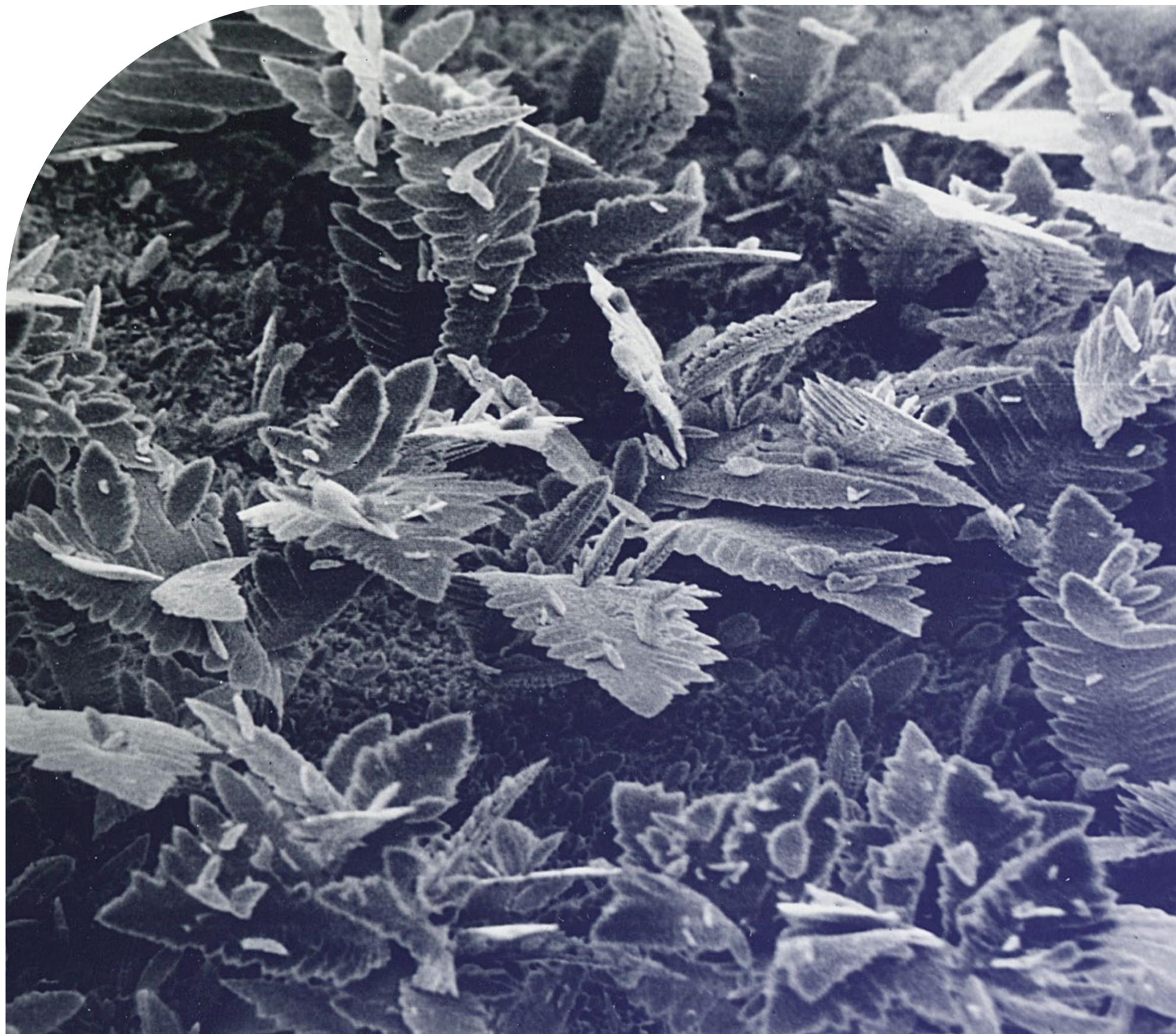




CENTER
FOR PHYSICAL SCIENCES
AND TECHNOLOGY

ANNUAL REPORT 2025



OUR MISSION

To advance science-based innovations and contribute to technological progress that benefit industry, society and national interests

OUR VISION

To shape FTMC the future of science and technology through challenge-based research

FTMC STRATEGIC PRINCIPLE

Challenge-based research and innovation



2025 – A Defining Year for FTMC

The year 2025 marked a pivotal moment for the Center for Physical Sciences and Technology. It was the year when FTMC's institutional strategy was formally approved, five-year strategic objectives were defined, and the 2026 Action Plan was adopted. I sincerely thank the entire FTMC community for their active engagement and meaningful contributions throughout this process. This strategy is not merely a formal document – it is a shared commitment to how we grow and work together as one community.

The approved strategy establishes a clear direction for FTMC, centred on high-impact applied research and innovation, increased international visibility, and collaboration with leading global scientific institutions. A key outcome of this work was the identification of defence and security as a horizontal strategic priority across the Center. In practical terms, this priority builds on and further accelerates our strong progress in microwave technologies, lasers and photonics, and advanced communication systems — areas that are critically important for modern defence and security solutions. In the current global context, this focus provides clarity and coherence for our research activities. Importantly, the strategic framework enabled FTMC to introduce institution-wide annual performance discussions for the first time, aligning organisational units and individuals towards shared objectives. This marks an important cultural shift towards a more coordinated and strategically focused institution.

Alongside strategic planning, 2025 marked the start of structural changes aimed at strengthening support for researchers. The Department of Project Management was established to strengthen support for project development and implementation. The Doctoral School became an integral part of FTMC's institutional structure, ensuring a consistent and high-quality doctoral training environment. In addition, the Department of Science Quality was established to support research excellence and quality assurance. To further strengthen institutional capacity, the Departments of Personnel and Communication and Marketing were also

established. The strengthening of the Department of Personnel and the creation of the Department of Communication and Marketing are particularly important steps towards becoming a more people-centred organisation – one that not only supports researchers administratively, but also invests in their professional growth, well-being, visibility and recognition. These changes are not simply structural adjustments – they are investments in our people, designed to reduce administrative burden on researchers and create an environment where scientific creativity and ambition can flourish.

The year was successful in terms of research and project activities. FTMC continued to expand its national and international project portfolio. In June 2025, the Chip Competence Centre “ChipsC² LT” was launched under the coordination of the Head of the FTMC Department of Laser Technologies. This initiative reflects FTMC's long-standing expertise in semiconductor research and development and reinforces its role in strengthening Europe's position within the global semiconductor value chain.

The achievements of 2025 were driven by the scientific excellence of FTMC researchers. During the year, one of our scientists was named among the “Photonics100” industry's most innovative people, and our photonics researchers received the Gentec-EO Laser Lab Awards — important international recognitions of their impact and innovation. Our colleagues were also honoured with major national awards, including the Presidential award of the Commander's Cross of the Order of the Lithuanian Grand Duke Gediminas and the Lithuanian Science Prize in the field of technological sciences, awarded by the Lithuanian Academy of Sciences. FTMC researchers additionally received Commemorative Medals and the Presidium's Acknowledgement of the Lithuanian Academy of Sciences. We can and should take pride in these achievements – they demonstrate that the work carried out at FTMC meets the highest international standards and that our researchers stand among the leaders of their fields.

Support for early-career researchers remained a priority. In 2025, 30 doctoral dissertations were successfully defended, and once again, an FTMC PhD student was awarded the title of best doctoral thesis. In parallel, the strategy for attracting

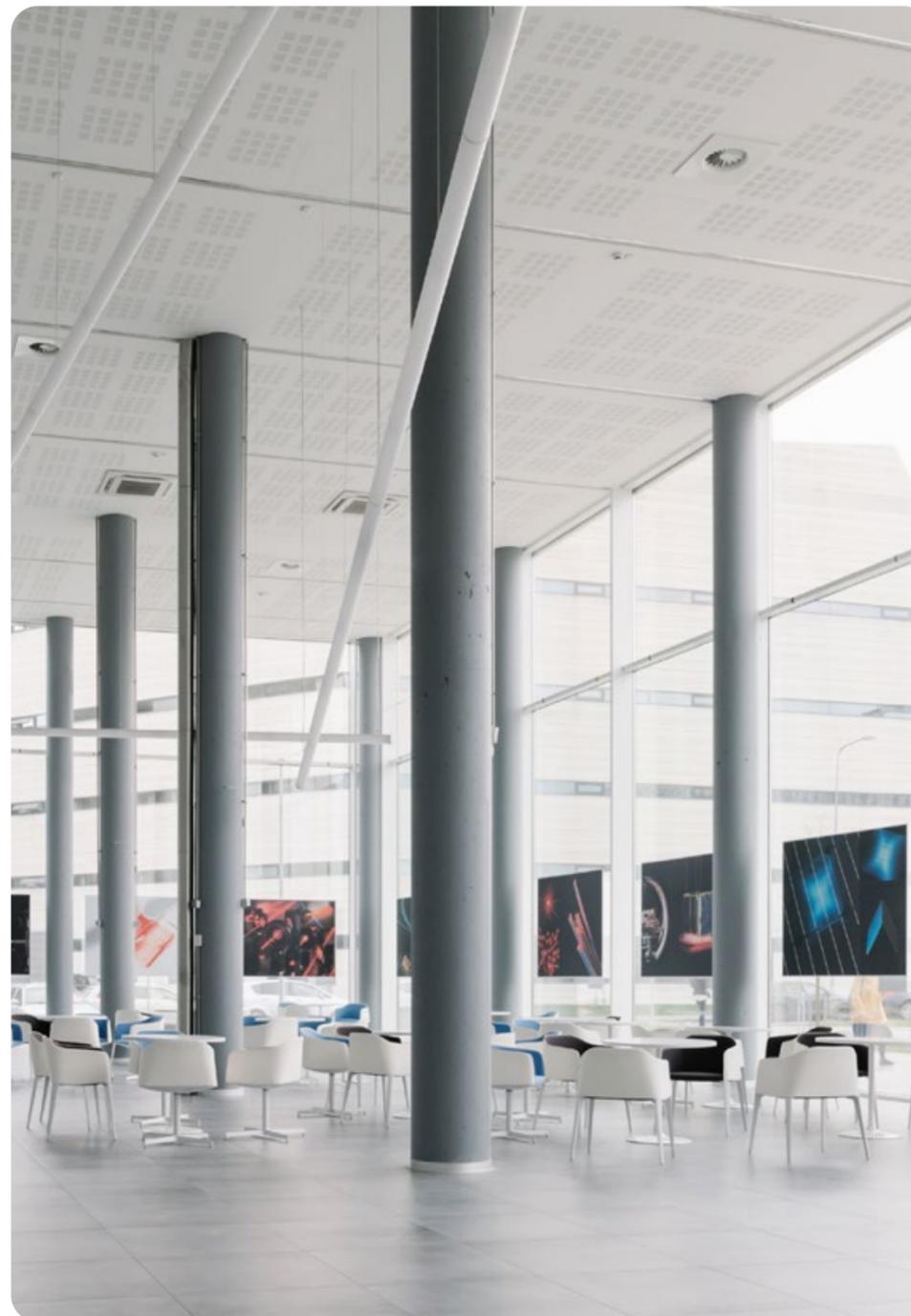


bachelor's and master's students to research activities proved effective: by the end of 2025, the number of students involved in scientific research increased by 56.5% compared to the end of 2024. Behind these numbers are talented young people who choose FTMC to build their scientific future – their growth is our long-term strength.

Institutionally, 2025 was a year of tangible growth for FTMC. The Center hosted several scientific conferences, organised a hackathon focused on quantum technologies, continued to increase licensing revenues, and reached a record budget exceeding EUR 31.6 million. This financial growth not only reflects the expanding scale of our activities but also strengthens FTMC's position as a competitive and responsible employer, enabling us to offer stable career prospects and competitive remuneration. However, our strategic focus remains on further strengthening the Center's position by expanding income from competitive projects and contract-based research.

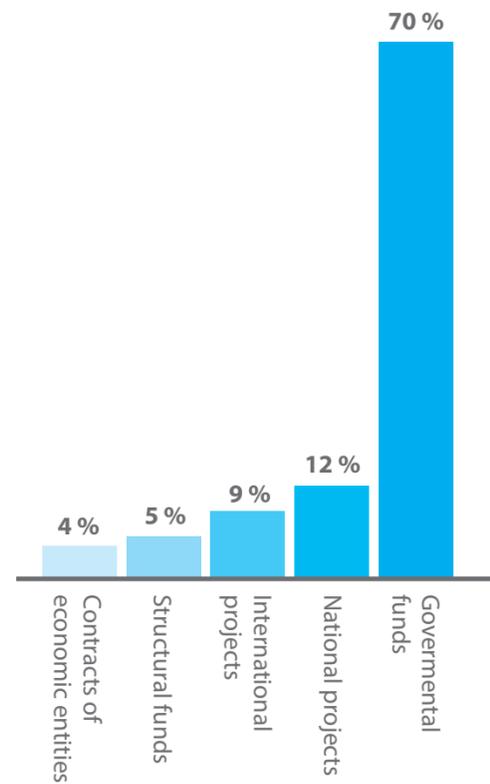
In summary, 2025 was a year of building strong foundations. The FTMC community aligned around a shared strategy and clearly defined priorities. I invite all of us to see these priorities not as formal targets, but as a common direction that requires focus, collaboration, and trust. Our ambition is to build a strong, integrated FTMC – because a strong FTMC ensures professional fulfilment, stability, and space for growth for every member of our community. Looking ahead to 2026, the focus shifts to implementation – bringing research ideas closer to tangible technological outcomes and functional prototypes. This will be supported by a review of scientific thematic areas and a strengthened role of the Science and Technology Park, with increased attention to supporting start-ups and early-stage technology development. These steps will help us move forward together – aligned in purpose, strong in collaboration, and focused on delivering results that matter.

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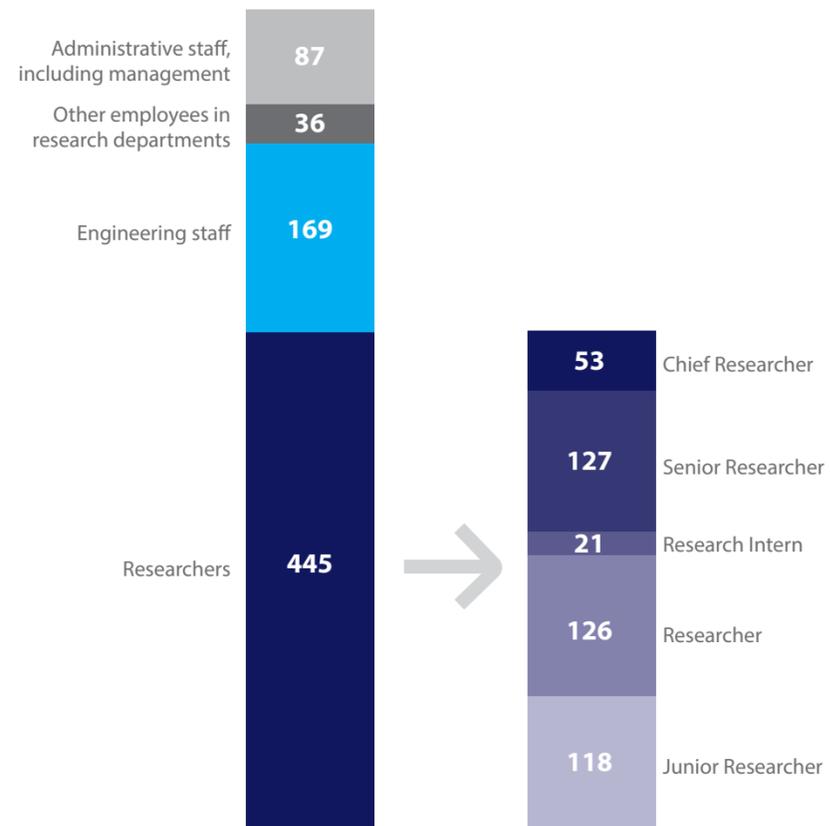
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FTMC Budget, kEur

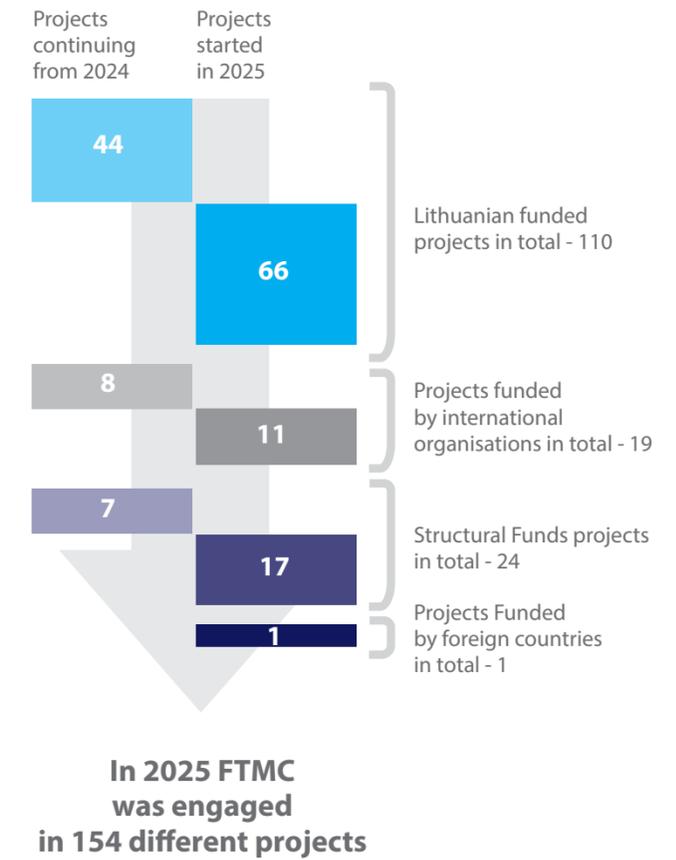


	2023	2024	2025
Governmental funds	16447,0	19028,5	21975,0
National projects	3191,6	4431,3	3815,9
International projects	269,4	1086,6	2700,6
Structural funds	2995,8	1381,3	1637,5
Contracts of economic entities	2951,0	1818,2	1502,5
TOTAL:	25854,85	27745,9	31631,5

FTMC employees by employee group



FTMC projects



Technology for Determining the Precise Speed of Objects Using Magnetic Field Measurement

MB "Mag Militaris"

Thick-Layer Copper Coating Deposition Technology

MB "H-altitude"

Controlling the Reflection, Absorption and Scattering Parameters of 3D Metal Surfaces Using Femtosecond Laser Texturing

MB "Asinve"

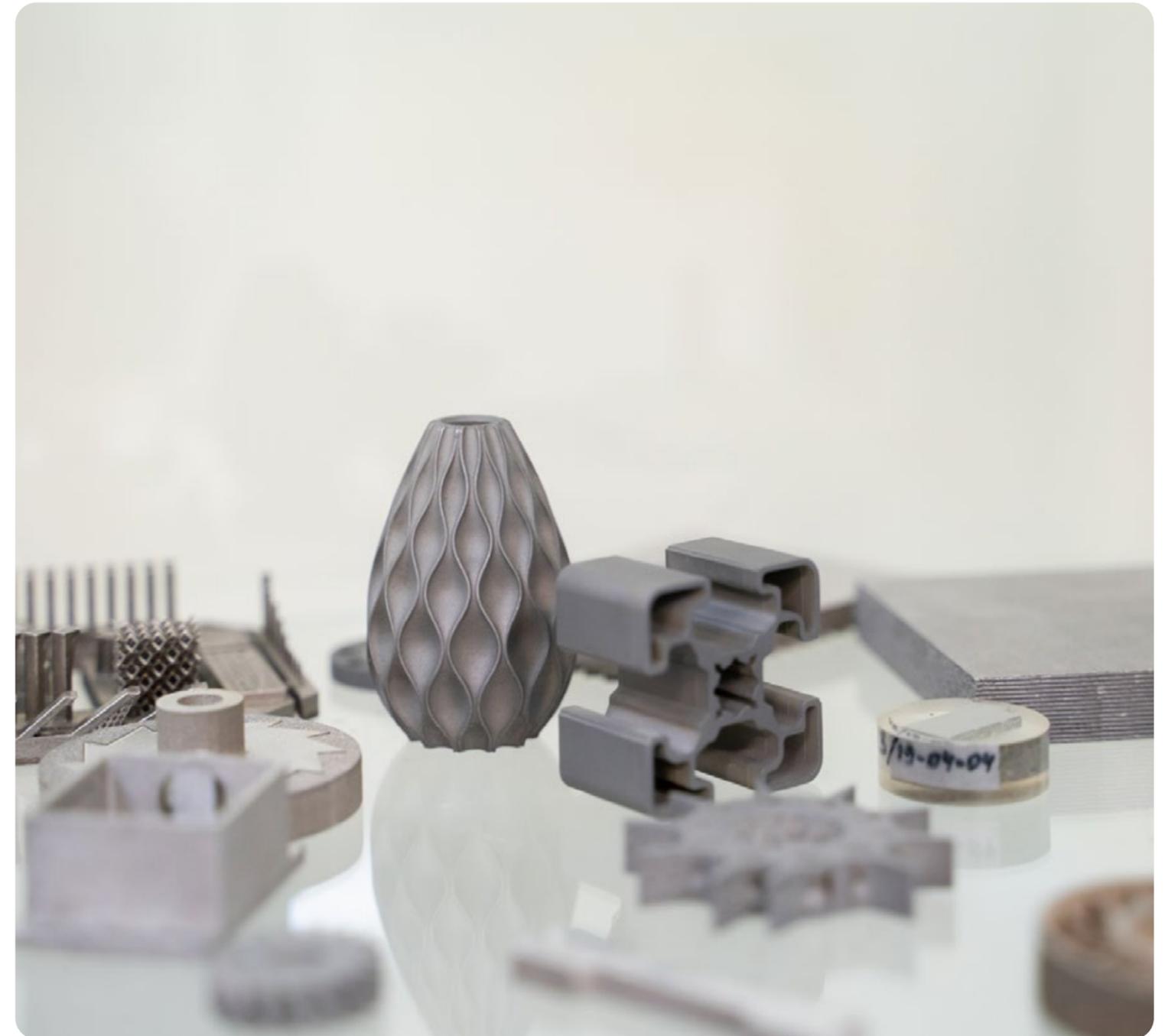
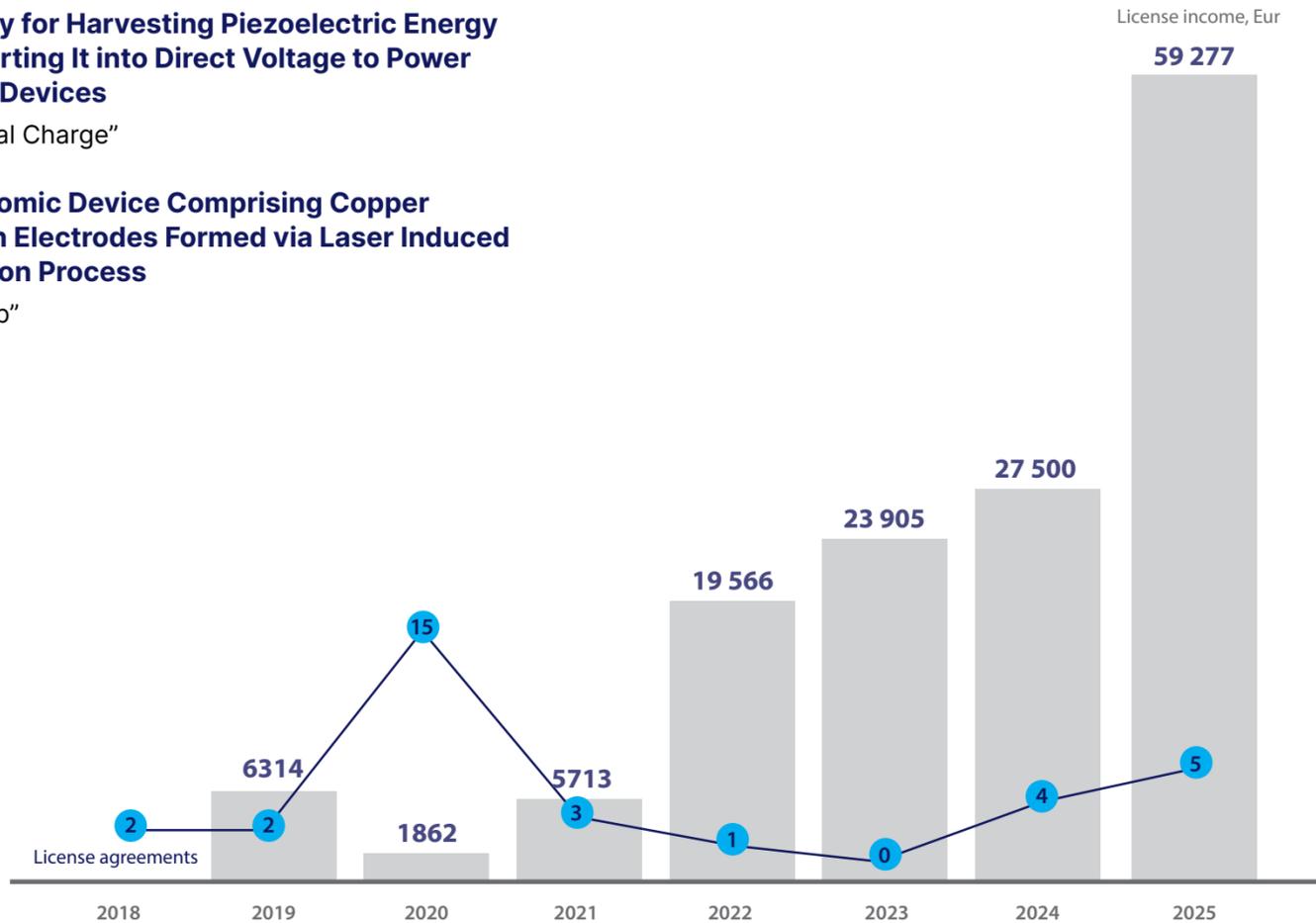
Technology for Harvesting Piezoelectric Energy and Converting It into Direct Voltage to Power Electronic Devices

UAB "Internal Charge"

Electrochromic Device Comprising Copper Micromesh Electrodes Formed via Laser Induced Metallization Process

MB "Optofab"

In 2025, FTMC continued its targeted efforts to enhance the practical application of scientific research results and expand collaboration with business partners. It actively pursued new opportunities for technology commercialisation by strengthening its ties with the private sector and further optimising internal processes for intellectual property management. These initiatives not only maintained but exceeded the results achieved in 2024. In 2025, more licensing agreements were concluded, accompanied by increased revenue, reflecting the growing competitiveness, maturity, and market appeal of technologies developed at FTMC.



Two-Terminal Tandem Solar Cell

EP 4095916 B1

Steponas Ašmontas, Jonas Gradauskas, Asta Grigucevičienė, Konstantinas Leinartas, Kazimieras Petrauskas, Laurynas Staišiūnas, Algirdas Sužiedėlis, Aldis Šilėnas, Edmundas Širmulis

The proposed two-terminal tandem perovskite/silicon solar cell differs from its analogues in that the tunnel junction is not formed in the silicon cell's top surface layer. Instead, it is created between the silicon cell and the electron transport layer by doping the transport layer during its deposition.

Hermetic Sample Holder for Electro-Optical Measurements in an Inert Atmosphere and Method for Switching of Electrical Contacts on a Sample Without Violation of the Hermetic Seal of the Sample Holder

EP 4455637 B1

Vidmantas Gulbinas, Andrej Dementjev, Titas Klepeckas

Air-sensitive electronic materials should be investigated under an inert atmosphere. Often, several samples with electrical contacts are prepared on a single substrate. This device construction enables contacting electrical probes to any pair of contacts without opening the hermetic chamber.

Method for Selective Metallisation of Inorganic Dielectrics or Semiconductors

US 012336114 B2

Karolis Ratautas, Gediminas Račiukaitis, Aldona Jagminienė, Ina Stankevičienė, Eugenijus Norkus

This invention describes a process for selectively depositing metal on the surfaces of inorganic dielectric materials, such as glass, ceramics, or semiconductor materials. The method enables the rapid and precise formation of electric circuits on both flat and three-dimensional surfaces.

Conveyor Band Surface Condition Monitoring System

EP 4546610 B1

Rimantas Simniškis, Žilvinas Andrius Kancleris, Justina Žemgulytė, Romualdas Trusovas, Karolis Ratautas

The patented system introduces a conveyor band surface-condition monitoring solution that integrates sensors, energy-harvesting electronics, and wireless communication directly into the conveyor belt itself. It uses a microwave-based energy-harvesting array—composed of flat antennas with rectifiers and capacitors—to capture energy radiated by a nearby wireless data hub, eliminating the need for batteries or wired power.

Bioactive Compound Delivery Assembly

US 12398405 B2

Erfle Holger, Ramūnas Valiokas, Vytautas Cėpla, Vytaute Starkuviene

The present invention relates to a bioactive compound delivery assembly, a method for stabilisation and/or encapsulation of bioactive compound compositions, a method for solid-supported transfection of living cells and the use of the bioactive compound delivery assembly.

Spectrally-Selective and Directional Thermal Electromagnetic Radiation Emitter

EP 4105693 B1

Vytautas Janonis, Irmantas Kašalynas

The invention relates to a device designed to emit quasi-monochromatic, coherent thermal radiation in the normal direction, enhanced through the excitation of hybrid surface plasmon-phonon polaritons. This hybrid polariton emitter produces a beam at a chosen frequency that exhibits high spectral purity (quasi-monochromatic behavior) and strong coherence (minimal angular divergence). These properties arise from the constructive coupling of all polarisation modes of the hybrid polaritons within a radially symmetric surface grating.

Device for the Determination of Specific Activity of Radiocarbon (¹⁴C)

EP 4273590 B1

Vidmantas Remeikis, Artūras Plukis, Artur Plotnikov, Žilvinas Ežerinskis, Jevgenij Garankin, Laurynas Butkus, Elena Lagzdina

Improved express method for specific ¹⁴C activity determination was used for the development of the stand-alone device (see Figure). The invention allows to reduce the detection limit of ¹⁴C by reducing the environmental background by determining the specific ¹⁴C activity in the sample, to increase the statistical accuracy of measurement results by implementing a freely selectable measurement exposure time, and to simplify, reduce the cost and optimise the CO₂ content measurement unit while expanding the scope of application of the device.

Detection Device, System and Method for the Determination of Incidence Angle of an Optical Beam

US 12474430 B2

Julijanas Želudevičius, Giedrius Dubosas

The invention relates to optical and telecommunication technologies and is dedicated to determine the direction of an optical beam in free-space optical communication systems. It is based on the property of interference optical filters (IOF), whose transmittance and reflectance of such filters for a beam with a given optical spectrum depend on the angle of the beam with respect to IOF surface normal.

European Research Executive Agency (REA) Project
European Compact Accelerators, Their Applications, and Entrepreneurship, EPACE. 2025-2028

Gediminas Račiukaitis

New technologies of compact accelerators, in particular plasma accelerators, and laser-based x-ray sources are on the verge of reaching maturity in this decade, making it today a perfect time to steer them towards a broader scope of applications in academia, medicine, and the industry.

This is the goal we pursue with the Marie Skłodowska Curie Action Doctoral Network EPACE (European Compact Accelerators, Their Applications, and Entrepreneurship). EPACE fosters a culture of excellence, innovation and critical thinking to help the next generation explore opportunities and guide it towards significant contributions in line with the EU missions. Emphasis is put on applications in industry, medicine, and impactful progress.



European Research Executive Agency (REA) Project
Excellent Laser Technologies for the Sustainable Prosperity of Europe, LASER-PRO. 2025-2028

Gediminas Račiukaitis

The Central Bohemian Region (Czech Republic) and Lithuania represent European regions where researchers in photonics and laser technologies are internationally recognised, and where business has a high added value. Intense interaction between science and business promotes development, creating significant potential for new company formation and the emergence of a new generation of industry based on laser technologies with more integrated solutions. As a key challenge in this area remains the creation of the photonics and laser technology sector, where operating companies produce products with higher added value and exceptional functionality. The Excellence Hubs initiative addresses this challenge by connecting two laser-based innovation ecosystems, fostering a real-place-based innovation culture in the Czech Republic and Lithuania.

Excellence Hub LASER-PRO is centered on key academic institutions - HiLASE Laser Centre in the Central Bohemian Region and the Centre for Physical Sciences and Technology in Lithuania. Complementary stakeholders include innovation centers, research clusters, and industry associations. Ukrainian partners are also involved through a mentoring scheme to enhance collaboration and innovation opportunities.



European Research Executive Agency (REA) Project
Towards a Terahertz Short-Range Wireless Communication System Based on Graphene Devices, HERMES. 2025-2029

Irmantas Kašalynas

The HERMES project has the ambitious goal of providing breakthrough technological solutions towards the implementation of ultra-fast (100 Gbit/s) short-range wireless communication systems at room temperature, significantly surpassing existing technologies such as Wi-Fi 7 (40 Gbit/s) and 5G mmWave (10 Gbit/s). Such a technology would be a breakthrough for applications like monitoring, security, or sensing/medical.

Most of the current technology limits in terms of data rate, carrier frequency, dimensions, energy efficiency, controllability, and tunability, are intrinsically related to the use of conventional materials and standard architectures. The HERMES project aims at overcoming these limits by demonstrating novel components of this envisaged system that combine the advantages of using graphene and other 2D nanomaterials with that of operating in the THz range.

The HERMES project has the ambition to design, fabricate and validate: a novel THz emitter made by using graphene and a novel THz detector made by using 2D nanomaterials, both integrated into silicon and working at room temperature; novel all-optical and electro-optical interfaces between THz devices and optical communication links. These goals will be achieved by the HERMES international network of academic and industrial partners, well-balanced in terms of competencies, expertise, and resources.



European Research Executive Agency (REA) Project
Atmosphere Spectroscopy Using Terahertz Sensors Dedicated to Quantum Cascade Laser Sensing, AtSpecTS. 2025-2027

Dovilė Čibiraitė-Lukenskienė

The project AtSpecTS aims to develop a compact and disruptive spectroscopic gas sensor technology for the 2–5 THz range, utilising advanced field-effect transistor (FET) technology and offer QCL users a new compact and cost-effective solution for atmosphere research.

Atmospheric gases like carbon dioxide, methane, nitrous oxide, and atomic oxygen are critical in greenhouse effects, chemical reactions, and energy regulation. Spectroscopy enables precise detection of these gases by analysing their absorption and emission of electromagnetic radiation.

The project focuses on improving the accuracy of gas detection and analysis in the terahertz range, where clearer signals with less spectral overlap can be obtained compared to IR spectroscopy. The expected outcome is a technology that is ready for participation in the next atmosphere research mission.



EURAMET Project Establishing Traceability Routes in Nuclear Medicine, ETRAIN. 2025-2028

Arūnas Gudelis

Nuclear medicine is a versatile and widely used diagnostic and therapeutic medical technique utilising radioactivity to diagnose and treat diseases in areas such as oncology, neurology and cardiology. The measurement of radioactivity in the clinical environment prior to injection, or as part of an imaging study, relies on the use of calibrated instruments. Despite being a heavily regulated environment, calibration and traceability routes across Europe vary in both availability and design leading to a disparity in measurement capability. This project aims to establish traceability routes for nuclear medicine services and provide guidance and tools to enable its widespread adoption beyond the EU.



EURAMET Project Metrology to Support Ammonia Use in Emerging Applications, MetNH3Energy. 2025-2028

Darius Valiulis

Through key initiatives such as REPowerEU, REFuelEU, and FuelEU maritime, the European Union seeks to reduce its greenhouse gas emissions. Green hydrogen is central to this context, but the demand will be met through import. In this context, ammonia is emerging as a promising hydrogen energy carrier with its extended use in end-use applications such as ammonia cracking, shipping, and power generation. The project aims to ensure that the necessary metrology infrastructure and relevant services are established to facilitate the use of ammonia in these emerging applications.



EURAMET Project Hybrid Metrology for Sustainable and Low-Carbon Footprint Battery Materials, HyMetBat. 2025-2028

Evaldas Naujalis

The European battery industry is under increasing pressure to improve the economic and environmental sustainability of the manufacturing supply chain. Existing high-capacity energy storage technologies, such as Li-ion batteries, rely on critical elements with low earth abundance, are produced via energy intensive and environmentally unfriendly processes and are difficult to recycle.

To support the transition to more sustainable battery chemistries and low carbon-footprint manufacturing processes, new metrology solutions are urgently needed. This project aims to develop a new hybrid metrology platform that integrates a combination of traceable analytical techniques for both *ex situ* and *operando* characterisation of battery materials to enable innovation in next-generation energy storage technologies.



Digital Europe Programme (DIGITAL-Chips-2024-SG-CCC-1) Project Lithuanian Chips Competence Centre, ChipsC2-LT. 2025-2029

Gediminas Račiukaitis,
Saulius Tumėnas

The project aims to establish and operate a Chips Competence Centre on advanced semiconductor technologies in Lithuania, providing a one-stop shop to support innovation and growth in the national semiconductor industry. ChipsC2-LT consolidates expertise from key research and higher education institutions in the country and specialises in chip design, heterogeneous integration, power electronics, and photonic integrated circuits to address the needs of local industry involved in e-mobility, security and communication sectors.

The ChipsC2-LT Centre aims to strengthen the capabilities and skill base of the Lithuanian semiconductor and electronics industry and contribute to Europe's strategic autonomy in this critical industry. To achieve this, the Center will provide comprehensive support services, including: 1) Access to advanced design tools, prototyping facilities, and testing infrastructure; 2) Training and skills development programs to address the semiconductor talent gap; 3) Technology transfer and commercialisation support for startups and SMEs; 4) Networking and ecosystem building to connect Lithuanian companies to European semiconductor initiatives; 5) Guidance on accessing funding through the EU Chips Fund and other mechanisms.



**European Research Executive Agency (REA) Project
Next Generation AI Researchers for Air Quality Excellence,
NextAIRE.
2025-2028**

Steigvilė Byčenkienė

NextAIRE is focused on boosting the interoperability, expanding expertise and providing a more balanced geographical and cross-sectoral circulation of European R&I talents in the field of air quality monitoring. The project actively involves environmental scientists, experts in hardware and Internet of Things (IoT) and machine learning engineers.

The training methodology, including planned secondments and numerous collaboration activities, such as buddy systems, workshops, hackathons, and ongoing assessment, is expected to drive sensor development and environment-related public health findings.

The project is made up of 16 partners forming a highly interdisciplinary consortium with numerous SME-sized hardware producers. From a scientific perspective, air quality monitoring through low-cost sensorics and artificial intelligence is at the project's core. However, NextAIRE will use these topics to provide R&I talents hands-on experiences to increase their research, entrepreneurial and other transferrable skills, strengthening the R&I human capital base and improving the excellence of the research carried out in Widening countries and beyond.

NextAIRE will also generate outcomes that will positively impact the employability and sustainable career prospects for European R&I talents in the field of air quality monitoring, in both the academic and non-academic sectors alike. Results such as the NextAIRE Competency framework, mathematical and AI models and an e-learning platform featuring training materials on topics such as AI, data science and air pollution research, will help to achieve this goal.



**European Innovation Council and SMEs Executive Agency
(EISMEA) Project
Multi-Material Additive Manufacturing with Electrostatic
Cold Spray, MADECOLD.
2025-2028**

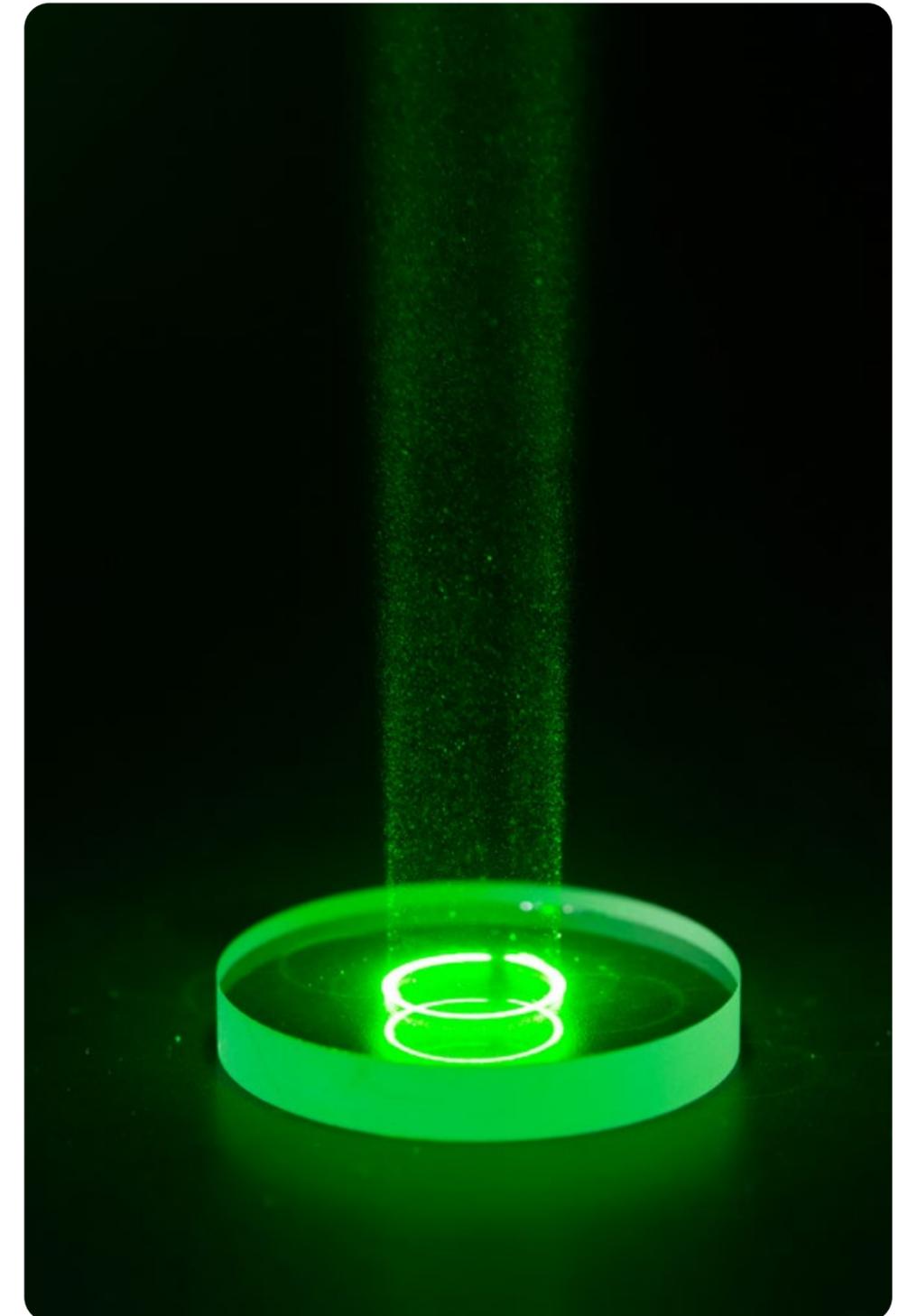
Paulius Gečys

While additive manufacturing (AM) is deemed the future of industrial production for its exceptional freedom in design, several technical limits hinder its full exploitation. Surprisingly, the most diffused AM techniques consume nearly four times more energy than conventional manufacturing processes, while also being more limited in build rate, size, material selection, and surface quality.

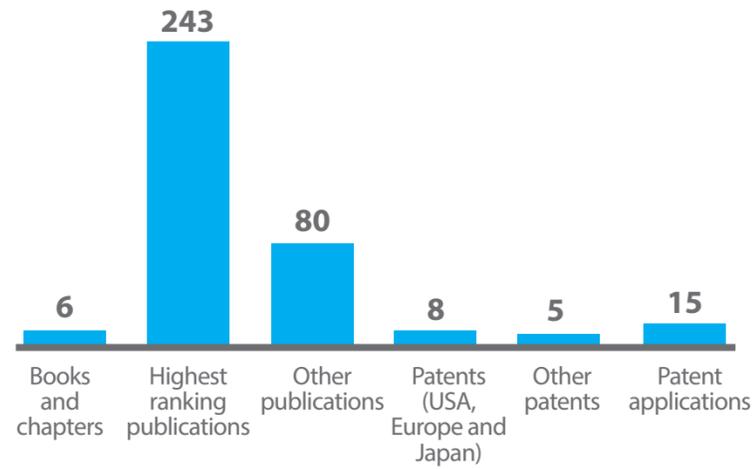
MadeCold aims to achieve a breakthrough in this direction by merging solid-state and electrostatic physics, control and monitoring, mechanical design, and materials science to develop a disruptive solid-state deposition process. The revolutionary principle of MadeCold is to charge and accelerate metal powders to supersonic velocities in a customised electric field, using the kinetic energy to induce bonding upon impact with a substrate. This has not been realised before.

Relying on our preliminary results, we will implement multiscale computational models and advanced experiments to develop a single launcher to prove bonding efficiency. Then, via a new control system, we will pair multiple launchers to exhibit the capacity of MadeCold for covering simultaneously a theoretically unlimited surfaces - compared to the point-wise print of the current AM.

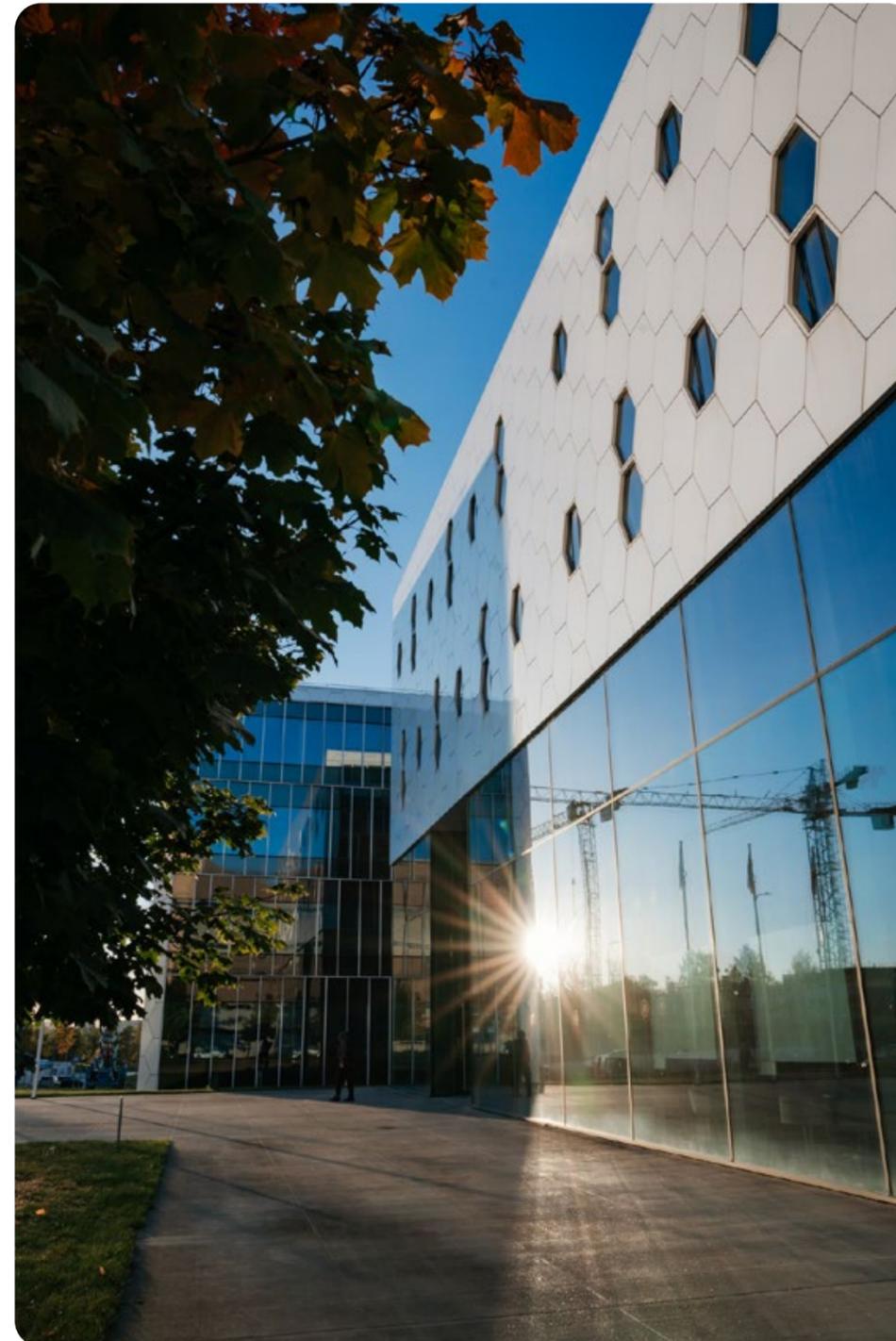
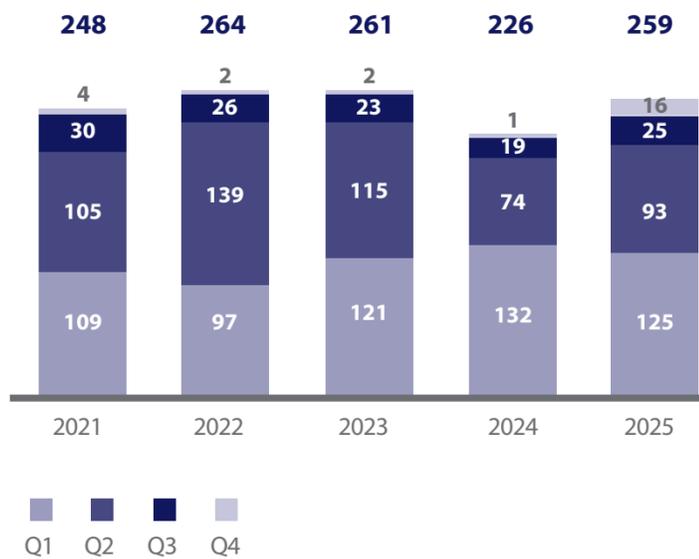
We will demonstrate that it outperforms the existing technologies regarding the accuracy, deposition rate, flexibility and scalability and paves the way to depositing functional multi-material structures with unprecedented properties. We intend to prove this in 3 key sectors: aerospace, energy and hybrid manufacturing with specific proofs of concept.



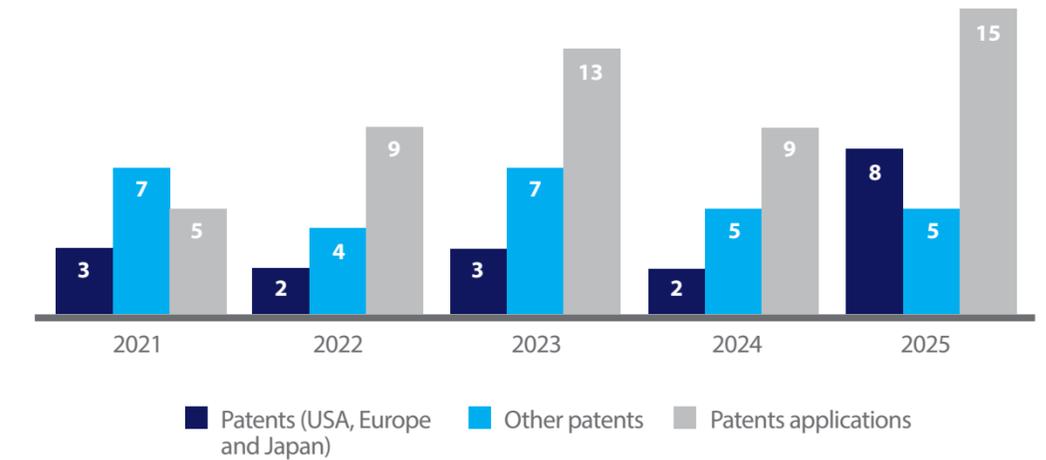
Research results in 2025



FTMC Q1-Q4 publications (2021-2025)



FTMC patenting results (2021-2025)



Most cited FTMC scientists in 2025 (from FTMC establishment)

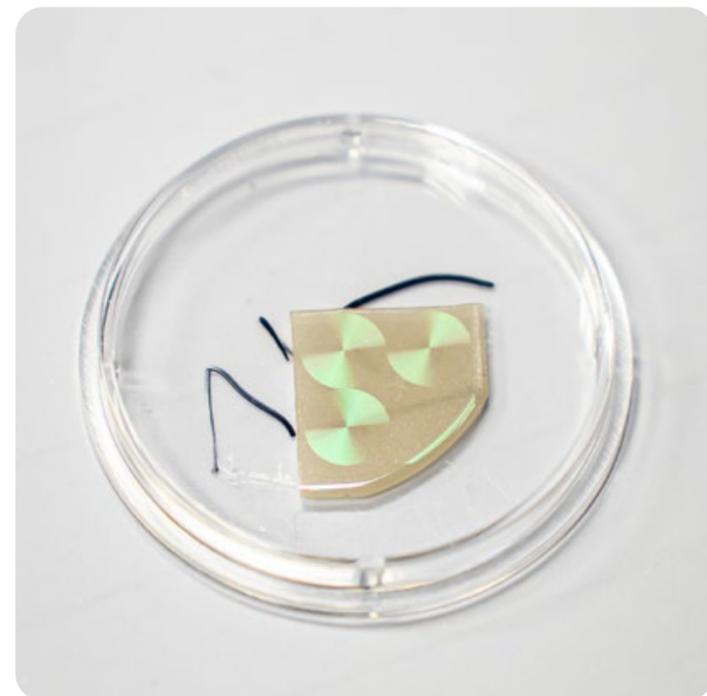
Scientist	Total times cited in 2025	H-Index
Arūnas Ramanavičius	1843	62
Gediminas Niaura	934	31
Martynas Talaikis	498	17
Gediminas Račiukaitis	427	33
Algirdas Selskis	352	24
Marius Franckevičius	322	24
Paulius Gečys	275	25
Vidmantas Gulbinas	255	27
Leonas Valkūnas	250	32
Sergejus Orlovas	199	17

Turning Heat Waste into Electricity: FTMC Physicists Reveal a Breakthrough for Electronics

One of the biggest joys in a scientific career is the moment when your discoveries turn into real, functioning devices. A recent example is a spectrally selective, directional thermal electromagnetic radiation emitter, patented in 2025 by physicists Dr. Irmantas Kašalynas and Dr. Vytautas Janonis from the FTMC Department of Optoelectronics.

It is the first invention of its kind in the world.

What makes it special? Ordinary thermal light sources – think of a light bulb – emit light in all directions and across the full spectrum of rainbow colours. That is why a room lights up instantly when you turn on the switch, allowing us to identify the colours of visible objects.



Scientists, however, sometimes need a different type of light: one that does not spread in all directions but instead forms a focused beam of a single selected colour. This type of light is known as coherent radiation, like the light produced by lasers. And this is exactly what the FTMC emitter can achieve.

Tiny Grooves, Big Impact

So how does it work? In simple terms, the device consists of a small gallium nitride crystal with microscopic grooves etched on its surface. These grooves are essential.

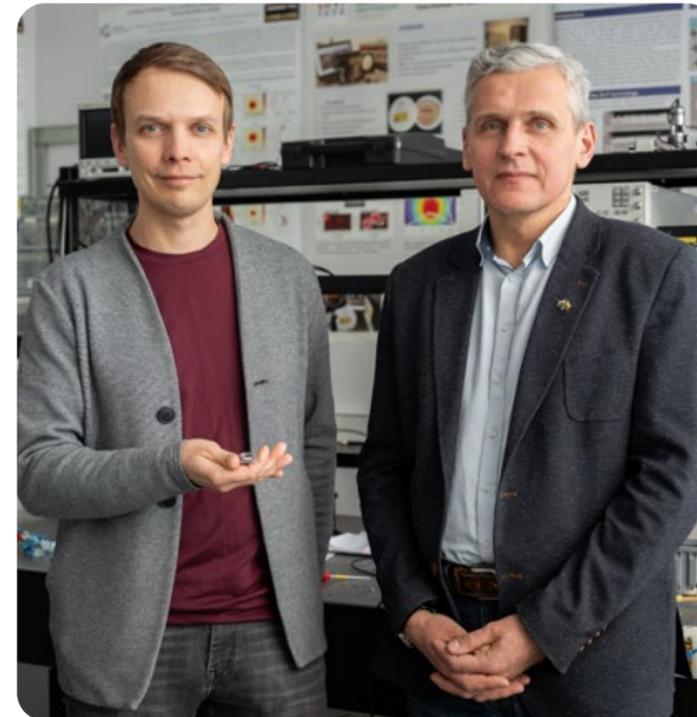
When the crystal is heated on a matchbox-sized heater, the grooves make it emit highly directional far-infrared radiation, with a wavelength of 17.5 micrometres or a frequency of 17 THz which is invisible to the human eye.

The grooves can be shaped differently. A typical diffraction grating made of straight lines disperse radiation at various angles, forming a rainbow of colours. In contrast, our source is composed of circular grooves that direct the infrared beam at the selected wavelength straight upward.

“These tiny structures on the crystal don’t just shine individually – you can arrange many of them side by side, designed with identical or different geometries. Together, they shine like miniature torches in a normal direction, creating small, focused beams of light,” explains Dr. I. Kašalynas.

“And because we use conductive gallium nitride, we don’t even need an external heater. In our experiments, we simply attached contacts and passed an electric current through the crystal, allowing it to heat itself. Its surface then emitted directional light at a single wavelength,” adds Dr. V. Janonis.

Gallium nitride is a wide bandgap semiconductor, chosen for a reason. It is one of the key materials behind the European Chips Act – the EU’s initiative to strengthen the semiconductor ecosystem. Although highly important, gallium nitride is also costly and rare. The Lithuanian



researchers therefore thank their partners at the Institute of High Pressure Physics (UNIPRES) of the Polish Academy of Sciences for supplying exceptionally high-quality gallium nitride crystals that enabled the practical realisation of the source (published in *Optical Materials Express* Vol. 13, Issue 9).

Moreover, the European patent by Dr. I. Kašalynas and Dr. V. Janonis states that similar radiation sources could also be produced using other polar semiconductor crystals, such as gallium arsenide or indium phosphide.

A Vision: From Home Offices to Outer Space

The invention is patented - but how could it be used in everyday life? FTMC researchers are exploring waste heat management: capturing excess heat from electronic devices and reusing it for energy recycling instead of letting it disappear.

These tiny and solid grooved crystal sources can be integrated into general-purpose electronics, multiplied easily, and readily modulated. That means that heat that would normally be lost could be transformed into electricity and directed exactly where it is needed.

“One of the most exciting applications is thermophotovoltaics: we could transfer heat that usually accumulates in certain electronic components into optical elements. Consider satellites – when one part heats up, its waste heat could be redirected to a sensor, a short-range communication device, or another component,” says Dr. Vytautas Janonis.

Dr. Irmantas Kašalynas offers a more everyday example:

“Computer microprocessors generate heat. With our surface-patterned crystals, this radiation could be directed straight to a battery. In this way, waste heat would be converted into electrical energy – and the device could power itself.”

And back to space: because the grooved structure patented by the Lithuanian team is relatively simple, it can cover very large areas. The technology can be scaled up as much as we like – in theory, it could be even used to cover entire buildings. This could radiate unwanted heat from Earth into space, providing passive cooling for houses.

The concept even extends to biology: molecules that absorb specific wavelengths could be selectively heated with targeted radiation – either to accelerate desired chemical reactions or to destroy harmful cells.

What’s next? FTMC researchers plan to expand and deepen their experiments, further improving their invention so that future applications can become reality as soon as possible.

In 2025, FTMC established the **Doctoral School** with the aim of fostering a strong and cohesive doctoral community grounded in the principles of academic ethics, openness, and collaboration. As doctoral students are an integral part of the FTMC community, particular attention is given to their integration through the development of a mentorship system, the encouragement of experience sharing, and informal community-building activities.

In autumn 2025, five senior doctoral students became mentors for first-year PhD candidates, guiding their introduction to FTMC and supporting their integration into the doctoral study process. In addition, team-building and networking events were organised to strengthen the doctoral community, promote peer-to-peer interaction, and foster interdisciplinary connections.

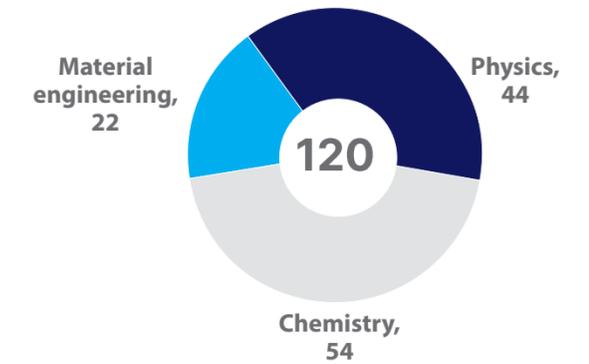
The establishment of the Doctoral School is expected to significantly strengthen FTMC's doctoral education ecosystem and contribute to the training of high-level researchers prepared for both academic careers and professional pathways beyond academia.



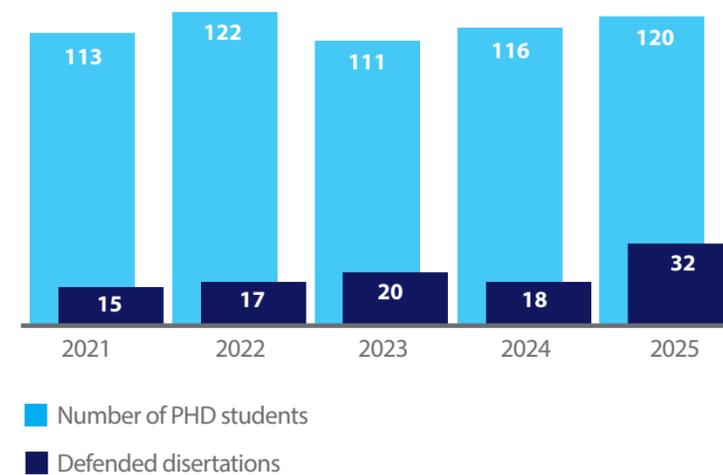
PhD students by nationality in 2025



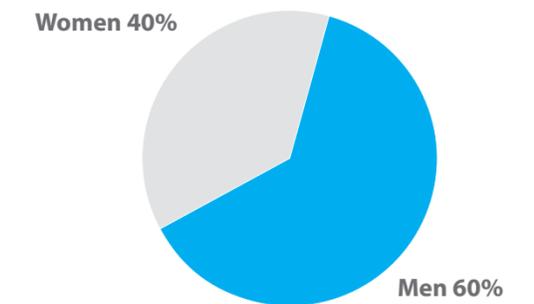
PhD students by field of study



PhD students



PhD students by gender



PHYSICS

JUSTINA ANULYTĖ

Strongly coupled extended plasmonic states for coherent energy exchange.

Scientific supervisor: prof. dr. Zigmas Balevičius

DARIA PASHNEVA

Atmospheric black carbon aerosol concentration dynamics in an urban environment.

Scientific supervisor: dr. Steigvilė Byčenkienė

AUGUSTINAS PETRULĖNAS

Dissertation title: femtosecond pulse generation in the 1.1–3 μm range by parametric and stimulated Raman amplification of supercontinuum.

Scientific supervisor: dr. Aleksėj Rodin

MATAS TARTĖNAS

Supermassive black hole feeding and feedback.

Scientific supervisor: dr. Kastytis Zubovas

LAURYNAS BUČINSKAS

Dynamics and balance of sulfur compounds in environmental systems.

Scientific supervisor: dr. Andrius Garbaras

JUSTAS BERŠKYS

Investigation of structured light topologies and its Lorenz-Mie scattering.

Scientific supervisor: dr. Sergejus Orlovas

SURYA REVANTH AYYAGARI

Integrated diffractive optical elements for terahertz beam shaping and polarisation control.

Scientific supervisor: dr. Irmantas Kašalynas

KLEMENSAS LAURINAVIČIUS

Vector optical bullets in free space and dispersive medium

Scientific supervisor: dr. Sergejus Orlovas

VYTAUTAS ŽALANDAUSKAS

Application of the SCAN density functional for modelling electronic excitations and electron-phonon interactions of point defects in semiconductors.

Scientific supervisor: dr. Lukas Razinkovas

EIMANTAS KRIŠČIŪNAS

Star clusters in the disc of the Andromeda galaxy.

Scientific supervisor: prof. dr. Vladas Vansevicius

TOUQEER GILL

Characterisation and source apportionment of carbonaceous aerosol in rural, urban and coastal environments.

Scientific supervisor: dr. Kristina Plauškaitė-Šukienė

YARASLAU PADREZ

Machine learning-based diagnosis of cancer and fibrosis with second harmonic generation microscopy.

Scientific supervisor: dr. Renata Karpič

ABDULLAH KHAN

Assessment of human exposure to traffic-related microplastics and black carbon in urban microenvironments.

Scientific supervisor: dr. Steigvilė Byčenkienė

ANDREA ZELIOLI

Growth and investigation of A3B5 quantum structures for VECSELS.

Scientific supervisor: dr. Renata Butkutė

MUHAMMAD MUJAHID

Machine learning-based diagnosis of cancer and fibrosis with second harmonic generation microscopy.

Scientific supervisor: prof. habil. dr. Steponas Ašmontas

CHEMISTRY

TOMA PETRULIONIENĖ

Investigation of overall and specific migration from food contact plastic materials made of polyethylene, polypropylene and their composites.

Scientific supervisor: dr. Evaldas Naujalis

ROMUALD EIMONT

Synthesis and nanofabrication of biomimetic hydrogels.

Scientific supervisor: dr. Ramūnas Valiokas

AUDRĖ KALINAUSKAITĖ

Investigation of the influence of fireworks and air mass transport on atmospheric aerosol mass concentration.

Scientific supervisor: dr. Steigvilė Byčenkienė

NADEŽDA TRAŠKINA

Preparation and characterisation of active components for aqueous sodium ion insertion batteries.

Scientific supervisor: dr. Linas Vilčiauskas

ALIONA KLIMOVICH

Surface-enhanced Raman spectroscopic study of adsorbed biomolecules at metal surfaces.

Scientific supervisor: dr. Ieva Matulaitienė

SUKOMOL BARUA

Anode and cathode materials for energy conversion systems.

Scientific supervisor: dr. Aldona Balčiūnaitė

JULIJA SARVUTIENĖ

The application of electrochemical and QCM sensors in studying interactions involving high molecular weight compounds.

Scientific supervisor: assoc. prof. dr. Urtė Prentice

BIRUTĖ SERAPINIENĖ

Electrocatalytic activity of Cu electrodes in electroreduction of CO₂.

Scientific supervisor: prof. habil. dr. Rimantas Ramanauskas

NERINGA BAKUTĖ

Biomaterials research in the field of biocompatibility, cell adhesion, and applications in microfluidic systems.

Scientific supervisor: dr. Arūnas Stirkė

TOMAS MOCKAITIS

Electrochemical methods for analysis of 3D cancer spheroids and enzyme activity

Scientific supervisor: dr. Inga Morkvėnaitė-Vilkončienė

MATERIAL ENGINEERING

ERNESTAS NACIUS

Development and application of beam shaping elements fabricated by laser micromachining in the NIR and THz wavelength ranges for material processing and imaging.

Scientific supervisor: dr. Vytautas Jukna

VITALIJ FIDOROV

Laser-assisted selective fabrication of metal traces on polymers by electroplating.

Scientific supervisor: dr. Gediminas Račiukaitis

MANTAS GAIDYS

Laser polishing and colouring of metals using ultrashort pulses.

Scientific supervisor: dr. Mindaugas Gedvilas

MIGLĖ MACKEVIČIŪTĖ

Efficient and fast glass cutting using laser bursts.

Scientific supervisor: dr. Paulius Gečys

LUKAS RAMALIS

Formation of sculptured thin films on crystalline substrates and their investigation in laser systems.

Scientific supervisor: dr. Tomas Tolenis

JULIJA PUPEIKĖ

Development and research of electrically conductive and wear resistant textiles by coating with PEDOT: PSS polymer.

Scientific supervisor: dr. Audronė Sankauskaitė

ADA STEPONAVIČIŪTĖ

Optimisation of the direct metal laser sintering technology and bimetallic structure formation.

Scientific supervisor: dr. Genrik Mord

An Ambitious European Defence Project: Smart Textile That Helps Soldiers Hide from the Enemy

Modern warfare is evolving rapidly – staying hidden is increasingly difficult as radar systems, drones, and other advanced equipment track soldiers day and night. A simple helmet and bulletproof vest are no longer enough. That's where scientists step in, developing smart textiles that will make soldiers "invisible".

Nineteen partners from nine European countries are collaborating on this vision through the European Defence Fund project ACROSS (Adaptive Camouflage for Soldiers and Vehicles).

One of the participants is the FTMC Department of Textile Technologies. Its head, Dr. Julija Baltušnikaitė-Guzaitienė, explains what makes this new generation of military clothing special.

When we talk about defence, we often picture weapons, tanks, or training grounds. But textiles are just as important, aren't they?

Exactly. In combat, the focus is on the human being – the person who needs protection when stepping out of a tank or leaving cover. The right clothing helps keep soldiers safe and ensures comfort and proper thermophysiological balance.

In our case, the camouflage we are developing is designed to reduce a soldier's contrast with the surrounding environment, helping them almost blend into it. Each of us leaves a detectable 'signature' – thermal, radar, and otherwise. We aim to minimise that signature as much as possible.

So, the core idea of ACROSS is to develop reliable textile solutions to protect soldiers and vehicles?

Yes. The project aims to create adaptive camouflage. The participating countries are developing multispectral,

adaptive camouflage solutions capable of adapting to a wide range of scenarios, effectively 'hiding' soldiers and vehicles across the full electromagnetic spectrum – from ultraviolet and visible light, to near- and far-infrared, and even through to the microwave range.

At FTMC, our focus is specifically on materials for soldiers rather than vehicles, including anti-radar textiles and materials that reduce thermal reflection in the far-infrared range.

We have already made significant progress. In each ACROSS research areas, technologies have been analysed and selected for the next phase of testing. For anti-radar applications, two technologies are advancing, and seven have been chosen for reducing thermal reflection.

The ultimate goal of ACROSS is a universal outfit that integrates technologies from all project partners into a single system protecting against electromagnetic detection.

The first field tests are scheduled in February at a training ground in Portugal. These trials will show how the smart textile performs in real-world conditions and whether different technologies function well together.

Simply put, how is adaptive camouflage created?

We are not working alone – we collaborate closely with the FTMC Microwave Laboratory, led by Dr. Paulius Ragulis. They develop metamaterials: tiny metallic structures that do not exist in nature. Because of their unique properties, microwave signals scatter when they hit these structures, making it difficult for radar to detect a person. Our role as textile specialists is to integrate these materials onto fabrics correctly and ensure they stay securely attached.

Of course, the simplest solution might seem to cover a soldier with metal plates, which would have a similar masking effect. But that is impractical – a soldier needs to move freely. Textile materials are a much better solution: they are lightweight, flexible, and breathable.



Defence and related technologies have become a key priority for FTMC. From your perspective, why it is important for scientists to engage in the security field?

We Lithuanians live in a kind of geopolitical 'seismic zone'. We share long borders with unfriendly states, and that poses a real threat. To live safely and peacefully, we must be fully prepared.

It is also important to remember that defence technologies often have dual-use applications. For example, we are developing textiles that regulate body temperature – useful not only on the battlefield but also for industrial workers exposed to extreme heat.

I believe every scientist should reflect on their field and consider how they might contribute to their country's security.



Dr. Gediminas Račiukaitis, Head of the FTMC Department of Laser Technologies and President of the Lithuanian Laser Association, was awarded the Officer's Cross of the Order of the Grand Duke of Lithuania Gediminas for the development and implementation of laser technologies in Lithuania, significant scientific achievements, active participation in organisational, expert, and public activities, and for promoting Lithuania internationally.

In 2025, he also received multiple recognitions. He was included in the Electro Optics journal "Photonics100" list for 2026 and was among the laureates. In Riga, the Baltic Awards were presented for the first time to representatives of Lithuania, Latvia, and Estonia for their contributions to the development of art, science, and architecture, highlighting the significance of this region in the European context. Gediminas Račiukaitis was the winner in the Science category. He was also honored with the St. Christopher Award, which recognises distinguished citizens of Lithuania's capital, Vilnius. He received the award in the category "For Merits in Science".



Professor Habil. Dr. Arūnas Ramanavičius, Head of the FTMC Department of Nanotechnology, received the Commander's Cross of the Order of the Lithuanian Grand Duke Gediminas for his significant contributions to Lithuanian science and society, and for promoting Lithuania internationally.



Professor Habil. Dr. Vidmantas Remeikis, former FTMC Director, received the Knight's Cross of the Order of the Grand Duke of Lithuania Gediminas for his high-level, internationally significant research in applied nuclear and reactor physics, radiation ecology, and environmental science.



Professor Dr. Ieva Plikusienė was appointed to the prestigious Scientific Advisory Board of UNESCO's International Basic Sciences Programme (IBSP), becoming the first Lithuanian scientist to hold this distinguished position.



Professor Habil. Dr. Gediminas Niaura, researcher at the FTMC Department of Organic Chemistry, was awarded the Knight's Cross of the Order of the Grand Duke of Lithuania Gediminas for his world-class scientific work in the field of molecular structure and functionality, contributing to the development and advancement of cutting-edge technologies.



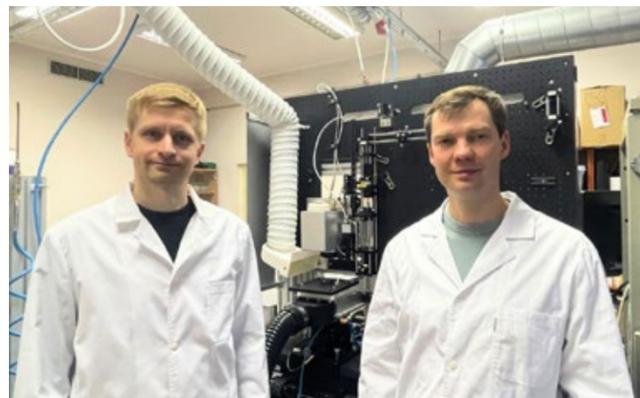
Dr. Andrejus Michailovas, physicist at the FTMC Department of Laser Technologies and Scientific Director of EKSPLA, won the 2024 Lithuanian Science Prize.



Dr. Simonas Ramanavičius, researcher at the FTMC Department of Electrochemical Material Science, was awarded the 2024 Prize in Mathematics, Physics, and Chemistry by the Lithuanian Academy of Sciences' Young Scientist Scholarship competition for his research work "Synthesis and Practical Applications of Nanostructured Titanium Suboxides and Their Hybrid Structures with $Ti_3C_2T_x$ MXenes."



Dr. Ramūnas Levinas, chemist at the FTMC Department of Catalysis, received the scholarship from the Research Council of Lithuania in the category of Natural, Medical and Health, Agricultural and Technological Sciences for his research “Development and Application of Innovative Catalytic Materials in Direct Methanol Fuel Cells”.



Dr. Paulius Gečys and **Dr. Juozas Dudutis** from the FTMC Laser Microfabrication Laboratory won the Gentec-EO Laser Lab Awards. As part of the award, the laboratory received a UP19K-15S-H5-BLU-D0 laser power detector, which will make a significant contribution to ongoing research activities.

Their research project “Glass Processing Using Bursts of Ultrashort Laser Pulses with Spatially Structured Beams” was selected for support. The project focuses on developing advanced laser processing technologies for transparent materials by combining short and ultrashort pulse bursts with spatially structured beams.



Dr. Vladislovas Čižas, physicist from the FTMC Department of Optoelectronics, was recognised for the Best Doctoral Dissertation of 2024. The Lithuanian Society of Young Researchers (LSYR) honoured him for his thesis “Coexistence of High-Frequency Parametric and Bloch Gain in Doped GaAs/AlGaAs Superlattices” (Academic Supervisor Prof. Habil. Dr. Gintaras Valušis) in the category of Natural Sciences, Technology, Medicine and Health, and Agricultural Sciences.

In his dissertation, Dr. Čižas developed new sources operating in the terahertz (THz) frequency range. An essential part of THz technologies is the source, the device that emits these electromagnetic waves. For this purpose, Dr. Čižas and his colleagues used quantum superlattices: square-shaped structures invisible to the naked eye, made from gallium arsenide crystal. Thanks to their unique properties, it is possible not only to generate THz waves but also to amplify them by up to a thousand times. Building on this discovery, the FTMC scientist patented the technology in 2023, which later became the basis of his doctoral dissertation.



The first quantum hackathon in the Baltic States, Quantum Boost 2025, took place in Vilnius, where FTMC team “**Quantum Bacon**” won first place. The FTMC team’s idea focuses on navigation without a GPS. Their idea, called Advanced Visual Odometry, enables a smartphone or other device to determine its position and movement in space by recognising surrounding buildings or objects with a camera, combined with a quantum magnetometer, quantum machine learning, and an inertial navigation system.



Professor Habil. Dr. Eugenijus Norkus, chemist at the FTMC Department of Catalysis, twice a laureate of the Lithuanian Science Prize, and an academician was honoured by the Lithuanian Academy of Sciences with the Presidium’s Acknowledgement, the LAS Commemorative Medal, and the Theodor Grotthuss Commemorative Medal for his contributions to chemistry.

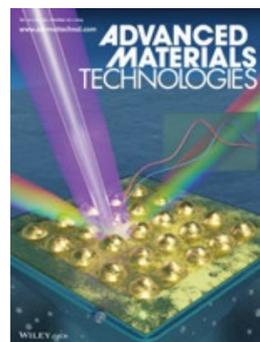


The remote CASSINI Hackathon brought together participants from 10 countries to develop and pitch innovative ideas. The competition aimed to explore how the EU’s Copernicus Earth observation programme could be used to support healthcare. In the Lithuanian category, the FTMC Department of Environmental Research team, “**Air Aware**”, won second place. The researchers proposed an interactive mortality prediction map using satellite data and machine learning. The system is expected to provide governments and public health agencies with an early-warning tool to target interventions, allocate healthcare resources, and develop environmental policies that protect the most affected communities.

“High-Quality Plasmonic Ag-Au Bilayer Nanobump Grating Sensor”

Physicists **Kernius Vilkevičius** and **Dr. Evaldas Stankevičius** from the FTMC Department of Laser Technologies, together with researcher **Tomas Rakickas** from the FTMC Department of Nanoeengineering, published the article “High-Quality Plasmonic Ag-Au Bilayer Nanobump Grating Sensor”, featured on the cover of the *Advanced Materials Technologies*.

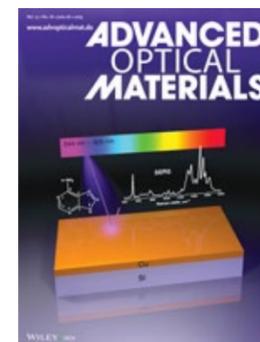
The Lithuanian team, in collaboration with the company OPTOMAN, developed an exceptionally sensitive hybrid plasmonic sensor. This device is an excellent tool for measuring small concentrations of a wide range of molecules and for applications in environmental monitoring and chemical analysis.



“Copper-Based Multiwavelength UV Surface-Enhanced Raman Spectroscopy”

Scientists from the FTMC Department of Organic Chemistry, **Professor Habil. Dr. Gediminas Niaura** and **Dr. Martynas Talaikis**, together with international collaborators, for the first time have demonstrated that copper is a suitable metal for ultraviolet surface-enhanced Raman spectroscopy (UV SERS) – a highly sensitive method for studying molecular vibrations.

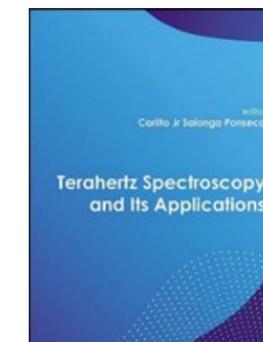
Their article, “Copper-Based Multiwavelength UV Surface-Enhanced Raman Spectroscopy” was published in the *Advanced Optical Materials*, appearing on its back cover. The achievement is significant on multiple levels: it enables far more precise detection of low-molecular-weight biochemical compounds and marks the first step towards next-generation early skin cancer diagnostics.



“Terahertz Spectroscopy and Its Applications”

The international publishing house World Scientific released a book, *Terahertz Spectroscopy and Its Applications*. The volume contains chapters written by scientists from around the world, presenting the latest advances in the application of terahertz spectroscopy in physics, chemistry, materials science, and engineering.

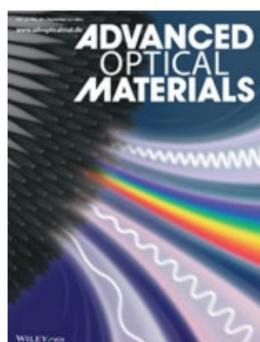
The book’s final chapter, “Terahertz Spectroscopy in Oil Investigation”, describes how terahertz waves can be used to examine the optical properties of various oils, lubricants, and fuels. The chapter was written by **Dr. Mindaugas Karaliūnas** from the FTMC Department of Optoelectronics. The research presented by the Lithuanian scientist is expected to contribute to fraud prevention in the food industry and to support efforts to identify sources of oil pollution in marine environments.



“Carbon-Coated Moth-Eye Structure: An Ultrabroadband THz-DUV Near-Perfect Absorber”

A team from the FTMC Department of Optoelectronics – **Dr. Irmantas Kašalynas**, **Dr. Saulius Tumėnas**, **Dr. Justinas Jorudas**, **Dr. Andrzej Urbanowicz**, **Dr. Vytautas Janonis**, **Dr. Daniil Pashnev** and **Dr. Surya Revanth Ayyagari** – together with international collaborators, developed a world-first universal electromagnetic wave absorber with potential applications in fields such as space research and defence. This device is an excellent tool for measuring low concentrations of a wide range of molecules, as well as for the use in environmental monitoring or chemical analysis.

Their article, “Carbon-Coated Moth-Eye Structure: An Ultrabroadband THz-DUV Near-Perfect Absorber”, was published in *Advanced Optical Materials* and featured on the journal’s back cover.



“Synthesis of High-Performance Multifunctional Electrode Material using Sweetwood Lignin as a Precursor”

An article entitled “Synthesis of High-Performance Multifunctional Electrode Material using Sweetwood Lignin as a Precursor” written by the FTMC researchers **Loreta Tamašauskaitė-Tamašiūnaitė**, **Daina Upskuvienė**, **Aldona Balčiūnaitė**, **Dijana Šimkūnaitė**, **Vitalija Jasulaitienė**, **Gediminas Niaura**, **Jolita Jablonskienė**, **Ramūnas Levinas**, **Eugenijus Norkus** in collaboration with **Ance Plavniece**, **Aleksandrs Volperts**, **Galina Dobeļe**, and **Aivars Zhurīnsh** from the Latvian State Institute of Wood Chemistry (LSIWC, Latvia), **Ivar Kruusenberg** and **Kätlin Kaare** from the National Institute of Chemical Physics and Biophysics (NICPB, Estonia), and **Luis César Colmenares-Rausseo** from SINTEF (Norway), has been selected as the lead research paper in the prestigious journal “*New Journal of Chemistry*” and has been featured on the journal cover, illustrated by the talented artist **Lelde Dobeļe**! This research is a great example of how scientific collaboration can drive the development of new materials and promote sustainable innovation





From AI and laser engraving to tackling microplastics and sustainable energy, FTMC scientists present their latest achievements and ongoing research at one of the FTMC's most important events - **THE ANNUAL SCIENTIFIC CONFERENCE**.



Whenever we speak of Lithuania's achievements in laser development, we should also remember the importance of optical coatings – without them, lasers would not function. Lithuanian researchers have decades of experience in developing and refining these technologies, and this strong tradition is continued by the Optical Coatings Laboratory at the FTMC Department of Laser Technologies. For the first time in Lithuania, a high-level international symposium **OPTICAL COATINGS FOR LASER APPLICATIONS (OCLA)**, dedicated to optical coatings for laser systems, was held.



The Innovation Agency Lithuania, together with the FTMC, organised the conference **"LITHUANIA'S CHIP INDUSTRY 2.0"**, where the new national Chip Competence Centre (ChipsC² LT) was presented. This is an exceptional project, the first of its kind in Lithuania, brings together four of the country's leading research institutions and universities: Center for Physical Sciences and technology (FTMC), Vilnius University, Vilnius TECH and Kaunas University of Technology. United by a shared goal to accelerate the growth of Lithuania's semiconductor industry. The initiative is coordinated by FTMC.



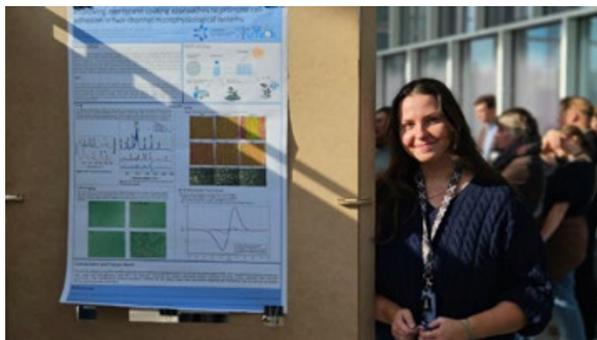
The international scientific conference **ECOBALT 2025** was held in Vilnius, organised by FTMC together with the Vilnius University Life Sciences Center and the Vilnius University Faculty of Chemistry and Geosciences. The speakers represented a variety of fields – physics, environmental physics, chemistry, and beyond. Many presentations focused on ecology, ecotoxicology, and environmental research. "Until now, EcoBalt was mostly regarded as an event for chemists. This year, however, there was no clear divide between physics and chemistry, as we often see at other conferences. It was a beautiful synthesis of the two sciences," said Dr. Arūnas Stirkė, Chair of the EcoBalt 2025 Organising Committee.



FTMC held an international **CONFERENCE CELEBRATING THE 220TH ANNIVERSARY OF THE FIRST THEORY OF ELECTROLYSIS BY THEODOR VON GROTTTHUSS**, the first Lithuanian physicochemist. This conference honored one of Lithuania's earliest and perhaps most famous scientists. Grotthuss's most significant contributions are related to the study of electrolysis and ion conductance – processes that explain how electric charges move through materials. "Today, this is the basis for many fields, from energy conversion and catalysis to electrochemistry and electroanalysis, for example, in the study of biological systems," says Dr. Linas Vilčiauskas, Head of the FTMC Department of Chemical Engineering and Technology and the main organiser of the event.



For the first time in Lithuania, the International Science Week **"(RE)SEARCH 2025"** brought together leaders from science, business, government, and international organisations for a week of discussions and networking. As part of the programme, the British Embassy in Vilnius, together with FTMC, organised the international practical conference **"TECH TRANSFER UNLOCKED: BRIDGING IDEAS ACROSS THE REGION AND UK"**. The event featured leading experts from prestigious academic and business institutions and promoted technology transfer and collaboration in innovation between the UK, the Baltic states, Finland, and Ukraine.



The annual FTMC conference for doctoral students and young scientists, **"FIZTECH 2025"**, attracted around 100 participants representing FTMC and other institutions. This event provided a great opportunity for young talents to present their work, discuss, and network. Authors of the best oral and poster presentations were recognised with awards



The year 2025 was marked by a series of significant **meetings with diplomats**. Over the course of the year, FTMC hosted around 20 ambassadors and honorary consuls from various countries, as well as delegations from Lithuanian and international organisations. We value the connections that have been established and strengthened, and we look forward to continuing collaborations that advance science, foster business partnerships, and the well-being of society.



FTMC hosted the international workshop **"PHOTONICS FRONTIERS: BUILDING STRONGER ECOSYSTEMS TOGETHER"**, which brought together laser technology experts from Lithuania, the Czech Republic and Ukraine. One of the key highlights of the event was the signing of a Memorandum of Understanding between the Lithuanian Laser Association and the Czech Optical Cluster. This international workshop forms part of ongoing activities of the LASER-PRO project *Excellent Laser Technologies for the Sustainable Prosperity of Europe*, launched in March 2025. The ambitious initiative unites 18 partners from Lithuania, the Czech Republic and Ukraine. The consortium is jointly led by the Czech research centre HiLASE and FTMC.



FTMC hosted a **MEETING OF THE EUROPEAN PARTNERSHIP ON METROLOGY (EPM) COMMITTEE** – the first ever held in Lithuania and the ninth overall. The field is coordinated by EURAMET, the association uniting Europe's national metrology institutes. Lithuania is represented by the National Metrology Institute (NMI), whose functions are carried out by FTMC. "EURAMET is a huge and powerful regional metrology organisation. Part of its role is to ensure that Europe's best measurement capabilities are recognised worldwide. The second task is to manage partnerships on metrology with research funding, to prepare for the future, and to answer the needs of industry and society. That is the reason we have gathered in Lithuania this time," said Maguelonne Chambon, Chair of the EURAMET EPM Committee, during her visit to Vilnius.



FTMC signed a **MEMORANDUM OF UNDERSTANDING (MoU)** with the prestigious Finnish state research centre **VTT TECHNICAL RESEARCH CENTRE OF FINLAND** to develop a partnership in the field of quantum technologies. The idea for this cooperation originated during an initial visit, when a delegation from the Lithuanian quantum technology association Quantum Lithuania met with representatives of VTT in Finland. "We look forward to turning this MoU into concrete steps soon. We see strong potential in various areas such as collaboration between Chip Competence Centres, joint work in metrology, and possible European Defence Fund (EDF) projects," said FTMC Director Prof. Dr. Ramūnas Skaudžius.



In 2025, FTMC also signed a **MEMORANDUM OF UNDERSTANDING** with the **LEIBNIZ INSTITUTE FOR CATALYSIS (LIKAT)** – one of Europe's leading scientific institutions specialising in catalysis. We welcome this significant step towards strengthening bilateral cooperation and hope that the MoU will mark the beginning of sustainable, science-driven partnerships between Lithuanian and German research institutions.



On the final day of the EcoBalt conference, FTMC welcomed an enthusiastic group of – hopefully – future scientists from all over Lithuania. The occasion was the finale of the student engineering competition **“VĖJUOTOS MINTYS: VĖJO JĖGAINIŲ IŠŠŪKIS”** (“Windy Ideas: The Wind Turbine Challenge”).

The competition welcomed students from grades 9–12, who were challenged to build a working wind turbine model in real time using the materials provided – and one of their own – and to generate enough energy to light a bulb.

We are delighted that a total of 51 students from 17 teams participated in the first competition organised by FTMC, Vilnius University Faculty of Chemistry and Geosciences and AB Ignitis Group.

Congratulations to the winners – the team from Klaipėda Ažzuolynas Gymnasium – and to all participants. We can’t wait to see you back again!



During the *“Open Readings”* conference in Vilnius, the finale of the first national school students’ crystal growing competition **“AUK₁”** took place.

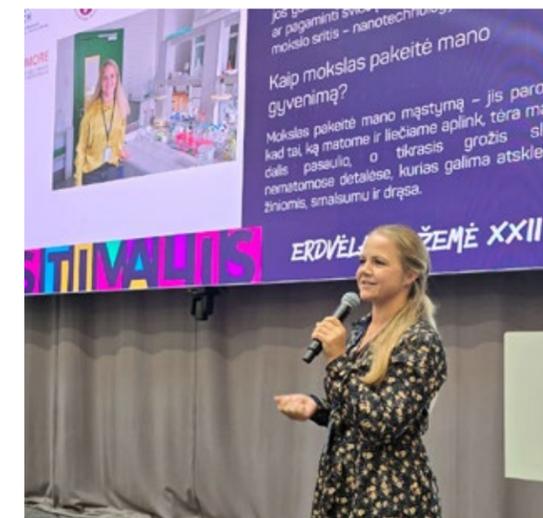
Organised by FTMC, the event attracted great interest, with dozens of crystal samples submitted by students from schools across Lithuania. Following a multi-stage evaluation, the jury selected winners in two age categories based on crystal mass, symmetry, quality, and documentation.

In the Grades 9–12 category, first place was awarded to a team from the Marijampolė Regional STEAM Open Access Centre. In the Grades 6–8 category, first place went to Vilnius St. Christopher Pragymsium. Congratulations to the young talents!



A growing question in public discourse is whether Lithuania is prepared to defend itself against hostile drones. FTMC scientists are working to address this question, now with a unique opportunity: they have received a Russian drone “Gerbera”, transported from the battlefield in Ukraine, for in-depth research. The drone was handed over to FTMC through the initiative of NGO **BLUE/YELLOW**, which supports Ukraine.

FTMC believes that studying this unmanned aerial vehicle (UAV) will deepen understanding of how such systems operate and help develop technological solutions to counter hybrid threats in the future. “This is more than scientific curiosity – it’s our contribution to national security. By understanding enemy technologies, we become stronger,” said Dr. Reda Nausėdaitė, FTMC Deputy Director for Innovation and Development.



For the 22nd time, Lithuania hosted its largest science communication festival, **“ERDVĖLAIVIS ŽEMĖ”** (“SPACESHIP EARTH”), held nationwide. FTMC also participated, offering visitors seven engaging events.

Our scientists gave presentations in their laboratories on tissue engineering, laser technologies, and the potential applications of spectroscopy. The largest number of young participants was attracted by the two-day **FTMC QUANTUM FORUM**, organised by Dr. Mažena Mackoit-Sinkevičienė, where physicists and chemists from FTMC presented their research in quantum technologies.

School pupils also actively participated in the **FTMC QUANTUM TIC-TAC-TOE CHAMPIONSHIP**. Using specially designed “coins”, players experienced how quantum rules operate and explored the differences between the classical and quantum worlds of this popular game.

Over the two days, the Forum and Championship drew over 200 participants!

LASER-PRO Project: Building a European Advantage in High-Precision Photonics

In January 2025, FTMC, together with partners from Lithuania, the Czech Republic, and Ukraine, launched the LASER-PRO (Excellent Laser Technologies for the Sustainable Prosperity of Europe) project. The consortium is jointly coordinated by the Czech HiLASE Centre and FTMC.

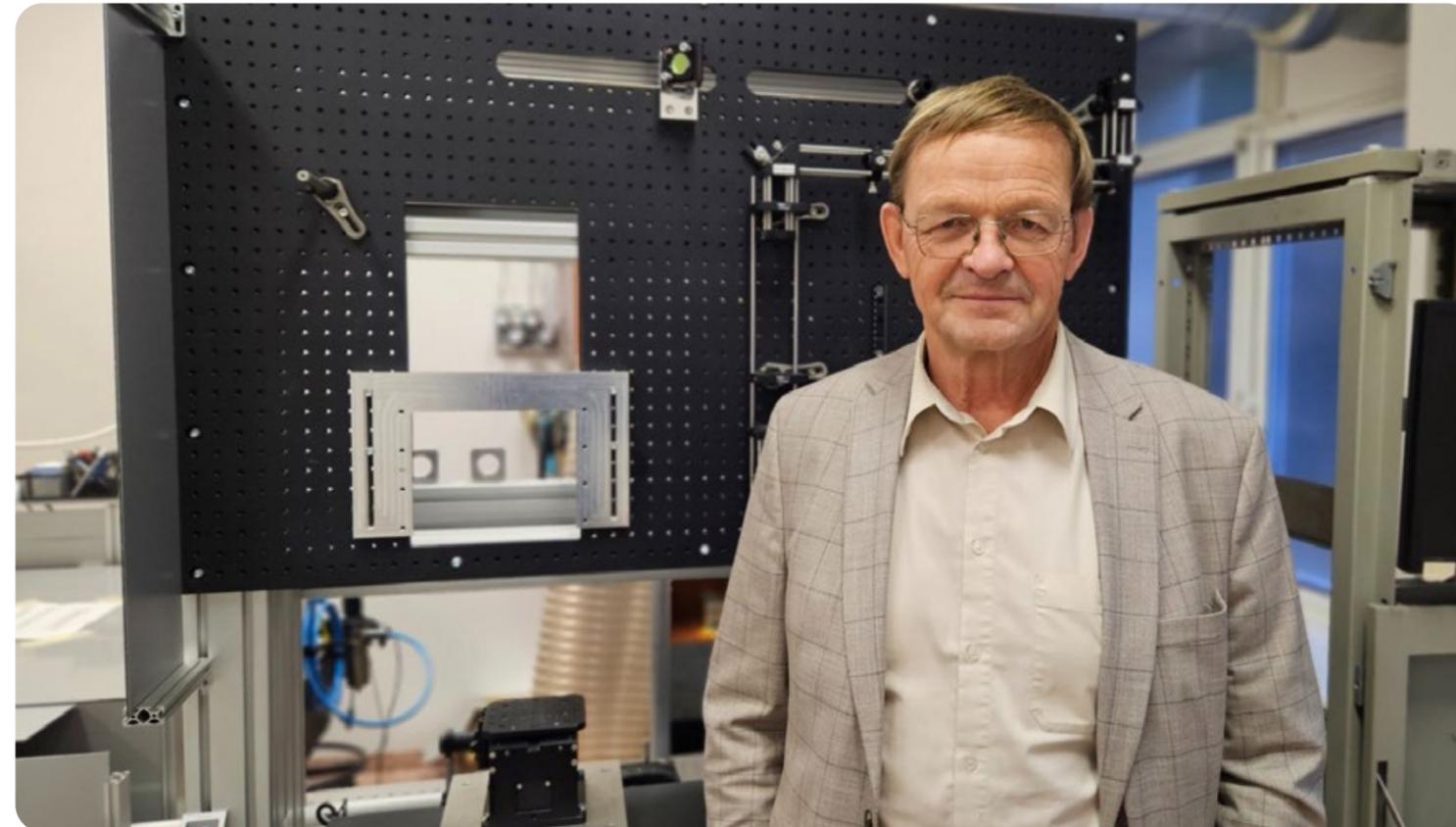
“This is an excellent opportunity to enter the Czech industrial market – not just for the FTMC Department of Laser Technologies but for the entire Lithuanian laser ecosystem. At the same time, Lithuania is of great interest to our Czech partners, who are eager to learn from our experience,” says FTMC LASER-PRO project manager Dr. Gediminas Račiukaitis.

The project partners have set ambitious goals: to unite leading research institutions, industrial pioneers and ambitious startups to build a world-class innovation ecosystem that drives economic growth, reinforces Europe’s position in photonics and deep technologies, and accelerates the green and digital transformation.

LASER-PRO research areas:

- Sustainable manufacturing
- Semiconductor industry
- Biomedical innovations
- Digital & 3D printing

The Czech Republic and Lithuania represent European regions where researchers in photonics and laser technologies are internationally recognised, and where businesses generate high added value. The strong collaboration between science and industry is intensive and development-driven, creating significant potential for the establishment of new companies. This environment provides opportunities to build a next-generation laser-based industry and to develop more integrated, high-performance solutions.



In this context, the Excellence Hubs initiative offers a unique opportunity to link two laser-driven innovation ecosystems and to foster a strong culture of innovation in both the Czech Republic and Lithuania. The project partners are also working to support the development of a laser ecosystem in Western Ukraine.

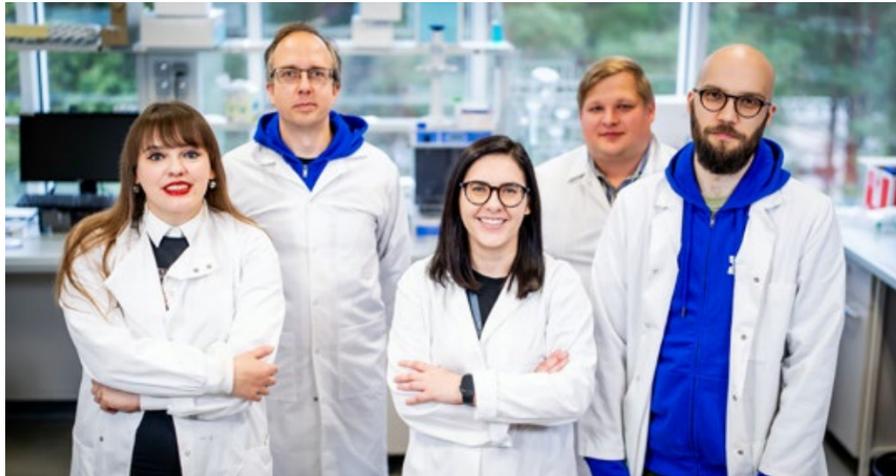
Through initiatives such as developing a joint R&D strategy, carrying out collaborative research projects, preparing coordinated action and investment plans, and promoting mutual learning and skills development, the project strengthens links among science, industry, public authorities, and society. As a result, a sustainable R&D ecosystem is taking shape in the advanced field of lasers and their applications.

The LASER-PRO open calls provide Lithuanian industry with the opportunity to experiment with and test new product ideas using laser technologies, as well as to manufacture end-products with comprehensive financial support. Participating companies gain access to world-class equipment and expertise while integrating into a broader European innovation network. This approach not only reduces financial risk and enhances market readiness.

During its first year, the project validated its scientific directions, strengthened cross-border collaboration through the Excellence Hub framework, and defined clear pathways for industrial uptake and societal impact. In November 2025, the Lithuanian Laser Association and the Czech Optical Cluster signed a Memorandum of

Understanding. This agreement opens new opportunities for developing the photonics ecosystem, exchanging knowledge and best practices, and transferring innovation. These outcomes directly support FTMC’s strategic objectives of advancing photonics technologies and increasing their societal impact.

In 2025, as part of the LASER-PRO project, the UPLAMP Summer School was held – an international educational program that brought together students, young researchers and world-renowned experts in the field. Participants had the opportunity to share knowledge and experience on advanced laser technologies, particularly the use of ultra-short pulse lasers in material processing. The event also fostered international networking within the global photonics community.



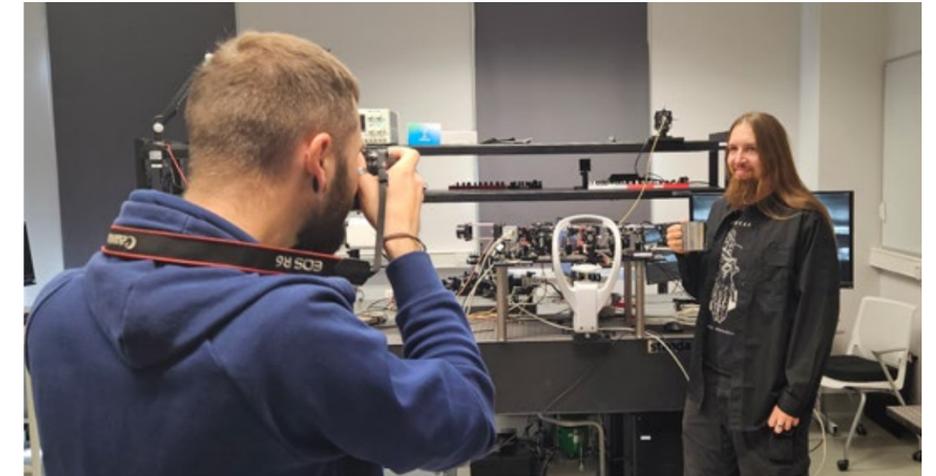
FTMC SCIENCE AMBASSADORS – Dr. Mažena Mackoit-Sinkevičienė, Dr. Vytautas Jakštas, Dr. Raimonda Bogužaitė, Dr. Vladislovas Čižas, and Dr. Vincentas Mindaugas Mačiulis – visit schools across Lithuania, engaging pupils with the fascination of the natural sciences.

But how can students be inspired when these subjects often seem challenging? Our ambassadors do it through hands-on experiments and interactive activities. They have developed their own learning kits, which pupils can explore directly in the classroom. Through this initiative, FTMC contributes to the advancement of STEAM initiatives, helps strengthen pupils' competencies in the natural sciences, and introduces them to the everyday work of scientists.



FTMC researchers do not just work in their laboratories. They also share their discoveries and insights with the wider public. The most active ones are physicists **DR. MAŽENA MACKOIT-SINKEVIČIENĖ** and **DR. KASTYTIS ZUBOVAS**.

Mažena runs her own YouTube channel, aptly named “Mažena Mackoit Sinkevičienė”, where she makes fascinating physics topics accessible and engaging. Kastytis shares his insights weekly on “Mokslo sriuba” (“Science Soup”), Lithuania’s most popular science podcast, discussing the latest developments in astrophysics. He also maintains his own blog, “Konstanta-42”, and publishes science articles online.



What are the most common myths about radiation? How can a next-generation laser system help diagnose eye diseases? What does a robot do in a chemical laboratory? And how could microlasers in watches help us monitor our health even more precisely?

FTMC scientists answer these and many other questions for journalists, appearing on internet portals, television, and radio programs. We are proud to share our expertise with the public and value every opportunity to **collaborate with the media!**





It has long been proven that physical activity boosts mental performance – and what better way to stay active than with colleagues?

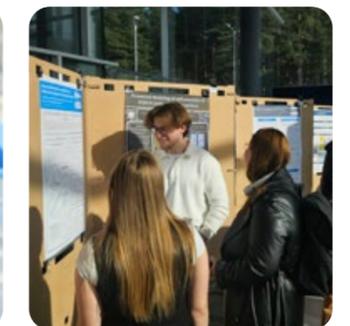
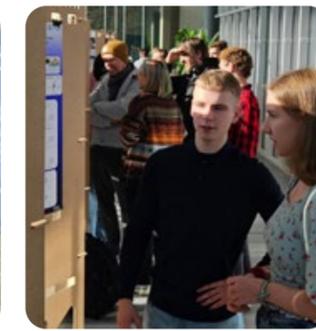
The FTMC Running Club, made up of our scientists and administrative staff, not only participates in sporting events like the Vilnius Marathon, but also organises them. Every autumn, winter and spring, the **FTMC CROSS** takes place in Vilnius, bringing together employees from research institutions across Lithuania.



The increasingly popular **FTMC CHESS TOURNAMENT** was held for the 6th time this year. It brought together FTMC scientists, representatives from other organisations and communities, and students. The tournament was initiated and founded by Linas Galkauskas, Dr. Žilvinas Ežerinskis, and Dr. Milda Tamošiūnaitė-Survilienė.

Played according to the FIDE rapid chess rules, the tournament rewards the 15 best-performing participants not only with prizes from FTMC but also with a chance to play a simultaneous exhibition match against chess grandmaster and informal tournament patron Viktorija Čmilytė-Nielsen.

We are delighted that this tradition continues to bring together and strengthen the Saulėtekis Valley community!



DEPARTMENT OF LASER TECHNOLOGIES

The Department of Laser Technologies focuses its research on optics, lasers, laser technologies and additive manufacturing. Our researchers have been active in their fields on structural all-silica coatings, new laser developments, plasmonics, laser microprocessing technologies for various applications, laser-assisted selective metal plating, as well as participating in and organising international events. The research results are illustrated in the following pages.

Furthermore, we continue to be extremely active and successful in applying to Horizon Europe, Chips JU, European Defence Fund, NATO, EuroStars, and Lithuania-Taiwan research projects. The European Chips Act and defence initiatives open new opportunities.

SUINK and MakeCold are Horizon projects that we joined through the Hop-on scheme on sustainable electronics and additive manufacturing. The new LASER-PRO project was launched in 2025, enhancing collaboration among the Lithuanian, Czech, and Ukrainian laser ecosystems. We are leveraging this unique opportunity to formulate a strategic vision and roadmap not only for our department but also for the whole laser and photonics ecosystem in Lithuania.

The Lithuania Chip Competence Centre (ChipsC2-LT) is another project under the European Chip Act initiative, aimed at expanding our knowledge and experience in the semiconductor and electronics industry. As laser technology developers, we see a great opportunity to advance laser technologies for the semiconductor sector and to intensify collaboration across Europe and with Taiwan.

The interaction of ultra-intense laser beams with gas targets, leading to laser wakefield acceleration and X-ray generation, has been intensively studied in collaboration with researchers from leading European laser facilities through the H2020 projects Multiscan 3D and i.FAST, as well as via user calls at the ELI – Extreme Light Infrastructure. This research is being continued within the new Marie Skłodowska-Curie project EPACE.

The Department collaborates closely with colleagues from other departments at FTMC and with photonics companies in Lithuania and internationally, generating new ideas for joint projects and applications. Established partnerships with institutions and companies in Germany, France, the UK, Australia, South Korea, and Taiwan provide additional opportunities for research collaboration and knowledge transfer.

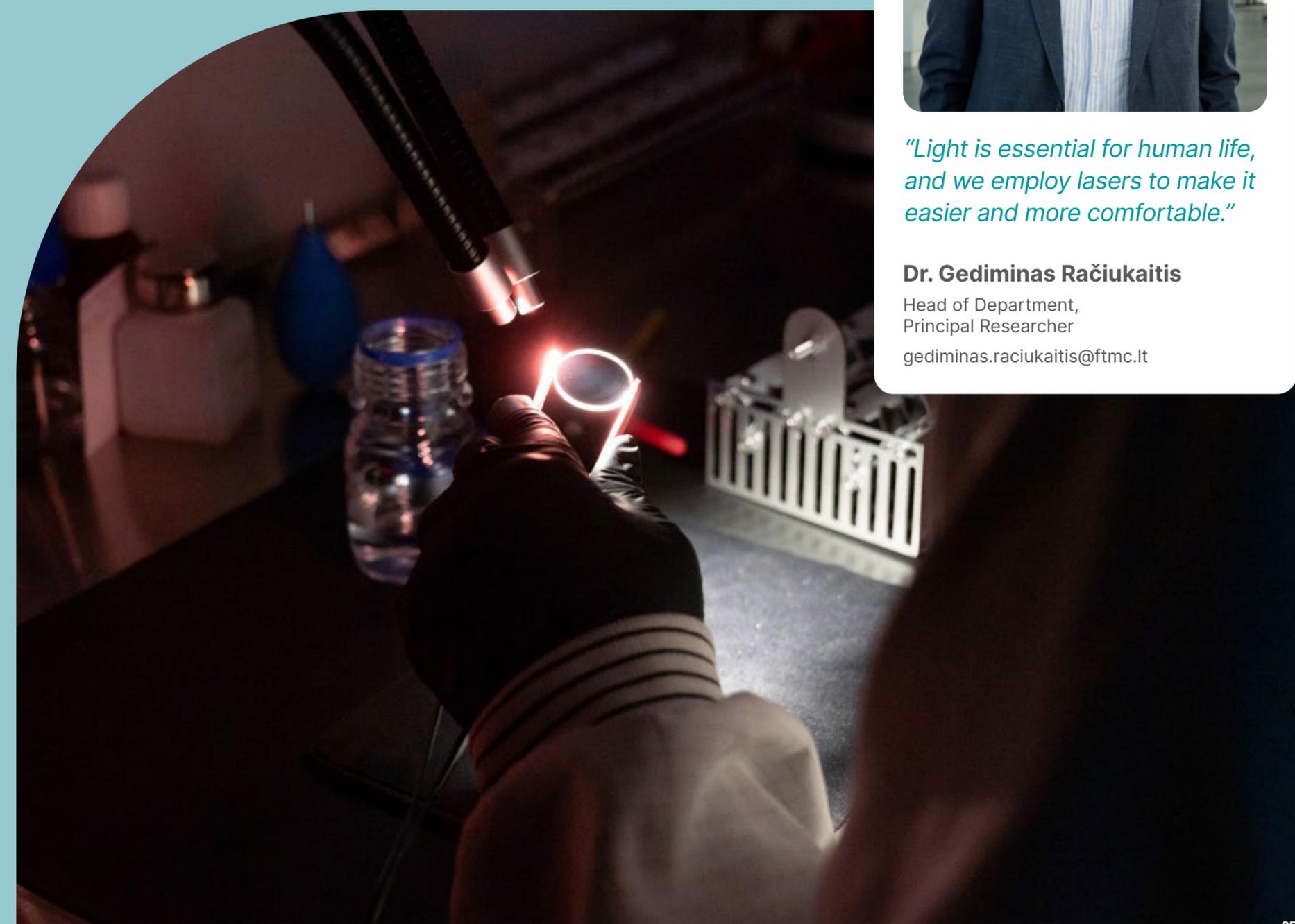


“Light is essential for human life, and we employ lasers to make it easier and more comfortable.”

Dr. Gediminas Račiukaitis

Head of Department,
Principal Researcher

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Double Fano Resonances in Nano-Modulated Thin Films for Frequency and Angular Filtering

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<https://doi.org/10.1016/j.optlastec.2025.113617>

Fano resonances in sub-wavelength-scale periodically modulated thin films are known to provide narrow transmission bandgaps in both the wavelength and incidence-angle domains. In this work, we demonstrate that the interplay of two nearby Fano resonances can generate extremely narrow frequency (or wavelength) high-pass bands in transmission, much narrower than the Fano resonances themselves.

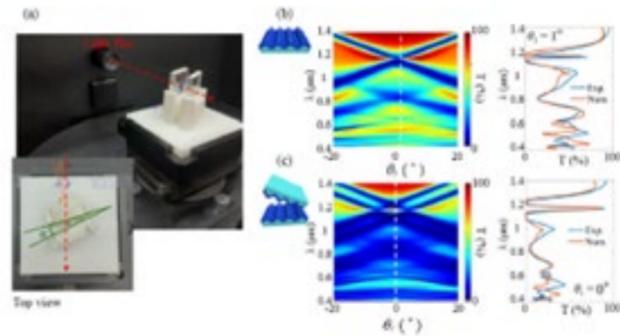


Fig. 1. (a) Images of the double-grating configuration used for the spectrophotometric measurements, (b) The transmission map for S-polarisation of a single grating structure.

Optical Coating Deposition on Submicron-Patterned Surfaces

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In this paper, we compare various thin-film deposition techniques, including electron-beam evaporation, atomic layer deposition, and ion-beam sputtering, to evaluate their ability to control multilayer coating growth on periodically modulated substrates. Our study demonstrates that both single-layer and multilayer coatings produced by ion-beam sputtering effectively replicate the initial geometry of structured surfaces, thereby enhancing the optical performance of the element.

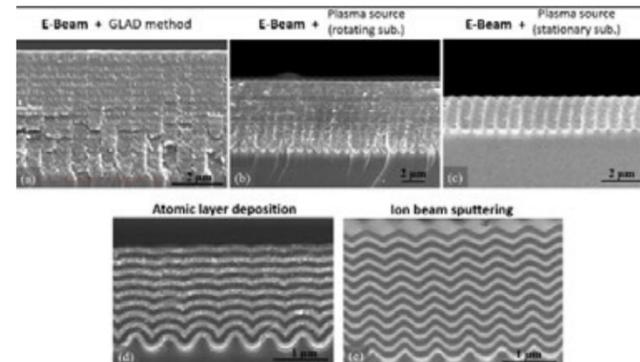


Fig. 2. The deposition of multilayer coatings on a patterned substrate using different technologies.

Enhancement of Total Internal Reflection in Nd:YAG Crystals by Multilayer Nanostructured Coatings

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<https://doi.org/10.1016/j.optlastec.2025.112807>

Total internal reflectance (TIR) depends on the refractive index ratio on each side of the interface. Enhancing its angular range is challenging in YAG laser systems due to the low index of the gain material. By employing a nanoengineered multilayer stack of silica formed by the glancing-angle deposition (GLAD) technique, we can increase the TIR angle to as low as 46 degrees. Additional spectral requirements for the designed cavity mirrors are needed, which can be achieved by depositing standard ion-beam sputtering (IBS) coatings on top of porous structures. Such a procedure adds additional difficulties, as the nanostructures are relatively mechanically weak and may be suppressed.

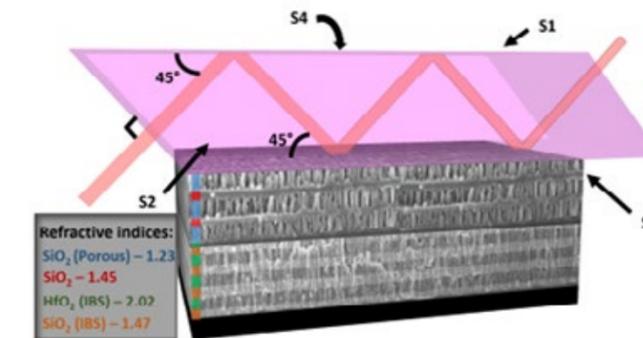


Fig. 3. Principal scheme of the YAG crystal. S1 is the top side, where the pumping laser is directed, S2 and S4 sides are covered with thermal paste for cooling, and S3 is coated with a hybrid coating for TIR.

A Breakthrough Method for Advancing Femtosecond Lasers into the Elusive Mid-IR Range

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<https://doi.org/10.1016/j.optcom.2025.132209>

Mid-IR femtosecond lasers pose challenges for the creation of coherent X-ray and THz radiation sources and particle accelerators. A nonlinear optical method developed at the Solid-State Laser Laboratory extends the spectrum of femtosecond lasers into the hard-to-reach mid-IR range, reaching $\sim 3 \mu\text{m}$ and beyond. It combines optical parametric chirped pulse amplification (OPCPA) with highly transient stimulated rotational Raman scattering (SRS). The essence of the method lies in the creation of a phonon “lake” in a Raman-active medium under the influence of high-intensity signal and idler pulses, which then trigger highly efficient cascade transitions into the mid-IR range.

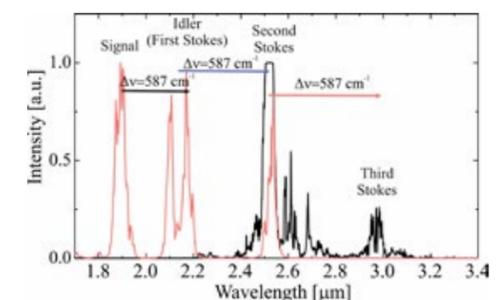


Fig. 4. Normalised output spectra from a $\sim 60 \text{ cm}$ (red line) and $\sim 40 \text{ cm}$ (black line) hydrogen cell at 6 MPa. Arrows indicate the Stokes shift at 587 cm^{-1} .

High-rate Stainless Steel Laser Colouring with GHz Femtosecond Bursts

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Laser colouring offers distinctive and highly desirable advantages, making it suitable for a wide range of industrial applications. In this study, using femtosecond pulses in GHz burst mode, we achieved colouring rates of up to 42.5 mm²/s and produced a variety of colours, including blue, purple, orange, yellow, and dark green. The dependence of the resulting colours on the number of pulses within the GHz burst, and the beam-scanning speed was investigated. Additional influencing parameters, such as MHz burst, Biburst configuration, hatch distance, number of scan repetitions, and laser frequency, were also examined. The coloured surfaces exhibited hydrophobic properties, further enhancing their potential applications. Both the colouration and hydrophobicity demonstrated long-term stability.

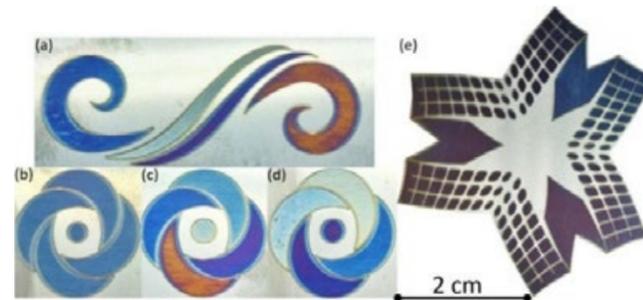


Fig. 5. Laser-coloured patterns produced on a stainless-steel sample: a) two half circles with two wavy lines; b-d) floral patterns; e) FTMC logo.

The Ultrafast Burst Laser Ablation of Metals: Speed and Quality Come Together

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The use of high-power ultrafast lasers in ablation-based industrial processes, such as milling, drilling, and cutting, demands both high productivity and superior quality. In this work, we demonstrate highly efficient, rapid, and precise laser micromachining of three key industrial metals: aluminium, copper, and stainless steel. Our proposed optimisation strategy, based on the temporal division of pulse energy, enables simultaneous improvements in ablation efficiency and ablation rate while maintaining a tightly focused laser beam and high spatial resolution. Experiments were conducted using an advanced femtosecond burst laser that generates pulses with $\tau = 350$ fs and an intra-burst repetition rate of $fP = 50$ MHz. The use of burst mode enhanced material removal efficiency and ablation rate by 18.0%, 44.5%, and 37.0% for aluminium, copper, and stainless steel, respectively, compared to the best single-pulse performance.

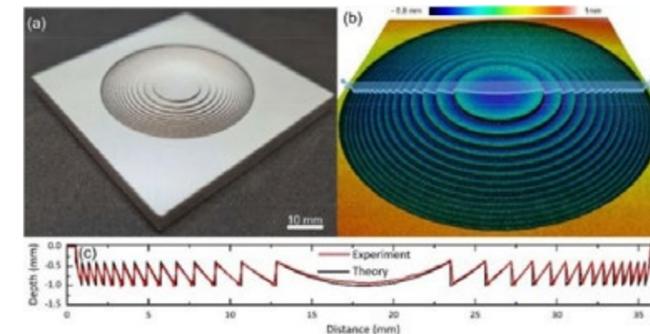


Fig. 6. Efficiently laser-milled aluminium Fresnel lens mould (diameter 35 mm): (a) optical photograph; (b) 3D height map; and (c) 2D profile from the middle of the structure.

Ultrafast Soda-Lime Glass Scribing via Self-Filamentation of Laser Bursts

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<https://doi.org/10.1016/j.jmapro.2025.06.047>

A laser burst-in-burst regime is used to form volumetric polarisation-controlled cracks in soda-lime glass via self-focusing. The volumetric modifications are exploited for scribing 1.1 mm-thick soda-lime glass. The distance between the modifications and, thus, the scribing speed were increased by aligning the cracks along the scribing line, achieved by positioning the polarisation perpendicular to it. Stable separation of the samples scribed at speeds up to 10 m/s was achieved using a galvanometric scanner and a telecentric f-theta lens system. To the best of our knowledge, we demonstrated the fastest glass scribing speed recorded to date.

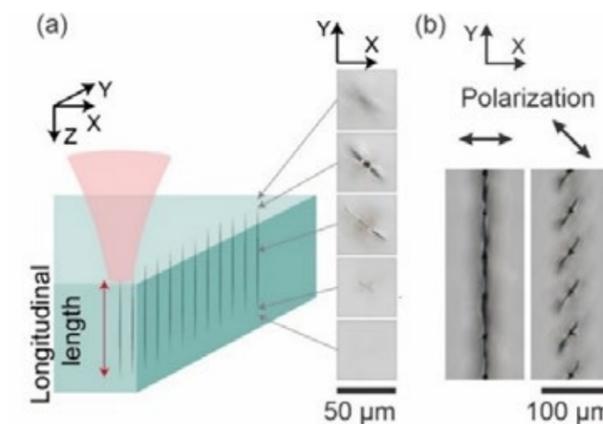


Fig. 7. Volumetric modification formation (a) and polarisation impact on scribing (b).

Transparent Microscale Electrodes Formed by Laser-Induced Metal Deposition in Combination with Electrochromic Layers on Glass for Smart Windows Application

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<https://doi.org/10.1016/j.optlastec.2025.113669>

Transparent conductive electrodes play a vital role in electrochromic smart windows, which help reduce energy consumption by regulating light transmission. Using Selective Surface Activation Induced by Laser (SSAIL), we developed a scalable approach to fabricate copper microscale electrodes directly on glass substrates. The electrodes can be formed with fs- or ps-laser pulses and typically feature widths of just a few micrometres. They exhibit low resistance (around 0.8 Ω) and high optical transparency (approximately 85% at 600 nm). Several electrode designs were explored and tested with PEDOT:PSS polymer and a LiClO₄ electrolyte for smart window applications. The results demonstrate that SSAIL-fabricated copper electrodes provide a sustainable alternative to conventional indium tin oxide (ITO), offering a cost-effective, flexible, and environmentally friendly solution for next-generation smart window technologies.

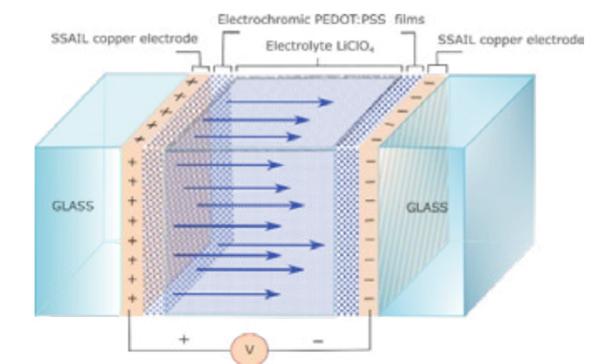


Fig. 8. Battery-type electrochromic smart window scheme.

High-Quality Grating-Coupled Surface Plasmon Resonances in Silver and Gold Bump Arrays Fabricated in Thin Metallic Films Using the Third Harmonic of a Femtosecond Laser

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<https://doi.org/10.1016/j.apsusc.2025.164127>

In this work, we demonstrate that a laser-based method can create highly ordered plasmonic structures with a period of about 550 nm on thin silver and gold films. These structures are shown to produce strong, high-quality optical resonances, often surpassing those achieved with gold nanoparticle arrays fabricated by lithographic techniques. Although silver typically exhibits better plasmonic performance due to lower damping and higher interband transition energy, gold bump arrays can generate resonances of comparable or even superior quality when the bump morphology and spacing are optimised. This reveals that resonance quality is influenced not only by the choice of material but also by the precise shape and arrangement of the laser-formed bumps. It is further observed that silver bump arrays support resonances at wavelengths below 500 nm, while gold arrays do not, due to higher interband losses in gold for wavelengths below 600 nm. Nevertheless, low-loss plasmonic features can be formed in both metals using this laser-based technique. Overall, the method's versatility opens new possibilities for developing more efficient biological and chemical sensors, plasmonic lasers, optoelectronic components, SERS substrates, and catalytic platforms.

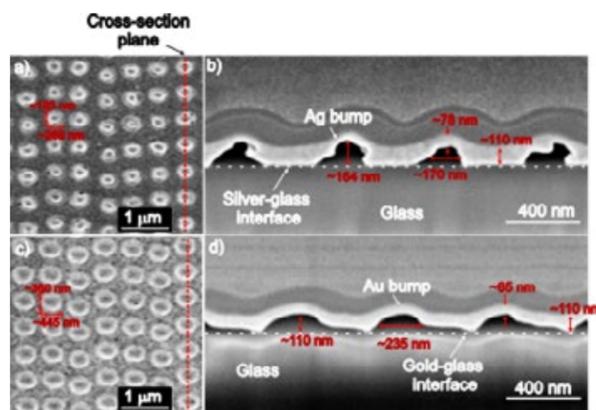


Fig. 9. Top views (a, c) and cross-sections (b, d) of silver and gold bumps. The cross-section micrographs were taken with a thin layer of platinum (dark area over the bumps) for better contrast at a sample tilt angle of 54°. Red dashed lines in (a) and (c) show the cross-sectional plane.

PIC Simulation of Wakefield Generation and Electron Acceleration in Underdense Plasma by a TW Few-Cycle Laser Pulse

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<https://doi.org/10.1007/s11082-025-08402-x>

This work investigates electron acceleration in underdense plasma driven by a terawatt few-cycle (8 fs) laser pulse using a tailored trapezoidal density profile and external electron injection. The study employs 2D quasi-static PIC simulations with the Wake-T code to analyse wakefield generation, beam dynamics, and phase-space evolution. The results show strong relativistic self-focusing of the laser pulse, which enhances the wakefield amplitude and improves electron trapping. An externally injected 150 MeV electron bunch is efficiently accelerated to energies exceeding 500 MeV. The generated electron beam exhibits quasi-monoenergetic peaks with significantly reduced energy spread. The divergence of high-energy electrons is shown to be very low due to relativistic stabilisation. Momentum spectra reveal high longitudinal momentum with minimal transverse components, confirming excellent beam quality. The laser field snapshots demonstrate increased amplitude at the plasma exit, indicating effective laser-plasma energy coupling. Analysis of the charge distribution confirms efficient trapping around specific energy ranges. Overall, the study shows that TW few-cycle kHz lasers can produce high-quality, well-collimated electron beams suitable for advanced applications such as free electron lasers and compact accelerators.

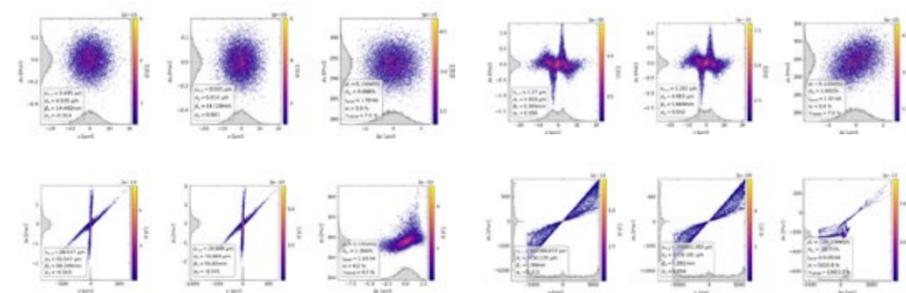
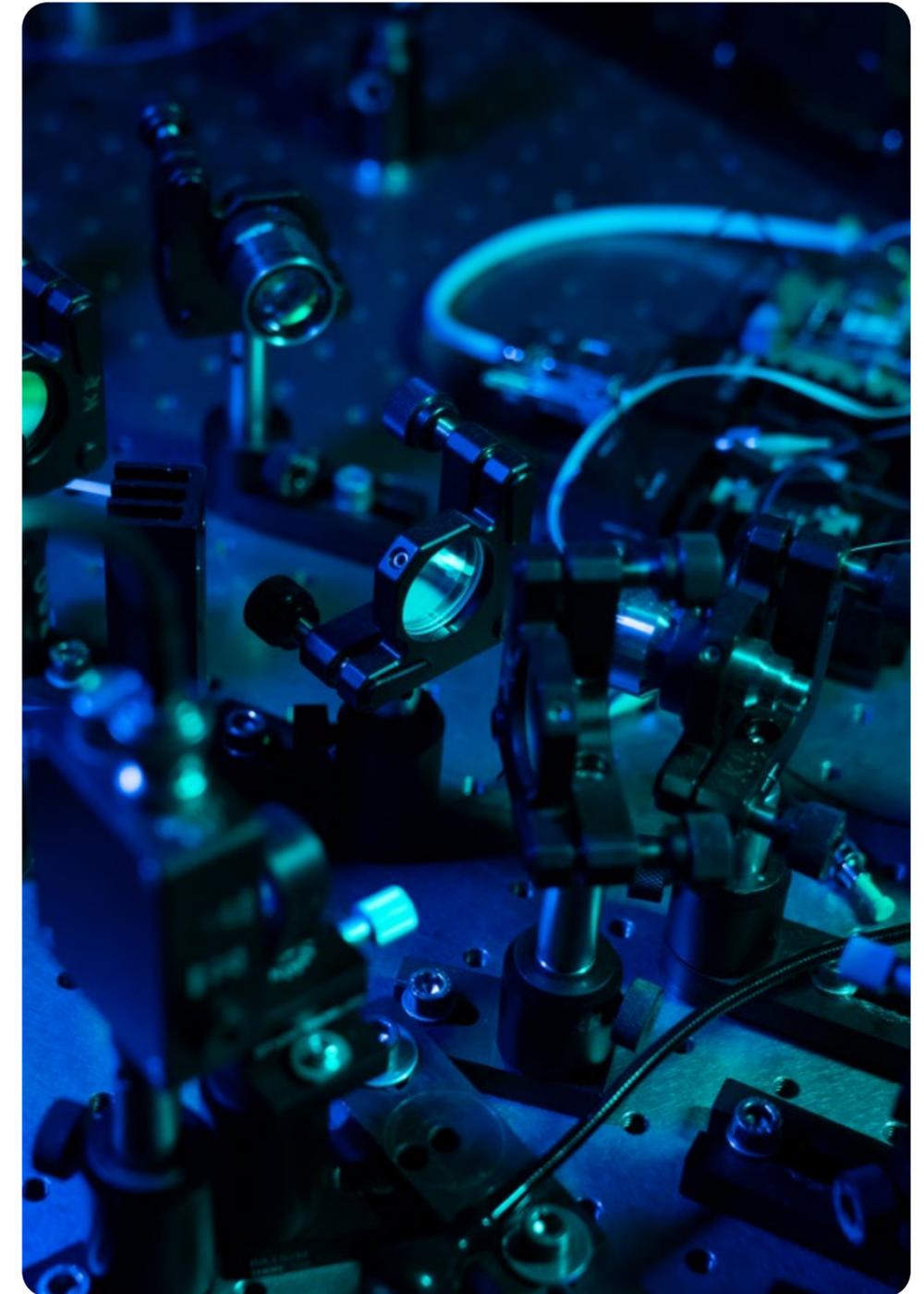


Fig. 10. Electron beam phase spaces (a, b) at the entrance and (c, d) exit of plasma.



Classical Top-Down Fused Silica Milling with a Femtosecond Laser Using Different Laser Pulse Burst Regimes

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<https://doi.org/10.1016/j.jmapro.2025.10.054>

Femtosecond lasers equipped with GHz bursts offer substantial flexibility in glass machining: burst modes provide high throughput, whereas single-pulse operation remains preferable for fine features requiring smooth surface finishes. In particular, GHz-burst and BiBurst (GHz burst in MHz burst) regimes enabled up to a 40-fold increase in glass ablation efficiency compared to the non-burst regime. This enhancement is associated with a shift from gentle ablation in the non-burst regime to a coarser, glass-fracturing mechanism that allows much faster material removal. However, this more destructive glass removal results in reduced surface quality, with the surface roughness S_a increasing by up to 40 times.

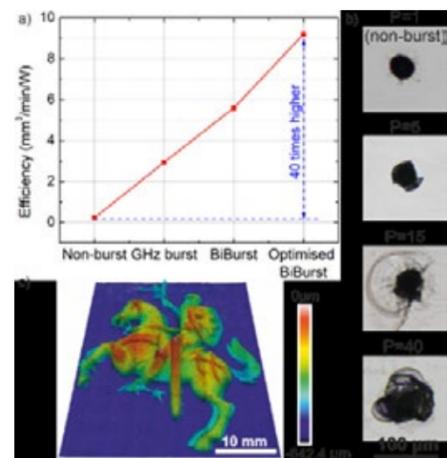


Fig. 11. (a) Ablation efficiency increases under burst regimes; (b) optical images of the craters formed on the glass surface reveal changes in the glass-removal mechanism; and (c) the topography of the coat of arms of Lithuania milled in a fused silica glass plate using the fastest BiBurst regime (ablation rate: 312 mm³/min). Letter P indicates the number of sub-pulses in the GHz burst.

Development of Continuous Fibre-Reinforced Polymer Composites Using In-Situ Co-Extrusion Towpreg Material Extrusion Process with Optimised Cooling and Evaluation of Their Mechanical Performance and Quality

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<https://doi.org/10.1016/j.jsamd.2025.100966>

In-situ co-extrusion using the towpreg process was employed to manufacture CCF reinforced composites using the FFF technique. The polymer composite fabricated with a layer thickness of 0.4 mm and a line width of 1 mm exhibited the highest tensile, shear, and compressive strengths of 364.69 MPa, 33.89 MPa, and 121.25 MPa, respectively, with a minimum porosity of 16.14 % and a reinforcement content of 26.12 % by volume. The research provides insights into how differences in printing settings affect the structural integrity, mechanical properties, and quality of composites, informing future optimisations to improve the performance and quality of 3D-printed thermoplastic composites. and 37.0% for aluminium, copper, and stainless steel, respectively, compared to the best single-pulse performance.

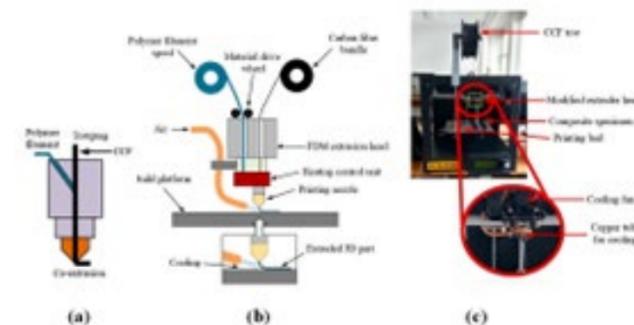


Fig. 12. Schematic of (a) co-extrusion with the towpreg process, (b) the designed FDM 3D printer, (c) the machine used for fabricating composite structures.

Comparative Study of AlSi10Mg and 304 Stainless-Steel Fillers in PA12 Composites Manufactured Using Injection Moulding Process for Liners and Sleeve-Based Applications: Microstructure, Mechanical Properties, Thermal Stability, and Wear Behaviour

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<https://doi.org/10.3390/polym17202785>

A laser burst-in-burst regime is used to form volumetric polarisation-controlled cracks in soda-lime glass via self-focusing. The volumetric modifications are exploited for scribing 1.1 mm-thick soda-lime glass. The distance between the modifications and, thus, the scribing speed were increased by aligning the cracks along the scribing line, achieved by positioning the polarisation perpendicular to it. Stable separation of the samples scribed at speeds up to 10 m/s was achieved using a galvanometric scanner and a telecentric f-theta lens system. To the best of our knowledge, we demonstrated the fastest glass scribing speed recorded to date.

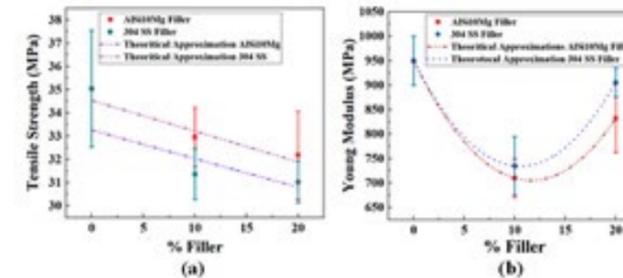


Fig. 13. Properties obtained for PA12 after incorporating metallic fillers; (a) tensile strength and (b) Young's modulus.

Physics of High-Charge Laser-Plasma Accelerators for Few-MeV Applications

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<https://doi.org/10.1103/PhysRevApplied.23.034033>

Laser-plasma accelerators are a promising technology for future compact acceleration systems, enabling the acceleration of tens of pC to above 1 GeV within just a few centimetres. The beam's average current is essential for future laser-plasma-based applications, such as three-dimensional X-ray tomography for cargo inspection. In this paper, we present experimental results on configurations that allow acceleration of electrons with energies up to a few MeV, charges of 5–30 nC and a maximum conversion efficiency of around 14 %. Our analysis indicates that most electrons are not trapped in a plasma wave; rather, they experience ponderomotive acceleration.

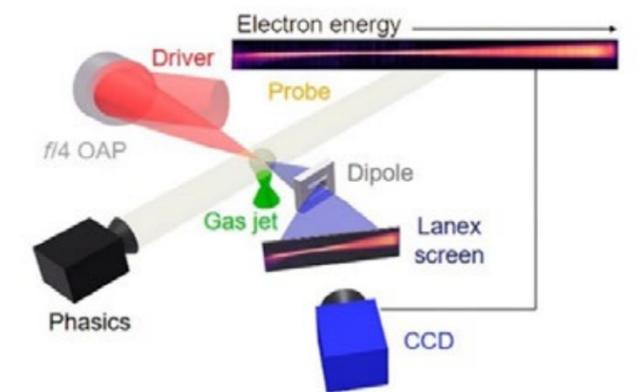


Fig. 14. Schematic representations of the experimental setup. The driver beam is focused using an f/4 off-axis parabola onto a supersonic gas jet. A transverse probe beam is employed to measure plasma density with the Phasics wave-front sensor. A magnetic spectrometer is used to measure electron charge and energy.

High-Quality Plasmonic Ag-Au Bilayer Nanobump Grating Sensor

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In this work, a single-step method is presented for fabricating a scalable bimetallic HLPR-based platform for liquid sensing. Glycerol-water solutions of varying concentrations are used to assess and characterise the platform's performance. The DLW-fabricated gratings, combined with an additional adhesion chamber, are compatible with standard spectrophotometers, allowing rapid measurement of spectral shifts caused by the tested fluids. With high sensitivity, stability, and repeatability, the platform is considered a strong candidate for practical sensing applications.

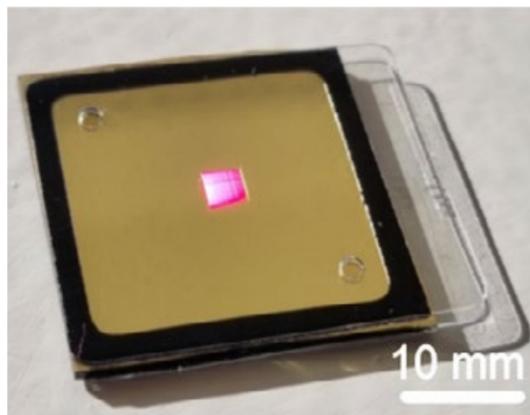


Fig. 15. AgAu bilayer nanobump grating sensor.

Plasmon-Exciton Polaritonic Emission Lifetime Dynamics under Strong Coupling

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<https://doi.org/10.1515/nanoph-2025-0129>

Plasmonics play an important role in the development of coherent light quantum nano-emitters for advanced optical sensing and integration in electronic circuits. Surface plasmons polaritons are coherent oscillations of free electrons. The contribution of resonant and non-resonant excitation conditions on the polariton decay dynamics of strongly coupled Rhodamine 6G (R6G) and Surface Plasmon Polariton (SPP) were studied. The fluorescence lifetime and back focal plane imaging techniques were implemented to study radiative polariton decay for resonant and non-resonant excitation conditions. The measured lifetimes cannot be explained without the influence of additional energy level in emission dynamics, such as incoherent transition from exciton reservoir to lower polaritonic branch. The fundamental understanding of coherent energy exchange dynamics has potential importance for development of quantum optical nanodevices, polaritonic lasers, polariton condensation.

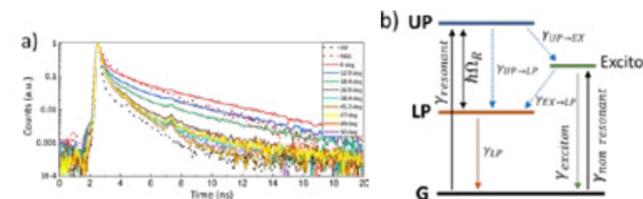
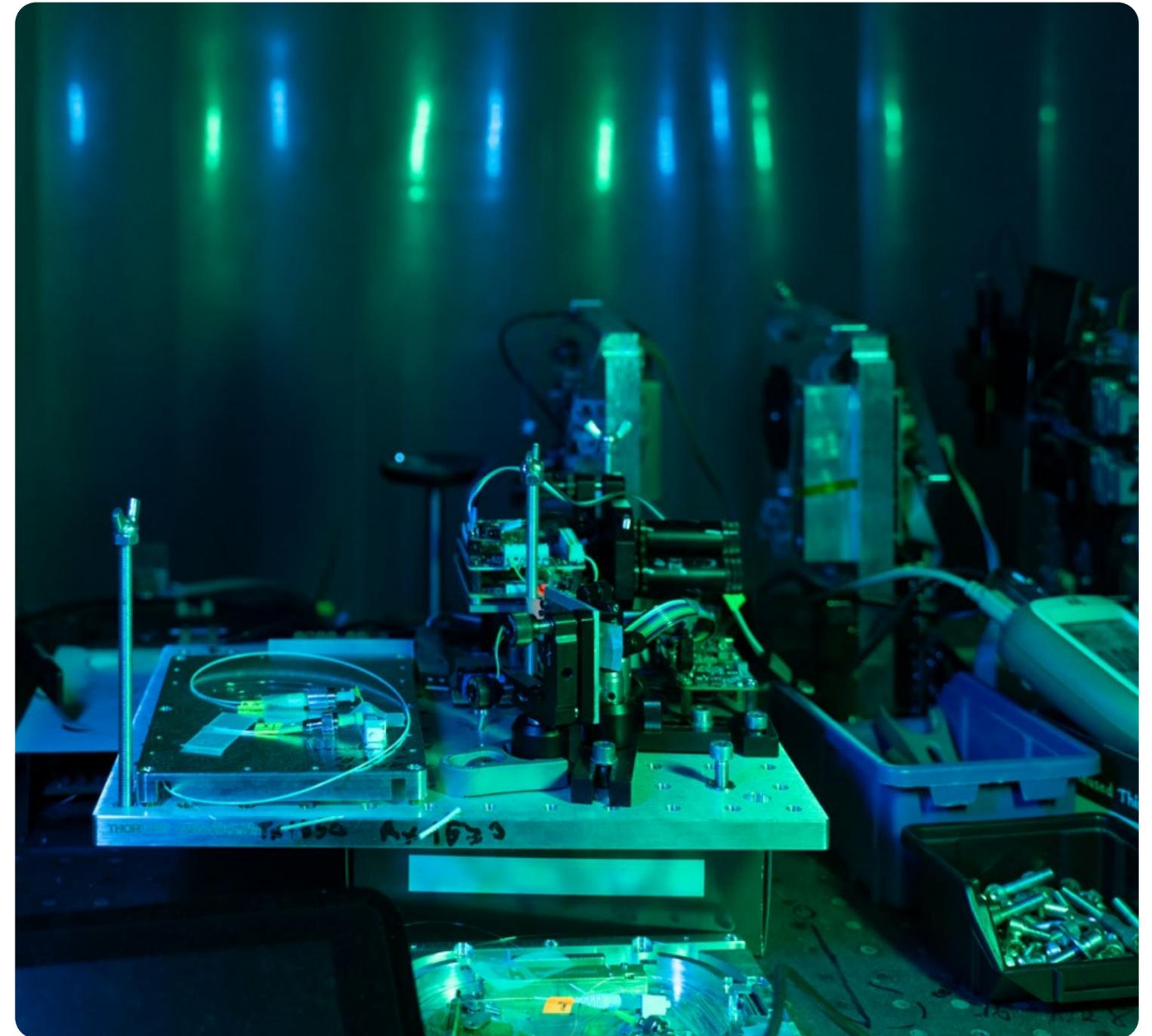


Fig. 16. a) Measured fluorescence decay curves of bare R6G-PMMA (red dotted curve) and in strong coupling regime with SPP for different angles of incidence (solid curves). b) Energy-level diagram of polaritonic emission decay pathways from the upper polariton state (UP) and the exciton reservoir (ER) upon resonant and non-resonant excitation.



DEPARTMENT OF OPTOELECTRONICS

The Department of Optoelectronics conducts fundamental and applied research in the fields of semiconductor material technology and physics, optoelectronic device fabrication, characterization, and quantum technologies. The department is equipped with modern semiconductor epitaxy equipment that enables the growth of novel material structures, such as group III bismides, the processing of wide-bandgap semiconductors, and the development of advanced optoelectronic devices operating in the infrared and terahertz (THz) frequency ranges.

The department's researchers perform a full range of optical characterization measurements of materials and employ advanced terahertz spectroscopy and imaging techniques to investigate the properties of new materials and device characteristics. The services of advanced Mueller matrix ellipsometry are provided for precise characterization of optical retarders, wave plates, and other polarization-modifying components, supporting both research institutions and industry partners. Spectroscopic ellipsometry and photo-modulated spectroscopy enable detailed characterization of the optical properties and electronic band structure of semiconductor materials and heterostructures. Research activities are carried out in laser additive processing of semiconductors and laser micromachining of metamaterials and nanoplasmonics, focusing on the development of integrated IR/THz components, novel photonic structures, surfaces, and components with artificially engineered optical properties.

The department uses its technological expertise to engineer structured electron gases and THz radiation tailored for specific imaging, telecommunication, sensing, and radar purposes. It also conducts research in quantum technologies, including the development and characterization of single-photon sources for quantum communications and electron spin-based quantum sensors, supported by single-atomic-defect confocal microscopy systems, time-correlated single-photon counting instrumentation, and coherent spin-control equipment for optically detected magnetic resonance. In addition, the department performs detailed characterization of infrared camera systems, enabling comprehensive evaluation of uniformity, noise characteristics, and overall imaging performance to support the development and reliability improvement of night-vision technologies. Overall, the department's activities cover the entire optoelectronic technology chain, from material growth and device fabrication to prototyping and implementation in various scientific and industrial applications.



"We transform scientific ideas into impactful technologies, bridging the terahertz and infrared domains through fundamental research, quantum technologies, and advanced optoelectronics."

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Simultaneous Transmission and Reflection Terahertz Homodyne Imaging System with Integrated Resonant C-Shaped Metalenses

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<https://doi.org/10.1021/acsp Photonics.4c01329>

This work presents an enhanced terahertz (THz) imaging system based on a homodyne detection scheme with integrated resonant C-shaped complementary split-ring resonator metalenses, specifically designed for 253 GHz frequency to address the imaging challenges posed by low-absorbing dielectric materials. The system provides significant improvements over conventional direct imaging techniques, offering simultaneous imaging in both transmission and reflection geometries, thus enabling a comprehensive evaluation of the relative absorption properties. The integration of complementary split-ring resonator metalenses allows for subwavelength resolution, enhancing image contrast and delivering over twice the dynamic range of 68 dB for homodyne and 30 dB for direct imaging. The performance of the proposed imaging system based on a homodyne detection scheme is compared with the hyperspectral THz time-domain spectroscopy, and its superiority over the conventional direct THz imaging technique is revealed.

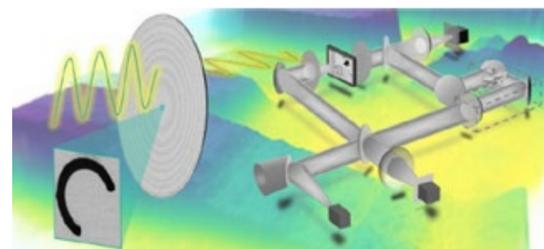


Fig. 1. Illustration of the metallic CSRR-based metasurface (on the left) and imaging setup of homodyne detection scheme (on the right) presented simultaneously in transmission and reflection geometries.

Asymmetric Phase-Split Axicon Masks for Improved Bessel Beam-Based Glass Stealth Dicing

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<https://doi.org/10.1016/j.optlastec.2024.112008>

The precision glass micromachining technology employing ultrashort laser pulses has reached a state of maturity. This technology enables precise drilling, cutting, or ablation of various types of glass, achieving accuracy up to a few microns. As laser sources continue to advance in average power and repetition rate, the efficient utilization of laser beam irradiation patterns becomes increasingly crucial. The Bessel beam, known for its ability to create elongated channels in transparent materials because of its invariant focal zone, gains significance in this context. The elongated focal zone of the Bessel beam proves advantageous for expeditious glass cutting, surpassing the efficiency of using a standard Gaussian beam. This study delves into the glass-cutting process by studying asymmetric phase-split diffractive axicon masks to generate such Bessel beams. For this purpose, geometric phase optical elements are created using transparent nanogratings inscribed in the volume of glass. This approach allows high-power asymmetric Bessel-like beams to be generated and experimentally used to investigate beam-shaping performance, ultimately determining the optimal parameter set for applications such as glass stealth dicing.



Fig. 2. Microscope images of the glass volume when 200 uJ pulse energy and 6 ps pulse duration were used in laser micro-processing. The orientation of the crack is consistent with the major axis of the elliptical spot of the beam (depicted by the dashed red line).

Imaging of Retinal Ganglion Cells and Photoreceptors Using Spatio-Temporal Optical Coherence Tomography (STOC-T) Without Hardware-Based Adaptive Optics

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The study shows that Spatio-Temporal Optical Coherence Tomography (STOC-T) can non-invasively reveal fine retinal structures in vivo that are normally difficult to detect with standard OCT currently used in hospitals. By combining wide-field illumination with reduced spatial coherence and controlled temporal modulation of the detected interference signal, the method suppresses speckle, reduces the effects of ocular aberrations, and achieves lateral resolution on the order of a few micrometres without hardware adaptive optics that is normally employed to cancel optical aberrations in the human eye. This allows volumetric datasets acquired in healthy eyes to reveal retinal ganglion cell bodies, their axonal bundles within the nerve fiber layer, and the cone photoreceptor mosaic. These structures - especially ganglion cells, which are nearly transparent - typically produce weak backscatters and are difficult to isolate from surrounding tissue. STOC-T improves their visibility by exploiting temporal fluctuations in the OCT signal to enhance contrast and distinguish cellular features from static background scattering. Access to ganglion cells and photoreceptors in vivo provides a pathway for studying early neurodegenerative processes, assessing photoreceptor integrity, and developing quantitative metrics for conditions such as glaucoma and retinal dystrophies. The approach therefore broadens the range of high-resolution retinal imaging techniques that are feasible for research and potential clinical translation.

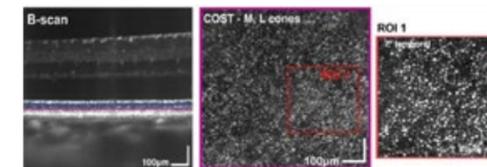


Fig. 3. Axial (left) and lateral (right) images of a human retina acquired in vivo. Axial image features various retinal layers, whereas lateral images show photoreceptors.

Near-Field Imaging and Hybrid Surface Plasmon-Phonon Polaritons in n-GaN semiconductor

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We have demonstrated for the first time near-field images and propagation dynamics of hybrid plasmon-phonon polaritons on surface of n-type GaN semiconductor by using a scattering-type scanning near-field optical microscope. The experimental results closely matched the numerical simulations, confirming long propagation distance of the hybrid polaritons required for practical applications in data transfer on a chip as well as the spectrally-selective and directional radiation emitters [EP4105693A1]. At an excitation of 920 cm^{-1} , the measured polariton decay lengths reached approximately 25 μm , while theoretical predictions indicated about 30 μm . For excitation at 570 cm^{-1} , the experimental decay length remained around 25 μm , whereas simulations yielded a significantly longer value of 105 μm —highlighting constraints imposed by the near-field microscope configuration. The resonant frequencies and damping rates of the hybrid polaritons revealed the need for further improvements in experimental capability. In addition, the conditions necessary to initiate near-field detection of the unusually high coherence of these surface plasmon-phonon polaritons were examined.

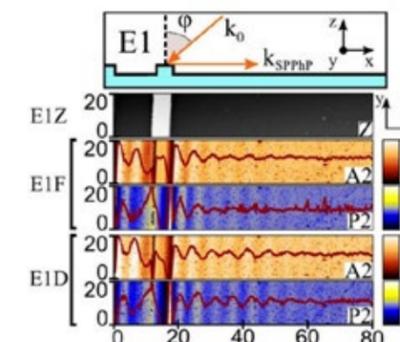


Fig. 4. The results of s-SNOM images at excitation frequency of 920 cm^{-1} demonstrating long propagation distance of the hybrid plasmon-phonon polaritons on surface of n-type GaN semiconductor.

Segregation-Driven Formation of Bismuth Quantum Dots in Parabolic GaAsBi/AlGaAs Quantum Structures

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<https://doi.org/10.1016/j.surfin.2025.106586>

This technological study explores the bismuth quantum dots (QDs) formation in GaAsBi using segregation mechanism as an alternative to Stranski-Krastanov method. The process was carried out via two types of annealing of gallium arsenide bismide quantum well structures with aluminium gallium arsenide parabolic barriers: in-situ annealing in a molecular beam epitaxy reactor (MBE) immediately after growth and ex-situ in a rapid thermal annealing oven. The two approaches could allow us to minimize density of defects related to Bi QDs and surrounding layers, thereby enhancing the efficiency of future devices. Results presented in this work indicate that the likely conditions for annealing temperature and time are around 700 °C and 180 s, respectively. Completion of the preliminary optimization of annealing procedure will allow us to avoid bismuth rich tails and increase photoluminescence intensity to a level suitable for applications in lasers.

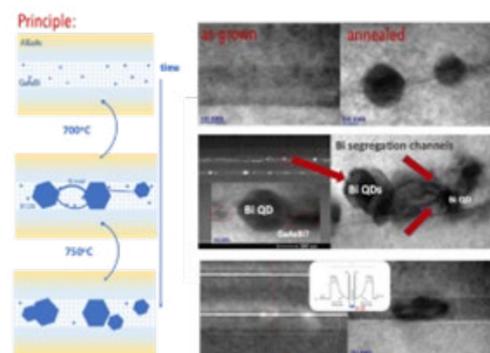


Fig. 5. Bismuth quantum dots formation in GaAsBi/AlGaAs parabolic quantum wells. Left: Principle of segregation mechanism using annealing in MBE reactor. Right: TEM pictures of as-grown and annealed quantum well structures (on the top). Middle images represent agglomeration of bismuth atoms to QDs with visual Bi tracks in the well (intermediate result) and bottom images show the formation of Bi QDs with dominating size of about 10 – 15 nm after incorporation of tunneling AlAs barriers to the parabolic QW structure.

Terahertz Tomography for Testing Wrapped Scintillating Crystals

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<https://doi.org/10.1016/j.radphyschem.2024.112176>

Terahertz time-domain spectroscopy (THz-TDS) is demonstrated to be effective in novel application, for 3D characterization of wrapped scintillator crystals in search of defects affecting the light-yeild of these crystals. This is of special importance for fast scintillators currently in demand to be exploited in high-energy physics experiments and medical imaging devices. Typical inorganic (GAGG:Ce) and organic (BC-408) scintillators wrapped in polytetrafluoroethylene (PTFE) and enhanced specular reflector (ESR) tapes have been studied. Time-of-flight information extracted from THz-TDS data reveals positions of the interfaces between the materials, wrapping thickness variations, and allows for the wrapping inspection with resolution better than a single layer, typically ~200 μm-thick, of PTFE, the currently most common wrapping material. The results are supported by the study of the properties of the wrapping materials in the THz range and evidence of the prospectiveness of THz-TDS technique as a novel tool for nondestructive inspection of wrapped scintillators.

Effects of Cationic Substitution on the Properties of Sb_{1-x}Bi_xSe (x = 0–1) Compounds

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<https://doi.org/10.1016/j.jallcom.2025.182292>

Pnictogen chalcogenide semiconductors are emerging materials with broad potential in energy-related applications, including solar cells, photocatalysis, photodetectors, batteries, supercapacitors, thermoelectric and piezoelectric generators. Their compositional flexibility allows fine tuning of structural and optoelectronic properties. In this study, microcrystalline powders of Sb_{1-x}Bi_xSe (x = 0–1) were synthesized from binary precursors by a solid-state method in evacuated quartz ampoules. Energy dispersive spectroscopy confirmed the successful substitution of Sb with Bi in Sb_{1-x}Bi_xSe. The formation of solid solutions was also supported by Raman spectroscopy and X-ray diffraction (XRD). All materials exhibited needle-shaped crystal morphologies and orthorhombic crystal structure (Pnma), expansion. Calculated lattice parameters (b and c) increased regardless of the Bi/Sb ratio. XRD patterns shifted toward smaller angles with increasing Bi content, indicating lattice linearly with Bi incorporation, while the lattice parameter (a) remained constant. Raman spectra exhibited characteristic peaks at 182 cm⁻¹ for Bi-Se vibration and 209 cm⁻¹ for Sb-Se vibration, with intensity ratios reflecting Bi content. UV-Vis-NIR diffuse reflectance spectroscopy revealed a direct band gap that decreased from 1.7 eV (SbSe) to 1.29 eV (BiSe). Room-temperature photoluminescence measurements exhibited a single emission band, shifting from 1.75 eV to 1.41 eV with increasing Bi content. Ultraviolet photoelectron spectroscopy indicated a shift in the valence band maximum from 0.44 eV (SbSe) to 1.1 eV (BiSe). These findings highlight the tunability of Sb_{1-x}Bi_xSe compounds, offering pathways for optimizing their properties for specific optoelectronic applications.

Emission Homogeneity in InGaAs Multiple Quantum Wells

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<https://doi.org/10.1038/s41598-025-17326-1>

High-quality InGaAs quantum wells are essential for efficient 976 nm VECSELs, but their optical performance can be strongly affected by strain-induced defects. We used large-area and micro-scale photoluminescence mapping to investigate how In content, QW thickness and barrier design influence emission uniformity in MBE-grown InGaAs/GaAs MQWs. Structures with uniformly thin GaAs barriers showed dense networks of dark, low-emission lines, especially at higher In content, revealing misfit dislocations caused by accumulated strain. By introducing an alternating barrier design, with thick GaAs layers separating QW pairs, we effectively suppressed strain build-up. These structures demonstrated fully homogeneous emission across the measured area, despite comparable nominal strain. This approach provides a simple and robust route to defect-free QW stacks for high-power 976 nm VECSEL applications, eliminating the need for complex strain-compensation schemes.

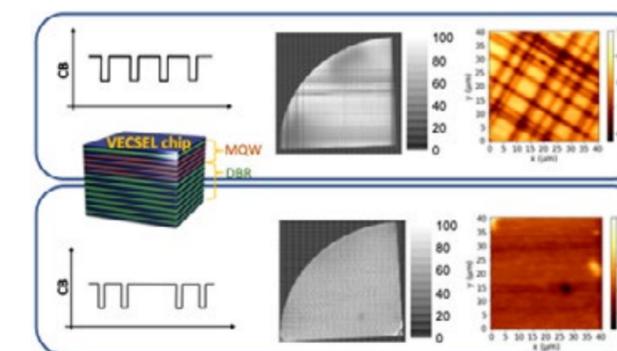


Fig. 6 Left: Schematic conduction-band profiles for MQWs with thin GaAs barriers (top), a VECSEL chip illustrating the active region and the distributed Bragg reflector (middle), and MQWs with alternating barrier compositions (bottom). Middle: Room-temperature PL maps of the two corresponding samples—InGaAs MQWs with thin barriers (top) and MQWs with alternating barriers (bottom). Right: Micro-PL maps of the same samples shown in the middle column.

Single-Pixel Terahertz Imaging with Enhanced Edge Detection Using Angular Momentum of Structured Light

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<https://doi.org/10.1063/5.0255550>

Structured light - electromagnetic waves with spatial inhomogeneity of amplitude, phase, and polarization - because of its fascinating ability to precisely control these properties, has garnered significant attention across various research fields. Interest is given to developing imaging systems where the requirement to increase image resolution, contrast, and ability to resolve tiny structures is of utmost importance. This task can be achieved well using single-shot imaging; however, it remains challenging to implement in conventional terahertz (THz) imaging systems using Gaussian modes. A single-pixel imaging scheme is more attractive for implementation in real operational conditions as it employs sophisticated schemes with single-pixel detectors to retrieve images. It was very recently determined that structured light illumination and image collection schemes are beneficial for various metrics in single-pixel THz imaging [S. Orlov et al., *Laser Photonics Rev.* 18, 2301197 (2024)]. This work introduces angular momentum in structured light illumination for THz image retrieval, demonstrating simultaneous enhancement of object edge detection while maintaining resolution and contrast. We investigated three experimental approaches at 253 GHz: a nonparaxial Fresnel zone plate, a THz vortex with a zone plate, and a THz Bessel beam with a vortex. The diffractive optical elements were fabricated by 3D laser printing, while silicon-based diffractive elements were prepared by laser ablation technology. Through comprehensive experimental studies supported by numerical modeling, we reveal distinct features of structured THz light induced by angular momentum. This approach establishes a new pathway for developing advanced single-pixel THz imaging systems that leverage the angular momentum of structured light, offering the foundation for future improvements in performance via enhanced edge detection and extended material characterization capabilities.

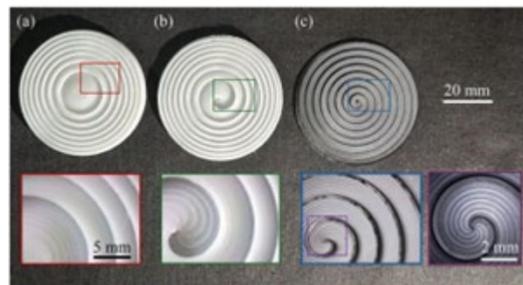


Fig. 7. Manufactured components: (a) nonparaxial zone plate quantized phase from HIPS, (b) nonparaxial zone plate and vortex phase combined and quantized from HIPS, and (c) Bessel axicon combined with vortex quantized phase from Si. The number of levels is $N = 8$, and the element diameter is $d = 50.8$ mm.

Carbon-Coated Moth-Eye Structure: An Ultrabroadband THz-DUV Near-Perfect Absorbers

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<https://doi.org/10.1002/adom.202500948>
<https://advanced.onlinelibrary.wiley.com/doi/10.1002/adom.70250>
<https://doi.org/10.1063/5.0288839>

These studies unveil a breakthrough material that can absorb over 98% of incoming light across an extraordinarily wide range - from low-energy terahertz waves all the way to deep ultraviolet radiation (frequency range from 1 to 1200 THz). Very few materials on Earth come close to this level of performance, the ultrabroadband absorbers, featuring laser-fabricated sub-millimeter-scale moth-eye structures coated with a 100-nm pyrolyzed carbon layer (PyC), resulting in efficient absorption of incident light. The moth-eye design provides a perfect impedance match with air via gradual change of the refractive index at low frequencies and simultaneously serves as a multiple scatterer at high frequencies while coating the moth-eye structure with PyC enables ultrabroad band absorption. The combination of the strong absorption in the PyC conductive film and moth-eye surface allows us to create a material capable of absorbing over 98% incident radiation across the entire spectrum. This makes this moth-eye/PyC structure a promising material for a wide range of applications, including energy harvesting, electromagnetic shielding, and the development of an ideal blackbody radiation source.

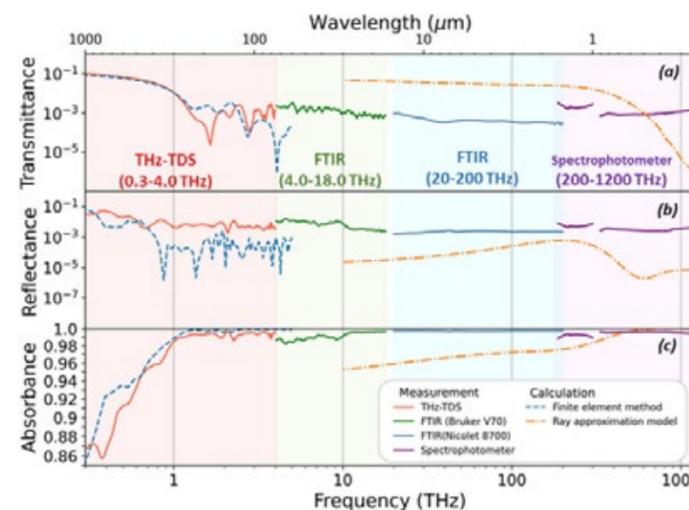


Fig. 8. The transmittance (a), reflectance (b), and absorbance (c) characteristics of the moth-eye/PyC structure in the frequency range of 0.3-1200 THz.

Improved Band-Structure Design in AlGaAs and GaAsBi Quantum Well Lasers for Biomedical Sensing

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<https://doi.org/10.3390/mi16050506>

We explore quantum well laser diodes for applications in pulse oximetry based on two material systems, namely, classical AlGaAs and a rather exotic GaAsBi, with lasing at around 800 nm and 1100 nm, respectively. These spectral regions and material families were selected due to their closely matched effective penetration depths into soft tissue. An improved design of the band structure of device active areas was tested on both material systems, yielding an enhancement of the two main parameters, namely, output power and threshold current. A maximum emission power of the AlGaAs laser diode was registered at 4.9 mW ($I = 60$ mA, $\lambda = 801$ nm). For the GaAsBi-based devices, the target emission of 1106 nm was measured in pulsed mode with a peak output power of 9.4 mW ($I = 3$ A). The most optimized structure was based on three GaAsBi quantum wells surrounded by parabolically graded AlGaAs barriers. This structure was capable of 130 mW peak power ($I = 2$ A, $\lambda = 1025$ nm) along with a more than tenfold decrease in threshold current to 250 mA compared to a classical rectangular quantum well active region.

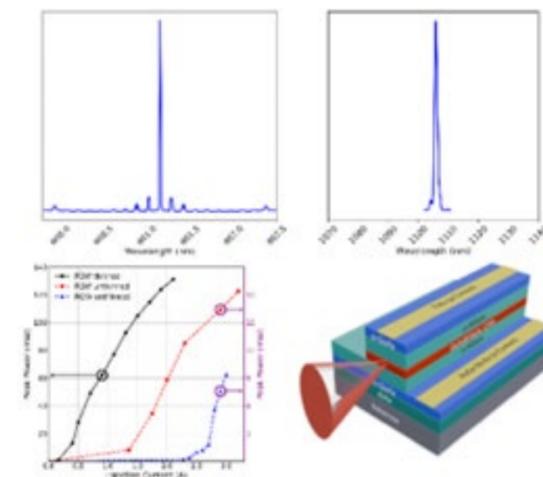


Fig. 9. Lasing spectra of AlGaAs-based (top left) and GaAsBi-based (top right) QW laser diodes. Comparison of lasing characteristics of rectangular and parabolic QW lasers (bottom left) and a cartoon sketch of a Fabry-Pérot laser diode.

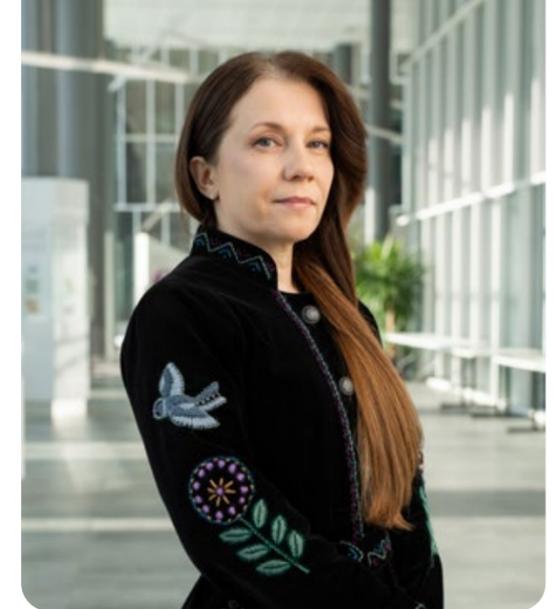
DEPARTMENT OF ENVIRONMENTAL RESEARCH

The Department of Environmental Research stands at the forefront of aerosol science in the Northern European and Baltic region. Internationally, the Department is distinguished for its long-standing excellence in atmospheric aerosol physics and chemistry, source apportionment, micro- and nanoplastic analysis, and aerosol measurement technologies. Through high-impact scientific contributions, breakthrough methodological innovations, and leadership in long-term atmospheric observation networks, the Department plays a decisive role in shaping contemporary understanding of air pollution dynamics and climate interactions. These measurement capabilities are complemented by machine-learning and data-driven modelling approaches accelerating the discovery of hidden atmospheric processes, improving the accuracy of air quality forecasting, and support the development of evidence-based environmental policy.

In parallel, the Department performs cutting-edge investigations of micro- and nanoplastics across diverse environmental media and clinical samples, uncovering their distribution, characteristics, and potential health implications. This includes the detection and physicochemical characterization in human tissues, comprehensive evaluations of removal pathways and efficiencies within wastewater treatment plants, and wide-ranging environmental monitoring of plastic pollution across riverine, coastal, and urban ecosystems, strengthened by both scientific and citizen-science methodologies.

OBJECTIVE. To develop and enhance principles, methods, instruments, and technologies for comprehensive environmental quality assessment, while advancing scientific excellence in atmospheric physics and chemistry, air pollution research, micro- and nanoplastic analysis, aerosol-climate interactions, and climate change studies.

TASKS. To develop and implement advanced environmental quality control technologies and instrumentation, including experimental platforms and analytical methods for studying aerosol chemical composition, micro-admixture dynamics, long-term trends, and their impacts on climate change.

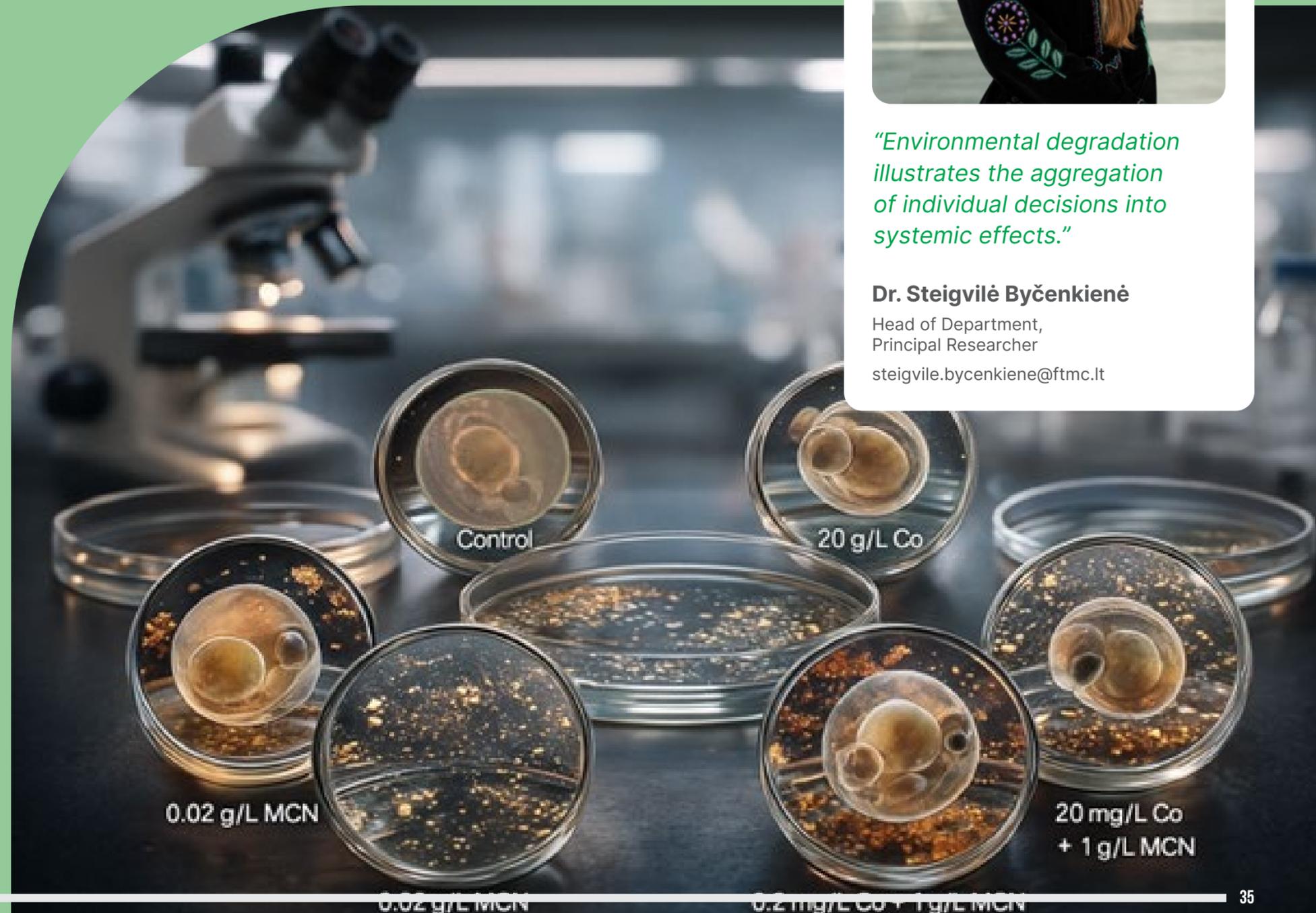


“Environmental degradation illustrates the aggregation of individual decisions into systemic effects.”

Dr. Steigvilė Byčenkienė

Head of Department,
Principal Researcher

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Evidence-Driven Indoor Air Quality Improvement: An Innovative and Interdisciplinary Approach to Improving Indoor Air Quality

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Indoor air quality remains an overlooked facet within the European Union's school curriculum, representing an opportunity for significant improvement. The EDIAQI project brings together 18 organizations from 11 different European countries that provide interdisciplinary skills and expertise in various fields, including environmental science and technology, medicine, and toxicology, as well as policy design and public engagement (see Fig. 1). Measurement campaign in Vilnius is an in-depth campaign which studies the impact of outdoor vehicular, biomass burning and transport-related pollution on IAQ. Advanced aerosol measurement tools, alongside low-cost sensors, were used to analyze various aerosol particle metrics, including ultrafine particle numbers and black carbon concentrations. The study also determines the sources and exposure levels of these particles in children.

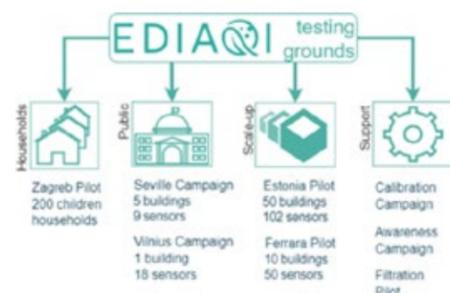


Fig. 1. Stakeholder profiles and anticipated numbers of testing grounds in the project.

Evaluating the Role of Urban Green Infrastructure in Combating Traffic-Related Microplastic Pollution

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This is the first study in Northern Europe to investigate how *Thuja occidentalis* hedges function as a natural defense against traffic-related airborne microplastics (MPs) pollution in Kaunas, Lithuania. Over a four-month campaign, the hedge reduced MP concentrations from 9.2 to 4.6 particles $\text{cm}^{-2} \text{day}^{-1}$, achieving up to 64.5% total removal efficiency, with fragment and fiber reductions of 64.3% and 71.4%, respectively (see Fig. 2). The most captured particles ranged from 50–100 μm , with efficiencies peaking at 94.2% in spring. These findings highlight the potential of integrating urban green infrastructure into city design to mitigate non-exhaust emissions and improve air quality and public health in urban environments.

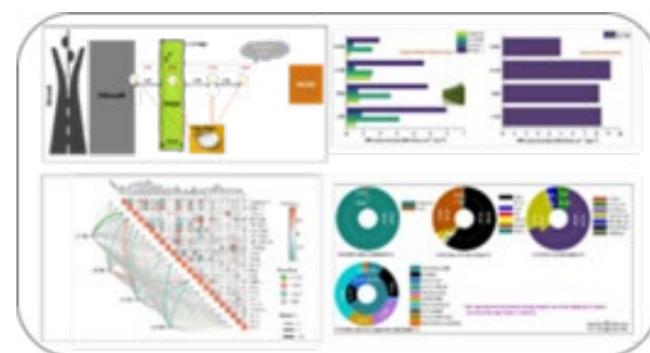


Fig. 2. Evaluation of traffic-related non-exhaust microplastic pollution mitigation by urban green infrastructure.

Analysis of Source Regions and Transport Pathways of Sub-Micron Aerosol Components in Europ

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<https://dx.doi.org/10.1016/j.envpol.2025.127110>

In this study, we combined year-long datasets of particulate matter (PM) from 15 different countries with Trajectory Statistical Methods (TSMs). We found possible source regions and seasonal variations of various PM components in Europe. It was shown that Eastern Europe was a major contributor to various aerosol components. In addition, other significant sources were identified in Northern France, the Benelux region, and the Mediterranean. By comparing models, it was observed discrepancies in certain regions such as the Po Valley and Poland, suggesting the need for improvements in emission inventories. The findings of the study highlight the importance of addressing air pollution in several regions to enhance overall air quality throughout Europe (see Fig. 3).

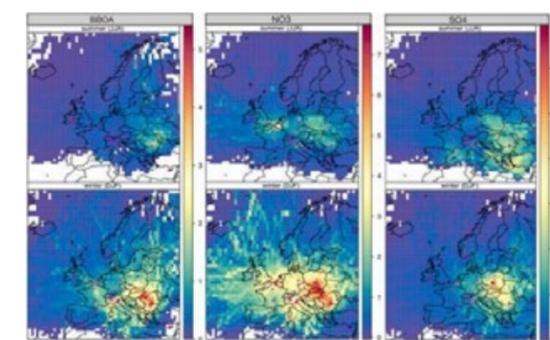


Fig. 3. Summer (on top) and winter (on the bottom) plots showing TSM results for biomass burning related organic aerosol (BBOA), NO₃, and SO₄. Color scale represents $\mu\text{g}\cdot\text{m}^{-3}$.

Surface-Enhanced Raman Spectroscopy for the Characterization of Filtrate Portions of Hepatitis B Blood Serum Samples Using 100 kDa Ultra Filtration Devices

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<https://doi.org/10.1016/j.saa.2025.125883>

Widespread of hepatitis B virus demands the fast and enhance sensitivity of optical instruments for detection of biochemical changes caused by HBV virus. In this study, 100 kDa centrifugal filtration devices were used to separate high molecular weight fractions (HMWF) and low molecular weight fractions (LMWF) biomarker proteins of blood serum from patients with Hepatitis B. These biomarkers were characterized through surface-enhanced Raman spectroscopy (SERS) with silver nanoparticles (Ag-NPs) as substrate. Results have shown the ultracentrifugation increased the efficiency in marking the protein as well as validity of prediction model (PLSR) using SERS spectral data sets also proved SERS to be an efficient technique for separation between healthy and patient's blood samples.

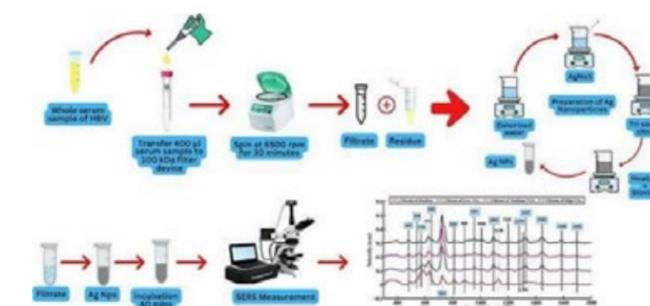


Fig. 4. Characterization scheme of filtrate portions of hepatitis B blood serum.

Multi-Pollutant Air Quality Assessment Around Urban Schools Using Machine Learning

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<https://doi.org/10.1016/j.uclim.2025.102567>

This study integrates satellite-derived columnar data for nitrogen dioxide (NO₂), sulfur dioxide (SO₂), and carbon monoxide (CO) with machine learning (ML) techniques - random forest (RF) and gradient boosting machine (GBM) - to develop spatial multi-pollutant classification maps for air quality assessment around schools in Vilnius, Lithuania, where ground-based monitoring stations are limited. The results showed that between the two ML models, RF demonstrated better performance than GBM, achieving an accuracy of 0.900, precision of 0.895, a recall of 0.897, and an F1 score of 0.896. To enhance prediction accuracy, the models incorporate meteorological variables (e.g., temperature, wind speed, humidity) alongside urban characteristics (e.g., building density, road density, and proximity to road networks). Comparison with surface-level NO₂, SO₂, and CO concentrations reveals the model's capacity to capture pollution patterns, particularly in the city center and densely built urban areas. The findings indicate that 37 % of schools are situated within 100–250 m of major roads, where NO₂ + CO and NO₂ + CO + SO₂ are the dominant columnar pollution classes (see Fig. 5). The results of the spatial analysis reveal that these schools are mostly in the city center primarily due to higher buildings and road densities, as well as lower levels of greenness.

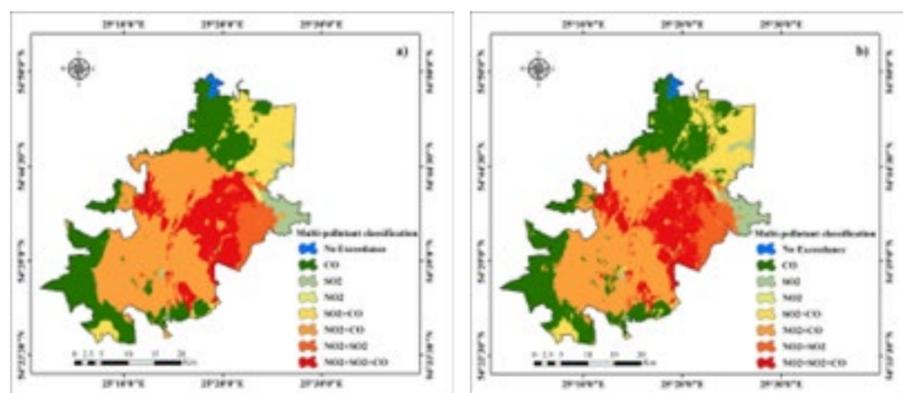


Fig. 5. Spatial distribution of multi-pollutants using RF (a) and GMB (b) Models.

Urban Pollution Impact Assessment in Six Lithuanian Cities with a Focus on Road Traffic Emissions - Integrated Framework for Environmental Health Studies

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<https://doi.org/10.1016/j.jhazmat.2025.139725>

An integrated framework was introduced and applied to assess the health impact of airborne pollution with greater physiological relevance, moving beyond conventional exposure metrics. Measured particle number size distribution (PNSD), ultrafine particle (UFP) and black carbon (BC) concentration data were integrated with regional respiratory tract deposition fractions to estimate total and alveolar deposited particle surface area concentrations. Land use regression modelling, combined with randomized commuting patterns, enabled the evaluation of city-specific alveolar surface area deposition doses, providing new insight into localized average exposure and its implications for public health. The results showed that although the mean street-level air pollution in Lithuania is higher than in other European cities, the urban background levels are on the same level. We found that the total respiratory deposited surface area concentration is up to 18-fold higher due to coarse particles, which also determines alveolar deposited particle surface area dose (see Fig. 6).

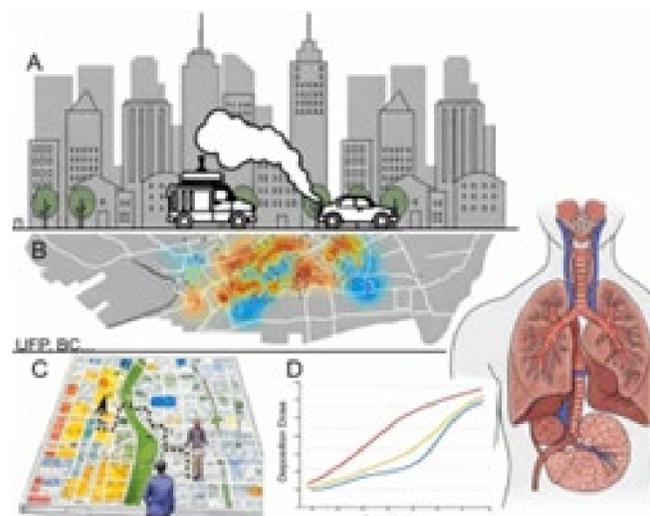


Fig. 6. Framework for integrated urban air pollution assessment based on mobile particle pollution measurements using toxicologically derived pollution metrics (A), city-scale pollution modeling (B), commuting pattern simulation (C), and computation of lung deposited particulate matter parameters (D).

Modulative Effects of Carbon Black and Polyethylene Micro-Nanoplastic Particles on Blood-Brain Barrier Model in Vitro

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This study investigates the effects of CBP and LDPE particles on human cerebral microvascular endothelium hCMEC/D3 cells, an *in vitro* BBB model. Using a stable NRF2 reporter cell line, we assessed barrier function via transendothelial electrical resistance (TEER), particle uptake through confocal microscopy, and morphological changes using CellProfiler. Inflammatory and oxidative stress responses were also evaluated. CBP exposure increased TEER values, suggesting an occluding effect on barrier integrity. Additionally, CBP enhanced phagocytic activity and reduced IL-1 β levels, indicating modulation of inflammation. In contrast, although internalized by cells, LDPE particles had minimal impact on morphology, phagocytosis, inflammation, or barrier function. These findings offer new insights into the cellular responses to airborne pollutants, highlighting the differential effects of CBP and LDPE particles on the BBB and underscoring the need for further studies on their combined impact (see Fig. 7).

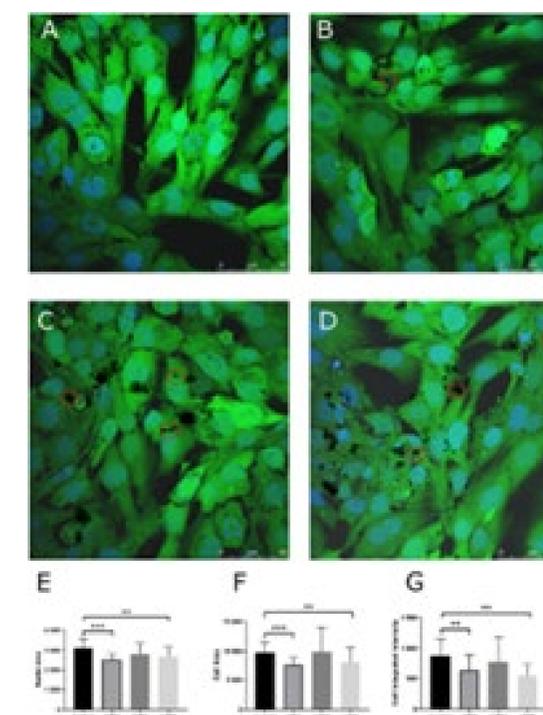


Fig. 7. Morphological changes in hCMEC/D3 cells after exposure to CBP I, CBP II, or LDPE. (A) Control hCMEC/D3 cells; (B) LDPE - exposure at 50 μ g/ml for 24 h; (C) CBP I - exposure at 10 μ g/ml for 24 h; (D) CBP II - exposure at 10 μ g/ml for 24 h. Quantified parameters are represented in graphs as follows: Nuclei area (E), Cell area (F), and Cell Integrated Intensity (G).

DEPARTMENT OF NUCLEAR RESEARCH

The activities of the Department of Nuclear Research include the development and application of conventional and innovative methods in the fields of nuclear fuel cycle technologies, experimental nuclear and mass spectroscopy, applications of ion beam for material analysis and modification as well as the applications of lasers for generation of ionizing radiation.

The Experimental Nuclear Research Laboratory investigates the interaction of ionising radiation with different materials for improvement of safety of nuclear installations and development of new technologies for optimised radioactive waste (RW) management including laser-based metallic waste decontamination setup prototype. Ion beam methods for material analysis and modification are developed both for semiconductor materials and laser technology applications. Organic scintillator materials are investigated for detection and spectroscopy of ionizing radiation particles for use in RW monitoring applications. The principles of the high energy particle acceleration are investigated using ultrashort laser pulses for practical application possibility in dielectric laser accelerator. Complementary information on material properties (magnetic properties, oxidation and corrosion of iron compounds) is determined by Mössbauer spectroscopy (combining with data of vibrating sample magnetometer for better characterization of multiferroics).

In the Isotopic Research Laboratory, special attention is paid to environmental impact assessment of energy generating facilities, impacts of land-use change and crop rotation applications on carbon sequestration in different environment. The aspects of isotopic niches of small organisms, source apportionment of carbonaceous aerosol from forested sites and a multi-isotope approach for contaminant monitoring are investigated. The application of stable isotope ratio analysis ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$, $\delta^{18}\text{O}$ and $\delta^{34}\text{S}$) in environmental, archaeological and food samples stimulate new promising technologies.

The Accelerator Mass Spectrometry Laboratory with ^{14}C measurements ensures activities related to carbon dating and analysis of triple carbon ratio for dedicated samples. The graphitization system upgrade work is being carried out through the R&D project: CORgiS Graphite Research and Methodology Development to Improve Graphite Characteristics for AMS Measurements.

The close collaboration of all laboratories allows the development of smart-environmental and environment-safe nuclear fuel cycle technologies, implementation of new analysis methods for public and business needs.



“We are a key link in ensuring excellence in applied nuclear research in Lithuania, from the safety of nuclear objects to the environmental aspects of isotope ratios.”

Dr. Artūras Plukis

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Principal Researcher
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Laser Decontamination of Metal Waste for the Needs of Ignalina NPP

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Research Council of Lithuania Agreement No: P-REP-25-11

Laser technologies for the decontamination of radioactive waste generated at nuclear power facilities are developed within the scope of a project funded by the Research Council of Lithuania (LazeRadA). The laboratory experiments with Coherent Prisma laser (532 nm, pulse power: 6W, repetition rate: 40 kHz, pulse duration: 12 ns, pulse energy: 150 μJ, focused beam diameter: 50 μm, energy density: 15 J/cm², power density: 306000 W/cm², scanning area: 0.01 – 0.04 mm²/s) have been performed for the metal surface laser cleaning testing at small scale. The proposed medium power equipment scheme (see Fig. 1) was established at the experimental Nuclear Research Laboratory of the Center for Physical Sciences and Technology (FTMC). The performance parameters of the laser ablation system, decontamination factor, decontamination thickness, decontamination efficiency, and aerosol collection control are being analyzed in this project. The laser cleaning prototype dedicated to metallic waste deactivation has been demonstrated recently at the INPP site. Evaluation of this technology application and practical recommendations will be reported.

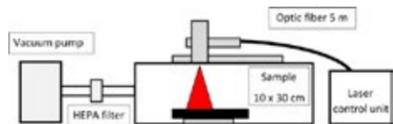


Fig. 1 a) Laser ablation system with decontamination control and radioactive dust collection equipment scheme; b) process of metallic samples cleaning at FTMC.

Recent Insights into Trends of Thyroid Cancer Incidence in the Lithuanian Population Exposed to Chernobyl Fallout Early in Life

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The risk of radiation at low and moderate radiation doses has been increasingly studied over the decades. Our research has led us to conduct a renewed assessment of age-specific thyroid doses, based on the levels of pasture grass and milk contamination that were measured in almost all regions of Lithuania following the Chernobyl accident until May 19, 1986. This allowed us to evaluate a possible association between radiation exposure and the incidence of thyroid cancer, with a particular focus on children and young adults who were residing in the area at the time of the accident. We observed a tendency toward an increased risk of thyroid cancer in the most exposed group of those who were children and adolescents at the time of the Chernobyl accident, especially in the 0-9 age group (see Fig. 2), and resided in western Lithuania, the most contaminated area by Chernobyl fallout.

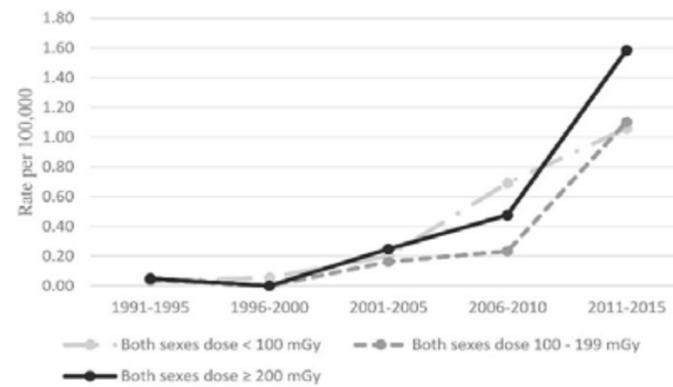


Fig. 2. Age-standardised thyroid cancer incidence rates in the age group of 0-9 years at the time of the Chernobyl accident by cumulative thyroid dose category. Thyroid cancer incidence rates had increased noticeably in the last two observation periods in all three dose categories; a higher increase was observed in the highest dose category in the period of 2011-2015.

Response of Pulcherrimin-Producing *Metschnikowia* Yeast to Different Iron Sources

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<https://doi.org/10.1016/j.funbio.2025.101679>

The production of the pigment pulcherrimin by *Metschnikowia* yeast is related to the growth inhibition of competing microorganisms, which can be applied for bioprotection of fruits and berries. In the case of *Metschnikowia* yeast, excess iron - including the breakdown products of metallic iron - can be processed into pulcherrimin. However, the biological role of this yeast pigment, pulcherrimin, is not yet fully understood. In the present study, the inhibition of *Metschnikowia* yeast growth due to excess iron was most clearly observed around fine metallic Fe powder spots, but pulcherrimin formation restricted iron distribution from these local solid iron sources (Fig. 3. A-C). Mössbauer spectroscopy (Fig. 3. D-F) was used to determine iron compounds formed through the interaction of the iron materials and the growth medium and the yeast. Apart from metallic iron and some non-pulcherrimin compounds around metallic spots, the Mössbauer spectroscopy has revealed the presence of pulcherrimin, intermediate Fe³⁺ compounds, and some Fe²⁺ containing substances in the rest of the plate (see Fig. 3C). It was demonstrated that restriction of iron distribution from iron sources can help to maintain characteristics for *Metschnikowia* yeast growth inhibition of competing microorganisms in other areas.

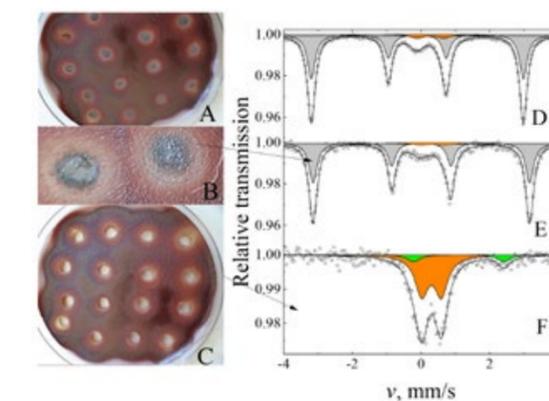


Fig. 3. Images and Mössbauer spectra of *M. pulcherrima* strain (producing highest levels of pulcherriminic acid) grown as lawn with α-Fe powder placed as spots as shown in A and B. on growth medium. Mössbauer spectra of light spots with α-Fe particles in the center (as indicated by the circle in B) were measured at room temperature (D) and at 11-13 K (E). F. Mössbauer spectrum of the remaining agar medium (as shown in C) measured at room temperature. The gray subspectrum is the contribution of α-Fe, the green and orange shows contribution of the Fe²⁺ and total Fe³⁺ respectively.

Carbon and Nitrogen Cycling in Ecosystem Processes Bivalve Monitoring Over French Coasts: Multi-Decadal Records of Carbon and Nitrogen Elemental and Isotopic Ratios as Ecological Indicators of Global Change

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<https://doi.org/10.5194/essd-17-799-2025>

Recent changes in climate and environment, influenced by both global and local factors, have had profound impacts on coastal ecosystem functioning and trajectories. The long-term perspective on how ecosystems are responding at various scales was obtained by examining archived samples from ongoing ecological monitoring efforts, particularly focusing on bivalves like mussels and oysters. In this study, analyses on carbon and nitrogen content (C%, N%) were conducted as well as elemental and isotopic ratios (C:N, $\delta^{13}C$, $\delta^{15}N$) of mussel and oyster soft tissues, which were collected annually at 33 sites along the French coast from 1981 to 2021 (see Fig. 4-5). This extensive dataset offers a comprehensive view spanning multiple decades and ecosystems allowing us to track how coastal ecosystems and marine species record changing climate, physical-chemical environments, and organic matter cycles. Additionally, these data are crucial for establishing isotope baselines for studying food webs. Ultimately, this dataset provides valuable information for more effective ecosystem conservation and management strategies in our rapidly changing world.

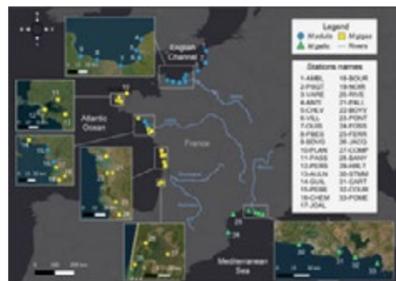


Fig. 4. Map of the 33 stations from the three sea coastal areas of France analyzed for bivalves' elemental and isotopic ratios.

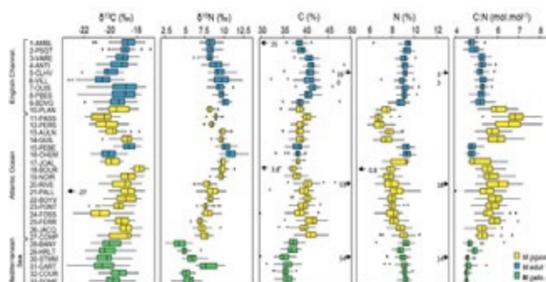


Fig. 5. Box plots of $\delta^{13}C$, $\delta^{15}N$, C, N and C:N values of bivalves for the 33 stations of the three French sea coastal areas over the period from 1981–2021 (Magallana gigas, Mytilus edulis, Mytilus galloprovincialis).

Impact of Microbial Strain on the Nitrogen Fixation of Soybean Varieties of Different Maturity Under Cool Climate Conditions of Northern Europe

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<https://doi.org/10.3390/ma17091940>

Soybean inoculation with nitrogen (N) fixing bacteria can be highly promising for enhancing biological nitrogen fixation (BNF) and improving crop productivity. Understanding the specific aspects and conditions is essential for establishing the BNF process in particular environments. To evaluate its effectiveness in cool-climate regions, we have analyzed two soybean varieties of different maturity groups inoculated with three *Bradyrhizobium japonicum* strains, as well as organic fertilizer and novel endophyte treatments. Natural-abundance nitrogen isotope analysis was used to determine nitrogen sources, uptake patterns, and isotopic distribution within plants. It was demonstrated that inoculation with *Bradyrhizobium japonicum* was more effective than fertilization, as the strains had a significant effect on nitrogen derived from the atmosphere (Nd_{fa}), produced stable nitrogen isotope ratios close to 0 ‰, and substantially increased nitrogen content, particularly in beans. Soybean varieties Laulema and Merlin, representing different maturity groups, exhibited distinct nitrogen uptake patterns. *Bradyrhizobium japonicum* strain AGF78 consistently produced the greatest effect on biological parameters in both varieties, particularly in seed yield and grain weight, with the later-maturing Merlin achieving the highest average yield of 3066.89 kg ha⁻¹. Notably, the Merlin inoculated with AGF78 resulted in the highest nitrogen fixation in beans, with 66.8% NDFA and 134.0 kg/ha of fixed nitrogen. Similarly, Laulema inoculated with AGF78 resulted in 88.2% NDFA and 123.2 kg/ha of fixed nitrogen. Inoculation with selected bacterial strains significantly increased protein content from 30% to 41%, with the effects being both strain- and variety-specific. Such promising results allow reducing dependency on chemical fertilizers, promoting sustainable agricultural practices, and minimizing environmental impacts.

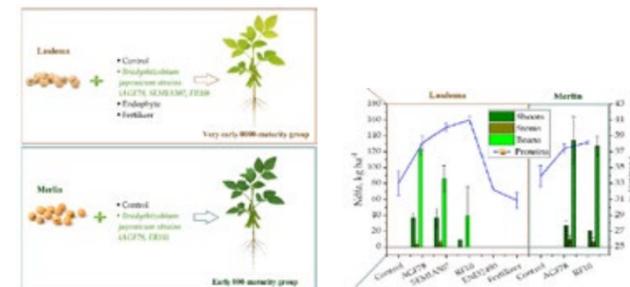


Fig. 6. Nitrogen derived from the atmosphere (Nd_{fa}) and protein content in Laulema and Merlin soybeans with different treatments.

Influence of Landscape Characteristics and Submerged Aquatic Vegetation on Sediment Carbon and Nitrogen Storage in Shallow Brackish Water Habitats

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<https://doi.org/10.1038/s41598-025-92217-z>

While marine seagrass habitats are acknowledged as sinks for carbon and nutrients, much less is known about sequestration in brackish-water vegetation. Here, we quantify the amount of organic carbon (C_{org}) and total nitrogen (TN) in shallow bay sediments (0–25 cm) in the brackish Baltic Sea and assess how it varies with morphometric isolation from the sea, catchment characteristics and abundance of brackish-water vegetation. The sedimentary C_{org} and TN content per surface area varied across the bay isolation gradient (mean C_{org}: 2500–4600 g/m²; mean TN: 320–570 g/m²), with enclosed bays having the highest percentage content of C_{org} and TN, but low sediment density (< 0.1 g cm³), while open bays had more compact sediment with lower percentage content of C_{org} and TN. The influence of catchment and vegetation characteristics on the sediment C_{org} and TN content was less clear, suggesting that coastal morphology affecting hydrodynamic exposure is an important determinant of C and TN accumulation in brackish-water bays. The results show that morphometrically isolated shallow coastal areas constitute significant sinks for carbon and nitrogen, which should be considered in management and in any regional estimates of blue carbon and nutrient sequestration functions.

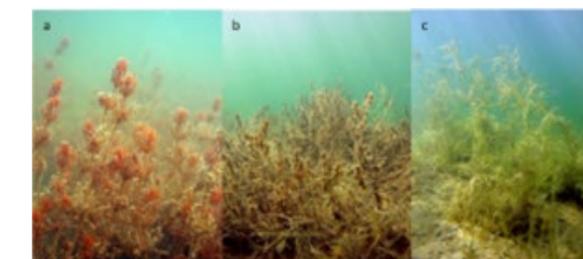


Fig.7. Examples of estuarine vegetation; Chara tomentosa (a), Najas marina (b), and Stuckenia pectinata (c). Photos: Joakim P. Hanse.

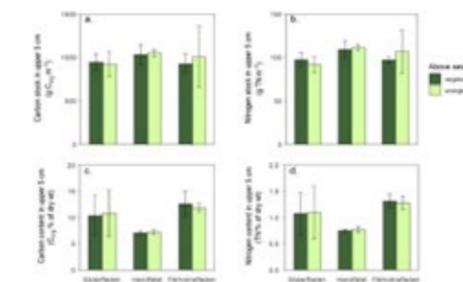


Fig. 8. Sediment stocks (a, b) and % content (c, d) of C_{org} and TN in the upper 5 cm of the sediment in patches with and without submerged vegetation (Najas marina or Chara tomentosa) in three bays. Data are means and standard deviations for four cores in each type of patch in each bay.

DEPARTMENT OF PHYSICAL TECHNOLOGIES

The Department of Physical Technologies unites the Microwave Laboratory and the Microsystems Technology Laboratory to advance ultrathin materials, optical microsystems, and electromagnetic sensing and energy-harvesting technologies. The department develops films down to single-atom thickness, synthesizes diverse 2D materials, fabricates prototype optoelectronic devices in ISO5/ISO7 clean rooms and studies interactions between matter and electromagnetic waves for applications ranging from IoT sensors to defense technologies.

The Microsystems Technology Laboratory focuses on thin-film growth, micro/nanofabrication, and device prototyping. Its clean-room capabilities support the development of photonic systems, IR-lasers and sensors for non-destructive inspection. Research in low-dimensional materials focuses on structures with nanoscale and atomic-scale thicknesses. We investigate the growth and properties of graphene, black silicon, TMDs (MoS_2 , TiS_2 , PdS , PdS_2) and tellurene/tellurium (Te) nanostructures to tune their electronic and optical behavior. Recent results show that minor changes in ultrathin Te growth conditions strongly affect nanostructure formation and charge transport. We also develop methods for transferring hexagonal boron nitride (hBN) layers to create single-photon emitters and fabricate SiO_2 and Si_3N_4 dielectric layers for integrated optoelectronic systems.

The Microwave Laboratory studies electromagnetic interactions with materials from modified fabrics to electronic prototypes and develops microwave applications. Work includes energy harvesting from WiFi-band radiation and antenna development, such as a four-element dielectric resonator array designed for improved gain and radiation control. The lab also develops a passive Radar Detection and Identification System capable of intercepting ship radar emissions and classifying them using AI-driven signal analysis.



“Targeted manufacturing technology can make a new sophisticated idea work in practice. This is the main stimulus for us to look for new ways to use semiconductors with advanced properties for innovative practical devices.”

Dr. Virginijus Bukauskas

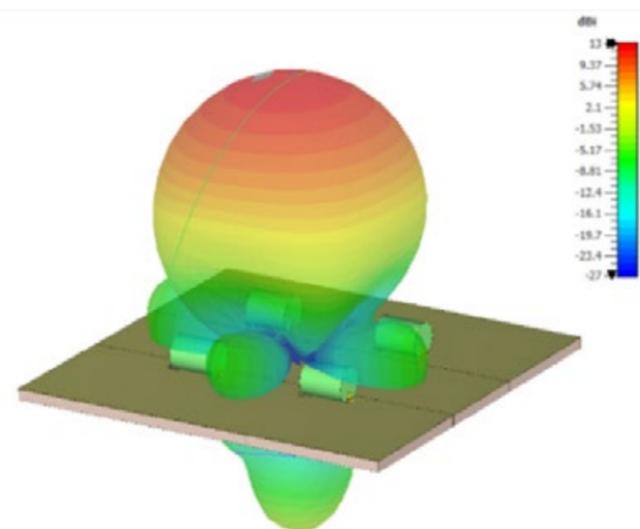
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NATO Partnership and Cooperative Security Committee Science for Peace and Security (SPS) Programme Project “3D Metamaterials for Energy Harvesting and Electromagnetic Sensing”, 2023-2026

Habil. Dr. Žilvinas Andrius Kancleris, Head of the Microwave Laboratory, coordinated the NATO Science for Peace and Security project “3D Metamaterials for Energy Harvesting and Electromagnetic Sensing”, which involves two partners from Ukraine. The project investigates an advanced dielectric resonator antenna (DRA) and its array to improve microwave energy harvesting efficiency. The figure shows a simulated four-element horizontally oriented DRA array designed to increase realized gain and shape the radiation pattern for optimal energy capture. Compared with single-element DRAs, the array provides significantly higher gain, around 10 dBi, and offers improved control over beam shape and polarization. By adjusting element spacing and introducing phase shifts between array elements, the system can generate a variety of radiation patterns, reduce unwanted side lobes, and even achieve circular polarization, which is highly beneficial for harvesting energy from signals arriving from different directions. Ongoing work focuses on the development of compact feeding and phase-shift networks to fully exploit these capabilities in practical energy-harvesting devices.



Project “Radar Detection and Identification System (RADIS)” funded by the Innovation Agency of Lithuania 2023-2025

The Microwave Laboratory has been leading the project “Radar Detection and Identification System” aiming to develop an advanced passive sensing system capable of detecting and recognising nearby vessels based solely on the radar signals they emit. Modern ships continuously use radars for navigation and obstacle avoidance, creating a unique electromagnetic “fingerprint” that can be intercepted without active transmission. By combining a high-speed spectrum analyser, directional antennas, and artificial intelligence tools, our system captures these radar emissions and classifies them using neural-network-based identification algorithms. The figure presents our newly developed prototype, enclosed in a compact weather-resistant radome. Inside, it integrates a complete system: a high-speed software-defined radio, multi-band antennas, and an embedded computer running our detection and identification algorithms. It has already undergone field testing on the shoreline, where it successfully detected, recorded, and identified real ship radar signals, while also validating and optimising our AI-based direction-finding and classification models.



Versatile High-Sensitivity EPR Using Superconducting Spiral Microresonators

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<https://doi.org/10.1002/smt.202501451>

This work demonstrates a three-order-of-magnitude improvement in spin-number sensitivity for standard X-band pulsed EPR spectroscopy. The enhancement is achieved using compact spiral-shaped microresonators with 7 nL mode volumes fabricated from yttrium barium copper oxide (YBCO) high-temperature superconductor, fully compatible with conventional EPR tubes and cavities. A wide range of microwave coupling is achieved by a single microresonator inside a conventional EPR tube loaded into an EPR cavity. The performance of the spiral microresonators is demonstrated through a suite of pulsed EPR experiments on standard samples, including dipolar and hyperfine spectroscopies. By placing a sample within a microfluidic microstructure fabricated to match the mode profile of the microresonator, a high-fidelity spin control is obtained with a spin-number sensitivity of 107 spins/G/√Hz. The approach significantly advances the applicability of superconducting microresonators as versatile and readily applicable tools for high sensitivity EPR.

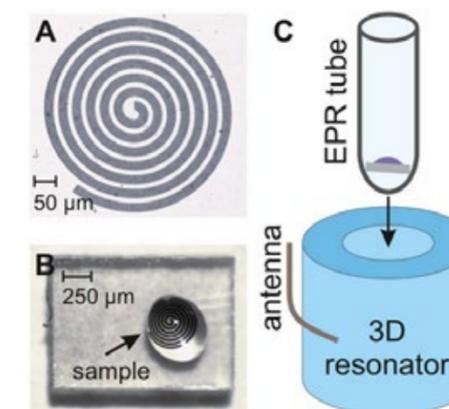


Fig. 1. Design and loading of the spiral microresonator. A) Fabricated planar YBCO spiral microwave microresonator on a sapphire substrate. (B) Individual microresonator with an aqueous droplet containing nitroxide radicals. (C) The microresonator sits approximately horizontally at the bottom of an EPR tube, which is then loaded into a standard 3D EPR resonator facilitating coupling to a microwave antenna.

DEPARTMENT OF MOLECULAR COMPOUNDS PHYSICS

Researchers in the Department of Molecular Compound Physics investigate electronic excited states and their dynamics upon light excitation. The department is formally divided into two laboratories. In the Photoelectronics Laboratory, research focus is on perovskite solar cells and light-emitting diodes, as well as organic electronic compounds, with research ranging from material science to properties of functioning devices. In addition, the laboratory investigates the properties of stilbene compounds and other related systems. The Biophysical Research Laboratory is deeply involved in photosynthesis research, from excitation dynamics in single light-harvesting complexes to the in vivo algae or moss samples. The laboratory also conducts analyses of cancerous tissues using a combination of second-harmonic generation microscopy and advanced machine learning techniques.

Both laboratories in the department are unified by common experimental approaches, primarily time-resolved fluorescence and ultrafast transient absorption measurements. These methods are supplemented by various microscopy techniques, steady-state spectroscopy and photoelectric measurements. The department also includes theoreticians working on the models of the excited state dynamics, quantum chemical calculations, and applications of open quantum systems theory.

The fundamental research conducted in the department aims to advance foundational knowledge and understanding of the photo-induced dynamics in the studied molecular systems, laying a solid basis for promising future applications.

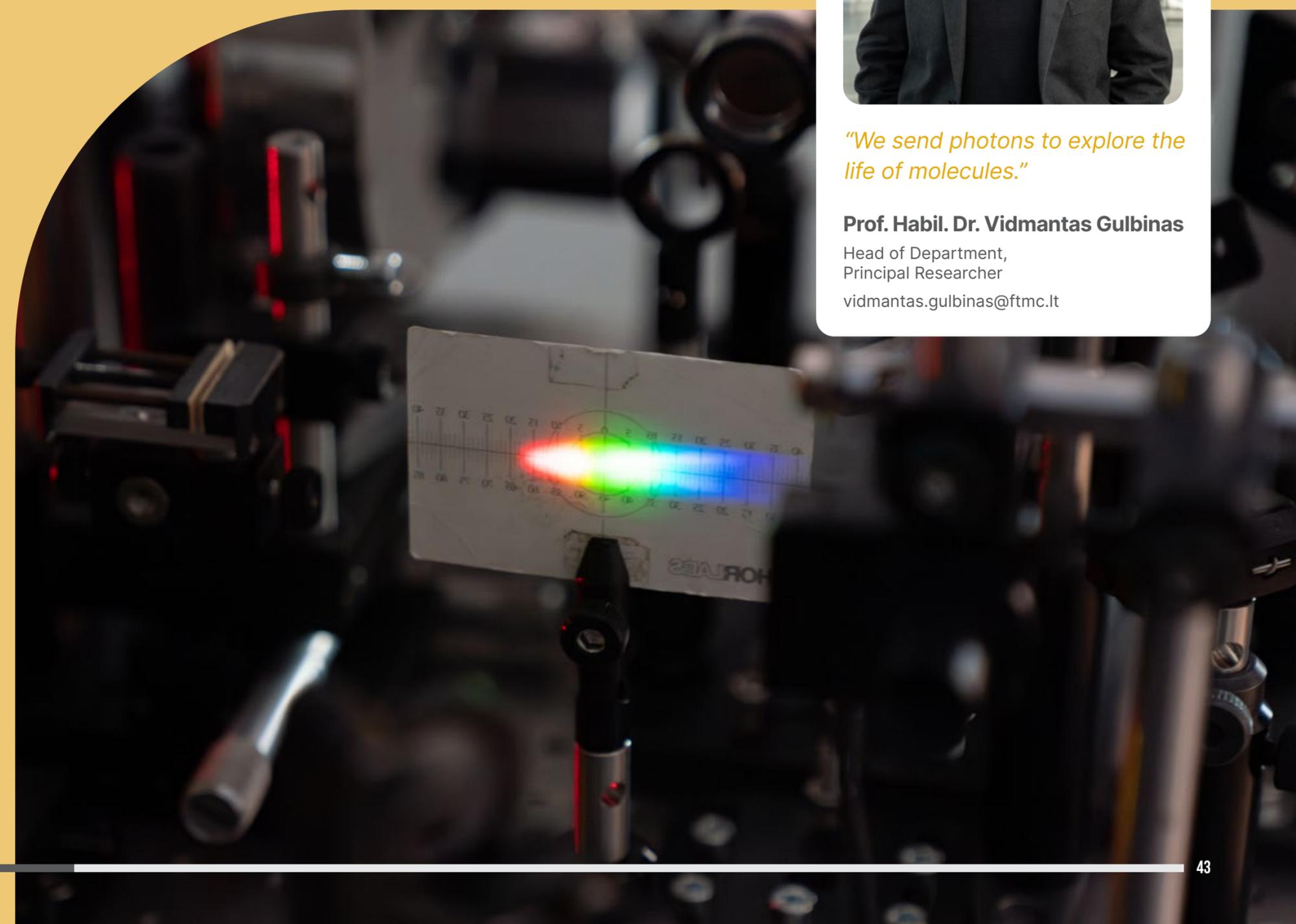


"We send photons to explore the life of molecules."

Prof. Habil. Dr. Vidmantas Gulbinas

Head of Department,
Principal Researcher

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Mimicking Dynamics of a Quantum Dimer with Coupled Classical Oscillators

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<https://doi.org/10.1016/j.physleta.2025.131053>

We have proposed a classical system that can exactly reproduce the temporal evolution of a quantum dimer. Our system is constituted by two pendulums that are coupled by a string. Observing the time-dependence of angles of the pendulums, one can obtain the values of the quantum variables. A key component of our approach is the use of time and amplitude scalings in the theoretical description. This allows us to circumvent the different typical values of quantum and classical parameters and deal with any initial conditions for a quantum system.

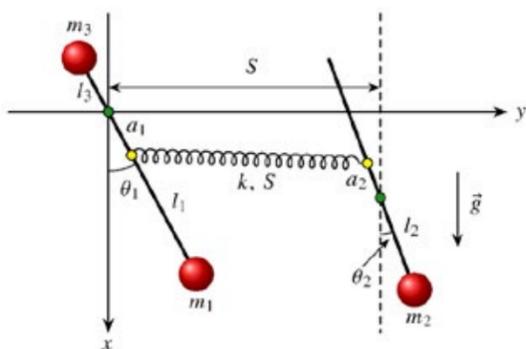


Fig. 1. A classical system composed of three beads that are attached to rigid rods. The rods are connected to each other with a spring. The fulcrums of oscillation are marked in green.

Transient Photoluminescence Reveals the Dynamics of Injected Charge Carriers in Perovskite Light-Emitting Diodes

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<https://doi.org/10.1021/acscami.4c19379>

Understanding the dynamics of injected charge carriers is crucial for the analysis of perovskite light-emitting diode (PeLED) operation. Here, we explore the recombination dynamics of injected charge carriers in a small grain methylammonium lead iodide (MAPI) PeLED pumped at high current densities by investigating the dynamics of additional carriers photogenerated by ultrashort optical pulses. We show that photogenerated charge carriers predominantly recombine in a geminate fashion within a single perovskite grain. Conversely, recombination between photogenerated and injected carriers is rare due to the spatial separation caused by the internal electric field, which confines injected carriers near opposite electrodes. This spatial separation is a key mechanism behind the EQE roll-off in PeLEDs.

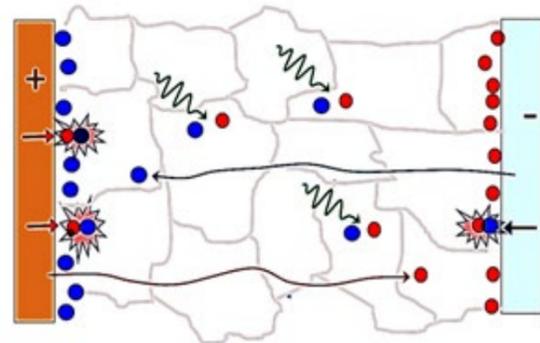


Fig. 2. Charge carrier dynamics induced by a common action of electrical injection and optical pulses.

Quantum Cutting in Lead Halide Perovskites: Photoluminescence Dynamics of Active and Inactive Ytterbium Species

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<https://doi.org/10.1016/j.bbabbio.2024.149493>

Ytterbium ions are important in lanthanoid-based optical materials due to their stable NIR emission and low nonradiative decay. In lead-halide perovskites, they enable quantum cutting - a route to enhance silicon photovoltaic efficiency. Previous studies have identified Yb³⁺ species that are active or inactive in photon cutting within the perovskite lattice. Here, we investigate photoluminescence (PL) dynamics and the oscillator strength of the ²F_{5/2} → ²F_{7/2} radiative transition of different Yb³⁺ species in CsPb(Cl_xBr^{1-x})₃ polycrystalline powders. We demonstrate how the PL decay rate varies with temperature across different perovskite matrices.

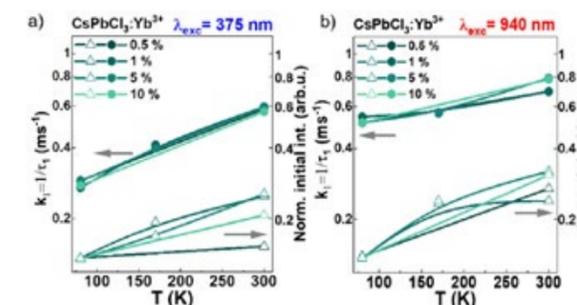


Fig. 3. Temperature dependencies of NIR PL relaxation rates (circles) and initial intensities (triangles) of 0.5-10% Yb-doped CsPbCl₃ upon a) 375 nm and b) 940 nm excitations



Supervised Machine Learning Thyroid Carcinoma Diagnosis Using Wide-Field SHG Microscopy

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<https://doi.org/10.1109/ACCESS.2025.3583435>

This study presents a novel artificial intelligence (AI) method for the critical differential diagnosis of papillary (PTC) and follicular (FTC) thyroid carcinomas. Using label-free wide-field second harmonic generation (SHG) microscopy, image datasets of the collagen network distributions in capsules of thyroid nodules were accumulated to train a supervised machine learning model. A key innovation was addressing dataset "label noise" via unsupervised segmentation to exclude mislabeled regions and leveraging capsular heterogeneity as a diagnostic feature. The developed classification model demonstrates robust generalization and provides sufficient classification accuracy for unknown samples, making it a reliable complementary technique for conventional methods. This work establishes SHG-based AI as a valuable automated adjunct to pathology, with strong potential to improve diagnostic precision and guide personalized treatment for thyroid cancer patients.

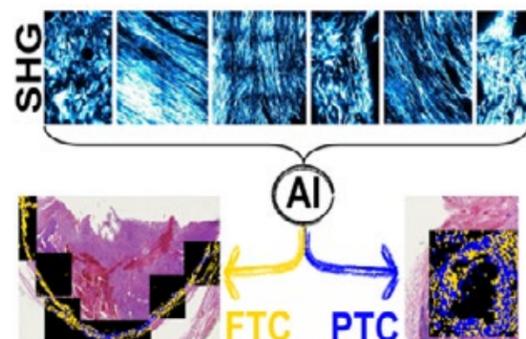


Fig. 4. Differential thyroid carcinoma diagnosing with AI-assisted SHG.

Spectroscopic Manifestation of a Weak van der Waals Interaction Between *Trans*-stilbene and Hexagonal Boron Nitride Surface

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<https://doi.org/10.1021/acs.langmuir.4c04717>

In this study, we present a comprehensive spectroscopic characterization of the van der Waals (vdW) complex of *trans*-stilbene (TS) and hexagonal boron nitride (hBN) from theoretical (DFT) and experimental (THz, Raman, and Fluorescence spectroscopy) perspectives; notably, the experimental characterization is considered *rare to date*. This combination of theoretical and experimental techniques is a useful tool to characterize molecular complexes. For the TS+hBN complex bound by London dispersion forces, Raman scattering proved to be the most effective method, while THz spectroscopy *showed great potential* for studying such systems. The studied complex serves as a good model system for investigating such complexes with various applications in photonics, energy conversion and biomedicine.

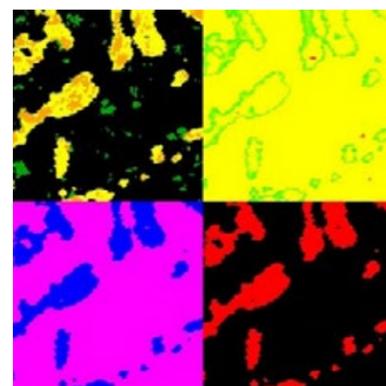


Fig. 5. Coherent anti-Stokes Raman scattering (CARS) microscopy (false-color image) of the TS + hBN complex. The image is constructed from the signals at 1370 cm^{-1} (hBN) and 1600 cm^{-1} . Microscopy revealed an almost uniform distribution of the hBN crystallites and randomly formatted smaller and larger TS crystals on hBN surface.



DEPARTMENT OF NANOENGINEERING

The Department is an interdisciplinary research unit dedicated to the investigation of nanometre-scale material properties and interfacial phenomena at the boundaries between solid and soft matter, as well as between synthetic and biological systems. In parallel, the Department develops novel fabrication, characterization, and analytical techniques. The group has a strong track record in international research projects and industry-oriented collaborations. The Department's expertise spans surface and bulk physical and chemical processes as well as life sciences, including surface chemistry, materials science, molecular biophysics, organic synthesis and supramolecular chemistry, laser technologies, scanning probe and fluorescence microscopy, electrochemistry, cell biology, and tissue engineering.

The experimental and technological capabilities of the Department are organized into the following core areas:

- Ultrathin organic coatings and functional modification of solid and soft material surfaces
- Alternative microfabrication approaches, including soft lithography and inkjet printing
- Scanning probe nanolithography and rapid prototyping of solid, organic, biological, and hybrid nanostructures
- Synthesis of multifunctional compounds, bioconjugates, and self-assembling building blocks
- Electrochemical sensing platforms for a broad range of analytes
- Carbon nanomaterials, nanoparticles, and micro-fabricated electrode systems
- Development and characterization of conducting polymer materials derived from natural monomers
- Advanced atomic force microscopy and force spectroscopy techniques
- Real-time molecular interaction analysis, including surface plasmon resonance
- Biochip technologies, biomaterials characterization, and 2D and 3D cell culture systems
- Automation, electronics, hardware, and custom equipment development

The Department is open to both academic and industrial collaboration and routinely provides research, development, and analytical services to small and medium-sized enterprises as well as multinational companies.



“We aim to control soft (bio) matter, precisely localize (electro)chemical processes and molecular components at the micro- and nanoscale, and integrate them into functional materials.”

Dr. Edvinas Orentas

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Fast Tilt Compensation in Non-Raster Rotation-Scanning Atomic Force Microscopy for Improved Force Control and Extended Scanning Range

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Seeking to advance the suitability of atomic force microscopy (AFM) to investigate large areas with high-throughput, we developed a new adaptive control method. It allows us to improve the probe-surface interaction force control and significantly expand the achievable scanning range. Employing extremely high scanning linear velocities of up to 3 cm/s, an area of 0.19 mm² was imaged in less than 10 minutes with a resolution of approximately 50 nm. This development is an important step towards expanding the AFM application areas for rapid, high-throughput nanoscale investigation of large samples with considerable mass. The patent application for the rotation-scanning and adaptive control method has been published.

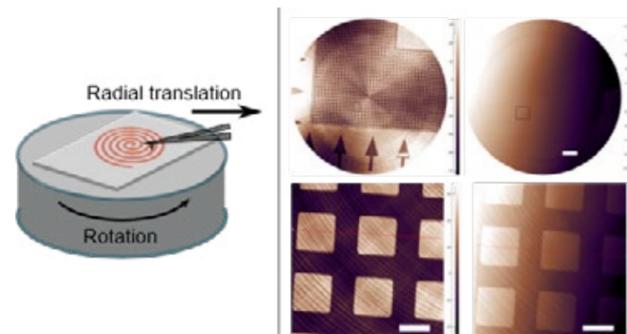


Fig. 1. Adaptive control method in conjunction with non-raster rotation-scanning enables a significantly extended AFM scanning range. Left panel: principle of rotation-scanning AFM; right panel: comparison of AFM images acquired with adaptive control on (left) or off (right). Scalebar: 30 μm (top images); 5 μm (bottom images).

Synthesis and Characterization of Exfoliated Graphite-Polypyrrole Composites as Active Electrode Materials for the Detection of Dopamine

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<https://doi.org/10.1016/j.apsusc.2024.162107>

In the Laboratory of Functional Nanomaterials, carbon nanomaterial composites with polymers are studied for potential use in electrochemical sensing. The exfoliated graphite-polypyrrole (GPPy) composites presented here were synthesised using three graphite precursors with grain sizes of <50 μm, ≥149–840 μm and 2000 μm. The graphite precursors were oxidised in H₂SO₄ and KIO₃, then annealed at 800 °C to produce exfoliated graphite. It was then modified with the conductive polymer polypyrrole (PPy) to create the GPPy samples. Spectroscopic characterisation confirmed the successful incorporation of nitrogen into the graphitic structure. Additionally, the sample obtained from the medium-sized graphite grains exhibited the highest elemental nitrogen content (5.12 at. %), 15.16% of which was graphitic-N, which is known to enhance electrocatalytic activity. Electrochemical investigations confirmed that this composite exhibited the most promising analytical parameters, including high sensitivity (2468 μA mM⁻¹ cm⁻¹) and a low limit of detection (34 nM) for dopamine. This study suggests that GPPy-based sensors offer a simple, cost-effective manufacturing approach and are thus promising candidates for highly sensitive tools for detecting the neurotransmitter dopamine.

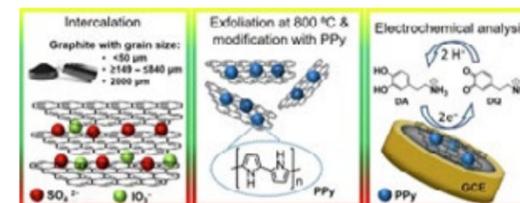


Fig. 2. Synthesis of GPPy (left and middle) and its application to the sensor development for dopamine (right).



DEPARTMENT OF ORGANIC CHEMISTRY

The Department of Organic Chemistry includes the Laboratory of Organic Synthesis, the Laboratory of Organic Analysis, and the Spectroelectrochemistry Laboratory. Together, they conduct fundamental and applied research in organic chemistry, spanning the design, synthesis, and characterization of functional molecules and materials, as well as the development of advanced analytical and spectroscopic techniques.

The Laboratory of Organic Synthesis focuses on advancing and applying fundamental principles of organic chemistry to optimize the design and synthesis of molecules essential to diverse research areas, including biology, biochemistry, medicine, pharmaceuticals, materials science, physics, optoelectronics, and semiconductors. The team specializes in the tailored synthesis of target compounds, emphasizing efficiency, cost-effectiveness, and high-quality outcomes to meet the needs of both academic and industrial partners.

The Laboratory of Organic Analysis develops, optimizes, and validates quantitative analytical methods based on gas and liquid chromatography–mass spectrometry. Its research aims to enhance the performance and reliability of measurement systems across a range of applications. Current projects include studies of essential oils from Lithuanian plants, volatile organic compounds (VOCs), and bioactive molecules, conducted in collaboration with other research institutes and private partners.

The Spectroelectrochemistry Laboratory is dedicated to the development and application of advanced spectroscopic and spectroelectrochemical techniques for the precise investigation of molecular adsorption, interfacial interactions, and electron transfer processes. The laboratory employs multiwavelength Raman spectroscopy, including surface-enhanced Raman scattering (SERS), resonance Raman spectroscopy (RRS), shell-isolated nanoparticle-enhanced Raman spectroscopy (SHINERS), and magneto-plasmonic nanostructure-enhanced Raman spectroscopy, to study molecular-level changes induced by electrochemical potential in self-assembled molecular structures, two-dimensional materials, and biological cells, including ex vivo detection of kidney cancer biomarkers. Unique surface-sensitive techniques, such as vibrational sum-frequency generation (VSFG) and surface-enhanced infrared absorption (SEIRA) spectroscopy, provide powerful tools for probing complex molecular systems and interfacial dynamics with high sensitivity. These approaches have been instrumental in elucidating the structural organization of lipid membranes, the interactions and dynamics of lipid–protein complexes, and the mechanisms by which membrane-damaging proteins affect membrane integrity and function.



“Synthesis and analysis, surface modification and investigation, spectroscopy and electrochemistry - all in one”

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Head of Department,
Principal Researcher

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Copper-Based Multiwavelength Ultraviolet Surface-Enhanced Resonance Raman Spectroscopy

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<https://doi.org/10.1002/adom.202500078>

Copper, an abundant and inexpensive metal, can become a powerful platform for molecular detection when its surface is engineered at the nanoscale. Herein, we demonstrated that chemically synthesized copper nanostructures act as efficient and stable substrates for ultraviolet surface-enhanced Raman spectroscopy across multiple excitation wavelengths. This work showed that copper enables strong UV-SERS responses for a wide range of π -conjugated biomolecules, revealing selective sensitivity for nucleic acid adenine. Experiments established that the enhancement mechanism is dominated by charge-transfer interactions rather than classical plasmonic effects.

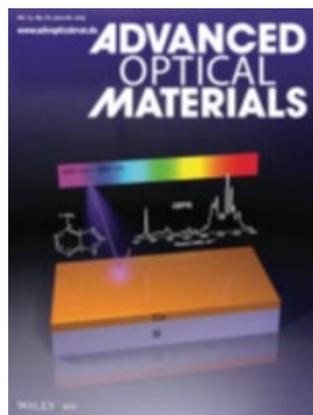


Fig. 1. The back cover of the publication: UV excitation of biomolecules on copper nanostructures yields strong multiwavelength UV-SERS responses, demonstrating copper's viability as a low-cost platform for molecular detection.

Characterization of Human Urotensin II Peptide Adsorbed on Silver Electrode by Surface-Enhanced Raman Scattering Spectroscopy

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<https://doi.org/10.1016/j.saa.2024.125565>

This work applied electrochemical surface-enhanced Raman spectroscopy to characterize how the human regulatory peptide Urotensin II interacts with metallic interfaces. The study revealed that peptide adsorption is governed by specific aromatic residues and that controlled electrical potentials induce predictable conformational rearrangements without disrupting the essential disulfide-bridged cyclic core. These findings provide a detailed model of peptide-surface interactions and highlight EC-SERS as a powerful analytical tool for probing structurally complex biomolecules in physiologically relevant environments. The insights obtained may inform future efforts in receptor-binding studies, biomimetic interface design, and the development of peptide-based therapeutic analogues.

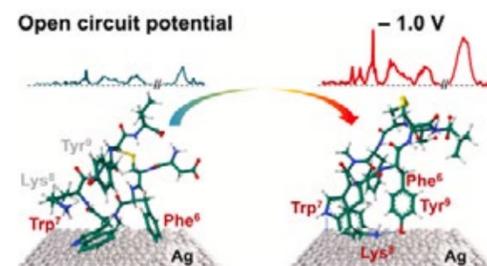


Fig. 2. Potential-dependent orientation of the Urotensin II peptide on a silver surface. At open-circuit potential, adsorption occurs mainly via Phe⁶ and Trp⁷ while at -1.0 V the peptide reorients and additional residues (Tyr⁹, Lys⁸) approach the surface, strengthening the interaction and enhancing the SERS response.

Synthesis and Characterization of Au@Ag Nanoparticles for Multiwavelength SERS Biosensing

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<https://doi.org/10.1016/j.saa.2025.126160>

This study developed tunable Au@Ag core-shell nanoparticles that provide strong, wavelength-flexible surface-enhanced Raman responses across the visible and near-infrared range. By precisely controlling silver shell thickness through seed-mediated growth, the team achieved large enhancement factors and demonstrated reliable detection of biologically relevant analytes, including the antioxidant ergothioneine at physiologically meaningful concentrations. The work clarified how shell thickness governs both plasmonic behavior and colloidal stability, establishing clear structure-function relationships. These results advance FTMC's capabilities in nanoscale sensing technologies and highlight core-shell plasmonic architectures as a promising platform for future biosensing and diagnostic applications.

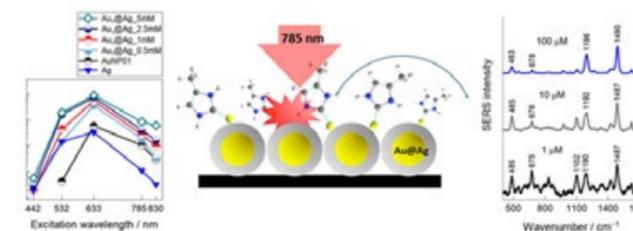


Fig. 3. Tunable Au@Ag core-shell nanoparticles provide strong, wavelength-flexible SERS enhancement and enable sensitive detection of biologically relevant molecules such as ergothioneine



Rhodium-Catalyzed Enantioselective 1,4-Addition of Arylboronic Acids to 2,3-Dihydro-4-pyridones Using 4,8-Substituted Bicyclo[3.3.1]nona-2,6-dienes as Ligands

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<https://doi.org/10.1002/ejoc.202401312>

It was demonstrated that second generation bicyclo[3.3.1]nona-2,6-diene bearing 4,8-endo-methoxy and 4,8-exo-3,5-dimethylphenyl substituents is a very efficient chiral bidentate steering ligand for the Rh-catalyzed asymmetric conjugate addition of readily available arylboronic acids to N-Cbz-2,3-dihydro-4-pyridone. Reactions proceed under mild conditions with a wide variety of sterically and electronically diverse arylboronic acids, yielding synthetically useful 2-aryl-4-piperidones in high yield (82–99%) and excellent enantioselectivity (up to 99.8:0.2 er). The synthetic application of the protocol was demonstrated by its utilization in the synthesis of the key chiral intermediate for the preparation of the drug Casopitant.

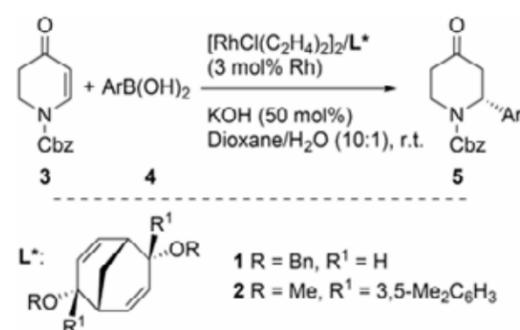


Fig. 4. Asymmetric Rh-catalyzed 1,4-addition of arylboronic acids to 2,3-dihydro-4-pyridone and 4,8-substituted bicyclo[3.3.1]nona-2,6-dieneligands.

Electrochemical UV-SERS of Adenine on Cobalt Electrode

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<https://doi.org/10.1016/j.saa.2025.125733>

This study established cobalt as an effective and economical substrate for ultraviolet surface-enhanced Raman spectroscopy, expanding FTMC's capabilities in advanced spectroelectrochemical analysis. By engineering nanostructured cobalt films through controlled electrodeposition, the team demonstrated strong UV-SERS activity at 325 nm, enabling detailed probing of nucleobase adsorption at electrochemical interfaces. Using adenine as a model system, the work revealed how specific nitrogen sites and the amino group bind to cobalt and how these interactions depend on potential, coverage, and isotopic environment. The findings provide molecular-level insight into nucleobase–metal interactions relevant to biosensing, molecular electronics, and catalytic surface design, while positioning cobalt as a promising, cost-efficient, and magnetically responsive material for UV-enabled Raman techniques.

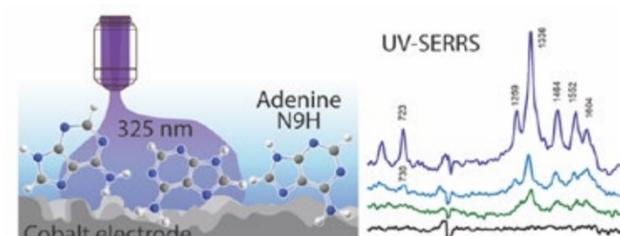
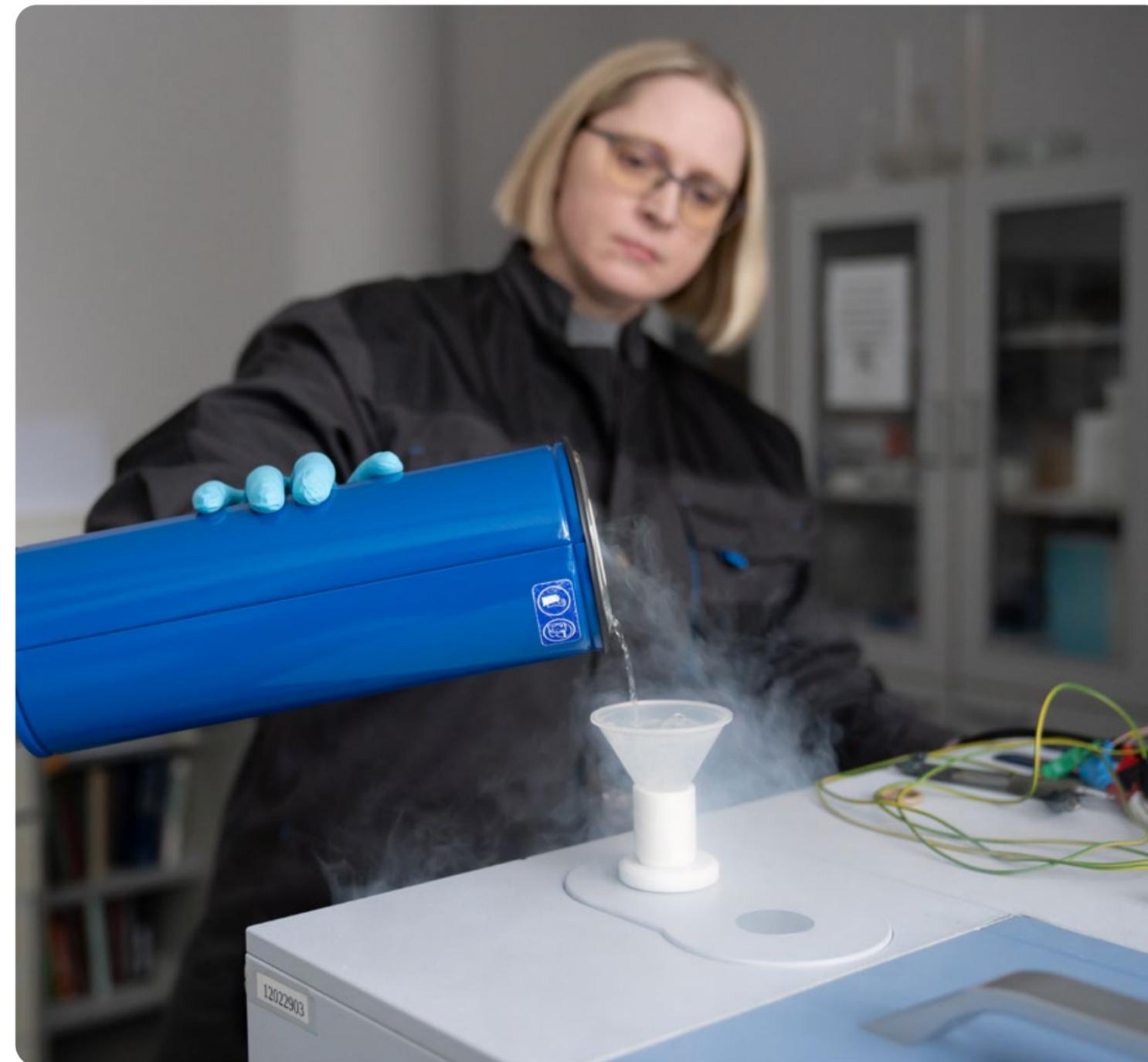


Fig. 5. UV-SERS of adenine on a nanostructured cobalt electrode using 325 nm excitation, revealing the N9H tautomer and its characteristic potential-dependent vibrational signatures.



DEPARTMENT OF CHEMICAL ENGINEERING AND TECHNOLOGY

The Department of Chemical Engineering and Technology develops cutting-edge solutions for renewable energy, sustainable materials, and advanced optical applications. Our research combine materials science, electrochemistry, and crystal engineering to address global challenges.

Key areas of expertise:

- Electrochemical energy storage: safe, low-cost and sustainable aqueous Na- and Zn-ion batteries for stationary applications
- Photoelectrochemical synthesis: light-driven production of hydrogen and strong oxidants for various applications
- Single-crystal growth: high-quality crystals for non-linear optics and photonic technologies

Our Electrochemical Energy Conversion and Single-Crystal Growth laboratories support innovation from fundamental research to practical applications, with sustainability and circularity guiding all our R&D efforts. We specialize in the preparation of inorganic materials and coatings, as well as their advanced characterization using structural, morphological, electrochemical, and durability techniques.



“Chemical and electrochemical engineering play a critical role in enabling renewable energy integration and advancing sustainable material systems.”

Dr. Linas Vilčiauskas

Head of Department,
Principal Researcher

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Photoelectrochemical Degradation of Diclofenac, Tetracycline, and Amoxicillin in an Aqueous Sulfate Medium: Analysis of Reactive Species

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<https://doi.org/10.1021/acsomega.4c10891>

As the environment becomes increasingly polluted, there is a pressing need for the development of effective remediation technologies, particularly in wastewater treatment. Recently, there has been a growing interest in advanced oxidation systems (AOSs) based on renewable solar energy. This study focuses on the investigation of photoelectrochemical (PEC) AOSs using WO_3 and $WO_3/BiVO_4$ photoanodes and an environmentally friendly aqueous sulfate electrolyte for visible light-induced decomposition of pharmaceutical compounds, namely, diclofenac (DCF), amoxicillin (AMX), and tetracycline (TCC). It was demonstrated that in contrast to conventional persulfate-based advanced oxidation processes, where $S_2O_8^{2-}$ is activated by UV, ultrasound, or thermal energy to generate highly reactive radical species, in photoelectrochemical systems reported here, radicals were generated by the interaction of photogenerated holes with H_2O molecules and SO_4^{2-} ions. These processes eventually led to the formation of $S_2O_8^{2-}$ with an estimated Faradaic efficiency of 70–80%. Persulfate has also been shown to contribute to the degradation of pharmaceutical compounds, particularly diclofenac. The degradation efficiencies of AMX, TCC, and DCF were 10–14, 19–21, and 75–80%, respectively, in both PEC–AOSs studies. The mechanism of visible light-induced generation of persulfate in the studied PEC systems was proposed based on thermodynamic considerations and experimental observations of pH variation during photoelectrolysis.

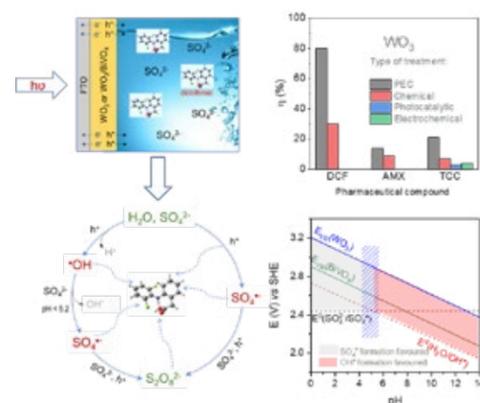


Fig. 1. Schematic representation of PEC processes and their mechanism (left); comparison of pharmaceutical degradation efficiencies under different treatments using WO_3 (top right); analysis of thermodynamic possibilities of various reactive species formation under experimental conditions (bottom right).

Corrosion and Biocompatibility Studies of Bioceramic Alumina Coatings on Aluminum Alloy 6082

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<https://doi.org/10.1021/acsami.5c00532>

This study evaluates the biocompatibility of bioceramic-coated aluminum (Al) alloy 6082 as a lightweight and cost-effective alternative for bone osseosynthesis plates. Al_2O_3 coatings were achieved through anodization using phosphoric and sulfuric acids. The untreated and anodized alloys were analyzed for chemical stability and biocompatibility and compared with medical-grade titanium alloy. All specimens exhibited excellent biocompatibility, demonstrating high adhesion and viability of the fibroblast cell line. Corrosion resistance and metal ion release were assessed in simulated body fluid, with all specimens effectively suppressing the release of Fe and toxic Al ions. The bioceramic coating obtained in sulfuric acid demonstrated 3 orders of magnitude higher corrosion resistance, indicating its potential suitability for biomedical applications. By addressing the limitations of traditional alumina ceramics, our approach enables the fabrication of products in diverse sizes and shapes, offering a practical solution for creating customized biomedical implants.

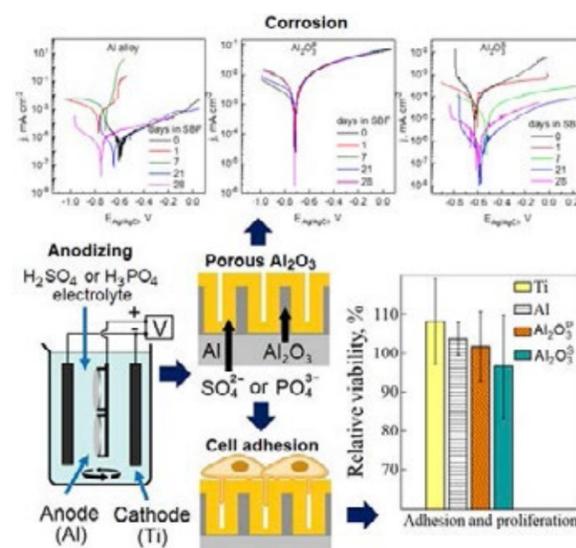


Fig. 2. The principal scheme of specimen preparation and investigation: anodizing, corrosion, and biocompatibility tests. The corrosion of untreated and anodized Al alloys is represented in Tafel plots before and after immersion in body fluids for 1 to 28 days. The impact of alloy extracts on the relative viability of L929 cells on overall growth is represented in the graph. The mean relative viability (%) was calculated based on the untreated control group, with error bars indicating the standard deviation. No significant differences were observed between groups.



DEPARTMENT OF ELECTROCHEMICAL MATERIALS SCIENCE

The Department of Electrochemical Materials Science focuses on the development of new materials of technological significance and advanced characterization methods in the areas of electrochemical research, resistance to environmental degradation, photocatalysis, etc. Recent research activities have included such fields as electrochemistry of silicon and its nanostructures, thin-film protection of semiconductors from environmental degradation, physical vapor deposition of ultrathin metal oxide layers, including transparent and conductive ones, and new materials for solar energy conversion. Nano-thin metal oxide layers have been developed to protect silicon and enhance its efficiency in solar energy conversion.

Researchers from the Nanostructure Laboratory have conducted studies on the synthesis and characterization of novel nanomaterials for applications in optoelectronics and energy conversion. The formation of titania, gold, and iron oxide nanostructures has also been developed, with a focus on advantageous surface functionalization. Recently, MXene-based nanocomposites and gold nanoparticles have been synthesized and characterized, showing significant potential in nanomedicine for biosensing and in vivo carcinoma tumor treatment.

Colleagues in the Department are experts in a wide range of techniques, such as photo-electrochemical characterization, physical vapor deposition (PVD), atomic layer deposition (ALD), adhesion of ultra-thin formations, accelerated corrosion studies in corrosion and climatic chambers. A significant part of the research has been performed in collaboration with Scientific Divisions of FTMC: the Laboratory of Electronic Processes, the Department of Chemical Engineering and Technology, the Department of Characterization of Materials Structure, and the Department of Nanotechnology. The Nanostructure Laboratory collaborates closely with the State Research Institute Centre for Innovative Medicine; Institute of Biochemistry, Life Sciences Center, Vilnius University; Laboratory of Biomedical Physics of National Cancer Institute.



“Material science is one of the most promising elds that will not lose its relevance, as no matter what topic we discuss, we always encounter material-related challenges.”

Prof. Habil. Dr. Eimutis Juzeliūnas

Head of Department,
Principal Researcher

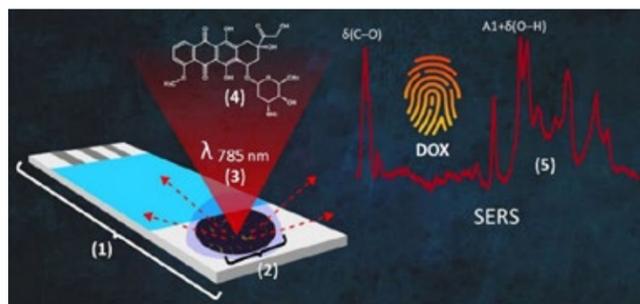
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Fabrication of Porous Black Gold Films by One-Step Anodic Treatment: Towards the Development of SERS-Active Nanosensors

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<https://doi.org/10.1016/j.mtchem.2025.102849>

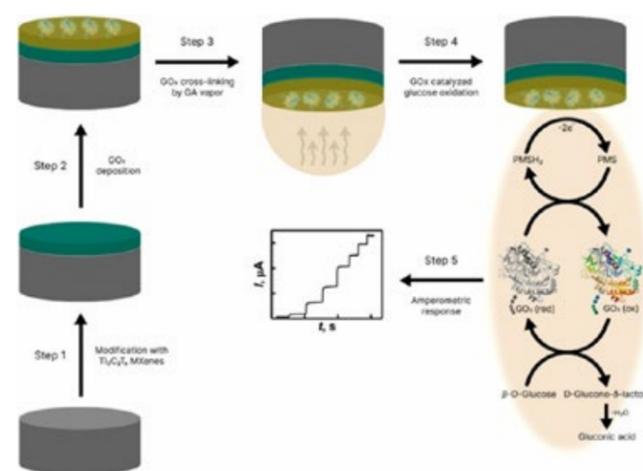
In this study, we present a novel, simple, and cost-effective approach to transform 2D gold surface morphology into porous 3D networks. The proposed method provides a dual-functional sensor system that renders screen-printed gold electrodes (SPE) suitable for electrochemical or surface-enhanced Raman scattering (SERS) ensing within minutes. This gold transition is achieved by anodic treatment of bare gold, including disposable SPE (1). This method is beneficial because it forms nanoporous black (2) gold (NPGox) layers in nonaggressive electrolyte solutions (i.e., oxalic acid) without the need for external gold sources. This feature may benefit the described techniques because it does not destroy the other parts of the SPE electrode (i.e., Ag-pseudo reference electrode) and enables easy-to-scale production. This feature is crucial for the large-scale production of SERS substrates. We estimate the cost of dual-functionalized NPGox-based SERS nanosensors (excluding the printing expense) at ca. 0.015 \$/item, proving its cost-effectiveness and sustainability. The established EF of proposed NPG_{ox}-based SERS nanosensors was 1.4×10^7 for 4-MBA. After exposure to a 785 nm laser (3, the Raman signal was significantly amplified using NPG_{ox} nanosensors, enabling us to rapidly and quantitatively detect an anticancer drug, doxorubicin molecule (4) by SERS (5), within the concentration range from 10^{-6} to 10^{-2} M. Furthermore, the proposed nanosensors (NPG_{ox}) outperformed commercial SERS substrates by offering lower fabrication costs and greater SERS amplification stability across the sensing electrode, making it a promising candidate for practical applications.



MXene-Based Electrochemical Glucose Biosensors: Comparative Enhancement with Aquivion and Nafion

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<https://doi.org/10.1016/j.mtnano.2025.100712>

Unlike many previous studies that focused on MXene-based nanocomposites, this work demonstrates the potential of using pristine Ti₃C₂T_x as an electrode modifier for glucose biosensing. The graphite rod electrode's surface was modified with pristine Ti₃C₂T_x MXenes, then glucose oxidase was deposited and crosslinked with glutaraldehyde vapor to improve the biosensor's electrochemical performance. Among the tested redox mediators, phenazine methosulfate provided the best electron transfer and was the most suitable for MXene-based glucose biosensors. To address incomplete electrode coverage and surface instability, Nafion and Aquivion were introduced as ionomer binders. This significantly improved MXene layer adhesion, morphology, and electroactive surface area. Biosensors prepared with 0.05% Aquivion and 0.01% Nafion exhibited a practically relevant linear range (0.1–5 mM), low limits of detection (23 μM and 48 μM), high sensitivities (97.5 and 88.9 μA·mM⁻¹·cm⁻²), and low relative standard deviations (5.1% and 3.8% for repeatability and <7.9% for reproducibility). Importantly, the practical applicability of the developed biosensors was confirmed by successfully determining glucose in human serum samples.

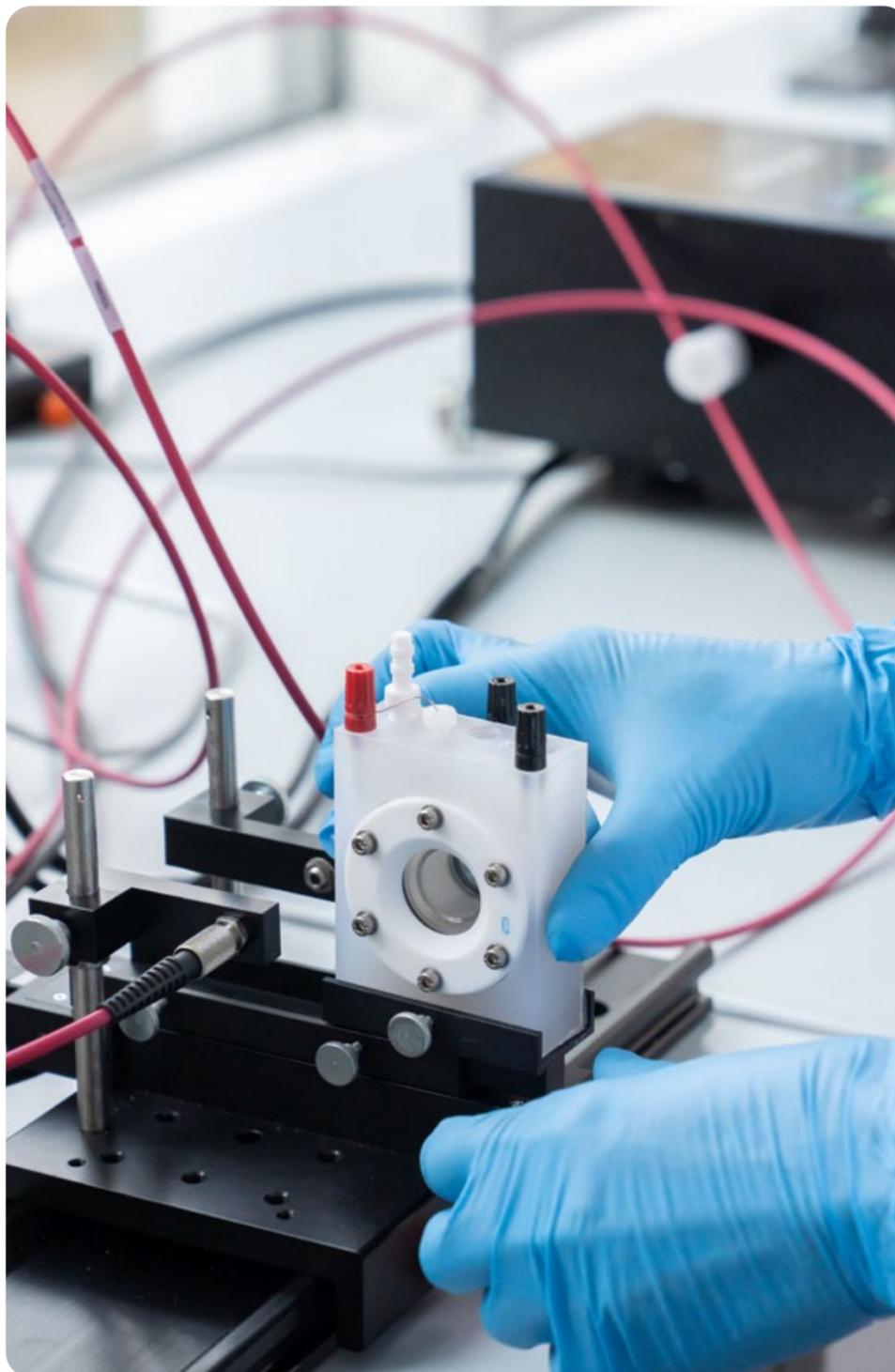
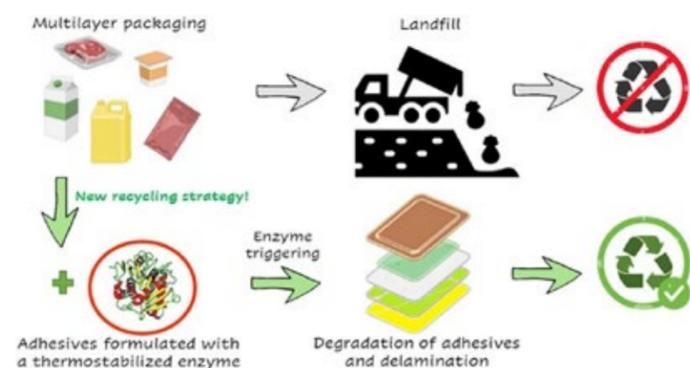


Tie-Layer and Polyurethane Formulations with Embedded Enzymes for On-Demand Degradable Adhesives

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<https://doi.org/10.1016/j.jece.2025.118218>

The management of plastic waste can be achieved through two primary strategies: recycling and the utilization of biodegradable alternatives to petroleum-based plastics. Despite the advancements, the recycling of specialized technologies remains imperative due to the wide variety of plastic types. Multilayer packaging, for instance, consists of thin layers of different materials that current technologies cannot effectively separate, causing most of these materials to be incinerated or landfilled. This study has developed specific adhesive formulations for multilayer packaging using tie-layers (TLs) and polyurethanes (PUR), all containing varying amounts of an immobilized cutinase enzyme from *Humicola insolens* (1–2.5–5% for TLs, 1–3% for PUR). Polycaprolactone (PCL) and poly(butylene succinate-co-adipate) (PBSA) were utilized as TLs, in conjunction with solvent-based (SB), solvent-free (SF), and DES-based (Deep Eutectic Solvent) PUR formulations. The enzyme, which remains dormant when immobilized, was activated by releasing it into an appropriate medium (sodium phosphate buffer, 0.1 M, pH 8). Weight loss tests and kinetic studies were conducted on most degradable formulations. TL formulations demonstrated high degradability within 120 minutes. Most PUR formulations experienced a weight reduction of over 50% after a duration of 96 hours. In contrast, SB formulations exhibited a release of less than 15% of cutinase, accompanied by minimal activity loss. Conversely, SF and DES-based formulations demonstrated a release of approximately 60% of cutinase, accompanied by partial activity loss. The degradation of adhesives facilitated the separation of multilayer films, enabling the recovery of materials, and substantiating the efficacy of the strategy.

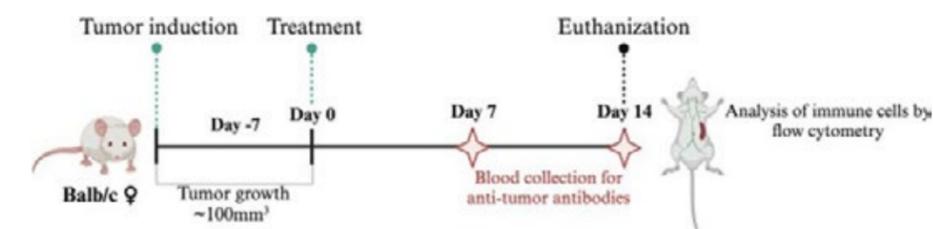


Improving Bleomycin Electrochemotherapy With Gold Nanoparticles: First *In Vivo* Study on Intra-Tumoral Field Amplification

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In this study, we demonstrate that microsecond-range bleomycin electrochemotherapy ($1.5 \text{ kV/cm} \times 100 \mu\text{s} \times 8 \text{ pulses, } 1 \text{ Hz}$), combined with gold nanoparticles (AuNPs, 13 and 46 nm), can be efficiently utilized for *in vivo* carcinoma tumor treatment. It was anticipated that AuNPs would promote a better treatment response due to local electric field amplification within the tumor as predicted by available *in vitro* research. We focus on the attenuation of tumor progression and reduction of the frequency of metastasis, including the immune response in the murine BALB/C and 4T1 cancer model. It is shown that the application of 13 nm AuNPs hardly influenced the dynamics of tumor progression (when compared to electrochemotherapy (ECT) alone), the synergistic effects are not statistically significant by the end of experiment, which is not the case *in vitro*. However, the application of 46 nm AuNPs significantly potentiated the efficacy of ECT, which confirms the promising alliance of conductive nanoparticles for local intra-tumoral electric field amplification and ECT.



DEPARTMENT OF CATALYSIS

The R&D activities at the Department of Catalysis focus on the development of advanced catalytic materials and processes. Research includes the design and development of high-performance multifunctional catalytic materials using various techniques, including electroless and/or electrochemical metal plating, dynamic hydrogen bubble template, microwave, and hydrothermal synthesis techniques. Coatings of noble and base transition metals and their alloys with different structures, compositions and very high electrochemically active surface areas have been developed and deposited on a variety of conductive and non-conductive flexible substrates (metals and their rigid foams, polymers: polyethylene, polypropylene, polyvinyl chloride, polyimide, polyetherimides), silicon carbide, quartz particles using the electroless metal plating method.

The R&D activities in this area focus on the development of novel electroless metal plating processes as well as fundamental studies of the reactions occurring in autocatalytic metal ions reduction systems using electrochemical quartz crystal microgravimetry and their application in microelectronics, renewable and low-carbon energy conversion and storage technologies, such as chemical and electrochemical hydrogen production, low-temperature fuel cells, metal-air batteries and supercapacitors, etc. Electroless metal plating is a well-known method for depositing metal coatings by a controlled chemical reduction and formation of small (nanoscale) metal particles. The autocatalytic metal ion reduction systems are widely used for decorative and functional purposes or selective metallization. The selection of suitable reducing agents and reaction conditions (temperature, the concentration of the reacting substances, etc.) plays a very important role in creating stable solutions and obtaining coatings with required properties, such as purity and surface roughness.

Researchers at the Department of Catalysis have experience in studying the electrocatalytic activity of engineered materials for a variety of catalytic reactions using electrochemical techniques such as cyclic voltammetry, chronoamperometry, chronopotentiometry, rotating disk electrode and ring-disk electrode, and electrochemical impedance spectroscopy methods.

Another major focus of the Department is the development of commercially viable and efficient biochar materials from waste of the wood, biorefinery, and pulp and paper industries. The synthesized novel high-performance, high-conductivity, electrocatalytically active, durable, low-cost, high-surface-area carbon materials with controlled pore size distribution have been successfully applied as electrode materials in supercapacitors, metal-air batteries and fuel cells.



„High-performance multifunctional catalytic materials for sustainable catalysis“

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Photocurrent Switching Effect and Visible Light Activity of Electrochemically Synthesized Bifunctional Through Oxide via TiO₂/CuO Composites

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This study reports on the electrochemical synthesis of a TiO₂/Cu composite electrode, where Cu is electrodeposited into a TiO₂ scaffold prepared by plasma electrolytic oxidation (PEO). Upon annealing at an optimized temperature, a mixed Cu₂O/CuO phase forms, while TiO₂ remains anatase. This gives the composite unique photoelectrochemical (PEC) properties – white light sensitivity and photocurrent switching performance. In addition, it is proposed that metallic Cu can act as a conductive pathway for photogenerated electrons from TiO₂, improving photovoltage generation kinetics. Such composites could be used as PEC devices or even for visible light sensing applications.

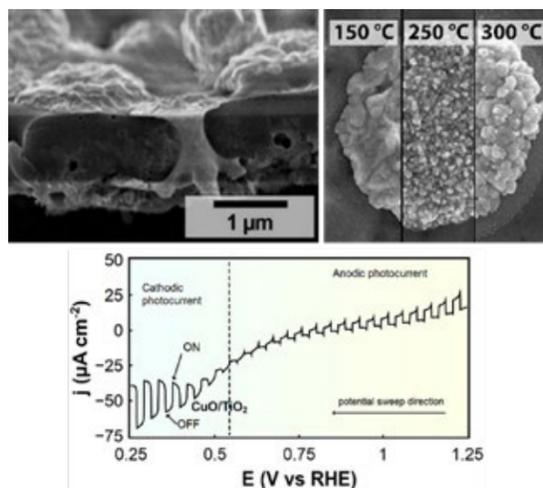


Fig. 1. (a) Cross-sectional morphology of TiO₂/Cu composite; (b) evolution of CuO nanostructure with annealing temperature; (c) chopped-light LSV curve of TiO₂/CuO film, showing photocurrent switching behavior.

Enabling Acidic-Like Hydrogen Evolution Reaction Activity in Alkaline Media Through Rh-Decorated Cu/TiO₂ Composites

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In this study, an optimized Cu/TiO₂ framework is used as the base for a galvanic displacement process, where an ultralow amount of Rh is spontaneously deposited on the exposed Cu, resulting in a highly efficient Rh@Cu/TiO₂ composite catalyst for HER in alkaline media. EDX mapping confirms the specific interaction of Rh with Cu consistently throughout the composition of the coating. Extensive characterization of the electrocatalytic HER properties reveals that excellent performance can be attributed to the highly evolved electrochemically active surface area. In addition, post-experiment structural characterization was employed to investigate the mechanism of deactivation for this composite.

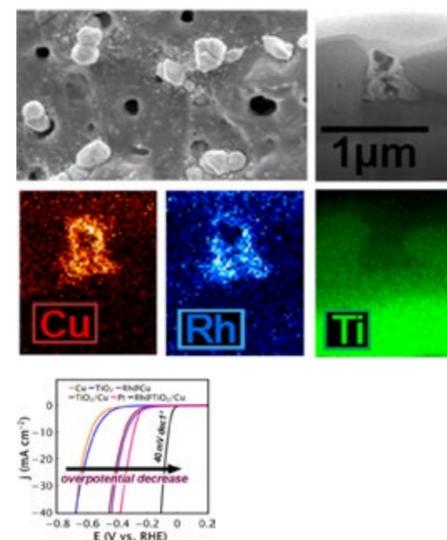


Fig. 2. (a) Surface morphology and cross-section elemental mapping of Rh@Cu/TiO₂ film; (b) LSV curves for HER on different substrates and their Cu/Rh composites.



DEPARTMENT OF CHARACTERISATION OF MATERIALS STRUCTURE

The department plays an important role in advancing materials research by conducting in-depth structural characterization of materials and material systems. Advanced analytical techniques, such as Scanning Electron Microscopy (SEM) equipped with focused ion beam (FIB), Transmission Electron Microscopy (TEM), X-ray fluorescence spectroscopy, X-ray diffraction (XRD) and X-ray Photoelectron Spectroscopy (XPS), are essential for understanding the structural, morphological, and chemical properties of materials. Most of the department activities involve applying these techniques to precisely evaluate material properties and structural characteristics which is important for the development of optoelectronic, optical coatings and energy materials-related technologies.

The department is organized into two specialized laboratories: Structural Characterization Laboratory and Photovoltaic Materials Laboratory. The former is dedicated to the comprehensive characterization of material structures through a wide range of microscopic and spectroscopic methods. Its research activities aim to uncover detailed information about crystalline structures, micro- and nanoscale morphology, surface chemistry, elemental composition, and crystalline phase composition. The team investigates a diverse array of samples, including epitaxial and polycrystalline thin films, bulk crystals, composite materials, crystalline powders and nanoparticles. The in-depth understanding of material structure acquired here, directly supports the development of improved optoelectronic materials, catalysts, energy-storage/conversion electrodes, and other functional systems. The Photovoltaic Materials Laboratory focuses on the synthesis, engineering, and characterization of chalcogenide materials for advanced optoelectronic applications. A major emphasis is placed on developing sustainable thin-film solar cell technologies that utilize earth-abundant and environmentally friendly materials. The research also includes the exploration of both wide- and narrow-bandgap chalcogenide semiconductors for integration into flexible, indoor, semi-transparent, and multijunction photovoltaic devices.



„Although department is small, it plays a vital role in aiding to develop various technologies raging from catalysis, energy materials to optical coatings and quantum structures”

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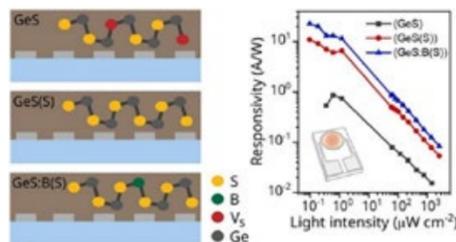


High-Performance GeS Thin-Film Photodetectors Obtained via Sulfurization and Boron Doping

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The next-generation photodetectors require materials that offer high performance in terms of responsivity and detectivity, especially in the visible spectrum. The two-dimensional semiconductors have recently emerged as promising materials for use in these devices due to their tunable optoelectronic properties. However, it is still a challenge to achieve competitive performance with conventional semiconductors. In this study, we have investigated the effects of sulfurization and doping on the performance of GeS thin-film photodetectors. We synthesized the pristine GeS, sulfurized GeS (GeS(S)), and boron-doped sulfurized GeS (GeS:B(S)) films using a rapid thermal evaporation method, which allowed us to obtain films exhibiting a pure GeS phase with a dominant hkl (100) orientation, characteristic of the layered structure. The structural, optical, and electrical properties of the films were characterized as functions of sulfurization and doping. The results show that sulfurization significantly enhanced the photocurrent, while boron doping provides additional improvements in responsivity and detectivity but at the expense of slower response times, reflecting the responsivity and speed trade-off typical for photoconductors. A lateral photoconductor device was fabricated using an interdigitated array (IDA) platinum electrodes operating on the photoconductive effect. Based on sulfurized and boron-doped GeS, the device demonstrated a high responsivity of 22.68 A/W and a detectivity of $1.38 \cdot 10^{13}$ Jones under 532 nm illumination, with switching times around 500 μ s. These findings indicate that sulfurization and boron doping are promising strategies to improve the performance of GeS thin-film visible-light photodetectors, making them reasonable candidates for high-performance optoelectronic applications. To the best of our knowledge, this work also shows one of the first experimental studies investigating boron doping in GeS thin films, opening perspectives for the further tuning of their optoelectronic properties.

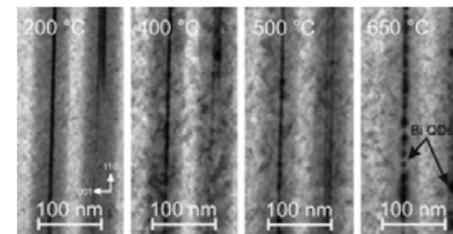


In Situ TEM Study of Size-Controlled Bi Quantum Dots in an Annealed GaAsBi/AlAs Multiple Quantum Well Structure

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<https://doi.org/10.1021/acsomega.4c10631>

This work presents an *in situ* transmission electron microscopy study of Bi quantum dot (QD) formation in an annealed GaAsBi/AlAs multiple quantum well (MQW) structure. The investigated structure, containing two GaAsBi QWs and embedded in an AlGaAs parabolic quantum barrier (PQB), was grown on semi-insulating GaAs (100) and was transferred onto an *in situ* heating holder and heated up to 650 °C. The sample evolution was continuously recorded *in situ* using bright-field STEM mode. The analysis revealed that QD formation occurs at lower annealing temperatures in case of *in situ* heating of lamella than in bulk. Additionally, we found that the mechanism governing Bi QD formation is different in the *in situ* TEM experiment compared to bulk *ex-situ* annealing. A comparison of the *ex-situ* and *in situ* annealed structures, as well as in-depth post-annealed TEM analysis, is presented.



DEPARTMENT OF NANOTECHNOLOGY

The major research activities of the Department of Nanotechnology focus on the development of advanced sensors, including optical (spectroscopic ellipsometry), acoustic (quartz crystal microbalance (QCM)), and electrochemical sensors. The department's research encompasses both fundamental and applied aspects of nanoscale materials and their integration into analytical systems. Electrochemical sensors are modified with self-assembled monolayers and conducting polymers, including molecularly imprinted polymers, to enhance their sensitivity and selectivity toward target analytes. The electrochemical characterisation of these systems is carried out using differential pulse voltammetry, cyclic voltammetry, pulsed amperometric detection, and other electroanalytical techniques.

The Laboratory of Bioelectrochemical Technologies develops biofuel cells and biological sensors and applies imaging and research methods, such as local electrochemical impedance spectroscopy and scanning electrochemical microscopy. Scanning electrochemical microscopy is further advanced using artificial intelligence and image recognition to create user-friendly measurement equipment that can be easily adapted to different objects and environments. In addition, mathematical models describing electrochemical processes and mechanical properties are developed.



„Nano-scale structures on top of electrode have an enormous and diverse potential on sensitivity and selectivity of electrochemical, optical, acoustic, or biological sensors“

Prof. Habil. Dr. Arūnas Ramanavičius

Head of Department,
Principal Researcher

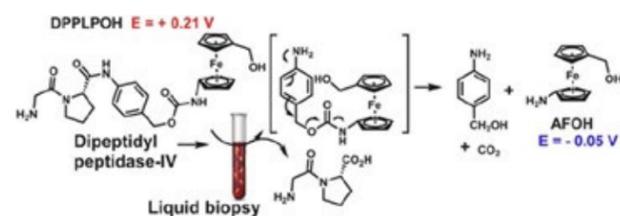
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Development of an Activity-Based Ratiometric Electrochemical Substrate for Measuring Circulating Dipeptidyl Peptidase-IV/CD26 in Whole Blood Samples

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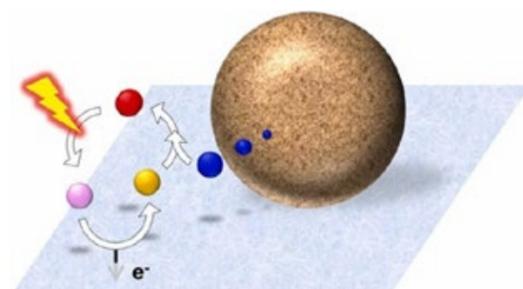
Dipeptidyl peptidase-IV (DPP-IV) is a circulating blood biomarker used to diagnose pancreatic and thyroid cancers, as well as type 2 diabetes. Although current DPP-IV detection methods show promise, real-time detection in whole blood is limited, as blood samples require tedious pre-treatment. To overcome these limitations, a DPP-IV targeted electrochemical substrate, DPPLPOH (DiPeptidyl Peptidase Latent Probe-OH (with Hydroxyl group)) was designed. When coupled with an electrochemical analytical method, this substrate enabled direct and convenient detection of DPP-IV in complex biofluids, including whole blood samples. In these assays, DPP-IV selectively hydrolysed DPPLPOH, which underwent a self-immolative reaction to generate a masked electrochemically sensitive amino ferrocene reporter (AFOH). This electrochemical analytical tool demonstrated excellent sensing performance, characterized by exceptional enzyme-binding properties. This method may be a valuable tool in the early detection of pancreatic and thyroid cancers and in post-treatment surveillance.



Electrochemiluminescence Microscopy of Diffusive Biocompounds as Co-Reactants in Cell Spheroids With [Ru(Bpy)3]2+

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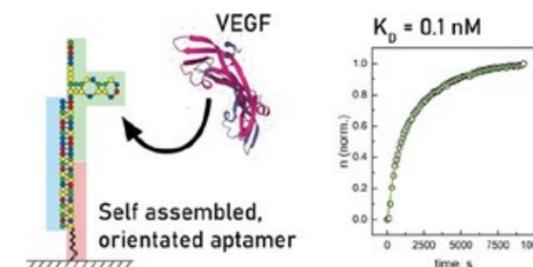
In vitro assays using three-dimensional cultured cells, such as spheroids, are widely used in drug screening as an alternative to animal experiments. Biocompounds in the spheroids must be evaluated to ensure their successful application. In this study, electrochemiluminescence (ECL) microscopy was used for their detection. To the best of our knowledge, this is the first report to visualize diffusive biocompounds from spheroids with a simple signal-on ECL device using [Ru(bpy)3]2+. This study presents the ECL microscopy of diffusive biocompounds as co-reactants inside cell spheroids using [Ru(bpy)3]2+. MCF-7 cell spheroids, a breast cancer cell line, were used in a proof-of-concept study. The discussion suggests that GSH is expected to be the main biocompound. Thus, the ECL approach using [Ru(bpy)3]2+ holds potential for spheroid analysis, and the proposed imaging system could be applied for drug screening using various *in vitro* models, including organoids.



Characterisation of Binding Kinetics for Vascular Endothelial Growth Factor with Self-Assembled DNA Aptamer Using Total Internal Reflection Ellipsometry

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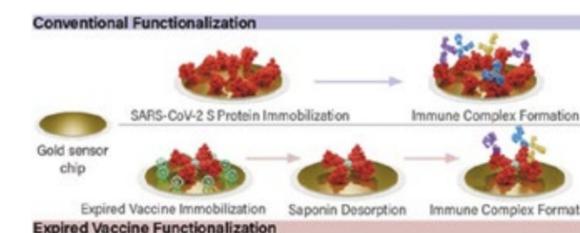
This study demonstrates real-time interaction between a hybridised DNA aptamer that consists of three self-assembling oligonucleotides (anti-VEGF aptamer) and its target analyte of vascular endothelial growth factor (VEGF). VEGF is responsible for the growth of new blood vessels and is also abundantly present in tumours, making VEGF a prime biomarker for cancer detection. Time-resolved complex formation kinetics was analysed using a sensitive and non-destructive total internal reflection ellipsometry (TIRE) method. The hybridized DNA structure contributed to a 5-fold enhanced binding affinity compared to the original SL2B aptamer. A comparison with a nonspecific GCSF-SCF dimer binding to anti-VEGF aptamer showed that the binding of VEGF was highly specific and strong, with a significant change in ellipsometric parameters, whereas the GCSF-SCF interaction resulted in a lower signal change. The study confirms that the immobilization and orientation of aptamer on the sensing surface play a critical role in enhancing VEGF binding efficiency and stability.



The Second Life for Unused COVID-19 Vaccines: Towards Biosensing Application

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<https://doi.org/10.1016/j.talanta.2025.127647>

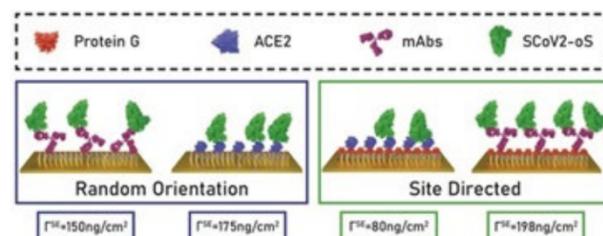
Many vaccines have been produced during the COVID-19 pandemic. Currently, an increasing number of vaccines have reached an expiration date without being used. Therefore, expired vaccines (EXVAX) based on virus-like particles (VLP) recombinant SARS-CoV2-S protein can be repurposed for biosensing application and provide a use, even though they are past their expiration date for vaccination. In the current study, we applied EXVAX based on VLP for gold sensor chip modification to use such surface for specific antibody detection from diluted human serum. For this purpose, we used total internal reflection ellipsometry for real-time kinetics measurement and mathematical modelling for the calculation of affinity constants. The results suggest that the EXVAX functionalisation is thermodynamically favoured. The interaction analysis of polyclonal antibodies from human serums shows that the EXVAX SARS-CoV2-S proteins retain their biological activity more than one year after the expiration date.



Comparison of the ACE2 Receptor and Monoclonal Antibodies Immobilisation Strategies for the Sensitive Detection of SARS-CoV-2 Variants of Concern

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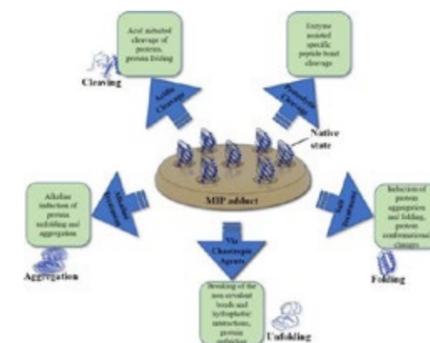
The investigation of antibody or receptor immobilisation and binding to the target analyte is essential for the development of effective immunoassays. In our research, we applied the combination of two surface-sensitive methods: spectroscopic ellipsometry and quartz crystal microbalance with dissipation. It enabled quantitative investigation of optical and mechanical properties of formed biomolecule layers consisting of monoclonal antibodies (mAb) or angiotensin-converting enzyme 2 (ACE2) receptors coupled with the Fc fragment, in complex with severe acute respiratory syndrome coronavirus 2 spike Omicron variant (SCoV2- α S). Random and site-directed immobilisation of ACE2 receptor gave 1.8 and 2.4 times higher dry surface mass density compared to random and site-direct mAbs immobilisation, respectively. Therefore, ACE2 had better potential for more sensitive detection of the target analyte SCoV2- α S. Our findings in this investigation indicated that ACE2 coupled with the Fc fragment is as effective in the recognition of SARS-CoV-2 as mAbs and it can be successfully applied for the development of immunoassays.



Formation of Molecularly Imprinted Polymers: Strategies Applied for the Removal of Protein Template (Review)

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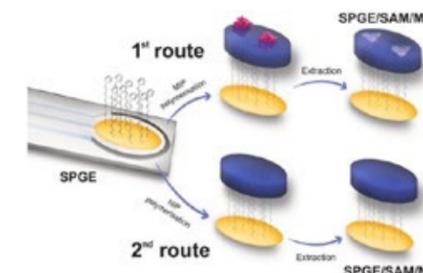
The key step in the entire molecularly imprinted polymer (MIP) preparation process is the formation of the complementary cavities in the polymer matrix through the template removal process. The template is removed using chemical treatments, leaving behind selective binding sites for target molecules within the polymer matrix. MIP template removal is especially challenging in the synthesis, where the molecular template is a macromolecule such as a protein. This review aims to provide a deliberate, systematic, and consistent overview of protein removal as the MIP template molecules. Five protein template removal approaches involving chemical treatment are highlighted, which include the utilisation of (i) chaotropic agents, (ii) salt, (iii) acidic cleavage, (iv) alkaline, and, finally, (v) proteolytic treatment focusing on studies conducted over the past decade. This review provides insights into MIPs protein template removal strategies while highlighting the prevalent issue of this understudied step of template removal.



Detection of the SARS-CoV-2 Nucleoprotein by Electrochemical Biosensor based on Molecularly Imprinted Polypyrrole Formed on Self-Assembled Monolayer

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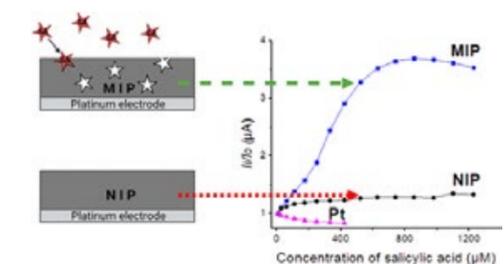
This study describes the development and characterisation of an electrochemical biosensor with a polypyrrole (Ppy)-based molecularly imprinted polymer (MIP) for the serological detection of the recombinant nucleocapsid protein of SARS-CoV-2 (rN). The electrochemical biosensor utilises a Ppy-based MIP formed on a self-assembled monolayer (SAM) at the gold interface to enhance Ppy layer stability on the screen-printed electrode (SPE). Electrochemical impedance spectroscopy (EIS) and square wave voltammetry (SWV) were employed for the electrochemical characterisation of screen-printed gold electrodes (SPGEs) modified with MIP or non-imprinted polymer (NIP) layers. Removing the rN protein template from the MIP layer increased electron transfer and decreased impedance, indicating the specificity of molecular imprinting. The electrochemical biosensor with a Ppy-based MIP exhibited higher sensitivity than the NIP counterpart, demonstrating its potential for selective rN protein detection. The specificity test confirmed minimal nonspecific binding, reinforcing the reliability of the novel electrochemical sensor with a Ppy-based MIP.



Electrochemical Salicylic Acid Sensor Based on Molecularly Imprinted Polypyrrole

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This study aims to provide new insights into the development of an electrochemical salicylic acid (SA) sensor based on a molecularly imprinted polymer (MIP). Polypyrrole (Ppy)-based MIP and nonimprinted polymer (NIP) layers were deposited on the platinum electrode and evaluated in a three-electrode electrochemical cell. The study used amperometry for monomer polymerization, cyclic voltammetry (CV) for the overoxidation of the polymer layer, and differential pulse voltammetry (DPV) for analyte detection. Selectivity was evaluated by comparing the electrochemical signals of SA with those of 3-hydroxybenzoic acid and melamine. Results confirm the selectivity of the electrochemical sensor. Density functional theory (DFT) calculations were performed to analyze the rebinding and recognition mechanism. The results of DFT calculations support the experimental findings. In conclusion, the polypyrrole-based MIP sensor exhibits higher selectivity and sensitivity toward salicylic acid detection compared to melamine and even to its isomer, 3-hydroxybenzoic acid (3-HBA).



DEPARTMENT OF FUNCTIONAL MATERIALS AND ELECTRONICS

The increasing demand for innovative functional materials with distinctive properties is the driving force of fabrication technologies. Within the Department of Functional Materials and Electronics, significant efforts are focused on developing pulsed injection MOCVD, magnetron sputtering, and pulsed laser deposition technologies for the creation of advanced thin films and nanostructures. Our department tailors ferromagnetic oxides, Heusler alloys, high-temperature superconductors, and 2D semiconductors, such as grapheme, for various applications. Numerical calculations and experimental investigations of the specific properties of the grown nanostructures are performed to clarify their responses to external stimuli, such as magnetic and electric fields, exposure to light and others, to develop spin valves, magnetic field sensors, proximity sensors, biosensors, and other devices.

We also explore the impact of electrical pulses on plasma membrane permeability across a variety of cells, from bacteria to mammalian cells. This research focuses on how plasma membrane permeability affects the survival of microorganisms with cell walls and aims to identify specialized testing methodologies. Additionally, there are efforts to develop electroporation-based technologies for managing harmful microorganisms.

Investigations extend to analyzing the effects of short nanosecond electrical pulses on intracellular signals, while also studying the impact of abiotic factors, such as light, temperature, and electric fields, on cellular signals. This research involves innovative, optically transparent polymeric materials for photodynamic therapy and develops organ-on-a-chip devices to explore electrically induced intercellular signals.



“The investigation of functional materials for their response to electrical, magnetic, optical or biochemical stimuli starting from fundamental research enables the exploitation of their properties for real-life applications.”

Prof., Dr. Nerija Žurauskienė

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Evaluation of the Stability of the β -carotene and Xylan Complexes Under Different Environmental and Long-Term Conditions

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β -Carotene is the most abundant carotenoid, serving as a precursor for vitamin A synthesis and playing a significant role in dietary, food, cosmetic, pharmaceutical, and biotechnological applications due to its contributions to normal vision, immune function, reproduction, growth, and development, as well as its high antioxidant activity. Since β -carotene is insoluble in water, it is crucial to create water-soluble complexes and investigate their stability. The stability of the β -carotene complex was analyzed in various environments, including long-term stability in the dark at 4 °C and 25 °C across a range of pH levels, storage stability at -18 °C, color changes, UV irradiation, and temperature effects. Additionally, degradation of reactions and reaction half-life by first order kinetics. The complex demonstrated good resistance in solution across a wide pH range, maintaining relative stability above 80% (see Fig. 1). After one month of storage, this dropped to 70%. The half-life ($t_{1/2}$) of the complex was found to be 190-259 days at 4 °C and 85-112 days at RT. After one month of storage at these temperatures, the $t_{1/2}$ decreased to 86-149 days and 59-82 days, respectively. The complex exhibited good antioxidant activity (AA) during long-term storage (see Fig. 2). The findings are summarized in the graphical abstract below (see Fig. 3).

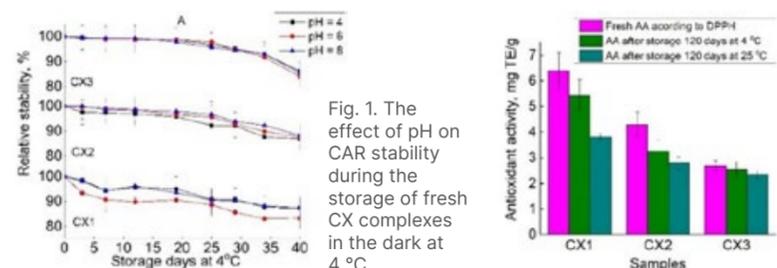


Fig. 1. The effect of pH on CAR stability during the storage of fresh CX complexes in the dark at 4 °C.

Fig. 2. The dependence on the antioxidant activity of fresh and after 120 days of storage at 4 oC and RT was assessed in Trolox units using DPPH.

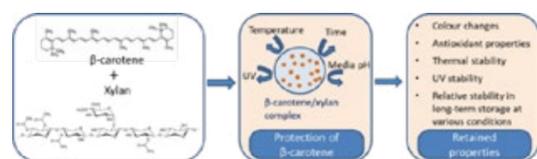


Fig. 3. Stability of β -carotene-xylan complexes under varied environments and long-term storage.

Hydrogel-Based Photodynamic Treatment of Chronic Biofilm Infections

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<https://doi.org/10.1021/acsomega.5c02315>

The development of advanced antimicrobial strategies is crucial for addressing persistent biofilm-associated infections, where deep-seated microbial communities resist conventional therapies. With this study, we present a novel hydrogel system, HG1MB1, incorporating the photosensitizer methylene blue (MB) to enhance photoinactivation of microbial biofilms. By utilizing a gel-like matrix, the hydrogel enables significantly improved penetration of MB into the deeper layers of the biofilm, facilitating stronger interactions with the extracellular polymeric substances (EPS) and promoting disruption of the biofilm structure. Upon light activation, the system generates reactive oxygen species that substantially boost its antimicrobial efficacy (see Fig. 4). This innovative approach not only achieves broad-spectrum activity against both bacterial and fungal biofilms but also opens new avenues for effective treatment of chronic, treatment-resistant infections. The findings are summarized in the graphical abstract below (see Fig. 5).

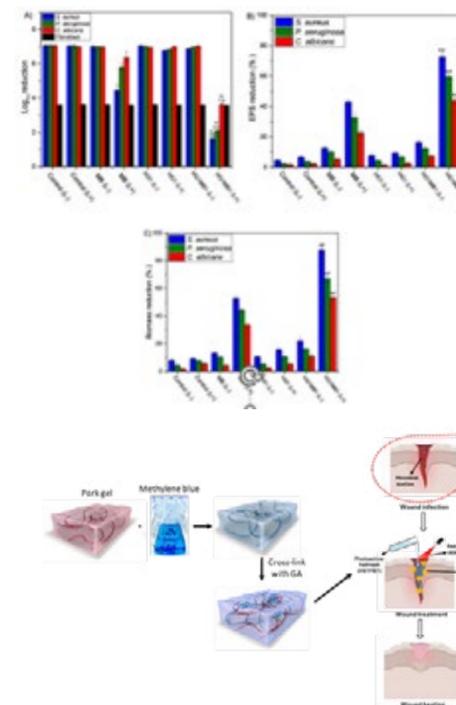


Fig. 4. Log reduction of microbial biofilms and fibroblasts after aPDT (A). Percentage of biofilms-EPS reduction after aPDT (B). Percentage of biofilm-biomass reduction after aPDT (C). Non-irradiated and irradiated cells are denoted as (L-) and (L+), respectively.

Fig. 5. Photodynamic hydrogel approach to persistent biofilm infections.

BSA/EGCG Binding Affinity Modified by Nanosecond-Pulsed Electric Field

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<https://doi.org/10.1016/j.foodhyd.2025.111184>

This study examined how nanosecond-pulsed electric fields (nsPEF) influence the protein bovine serum albumin (BSA) and its interaction with epigallocatechin gallate (EGCG), a natural antioxidant found in green tea. We applied short, high-intensity electric pulses to BSA alone and to mixtures of BSA with EGCG and then analyzed the resulting changes using a range of spectroscopic methods and molecular modeling. The results showed that nsPEF altered the size and structure of BSA, making the protein particles larger and changing how they folded. When EGCG was present, these effects were even stronger: BSA particles grew significantly in size, their surface properties shifted, and their ability to bind with EGCG increased. Structural changes were confirmed by Raman and FTIR spectroscopy, while molecular docking demonstrated that BSA can form hydrogen bonds with EGCG at specific sites. The proposed mechanism on the effects of nsPEF on binding is presented here (see Fig. 6). Overall, our findings highlight nsPEF as a promising, eco-friendly technology for modifying protein structures and enhancing their interactions with bioactive compounds, opening new possibilities for food science and biotechnology applications.

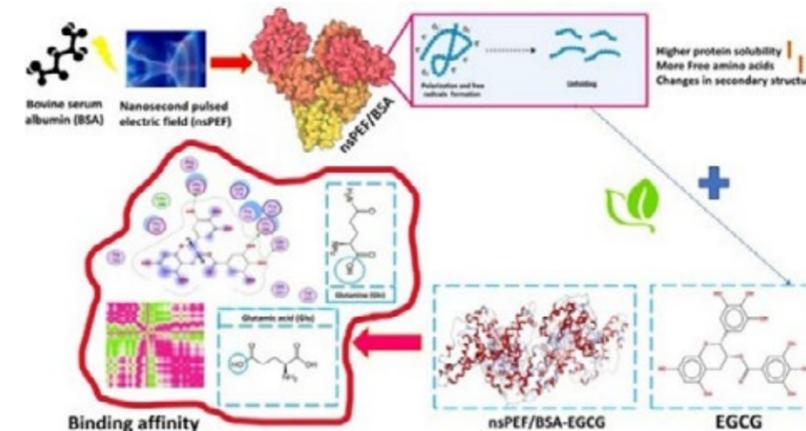


Fig. 6. Proposed mechanism on the effects of nsPEF on the BSA/EGCG binding affinity.

Hybrid Manganite-Graphene Sensor for Magnetic Field Magnitude and Direction Measurement

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<https://doi.org/10.1038/s41598-025-94248-y>

A novel hybrid manganite-graphene sensor was successfully developed, capable of measuring both the magnitude and direction of magnetic fields with enhanced sensitivity (see Figs.7-8). By combining the negative magnetoresistance of manganite with the positive magnetoresistance of graphene, the sensor achieved superior performance and accurate detection across a wide range of magnetic field strengths and orientations. The optimized design featuring precise adjustments to electrode spacing and layer dimensions resulted in a significant increase in magnetoresistance and sensitivity, particularly, when the magnetic field was perpendicular to the sensor's surface. An integrated data acquisition system enabled real-time processing of sensor outputs, allowing precise determination of both the magnetic field and its orientation. This hybrid sensor demonstrates strong potential for applications requiring reliable measurements of magnetic field magnitude and direction over a broad magnetic field and temperature ranges.

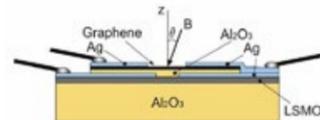


Fig.7. Schematic drawing of the hybrid manganite-graphene sensor.

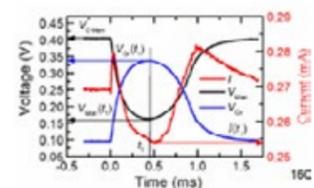


Fig. 8. The example of measured current through the hybrid sensor and voltage across manganite and graphene elements in response to a pulsed magnetic field with the amplitude of 15 T and 51° angle to the sensor plane.

Numerical Study of INDO4 Molecules: Ordering of Centered Honeycomb Structures and Central Molecule Switching

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<https://doi.org/10.1021/acs.langmuir.5c03068>

We simulated the ordering of INDO4 molecules into centered hexagon structures, which are characterized by the sequence of elongated honeycombs (see Fig. 9). Specifically, we focused on two such structures that differ in the orientation of the central molecule with respect to the molecules of the hexagonal frame. To account for the positions and angles of the INDO4 molecules, we proposed a six-state model. Our model and extensive Monte Carlo simulations allowed us to describe the ordering into both hexagonal phases and explain the reasons for the degeneracy of the central molecule. Additional density functional theory results confirmed this degeneracy and allowed us to evaluate the expansion distance of the hexagonal frame caused by the crystal surface effects.

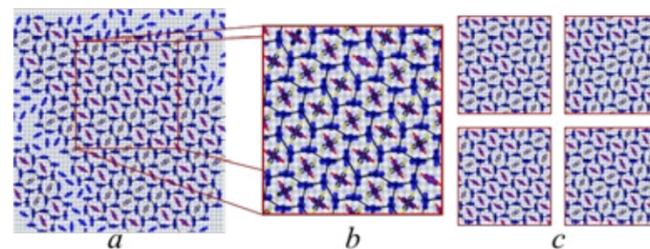


Fig. 9. Snapshots of Monte Carlo simulations at $e_{30} = e_{60}$ and $e_{60}/e_0 = e_{90}/e_0 = 1$ demonstrating the degeneracy of the hexagonal phases. Here, INDO₄ molecules are depicted in blue, and their orientation by red or yellow lines. (a) Hexagonal-centered phase after 10^5 Monte Carlo steps. (b) The result of further equilibration of the system. Zoomed view of the domain accumulated as a sum of four subsequent snapshots (c) taken every 0.25×10^4 Monte Carlo steps.



LABORATORY OF ELECTRONIC PROCESSES

The mission of the Laboratory is to pursue cutting-edge fundamental and applied research that enhances our nation's global reputation through scientific excellence. We focus on advancing knowledge of charge-carrier transport and electronic processes driven by electromagnetic radiation, spanning the spectrum from microwaves to visible light.

Our research and experimental development activities include:

- Exploring interactions between electromagnetic radiation and semiconductor nanostructures across a wide frequency range
- Investigating optical transitions in semiconductor nanostructures using highly sensitive single-photon detection techniques
- Solving Maxwell's equations in microwave systems and metamaterials
- Studying charge-carrier transport, including hot-carrier phenomena, in perovskite and semiconductor solar cells
- Developing innovative devices for microwave, terahertz, and infrared electronics

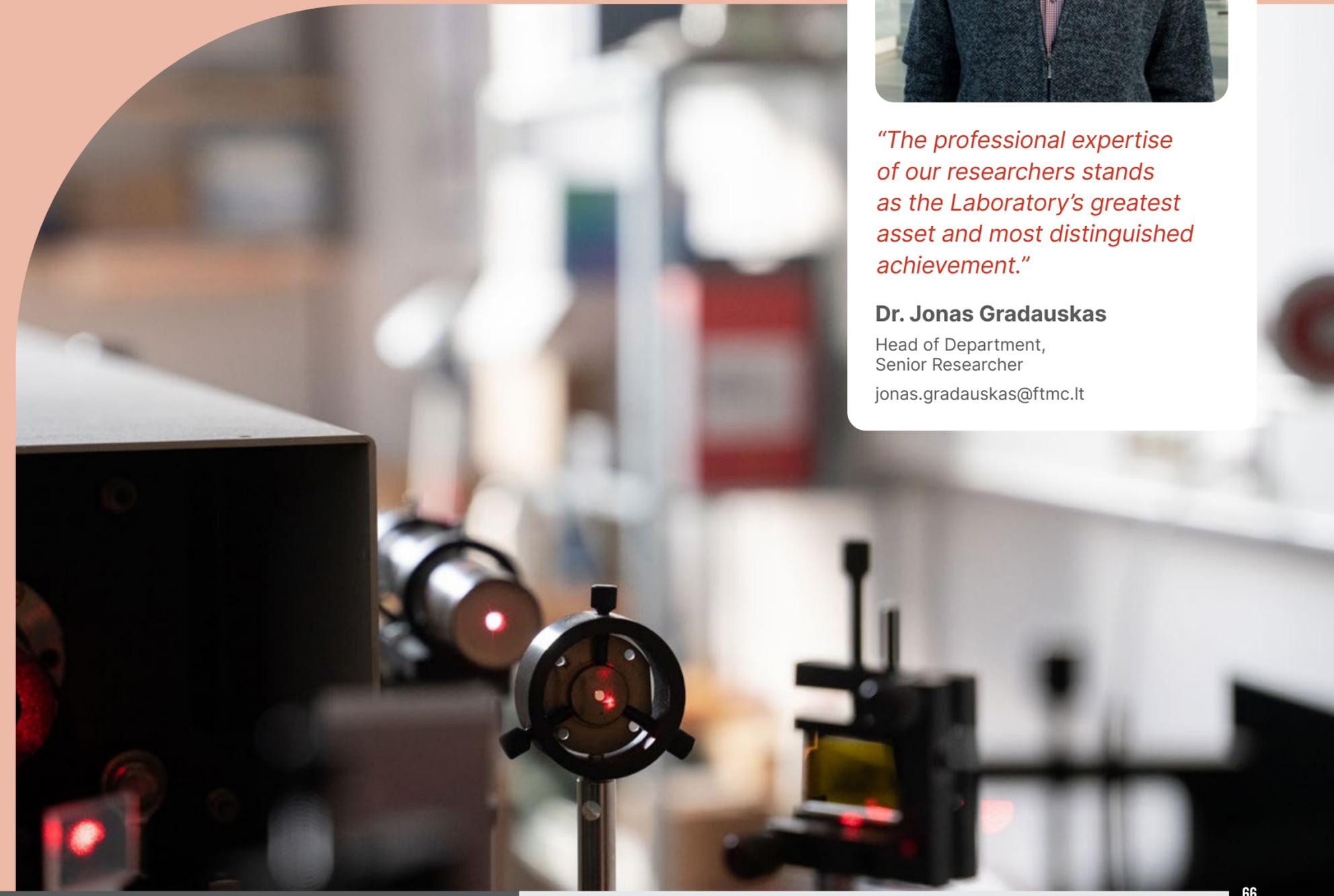


"The professional expertise of our researchers stands as the Laboratory's greatest asset and most distinguished achievement."

Dr. Jonas Gradauskas

Head of Department,
Senior Researcher

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Unveiling The Influence of Hot Carriers on Photovoltage Formation in Perovskite Solar Cells

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Two types of solar cells were fabricated of cesium-containing triple cation perovskite films: Pb-based and Pb-Sn-based. It was found that laser pulse-induced photovoltage across the solar cells consists of two components, $U = U_{ph} + U_r$. The first one, U_{ph} , is the traditional photovoltage arising due to electron-hole pair generation. The second one, U_r , is the fast component following the laser pulse and has a polarity opposite to that of U_{ph} . This component results from the laser radiation-caused heating of free carriers. The transient photovoltage measurements show that the hot carrier component appears in both types of perovskite solar cells.

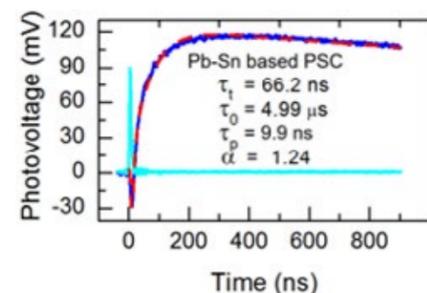


Fig. 1. The transient photovoltage decay observed in solar cells constructed from Pb-Sn based perovskite films. Excitation laser wavelength is 532 nm, and power density is 0.8 mW/cm². The laser pulse is shown in cyan.

Semiconductor-Driven Nanostructured Metamaterial with Epsilon-Near-Zero Transition Layer for Tunable Enhanced Absorption

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<https://doi.org/10.1007/s11468-025-02778-y>

A theoretical demonstration was made of the nature of a surface plasmon polariton propagating via a realistic nanostructured metamaterial interface, where a small transition layer is always present. It is possible to tune the absorption by engineering geometry of the nanostructured metamaterial. Collusive radiative losses are found to be on par with or even greater than Joule losses in a metal at ambient temperature, even for atomically flat surfaces where the transition layer is produced by spill-out electrons. For rough interfaces, which significantly accelerate the rate of radiative losses, the transition layer is substantially thicker. Thus, plasmonic devices seem to be less efficient due to radiative losses.

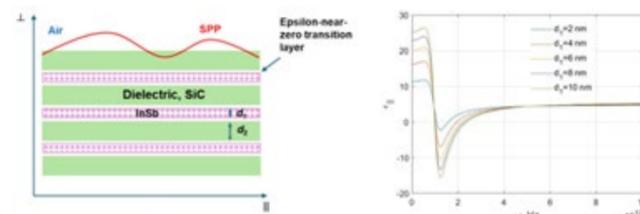


Fig. 2. Left: Diagram of the contact between air and an infinitely layered nanostructured metamaterial made of alternating dielectric and semiconductor layers. Right: Permittivity parallel component of the nanostructured metamaterial ($d_2 = 10$ nm, $T = 350$ K).

Bow-Tie Microwave Diodes on the Base of Modulation-Doped Semiconductor Structure with Wide Spacer: Theory and Experiment

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The comprehensive analysis focuses on the influence of diode metal contact geometry, illumination conditions, and orientation relative to the crystallographic axes. To elucidate the origin of the voltage detected by bow-tie diodes, we compare theoretical predictions of their electrical parameters, including voltage sensitivity, electrical resistance, asymmetry of the I-V characteristic in weak electric fields, and the nonlinearity coefficient of the I-V characteristic in strong electric fields, with corresponding experimental results. The results of investigations indicate that, for most diodes, the detected voltage originates from electron heating by the microwave electric field, as evidenced by the polarity of the detected voltage matching the thermoelectric emf of hot carriers.

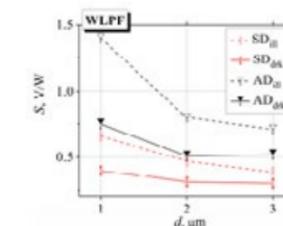
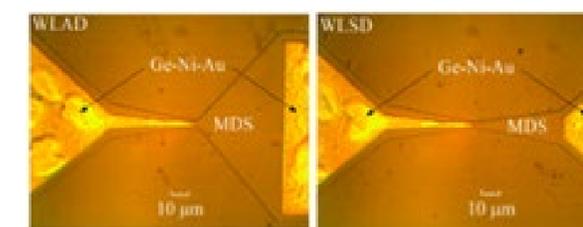
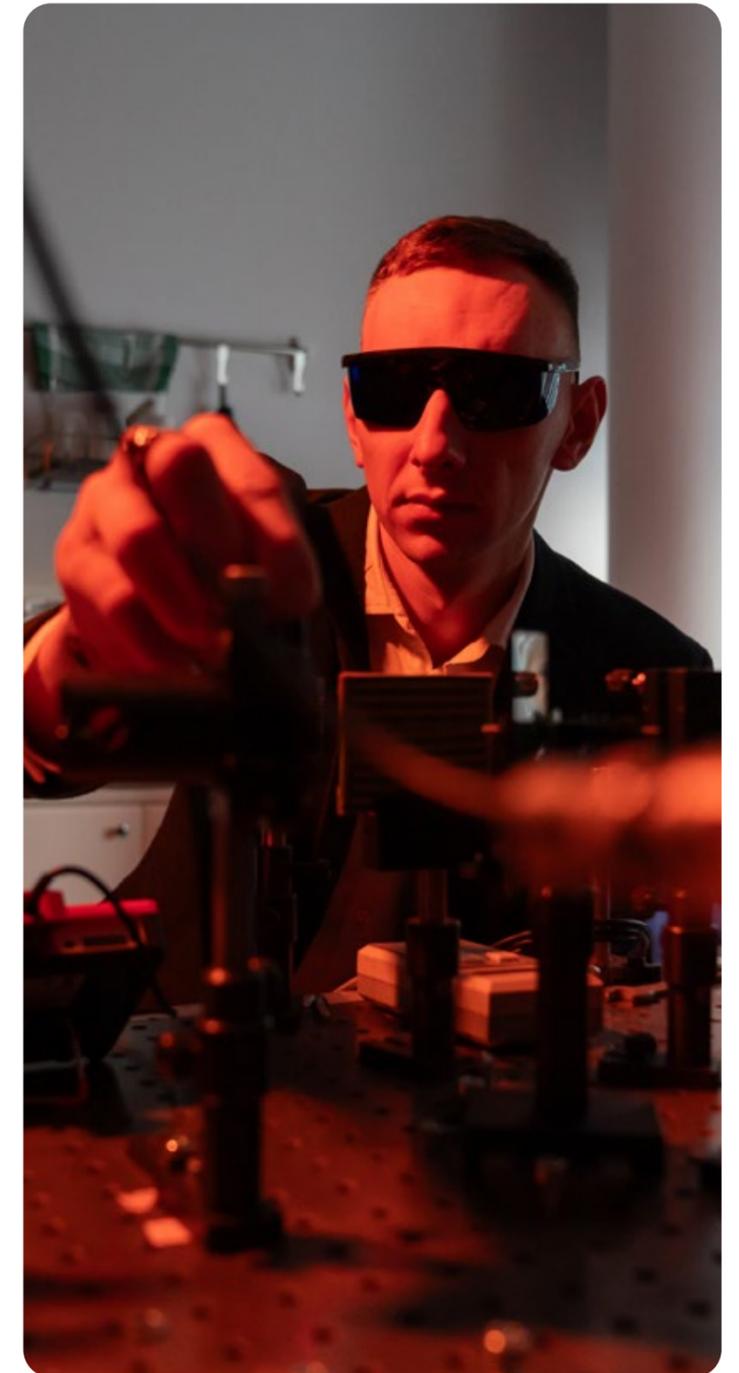


Fig. 3. Top: Micrographs of asymmetric (left) and symmetric (right) bow-tie microwave diodes. Bottom: Voltage sensitivity to 30 GHz microwave excitation in symmetric (SD) and asymmetric (AD) bow-tie diodes as a function of neck width d , both in the dark and under white-light illumination.



DEPARTMENT OF FUNDAMENTAL RESEARCH

The primary goal of the department is to produce high-level scientific knowledge to enhance the country's competitiveness in the long-term perspective. Our research focus on developing and applying theoretical and experimental methods to solve fundamental problems in biophysics, solid state physics, and astrophysics.

Main research directions of the department:

- Application of nonlinear dynamics and control theory methods in the study of neural networks
- Development of electronic structure theory methods for studying semiconductors
- Application of fluctuation methods for studying semiconductors
- Studies of the Universe from our Galaxy to the Big Bang



"Without fundamental science, there would be no Science..."

Prof. Dr. Vidas Vansevičius

Head of Department,
Principal Researcher

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Accuracy of the TRGB Distance Determination Method: Testbed – the M33 Galaxy

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To solve the so-called Hubble tension problem, highly accurate methods of determining extragalactic distances are needed. Therefore, the accuracy and applicability of the tip of the red giant branch (TRGB) method is of the utmost importance. In this work, we studied variations in the TRGB versus location in the M33 galaxy disc and derived radial (metallicity) and azimuthal (galaxy inclination) variations in the TRGB magnitude (I^{TRGB}). We found the $I^{\text{TRGB}} = 20.638 \pm 0.008$ magnitude to be virtually constant over the radial distance from 7 to 11 kpc. Assuming the absolute TRGB magnitude, $M_I^{\text{TRGB}} = -4.05$, and foreground extinction, $A_I = 0.062$, we derived the true distance modulus of the M33 galaxy: $(I^{\text{TRGB}} - M_I^{\text{TRGB}})_0 = 24.626 \pm 0.008_{\text{stat}}$ (842 kpc). This study demonstrates the ability of the TRGB method to discern the distance difference between the proximal and distal parts of the galaxy disc, which is $\sim 1.3\%$ of the distance to M33. The results show that the TRGB method is highly accurate and can be reliably applied to the red giant branch star populations of low metallicity ($[\text{Fe}/\text{H}] \lesssim -1.3$).

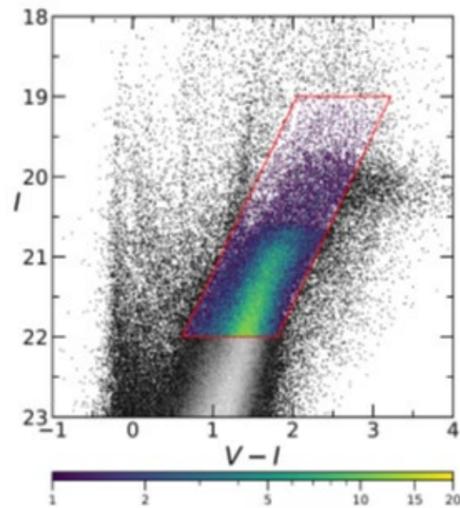


Fig. 1. CMD of the M33 stars residing in the range of radial distances from 6 to 10 kpc (number of stars – 162 087). The region from which stars were selected for the TRGB analysis is outlined with red lines and the number density of stars is color-coded. The color bar indicates the number of stars in a box of 0.01×0.01 mag

Deriving Physical Parameters of Unresolved Star Clusters: IX. Sky Background Effects in the Aperture Photometry

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<https://doi.org/10.1051/0004-6361/202555153>

The aim of this study was to determine how the sky background affects the limits and applicability of the aperture photometry method in star cluster analysis. We used a large sample of star cluster models spanning the parameter space of M31 clusters. To determine how the background affects star cluster photometry, we placed images of simulated clusters into five background fields of different stellar densities from the Panchromatic Hubble Andromeda Treasury (PHAT) survey and measured them using aperture photometry. We determined age and mass limits for the M31 disc star clusters at which photometric uncertainties enable the determination of cluster parameters using the aperture photometry method. We demonstrated that for typical-size clusters, optimal aperture diameters are of ~ 3 half-light radii. Our results suggest that a significant selection of bias towards more compact clusters may exist in the PHAT survey. We derived low-mass limits of the cluster mass function in the PHAT survey and stressed the necessity of careful accounting for selection effects arising due to sky background variations.

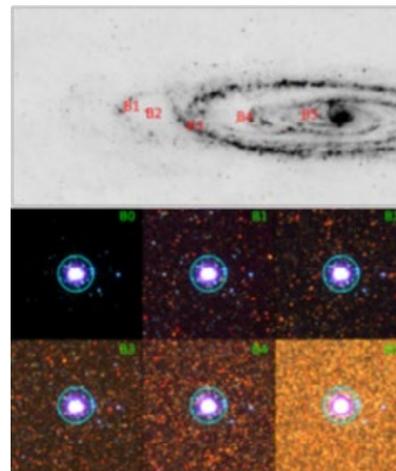


Fig. 2. Background fields in M31. The top panel shows a map of M31 with the marked locations of background fields (B1–B5). The bottom panels show images of the artificial star clusters placed in the background fields. B0: background-less case. Magenta and cyan circles mark apertures with radii 1 and 2 arcsec, respectively. The color images (15×15 arcsec) were produced by combining PHAT F336W, F475W, and F814W frames.

Active Galactic Nucleus Outflows Accelerate When They Escape the Bulge

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<https://doi.org/10.1051/0004-6361/202555667>

Large-scale outflows driven by active nuclei are a key ingredient in galaxy evolution. Detailed analysis of their properties allows us to probe the activity history of the galactic nucleus and, potentially, other properties of the host galaxy. Recently, astronomers determined detailed radial velocity profiles of outflows in multiple AGN host galaxies, showing a common trend of approximately constant velocity in the centre followed by rapid acceleration outside $\sim 1\text{--}3$ kiloparsecs. We use a 1D semi-analytical model of AGN-driven outflow propagation to show that this is a consequence of the outflows clearing the gaseous bulges of the host galaxies and beginning to expand into a region of negligible gas density (see Fig. 3). Our results are robust to uncertainties in AGN luminosity and gas distribution and apply equally well to galaxies with masses differing by more than two orders of magnitude. We conclude that a simple AGN-driven wind feedback model can explain the detailed velocity profiles of real outflows in local AGN hosts.

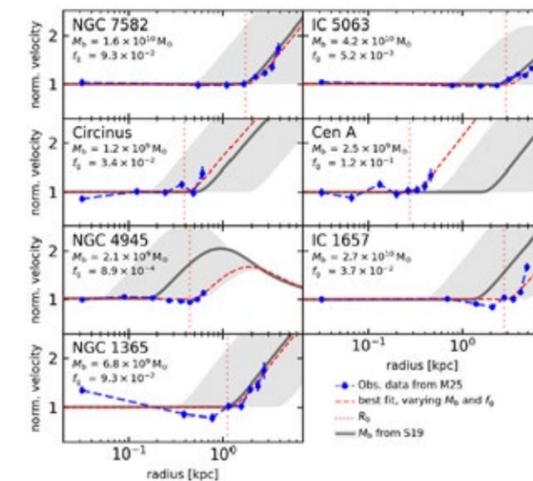


Fig. 3. Expansion of outflows within and outside the bulge region. Blue points show observed outflow velocity profiles from Marconcini et al. (2025). Red and grey lines are our model results. In each galaxy, all velocities are normalized to the mean observed outflow velocity in the central kiloparsec or within the modelled bulge radius, whichever is lower. The black lines and shaded regions correspond to the model where the bulge mass is taken from the observed black hole – bulge mass relation and its observational scatter (Schutte et al. 2019), while the gas fraction value is chosen to fit the velocity in the central region. The dashed red line is the result of choosing both the gas fraction and the bulge mass to produce the best fit to the observed outflow profile; these values are given in each panel next to the galaxy name. The vertical dotted red line shows the bulge radius in the latter case, which is also the point where the outflow begins to accelerate.

Theory of the Divacancy in 4H-SiC: Impact of Jahn-Teller Effect on Optical Properties

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<https://doi.org/10.1038/s41524-025-01609-2>

Understanding the optical properties of color centers in silicon carbide is crucial for their application in quantum technologies, such as single-photon emission and spin-based qubits. In this work, first-principles calculations were employed to investigate the electronic and vibrational properties of neutral divacancy configurations in 4H-SiC, with particular attention to the dynamical Jahn-Teller effect in the excited states of axial defects. By explicitly solving the multimode dynamical Jahn-Teller problem, we obtained emission and absorption lineshapes that reveal the interplay between electronic and vibrational degrees of freedom. Importantly, these calculations show excellent agreement with the experiment, providing reassurance in the accuracy of our findings. The calculations further predict spontaneous symmetry breaking in the excited state of the kh divacancy due to the pseudo Jahn-Teller effect, accompanied by the weakest electron-phonon coupling and distinct polarizability among all divacancy configurations. These results underscore the significance of electron-phonon interactions and optical response in spin defects with strong Jahn-Teller effects, providing valuable insights for designing and integrating quantum emitters in future quantum technology applications.

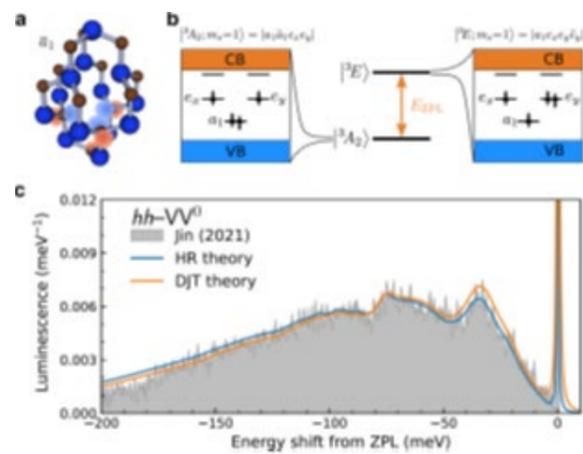


Fig. 4. a) Ball-and-stick representation of the $kk-VV^0$ divacancy in 4H-SiC together with an isosurface of the single-particle orbital associated with the a_1 defect level. b) Schematic single-particle level diagram within the 4H-SiC band gap, illustrating the orbital occupations in the ground-state 3A_2 and excited-state 3E configurations of the $kk-VV^0$ center. c) Luminescence lineshapes calculated using Huang-Rhys (blue) and dynamical Jahn-Teller (orange) theories, shown alongside the experimental spectrum for comparison.

Developing Machine Learning Models for Anticipatory Synchronization with Chaotic Time Series: Real-Time Prediction

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<https://doi.org/10.1103/mc1j-ldgj>

We show that combining the ideas of anticipatory synchronization (AS) and machine learning (ML) enables real-time prediction of scalar chaotic time series without prior knowledge of the system model. AS is a counterintuitive nonlinear phenomenon in which two identical chaotic systems, coupled unidirectionally in a master-slave configuration, can synchronize their motion such that the slave predicts the trajectory of the master. This phenomenon usually occurs due to the presence of time-delayed feedback in the slave system. AS is a promising tool for predicting chaotic dynamics in real time. However, this approach assumes that the system model is known because the slave system is built as a copy of the master system. ML provides a data-driven approach for creating a digital twin of a system — a digital model that can be used as a slave system in an AS scheme. We use next-generation reservoir computing (NGRC) to develop slave system models and construct a model-free AS algorithm. The multidimensional state space is reconstructed using time-delay embedding coordinates. The developed models satisfy the requirement of the negativeness of the largest transverse Lyapunov exponent (TLE), which is necessary for the stability of the AS mode. The prediction time of one slave system constructed in this way is equal to the embedding delay time τ . We increase the prediction time by implementing a chain of serially connected slave systems. The forecasting efficiency using AS and ML is demonstrated for chaotic time series of the Lorenz systems in Fig. 5.

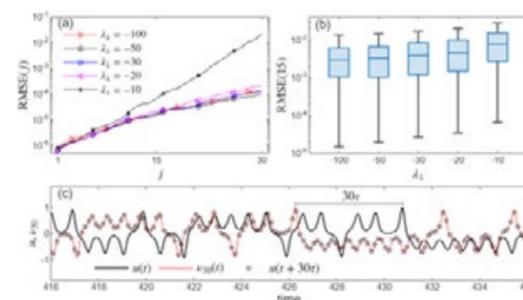
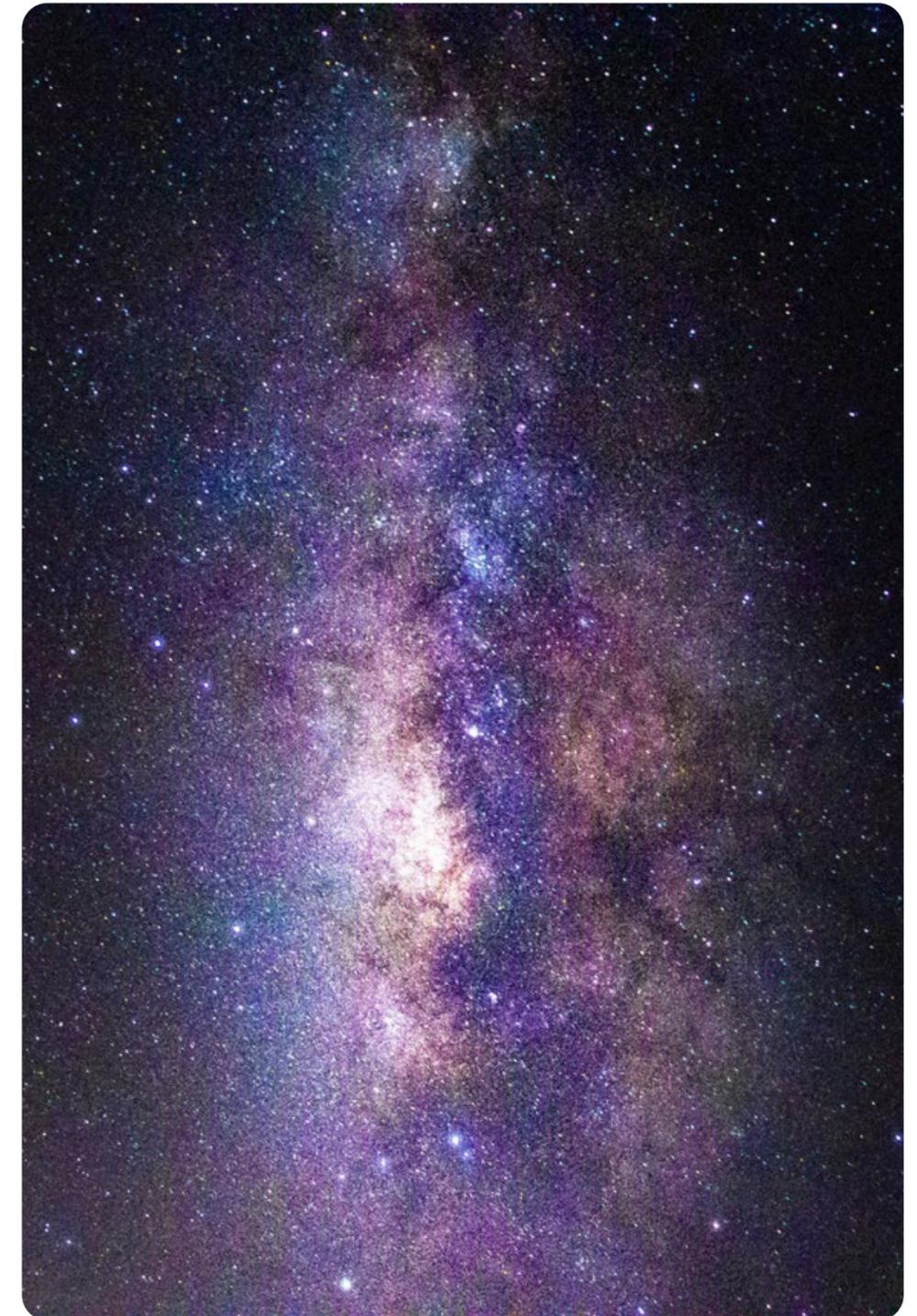


Fig. 5. Anticipatory synchronization of ML models with a scalar chaotic time series $u(t)$ of the Lorenz system. The digital model of a slave system was built in a training phase of duration $t_{train}=300$. (a) Dependence of root-mean square error $RMSE(j)$ of the j th slave system in the chain for different values of the TLE λ (b) RMSE statistics of the 15th slave system computed for 100 different initial conditions on the strange attractor. (c) Fragment of the anticipatory synchronization of the output $v_{30}(t)$ of the 30th slave system with the control signal $u(t)$. Here $\lambda=-50$. The prediction time $30\tau=4.5$, indicated by the horizontal line, exceeds four Lyapunov times of the Lorenz system.



DEPARTMENT OF TEXTILE TECHNOLOGIES

The Department of Textile Technologies continues to expand its scientific and technological capabilities, reinforcing its role as a key contributor to innovative and sustainable textile development. This year, particular emphasis was placed on advancing resource-efficient processing methods and environmentally responsible material solutions that support the transition toward greener industrial practices. By integrating modern functional materials, advanced modification technologies, and data-driven analysis, the department delivered textile solutions tailored to current market demands and emerging technological challenges.

In parallel with sustainability initiatives, the Department continues its substantial involvement in defence-oriented textile research. The ongoing activities under the European Defence Fund (EDF) project ACROSS focus on adaptive camouflage technologies designed for dynamic operational environments. Additionally, the department carries out R&D initiatives in ballistic protection technologies and the development of protective components for helicopter interior structural elements, further strengthening its role in advancing defence material innovations. Building on its long-term expertise, the Department developed a comprehensive methodology for evaluating the concealment properties of innovative camouflage textile materials in the infrared (IR) radiation spectrum. This work was carried out as part of the R&D activity evaluating the performance of different textile structures in the IR range, particularly in the MWIR and LWIR bands that are critical for thermal imaging systems.

Alongside defence research, the department actively advanced two major projects on developing novel textile modification technologies. The PLAZTEKS project "Development of a System for Fast and Continuous Plasma Processing of Textile", co-financed by the European Union, continued the creation of a new system for fast and continuous low-pressure plasma treatment of textile materials. Initial tests of textile material coating with carbon-nano structures, using a newly developed plasma source for pre-treatment, are planned and are expected to demonstrate improved hydrophilicity and adhesivity, as well as better coating homogeneity. Following the development of the first plasma source by the project partner, the integration of the prototype into the laboratory coating equipment will be carried out, and subsequent industrial-level testing is expected to confirm the potential of this technology to become an eco-friendly alternative to currently used finishing solutions.



"The Department of Textile Technologies is committed to developing advanced, sustainable textile technologies that generate tangible value to society and industry - from eco-efficient processes to high-performance protective solutions."

Dr. Julija Baltušnikaitė-Guzaitienė

Head of Department,
Senior Researcher

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The EUREKA project “Fashion Forward: Unlocking the Potential of Pure Hemp for Clothing”

The EUREKA project “Fashion Forward: Unlocking the Potential of Pure Hemp for Clothing”, progressed toward unlocking the potential of pure hemp fibres for next-generation sustainable clothing, carried out with the project partner MB “Modus Circulum”, aims to revolutionize sustainable fashion by unlocking the full potential of pure hemp as a primary material for clothing. Hemp is an eco-friendly, renewable resource with outstanding durability, breathability, and an ecological footprint twice as low as cotton. The research focuses on developing innovative knitted fabrics using natural dyes derived from agricultural and food waste, with particular attention to the aesthetics of the materials. Using the expertise of the project partners, prototypes of pure hemp knitted fabric were developed. In collaboration with fashion designers, new fabric structures and colour solutions are under development.

In addition to research activities, the Department continues to provide accredited material testing services, protective clothing certification and textile quality assessment. The laboratory's infrastructure and testing capabilities ensure compliance with European regulatory standards and supported industry partners across multiple sectors. Through consistent quality assurance processes, the Department enhances the reliability and performance of personal protective equipment used in both civilian and defence applications.

By combining interdisciplinary research, collaboration with industry and a focus on sustainable solutions, the Department continues to advance modern textile science. It remains committed to developing materials that meet the highest standards of quality, safety and environmental responsibility, and will further contribute to addressing the technological challenges of a rapidly changing environment.

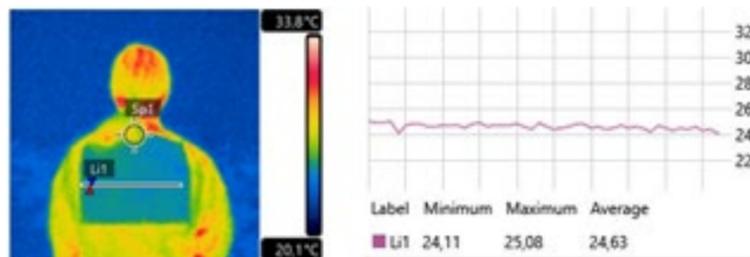


Fig. 1. Based on the results, the methodology enables a consistent comparison of materials with varying emissivity and thermal response characteristics and supporting the development of more effective protective textiles.

Thermal Comfort Properties of Biodegradable Hemp and Polylactide Fiber Knitted Fabrics

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doi.org/10.3390/polym17070903

In line with the global strategy of the Green Course, the production of sustainable textiles using different biodegradable fibres has immense potential for the development of sustainable products. Using one of the most sustainable biobased yarn combinations of pure hemp and polylactide fibers, four new biodegradable three-layer weft knitted fabrics with good thermal comfort properties were developed. The inner layer (worn next to the skin) and the middle layer of the knits were formed from hydrophobic polylactide fibers, while the outer layer contained different amounts (36-55%) of hydrophilic natural hemp fibers. The properties of the knitted fabrics were analysed and compared in terms of thermoregulatory behaviours, including moisture management, thermal resistance, air and water vapour permeability. The results demonstrated that all developed fabrics were assigned to moisture management materials, showing good to very good overall moisture management capability (OMMC=0.536–0.718). The highest OMMC was achieved with 55% hemp fiber content, confirming a strong positive correlation between hemp composition and moisture management performance (see Fig. 2). These biodegradable fabrics also exhibited sufficient breathability and thermal resistance, making them suitable for use next to the skin and as intermediate clothing layers in both warm and cold climate conditions during increased physical or recreational activity. This work highlights the potential of combining hemp and PLA fibers in multi-layer knit structures to create high-performance, eco-friendly textiles. The developed knitted materials (see Fig. 3) offer a sustainable alternative to petroleum-based fabrics for sports, leisure, and activewear.

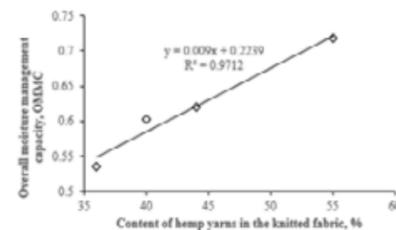


Fig. 2. Relationship between overall moisture management capability and content of hemp fibers in knitted fabrics.

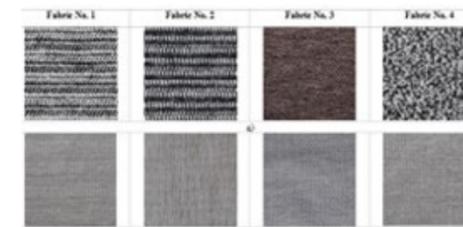
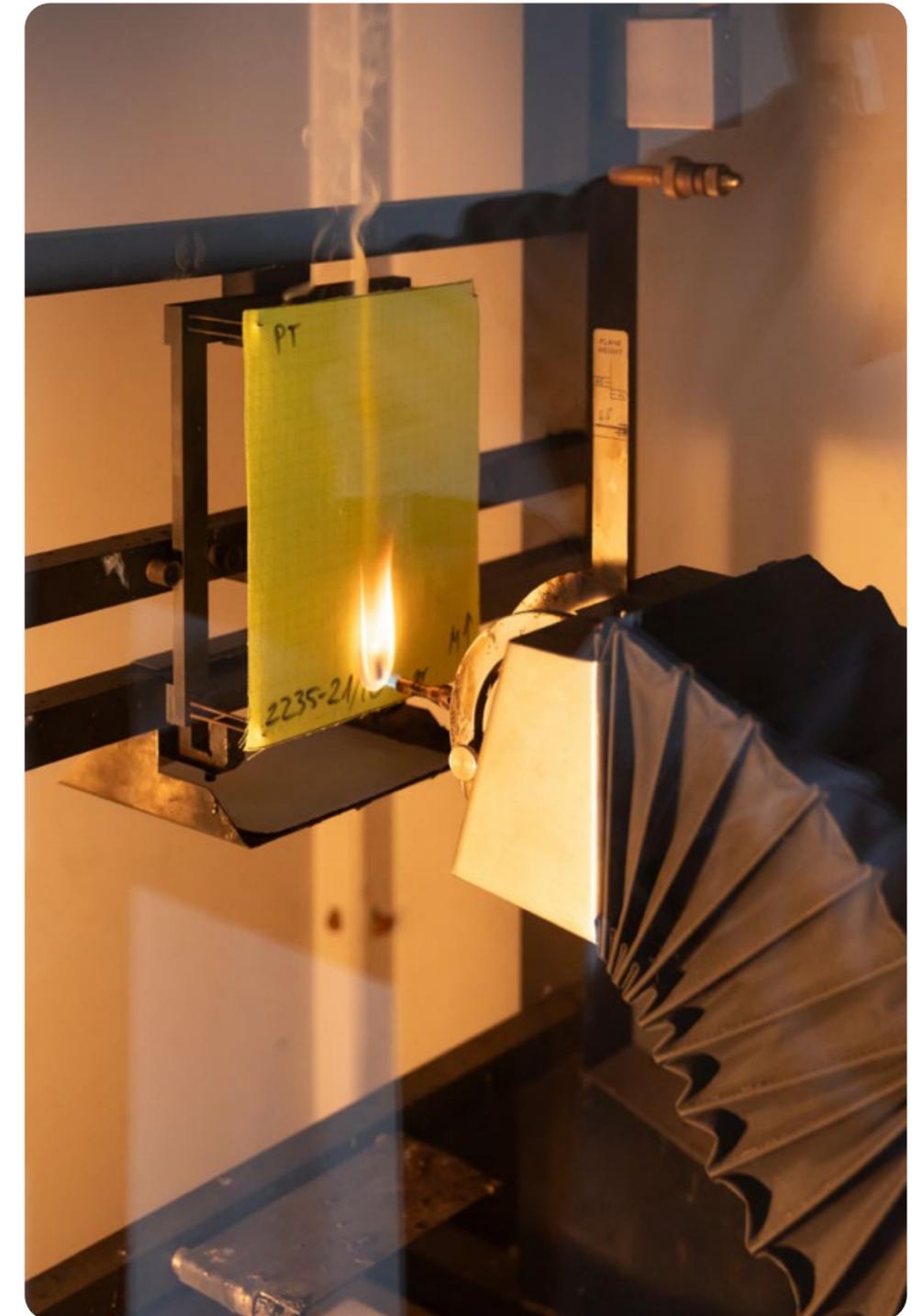


Fig. 3. The view of the designed weft knitted fabrics: a) the front side (outer layer); b) the backside (inner layer).



NATIONAL METROLOGY INSTITUTE

Metrology: The Science of Accurate and Reliable Measurement

Metrology, the science of measurement, plays a crucial role in ensuring accuracy, reliability, and consistency across various fields – from scientific research and industry to healthcare and trade. At its core, metrology is not just about obtaining measurement results but also about validating their accuracy and defining their limitations. By evaluating uncertainty and maintaining traceability, metrology provides a foundation of confidence in data, supporting innovation, quality assurance, and global standardization.

Since July 1, 2014, FTMC has been authorized to perform and implement the functions of the National Metrology Institute (NMI). To ensure compliance with international standards, a Quality Management System (QMS) was established in accordance with LST EN ISO/IEC 17025:2018 standard. The QMS undergoes regular peer reviews and has been recognized by EURAMET. In 2021, Lithuania's NMI became one of eight NMIs in the Nordic-Baltic region to participate in the European Metrology Network (EMN) "Smart Specialisation in Northern Europe". FTMC further expanded its international engagement by joining the European Metrology Network for Pollution Monitoring in 2023 and the Advanced Manufacturing and Quantum Technologies Networks in 2025.

Currently, FTMC maintains the national standards in seven areas of measurement: electricity and magnetism, ionising radiation, length, mass, amount of substance, thermometry, and time and frequency.



"Without metrology there is no measurement, without measurement, there is no knowledge. Accurate measurements build great trust."

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UTC(LT) – Lietuvos nacionalinio laiko ir dažnio etalono atkuriamas laikas



ELECTRICAL STANDARDS LABORATORY

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The mission of the Electrical Standards Laboratory (ESL) is to maintain and develop the national standards for the unit of voltage, the volt (V), and the unit of resistance, the ohm (Ω), ensuring their traceability to the International System of Units (SI). The ESL calibrates working standards and measurement devices, and conducts research in the measurement of voltage, resistance and electrical current.

Services. The ESL provides calibration services for a wide range of instruments, including resistors, resistance boxes, ohmmeters, resistance bridges, DC and AC voltage sources, voltmeters, multimeters, and calibrators.

Traceability. The maintained reference resistance values are traceable to SI resistance value using regular calibrations with quantum Hall system at international metrology laboratories (CMI, PTB, NPL). DC and AC voltage values are traceable to the SI volt via the local primary Josephson standard.

The primary voltage standard, manufactured by *Hypres*, is based on the Josephson effect, a superconductivity phenomenon that relates Josephson junction voltage and electromagnetic wave frequency through fundamental constants of physics. Superconductivity is achieved when Josephson junction array is cooled down to $\sim 4\text{K}$ temperature using closed cycle helium gas compressor.

The secondary voltage standard consists of a block of Zener voltage sources, where reference voltages are maintained.

The national resistance standard is maintained at the secondary level and consists of 1 Ω and 10 k Ω national standards, preserved in groups of resistors, and precision decade resistor set ranging from 0,001 Ω to 1 T Ω . Calibration of the group resistors and decade resistors is performed using 6010Q and 6000B resistance bridges. Temperature control for both the standard resistors and the resistors under calibration is provided using oil baths and air thermostats.



Fig. 1. Primary Josephson Voltage Standard (CCR).



Fig. 2. Precision liquid stirred oil bath with standard resistors.

THE IONIZING RADIATION METROLOGY LABORATORY

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The Ionizing Radiation Metrology Laboratory (IRML) maintains the national standard for radionuclide activity, with a focus on establishing new Calibration and Measurement Capabilities (CMCs) and supporting applications in both nuclear medicine and environmental radioactivity areas.

A total of 11 new CMCs have been published in the Key Comparisons Data Base (KCDB) of the BIPM for activity measurements of the following radionuclides: H-3, C-14, Cl-36, Ni-63, Ga-67, Sr-90, Tc-99, Tc-99m, In-111, I-129, and I-131. These CMCs represent Lithuania's first recognized entries in the field of ionizing radiation.

The IRML was piloting the supplementary comparison EURAMET.RI(II)-S9, "The Third Intercomparison of the Radionuclide Calibrators". Draft B of the report was prepared and submitted in October to the EURAMET Technical Committee of Ionizing Radiation (TC-IR).

The IRML has calibrated the activity meters used in hospitals across Vilnius, Kaunas and Klaipėda, ensuring their traceability to the national standard. The laboratory's ionization chambers are linked through comparison with the standard of the Czech Metrology Institute.

The IRML has been collecting environmental samples to assess radionuclide dispersion in atmospheric and water pathways, particularly in relation to potential impacts from the Astravets Nuclear Power Plant (Belarus).



Fig. 3. Preparations for check-source measurement with the secondary standard Fidelis.

TIME AND FREQUENCY STANDARDS LABORATORY

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The Time and Frequency Standards Laboratory (TFSL) reproduces the unit of time, the second (s), and the unit of frequency, the hertz (Hz). Its mission is to represent the Lithuanian Coordinated Universal Time, UTC(LT), ensure the traceability of the magnitudes reproduced to the International System of Units (SI), and disseminate them to the Lithuanian scientific institutions, as well as to legal and private entities, through the calibration of working standards and measurement devices and other relevant means of time dissemination.

In cooperation with the JSC *BaltStamp*, the TFSL provides qualified time-stamping services that meet the eIDAS regulations and ETSI standards. The service issues more than five million time stamps per month for Lithuanian governmental organisations and users across Europe.

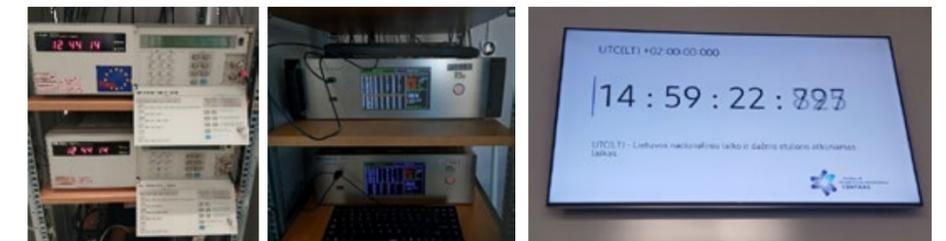


Fig. 4. Cesium atomic clocks, view of the laboratory equipment and the UTC (LT) time on the main information board of the FTMC.

LABORATORY FOR REFERENCE MATERIALS AND MEASUREMENTS

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The staff of the Laboratory for Reference Materials and Measurements (LRMM) provide reliable, traceable, and accurate chemical measurements across biotechnology, healthcare, safety, and environmental protection. The main challenge in chemical metrology is that its fundamental SI unit, the mole, cannot be directly realized in practice. Instead, measurements typically focus on substance concentration, composition and/or purity rather than on the absolute quantity. Unlike physical measurements, chemical measurements are influenced by factors such as sample preparation, matrix effects, and chemical interactions, making them more challenging to standardize and to obtain reliable results. Ensuring traceability and accuracy in chemical metrology requires the use of certified reference materials, validated methods, and rigorous evaluation of measurement uncertainty.

The LRMM is actively participating in the European Partnership on Metrology (EPM) research and innovation program. This research program facilitates the collaboration of members and associates in disseminating measurement standards and providing metrological solutions to key societal challenges. It brings together the measurement science community and stakeholders to deliver on global challenges, including health and climate, supports the European Green Deal, and underpins innovation in industry through collaborative research.

The new joint research EPM project 24GRD09 HyMetBat, “Hybrid Metrology for Sustainable and Low-Carbon Footprint Battery Materials” commenced implementation in September 2025 for a three-year period, in collaboration with the Department of Chemical Engineering and Technology. This project has received funding from the European Partnership on Metrology, co-financed by the European Union’s Horizon Europe Research and Innovation Programme, as well as by the Participating States.

New metrology is urgently required to support the transition to more sustainable battery chemistries and low-carbon footprint manufacturing processes. This project aims to develop a new hybrid metrology platform that integrates traceable analytical techniques for both ex situ and operando characterisation of battery materials, enabling innovation in next-generation energy storage technologies.

In addition, LRMM, together with six European partner NMIs/Dis (from Germany, Greece, France, UK and Turkey as internal beneficiaries) and nine external partners submitted the JRP application H13 Met4Metab - “Standardisation of Targeted and Untargeted Metabolomic Quantitative Methods for Their Future Use in Routine Clinical Diagnostics” - under the Metrology Partnership Health Call 2025.



Fig. 5. Triple point Water cell and the view of the laboratory equipment

LENGTH STANDARDS LABORATORY

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The Length Standards Laboratory (LSL) maintains the national standard of length, covering measurements from 0.5 mm to 100 mm, with an uncertainty ranging from 48 nm to 100 nm.

The functions of the LSL are:

- To carry out research on the national length standard.
- To maintain the national length standard within the range from 0.5 mm to 100 mm and transfer its value to other standards in the metrological chain.
- To participate in international comparisons to ensure the equivalence of length standards.

In February 2025, the FTMC national length measurement standard moved its CMC entries from the grey zone to the green zone. The approved CMCs are publicly available in the CIPM MRA database (KCDB). The KCDB is an evidence-based platform, where all data are reviewed by international expert groups and approved for multilateral recognition.

The LSL participated in the international comparison "Supplementary Comparison EURAMET.L-S2.2.n01", achieving positive results.



Fig.6. Steel gauge blocks CARY (K-class, Switzerland) and Comparator Mahr 826 (Germany).

MASS STANDARDS LABORATORY

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The Mass Standards Laboratory (MSL) maintains and develops the national mass standard. The MSL is equipped with calibrated OIML Class E0 1 kg mass standard set, several E1 – E2 reference calibration weight sets, and mass comparators (Sartorius, Germany) for mass measurements in the range of 1 mg to 10 kg

Currently, the Calibration and Measurement Capabilities (CMC) entries of the MSL are in the grey zone, as the laboratory is re-establishing its operations following the relocation from the Vilnius Metrology Center to FTMC. Nevertheless, the participation in the upcoming international key comparison is confirmed and scheduled for 2026, which is necessary for the review and reassessment of the CMCs.

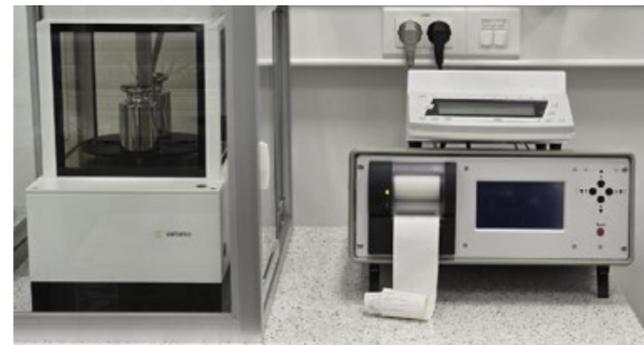


Fig. 7. The setup of the mass comparison procedure of 1 kg weight.

TEMPERATURE STANDARDS LABORATORY

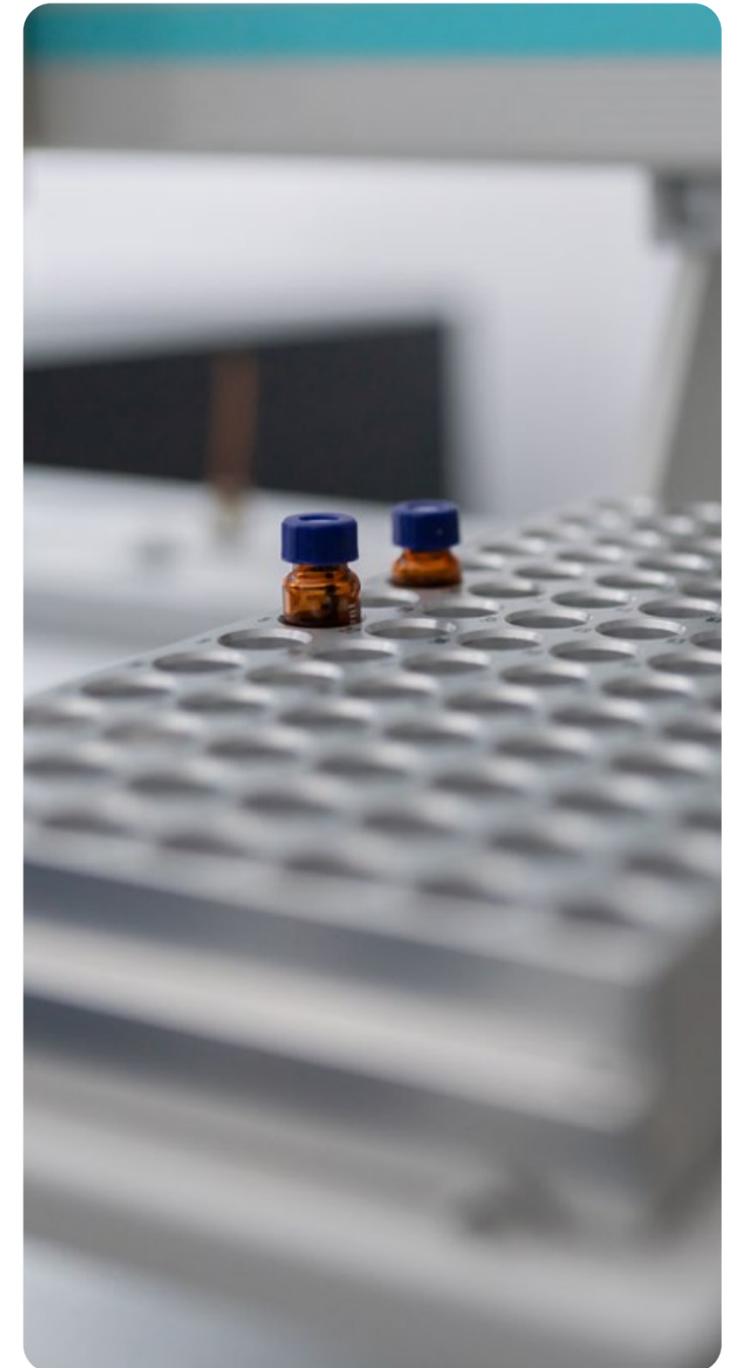
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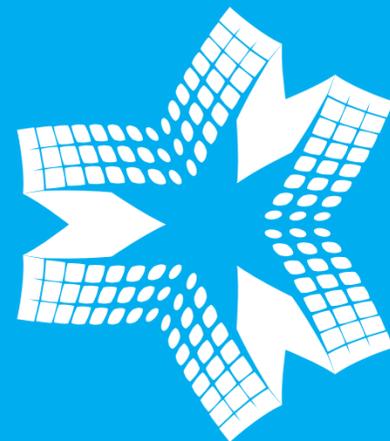
The Temperature Standards Laboratory (TSL) was established in 1997 and, in 2002, was recognized as the State Temperature Standards Laboratory.

The mission of the TSL is to realize the international temperature scale ITS-90 and the value of the unit of temperature, the kelvin (K), ensuring their traceability to SI. The Lithuanian National Standard of temperature, covering the range from -195°C to +961.78 °C, is maintained at the primary level, while the freezing point of Cu (+1084.62 °C reference point) is the secondary-level standard. The ITS-90 scale is realized using cells of the pure substances, including Ar, Hg, H₂O, Ga, Sn, Zn, Al, Ag and Cu.

The TSL calibrates platinum resistance thermometers, thermocouples, and digital thermometers and thermometer calibration baths, both at reference temperatures and at any temperatures necessary within the operating range of the standard.

One of the most important reference cells of the standard is the triple point of water cell. It is a sealed, evacuated vessel, with simultaneously existing three thermodynamically equilibrium phases of water: liquid, solid (ice), and saturated vapour filling the space above the surface of water (with no air present). Its temperature is the most important reference temperature of ITS-90.





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