingly independent on temperature and metal type (Fig.1 (a)). By improving understanding of the fundamental properties of the stacked up structures with the 2D material layers, ultra-thin metal oxides and metal films, we expect to create a novel type of miniaturised autonomous hybrid sensor systems for light controlled gas detection.

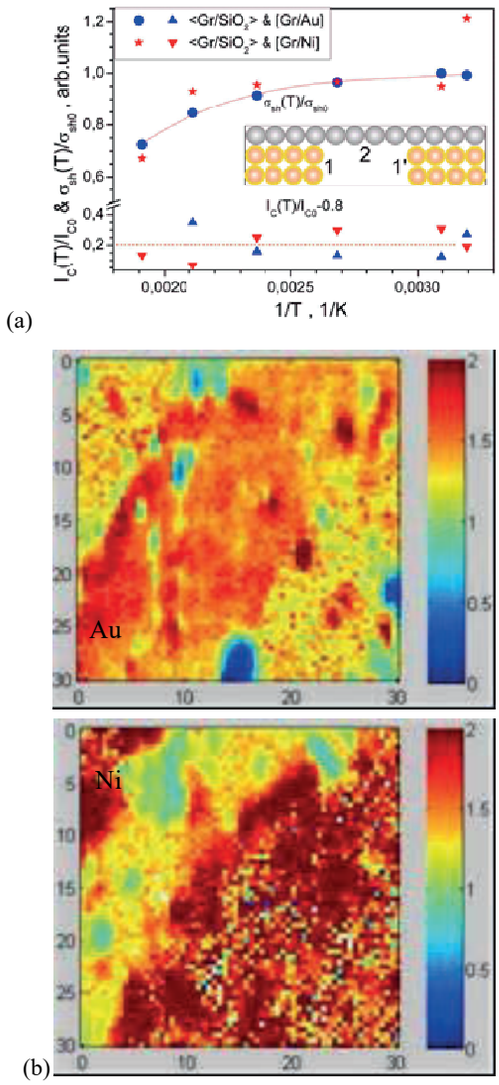


Fig. 1. (a) The normalized contact current $I_C(T)$ and normalized sheet conductance $\sigma_{sh}(T)$ vs. reciprocal working temperature for the circular graphene samples with Au and Ni contacts. Inset: construction of the sample with metal contacts 1 and 1' and graphene sheet 2. (b) Images of circular samples with graphene monolayer on the top of the metal contacts (Au – above, Ni – below) visualized by the maps (30x30 μm^2 area) of the ratio between the intensities of the 2D and G lines I_{2D}/I_G of the Raman shift spectra. Colour scale from blue to red correspond to $0 \le I_{2D}/I_G \le 2$.

Magnetoresistance anisotropy of ultrathin epitaxial manganite films

Manganite thin films exhibiting colossal magnetoresistance (MR) phenomenon are promising materials for the fabrication of magnetic field sensors. The magnetic properties of these films can be managed by chemical composition, growth conditions and control of film structure. It was obtained that magnetic properties of thin epitaxial $La_{0.83}Sr_{0.17}MnO_3$ films with thickness from 4 nm to 140 nm grown on $NdGaO_3$ (001) substrate by a pulsed injection metal organic chemical vapor deposition technique exhibit strong changes with the increase of film thickness. The structural study, made by using Grazing Incidence X-Ray Diffraction (Beamline I811, MaxLab-II, Sweden), has shown the anisotropic strains in the plane of these films (Fig. 2), which are caused by a mismatch between lattice parameters of manganite and NGO substrate. The strain has different sign at different directions of the substrate and can be controlled by changing film thickness. It was demonstrated that the MR and its anisotropy (AMR) strongly depends on these strains and AMR can change its sign from positive (thicker films) to negative (ultrathin films) (Fig. 3). It was noted that at intermediate thickness (20 nm), when the current is flowing perpendicular to the easy magnetization axis [010], the AMR value is very small. While the positive AMR effect is assigned to the conventional magnetic ordering of manganites, the AMR of ultrathin films is shown to be influenced by the pinning of magnetization to the easy axis. The change of the AMR sign with film thickness is well described by the two-region model assuming that the relative concentration of both regions changes with the film thickness. The effect of the AMR compensation can be used for the development of scalar in-plane magnetic field sensors.

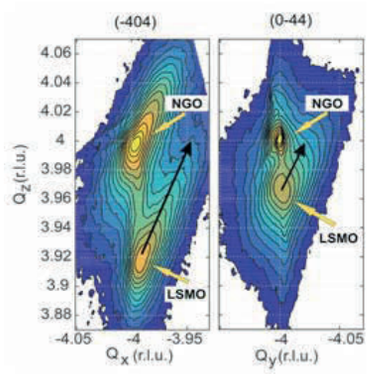


Fig. 2. θ–2θ X-ray diffraction scan taken from a 20 nm thick LSMO film grown on the (001) NGO substrate.

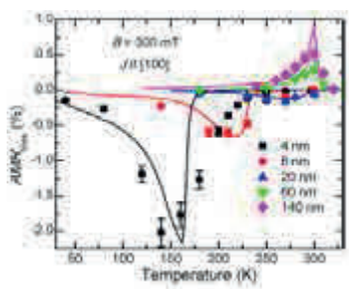


Fig. 3. The AMR as a function of temperature for $La_{0.83}$ $Sr_{0.17}$ MnO_3 films of different thickness.

Improved whole yeast cell sensors

Microbial cells are often used in various whole cell-based sensors. The main exclusivity of such biosensors is that they identify and quantify the analyte or component of interest within the cell. The yeast cells are also used for whole-cell biosensors, but natural barrier functions of the cell wall and cell membrane often retards entry of substrates and release of products. Besides barrier function, envelope provides protection from osmotic stress and is important for yeasts defence against toxic compounds, self-recognition as well as flocculation. Usually, the chemical permeabilization is a typical approach to enhance response of whole cell based sensors. However, stability and viability of the sensory cells is still a challenge for stable, long lasting and selective operation of biosensor. One of the possible techniques, which could be used to improve permeability for target molecules, is pulsed electric field (PEF), yet there is still a lack of sufficient data related to the effects of PEF on yeast cells. Here we employed yeast itself as an amperometric whole cell sensor for the investigation and development of PEF improved whole yeast cell sensors. The electroanalytical tools can be effectively exploited as a useful method for investigation of various cellular responses after PEF treatment. Moreover, the PEF improved whole cell sensors could be a toolbox for investigation and developing of enhanced biocatalysis.

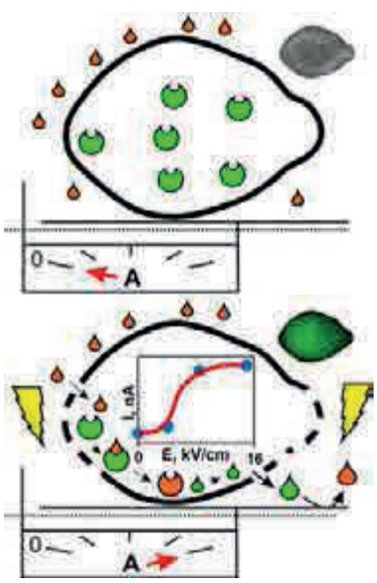
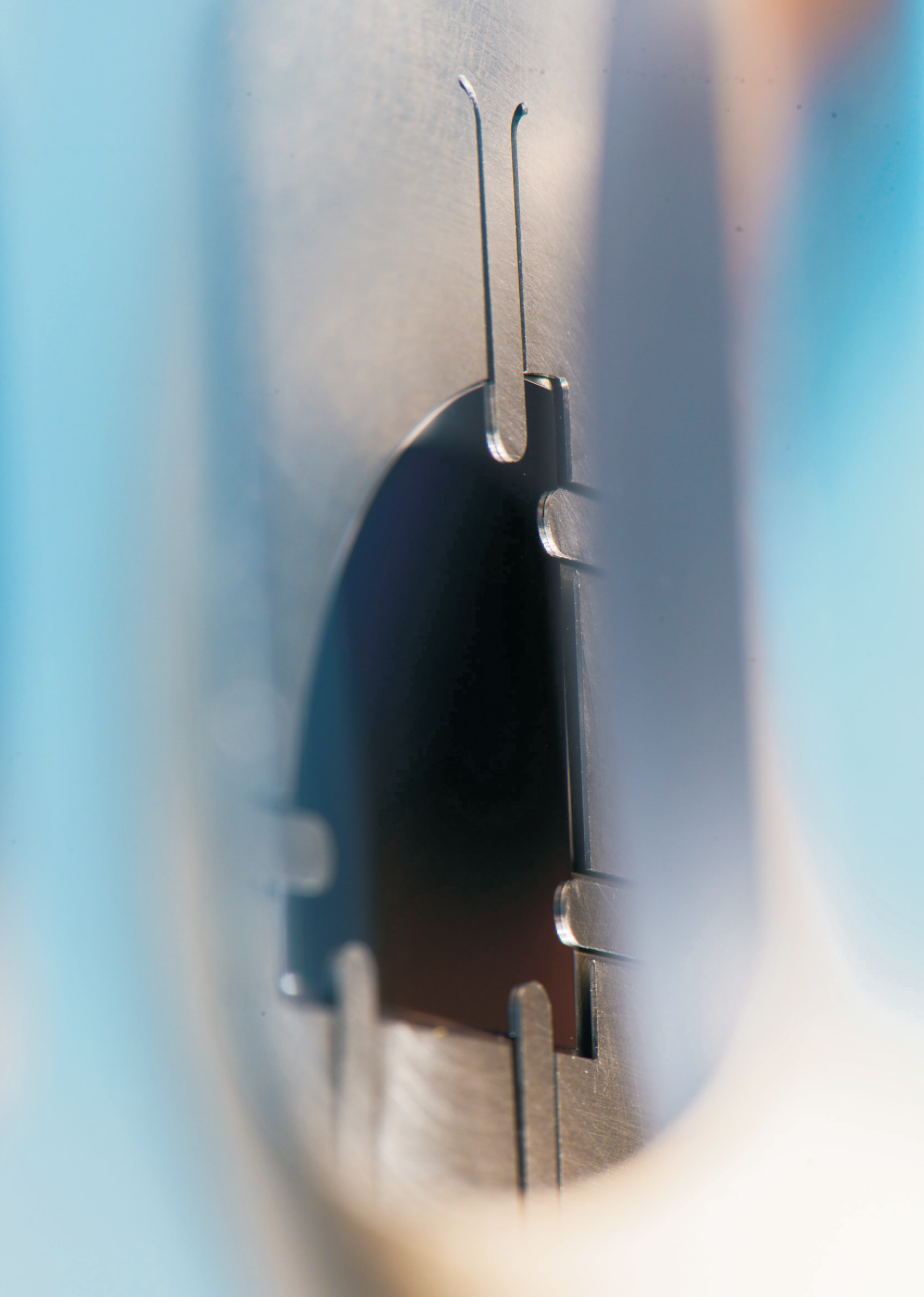
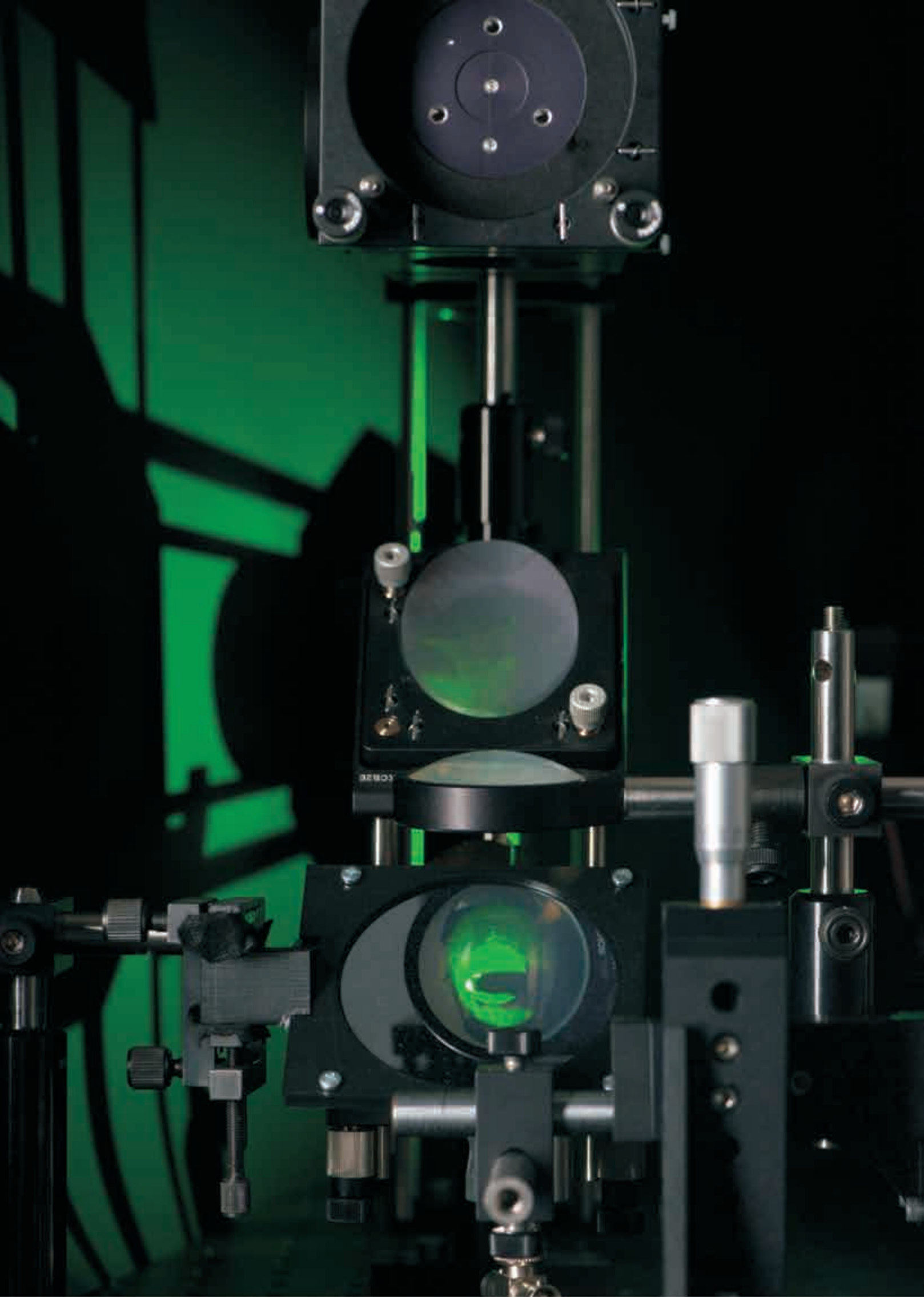
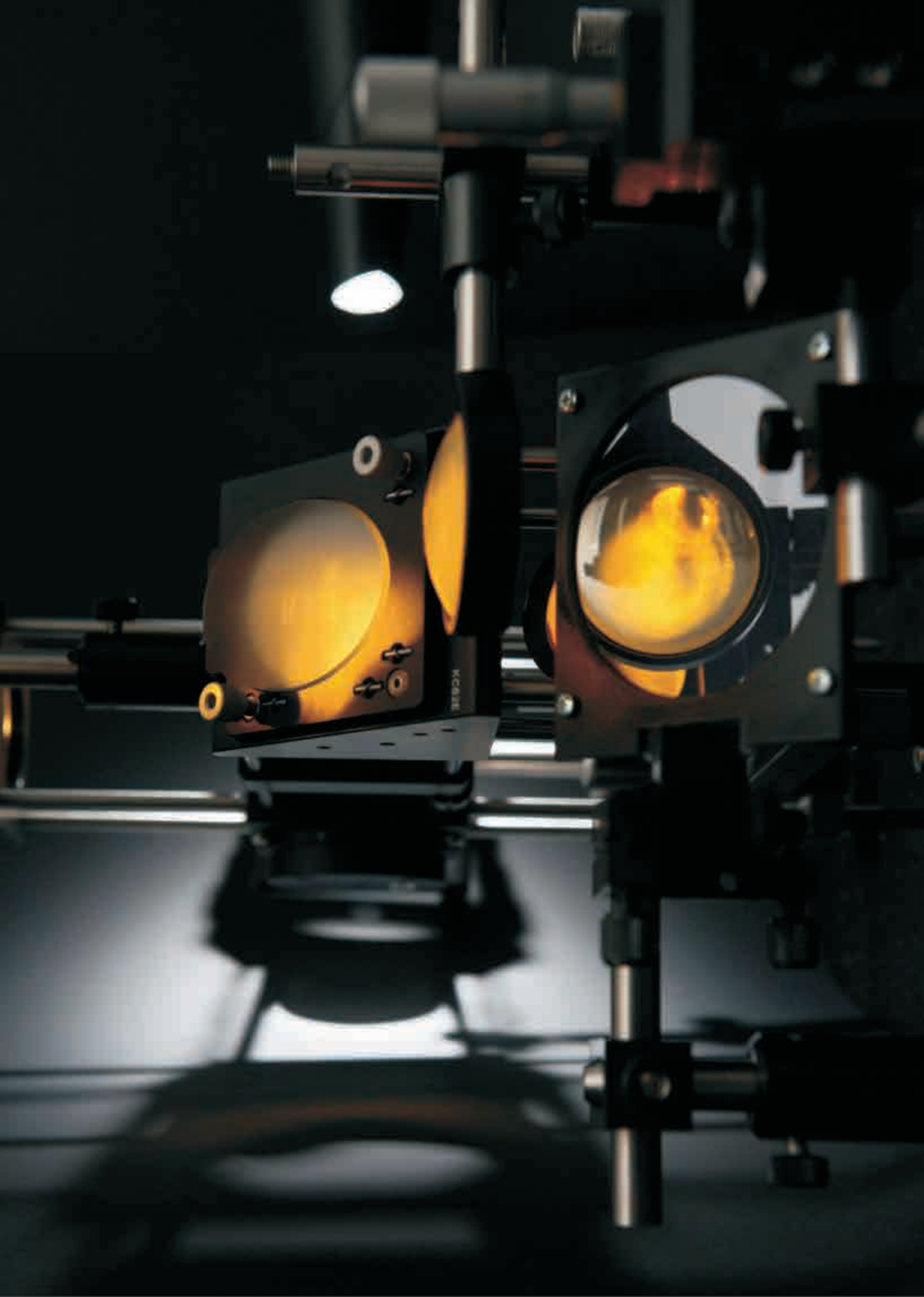
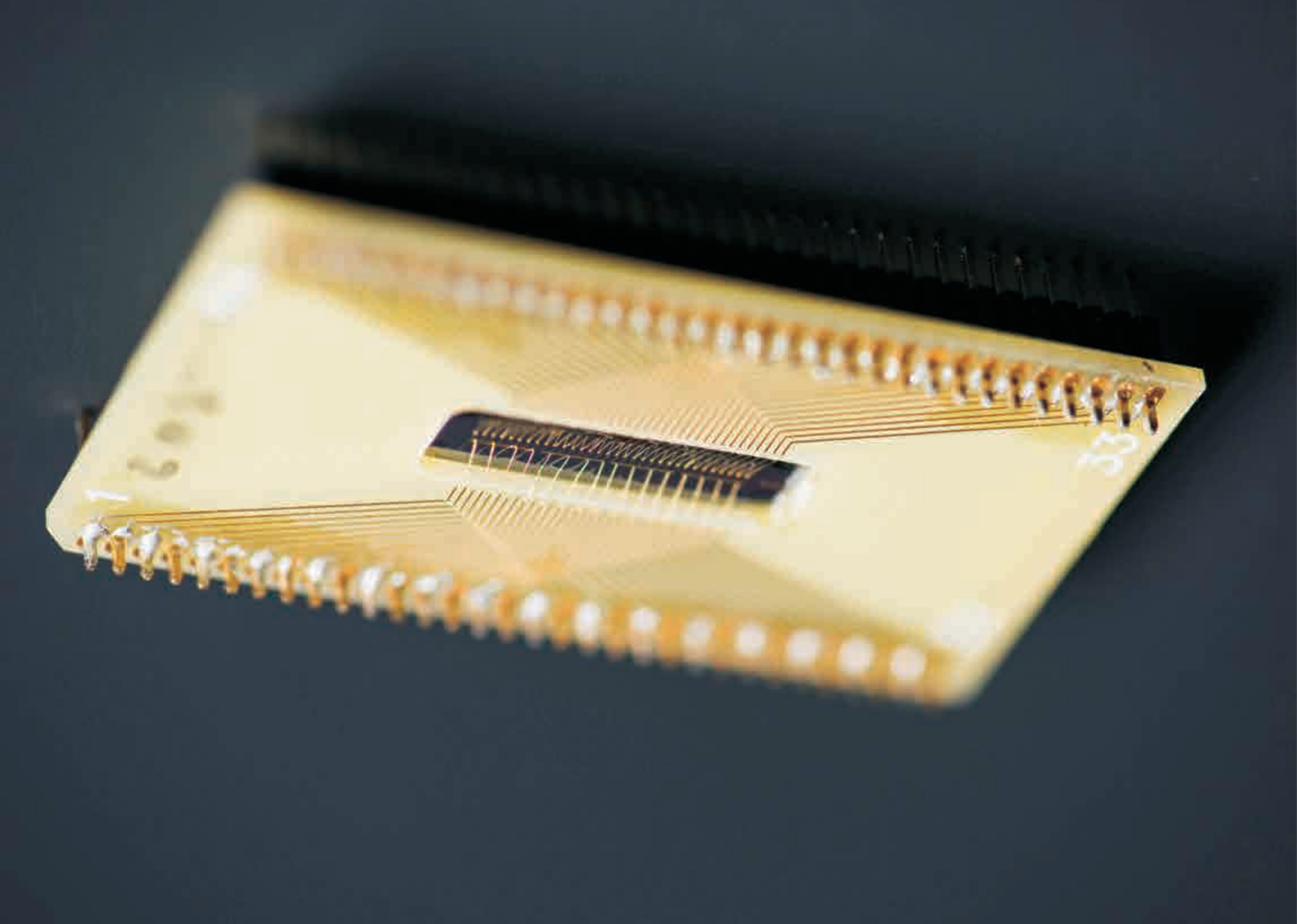


Fig. 4. The PEF effect on the whole cell sensor. Above: untreated yeast cell. Below: PEF - treated cell. The mediator can enter only PEF-treated cell, where it is reduced. When such a mediator reaches electrode surface, it oxidizes generating detectable current.









Metrology

National metrology institute of Lithuania

"A one-inch error at the start can be a thousand miles at the end" (Chinese proverb)

In metrology, which literally is the science of measurements we have to go one step ahead to assure the correctness, accuracy and reliability of measurement result. To measure is not the specificity of metrology, but the core of metrology lies in the validation of the result, particularly by specifying its actual limitations. Since 1 July, 2014 FTMC Metrology Department (MD) was authorized to perform and implement the functions of the National Metrology Institute (NMI).

MD maintains national standards in five different measurement fields. **Time and Frequency Standard Laboratory** (TFSL) is reproducing values of the unit of time, the second (s) and the unit of frequency- hertz (Hz). Its mission is to represent the Lithuanian Coordinated Universal Time UTC(LT), ensuring the traceability of the magnitudes reproduced to the International System of Units (SI), disseminating them to Lithuanian scientific establishments, personal and legal bodies by calibrating their working standards and measurement devices, disseminating Lithuanian time scale, and other relevant means.

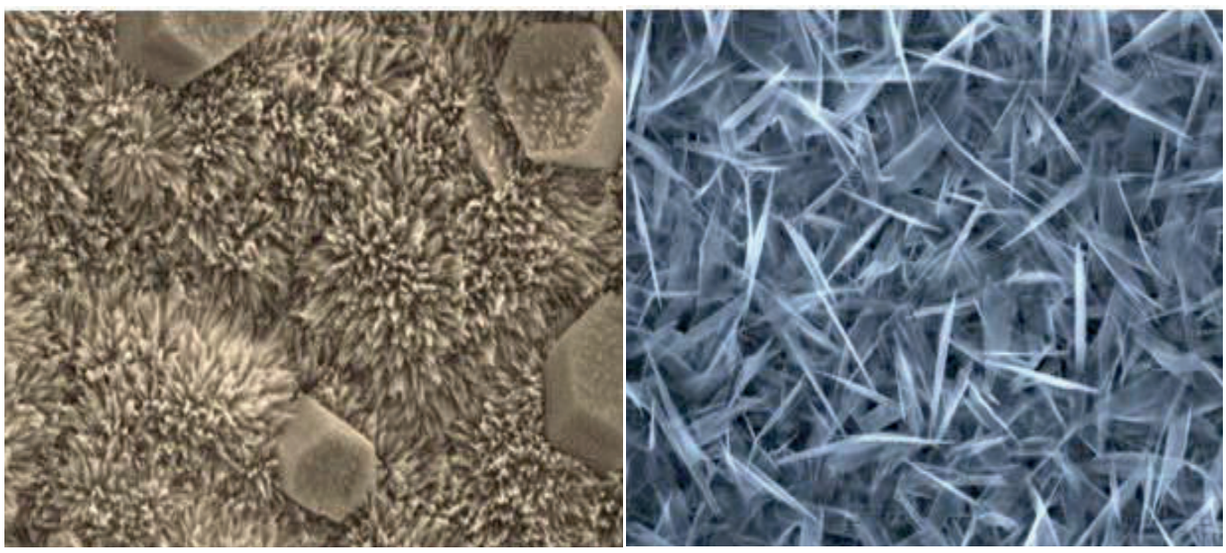
The mission of the **Electrical Standards Laboratory** (ESL) is the maintaining and developing the standards of unit of voltage, the volt (V), and unit of resistance, the ohm (Ω), ensuring their traceability to the SI system, calibrating working standards and measurement devices, pursuing research in the field of measurement of voltage, resistance and electrical current.

The **Temperature Unit Standard Laboratory** (TUSL) is implementing the international temperature scale ITS-90 and the value of the unit of temperature - kelvin (K) and ensuring their traceability to the SI system. Lithuanian national standard of the temperature unit in the range from -195°C to +961,78 °C is of primary level and +1084,62 °C reference point (freezing point of Cu) is of the secondary level.

In the **Ionizing Radiation Metrology Laboratory** (IRML) radionuclides ^{3}H, ^{14}C, ^{36}Cl, ^{63}Ni, ^{90}Sr, ^{99}Tc and ^{129}I have been standardized with the Triple-to-Double Coincidence Ratio (TDCR) apparatus, the uncertainty budget was evaluated.

Metrology is not restricted only to standards of physical units, but also to reliable and accurate chemical measurements in sectors of health care, food safety and environment protection which are provided by the **Laboratory for Metrology in Chemistry** (LMiC).

Electrochemistry & tribology



Electrochemical materials science

The R&D activities in this area are focused on the application of electrochemical methods for development and characterization of new functional materials such as:

- alloys of light and refractory metals (Mg, Al and Cr, Nb, Zr, Ta) with controllable corrosion resistance;
- semiconductor nanowires loaded inside the alumina pores and nanostructured titanium or iron oxides;
- transparent conductive oxide layers and their heterostructures;
- superparamagnetic and luminescent nanoparticles with possible applications in nanomedicine;
- new effective materials for photovoltaic and nanoelectronic technologies;
- smart coatings with active corrosion protection ability for metals in aggressive environments.

Electrochemical, chemical as well as physical (magnetron sputtering, atomic layer deposition) methods are applied for the surface modification and production of smart materials with exceptional anticorrosive, electrocatalytic, magnetic, mechanical or other properties. The integral part of the process of new materials development is thorough characterization of their structure, morphology and chemical composition. Environmental friendliness is an imperative for all newly developed technologies.

Another trend of scientific research is related to tribology and formation of compositions of biofuels, lubricants and plasticizers, using biodegradable components. These activities include search for tribologically efficient materials for new type anodic aluminum coatings with exceptional resistance to friction and attrition. The results are tested directly in Anodization pilot plant, located in the Chemical technologies department of the Center. Corrosion, tribological, physical and electrochemical studies of the interaction of biofuels (ethanol, biodiesel, biolubricants) with metal surfaces are carried out as well.

Corrosion Testing Laboratory, accredited in 2007, performs corrosion testing and evaluation of the corrosion-caused changes in metals, alloys, composite coatings, paints and lacquers in natural and artificial atmosphere as well as testing of microbially induced corrosion of materials in atmosphere and model medium.

Methionine-mediated synthesis of superparamagnetic nanoparticles with Au^0/Au^+ quantum dots for theranostics

Smart functionalization of superparamagnetic nanoparticles (Nps) with gold quantum dots (QDs) and ultra-small Au^0 Nps represents a promising multi-task platform for magnetic Np linking with the specific targeting ligands, such as aptamer and antibody, for diagnosis and therapy of disease sites at their initial stage of growth. In Nanostructure laboratory an efficient protocol for superparamagnetic cobalt ferrite ($CoFe_2O_4$) Nps synthesis and decoration with Au^0/Au^+ quantum dots and ultra-small Nps (Fig. 1) was created. Methionine amino acid was used as Np stabilizing shell during synthesis and subsequent reduction of $AuCl_4^-$ ions. It is envisaged that in an alkaline medium methionine anions interact with the surface of cobalt ferrite Nps through the carboxyl bond reducing gold-containing ions at the solution/particle interface and linking Au^0/Au^+ species through the formation of –S-Au bonds. It is believed that the strategy developed here can be easily extended to coat magnetic Nps composed of other iron oxides with a gold shell.

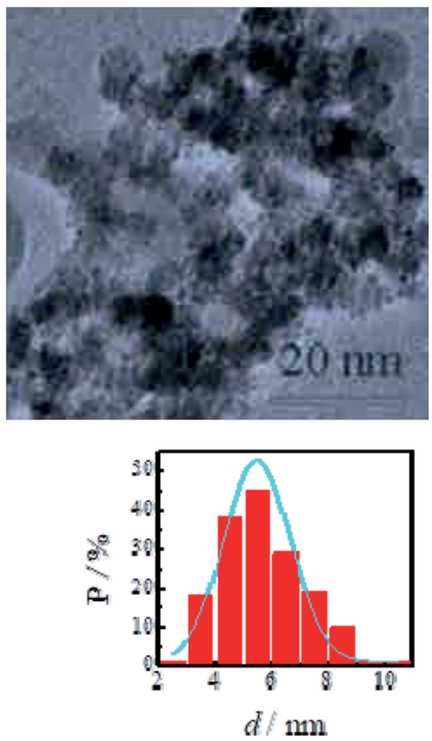


Fig. 1. TEM view and size distribution histogram of $CoFe_2O_4$ Nps decorated with gold.

Dry sliding tribological behavior of Cr coatings electrodeposited in trivalent chromium sulphate baths

Electrodeposition of chromium coatings is widely used in various industries. Usually chromium coatings are deposited from hazardous hexavalent chromium baths. Deposition of coatings from trivalent chromium baths is a very promising technology, because Cr(III) compounds are not toxic and can replace conventional hexavalent Cr electrolytes, thus eliminating serious environmental hazards. The tribological properties of Cr coatings electroplated in Cr(III) sulphate baths with complexing agents (formate-urea, glycine and oxalate) on 316Ti stainless steel substrate have been investigated. To assess the tribological behavior of the coatings, the dry sliding wear test against a 100Cr6 steel ball was performed with a ball on a flat configuration. The investigation of the friction coefficient has shown that Cr coatings deposited in Cr(III) baths exhibit better tribological properties compared to those of Cr coatings deposited in Cr(VI) baths (Fig. 2).

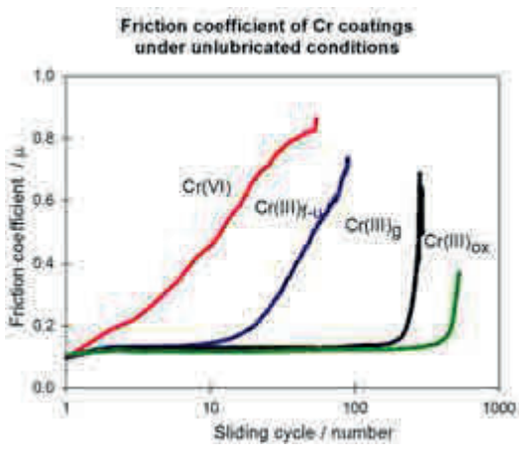
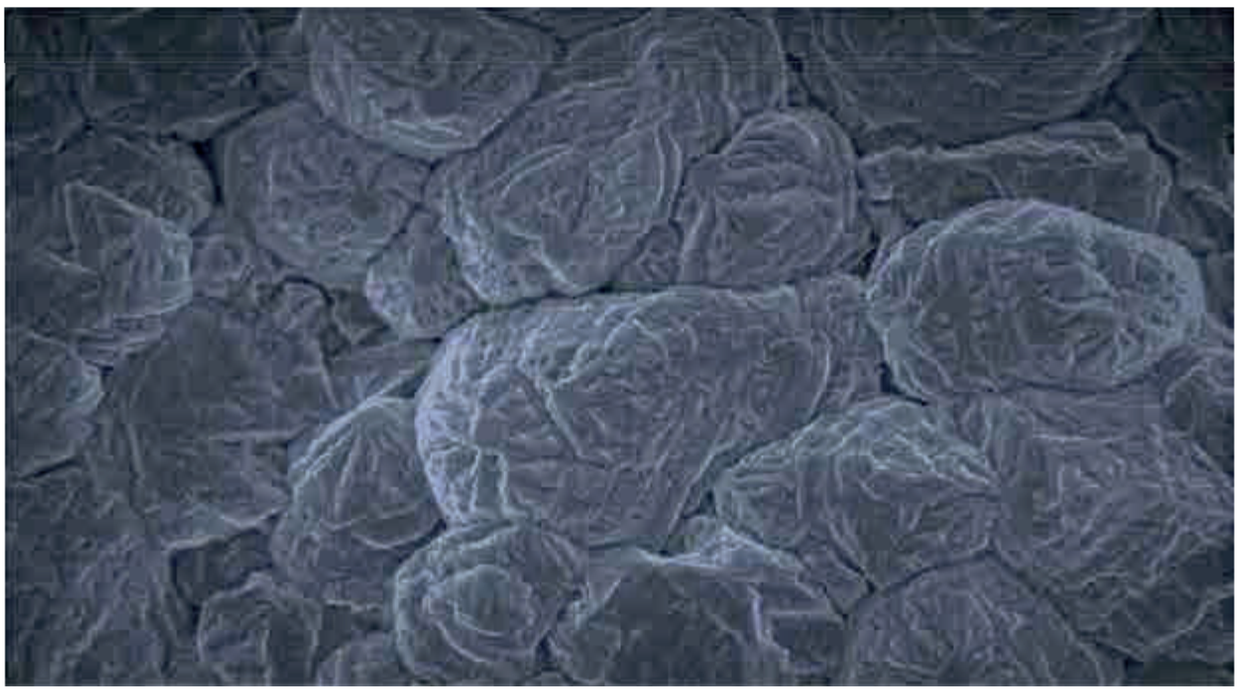


Fig. 2. Friction coefficient as a function of the friction cycles of Cr coatings obtained from baths: Cr(VI) and Cr(III) formate-urea, Cr(III) glycine, Cr(III) oxalate.

Materials for catalysis



Electroless metal deposition: from fundamental research of autocatalytic reactions of metal ion reduction to application for microelectronics, fuel cells and in other areas

Electroless metal plating is a well-known method for deposition of metal coatings by a controlled chemical reduction and formation of small (nano-scale) metal particles. The autocatalytic metal ion reduction systems are widely used for decorative and functional purposes, i. e. for deposition of conductive metal layer on dielectrics, semiconductors or on conductors with a complicated configuration without external current. The selection of suitable reducing agent and conditions of the reaction (temperature, concentration of the reacting substances, etc.) plays a very important role for creating of stable solutions and obtaining coatings with required characteristics, such as purity and surface roughness. The use of conventional hydrogen-containing reducing agents is connected with environmental and technological problems: (i) the plating bath cannot be recycled, i. e. the reducing agent oxidizes irreversibly, (ii) the plating rate and solution stability are not high enough. For these reasons the search and investigations of the reducing agents of a new type, e. g. charge-transfer reducers, namely the different oxidation state metal-ion redox couples, are actual nowadays, and they are developed and applied in the Department of Catalysis. The main reducing agents used are Ti(III) and Co(II), which oxidize during the electroless plating processes to Ti(IV) and Co(III). Additional advantage of such systems, where no hydrogen is formed during the electroless plating process, is the possibility to reduce the oxidized form of the reducing agent to the initial state. The R&D activities of our department in this area are focused on the development of new electroless metal plating processes as well as fundamental studies of reactions occurring in autocatalytic metal ions reduction systems by means of electrochemical quartz crystal microgravimetry. The electroless metal plating method is also successively used for fabrication of new catalytic materials for fuel cells. The non-noble metal and noble metal catalysts with low amount of noble metal supported titanium or titania nanotube arrayed surfaces, carbon, graphene powder or other supports, with enhanced activity towards the oxidation of various fuels, have been developed. The catalysts obtained are promising anode materials and can be used in the practical fuel cells.

Development of electroless metal plating processes

The following technologies were developed:

- Electroless deposition of continuous platinum layer using complexed Co^{2+} metal ion as a reducing agent,
- Electroless deposition of continuous cobalt layer using complexed Ti^{3+} metal ions as reducing agents,
- Electroless deposition of continuous nickel layer using complexed Ti^{3+} metal ions as reducing agents,
- Electroless deposition of continuous palladium layer using complexed Co^{2+} metal ions or Ti^{3+} metal ions as reducing agents.

The technology for deposition by electroless plating of high surface roughness as well as thick (>20μm) copper coatings, used as conducting layers in solar cells, has been developed (Fig. 1).

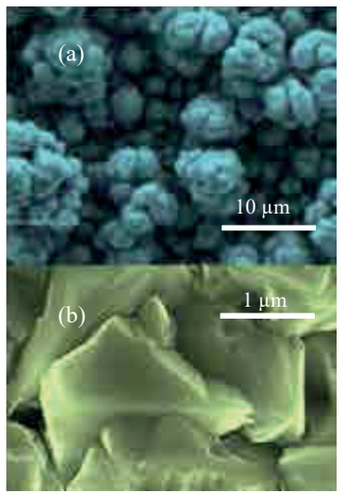


Fig. 1. SEM images of copper coatings electrolessly obtained from the plating solutions containing (a) 0.05 M $CuSO_4$, 0.15 M formaldehyde and 0.30 pyridine-2,6-dicarboxylic acid (pH 13) and (b) 0.05 M $CuCl_2$, 0.15 M $CoCl_2$ and 0.6 M diethylenetriamine.

Development of catalysts

A simple approach for fabricating of the effective catalysts for hydrogen generation from an alkaline sodium borohydride solution has been developed. We employed a nickel 3D-structured foam with an extremely high surface area as the support for the immobilization of Pt and Ni crystallites using the electroless metal deposition and galvanic displacement methods. A thin nickel layer was deposited on the nickel 3D-structured foam by using electroless metal plating method and sodium hypophosphite as a reducing agent. Pt crystallites were deposited on the prepared Ni/Ni foam catalyst by its immersion into the Pt(IV)-containing solution at a temperature of 25°C for various time periods. It was found that the deposition of a low amount of Pt on Ni/Ni foam significantly increases hydrogen generation rates from sodium borohydride solution. The catalysts obtained could have practical application as catalytic materials generating hydrogen for fuel cells.

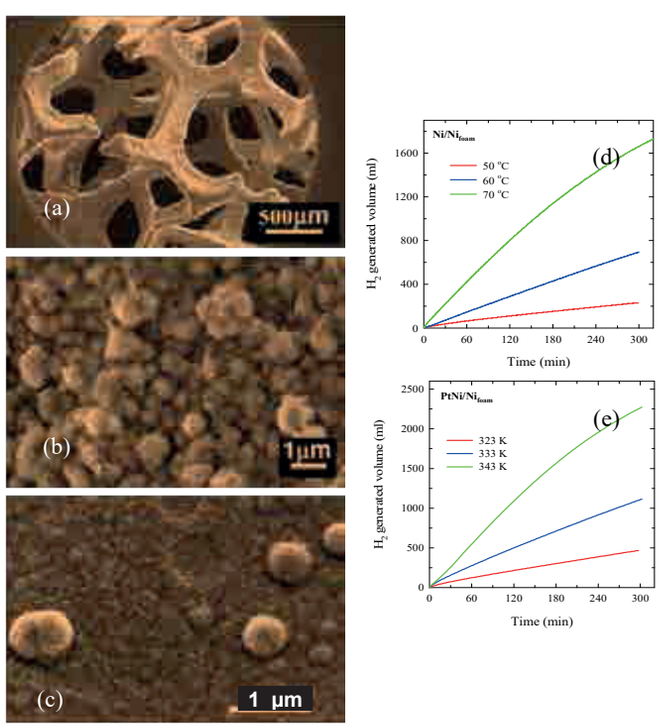
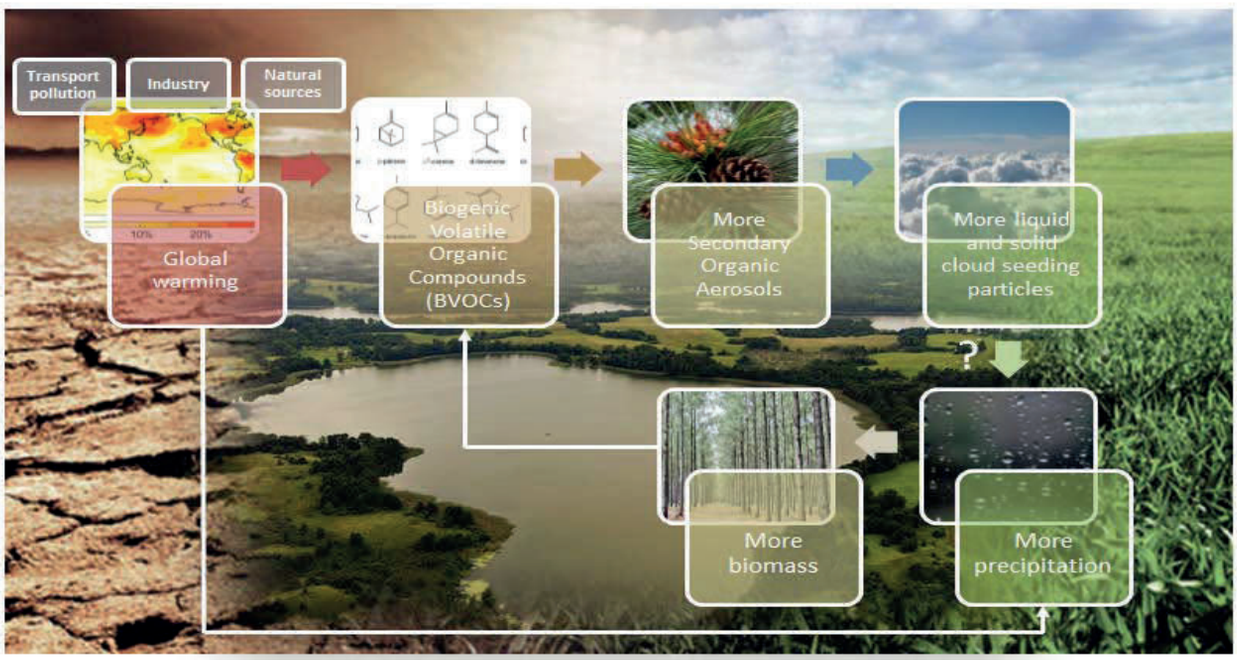


Fig. 2. SEM images of Ni foam (a) before, (b) after the electroless Ni plating and (c) Ni/Ni foam decorated with Pt crystallites. H_2 generation from 5 w% $NaBH_4$ + 0.4 w% NaOH solution catalyzed by (d) Ni/Ni foam and (e) PtNi/Ni foam catalysts.

Environment



The environmentally-friendly technologies for observation, simulation, prevention and mitigation of atmospheric pollution, and relation to the climate change

A modern environmental research relies on solutions that bring together the recent achievements in technologies and sciences that underpin our understanding of the Nature to deliver a sustainable environmental future and economic growth. In the Department of Environmental Research the main focus is directed towards investigations of chemical composition of non-refractory submicron aerosol particles using mass-spectrometry methods as well as to processes that control aerosol formation and evolution. We are also interested in the impact of changing atmospheric composition on air quality, human health, climate change and ecosystems. By conducting the fundamental and applied research, we are trying to find long-term solutions, especially in experimental techniques devoted to aerosol studies, with the ultimate goal of promoting development towards modern environmentally-friendly technologies based on radionuclide methods which are suitable in the environmental science technologies in general and may be applied in the vicinity of facilities in particular.

Objectives: To develop and improve principles, means and technologies of the environment quality evaluation and to ensure the scientific competence in the fields of environmental physics and chemistry, environment contamination and climate changes.

Tasks:

i) Development of technologies and equipment for the environment protection quality control as well as methods and experimental basis in the environmental research, investigation of micro-admixture dynamics and balance in the environment components and characterization of the impact of environment contamination on climate change.

ii) Evaluation of efficient instrumentation and assessment of methods suitable for characterization of the impact of industry, transport and consumer sectors on the environment quality. The Department is especially interested in combining of spectrometric methods in evaluating the aerosol particle mass and sizes as well as in investigations of physical-chemical aspects of the aerosol particle formation.

Argon offline-AMS source apportionment of organic aerosol

The offline application of aerosol mass spectrometry entailing the analysis of nebulized water extracted filter samples (offline-AMS) increases the spatial coverage accessible to AMS measurements. Particulate matter (PM1) filter samples were collected in Lithuania at three different locations. Aqueous filter extracts were nebulized in Ar, yielding the first AMS measurements of water-soluble atmospheric organic aerosol (WSOA) without interference from air fragments. WSOA spectra were analysed using positive matrix factorization. These factors included biomass burning OA (BBOA), local OA (LOA), and two oxygenated OA (OOA) factors, summer OOA (S-OOA) and background OOA (B-OOA). The contribution of traffic exhaust OA (TEOA) was estimated using a chemical mass balance approach, based on the concentrations of hopanes.

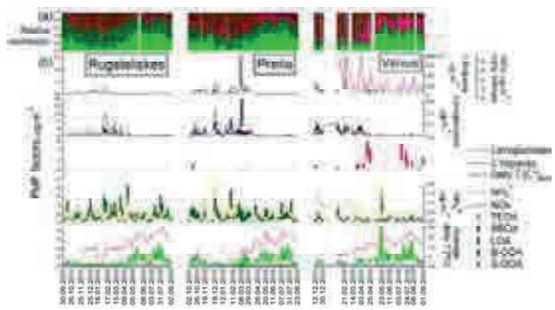


Fig. 1. (a) Temporal evolutions of the relative contributions of the OA factors. (b) The OA sources and corresponding tracers: concentrations and uncertainties (shaded areas).

Characterization of aerosol particles over the south-eastern Baltic Sea region

Studies of aerosol particle number concentration (PNC) level over open sea in the southern and south-eastern Baltic Sea regions were performed during five cruises (2005–2006, 2008–2010) by RV Oceania and at the coastal Preila station (Lithuania). A comparative analysis was performed of aerosol PNC variation at open sea versus measurements taken at the coastal site under various conditions (breaking waves, fog events, new particle formation (NPF)), considering transport of forest fire products and advection of different air mass types to the investigation sites. Breaking waves (BW) under stormy conditions had the strongest effect on the aerosol PNC over the Baltic Sea. The open sea environment may facilitate a more favourable condition for the NPF (with PNC up to 5000–10 000 cm^{-3}), due to exhaust and biogenic emissions from ships and marine environment.

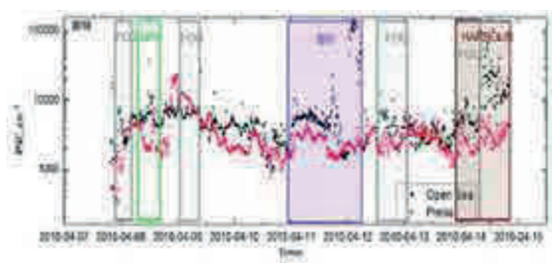


Fig. 2. Course of aerosol PNC in marine boundary layer of the Baltic Sea and at the coastal site. Coloured rectangles indicate various events: green – NPF, violet – BW, grey – fog, brown – harbour area.

Magnetic graphene oxide based nano-composites for removal of radionuclides and metals from contaminated solutions

Magnetic graphene oxide based composites of the nano-particle size of <10 nm were synthesized, characterized and used in sorption experiments. The adsorption of Cs(I), Co(II), Ni(II), Cu(II) and Pb(II) to nano-composites was studied in a wide range of initial concentrations and analysed by Langmuir and Freundlich models. In addition, the effects of pH and coexisting ions on the adsorption of Cs to Prussian blue based composites were investigated. The maximum adsorption capacities of studied elements varied from 29 to 641 mg g^{-1}. The obtained Langmuir and Freundlich constants indicated the dominating physisorption mechanism and favourable adsorption conditions.

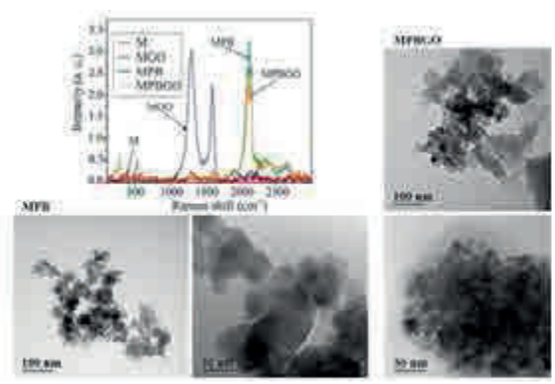


Fig. 3. Raman spectrum and TEM images of magnetic Prussian blue (MPB) and magnetic Prussian blue graphene oxide (MPBGO) composites.

Nuclear

Nuclear research for actual applications today and innovative technologies for future

The Department of Nuclear Research develops and applies known and innovative technologies and methods in the fields of experimental nuclear spectroscopy, nuclear energy safety, radiation protection, radiochemistry, mass spectroscopy, Mössbauer spectroscopy, ion beam analysis and material modification. The keystones of the safety field are the safe operation assurance of nuclear facilities, the optimization of radioactive waste management, the assessment of shielding materials and comprehension of processes of radionuclides transport through engineering barriers to enable nuclear facility safety. The special attention is paid to environmental impact assessment of energy generating facilities, elemental and isotopic analysis of groundwater, food fabrics and products and also industrial stocks, medical samples with sensitivity up to 1 ppq (for non-interfered isotopes). Application of stable isotope ratio analysis ($\delta^{13}C$, $\delta^{15}N$, $\delta^{18}O$ and $\delta^{34}S$) in environmental, biomedical and food samples stimulates new promising technologies. The ^{14}C measurements open the potentially new field of activity related to carbon dating and analysis of triple carbon ratio for dedicated samples. Complimentary information on material properties (magnetic properties, oxidation and corrosion of iron compounds) is determined by Mössbauer spectroscopy. Development of ion beam methods for material analysis and modification is important part of our activities having intersection both with semiconductor materials and applications for lasers. Investigation of organic scintillator films opens new possibilities of simple scintillator material application for detection and spectroscopy of ionizing radiation particles. In search of future practical applications, the high energy electromagnetic radiation generation is investigated using ultrashort laser pulses.

Advanced technology to detect tiny changes of ^{14}C concentrations in the environmental samples

We demonstrated using modern accelerator mass spectrometry (AMS) technique that the tiny changes of ^{14}C concentrations in the environmental samples can be detected due to the historical global fallout (nuclear tests) or local ^{14}C discharges from operating nuclear facilities, in our particular case the Ignalina NPP. The annual ^{14}C variations in pine tree rings for the period of 1955–2015 were analysed, and the time frame from 1983 to 2015 was studied in more detail, in order to take into account the stages of the Ignalina NPP operation and decommissioning. According to the measured ^{14}C excess, the time span was divided into the three periods: I – operation with minor maintenance activities (1983–1997, ^{14}C concentration average of 3 pMC); II – operation with enhanced maintenance activities up to the final shutdown of both Units (1998–2009, ^{14}C concentration average of 7 pMC); III – plant post-shutdown operation with ongoing decommissioning activities (2010–2015, ^{14}C concentration of 3-7 pMC). It has been demonstrated, that the maintenance and radioactive waste management activities at NPPs can be a considerable source of $^{14}CO_2$ airborne releases.

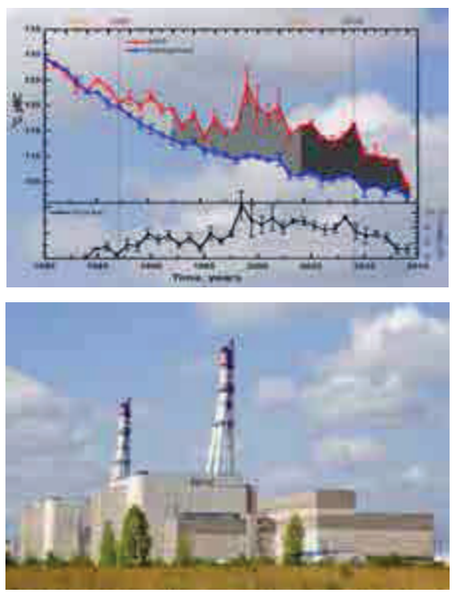


Fig. 1. Changes of ^{14}C concentrations in the environmental samples due to the global fallout and local ^{14}C discharges from INPP.

Advanced technologies for radioactive waste characterization

Identification of the most significant radionuclides in irradiated graphite and use of nuclide vector for characterization was developed based on MCNP6 and SCALE6.2 3D modeling and experimental measurements. The ^{14}C, ^{134}Cs, ^{137}Cs, ^{36}Cl, ^{154}Eu, and ^{60}Co in Ignalina NPP Unit 1 graphite have been analysed. The sufficient correlation (>0.5) with the gamma emitter ^{60}Co was obtained for different nuclides (^{134}Cs, ^{137}Cs, ^{36}Cl, ^{154}Eu) except for ^{14}C, for which the experimental determination should be performed. Obtained results are important for decommissioning of NPPs with graphite-moderated reactors.

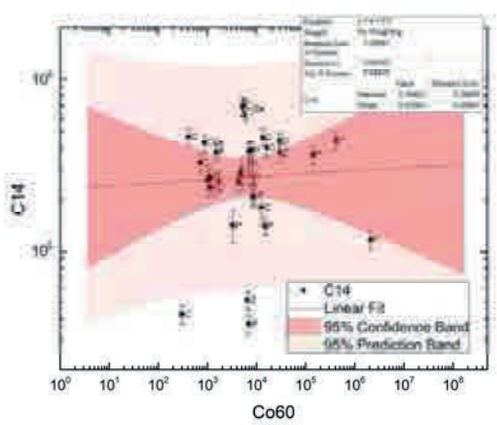


Fig. 2. The measured values of ^{14}C versus ^{60}Co in the graphite samples.

Separation of ionizing radiation by using organic scintillators

The novel method for separating particles of ionizing radiation was applied for organic scintillators. A thin polyethylene naphthalate (PEN) film was used to separate α (5.49 MeV) and β (up to 2.2 MeV) particles coming from ^{238}Pu and ^{90}Sr+^{90}Y sources, respectively. Acquired photomultiplier pulses were analyzed by the long tail method based on the delayed fluorescence intensity dependence on the mass and charge of particles absorbed. For determination of the separation quality, the figure of merit (FOM), based on the ratio of short and long tails, was used. It was found that due to high FOM values of α/β separation, the thin PEN film is suitable for separation of the ionizing radiation particles.

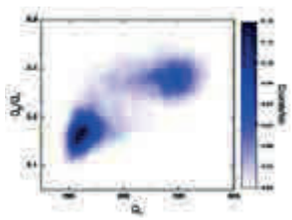


Fig. 3. Delayed fluorescence and total integrals ratio (Q_D/Q_T) versus the total integral (Q_T) for alpha and beta irradiation of the 125 μm PEN sample.

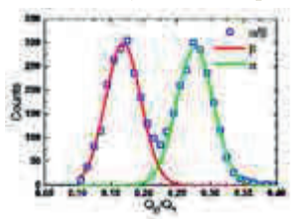


Fig. 4. The quality of discrimination of α and β particles using the PEN detector. The obtained FOM=0.85±0.02.

Mass spectrometry for new applications

Stable isotope ratio mass spectrometry (IRMS) was applied to quantify the sources of organic aerosol in the atmosphere and improve the well-being of animals in the farms. The IRMS was used to investigate the main sources of organic carbon and the effects of photochemical processing on atmospheric aerosol. The isotopic composition of the aerosol was used to differentiate between the two main sources of organic aerosol in winter, biomass burning and fossil fuel combustion.

Stable isotope analysis was applied to describe the poultry house environment. The study of isotope fractionation between microorganisms and their media indicated the applicability of stable isotope analysis in bulk samples for the identification of the source material. The analysed examples imply that stable isotope analysis can be used to examine the indoor environment along with its biology and ecology, and serve as an informative bioanalytical tool.

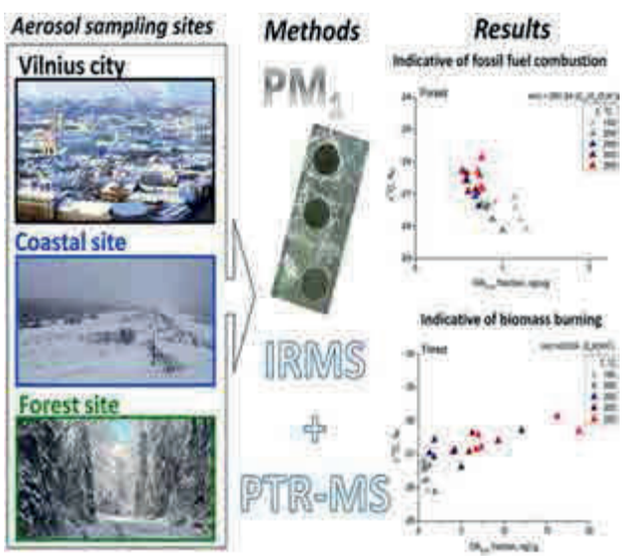


Fig. 5. The sources of organic carbon and the effects of photochemical processing on atmospheric aerosol.

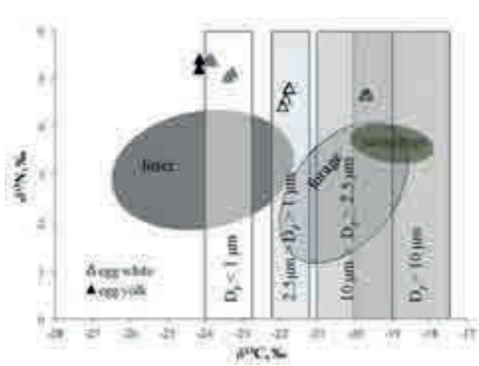
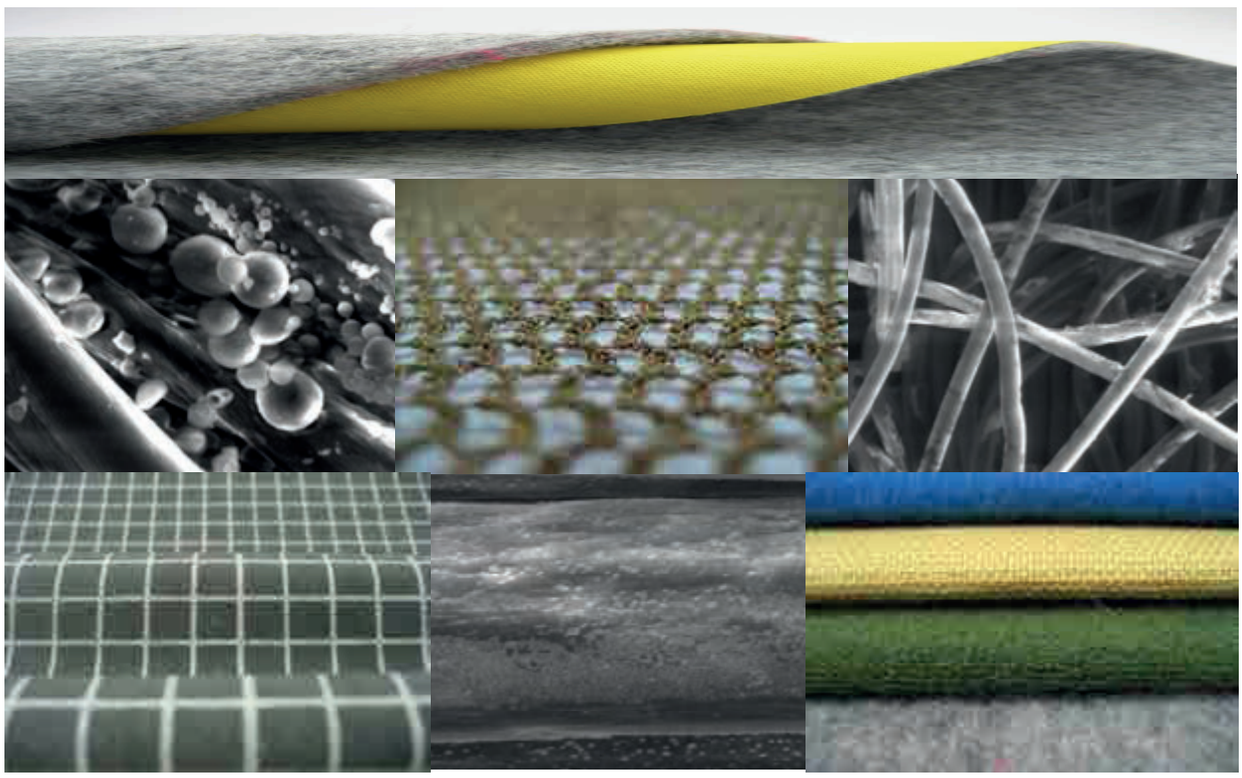


Fig. 6. Stable isotope analysis of poultry house environment.

Textile technologies



Advanced textiles

The researchers of the Textile Institute of FTMC are performing investigations in the field of textile materials functionalization using low temperature plasma treatment, micro- and nano-finishing, electro-conductive polymers coating and in some other fields of research, including numerical modeling. They are looking for modern solutions in the field of smart functional coatings and protective armoured vests and develop protective and bio-composite technologies.

The Institute also offers a wide range of services:

– testing of textile materials in accredited laboratory and certification of protective clothing at notified body,
– examination of quality of textile materials,
– prototyping of woven and knitted fabrics and garments and applied research for industry.

An important trend of research is the development of smart and e-textiles for both commercial and defence applications, including enhanced ballistic protection and electromagnetic radiation shielding. The participation in NATO S&T organization SET panel working group – SET-ET-096 on “Smart Textiles, Wearables and Sensors for the Integration of Soldier System Capabilities” facilitates the progress in this field.

Nowadays the Institute started to focus on strengthening new competencies of research in the fields of interdisciplinary textile technologies, materials science, physics, informatics and electronics. This has to open new opportunities for the development of advanced textiles, promising materials for future consumers. The Textile Institute is a place of fresh ideas, innovative minds and successful solutions.

BioPCM Microcapsules for smart textile and their thermal conductivity enhancement

The capability of phase change material (PCM) to absorb heat, while temperature is increasing, and to release it into the environment, while temperature is decreasing, is defined as the latent heat (LH) of material. The value of LH depends on the chemical nature of PCM. For textile applications, the most commonly used PCM is the petroleum-based paraffinic PCM characterized by relatively high LH. However, its broad application is limited due to high flammability and low thermal conductivity. In our research, as an alternative to paraffinic PCM, a biological nature PCMs (BioPCMs) are investigated. They consist of some saturated fatty acids and their eutectic mixtures are characterized by lower flammability, lightness and lower (compared to paraffin's), but sufficient LH. Nowadays, to improve thermoregulation properties of the textile, harmful for environment and human health melamine-formaldehyde microcapsules are commonly used. Therefore we apply biobased polyesters as the shell-forming polymer. The BioPCM was loaded into the biopolymer shell using solvent evaporation method. Morphology and size distribution of created biopolymers/BioPCM microcapsules were characterized by optical microscopy. The encapsulation effectiveness was also calculated and confirmed by Fourier transform infrared analysis. Furthermore, the LH capacities of synthesized BioPCM microcapsules were determined by differential scanning colorimetry technique and compared with those of used pure saturated acids. To improve thermal conductivity of BioPCM microcapsules, we plan to use some nanostructured additives.

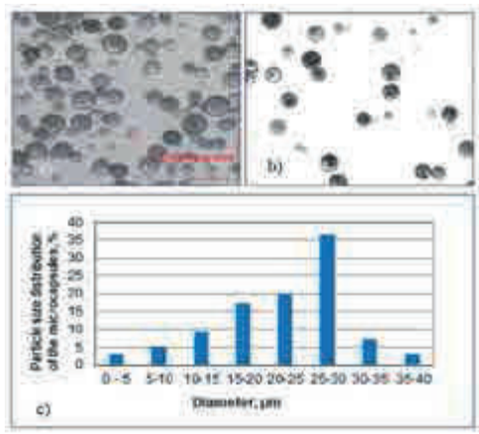


Fig.1. Characterization of created BioPCM microcapsules by (a), (b) optical micrographs and (c) size distribution.

Development of moisture management textile fabrics

The most important functional purpose of the textile fabric, used for the high physical activity products and worn in touch with the skin, is to ensure wearing comfort while creating and maintaining a constant and pleasant microclimate at the skin surface independently of the environmental conditions. One of the most important thermoregulation properties is the ability of the clothing to transfer the collected moisture (perspiration) from the skin surface to the outer layers of the garment. Double layer weft knitted fabrics, characterised by high moisture management outwards, were developed by using new generation functional raw materials, selecting a target pattern and various geometrical parameter combinations of hydrophobic and hydrophilic fibers in individual layers. Developed knitted fabrics have good moisture transporting properties from the body to the outside and good surface resistance to fuzzing and pilling. The overall moisture management capability (OMMC) of the fabric is either of good or very good level. Achieved moisture management properties of new developed knitted fabrics are described in the obtained patent No. 6364 specification "Double layer moisture management knitted fabric" of the State Patent Bureau (SPB) of the Republic of Lithuania.

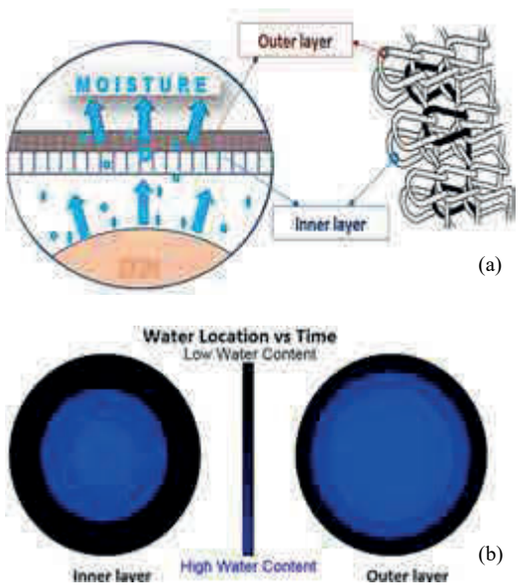
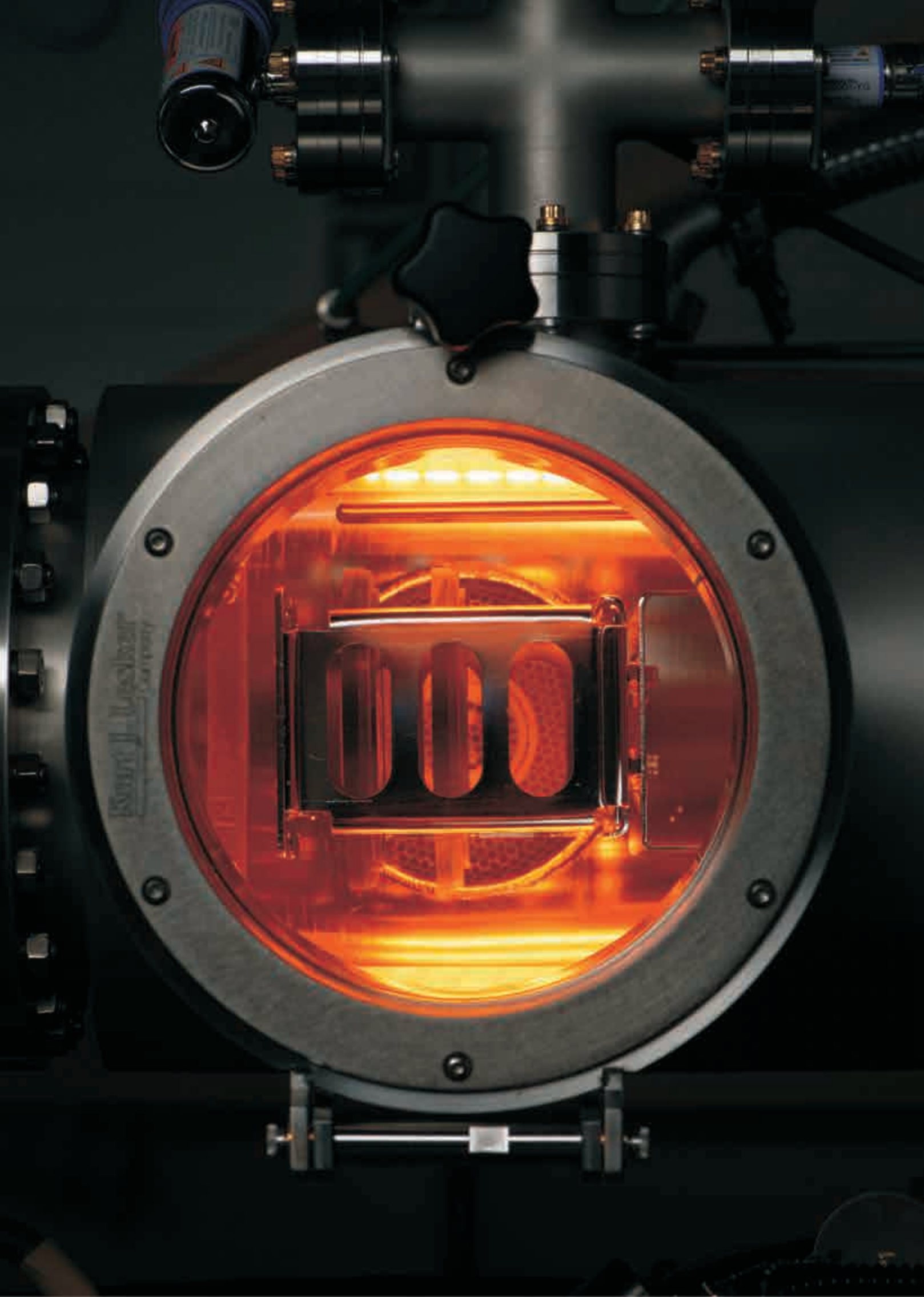
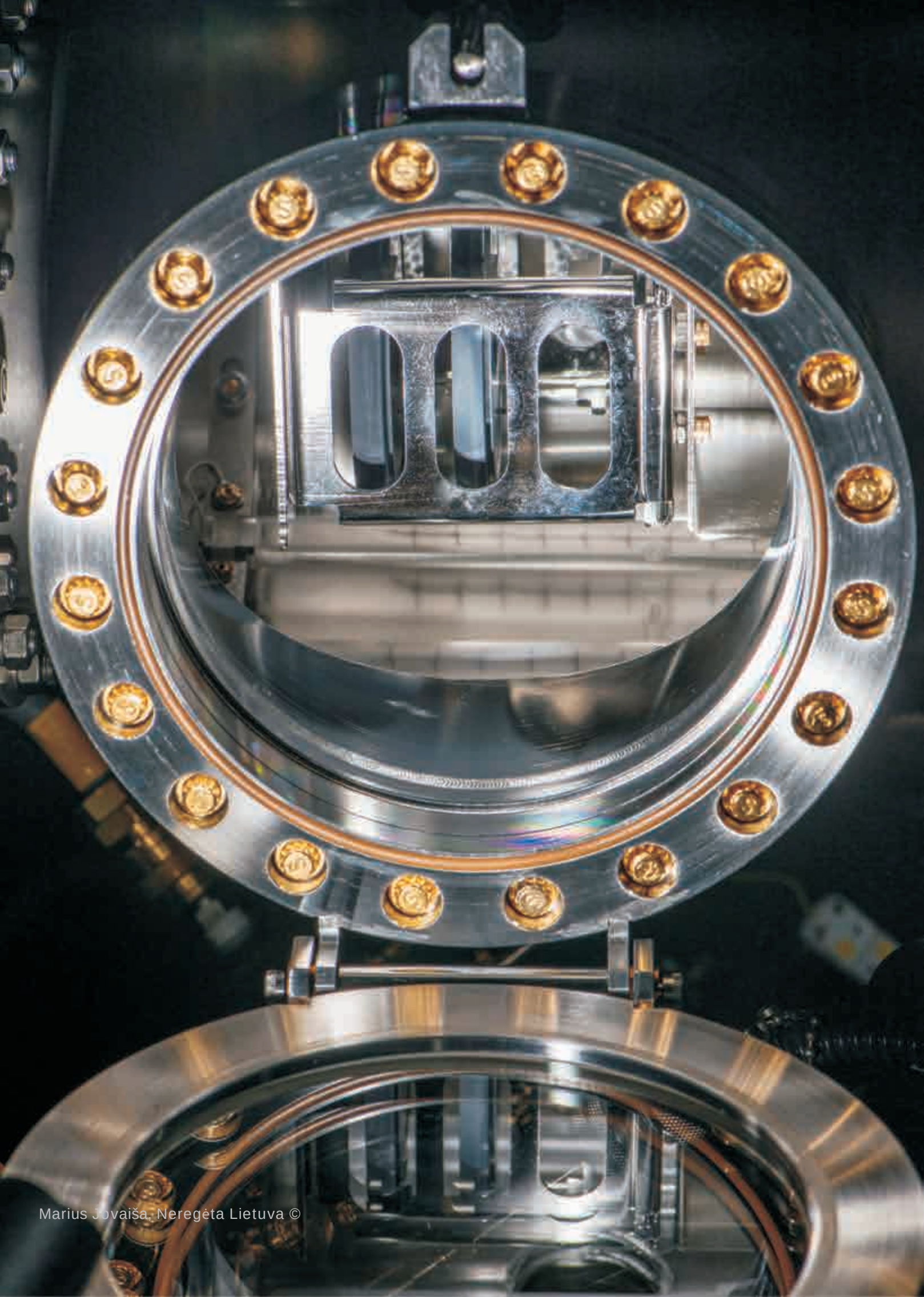
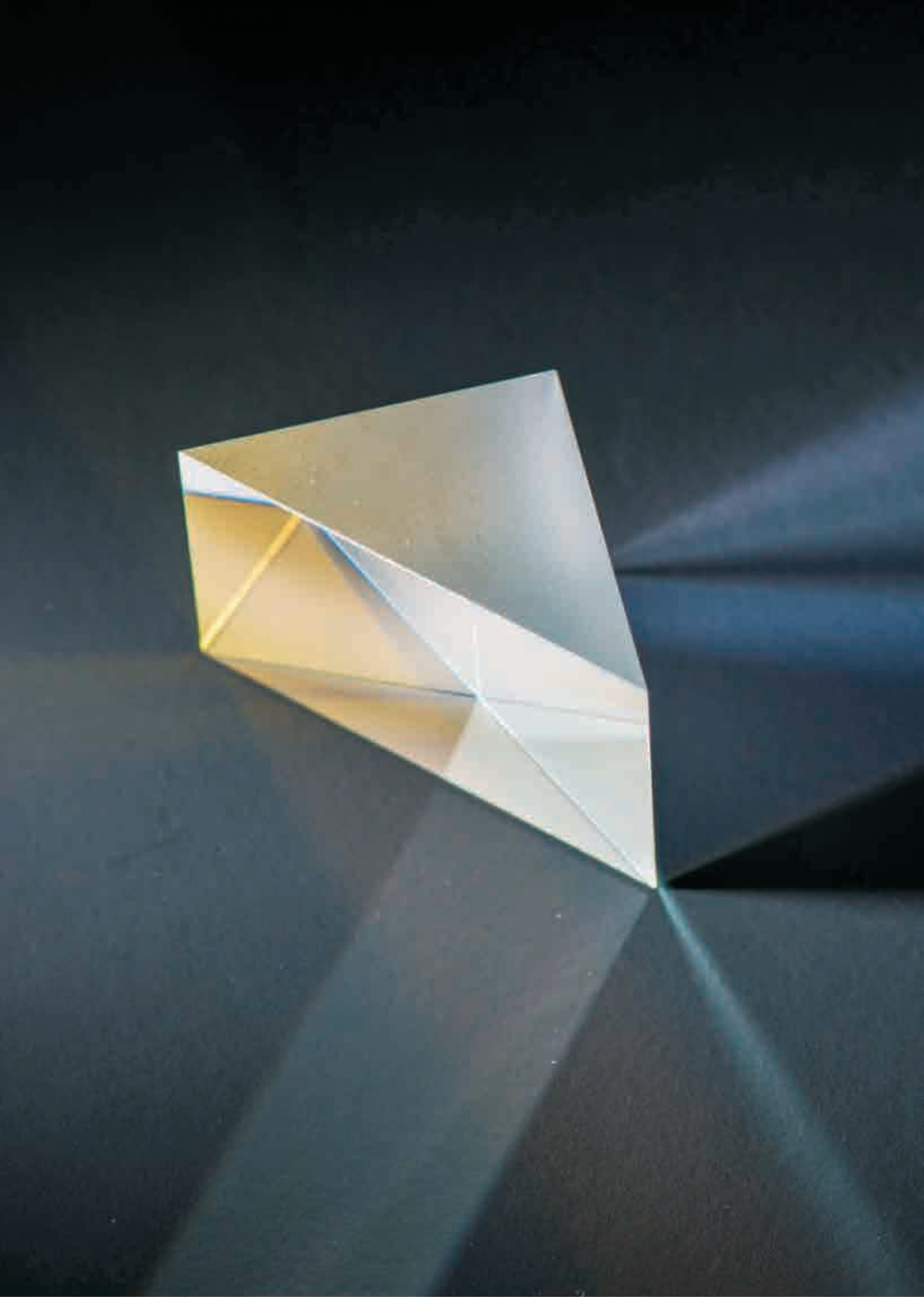


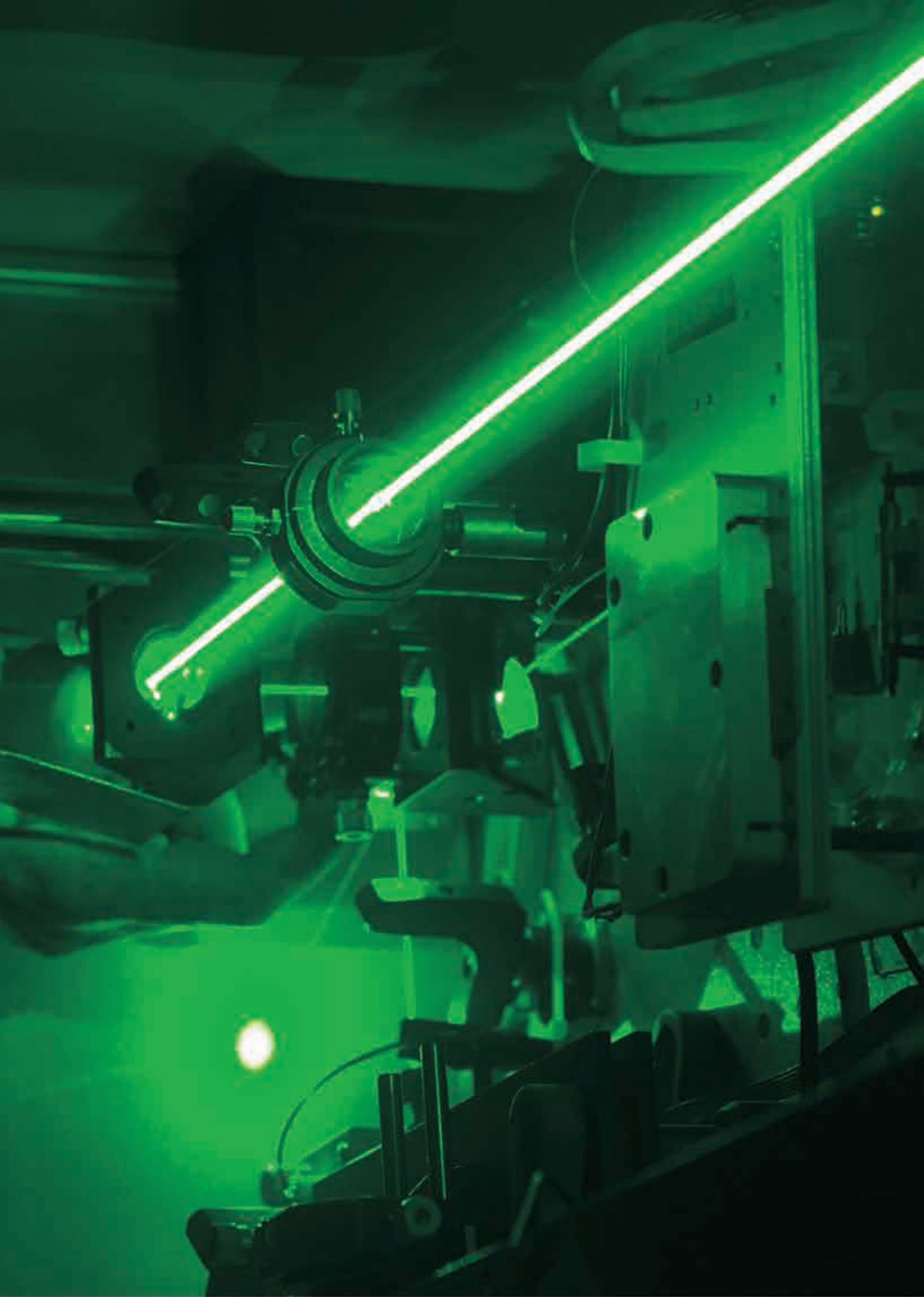
Fig.2. (a) Principal scheme of moisture transporting from the body to outside through two layer knitted fabric. (b) Final spread location of liquid water content on the "moisture management" fabrics inner and outer surfaces with very good OMMC (MMT 290, AATCC 195–2012).





Marius Jovaiša, Neregėta Lietuva ©





Projects

7th Framework programme project
"Hub of Application Laboratories for Equipment Assessment in Laser Based Manufacturing" (APPOLO)

G. Račiukaitis

7th Framework programme project
"Novel Type of Terahertz Devices"

A. Krotkus

Research Executive Agency (REA), delegated by the European Commission project "Camelina&crambe Oil Crops as Sources for Medium-chain Oils for Specialty Oleochemicals" (COSMOS)

S. Asadauskas

Research Executive Agency (REA), delegated by the European Commission project "Energy losses in nitride light-emitting diodes" (NITRIDE-SRH)

A. Alkauskas

European Commision European Atomic Energy Community (Euratom) project "Baltic Region Initiative for Long Lasting Innovative Nuclear Technologies" (BRILLIANT)

L. Juodis

European Space Agency (ESA) project
"Bismides for Infrared photodetector" (BIRD)

A. Krotkus

Horizon 2020 programme project
“PHotonics enhanced fAB LABS supporting the next revolution in digitalization“ (PHABLABS)

S. Orlovas

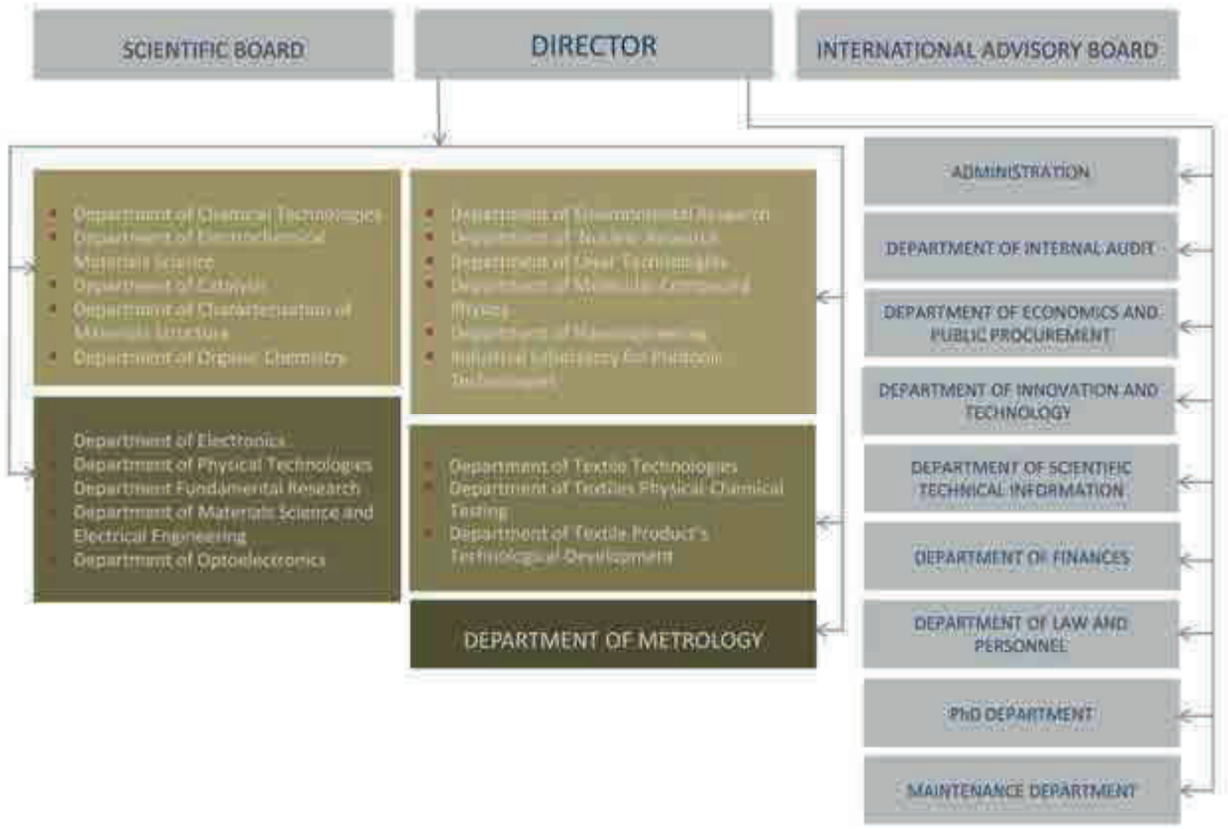
Research Executive Agency (REA), delegated by the European Commission project "Graphene-Manganite nanostructures for novel pulsed magnetic field sensors" (GRAMAS)

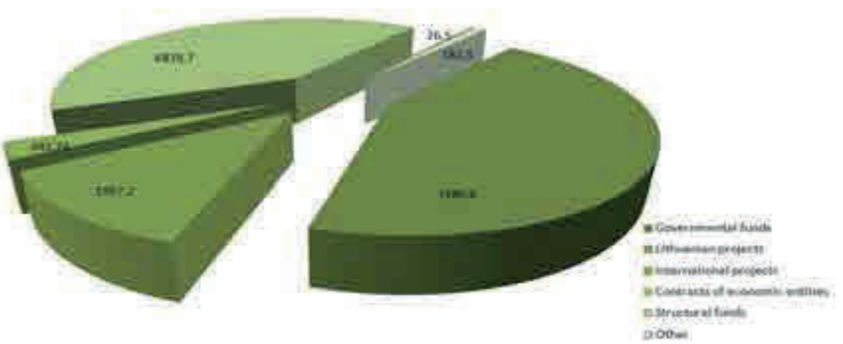
R.Lukošė

European Space Agency (ESA) project
"IntraRed Bismuth-based Sources" (IRBIS)

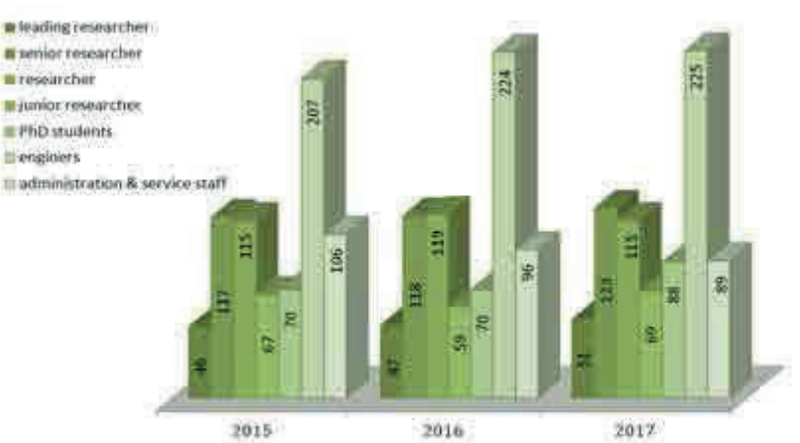
R.Butkutė

Structure and statistics





Budget of FTMC 2017, kEur



Staff dynamics

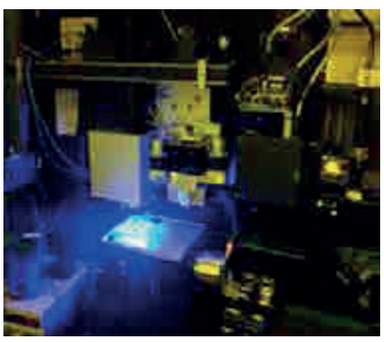
Open access centers

OAC for electron microscopy, X-ray diffractometry and spectrometry

has well developed infrastructure and experienced staff for the characterisation of solid materials using SEM, SEM-FIB, TEM, EDX, XRD, HRXRD, WDXRF, XPS techniques.

Available equipment:

Scanning electron microscopes: Helios Nanolab 650, EVO-50;
Transmission electron microscope Tecnai G2 F20 X-TWIN;
X-ray diffractometers: SmartLab (Rigaku), D8 Advance (Bruker);
X-ray fluorescence spectrometer (WDXRF) Axios mAX (Panalytical);
X-ray photoelectron spectrometer ESCALAB-MKII;
Carbon and sulphur analyser CS-2000.



OAC of processing technologies BALTFAB

is a joint open user facility between Laser technologies and Nano-engineering departments, offering a full range of nano/micro and macro fabrication as well as laser patterning, marking and cutting on any required material. State of the art Laser-fab is equipped with full variety of industrial ns, ps and fs lasers. The team is experts to set-up, test and develop laser micro-machining processes and systems. Soft nano-lithography tools for rapid creation of nano-structures are tested to be live cell compatible. The patterns are routinely applied to improve the bio-compatibility of medical devices. The team is developing tools for detection of molecules on surfaces, to fasten the testing and evaluation of cells or drugs. More: see www.baltfab.com

Services: 1) Laser processing: in-Glass marking; laser beam interference ablation; laser direct writing; ultrashort pulse laser ablation. 2) Molecular: dip pen nanolithography; microcontact printing; piezoelectric inkjet printing; colloidal nanolithography. 3) Analytical: bio AFM; electrochemical sensors; imaging surface plasmon ellipsometry.

Available equipment:

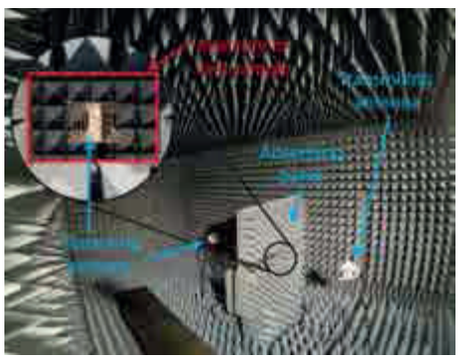
Ultra short pulse Laser stations for rent and user training services.
Dip pen nanolithography and imaging ellipsometry for creating and imaging of molecular surfaces.

OAC for converse and chemical coatings

specializes in aluminum and its alloys anodation, galvanic precious metals plating and related fields. The services provided: electrodeposition of protective, decorative as well as technical converse (anodic) coatings, structural etching of decoration elements, adsorption coloring of anodized surfaces, modification of aluminum and its alloys surfaces with a passivation film that provides the required conductivity, protection and other properties, chemical deposition of passivation coatings onto alloy steels.

Available equipment:

Experimental equipment for environment-friendly galvanic processes, anodizing line.
Chemical passivation line for chromium-free passivation process of aluminium and its alloys, IRIDITE NCP.



Setup for microwave signal transmission, reflection and absorption in an anechoic chamber.

Microwave transmission, reflection and absorption

In a new microwave anechoic chamber of the Center for Physicals Sciences and Technology we developed a setup for microwave transmission and reflection measurement in a frequency range from 1 GHz to 18 GHz. Configuration of the measurement setup with transmitting and receiving antennas is shown in Fig. 2. Measured sample is placed in the aperture of the absorbing panel. Using this technique it is possible to measure microwave properties of various modern materials: windowpanes, absorbing textiles, shielding materials, etc.

OAC for prototype formation and integration

Clean room technology for prototyping of semiconductor based devices

Based on collaboration between the Departments for Physical Technologies and Optoelectronics, a complete cycle of the clean room (CR) microfabrication line (see Fig. 1a) has started to function which is acceptable to produce the working models and the demonstration prototypes of chemical and photo-sensitive devices as single units and as limited batches of products. The prototyping of innovative devices is based on a few key enabling technologies including the PECVD/CVD for synthesis of 2D materials, namely graphene and MoS2, multimode magnetron sputtering for deposition of multicomponent functional films and molecule beam epitaxy for GaAs based optoelectronic devices.

The CR services include the following: 1) CR (ISO7–ISO5 about 300 m^2) operations, 2) photolithography, 3) laser lithography, 4) wet chemical processing, 5) thermal processing, 6) metal and oxide coatings, 7) assemblage and testing.

Characterisation and testing of prototypes

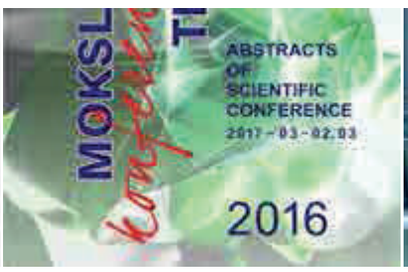
The R&D projects in the OAC for prototype formation and integration can range from proof of concepts (TRL – Technological Readiness Level- 3), validation of technologies in laboratory (TRL 4) or relevant environment (TRL 5), and up to demonstration in relevant environment (TRL 6). In specific cases the collaboration can reach prototyping in operational environment (TRL 7). We use the methods acceptable to characterize the components and devices at the nanometer scale level and at the level of complete unit.

The characterization includes: 1) topography, force spectroscopy, tunneling current spectroscopy by scanning probe microscopy, 2) standard I-V and C-V characteristics in the dc- and ac-modes by the probe station, 3) photovoltaic parameters with the A1.5 solar source by special set-up, 4) gas response in the synthetic atmosphere under strictly controlled conditions by gas flow control system. We also carry out special set of tests to determine the response and resistivity to the microwave irradiation.

Events

ANNUAL FTMC CONFERENCE

/2017 03 1–2/

Reports on development of Long-Term Programs of scientific research and experimental development have been presented by the program leaders. Invited talks were given on the most interesting results obtained in 2017. G. Valušis, the Director of FTMC, presented his annual report mentioning the achievements of the year and nominating best scientists.

ENVIRA 2017

/2017 05 29–06 02/

The International Conference on Environmental Radioactivity organized by the Center for Physical Sciences and Technology in Vilnius, from May 29 to June 2, 2017. Conference topics of the ENVIRA 2017 were focus on "Radionuclides as Tracers of Environmental Processes".

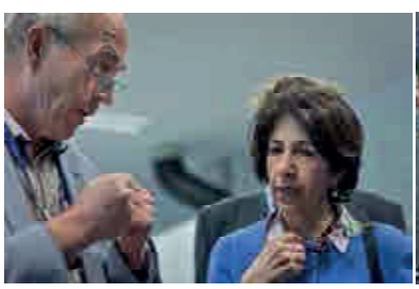
VISIT OF MEMBERS OF LITHUANIAN PARLIAMENT

/2017 06 07/

A numerous delegation of Lithuanian MPs visited FTMC. The director of FTMC acquainted the guests with the activities of the Center and discussed the problems of development of scientific institutions.

THE VISIT OF CERN DIRECTOR

/2017 06 27/


The CERN director Dr. Fabiola Gianotti visited FTMC. For many years working in the field of particle physics, she was interested in on-going reseach activities of our Center. In her talk she emphasized the importance of physical and nature sciences and necessity of young well-prepared specialists in these fields.

“APPOLO” SUMMER SCHOOL

/2017 07 3–7/



The APPOLO Summer School on Ultra-short Pulse Lasers Applications in Material Processing (UPLAMP), organized by FTMC took place in our Center and Laser and Engineering Technologies Cluster. The 23 Students from Lithuania, Switzerland, Germany, Greece, France, Ukraine and Russia participated at the Summer School. Lectures were presented by invited speakers and APPOLO partners. The students presented their experiments in various ultra-short pulse lasers applications during oral talks and poster presentations. All summer school participants visited Lithuanian laser companies “Light Conversion”, “Ekspla”, “ELAS” and laboratories of the Department of Laser Technologies, FTMC. Following the success of this school, the APPOLO Summer School will be organized again - in July, 2019.

LITHUANIAN NATIONAL CONFERENCE OF PHYSICS

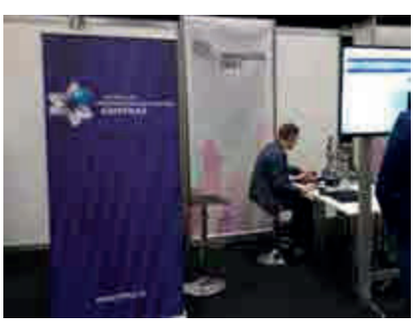
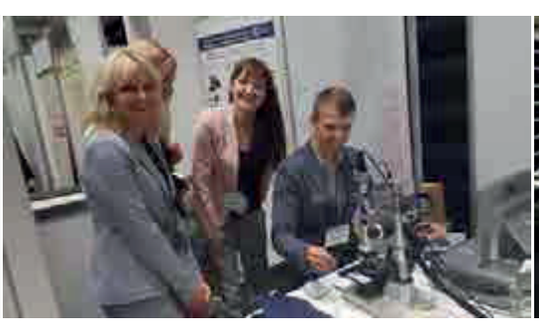
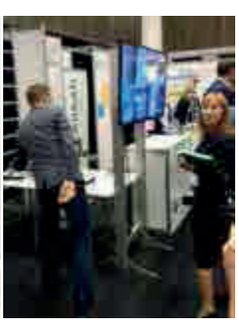
/2017 10 4-6/

Lietuvos Nacionalinė Fizikos Konferencija

The center co-organized the 42-nd Lithuanian National Conference of Physics. This traditional biannual event is an important meeting of Lithuanian physicists working in Lithuania and abroad as well as the researchers from physics-related fields, physics teachers and all interested in new trends of physics. This year the lectures were given by the the laureates of the Lithuanian Science prize and the Science prize awarded to researchers of Lithuanian origin living abroad, as well as other well-known physicists. More than 300 works have been presented at the conference (see: www.lnfk42.vu.lt)

INNOVATION DRIFT

/2017 10 12/

The R&D activities of FTMC were introduced in the largest in the Baltic States innovation forum „Innovation Drift“ in Vilnius. The forum is devoted to future challenges to communities, technologies and cities and discuss the state of innovation in Europe.

DAY OF PHOTONICS AT FTMC

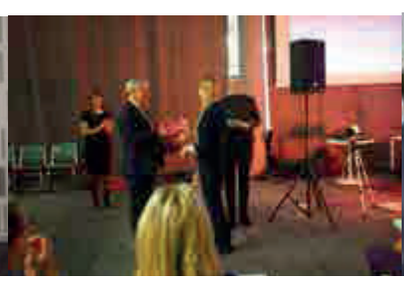
/2017 10 18/



The day of Photonics was commemorated at the new building of FTMC. The program of the day comprised the lecture of Dr. Pranciškus Vitta „The raving of light photons: from the radish shape to the change of mood“, the concert of intelectual rock group „Garbanotas Bosistas“ and the lazer show in the Science square.

7TH FTMC CONFERENCE FOR DOCTORANTS AND YOUNG SCIENTISTS

/2017 10 24–25/


Young scientists and doctorants presented their research in physics, chemistry, material science and engineering. One of the sessions was devoted to the meeting of conference participants with the director of FTMC Gintaras Valušis. Young researchers had the opportunity to discuss their studies and receive the opinion of senior colleagues on a broad spectrum of actual problems.

VISIT WITH A NARRATIVE

/2017 12 01/

The FTMC was visited by Professor Robert J. Shiller (Yale University, USA), the Nobel Prize winner in economy (2013) and a member of the International Advisory Committee of the Center. After visiting some of the laboratories Prof. Shiller had a discussion on marketing and commercialization of new research results with the administration of the Center. Later that day he gave a highly attended lecture ”Narrative Economics and Neuroeconomics” for the scientific community of the Saulėtekis campus

FINAL MEETING OF “APPOLO” PROJECT

/ 2017 12 21-22/

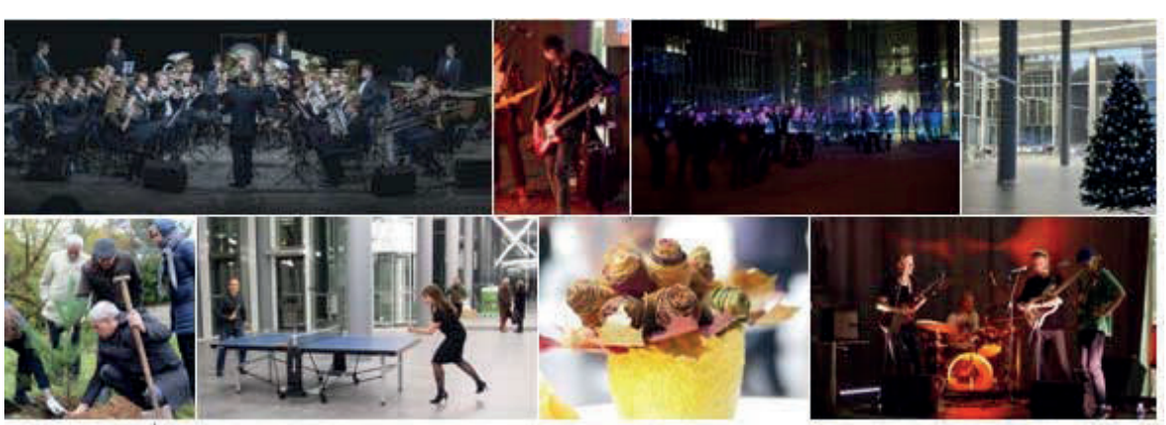
The final review meeting for the FP7 project – APPOLO with attendance of the majority of the 36 project partners was organised in FTMC. The results of project activities and exploitation plans were presented to the reviewers. The main outcome

of the project – five project partners (FTMC, BUAS, UPM, IOM and Engage) signed the APPOLO HUB (www.appolohub.eu) agreement which sustains activities of laser application laboratories network and provides the laser micromachining assessment services for industry partners after the end of the project. The HUB agreement is open for new partners from research and associated partners – laser system integrators. The network already gained interest from European research institutions outside the APPOLO consortium. The APPOLO project got a positive feedback from the reviewers. Some APPOLO activities like APPOLO HUB network and APPOLO Summer School will be continued after the project.

SAULĖTEKIS SEMICONDUCTORS PHYSICS SEMINARS

When in early 2016 the FTMC moved to its new Saulėtekis campus, it found itself in close proximity to the Physics Faculty of Vilnius University. Semiconductor physics research in both institutions was a top priority and nearly all of Lithuania's semiconductor research were collected together. It therefore made a perfect sense to start organizing all-campus Saulėtekis semiconductor physics seminars, in which our Center took an initiative. The purpose of the seminar is to provide a platform to discuss the research in semiconductor physics, its newest developments and outstanding problems. At the same time, it is a venue for education in semiconductor physics research, its application and commercialization. Thus, the seminars cover both fundamental and applied aspects. Semiconductor physics seminars are attended by master and PhD students, early-stage researchers, as well as senior scientists. In 2017, the second year in the Saulėtekis campus, more than 20 seminars were held. We were happy to host world-class scientists such as Prof. Sajeev John (University of Toronto, Canada), Prof. Agnieszka Zalewska (Jagellonian University of Krakow, Poland), Prof. Fedor Jelezko (University of Ulm, Germanay), Prof. Adam Gali (Wigner Research Center, Hungary) or Prof. Eddy Simoen (University of Ghent, Belgium). We are particularly keen inviting Lithuanians from abroad to give talks at our seminars, and in 2017 we had pleasure to hear talks from Dr. Vytautas Astromskas (Lancaster University, UK), Dr. Julius Janušonis (University of Groningen, Netherlands), as well as Dr. Gabija Kiršanskė (University of Copenhagen, Denmark). The seminar is supported by „Brolis Semiconductors" (one of the initiators of the seminar) and the „Young Minds" project of the European Physical Society.

LEISURE LABORATORY



Awards

Mindaugas Dagys and Žilvinas Kancleris
– For lifetime achievements

Žilvinas Kancleris, graduate of Vilnius University, studied warm electron phenomenon in semiconductors. He investigated electron-electron interaction, developed special Monte Carlo method for calculation of parameters of slightly heated electron gas, and used numerical methods to study microwave scattering by semiconductors. Mindaugas Dagys, graduate of Vilnius Technical University, was more into applied research developing special resistive sensors for high power microwave (HPM) pulse measurement. Mindaugas and Žilvinas developed various designs of resistive sensors which were manufactured and provided to customers worldwide. Semiconductor Physics Institute, which later became the part of FTMC, was the only place, where they worked for almost 50 years.

Gediminas Račiukaitis
– For scientific achievements

Recent excellent achievements of Gediminas group in materials processing extended widely the application areas of laser technologies. Coherent work of young and enthusiastic team enabled to provide a new level of scientific investigation and complete successfully the EC sponsored project “Hub of Application Laboratories for Equipment Assessment in Laser Based Manufacturing“ (Appolo).

Ramūnas Valiokas – For innovations

Interdisciplinary research of Ramūnas team has opened a novel avenue to convert obtained results into high-added value products and their further development in founder companies “Ferentis” and “Erumpo”.

Rimgaudas Žaliauskas
– For the scientifically invisible activity

For the remarkable work completing the transfer of the FTMC from A. Goštauto street to Saulėtekis avenue and for the notable contribution in alignment of all operating systems in the new building of the Center.

Linas Minkevičius - Debut of the year

The award for the best Lithuanian PhD thesis 2016 in Physics, Technology, Biomedicine and Agriculture sciences. This is how Linas decribed the secret of success of his thesis "Terahertz imaging arrays for room temperature operation": "This is a wonderful appreciation of my efforts. I developed the theme of my work from my bachelor studies and now I can name its three main ingredients: persistent work, excellent supervisor, prof. Vincas Tamošiūnas, and our Center which provided me with all needed scientific infrastructure."

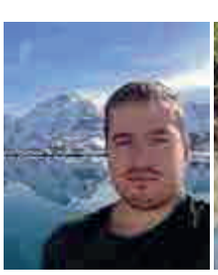
Marius Franckevičius - Debut of the Year

M. Franckevičius leads investigations of perovskites and development of perovskite-based optoelectical devices in the Center. He gained experience in this field during his internship in Swiss Federal Institute of Technology. His research interests include application of perovskites for solar cells and photodetectors. Major experimental techniques, which he uses for investigations, are time-resolved fluorescence and various steady-state and time-resolved photoelectrical measurements. Marius is the coauthor of 21 publications cited more than 400 times.

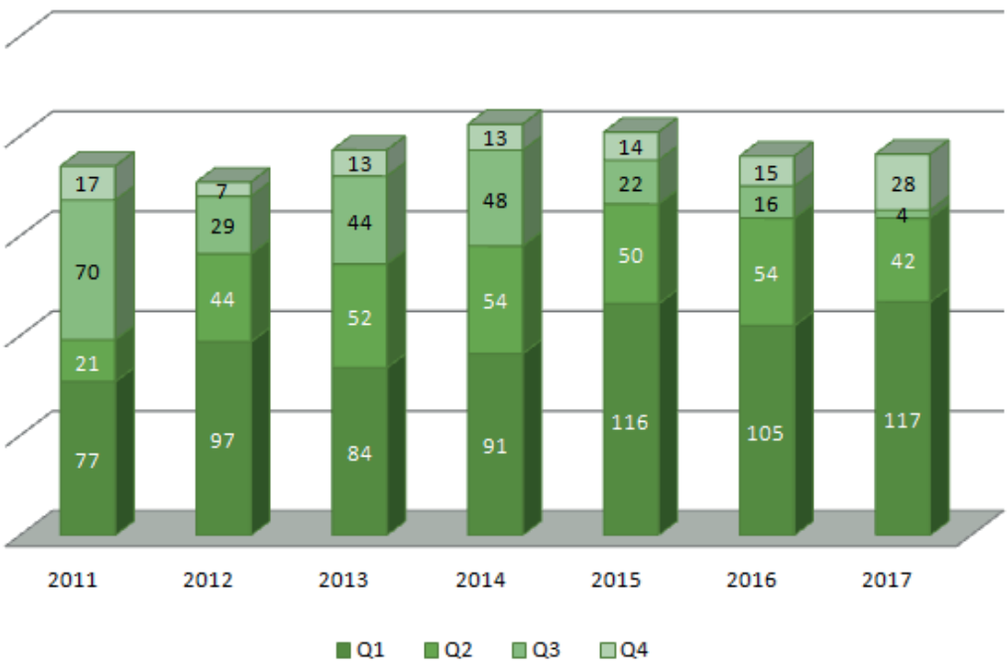
Jonas Berzinš and Vytautas Butkus - Special Center Award

for transforming Open Readings conference into global phenomenon

This year Open Readings conference was extremely impressive. Due to the efforts of its main organizers, Vytautas and Jonas, we had the opportunity to follow the presentations of the Nobel prize winner chemist Ben Feringa, the expert in genetic engineering Robin Lovell-Badge, nanotechnologist Naomi Halas and outstanding physicists: Michael Gratzel, John Ellis, Eugenio Coccia, Xi-Cheng Zhang and Phillip Russel.



Publications



Publications with FTMC affilations in 2017 in top quartile (Q1) journals

1. Chernyakova, K.; Karpič, R.; Zavadski, S.; Poklonskaya, O.; Jagminas, A.; Vrublevsky, I. Structural and fluorescence characterization of anodic alumina/carbon composites formed in tartaric acid solution // Journal of luminescence. ISSN 0022-2313. Vol. 182 (2017), p. 233-239.
2. Želudevičius, J.; Regelskis, K.; Račiukaitis, G. Experimental demonstration of pulse multiplexing and beam combining of four fiber lasers by noncollinear frequency conversion in an LBO crystal // Optics letters. ISSN 0146-9592. Vol. 42, iss. 2 (2017), p. 175-178.
3. Tamašauskaitė-Tamašiūnaitė, L; Zabielaitė, A.; Balčiūnaitė, A.; Šebeka, B.; Stalnionienė, I.; Buzas, V.; Mačiulis, L.; Tumonis, L.; Norkus, E. Deposition of Pt nanoparticles on Ni foam via galvanic displacement // Journal of the Electrochemical Society. ISSN 0013-4651. Vol. 164, iss.2 (2017), p. D53-D56.
4. Stankevič, V.; Račiukaitis, G.; Bragheri, F.; Wang, X.; Gamaly, E.G.; Osellame, R.; Juodkazis, S. Laser printed nano-gratings: orientation and period peculiarities // Scientific reports. ISSN 2045-2322. Vol. 7 (2017), p. art. no. 39989 [1-8].
5. Gečys, P.; Markauskas, E.; Nishiwaki, Sh.; Buecheler, S.; De Loor, R.; Burn, A.; Romano, V.; Račiukaitis, G. CIGS thin-film solar module processing: case of high-speed laser scribing // Scientific reports. ISSN 2045-2322. Vol. 7 (2017), p. art. no. 40502 [1-9].
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