INSTITUTE OF MATERIALS RESEARCH

SLOVAK ACADEMY OF SCIENCES

FIVE YEAR REPORT

2020-2024

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Dear readers, colleagues, friends of the Institute of Materials Research of the Slovak Academy of Sciences,

Another five years have passed since the last release of a similar book in year 2020, many events have taken place, we have faced many challenges and changes.

Just as everyone in the world, we have gone through the pandemic years, learning new types of work, new organizational skills and new manners of conducting our activities, particularly team work. In this period the whole Slovak Academy of Sciences underwent an important legislative change, all its institutes were transformed from governmental organizations to public research institutions. This transformation posed many new challenges. We had to adapt to new situations and to this point we have still been learning new types of managing research and its financing.

Also, this recent period has been marked by several significant world crises, among them the most serious being war conflicts, but also ecological and humanitarian emergencies. Our institute actively approached these issues and made efforts in helping scientists who face problems in their home countries. We have provided working conditions for them, opened our scientific infrastructure, we are helping in the immigration processes, assisting in getting scientific projects and finances for them.

Internally, Slovak Academy of Sciences conducted a large assessment (periodic accreditation) of all its institutes and branches. Our institute has proved that we successfully maintain high quality science, we are on par with our partners and friends from Europe and also worldwide. Our results are able to resonate in international scientific circles, we are a valuable part of the European research area. At the same time we keep good working contacts with our industrial partners, mostly in Slovakia, usually through common projects. Here, we would welcome greater willingness of Slovak industrial partners to invest more in joint research activities, so that both industry and academia could successfully grow and contribute to society's progress and development.

The Slovak scientific landscape is forming a new competitive system of budgeting, which is still undergoing transformations. We are preparing for yet

more types and modes of securing the finances for our future development.
We have significantly broadened our relationships with universities, we have started 5 new study programs through new agreements with universities in East Slovakia, and we continue to work on more contractual collaborations with other educational organizations and schools. In connection to that, we have also intensified our popularization and outreach activities towards educational entities and the general public. Here we can show great progress (starting a number of periodic popularizing activities, establishing dedicated open laboratories), which was also recognized on the level of the entire Slovak Academy of Sciences.
We have greatly expanded our international reach, intensified our collaboration with foreign institutions. The number of academic visitors increased dramatically, not only in their quantity but also in the length of their stays. Nowadays, they often come for many months at a time, which allows us to build and strengthen the working ties, establish fruitful and long-lasting collaborations. This results in mutual enrichment of our work and knowledge.
In this book the reader can find a brief summary of all our scientific activities during five years, news about our infrastructure, capacities and capabilities. We show recognition of our successes, we try to present the societal impact of our work, and we also point out our plans in the form of new research projects.
Finally, relying on the presented potential, dedication and talent of our people, I surely can say that we can look into the past with pride and into the future with courage and confidence.

Košice, 24.04.2025

Assoc. Prof. RNDr. Pavol Hvizdoš, DrSc.
Director IMR SAS

70th Anniversary - A Brief History of the Institute of Materials Research of SAS

In 2025, it will be **70 years** since the establishment of the Institute of Materials Research of the Slovak Academy of Sciences. 70 years is a respectable age. If a scientific and educational public institution reaches such an age, it is proof of its viability and certainly of its ability to contribute to society, to bring value to its partners and to the scientific and research environment in which it is active.

So let us briefly look back to the history of the Institute of Materials Research of the Slovak Academy of Sciences:

Today´s Institute of Materials Research was established on July 1, 1955 as the **Laboratory of Mechanical and Metallurgical Technology of the Slovak Academy of Sciences** in Košice (*Laboratórium strojníckej a hutníckej technológie SAV*) as a detached unit of the laboratory of the same name in Bratislava.

In 1959 it became independent as the **Laboratory of Metallurgical Technology of the Slovak Academy of Sciences** (*Laboratórium hutníckej technológie SAV*). Its activities at that time were related to the work and fate of the then newly built large heavy industry, metallurgy plant - the East Slovak Ironworks (Východoslovenské železiarne).

On July 1, 1963, it was incorporated into the **Faculty of Metallurgy of the Technical University** (*Hutnícka fakulta Vysokej školy technickej*) in Košice as the **Laboratory of Metallurgical Technology** (*Laboratórium hutníckej technológie HF VŠT*).

On January 1, 1971, it was delimited back to the Slovak Academy of Sciences, this time under the name of the Institute of Experimental Metallurgy (Ústav experimentálnej metalurgie SAV). During the 1970s, the focus of the institute's activity was the progressive direction of powder metallurgy of iron, copper and aluminum, including the issue of sintered carbides.

In the 1980s, the institute participated in the initiation of basic research in the field of advanced structural ceramic materials throughout Czechoslovakia.

The 1990s brought serious social and economic changes. For the institute, the new situation meant a radical reduction, when the number of employees fell by almost half in a short time. However, the institute reacted flexibly. The scientific and research orientation was redefined by expanding the areas of interest and expertise – unconventional and very advanced materials were added at that time, not only refractory and structural ceramics were developed, but also functional electroceramics, and later biomaterials, polymers and complex composites.

This development was reflected in the change of name to the **Institute of Materials Research** (*Ústav materiálového výskumu*) **of the Slovak Academy of Sciences** on 1.6.1992. The changed conditions were also reflected in the change in the functioning of the institute, when from 1993 the institute switched to a contributory form of management and secured part of its income through its own economic activity. The organizational structure is also changing. In the 1990s, the focus shifted to the system of competitive financing through projects – first financed by domestic grant agencies, then within international European programs. On the basis of projects solved in this way, new research teams were gradually profiled and by 2003 a new organizational structure was established, which lasted until 2015.

An important milestone was the entry of the Slovak Republic into European structures, when new horizons opened up for scientists and research teams, which enabled them to enter international consortia and collaborations in a more significant way.

After Slovakia's accession to the EU, another significant shift took place and the institute was very actively involved in obtaining funds from the EU structural funds. Thanks to them, when the institute completed 6 SF projects over the course of 10 years as a beneficiary/coordinator and participated in 6 as a partner, it was possible to significantly expand and improve the experimental infrastructure and thus strengthen and expand the scientific research potential of the department. The more than 5 million euros raised were used to build a number of new laboratories, many equipped with new unique methods, experimental techniques and technologies. Of the larger units, we can mention several - the joint TEM laboratory, a powerful laser station, an ultrafast sintering unit, or a laboratory of coating using physical vapor deposition methods.

This development culminated in 2015-2016, when the IMR, in cooperation with close partners and colleagues and under the auspices of the Presidium of SAS, built and equipped a new joint **scientific research center for new materials and technologies PROMATECH**.

During the same period, the current and planned changes in the SAS, the preparation of the transition to the system of public research institutions, as well as the demands of the new EU planning period required an intervention in the organizational structure of the institute. Since the beginning of 2016, the scientific teams have been grouped into three scientific divisions according to the prevailing material focus -

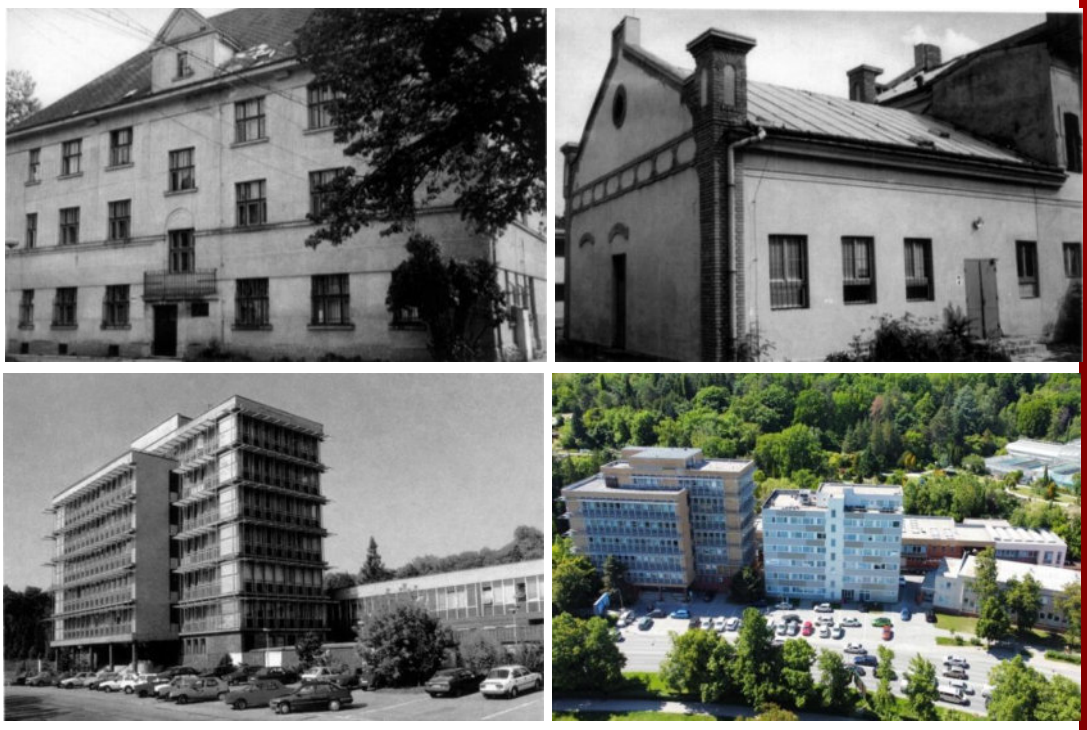
1. **Division of Metallic Systems,**
2. **Division of Non-metallic and Ceramic systems,** and
3. **Division of Functional and Hybrid Systems.**

This structure was also a logical result of the development of the active scientific fields and the association of the particular teams with related scientific topics.
In parallel with this development, the efforts of the SAS management to objectively assess the position of Slovak science and its institutions in the international context intensified, and in 2016 the first comprehensive accreditation of the SAS by an independent international panel took place, which showed its qualities and weaknesses - the institute was evaluated positively as visible at the European level.
In 2020-2021, the whole world struggled in the difficult period of the pandemic, where we had to learn new methods of work. With the contribution of new technologies and the application of creative organizational procedures, we were able to achieve very solid scientific results even at that time.
A big change occurred in 2022, when we, together with other institutes and organizations of the Academy, were legally transformed into public research institutions, which again required a flexible approach to the implementation of many activities.

At present, our main research activities generally include areas such as

- **modern steels,**
- **advanced powder metallurgy methods and materials,**
- **modern structural and functional ceramics,**
- **nanostructured materials;**
- **hybrid metal-ceramic and metal-polymer materials, and**
- **modern biomaterials.**

IMR SAS has been involved in a number of national and international projects. Presently, it works on 18 projects as part of the calls within the framework of the Recovery and Resilience Plan, and we are members of two transformational innovation consortia projects. Demographic and social development has also brought new challenges, and like the entire scientific community, the IMR is facing a lack of interest from the younger generation. Therefore, it develops significant activities towards the internationalization of its activities, it is open to those interested in scientific work and study from abroad, it hosts scientists from Ukraine and many other countries from the EU and beyond.
This is related to an increased interest in attracting the scientific "youth" and to an active approach to the popularization of science among the general public.
The Institute pays particular attention to working with pupils and students at all levels, from the youngest, through primary and secondary schools to universities. The employees of the institute have brought quite original and fresh ideas and projects to these types of activities several times, and the employees of the institute have been awarded several times for their popularization activities.



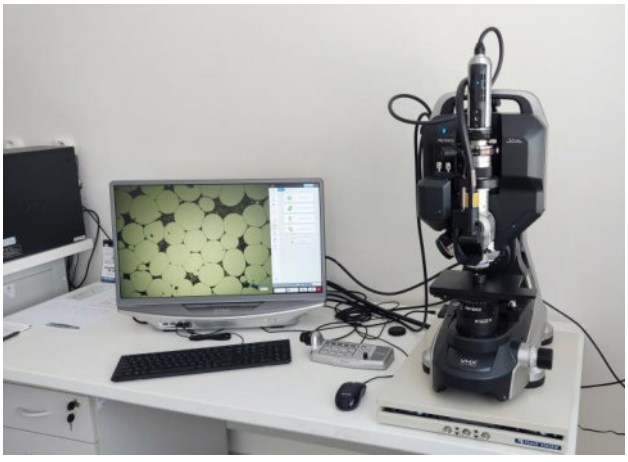
Figures: The IMR SAS buildings -Then and Now

Figure: The PROMATECH building - Opening ceremony in 2016

Figures: Directors of the IMR SAS: Prof. Dr. Ing. Jaroslav Kubelík (1955-1969); Prof. Ing. Juraj Buša, CSc. (1970); Prof. Ing. Milan Šlesár, DrSc. (1971-1990); Prof. Ing. Ľudovít Parilák, CSc. (1990-2006); RNDr. Peter Ševc, CSc. (2006-2015); Doc. RNDr. Pavol Hvizdoš, DrSc. (2015-2025)



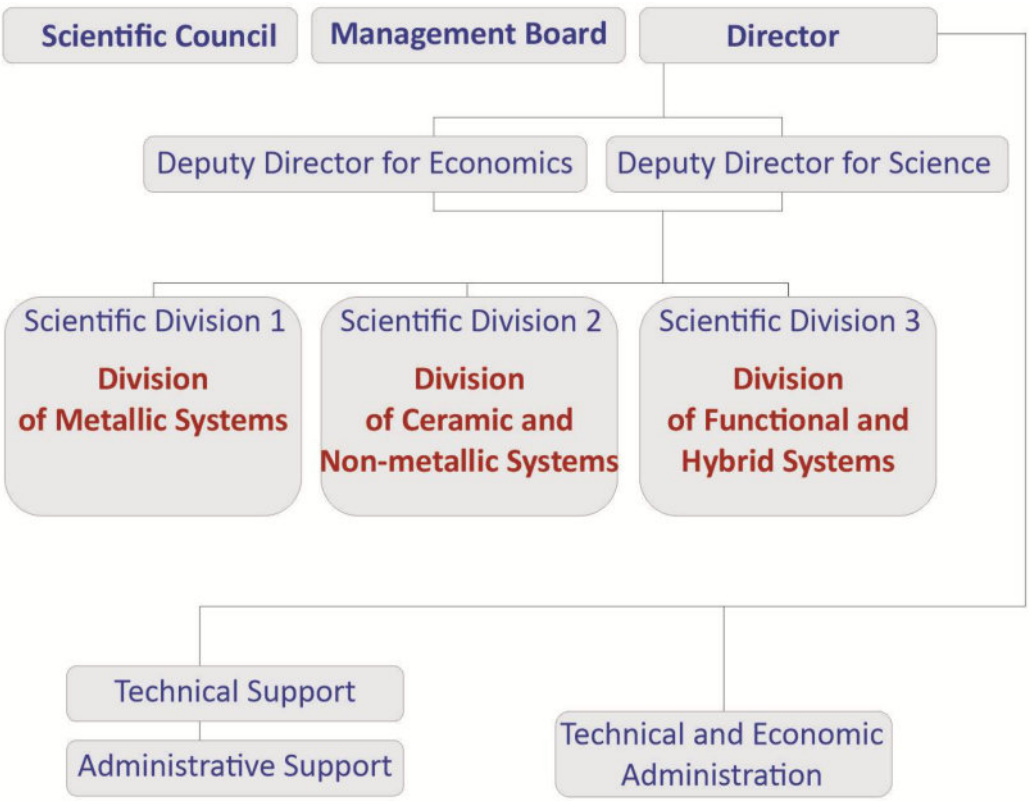




Figures: The conferences organized at IMR SAS and the infrastructure: Then and Now

Organizational Structure

The Institute is a governmental non-profit organization funded by the Government of the Slovak Republic and by finances from ongoing projects. They include national and international scientific grants supported by Slovak grant agencies and various international programs as well as collaborations with the commercial sector, industrial establishments, universities and research institutes. The Institute has approximately 105 employees, including scientific and research workers, PhD students, technicians and administrative staff.



Director
doc. RNDr. Pavol Hvizdoš, DrSc.

Deputy Director for Economics
RNDr. Ján Mihálik

Deputy Director for Science
Ing. Alexandra Kovalčíková, PhD. (from 2021)
doc. Ing. Karel Saksl, DrSc.

Head of Scientific Division 1
Ing. Ladislav Falat, PhD. (from 2021)
doc. Ing. Karel Saksl, DrSc.

Head of Scientific Division 2
prof. RNDr. Ján Dusza, DrSc.

Head of Scientific Division 3
Ing. Ľubomír Medvecký, DrSc.

Head of Scientific Council
Ing. Alexandra Kovalčíková, PhD. (from 2024)
Ing. Ľubomír Medvecký, DrSc.

Technical Support
RNDr. Miroslav Džupon, PhD.
Ing. Vladimír Katana

Administrative Support
Terézia Rácová (from 2024)
Jana Torkošová

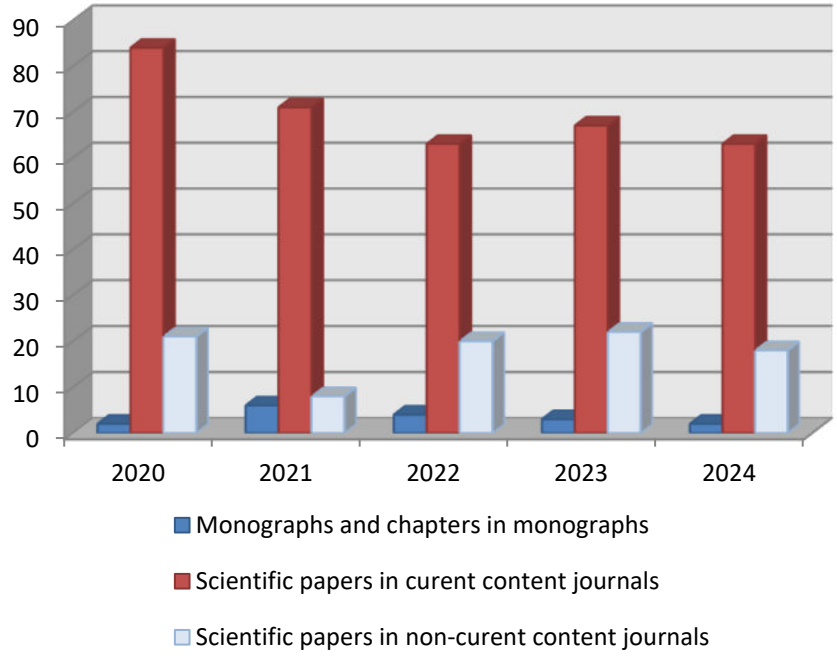
Projects Support
Ing. Františka Dorčáková, PhD.

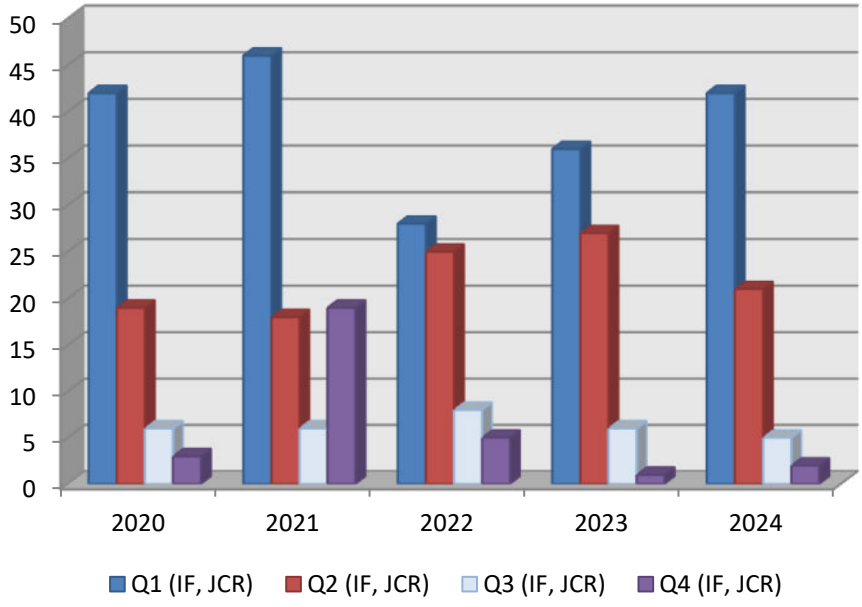
Technical and Economic Administration
JUDr. Glória Gajdošová

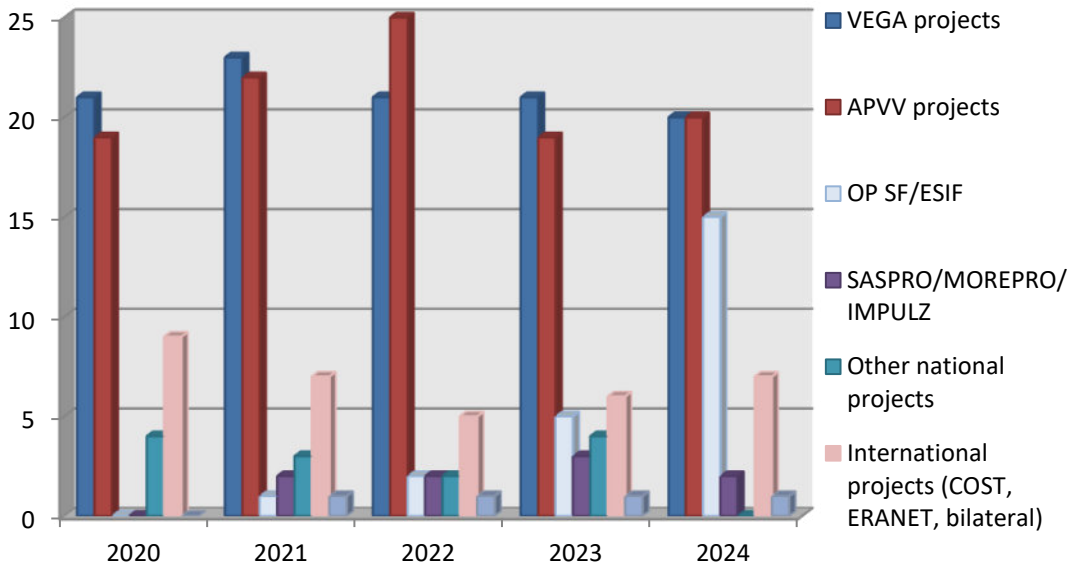
Management of the Institute of Materials Research
Slovak Academy of Sciences

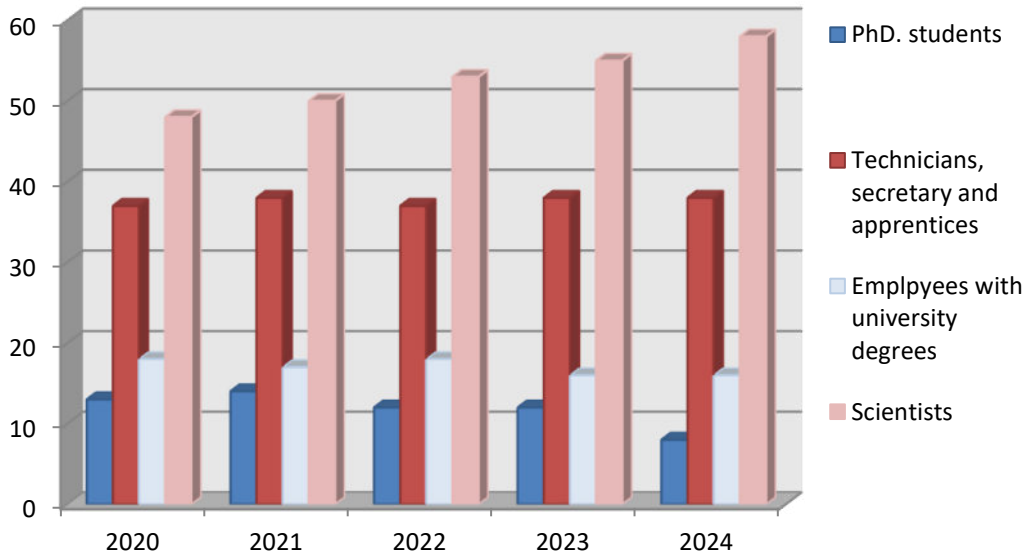
IMR SAS in Figures

Overview of the number of employees, projects and publications of IMR SAS in years 2020-2024.






25
20
15
10
5
0
2020
2021
2022
2023
2024
VEGA projects
APVV projects
OP SF/ESIF
SASPRO/MOREPRO/ IMPULZ
Other national projects
International projects (COST, ERANET, bilateral)


60
50
40
30
20
10
0
2020
2021
2022
2023
2024
PhD. students
Technicians, secretary and apprentices
Emplpyees with university degrees
Scientists

Division of Metallic Systems

Head:
Ing. Ladislav Falat, PhD.
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Phone: +421 -55 -792 -2443

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Ing. Beáta Ballóková, PhD.
Ing. Mgr. Ladislav Ceniga, DrSc.
Ing. Dávid Csík, PhD.
Ing. Lucia Čiripová, PhD.
Ing. Katarína Ďurišinová
Ing. Róbert Džunda, PhD.
RNDr. Miroslav Džupon, PhD.
RNDr. Viera Homolová, PhD.
Doc. Ing. Yuliia Chabak, DrSc.
Prof. Ing. Vasyl Iefremenko, DrSc.
RNDr. František Kováč, CSc.
Ing. František Kromka, PhD.
Mgr. Katarína Kušnírová, PhD.
doc. Ing. Ondrej Milkovič, PhD.
Ing. Zuzana Molčanová, PhD.
RNDr. Katarína Nigutová, PhD.
Mgr. Lenka Oroszová, PhD.
Mgr. Ivan Petryshynets, PhD.
Ing. Mária Podobová, PhD.
Ing. Viktor Puchý, PhD.
doc. Ing. Karel Saksl, DrSc.
Mgr. Vadym Zurnadzhy, PhD.
Ing. Dagmara Vatraľová, PhD.

PhD. students:
Ing. Miroslava Ďurčová
Mgr. Marianna Hodorová
Ing. Marcela Motýľová

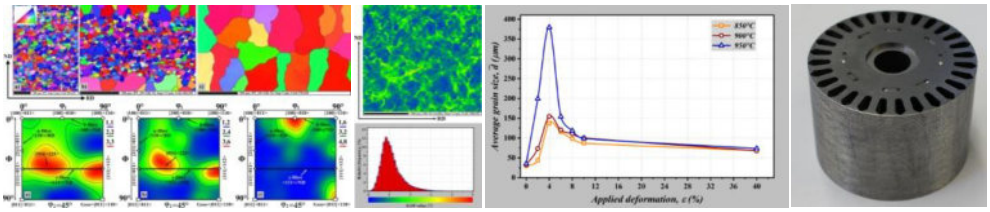
Characteristic of the division

The scientific division is focused on a wide range of research topics in the field of basic research as well as applied research and development of advanced metallic materials. The common denominator of the research is the study of the interrelationships between the microstructural characteristics of the investigated material systems and their resulting properties. In the past 5-year period, the division was dealing with research activities in the following areas:

A: Electrical steels for motors of electric and hybrid vehicles

A current challenge lies in developing novel electro-technical steels that offer an optimal balance between mechanical strength and magnetic properties. The primary objective of this research is to propose and evaluate a new concept for the microstructure and substructure design of high-strength isotropic electro-technical steels. These materials aim to achieve both high strength and

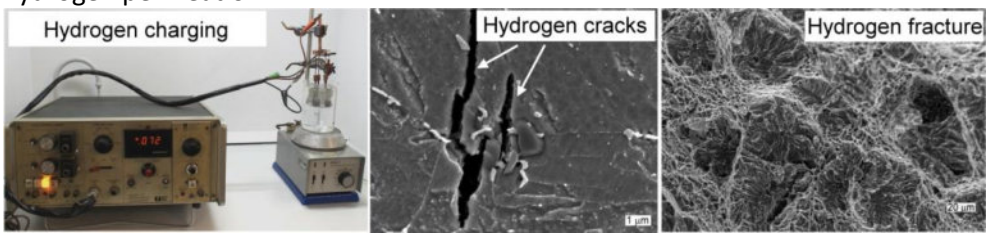
exceptional electro-technical performance, making them suitable for use in rotor cores of electric vehicles and hybrid cars. The research approach is grounded in understanding the evolution and kinetics of structure-forming processes in electro-technical steels under conditions of thermal-deformation activation.



Figures: Colored Inverse Pole Figure (IPF) maps and Orientation Distribution Function (ODF) sections illustrating the microstructural characteristics of FeSi steels in various states. The distribution of local plastic strains in deformed FeSi steel is visualised using Kernel Average Misorientation (KAM) maps. The evolution of average grain size as a function of applied deformation and annealing temperature is also presented. In addition, an image of the rotor from an electrical motor is included to demonstrate the practical relevance of the investigated materials.

B: Thermal degradation and hydrogen embrittlement of metals and alloys

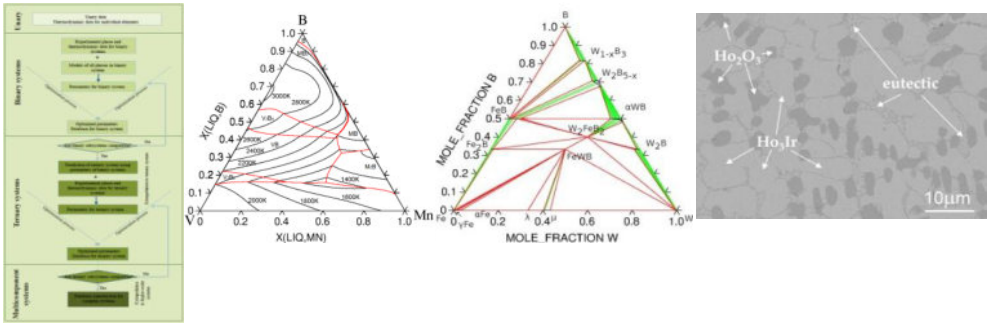
The study of degradation phenomena of metallic materials for power engineering, especially high alloy steels is important in terms of estimation of their reliability and safety in operational conditions. For this class of materials, two main degradation phenomena, namely thermal degradation and hydrogen embrittlement are studied by complex material analyses including detailed microstructural investigations, mechanical tests under varying loading conditions and fractographic characterization of long-term aged and subsequently hydrogen-charged material states. Experimental solutions for elimination or mitigation of the degradation processes are investigated, e.g. by rejuvenation heat treatments and application of barrier coatings against hydrogen permeation.



Figures: Hydrogen embrittlement research conducted using electrolytic hydrogen pre-charging apparatus - potentiostat/galvanostat - model 173, Princeton Applied Research, Oak Ridge, TN, USA (left); Example of hydrogen-induced cracks in metallographic cross-section of low alloy boiler steel (middle) and its corresponding fracture surface (right).

C: Calculation of phase diagrams and thermodynamic modeling

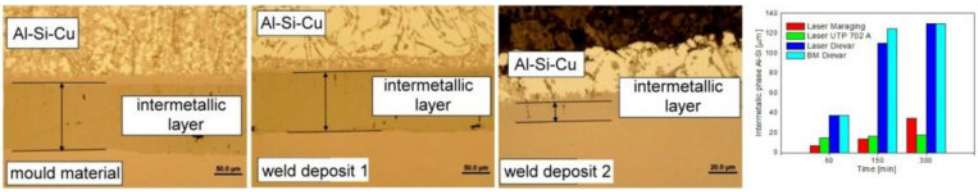
Research is focused on the modeling phase diagrams, development and optimization of thermodynamic databases by semi-empirical method Calphad for ternary and consequently for more complex material systems. Developed databases enable the performance of various types of thermodynamic calculations for the given systems and all subsystems, i.e. enabling the determination of phase equilibrium, chemical compositions of equilibrium phases, calculating values G, H, S, Cp and their dependence, drawing phase diagrams and their various sections, projection of liquidus, etc., and this to the full extent of the chemical composition. Databases extend the possibilities of designing new materials for high-temperature use by computational methods without the need for time-consuming experimental testing. Intensive research is done e.g. on ternary systems with boron as subsystems of steels containing boron, then also borides of transition elements (application in the nuclear and chemical industries), compounds of boron and carbon (materials for cutting tools and armour). Research is also carried out in the area of complex metal alloys, where very little information is yet available. Another subject of research is also Iridium systems as part of materials for ultra-high temperature applications.



Figures: Scheme of the Calphad method; calculated liquidus projection for the B-V-Mn system and the isothermal section for the B-Fe-W system at 1273 K. The SEM image presents some of the experimental information used for modeling, specifically in the Ho-Ir-O system.

D: Gradient materials for engineering applications

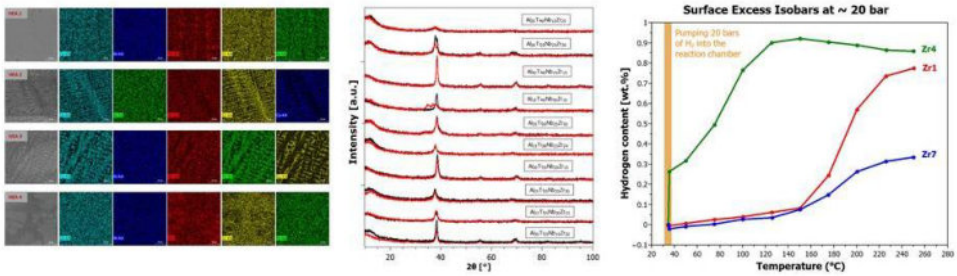
Research activities are focused on identification and testing the possibilities for lowering wear and increasing technological lifespan of innovative gradient materials of systems such as coating/substrate, overlay/substrate and the like. Areas of research are focused on material solutions for parts of forms for pressure casting Al-alloys, parts of shaping and machining instruments, and instruments for pressure bonding sheets.



Figures: Metallographic cross-sections showing comparison of various microstructural gradients of intermetallic layers formed on either steel mould material or two different investigated weld deposits subjected to Al-Si-Cu alloy melt; Graphical comparison of intermetallic layer thickness vs. melt exposure time for various laser deposited alloys.

E: Metalhydrides for efficient hydrogen storage

Metalhydride alloys are promising materials for the **efficient storage of hydrogen.** Hydrogen storage plays a crucial role, particularly in the automotive and transportation industries. Our research focuses on developing new metalhydride alloys to enhance storage efficiency. A comprehensive analysis of their macro- and microstructure, heat stability and mechanical properties is carried out using standard materials research techniques, including electron microscopy, X-ray diffraction and differential scanning calorimetry. In addition, synchrotron radiation is used for advanced X-ray diffraction and absorption spectroscopy at European research centers such as DESY (Germany), ESRF (France) and Diamond Light Source (United Kingdom).

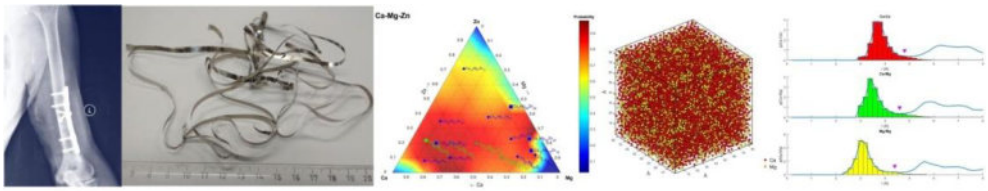


Figures: Illustrate the microstructure, EDS elemental maps, and X-ray diffraction data of the as-prepared alloys (black curves) and after hydrogen exposure (red curves), as well as the hydrogen absorption capabilities of some of our studied alloys under constant pressure and increasing temperature.

F: Biocompatible and bioresorbable alloys

The aim of the research is to prepare and investigate the properties of new types of metal alloys that will be made from biocompatible and bioresorbable elements based on Zn, Ca, Mg, Li, Mn prepared by the method of intense plastic deformation, analysis of micromechanisms of failure in relation to microstructure and basic mechanical and technological properties. The alloys Ca-Mg, Ca-Zn, Ca-Al, Ca-Cu, as well as ternal alloys of the type Ca-Mg-Zn and

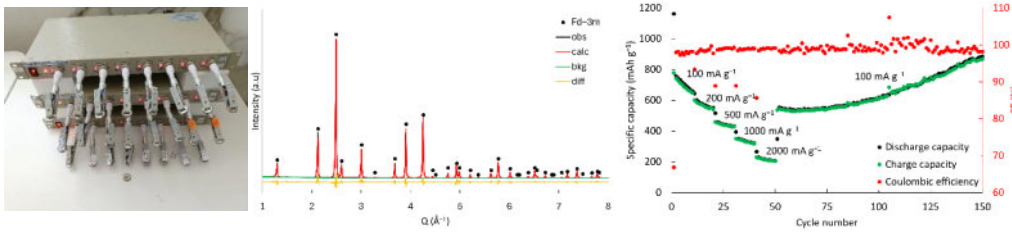
Ca-Mg-Cu are characterized by the very small specific values (~2000 kg.m-1), the lowest among the metal glasses known to this point. Their model of elasticity (Young`s module) ~20-35 GPa is close to the values of the elasticity of human bones. Moreover, these alloys exhibit very low glass transition temperature Tg (~120-250 °C), during which they transform from the hard and solid state to the easily formable state, this caused by the plunge in viscosity of the alloys by several orders.



Figures: Example of application of bioabsorbable alloys in reconstruction surgery, thin ribbon made by the melt spinner. The Ca-Mg-Zn ternary diagram showing in colour map prediction of glass forming probability. The three-dimensional atomic configuration of Ca-Mg amorphous alloy obtained from RMC modelling. The partial pair distribution functions of Ca-Ca, Ca-Mg and Mg-Mg pairs obtained from the RMC model.

G: Materials for New Generations of Batteries

Batteries are an indispensable part of our daily lives. They are found in personal electronic devices and are increasingly used in the automotive industry. Our battery research focuses on ecological and economic aspects to mitigate the negative impact on the environment while improving the electrochemical properties of batteries, such as energy density, load capacity, and cycling stability. We specifically focus on anode materials based on high-entropy and medium-entropy oxides, which exhibit exceptional cycling stability during charging and discharging while maintaining high capacity. Another key component of batteries is binders, which are often toxic. Therefore, our research also explores new bio-based binders to reduce environmental impact.



Figures: Battery testing station for coin-type cells (a); XRD pattern of single-phase high-entropy oxide $(CrMnFeCoNi)_3O_4$ with a spinel structure (b); rate capability test of $(CrMnFeCoNi)_3O_4$ high-entropy oxide (c).

H: Metal-ceramic nano-composites for demanding friction applications

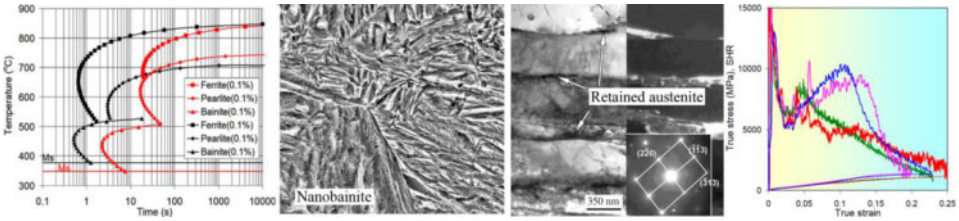
The aim of this research task is to investigate the properties of nano-composites with a metal matrix based on Fe-Cu, Ti-Cu with the addition of SiC, ZrO_2, Al_2O_3 and graphene and with the addition of metal wastes from conventional machining operations such as Al, CuZn, stainless steel, Ti, MgAl, etc. The composites are to be dry-mixed in a 3D turbula, attritor, and mixed also by the method of high-energy ball-miling in ethanol. The method used for compaction is rapid sintering using a pulsed electric current in a vacuum under the simultaneous action of uniaxial pressure (SPS "spark plasma sintering"). The results will be used for mapping and optimize the properties of prepared nano-composites, such as hardness, strength, abrasion resistance, thermal and structural stability (DSC / TG), coefficient of friction and wear and selection of nano-composites with the best possible combination of individual components.

Figures: Morphologies of the four input waste materials: Ti (a), MgAl (b), CuZn (c), Cu (d), and SSt stainless steel (e).TC1–TC3 (from left to right) composite powder mixtures afterplanetary ball milling.

I: Ultrahigh-strength nano-structured steels

The project is aimed at the development of novel cost-saving 2 GPa steel for ultrahigh-strength applications (machinery, aviation, armor vehicles, etc.) and the technology of its heat treatment which can be easily integrated into the production lines existing at the metallurgical plants. The advanced mechanical properties will be enabled by formation of a multi-phase “smart” structure with nano-sized micro-constituents (nano-bainite, nano- precipitates, retained austenite films, etc.) that can respond to the external load by TRIP/TWIP effects leading to self-strengthening and stress relaxation. This structure will be

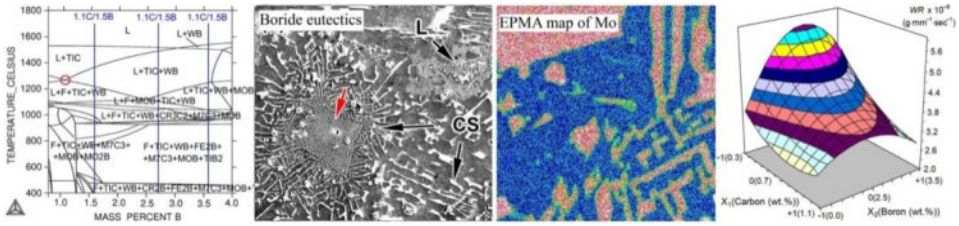
developed by an appropriate chemical composition selection and the novel processing route allowing for a reduction of the process duration, energy consumption and using conventional “easy-in-operation” equipment.



Figures: Temperature-Time-Transformation diagram of novel complex-alloyed TRIP-assisted steel (a), the microstructure of carbide-free nanobainite in high-strength steel (b), TEM characterization of retained austenite in nanobainite structure (c), the strain-hardening behavior of high-strength steels manifesting the TRIP-effect under tensile testing (d).

J: “Hybrid” multi-component cast alloys for tribological applications

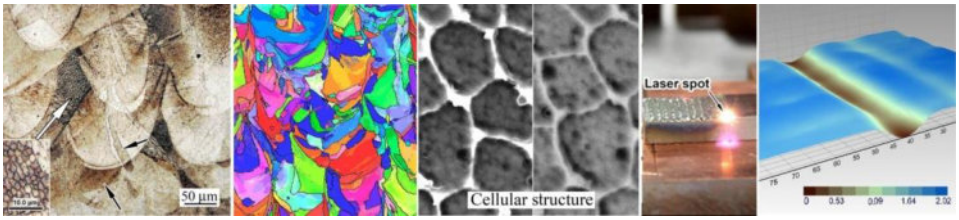
The relevance of the project is determined by the need to further increase the service life of machine parts and equipment which operate under severe abrasive wear (in mining, metallurgical, cement, etc. industries). The project is aimed at development of advanced wear-resistant alloys based on a new – "hybrid" – approach that combines different principles of alloying known wear-resistant materials. The new design concept will enable formation heterophase structure comprising the multiple superhard carboboride phases beneficial for wear resistance. The laser-based structure modification is also in the focus to further improve the wear properties of "hybrid" alloys. The novel alloys will perform a higher (at least 25%) wear behavior compared to conventional wear-resistant alloys.



Figures: Thermo-Calc simulation of phase constituents in boron-added Fe-W-Mo-Cr-Ti cast composition (a), carboboride eutectics in “hybrid” multi-component alloy (b), EPMA study of Mo phase distribution (c), effect of carbon and boron on abrasive wear response of a “hybrid” multi-component alloy (d).

K: SLM-fabricated biomedical alloys

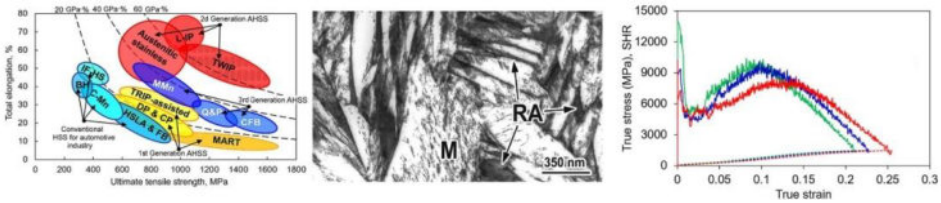
Research addresses the issues of adopting the additive manufacturing for biomedical applications. Specifically, the selective-laser melted (SLM) alloys (stainless steel, Ti-based and Co-based alloys) are assessed to be used for the artificial implants manufacturing instead of conventional metallic materials. For this purpose, the SLM-fabricated alloys are comparatively studied together with their wrought counterparts through the comprehensive microstructure characterization and testing (mechanical/micromechanical, corrosion, tribo-corrosion). Moreover, the mechanical behaviour of SLM-alloys under the hydrogen saturation is investigated. The effect of post-processing (bulk heat treatment, plasma/laser surface modification, and ultrasonic impact nanostructurizing) is also evaluated in order to further enhance the as-built metallic components' structural integrity and mechanical/corrosion properties.



Figures: The melt-pool pattern of SLM-manufactured 316L steel (a), inverse pole figure of as-built microstructure of SLM 316L steel - EBSD study (b), SEM image of the cellular structure pattern of SLM Co-28Cr-6Mo alloy (c), the process of a laser surface modification of SLM 316L sample (d), the wear track on the SLM Co-28Cr-6Mo alloy surface after the sliding test in simulated body fluid media (e).

L: Third-generation of Advanced High-Strength Steels (AHSS)

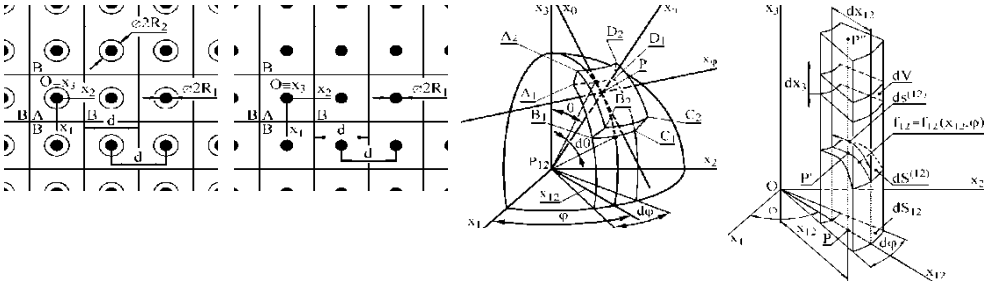
Third-generation Advanced High-Strength Steels (AHSS) represent a fundamental change in material science, targeting the simultaneous enhancement of strength and ductility. These alloys address the limitations of preceding generations by employing complex microstructural engineering. The design philosophy is focused on achieving a multi-phase microstructure, typically including retained austenite (RA), nanostructured bainite and martensite, through the application of specialized treatment technology. Our research in this area is aimed at developing new types of these steels and further optimising their chemical composition and treatment parameters in order to achieve improved mechanical behaviour. This advancement facilitates the production of thinner components, contributing to substantial weight reduction in automotive and structural applications, thereby enhancing energy efficiency and overall structural integrity.



Figures: Characteristics of 3rd Gen AHSS: mechanical properties (1), phase-structural state (2) and deformation behavior (3).

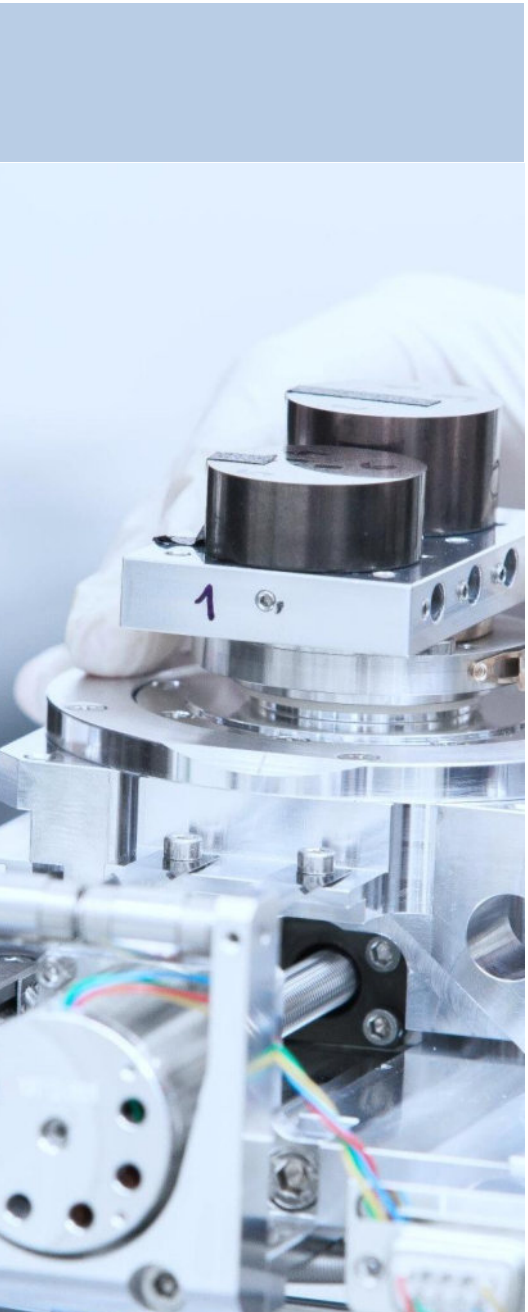
M: Analytical mechanics of a solid continuum

The research is focused on (1) original mathematical models of thermal, phase-transformation, coherent-interface-induced stresses and hydrogen-induced stresses in such model two- and three-component material systems without or with pores, which correspond to real two and three-component composite material (e.g., matrix-precipitate composites, dual-phase steel, etc.); (2) original mathematical models of intercrystalline and transcrystalline crack formation in components of these model material systems, including mathematical definitions of critical limit states with respect to the material crack formation, which is induced by these stresses; (3) original mathematical models of material micro- and macro-strengthening in components of these model systems, which is induced by these stresses. The material strengthening and the limit states represent important phenomena in material science and engineering. The mathematical models are functions of microstructural parameters of the real two- and three-component materials, and are applicable within basic research (mechanics of a solid continuum, theoretical physics), as well as the engineering practice (i.e., material technology).



Figures: The matrix-envelope-inclusion model material system, corresponding to three-component real materials, imaginarily divided into identical cubic cells, the inter-inclusion distance d along the axes x_1, x_2, x_3 of the Cartesian system ($Ox_1 x_2 x_3$), the inclusion centre O, the inclusion radius R_1, the envelope radius R_2. The cubic cell A, the neighboring cells B.

Division of Ceramic and Non-metallic Systems



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Characteristic of the division

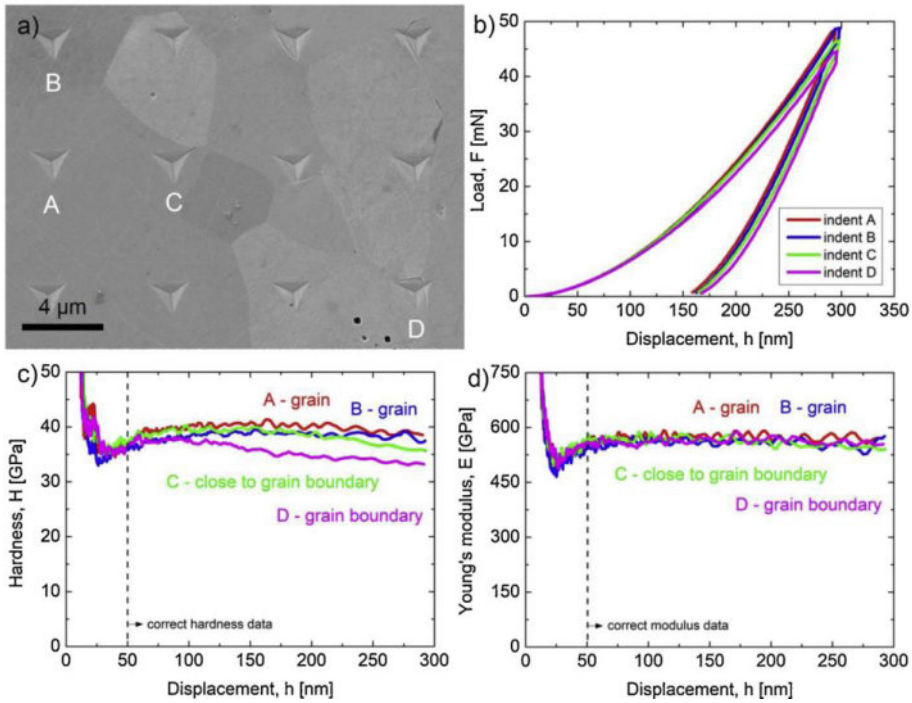
The scientific activities of the division are focused on the research and development of advanced ceramics, ceramic composites and nanocomposites, nano/microfibers, ceramic thin layers and coatings. During the development of these advanced materials, progressive processing routes are applied as spark plasma sintering, physical vapour deposition - impulse magnetron sputtering/high-target utilization sputtering and electrospinning. The developed systems are characterized using advanced techniques - scanning electron microscopy, transmission electron microscopy, atomic force microscopy, Raman spectroscopy, focused ion beam technique, etc. The fracture - mechanical properties and wear characteristics are measured at nano/micro/macro level at room and high temperatures. The main attention is focused on determination of the relationships between the processing route, microstructural parameters and final functional and mechanical properties of the systems designated for advanced applications. During the last 5 years the research activities in the division were realized in strong collaboration with partners from Slovakia and from foreign countries such as England, Germany, Hungary, Poland, Czech Republic, Japan, etc. The main research areas were as follows:

1. Bulk (3D) and coating (2D) high entropy ceramics: carbides, nitrides, carbonitrides, dual – phase boride/carbides,

2. Ultra – high temperature ceramics,
3. Advanced ceramic – carbon structure composites,
4. Micro/nano fibers and fiber membranes.

A: High entropy ceramics – carbides, borides, carbonitrides, dual – phase boride/carbides

Advanced high entropy ceramics with improved room and high/ultra-high temperature properties suitable for extreme operating conditions as thermal protection materials on hypersonic aerospace vehicles, specific components for propulsion, refractory crucibles, etc., requiring excellent thermal stability, super hard hardness, excellent tribological properties. Systems of interest involving bulk as well as PVD coating materials are based on transition metal carbides, borides, nitrides, dual – phase systems, etc., processed using high – tech processing routes (high–energy milling, spark plasma sintering, hot pressing, etc. for bulk systems and PVD techniques – DC magnetron sputtering, High Power Impulse Magnetron Sputtering, High Target Utilization Sputtering, etc. for thin coatings) and characterized using high–tech methods such as micro/nano mechanical testing, high resolution TEM, etc.



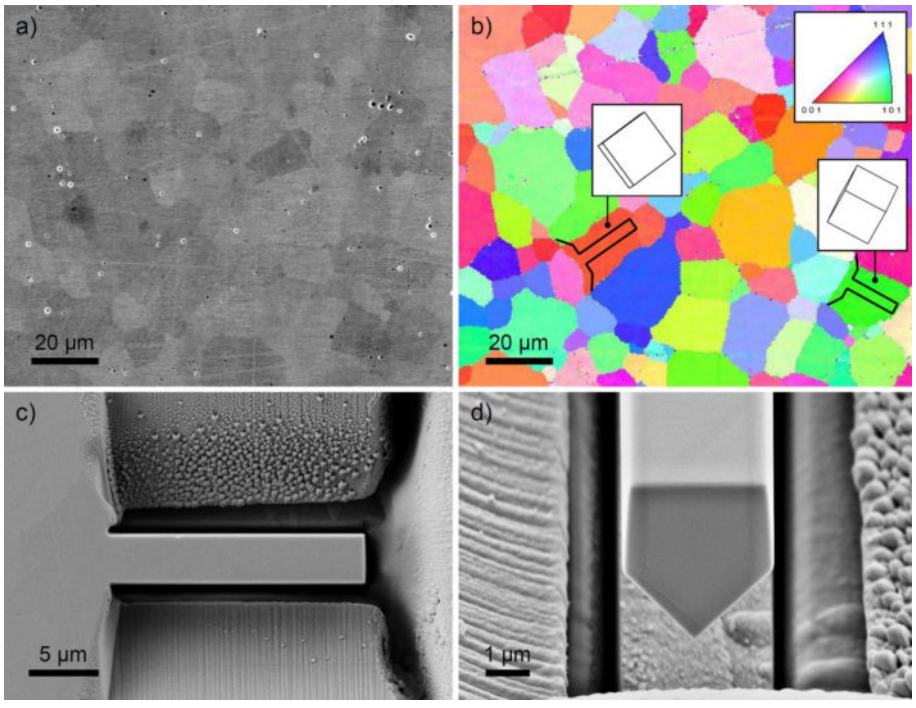
Figures: Nanohardness of carbide grains and grain boundaries in (Hf-Ta-Zr-Nb-Ti)C bulk ceramics.

The emerging topic of high entropy ceramics opens up a large new compositional space, with the possibility of new materials with enhanced properties and demonstrating new phenomena. At the division, basic research was realized during the last 5 years with significant results in the following fields:

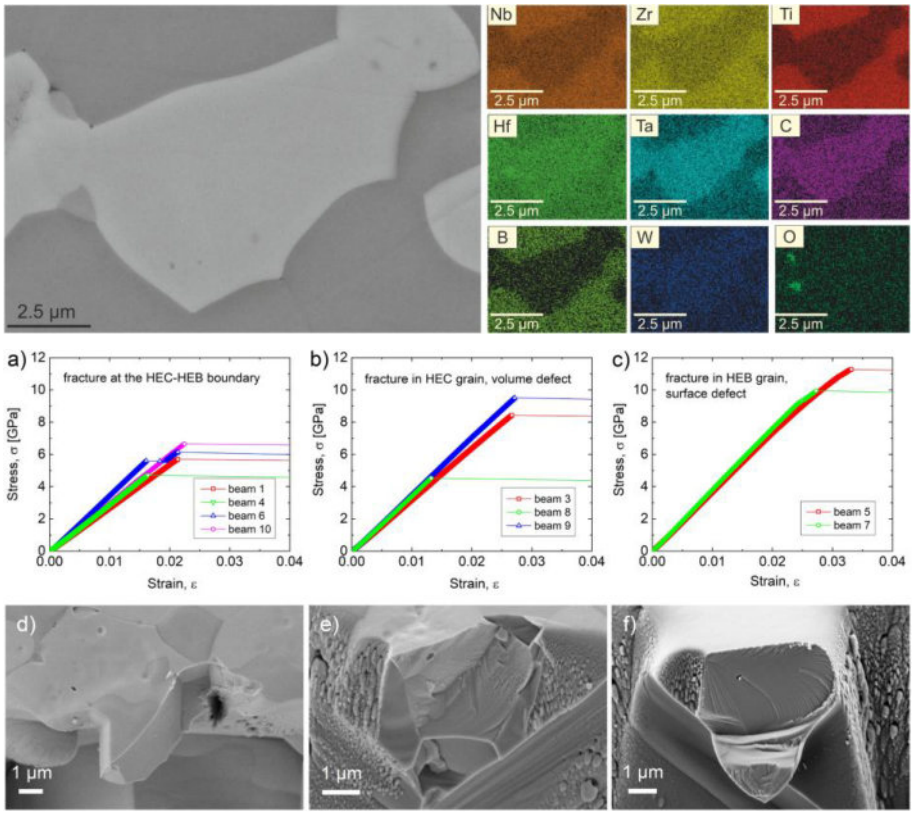
• Theoretical prediction of the physical and mechanical properties of high entropy ceramics.

• Preparation of dense bulk high entropy ceramic materials on the base of transition metal carbides nitrides, dual – phase boride/carbide with the help of advanced processing routes as boro/carbide reduction, reactive spark plasma sintering, rapid hot pressing, etc., with different chemical compositions.

• Investigation of the potential of different PVD deposition techniques and their optimization in the preparation of thin hard coatings involving multiprincipal transition metal (Ti,Zr,Hf,Ta,Nb,V,Mo,W) nitride and carbonitride systems with different stioichiometry.



Figures: Strength of HEC grains with different crystallographic orientations.

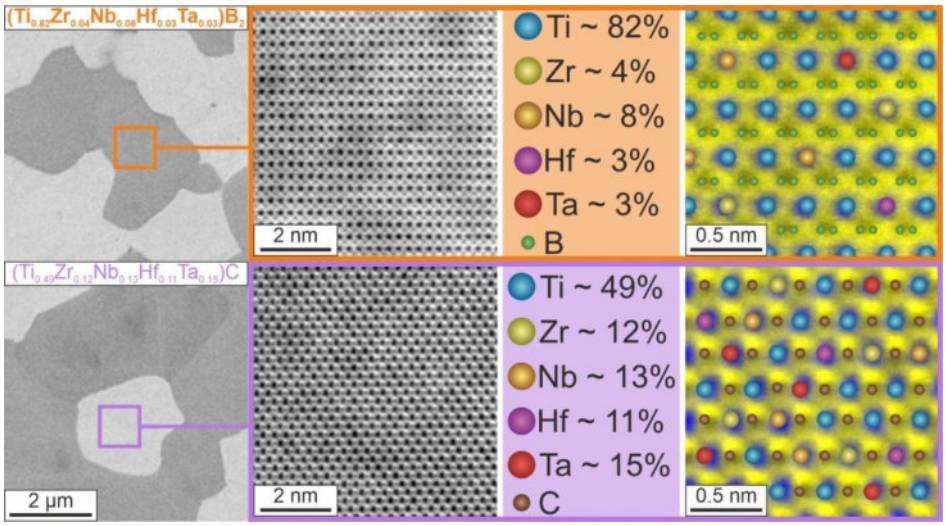


Figures: Investigating the strength of grains (cca. 8 GPa) and grain boundaries (cca. 4.5 GPa) in reactive sintered equimolar dual-phase high-entropy ultra-high temperature ceramics using a microcantilever bending experiment and detailed fractography-based analysis was performed.

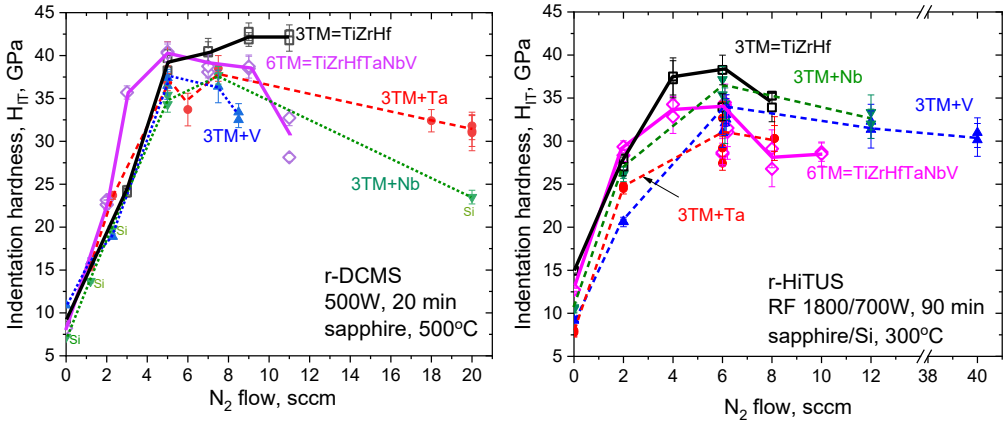
• Detailed investigations of the microstructure characteristics and chemical composition, of prepared bulk and coating systems at micro, nano and atomic level.

• Measuring physical, mechanical and tribological properties of the sintered bulk ceramics and PVD coatings using nano/micro/macro mechanical and tribological tests (nanoindentation, micropillar compression, micro cantilever, etc.) at room and elevated temperatures.

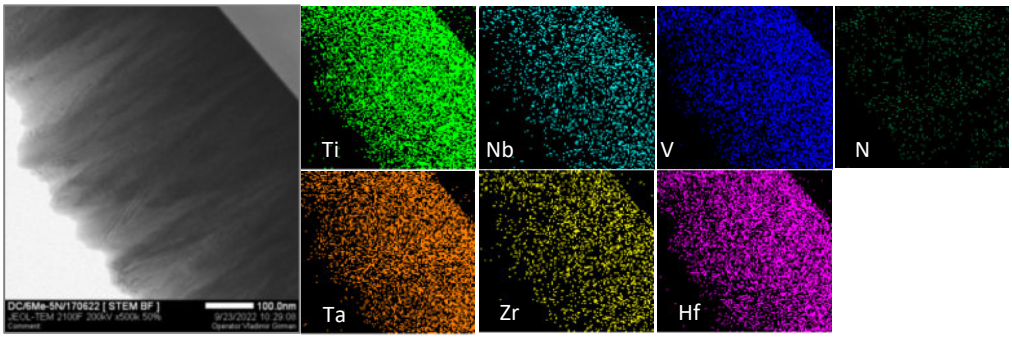
• Understanding of the relationship between the processing steps, microstructure and required final physical, fracture/mechanical, thermal and tribological properties.



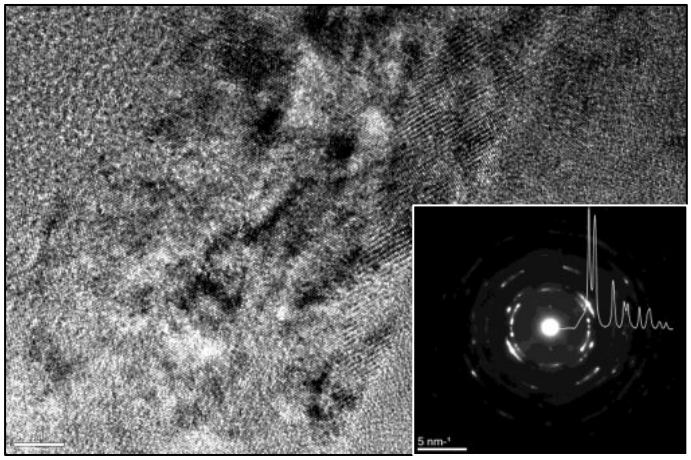
Figures: Microstructure analyses of grains and grain boundaries in reactive sintered non - equimolar dual-phase high-entropy ultra-high temperature ceramics at atomic/nano/micro level.



Figures: Indentation hardness of TiZrHf+V/Nb/Ta-xN coatings deposited using a - reactive DC magnetron sputtering and b – reactive High Target Utilization Sputtering over wide range of nitrogen stoichiometry (x – flow of nitrogen in sccm during deposition). Apparently, hardness exceeding 40 GPa can be achieved in medium-entropy stabilized TiZrHf-xN coatings deposited by DC magnetron sputtering at x = 8-10 sccm N_2 corresponding to the near-stoichiometric composition.



Figures: Scanning transmission electron microscopy and EDS mapping of the distribution of the elements in the multiprincipal transition metal nitride TiZrHfVNbTa-6N coatings deposited by the reactive DC magnetron sputtering. Homogeneous distribution of all transition metals and nitrogen confirms formation of the homogeneous solid solution in agreement with the concept of structure stabilization by high entropy (in the metallic sub-lattice).

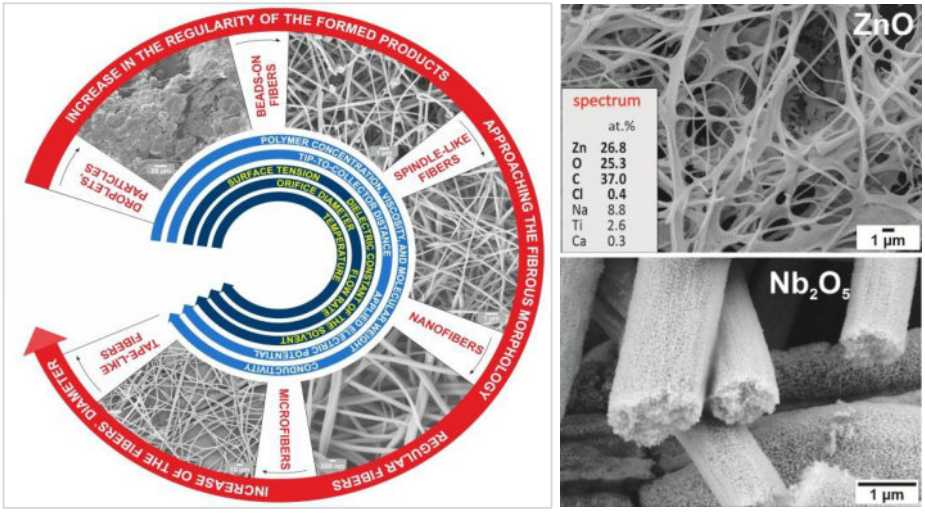


Figures: TEM observation of the columnar growth in reactive HiTUS TiZrHfVNbTa-6N coatings; single phase composition with the textured fcc structure was confirmed using selected local area diffraction (SAED and corresponding azimuthal integral SAED.

B: Detailed investigations of nano/microfibers in form of fibrous mats and cotton-like aerogels for special technical applications

Needle-less electrospinning stands as a versatile technique for the fabrication of a diverse array of nano/microfibers, encompassing polymers, ceramics, composites, and carbonaceous materials. These fibers, typically exhibiting diameters within the submicron range (predominantly 50-700 nm), are distinguished by their unique one-dimensional (1D) morphology and

exceptional functional attributes. Research endeavors in this domain are primarily directed towards the synthesis and in-depth investigation of ceramic fibers tailored for a broad spectrum of functional applications. This includes, but is not limited to, advanced gas sensors, next-generation Li-ion and Li-S batteries, and high-efficiency photocatalysts. Furthermore, their potential as reinforcing fillers in ceramic matrix composites for structural applications is being rigorously explored. For instance, TiO_2 nanofibers and nanofibrous membranes have demonstrated remarkable efficacy in the photocatalytic decontamination of wastewater, addressing critical environmental concerns. Similarly, Nb_2O_5 nanofibers are emerging as promising materials for energy storage applications, particularly in Li-S batteries, offering a pathway towards more sustainable energy solutions. A significant portion of the studied fibers are derived from synthetic polymers and commercially available ceramic precursors, providing a reliable foundation for material development. However, the pursuit of sustainability and resource efficiency has spurred investigations into alternative feedstocks. Moreover, a growing emphasis is placed on the integration of green approaches, particularly metal recycling, to minimize waste and promote a circular economy. In this context, ZnO and CuO fibers have been successfully synthesized from solutions obtained through the hydrometallurgical treatment of industrial waste streams. The production of electrospun ZnO fibers from waste products is particularly significant, as it facilitates the acquisition of low-cost input materials while simultaneously mitigating environmental pollution and creating value-added products.



Figures: Scheme of the influence of the electrospinning parameters on the morphology of the final product. Zinc oxide and niobium oxide fibers for applications in photocatalytic water remediation and Li-ion and Li-S batteries.

Division of Functional and Hybrid Systems

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Characteristic of the division

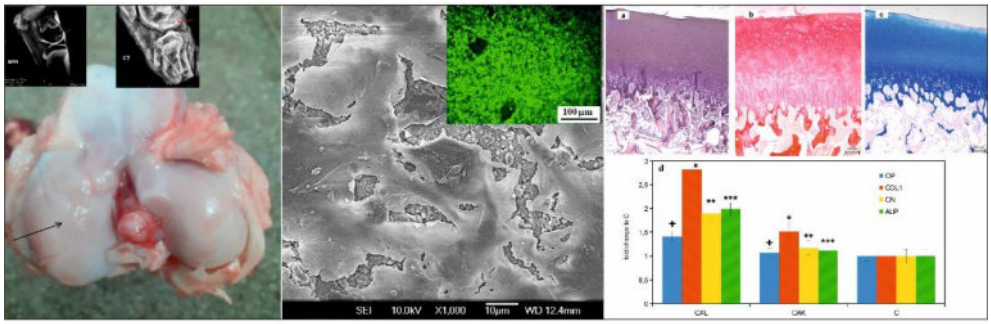
A: Research and development of new and modified biomaterial systems for the regeneration of hard and soft tissues

• Preparation and characterization of the properties of calcium phosphate-based biocement systems.

• In vitro cytotoxicity testing and identification of selected specific markers characterizing the biological activity of cells in contact with biomaterials.

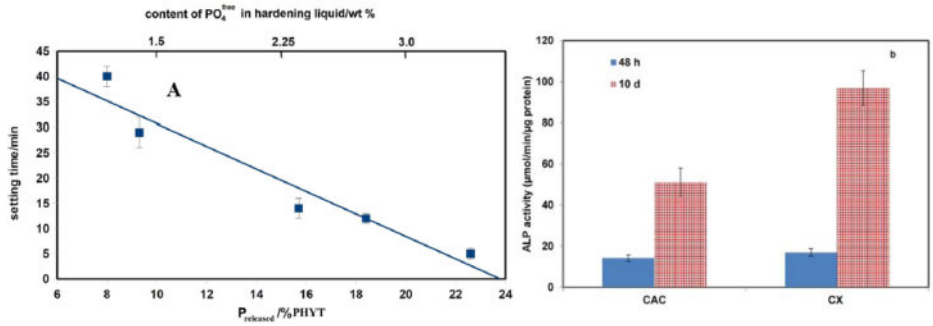
• Developed new composite biocement systems with the addition of an amino acid component supporting the formation and growth of cartilage tissue;

successfully applied to the treatment of artificially created osteochondral defects in *in vivo* animal models.



Figures: Macroscopic, MRI and CT evaluation and histological analysis of osteochondral defect tissue treated with biocement after 12 months of healing; SEM observation of seeded cells and stained living cells on the surface of biocement; upregulation of osteogenic cell marker genes in extracts from biocements containing amino acids.

• Studied a new setting method of a biocement system based on a tetracalcium phosphate/monetite mixture using enzymatic release of inorganic phosphates originated from a natural organic source (phytic acid) – confirmed stimulation of osteogenic activity of cells.



Figures: Regulation of setting time of enzymatically hardened biocement systems using enzymatic hydrolysis of phytic acid; stimulation of osteoblastic differentiation of mesenchymal cells (MSCs) in extracts of biocement systems.

• Demonstrated strong osteogenic potential of a new biocement composite containing a soluble calcium sulfate hemihydrate component as a source of calcium ions supporting osteoblast differentiation for enhancing their activity during bone tissue formation.

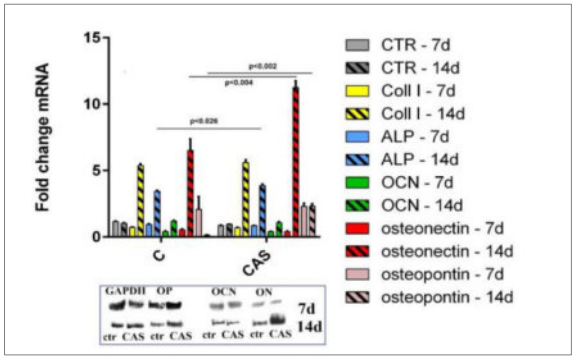
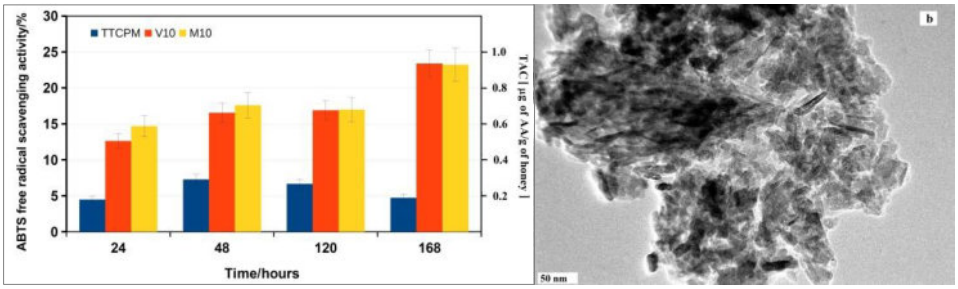


Figure: Relative content of specific markers and gene expression of collagen I (COL1), osteocalcin (OCN), osteonectin (ON), osteopintin (OP) and alkaline phosphatase (ALP) genes in MSCs cultured for 7 and 14 days in extracts confirming increased osteogenic activity of cells after the addition of calcium sulfate hemihydrate to biocement.

• Preparation and characterization of the properties of a composite biocement system containing honey as a natural additive improving the antimicrobial, antioxidant and osteogenic properties of the composite.



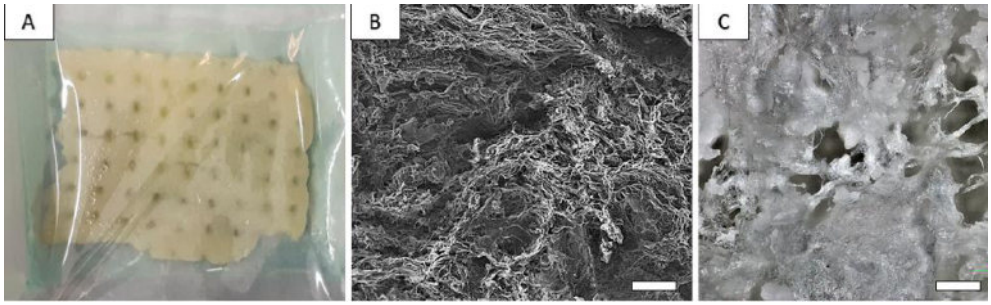
Figures: Significant increase in free radical scavenging activity and antioxidant activity (TAC) of extracts from biocements with the addition of bee honey depending on the extraction time; morphology of nanohydroxyapatite particles in hardened biocements after 7 days of soaking at 37 °C in a simulated body fluid solution.

• Developed synthesis method and analyzed properties of composite biocements containing glycerol/citrate component improving mechanical properties of the system.

Sample	Compressive strength σ (MPa)	Microhardness *HV*0.3 (MPa)	Nanohardness *H* (MPa)	Young's modulus *E* (GPa)
C	33 ± 2.9	233 ± 19	460 ± 60	16.0 ± 1.7
GCA/C105	57 ± 3.7	307 ± 17	500 ± 130	16.8 ± 2.5
GCA/C170	50 ± 6.4	362 ± 21	540 ± 130	14.8 ± 2.1

• Developed injectable forms of calcium phosphate biocements containing a natural protein component (fibroin).

• Chitosan-based biopolymer systems with excellent properties suitable for skin and skin wound regeneration applied in an in vivo animal model.



Figures: Macroscopic image and microstructure of prepared composite biopolymer substrates documenting high porosity and fibrous morphology of polymeric components.

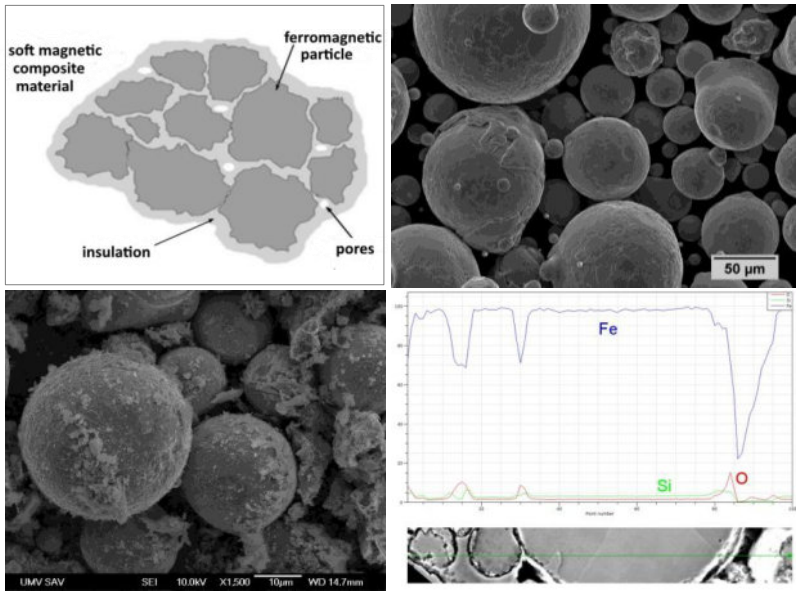
B: Preparation, characterization and application of compacted soft magnetic composites

Soft magnetic composites prepared from powdered ferromagnetic particles isolated by a thin layer of dielectric material are nowadays sought after for the purpose of manufacturing three-dimensional (miniaturized) electromagnetic components that require high frequencies in an alternating magnetic field. The decisive parameter is the preparation of a homogeneous and highly adhesive coating that will ensure high values of specific electrical resistance and permeability.

• The primary component of the composites are ferromagnetic metals Fe, Co, Ni and their alloys. The secondary electrical insulation component is distributed in the form of a thin layer on the surface of the ferromagnetic powder particles. By pressing and heat treatment, a microstructure of a continuous electrical insulation network is created in the ferromagnetic matrix. The main idea is to minimize the formation of eddy currents in an alternating magnetic field with a higher than industrial frequency.

• Composites consist of mutually electrically isolated magnetic particles, offer relatively low energy losses in the range of medium-high and higher

magnetization frequencies due to low eddy current losses (the insulating layer between individual magnetic particles ensures minimal paths for eddy currents), relatively high saturation magnetic induction, isotropic behavior of physical properties and wide possibilities for the production of 3D components using powder metallurgy technologies.



Figures: Preparation of powder composite.

• Composites consist of mutually electrically isolated magnetic particles, offer relatively low energy losses in the range of medium-high and higher magnetization frequencies due to low eddy current losses (the insulating layer between individual magnetic particles ensures minimal paths for eddy currents), relatively high saturation magnetic induction, isotropic behavior of physical properties and wide possibilities for the production of 3D components using powder metallurgy technologies

• Applications of compacted magnetically soft composites are in the field of development of high-frequency multi-pole electric motors, high-frequency inductors, electromagnetic shielding, etc.

Focus on three types of coatings: organic, inorganic and hybrid.

Organic coatings are synthesized on the basis of phenol formaldehyde resins, inorganic coatings are represented by ferrites with a spinel structure, and hybrid coatings consist of a combination of the previous two types in an appropriate

ratio.

Preparation of powder materials:

- Powdered metal, non-metal, composite and hybrid materials intended for processing by compaction or for use in powder form.
- Mechanical methods of alloying, modification of particle size and shape, mechanosynthesis, coating of powder particles, homogenization of powder mixtures.
- Deagglomeration and homogenization of powder and liquid mixtures by resonant acoustic mixing, ultrasonic homogenizer.

Characterization of powder materials:

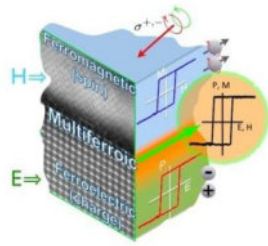
- Density of powder, liquid and compacted materials by multiple weighing method (Archimedes method) and helium pycnometry.
- Size distribution of powder particles by laser diffraction method and sieving monitoring method of powder materials.
- Qualitative and quantitative analysis of the shape and surface morphology of powder particles by optical and electron microscopy methods.
- Analysis of the compressibility of powder materials, compression curves of powder materials and mixtures.
- Analysis of sinterability of powder materials, sintering kinetics.

Progressive methods of compaction of powder materials:

- Uniaxial cold and hot pressing.
- Sintering by focused and diffused microwave radiation or traditional heating.
- Heat treatment of powder and compacted materials by microwave heating.
- Research and development of progressive methods of compaction of powder materials - vacuum sintering, isostatic pressing, plasma discharge sintering, microwave sintering, powder deposition, additive manufacturing.

C: Ferroelectric and multiferroic materials, dielectrics for energy storage

- Electro- and magneto-active materials with hysteretic response to external fields (electric, magnetic, mechanical).



• Applications in sensors, actuators, accelerometers, converters, RAM memories, energy storage and conversion.

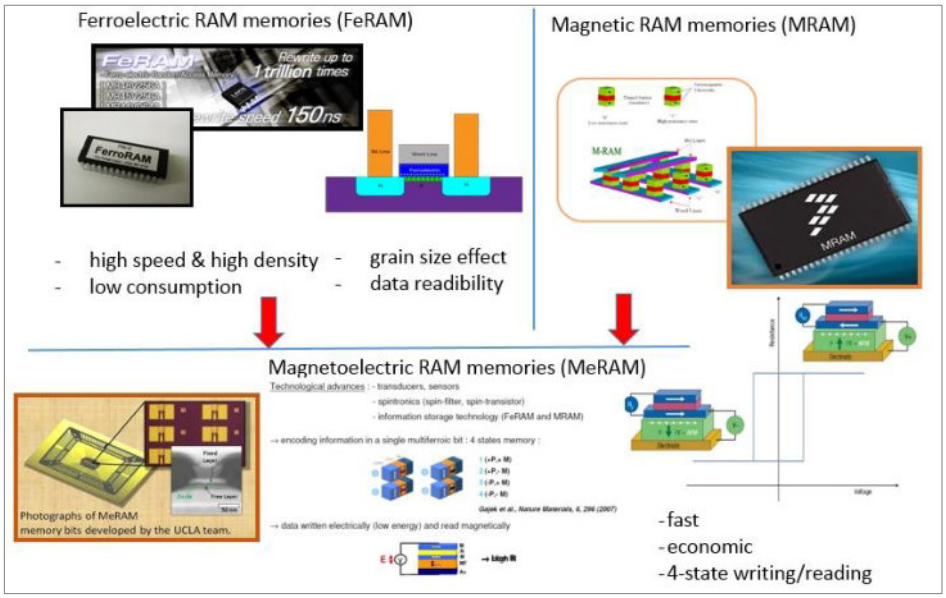
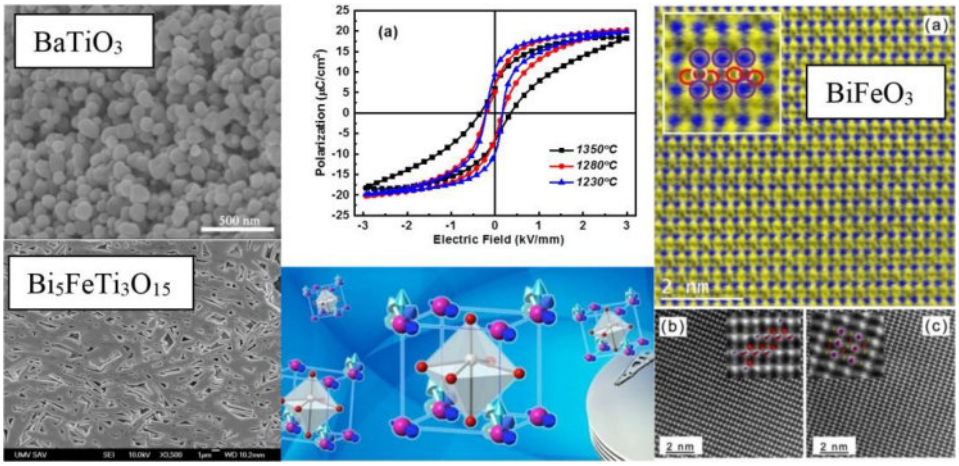


Figure: Applications of ferroelectric and multiferroic materials in RAM memories.

• Focusing on perovskite oxides of the type $Pb(Zr,Ti)O_3$, $BaTiO_3$, $Bi_{0.5}Na_{0.5}TiO_3$, $BiFeO_3$, and layered structure Aurivillius phases, such as $Bi_5FeTi_3O_{15}$.



Figures: Microstructure (left images) and atomic resolution TEM images (right side) of perovskite electroceramics ($BaTiO_3$, $BiFeO_3$) and Aurivillius-phase ceramics ($Bi_5FeTi_3O_{15}$). P-E hysteresis loops of $BaTiO_3$ (in the middle, top) and perovskite unit cell (in the middle, down).

D: Lanthanide-based luminescent materials

• "Green" solvothermal syntheses of nanopowders, development of knowledge in the field of preparation of thin layers and films based on lanthanide elements (Ln) as well as development of experimental methodologies for investigating their phase composition, microstructure and physical properties.

• "Metal-Organic Framework" (MOF) porous powder precursors based on lanthanides LnMOF (Ln = Eu, Gd and Tb).

• LnMOFs with rod-shaped particles with a size of ~20-100 nm represent a tetragonal $C_{12}H_{21}O_{24}Ln$ structure, composed of Ln^{3+} cations and ligands of 1,3,5-benzenetricarboxylic acid (BTC).

• Transparent porous LnMOF thin films with a thickness of ~200-500 nm were prepared from colloidal solutions of Ln-BTC nanocrystals by spin-coating onto $Pt/SiO_2/Si$ substrates and annealing at 80 °C.

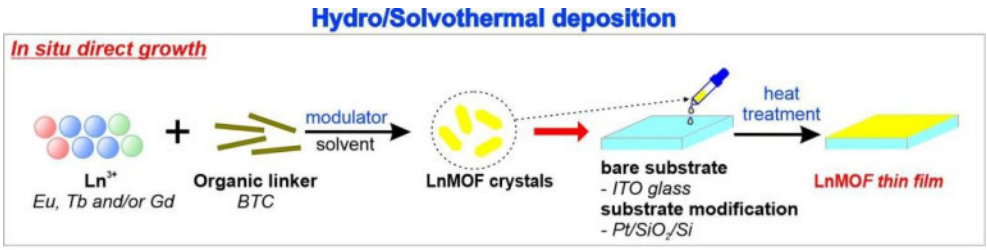
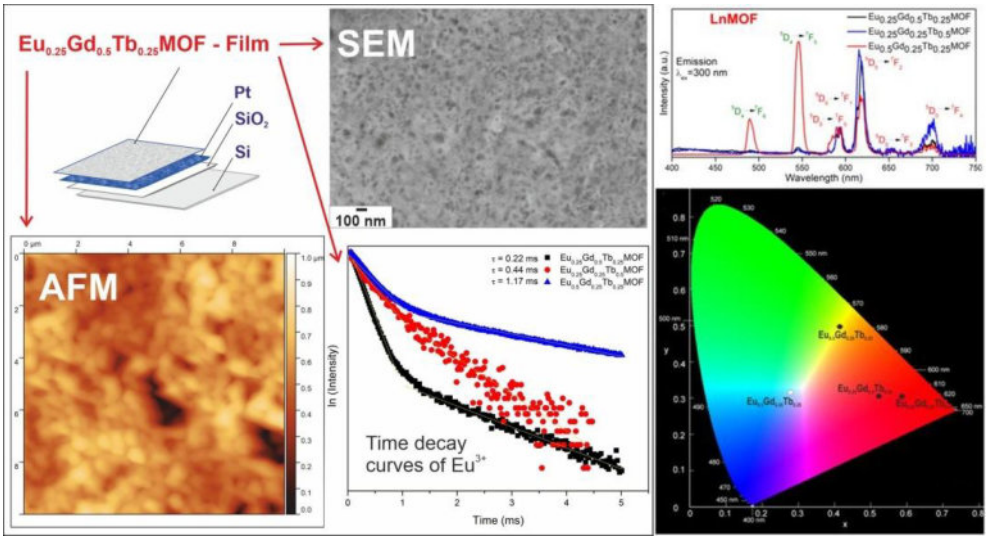


Figure: Schematic depiction of hydro/solvothermal method (green synthesis) of LnMOF (Ln-BTC) thin films on ITO glass or $Pt/SiO_2/Si$ substrates.

• Determination of the influence of lanthanide component in individual mono-, bi- and tri-lanthanide systems on the phase composition, microstructure and topography of films.

• Characterization of luminescence properties using excitation and emission spectra and investigation of the relationship between luminescence and the microstructure of films.



Figures: Design, SEM surface microstructure and AFM topography of $Eu_{0.25}Gd_{0.5}Tb_{0.25}MOF$ ($Gd_{0.5}$) thin film on silicon substrate with SiO_2 and Pt interlayer, Eu^{3+} decay time curves (τ) for three luminescent Eu/Gd/Tb-MOF films; Emission spectra for three mixed LnMOF films and illustration of the color diagram CIE and chromaticity coordinates (x, y) obtained for films.

- Design and development of three new mixed white light emitting films in the trichromatic $Eu_xTb_yGd_zMOF$ system (Ln = $Eu_{0.25}Gd_{0.5}Tb_{0.25}$, $Eu_{0.25}Gd_{0.25}Tb_{0.5}$ and $Eu_{0.5}Gd_{0.25}Tb_{0.25}$) for LnMOF films, designated as $Gd_{0.5}$, $Tb_{0.5}$ and $Eu_{0.5}$.

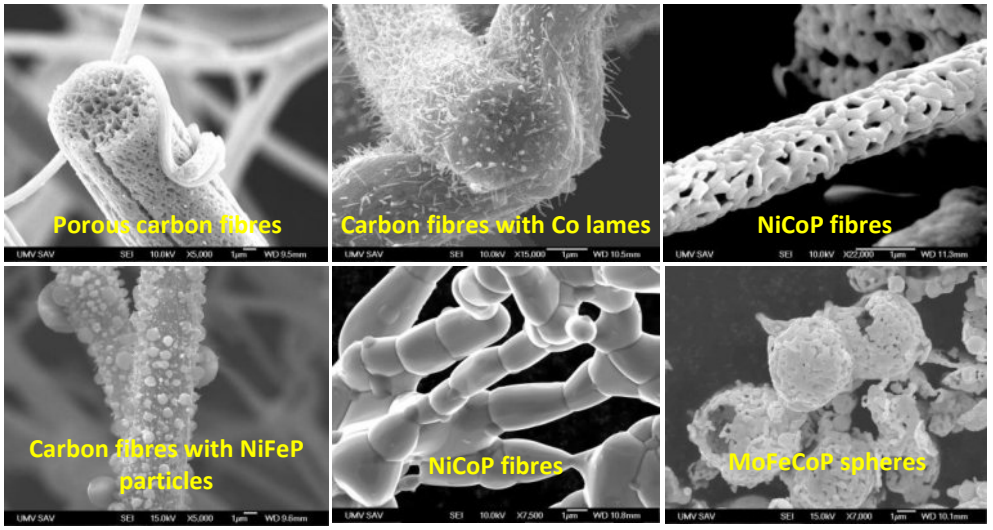
- Eu^{3+}, Tb^{3+} and Gd^{3+} ions emitting red, green and blue light were incorporated into the resulting structure ("antenna" effect) so that it was able to generate white light (chromatic coordinates x = 0.33; y = 0.33).

- The $Eu_{0.5}$ film (x = 0.28; y = 0.32) represents an increase in the average lifetime (τ = 1.17 ms) of europium by more than fivefold and an improvement in quantum efficiency by 100%, relative to the $Gd_{0.5}$ film.

- LnMOF thin films were prepared with the aim of expanding their potential use in luminescent sensors and LED applications.

E: Preparation of a new family of electrocatalysts with different morphologies for enhanced hydrogen and oxygen evolution reactions.

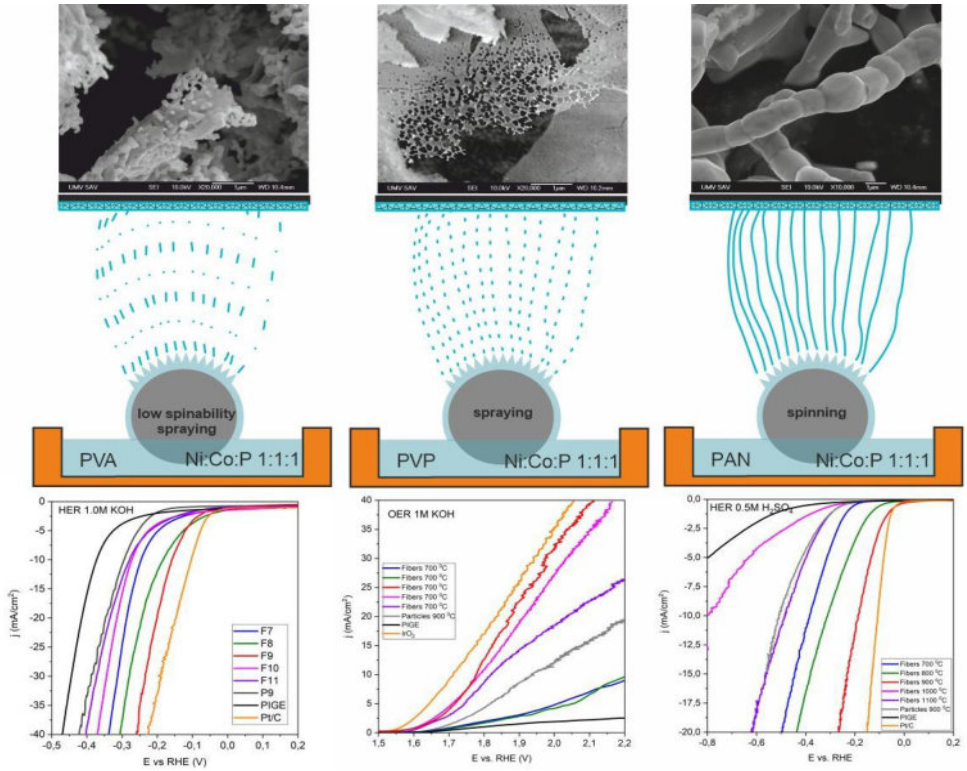
A new family of electrocatalysts was synthesized using different methods. The use of user-friendly techniques such as electrospinning or spray-dry atomization led to different morphologies with an increased surface area, providing more active sites to enhance the electrolysis of water Fig1. The hydrogen evolution and oxygen evolution efficiencies were studied using voltammetric techniques such as cyclic voltammetry and linear sweep voltammetry. EIS (Electrochemical Impedance Spectroscopy) analysis was employed as a promising tool to describe the kinetics and mechanisms of gas evolution on catalytic surfaces. The main goal of our work is to prepare, characterize, and study inexpensive, stable, and catalytic materials for hydrogen production as an alternative fuel for the future.



Figures: Different fibrous and spherical morphologies of transition metal phosphides prepared by needle-less electrospinning and spray-drying methods.

F: Optimization of synthesis and preparation methods for transition metal phosphides as efficient electrocatalysts.

- Electrochemical, structural, morphological and thermodynamic evaluation of the new catalysts.
- Evaluation of the stability and durability of the catalysts.



Figures: NiCoP fibers as electrocatalyst for HER.

Technical and Administrative Support

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Rastislav Motýľ
Jozef Novák
Edita Ridarčiková
Štefan Siládi
Martin Štofčík

Infrastructure at IMR SAS

Ceramographic Laboratory

The laboratory is used for the preparation of ceramographic samples for observations in an optical microscope, scanning electron microscope, atomic force microscope, as well as for the preparation of samples of suitable dimensions and shape for their further mechanical testing. Almost every mechanical method of testing ceramic materials requires sample preparation in a ceramographic laboratory. Whether it is hardness tests, strength, tribological properties, high-temperature creep tests, a defined surface treatment is required everywhere to obtain relevant results. The laboratory specializes in the treatment of surfaces of ceramic materials - structural, functional ceramics and bioceramics, as well as hard thin layers. The laboratory also prepares samples of suitable dimensions for subsequent mechanical tests.

Coating Technologies Laboratory

The laboratory conducts research into the latest PVD technologies for coating structural and other materials with hard, superhard and possibly also functional coatings based on modern single- and multi-component systems, including nanocomposite, multilayer and gradient coatings with the aim of research and development of superhard materials for engineering applications in the mechanical engineering industry. The aim is to develop the latest PVD magnetron sputtering technologies in applications aimed at extending the service life and reducing energy losses during friction in a wide range of engineering products. It is based on magnetron sputtering technologies using conventional DC and RF sources, as well as unconventional methods with HiPIMS and HiTUS technologies.

Coating Technologies Laboratory

Electrochemical Laboratory

The electrochemical laboratory primarily focuses on the electrochemical characterization of electrocatalysts for water splitting from different environments. The electrocatalysts are prepared as alternative components for membrane electrode assemblies in new electrolyzers and fuel cells for hydrogen production and consumption. The laboratory is fully equipped to characterize electrolytic efficiency, study kinetic behavior, electrochemical measurements at various temperatures and stability tests. The Vionic potentiostat (from Metrohm company) allows for operation at a current of 6A and a potential of 50V. Electrochemical characterization includes all necessary voltammetry techniques, such as linear sweep voltammetry, cyclic voltammetry, impedance analysis, chronoamperometry and potentiometry. The three-electrode setup includes different working electrodes (e.g., glassy carbon, paraffin-impregnated graphite electrode, nickel foam, etc.), a reference electrode (Ag/AgCl), and a Pt counter electrode. The rotating disk electrode (RDE) with an Hg contact is used to facilitate the smooth escape of gases from the electrode surface. The Pt RDE is used as a reference for hydrogen evolution catalysts.

Laboratory for Powder Materials Conditioning

The laboratory is focused on complex preparation of powder materials and mechanochemical synthesis. High-purity powders, composite coated powders and powder mixtures of metal, ceramic, polymer and hybrid particles are prepared. The laboratory is dedicated to the research of composite powder systems of the core/shell type, for example for magnetic soft composites ferromagnetic/insulator, modern ceramic materials ceramics/hardening component. Sophisticated composite powders prepared under controlled laboratory conditions with chemical, phase and granulometric composition are the basis for modern shaping and compaction technologies (microwave and

discharge plasma sintering) for the preparation of modern sintered metal, ceramic and composite materials. Application of the materials mentioned is directed to the field of electrical engineering, electronics and precision engineering for specific combinations of electrical, magnetic, thermally conductive and mechanical properties.

Laboratory of Analytical and Physical Chemistry

The Laboratory of Analytical and Physical Chemistry specializes in the synthesis and investigation of advanced functional materials, including biomaterials, organic polymers, and fibrous systems for hydrogen evolution. Our expertise includes the preparation of calcium phosphate phases, fibrous catalysts, and hybrid organic-inorganic materials, supported by techniques such as elemental analysis, pH monitoring, and thermal curing. The laboratory is equipped to carry out processes ranging from ball milling and steel etching to controlled incubation and solution-based synthesis. Through an integrative approach combining experimental chemistry and physical analysis, we aim to advance material performance across biomedical and energy-related applications.

Laboratory of Analytical and Physical Chemistry

Laboratory of Computational - Materials Research

The laboratory enables the realization of phase diagram calculations, chemical thermodynamics and machine learning methods for the development of new materials not only for soft magnetic materials, but also for a wide range of materials. In the laboratory, it is also possible to measure the Young's modulus by the non-destructive method of the excitation pulse, as well as measure the resistance by the 4-point method and the coercive force of magnetic soft materials. Calculations and measurements are carried out according to the needs of research, as well as the requirements of potential interested parties from the field of industrial research.

Laboratory of Characterization of Powder Materials

The laboratory is part of the research and development cycle for the preparation of composite materials using the latest modern powder technologies. Powdered metals, ceramics and polymers are characterized in terms of basic physical properties (particle size distribution, density), microstructural and chemical Laser Induced Breakdown Spectroscopy (LIBS) analysis determining the parameters of subsequent shaping and compaction technologies. The laboratory is focused on the development and optimization of methodologies for the analysis of the granulometric composition of micro- and nanocomposite powders of the metal/polymer, ceramic/polymer and metal/ceramic types intended for the preparation of modern structural and functional composite materials. The combination of He pycnometry and the Archimedes density determination method allows the measurement of open and closed porosity of compacted materials. The available laboratory equipment allows for the analysis of granulometry, density, porosity, microstructural and chemical analysis of powder materials and waste from various industrial processes.

Laboratory of Chemical Surface Analyses

The laboratory is dedicated to surface chemical analyses to ensure operational research of local chemical composition necessary for the development of the latest metal and ceramic materials, as well as developed biomaterials and PVD coatings. This method of investigating the chemical composition of surface and subsurface layers is expected to provide fast, experimentally simple and economically undemanding monitoring of the elemental composition of a wide range of materials, their changes in oxidation, corrosion, moisture effects,

tribological and other wear, etc. at both qualitative and quantitative levels from concentrations of several ppm. The above methods can be used without limitations to investigate all solid materials, sufficiently deep subsurface layers, including thin coatings.

Laboratory of Fractography and Image Analysis

The laboratory is dedicated to research microstructural analysis (stereoscopic, optical microscopy), image analysis and fracture analysis of various types of prepared experimental as well as materials from normal industrial operation. The laboratory enables the observation of powders, liquid and compact materials and biopreparations in reflected light, transmitted light, fluorescence imaging, as well as polarized light. At the same time, it is possible to prepare an image for image analysis with automatic programmable shifting in the XY and Z directions, and with automatic focusing and automatic joining of image series. In a light microscope with a high-temperature chamber up to 1400 ºC, it is possible not only to observe, and to save not only individual images but also a video recording of the process using a digital camera. It is based on both the basic needs of research and the requirements of potential interested parties from the field of applied research. It follows that testing is carried out at different levels according to the requirements of researchers or industrial partners.

Laboratory of Fractography and Image Analysis

Laboratory of Microwave Sintering and Pressing

The laboratory is focused on high-precision compaction of powder materials and microwave sintering of powders and compacted materials. On the pressing

device, we can study the pressing parameters of various powder systems, and based on the results, determine the optimal pressing conditions for individual powder systems. On the single- and multi-mode microwave device, it is possible to sinter powders and compact samples. On the single-mode device, it is possible to study the sintering parameters. The application of optimal pressing procedures and the introduction of energy-efficient sintering methods aims to reduce energy and material requirements in the development and production of components for the field of electrical engineering, electronics and precision engineering for specific combinations of electrical, magnetic, thermally conductive and mechanical properties.

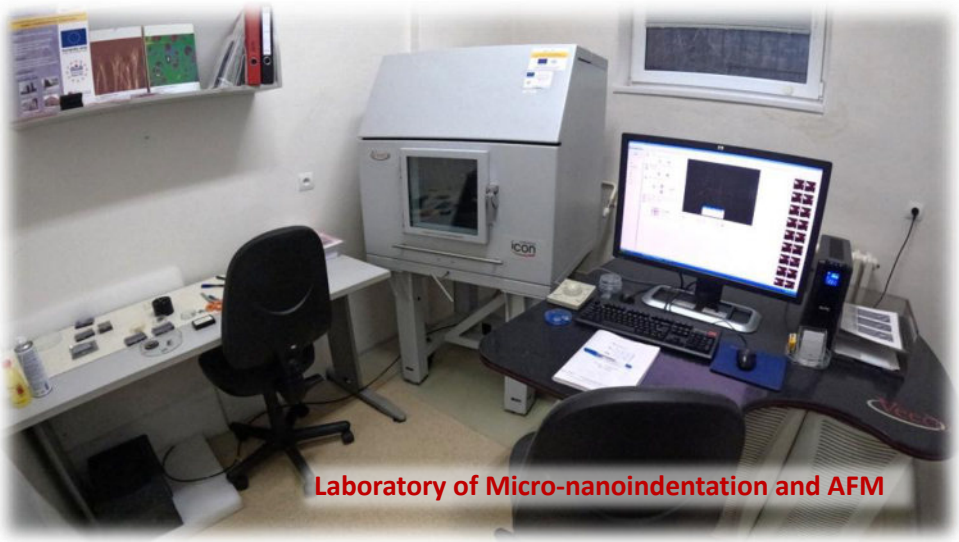
Laboratory of Microwave Sintering and Pressing

Laboratories of Light Microscopy

The laboratories are dedicated to research into the internal structure and microstructure of materials as well as operational observations in a wide range of magnifications from conventional optical magnifications at the level of 10x to atomic magnifications through a combination of several observation techniques. The basis is metallography based on conventional optical microscopy in bright and dark field, polarized light and using interference contrast with the possibility of fast and high-quality digital recording with high resolution. In addition, three-dimensional surface topography is investigated in a wide range of magnifications and with a significant depth of field using confocal microscopy and/or optical profilometry based on optical interference. Other measurements are fast optical measurements of chemical composition or local bonds using Raman microscopy.

Laboratory of Micro-nanoindentation and Atomic force microscopy

The Laboratory of Micro-Nanoindentation and Atomic Force Microscopy focuses on characterization of hardness, indentation module of elasticity of materials in dry conditions at room and elevated temperatures by means of instrumental indentation and nanoindentation. It allows measurement of these mechanical properties at a load level from 1nN to 10N and in nano- and micro-metric dimensions. It is suitable for precise characterization of thin films, coatings, individual grains and phases in composite, gradient, homogeneous and inhomogeneous materials. The Laboratory also allows assessment of topography and functional surface characteristics of materials by atomic force microscopy (AFM) – metals, ceramics, polymers, coatings and thin films.



Laboratory of Micro-nanoindentation and AFM

Laboratory of Progressive Alloys

The laboratory is focused on the preparation of metal alloys, rapidly cooled/amorphous materials, metal and ceramic powders. The preparation of materials is based on both the needs of basic research and the requirements of potential interested parties from the field of industry and implementation. This primarily concerns:

a. preparation of metal alloys of the desired chemical composition in the form of small ingots;

b. preparation of rapidly cooled alloys in the form of thin strips or small ingots;

c. preparation of powders by the high-energy grinding method. In this way, it is possible to prepare powder materials, as well as composite mixtures (such as metal oxides, nitrides, borides, etc.) with the desired size of the resulting powder and the desired volumetric homogeneity.

Laboratory of Progressive Alloys

Laboratory of Sintering and Heat Treatment

The sintering laboratory provides one of the most important operations in the entire process of developing materials based on powdered metals. The laboratory's activities are focused on a comprehensive chemical and physical analysis of processes during sintering of new types of materials (biomaterials based on powdered metals, composite materials and progressive sintered steels).

Laboratory of Tribotechnology

Mechanical Testing Laboratories

The laboratories are dedicated to testing the mechanical properties of new materials. The area of research/development is focused on mechanical testing of new materials and technologies as well as their transfer to industrial production. These are mainly the areas of research and development of new progressive steels for the automotive industry, new steels for the electrical industry, modern and new heat-resistant steels and special heat-resistant alloys including model alloys and their welds, progressive iron-based materials prepared by powder metallurgy technologies, structural and modern ceramic materials, bioceramic materials based on hydroxyapatites and mechanical testing of plastics. These are mainly hardness tests, microhardness, tensile, compression, bending tests at room and higher temperatures, dynamic bending tests of progressive steel sheets for the automotive and electrical industry and materials prepared by powder metallurgy technologies.

Metal Processing Laboratory

The laboratory for processing metallic and non-metallic conductive materials is focused on the processing and manufacturing of complex shaped samples or miniature samples with a thickness of up to 0.08 mm for the needs of material analysis or testing. Mainly hardened metal materials, hard metal materials, ceramic conductive materials are processed by cutting. Complex shaped products of miniature dimensions with roughness with a given grinding quality can be produced.

Nanotechnology Laboratory

The laboratory is focused on the development of nanofibers for various

technical applications using needle-less electrospinning technology by NANOSPIDER™ NSLab 200. This method can produce various types of continuous nanofibers with diameters from 50 nm to 1500 nm. Such nano/microfibers have great potential for applications in areas related to clean energy sources, such as: solar cells with lower production and energy costs; lithium batteries; microdevices for generating electricity from waste mechanical energy; filters for the automotive industry; sound insulation; filter extraction and many others.


Nanotechnology Laboratory

Sample preparation for TEM

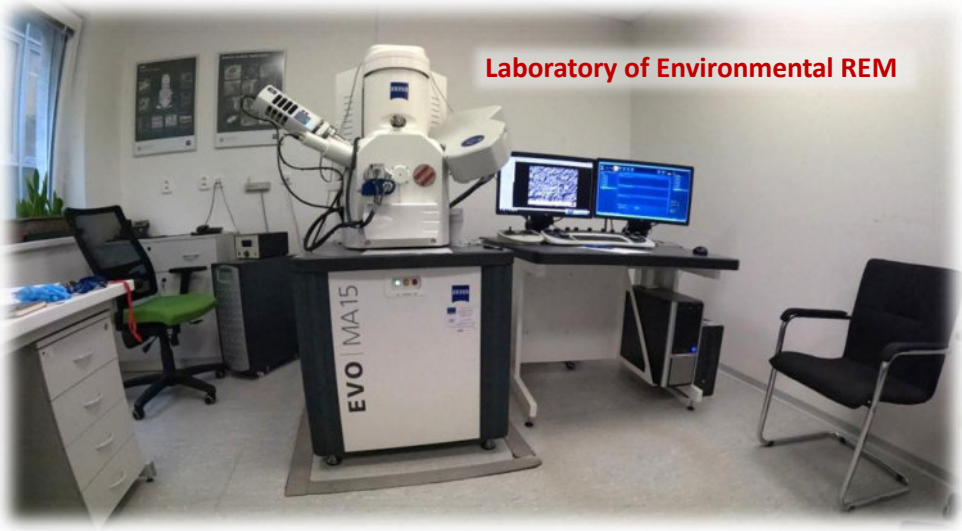
The purpose of the TEM sample preparation room is to prepare samples from various types of materials for observation in a transmission electron microscope, which allows for sufficiently accurate documentation of the development of the macrostructure in materials or their microstructural and phase changes.

Laboratories of Electron microscopy

Dedicated to research and monitoring of the microstructure and topography of the latest metallic and ceramic materials, biomaterials, coatings, and composite materials, from nano to micrometer dimensions of microstructure units in a wide range of magnifications (up to 800 000 x) and working pressures. Research in the field of defect analysis, material shaping using nano-machining, sample preparation and treatment for transmission electron microscopy, treatment of a specific sample location according to special needs, chemical analysis of surfaces towards the interior of the material, etc. Apart from morphological observations of microstructural objects, in combination with

analytical Energy Dispersive Spectroscopy (EDS), Wavelength Dispersive Spectroscopy (WDS), and Electron Backscatter Diffraction (EBSD) units, it enables obtaining information about elemental composition, phase composition and crystallographic orientation of the investigated materials.

SEM/FIB Laboratory



Laboratory of Environmental REM

Spark Plasma Sintering Laboratory

The laboratory is engaged in research in connection with the compaction/sintering of various metal and ceramic powder materials with the prospects of their use in various areas of the economy as structural, functional and bio-medical materials. The goal is to build a laboratory for rapid sintering

and thus prevent grain growth during sintering and prepare nanostructured materials and composites.

Technological Laboratory

The laboratory is dedicated to the preparation of polycrystalline materials, ceramics, nanoparticles and single crystals from a wide range of strongly correlated electron systems, including superconductors, borides and materials belonging to the group of multiferroic materials.

Laser Laboratory

The laboratory focuses on solving the problem of the driving force of selective growth of goss grains and on the modification of the magnetic domain structure using the laser scribing procedure. The originality of the procedure lies in the fact that in the process of selective growth of goss grains, in addition to thermal activation, a controlled gradient of deformation energy between goss grains and grains with inappropriate crystallographic orientation in the plane of the sheet is used as the driving force of grain boundaries, initiated by thermal dilations due to local laser exposures. In the laboratory, samples of materials are prepared primarily from electrical steels (transformer and dynamo steels) but also from other compact materials according to the requirements of basic and applied research - metals, ceramics and composites.

Laser Laboratory

Thermal Materials Analysis Laboratory

The laboratory is used to analyze a wide range of materials, in which the change in physical or chemical properties of substances and reaction products is monitored depending on the temperature. The following are evaluated in

particular: enthalpy, melting point, evaporation, sublimation, phase transformations, heat capacities of solid and liquid substances. It can also be used to determine the purity of substances, glass transition temperatures, demagnetization, to study phase diagrams and polymorphism, oxidation induction times of solid and liquid substances, to measure the rate of reactions and phase transformations, as well as for many other applications.

XRD Laboratory

The XRD laboratory is dedicated to phase analysis, identifying present phases and their parameters in samples. We can perform both quantitative and qualitative phase analysis, determine crystalline sizes, and analyse microstrain in powder and bulk samples. The laboratory is equipped with a Philips X'Pert Pro diffractometer operating in Bragg-Brentano mode. The use of an X'Celerator RTMS detector enables measurements to be completed within tens of minutes. Additionally, the XRD system features a high-temperature chamber capable of measurements up to 1600°C and a spinner that enhances measurement quality.

Joint TEM Laboratory and Sample Preparation Room

Currently, research into the relationship between the structure and physical properties of amorphous cupric glasses and nanocrystalline metals prepared by primary crystallization of amorphous metals is highly topical. Knowledge of the details of the structure of the material produced using electron microscopy is therefore a basic prerequisite for fulfilling the research objective, which is being carried out in the given laboratory. In the near future, it is planned to expand the research to other unconventional materials (e.g. thin films or powder materials) with great prospects for practical application.

Retrospectives

International projects

Programme: Bilateral projects, Mobility

Project name: Príprava a charakterizácia pokročilých anorganicko-organických polymérnych hybridov pre 3D tlač *(Syntesis and characterization of novel organic-inorganic polymeric hybrids for 3D printing)*
Programme: MAD SAV - AVČR
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Radovan Bureš
Realised: 1.1.2018 / 31.12.2020

Project name: Progresívne metódy úpravy funkčných a mechanických vlastností práškových materiálov *(Progressisve methods for treatment of the functional and mechanical properties of powder materials)*
Programme: MAD SAV - AVČR
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Vladimír Kovaľ
Realised: 1.1.2018 / 31.12.2021

Project name: Nízkoteplotné elektrohydrodynamické metódy na prípravu biokeramických povlakov *(Low temperature electrohydrodynamic techniques used for peparation of bioceramic coatings)*
Programme: MAD SR-HU
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Tibor Sopčák
Realised: 1.1.2019 / 31.12.2021

Project name: Príprava magneticky mäkkých kompozitov pre priemysel *(Preparation of soft magnetic composites for infustrial application)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Magdaléna Strečková

Project name: Výskum a vývoj vysokoentropických feroelektrických materiálov pre uskladnenie elektrickej energie *(Research and development of high-entropy ferroelectric materials for energy storage)*
Programme: APVV SK-CN-23-0014
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Vladimír Kovaľ

Realised: 1.7.2024 / 30.6.2026

Programme: COST

Project name: Kritické suroviny pri extrémnych podmienkach *(Solutions for Critical Raw Materials Under Extreme Conditions)*
Programme: CA15102
Scientist in charge at IMR SAS: Pavol Hvizdoš
Realised: 17.11.2015 / 30.3.2020

Programme: International Visegrad Found (IVF)

Project name: Vývoj pokročilých horčíkových zliatin pre multifunkčné aplikácie v extrémnych prostrediach *(Development of Advanced Magnesium Alloys for Multifunctional Applications in Extreme Environments)*
Programme: JP39421
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: František Lofaj
Realised: 1.11.2021 / 31.10.2024

Programme: European Interest Group (EIG) CONCERT-Japan

Project name: Zvýšenie uskladňovacej schopnosti vodíka v ľahkých vysoko-entropických zliatinách (HEA) typu AlTiVCr prídavkom Ti3C2 Mxenu a veľkej plastickej deformácie *(Enhancement of Hydrogen Storage Properties of AlTiVCr Light Weight High Entropy Alloys (HEA) by Ti3C2 Mxene and Several Plastic Deformation)*
Programme: EIG CONCERT- Japan/2021/215/EHSAL
Scientist in charge at IMR SAS: Karel Saksl
Realised: 1.4.2022 / 31.3.2025

Programme: M-ERA.NET

Project name: Inovatívne Ni-Cr-Re povlaky so zvýšenou odolnosťou voči korózii a erózii pre vysokoteplotné aplikácie v energetike *(Innovative Ni-Cr-Re coatings with enhanced corrosion and erosion resistance for high temperature applications in power generation industry)*
Programme: M-ERA.NET (H2020)
Scientist in charge at IMR SAS: Ján Dusza
Realised: 1.9.2017 / 31.8.2020

Project name: Multifunkčné hrubé povlaky keramika-grafén pre perspektívne aplikácie *(Multifunctional Ceramic/Graphene Thick Coatings for New Emerging Application)*
Programme: FLg-ETA II Joint Transnational Call (JTC 2017)
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Ján Dusza
Realised: 1.1.2018 / 31.12.2020

Project name: Odolné keramické kompozity so supertvrdými časticami pre obrábacie nástroje so zvýšenou odolnosťou voči opotrebeniu *(Durable ceramics composites with superhard particles for wear-resistant cutting tools)*
Programme: M-ERA.NET Call 2017
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Ján Dusza
Realised: 1.7.2018 / 30.6.2021

Project name: Vysoko odolná duplexná keramika pre efektívne obrábasnie niklových superzliatin *(High performance duplex ceramics for efficient maschining of nickel superalloys)*
Programme: M-ERA.NET 3/2021/295/DuplexCER
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Ján Dusza
Realised: 1.6.2022 / 31.5.2025

Project name: Vývoj a spracovanie pokročilých metalhydridových kompozitných materiálov pre uskladnenie vodíka určených pre mobilné aplikácie *(Developoment and processing of advanced metal hydride composites with specific microstructure properties for mobile hydrogen storage applications)*
Programme: M-ERA.NET 3/2022/235/H2MobilHydride
Scientist in charge at IMR SAS: Katarína Nigutová
Realised: 1.5.2023 / 30.4.2026

National projects

Programme: APVV

Project name: Vývoj REBCO supravodičov pre biomedicínske aplikácie *(Developmnt of REBCO superconductors for biomedical applicatios)*
Scientist in charge at IMR SAS: Ján Dusza
Realised: 1.8.2018 / 30.6.2022

Project name: Keramické materiály pre použitie v extrémnych podmienkach *(Ceramic materials for extreme operating conditions)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Ján Dusza
Realised: 1.7.2016 / 30.6.2020

Project name: Nové vysokoentropické keramické materiály pre pokročilé aplikácie
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Ján Dusza
Realised: 1.8.2020 / 31.7.2022

Project name: Výskum vplyvu inovácií postupov výroby na životnosť nástrojov a komponentov lesných mechanizmov *(Research on the impact of process innovation on lifespan of forestry machinery tools and components)*
Scientist in charge at IMR SAS: Miroslav Džupon
Realised: 1.7.2017 / 31.12.2020

Project name: Využitie inovatívnych technológií obnovy funkčných plôch foriem na výrobu odliatkov pre automobilový priemysel *(The utilization of innovative technology for repair functional surfaces of mold casting dies for castings in automotive industry)*
Scientist in charge at IMR SAS: Miroslav Džupon
Realised: 1.7.2017 / 31.12.2020

Project name: Zvyšovanie efektívnosti lisovania a spájania dielov hybridných karosérií *(Increasing the efficiency of forming and joining parts of hybrid car bodies)*
Scientist in charge at IMR SAS: Miroslav Džupon
Realised: 1.7.2018 / 31.12.2021

Project name: Kompozitné vrstvy pre vysokoteplotnú protikoróznu ochranu kovov *(Advanced composite coatings for high temperature corrosion protection of metals)*
Scientist in charge at IMR SAS: Pavol Hvizdoš
Realised: 1.07.2016 / 30.06.2020

Project name: Rozvoj poznatkovej bázy v oblasti pokročilých kovových materiálov s využitím moderných teoretických, experimentálnych a technologických postupov *(Advancement of knowledge in area of advanced metallic materials by use of up-to-date theoretical, experimental, and*

technological procedures)
Scientist in charge at IMR SAS: Viera Homolová
Realised: 1.07.2016 / 30.06.2020

Project name: Výskum a vývoj energeticky úsporného hybridného ložiskového reduktora so zníženým opotrebením pre robotické zariadenia (pre Priemysel 4.0) *(Research and development of energy saving hybrid bearing reducer with lowered wear rate for robotic equipment (for Industry 4.0))*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Pavol Hvizdoš
Realised: 1.7.2019 / 30.6.2022

Project name: Vývoj vysoko-legovaných izotrópnych elektro ocelí pre trakčné motory elektromobilov *(Development of high-alloy isotropic electrical steels for traction engines of electric vehicles)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: František Kováč
Realised: 1.7.2019 / 30.6.2022

Project name: Spekané biologicky odbúrateľné kovové materiály *(Sintered biodegradable metallic materials)*
Scientist in charge at IMR SAS: Miriam Kupková
Realised: 1.7.2017 / 31.12.2020

Project name: Multikomponentné boridové a nitridové PVD povlaky pre ultravysokoteplotné aplikácie *(Multicomponent boride and nitride coatings for ultrahigh temperature applications)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: František Lofaj
Realised: 1.8.2018 / 30.6.2021

Project name: Nové sklené a sklokeramické fosfory na báze hlinitanov vzácnych zemín pre aplikácie v pevnolátkových energiu šetriacich svetelných zdrojoch vyžarujúcich biele svetlo (pc-WLED diódy). *(Novel glass and glass-ceramic rare-earth aluminates-based phosphors for energy-saving solid state lighting sources emitting white light (pc-WLEDs)*
Scientist in charge at IMR SAS: František Lofaj
Realised: 1.8.2018 / 31.7.2022

Project name: Štúdium procesov vyvolaných elektrónovým zväzkom a elektromagnetickým žiarením v chalkogenidových sklách *(Investigation of phenomena induced by electron beam and electromagnetic radiation in*

chalcogenide glasses)
Scientist in charge at IMR SAS: František Lofaj
Realised: 1.8.2018 / 31.7.2022

Project name: Injektovateľné hybridné kompozitné biocementy *(Injectable hybrid composite biocements)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Ľubomír Medvecký
Realised: 1.8.2018 / 30.6.2021

Project name: Vývoj a testovanie respirátorov s efektívnou degradáciou vírusov filtra s obsahom antivirotických materiálov *(Development and testing of respirators with efficient degradation of viruses by filters containing antiviral materials)*
Scientist in charge at IMR SAS: Beáta Ballóková
Realised: 16.9.2020 / 31.12.2021

Project name: Vývoj nových biodegradovateľných kovových zliatin určených pre medicínske a protetické aplikácie *(Development of new biodegradable metal alloys for medical and prosthetic applications)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Karel Saksl
Realised: 1.8.2018 / 30.6.2021

Project name: Elektrochemická detekcia vírusov *(Electrochemical detection of viruses)*
Scientist in charge at IMR SAS: Magdaléna Strečková
Realised: 16.9.2020 / 31.12.2021

Project name: Vývoj žiaruvzdorných pyrochlórnych fáz pre vysokoteplotné aplikácie neoxidovej keramiky *(Development of refractory pyrochlore phases for high temperature applications of non-oxide ceramics)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Ján Dusza
Realised: 1.8.2018 / 30.6.2022

Project name: Vývoj nových 3D materiálov pre post Li-iónové batérie s vysokou energetickou hustotou *(Development of novel 3D materials for post lithium ion batteries with high energy density)*
Scientist in charge at IMR SAS: Beáta Ballóková
Realised: 1.7.2021 / 31.12.2024

Project name: Funkčné vlastnosti kompaktovaných kompozitov na báze magnetických častíc s povrchovo modifikovanými vlastnosťami *(Functional properties of compacted composites based on magnetic particles with surface-modified properties.)*
Scientist in charge at IMR SAS: Radovan Bureš
Realised: 1.7.2021 / 30.6.2025

Project name: Inovatívne prístupy pri obnove funkčných povrchov laserovým naváraním *(Innovative approaches to the restoration of functional surfaces by laser weld overlaying)*
Scientist in charge at IMR SAS: Miroslav Džupon
Realised: 1.7.2021 / 30.6.2024

Project name: Degradovateľné kovové biomateriály s riadeným uvoľňovaním liečiv *(Degradable metallic biomaterials with controlled drug release)*
Scientist in charge at IMR SAS: Miriam Kupková
Realised: 1.7.2021 / 31.12.2024

Project name: Chorioalantoická membrána - in vivo model pre štúdium biokompatibility materiálov *(Chorioallantoic membrane - in vivo model for study of biocompatibility of materials)*
Scientist in charge at IMR SAS: Ľubomír Medvecký
Realised: 1.7.2021 / 30.6.2025

Project name: Kompozitné biomateriály s komplexnými prírodnými aditívami *(Composite biomaterials with complex natural additives)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Ľubomír Medvecký
Realised: 1.7.2021 / 30.6.2024

Project name: Vývoj nových bioresorbovateľných zliatin pre vnútrotelové implantáty
Scientist in charge at IMR SAS: Zuzana Molčanová
Realised: 1.7.2021 / 30.6.2024

Project name: Výskum a vývoj nových vysokoentropických zliatin určených na efektívne uskladnenie vodíka v energetických aplikáciách *(Research and development of new high - entropy alloys for efficient hydrogen storage in energy applications)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Karel Saksl
Realised: 1.7.2021 / 30.6.2024

Project name: **Elektrokatalyzátory pre efektívnu produkciu vodíka pre budúce elektrolyzéry a palivové články** *(Hydrogen evolution electrocatalysts for future electrolyser and fuel cells)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Magdaléna Strečková
Realised: 1.7.2021 / 30.6.2025

Project name: **Inovatívne prístupy k zvyšovaniu životnosti a znižovaniu energetickej náročnosti rezných nástrojov pri spracovaní dreva v lesníctve** *(Innovative approaches to increase the lifetime and reduce the energy consumption of cutting tools in wood processing in forestry)*
Scientist in charge at IMR SAS: Miroslav Džupon
Realised: 1.7.2022 / 30.6.2026

Project name: **Tvrdé a húževnaté vrstvy na báze boridov a nitridov pripravené progresívnymi PVD technikami** *(Hard and tough boride and nitride-based coatings prepared by advanced PVD techniques)*
Scientist in charge at IMR SAS: František Lofaj
Realised: 1.7.2022 / 30.6.2025

Project name: **Vývoj inovatívnych spôsobov spracovania a spájania elektrotechnických ocelí pre vysokoúčinné aplikácie v e-mobilite** *(Development of innovative methods of processing and joining electrical steels for high-efficiency applications in e-mobility)*
Scientist in charge at IMR SAS: Ivan Petryshynets
Realised: 1.7.2022 / 30.6.2025

Project name: **Vývoj technológie prípravy povrchových nano-štruktúr nástrojových ocelí novej generácie za účelom zvyšovania kvality lisovania hybridných karosérií automobilov s nízkymi CO2 - emisiami z vysokopevných TRIP - ocelí** *(Technology development of surface nanostructuring of new generation tool steel for increasing the quality of low CO2 - emission cars hybrid bodies stampung using high - strength TRIP - assisted sheet metal)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Ivan Petryshynets
Realised: 1.2.2022 / 31.12.2023

Project name: **Termoelektrický materiál Ag2S ako ekologický konvektor tepla ľudského tela na elektrinu** *(Thermoelectric material Ag2S as green converter of heat from human body into electricity)*

Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Karel Saksl
Realised: 1.1.2022 / 31.12.2023

Project name: Výskum a vývoj prototypu nízkotlakovej čerpacej stanice pre zásobovanie metalhydridových zariadení zeleným vodíkom *(Research and development of a prototype of a low-pressure refuelling station for refuelling metal hydride equipment with green hydrogen)*
Scientist in charge at IMR SAS: Karel Saksl
Realised: 1.7.2022 / 30.6.2025

Project name: Štruktúra a vlastnosti reaktívne spekaných vysoko entropických kovových diboridov *(Structure and poroiperties of reactively sintered high-entropy metal diborides)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Richard Sedlák
Realised: 1.2.2022 / 31.12.2023

Project name: Vývoj nových keramických materiálov komplexného zloženia pre extrémne aplikácie *(Development of new compositionally-complex ceramics for extreme applications)*
Scientist in charge at IMR SAS: Alexandra Kovalčíková
Realised: 1.7.2022 / 30.6.2026

Project name: Ultra-vysokoteplotné karbidy so zvýšenou oxidačnou odolnosťou *(Novel enhanced oxidation-resistant ultra-high temperature carbides)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Alexandra Kovalčíková
Realised: 1.7.2023 / 30.6.2027

Project name: HydroX: Optimalizácia horáka orientovaná na dekarbonizáciu *(HydroX: Burner Optimization for Decarbonization)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Ladislav Falat
Realised: 1.9.2024 / 30.6.2028

Project name: Vývoj pokročilej odľahčenej nanoštruktúrovanej ocele a jej výroby prostredníctvom jednoduchého tepelného spracovania pre náročné pevnostné aplikácie. *(Development of advanced lightweight nanostructured steel and its manufacturing-easy heat processing for ultrahigh-strength applications)*

Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Vasyl Iefremenko
Realised: 1.7.2024 / 31.12.2027

Project name: Inovatívne biopolymérne materiály s prírodnými aditívami pre liečbu popálenín a chronických rán *(Innovative biopolymer materials with natural additives for the treatment of burns and chronic wounds)*
Scientist in charge at IMR SAS: Ľubomír Medvecký
Realised: 1.7.2024 / 30.6.2027

Project name: Vývoj pokročilých materiálov budúcich bioresorbovateľných implantátov *(Development of advanced materials for future bioresobable implants)*
Scientist in charge at IMR SAS: Zuzana Molčanová
Realised: 1.7.2024 / 30.6.2027

Programme: other projects

Project name: Výskum inovatívnych foriem liečenia kostných defektov prepojením bioaktívnych biomateriálov s autológnymi rastovými faktormi *(Research of innovative forms treatment of bone defects by joining bioactive biomaterials and autologous growth factors)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Ľubomír Medvecký
Realised: 15.12.2018 / 14.12.2021

Project name: Nanokompozitný materiál pre balistickú ochranu *(Nanocomposite material for balistic protection)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Viktor Puchý
Realised: 1.5.2019 / 31.8.2021

Project name: Spevnenie a plasticita vysokoentropických ultra vysokoteplotných karbidov *(Strengthening and plasticity of high-entropy ultra-high temperature carbides)*
Programme: H2020-MSCA-IF
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Tamás Csanádi
Realised: 1.7.2021 / 30.6.2024

Project name: Prídavná flexibilná balistická nanokompozitná ochrana horných a doných končatín

Programme: SEMOD-EL76/39-12/2023
Scientist in charge at IMR SAS: Viktor Puchý
Realised: 1.1.2023 / 30.11.2023

Project name: Progresívne fotokatalytické materiály pre biologickú a chemickú dekontamináciu
Programme: SEMOD-EL76/49-11/2023
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Ivan Shepa
Realised: 7.2.2023 / 30.11.2023

Programme: MoRePro

Project name: Development of technology for the manufacture of FeGa-based alloys for high-frequency devices. *(Development of technology for the manufacture of FeGa-based alloys for high-frequency devices.)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Vasily Milyutin
Realised: 15.10.2020 / 14.10.2023

Programme: SASPRO

Project name: Dvojfázová vysokoentropiská ultravysokoteplotná keramika *(Dual-phase high-entropy ultra high temperature ceramics)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Annamária Naughton-Duszová
Realised: 1.10.2021 / 30.9.2024

Programy: IMPULZ

Project name: Spevnenie a plasticita vysokoentropickej keramiky na atómovej úrovni *(Atomic-scale controlled strengthening and plasticity of high-entropy ceramics)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Tamás Csanádi
Realised: 1.9.2023 / 31.8.2028

Programme: Structural founds

Project name: Rozvoj a podpora výskumno – vývojových aktivít Centra pre testovanie kvality a diagnostiku materiálov v oblastiach špecializácie RIS3 SK

(Advancement and support of R&D for "Centre for diagnostics and quality testing of materials" in the domains of the RIS3 SK specialization)
Scientist in charge at IMR SAS: Ján Dusza
Realised: 1.1.2019 / 30.6.2023

Programme: EU Recovery Plan

Project name: Štipendiá pre excelentných výskumníkov ohrozených vojnovým konfkliktom na Ukrajine
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Ivan Petryshynets
Realised: 1.10.2022 / 30.9.2025

Project name: Štipendiá pre excelentných PhD. študentov a študentky (R1)
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Pavol Hvizdoš
Realised: 1.9.2023 / 30.6.2026

Project name: Štipendiá pre excelentných výskumníkov ohrozených vojnovým konfkliktom na Ukrajine
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Pavol Hvizdoš
Realised: 1.3.2023 / 28.2.2026

Project name: Štipendiá pre excelentných výskumníkov ohrozených vojnovým konfkliktom na Ukrajine
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Ivan Petryshynets
Realised: 1.1.2023 / 31.12.2025

Project name: "Matching" granty ku zdrojom získaným od súkromného sektora v rámci váskumnej spolupráce ÚMV SAV, v. v. i.
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Radovan Bureš
Realised: 1.11.2024 / 31.3.2026

Project name: Extrémne tvrdé a odolné vysokoentropické keramické materiály pre ultra vysoké teploty
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Ján Dusza
Realised: 1.10.2024 / 31.3.2026

Project name: **Kapitálový booster APVV-22-0493**
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Alexandra Kovalčíková
Realised: 1.6.2024 / 31.5.2025

Project name: **Dvojfázne boridovo/karbidické viackomponentné povlaky na báze kovov prechodových prvkov pripravené naprašovaním s vysokou využiteľnosťou terča (HiTUS)** *(Dvojfázne boridovo/karbidické viackomponentné povlaky na báze kovov prechodových prvkov pripravenDual-phase multi-TM-boride/carbide coatings by High Target Utilization Sputtering)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: František Lofaj
Realised: 1.9.2024 / 31.8.2026

Project name: **Vývoj novej bezkobaltovej keramiky pre rezné nástroje** *(Development of New Cobalt-Free Ceramics for Cutting Tools)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Dávid Medveď
Realised: 1.9.2024 / 31.8.2026

Project name: **Dvojfázová vysokoentropická keramika vystužená uhlíkovými vláknami** *(Carbon fibers reinforced dual-phase high-entropy ceramics)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Annamária Naughton Duszová
Realised: 1.10.2024 / 30.6.2026

Project name: **Vývoj Fe-Si zliatin s dvojito orientovanou kubickou kryštalografickou textúrou** *(Development of Fe-Si alloys with double-oriented cube crystallographic texture)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Ivan Petryshynets
Realised: 1.9.2024 / 31.8.2026

Project name: **Nový reaktívny prístup k syntéze kompozitov s keramickou matricou vystužených mikrovláknami UHTC** *(Novel reactive approach towards the sysnthesis of UHTC microfibers reinforced ceramic matrix composites)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Richard Sedlák
Realised: 1.9.2024 / 31.8.2026

Project name: **Pokročilé nanovlakenné materiály na báze vysokoentropickej keramiky pre použitie vo fotokatalýze** *(Advanced nanafibrous materials based*

on high entropy ceramics for application in photocatalysis)
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Ivan Shepa
Realised: 1.9.2024 / 31.8.2026

Project name: Kalcium fosfátové cementy s prídavkom esenciálnych olejov prostredníctvom termosetových polyesterov určených na regeneráciu tvrdých tkanív *(Calcium phosphate cements incorporating essential oils through thermosetting polyesters used for hard tissue regeneration)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Tibor Sopčák
Realised: 1.9.2024 / 31.8.2026

Project name: Neušľachtilé katalyzátory pre efektívne štiepenie vody v pokročilých elektrolyzéroch *(Non-Noble Electrocatalysts for Efficient Water Splitting in Advanced Electrolyzers)*
Coordinator: Institute of Materials Research of SAS
Scientist in charge at IMR SAS: Magdaléna Strečková
Realised: 1.9.2024 / 31.8.2026

Publications

Scientific monographs published by foreign publishers

CENIGA, Ladislav *Analytical models of coherent-interface-induced stresses in composite materials I*. New York : Nova Science Publishers, 2020. 110 p. ISBN 978-1-53617-039-9.

CENIGA, Ladislav *Analytical models of coherent-interface-induced stresses in composite materials II*. New York : Nova Science Publishers, 2021. 144 p. ISBN 978-1-68507-003-8.

CENIGA, Ladislav *Analytical models of coherent-interface-induced stresses in composite materials III*. New York : Nova Science Publishers, 2021. 171 p. ISBN 978-1-53619-996-3.

CENIGA, Ladislav *Analytical models of interstitial-atom-induced stresses in isotropic metallic materials*. New York : Nova Science Publishers, Inc., 2022. 88 p. Dostupné na: <https://novapublishers.com/shop/analytical-models-of-interstitial-atom-induced-stresses-in-isotropic-metallic-materials/>. ISBN 978-1-68507-429-6.

CENIGA, Ladislav *Analytical models of hydrogen-induced stresses in materials II*. 2. New York : Nova Science Publishers, Inc., 2022. 102 p. Dostupné na: <https://novapublishers.com/shop/analytical-models-of-hydrogen-induced-stresses-in-materials-volume-ii/>. ISBN 978-1-68507-339-8.

CENIGA, Ladislav *Interstitial strengthening in anisotropic metals*. New York : Nova Science Publishers, Inc., 2022. 100 p. Dostupné na: https://doi.org/10.52305/NCEG9468. ISBN 979-8-88697-111-8.

CENIGA, Ladislav *Mathematical determination of residual stresses in two-component materials*. New York : Nova Science Publishers, Inc., 2022. 94 p. Dostupné na: https://doi.org/10.52305/BLHY9905. ISBN 979-8-88697-112-5.

CENIGA, Ladislav *Analytical models of thermal stresses in porous two-component materials*. New York : Nova Science Publishers, Inc., 2023. 96 p. Dostupné na: https://doi.org/10.52305/THOP2707. ISBN 979-8-88697-113-2.

Scientific monographs published in domestic publishers

MEDVECKÝ, Ľubomír - DANKO, Ján - GIRETOVÁ, Mária - KREŠÁKOVÁ, Lenka - ŠTULAJTEROVÁ, Radoslava - VDOVIAKOVÁ, K. - SOPČÁK, Tibor. *Biomateriály na*

báze fosforečnanov vápenatých : vlastnosti a aplikácie : (materiály na liečbu kostných a chrupkových defektov v regeneračnej medicíne). Bratislava : Veda, vydavateľstvo SAV, 2024. 220 s. ISBN 978-80-224-2068-6.

Chapters in scientific monographs published by foreign publishers

GALDUN, L. - RICHTER, K. - GAMCOVÁ, Jana - IBARRA, P. - HUDÁK, R. - ŠULLA, Igor - MUDROŇOVÁ, D. - GALIK, J. - SABOL, R. - RYBA, T. - HVIZDOŠ, L. - KLEIN, P. - MILKOVIČ, Ondrej - VARGOVÁ, Z. - VARGA, R. Sensoric application of glass-coated magnetic microwires. In *Magnetic nano- and microwires : Design, synthesis, properties and applications*. 2. edition. - Amsterdam : Elsevier Ltd., 2020, p. 833-868. ISBN 978-0-08-102832-2.

LOFAJ, František - MIKULA, Marian. Wear and erosion resistant ceramic coatings. In *Encyclopedia of Materials: Technical ceramics and glasses*. - Oxford : Elsevier, 2021, p. 425-439. ISBN 978-0-12-818542-1. Dostupné na: https://doi.org/10.1016/B978-0-12-818542-1.00003-5.

HVIZDOŠ, Pavol - VENCL, Aleksandar. Ceramic matrix composites with carbon nanophases: Development, Structure, mechanical and tribological properties and electrical conductivity. In *Encyclopedia of Materials: Composites*. Vol. 2. - Oxford : Elsevier, 2021, p. 116-133. ISBN 978-0-12-803581-8.11858-2. Dostupné na: https://doi.org/10.1016/B978-0-12-803581-8.11858-2.

HVIZDOŠ, Pavol. Wear and erosion resistant ceramic materials. In *Encyclopedia of Materials: Technical ceramics and glasses*. - Oxford : Elsevier, 2021, p. 416-424. ISBN 978-0-12-818542-1. Dostupné na: https://doi.org/10.1016/B978-0-12-818542-1.00056-4.

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SLOVENSKÝ, Peter - ZELEŇÁKOVÁ, Adriana - KOLLÁR, P. - FÜZER, J. - JAKUBČIN, M. - FÁBEROVÁ, Mária. Preparation and characterization of Fe based soft magnetic composites coated by SiO_2 layer prepared by Stöber method. In *Acta Physica Polonica A*, 2020, vol. 137, no. 5, p. 872-875. ISSN 1898-794X.

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KOVÁČ, František - PETRYSHYNETS, Ivan. *Spôsob valcovania rozvalku vysokopevnej elektrotechnickej ocele na teplej širokopásovej trati : Patentová prihláška č. PP 78-2021*. Banská Bystrica : ÚPV SR, 2021. nestr.

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DŽUPON, Miroslav - VIŇÁŠ, J. - BREZINOVÁ, Janette - BREZINA, Jakub. *Testovacie zariadenie na cyklický ohrev skúšobných vzoriek : Zverejnená prihláška úžitkového vzoru č. 94-2024*. Bratislava : ÚPV SR, 2024. 6 s.

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DŽUPON, Miroslav - BREZINOVÁ, Janette - PETRYSHYNETS, Ivan - FALAT, Ladislav - VIŇÁŠ, J. *Spôsob hodnotenia odolnosti návarov v tavenine zliatin hliníka na báze hliník-kremík : Patentová prihláška č. PP 50-2024*. Banská Bystrica : ÚPV SR, 2024.

Defended PhD. thesis

IMR SAS is accredited as an external educational institution for the implementation of education in the third level of university studies in the **Advanced Materials** study program in collaboration with the Faculty of Science University of Pavol Jozef Šafárik in Košice, in the **Materials Science** study program in collaboration with the Faculty of Materials, Metallurgy and Recycling Technical University Košice, and in **Biomedical Engineering** and **Engineering Technologies and Materials** study programs in collaboration with the Faculty of Mechanical Engineering Technical University Košice.

2020

Ivan Shepa
Development of Precursor and Ceramic Fibers by Electrospinning Technology

Katarína Šuľová
Research and Development of Novel Alloys for Hydrogen Storage

2021

Ivana Kirkovska
Thermodynamic Modelling of B-Fe-W System

Mária Štelmáková
Vývoj jednorozmerných kompozitných vláknitých materiálov pre potenciálne využitie v energetike

2022

František Kromka
Koncept teplotne stabilnej nanokryštalickej štruktúry kompozitu na báze medi so zameraním na jeho využitie pre priemyselné aplikácie

Jana Milkovičová
Korelácia štruktúrno-mechanických vlastností vybraných progresívnych materiálov skúmaná difrakciou a indentáciou

2023

Dagmara Varcholová
Vývoj a výskum nových metal hybridových materiálov

Miloš Fejerčák
Vývoj a výskum nových termoelektrických materiálov

Michal Ivor
Tribológia a vysokoteplotné vlastnosti ultra vysokoteplotných keramických materiálov

Karol Kovaľ
Spekané biologicky odbúrateľné kovové materiály

2024

Cyril Bera
Elektrokatalyzátory na báze fosfidov pre rozklad vody

Dávid Csík
Vývoj a výskum materiálov pre nové lítium-iónové batérie

Ihor Koribanich
Preparation and characterization of ceramic matrix composites with special fillers

Defended DrSc. thesis

Vladimír Kovaľ
Štruktúra a funkčné vlastnosti moderných feroelektrických a multiferoických materiálov. Doktorská dizertačná práca. Košice : ÚMV SAV, 2021. 13 s. + prílohy

Ľubomír Medvecký
Biomateriály na báze fosforečnanov vápenatých určené na regeneráciu defektov kostných tkanív. Doktorská dizertačná práca. Košice : ÚMV SAV, 2021. 107 s. + prílohy

Awards

2020

Zuzana Birčáková

3rd place in Competition of Young Scientists under the age of 35 years; *awarded by the Presidium of Slovak Academy of Sciences*

Alexandra Kovalčíková, Erika Múdra, Ivan Shepa

Award for the Popularization of Science and Social Applications of Science; *awarded by the Presidium of the Slovak Academy of Sciences*

Ján Dusza

Science and Technology Award 2020; *awarded by the Ministry of Education, Research, Development and Youth of the Slovak Republic*

Tamás Csanádi

Exceptional young scientist in Slovakia under the age of 35years; *awarded by the Eset Science Award*

2021

Ivan Shepa

Honorary recognition of young scientists of the Slovak Academy of Sciences under 35 years of age; *awarded by the Presidium of Slovak Academy of Sciences*

The laureate of the category Exceptional young scientist in Slovakia under the age of 35 2020 was Tamás Csanádi.

Ján Dusza
Outstanding individual contributor to Slovak science award; *awarded by the Eset Science Award*

Jozef Janovec
STU plaque; *awarded by the Slovak University of Technology in Bratislava*

Dagmara Varcholová
TOP doctoral final thesis at TUKE 2021; *awarded by the Technical University of Košice*

Ján Dusza
Alexander von Humboldt Award; *awarded by the Foundation "Alexander von Humboldt-Stiftung"*

The laureate of the Alexander von Humboldt Award was Ján Dusza.

2022

Ján Dusza
Greeting letter from the SAS; *awarded by the Presidium of Slovak Academy of Sciences*

Ján Dusza
Gold Medal SAS; *awarded by the Presidium of Slovak Academy of Sciences*

Vladimír Kovaľ
Award for Top Publication; *awarded by the Presidium of Slovak Academy of Sciences*

Ján Dusza, Pavol Hvizdoš, Alexandra Kovalčíková, Lenka Kvetková, Erika Múdra, Viktor Puchý, Richard Sedlák
Science and Technology Award, Science and Technology Team of the Year 2021; *awarded by the Ministry of Education, Research, Development and Youth of the Slovak Republic*

Ján Dusza
Honorary citizen of Gemerska Hôrka; *awarded by the Gemerská Hôrka*

Ján Dusza
Medal of TUKE; *awarded by the Technical University of Košice*

Ján Dusza
Silver Medal of UPJŠ; *awarded by the The University of Pavol Jozef Šafárik in Košice*

Ján Dusza
Award of Pro Universitate; *awarded by the Óbudai University, Budapest, Hungary*

Tibor Sopčák
CERTIFICATE - OKLEVÉL; *awarded by the Hungarian Academy of Sciences*

2023

Tamás Csanádi, Ján Dusza
Award for top publication; *awarded by the Presidium of Slovak Academy of Sciences*

František Lofaj, Lenka Kvetková
Award for top publication; *awarded by the Presidium of Slovak Academy of Sciences*

Al**exandra Kovalčíková and colleagues**
Commemorative Medal on the occasion of the 70th anniversary of the Slovak Academy of Sciences, for the popularization of science; *awarded by the Slovak Academy of Sciences*

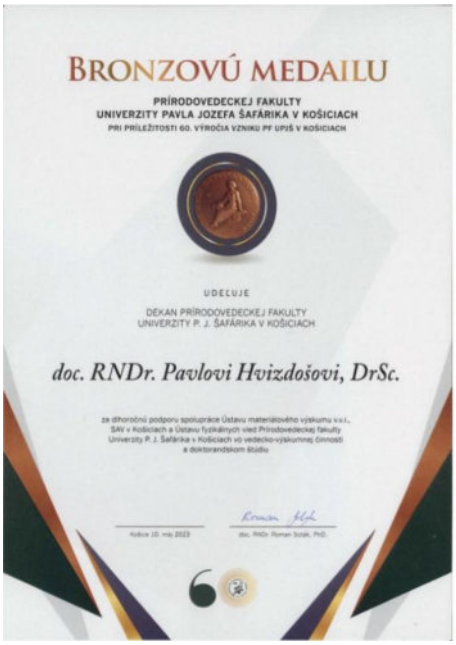
Ján Dusza
The President's Award of the Košice Self-governing Region; *awarded by the Košice Self-governing Region*

Pavol Hvizdoš
Bronze Medal of UPJŠ, Košice; *awarded by the Faculty of Science, University of Pavol Jozef Šafárik in Košice*

Pavol Hvizdoš
Letter of thanks from the Dean of the Faculty of Science, UPJŠ; *awarded by the PF UPJŠ*

Ján Dusza
Lovagkereszt - Award for cooperation between Slovak and Hungarian scientists; *awarded by the President of the Republic of Hungary*

Ján Dusza
Stuijts Awards - ECerS 2023; *awarded by the European Ceramic Society*



2024

Lenka Ďaková
Student Personality of Slovakia award 2023/2024, Laureate in the category: Metallurgy, mechanical engineering, energy; *awarded by the JCI-Slovensko*

Lenka Ďaková
TOP Student Personality of Slovakia award 2023/2024; *awarded by the JCI-Slovensko*

TOP Student Personality of Slovakia award 2023/2024 was Lenka Ďaková.
Ref.: Ivan Majerský, Pravda

Pavol Hvizdoš
Commemorative plaque of the UVMP in Košice on the occasion of the 75th anniversary; *awarded by the Rector of the University of Veterinary Medicine and Pharmacy in Košice*

Annamária Naughton Duszová, Dávid Medveď, Lenka Ďaková, Alexandra Kovalčíková, Peter Tatarko, Pavol Hvizdoš, Ján Dusza
IOM3 Pfeil Award for the best ceramics article published in the last two years; *awarded by the Institute of Materials, Minerals & Mining (IOM3), London, UK*

Kateryna Nemesh
ASFLOW Best Presentation Award; presented at the Conference: The 18th International Symposium on Novel and Nano Materials 2024, Vienna, Austria; *awarded by the Organizing Committee of ISNNM 2024*

Ivan Shepa
JECS Trust Award for the Best poster; presented at the Conference: Ultra-High Temperature Ceramics: Materials for Extreme Environment Applications VI, 2024, Sicily, Italy; *awarded by the Journal of the European Ceramic Society Trust.*

Events

2020

- **1st Virtual ESIS Summer School**: *VESS1 Thematic symposium TC6* – Ceramics was held online, 10.7.2020 (co-organisation of scientific session).

- **ISSNM 2020**: The 16th International Sympoisium on Novel and Nano Materials, *Session Refractory Metals and Hard Materials*, Phoenix Jeju, Korea, 03.11 .- 06.11.2020. (co-organisation of session).

2021

- **BaltMatTrib 2021**: Modern Materials and Manufacturing was held online, 27.04. - 29.04.2021 (co-organisation of scientific session).

- **CMSE 2021**: The 10th Global Conference on Materials Science and Engineering was held online, Shenzen, China, 01.08.-04.08.2021. (co-organisation of scientific session).

2022

- **Metallography & Fractography 2022**: The 18th International Symposium on Metallography, Fractography and Materials Science, Vysoké Tatry, Slovakia, 27.04.-29.04.2022.

Metallography & Fractography 2022.
Ref.: https://www.konferencie.net/metalo

- **ECF 23**: The 23rd European Conference on Fracture, Special topic: TC06 Fracture mechanics and fracture of advanced ceramics, Funchal, Portugal, 26.06.-02.07.2022 (co-organisation of scientific session).

- **LMP 2022**: 15th conference on Local Mechanical Properties, Košice, Slovakia, 11.11.-13.11.2022.

- **ISSNM 2022**: 17th International Symposium on Novel and Nano Materials, Jeju, Korea, 14.11.-18.11.2022 (co-organisation of scientific session).

- **MatScience-2022**: 1st International Conference on Materials Sciences and Technology, Khenchela, Algeria 13.12.-15.12.2022 (co-organisation of scientific session).

The 15th conference on Local Mechanical Properties 2022, Košice.
Ref.: http://www.lmp-conference.cz

2023

- **FAC 2023**: Fractography of Advanced Ceramics 2023, Leoben, Austria, 03.09.-05.09.2023.

2024

- **ICSHM12**: The 12th International Conference on the Science of Hard Materials, Taj Bentota, Sri Lanka, 11.03.-15.03.2024 (co-organisation of scientific session).

- **LMP 2024**: The 16th conference on Local Mechanical Properties, Praha, Czech Republic, 29.05.-31.05.2024.

The 16th conference on Local Mechanical Properties 2024, Praha.
Ref.: http://www.lmp-conference.cz

- **CMCEE-14**: The 14th International Conference on Ceramic Materials and Components for Energy and Environmental Systems, Budapest, Hungary, 18.08.-22.08.2024 (co-organisation of scientific session).

- **FKM 2024**: Functional composite materials (Funkčné kompozitné materiály) 2024, Košice, Slovakia, 24.10.2024.

POPULARIZATION - Fun Natural Science

As part of the Open Academy strategy, an entertaining-educational series has been running since 2017 on the premises of the PROMATECH Research Center for Advanced Materials and Technologies and at the Institute of Materials Research of the Slovak Academy of Sciences in Košice. These popularization activities are intended for pupils and students of primary and secondary schools. The main purpose of this project is to show children and students the work and life of a scientist, to introduce them to science as a normal part of life. In an interesting and playful way, through entertaining experiments and tests in the fields of physics, chemistry, biology and materials engineering, students are given the opportunity to form a positive image of the work of a scientist and of nature and technology.

IMR SAS has long been involved in popularization activities that promote science, the work of scientists and the institution itself and are intended for specific age categories of those interested in the information. Recently, a good connection to the local radio and TV stations has also been established and a series of short programs is being produced.

List of selected popularization activities:

• **ŠkôlkoVEDA** - these are playful field trips for preschool children.

• **Fun Natural Science** is an entertaining and educational cycle designed for children in the 1st grade of primary schools, which takes place on the premises of the Institute of Natural Sciences of the Slovak Academy of Sciences.

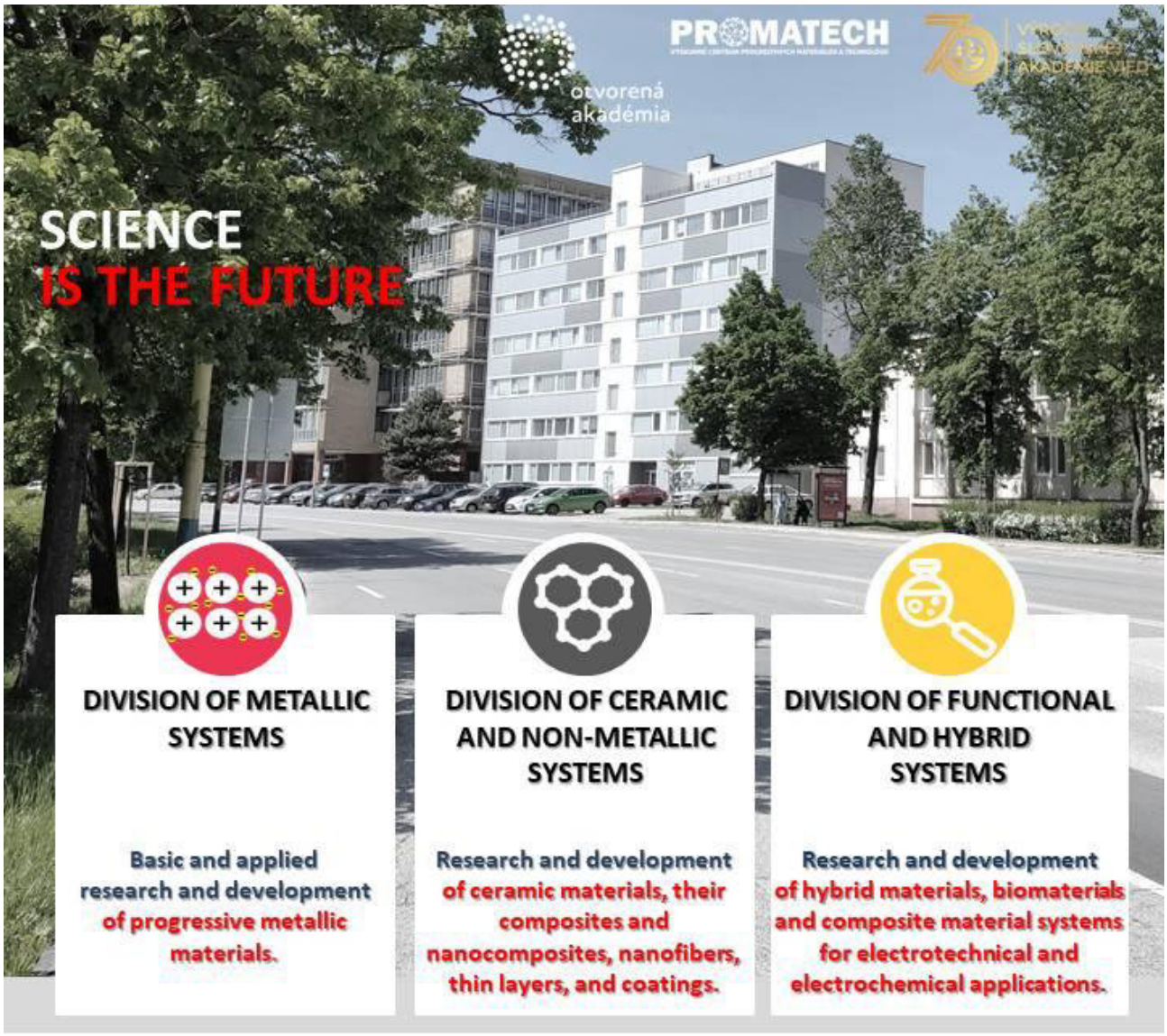
• **Have Fun with Science** is an entertaining and educational cycle, where children in the 2nd grade of primary schools on the premises of the Institute of Natural Sciences of the Slovak Academy of Sciences complete their first scientific experiences.

• **Open Day** is an annual activity associated with scientific lectures and interesting excursions to selected scientific laboratories intended for larger groups of secondary school students.

• **The Summer School of Young Scientists** at the Institute of Natural Sciences of the Slovak Academy of Sciences is a week-long activity for older students of primary and secondary schools, carried out during the summer holidays.

• Every year, the Institute of Natural Sciences also participates in joint promotions intended for the wider public, such as **European Science Night**, **Science and Technology Week**, **Weekend with SAS**.

• The institute organizes numerous excursions throughout the year for high school students, university students, industrial partners, and the general public.



DIVISION OF METALLIC SYSTEMS

Basic and applied research and development of progressive metallic materials.

DIVISION OF CERAMIC AND NON-METALLIC SYSTEMS

Research and development of ceramic materials, their composites and nanocomposites, nanofibers, thin layers, and coatings.

DIVISION OF FUNCTIONAL AND HYBRID SYSTEMS

Research and development of hybrid materials, biomaterials and composite material systems for electrotechnical and electrochemical applications.

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Slovak Academy of Science
Watsonova 47, 040 01 Košice

PROMATECH

Research Centre for Advanced Materials and Technologies

Mission

Research Centre "PROMATECH" has an ambition to become a top, national, integrated, interdisciplinary and sustainable centre, producing excellent frontier and applied research, performing excellent international co-operation, expertise activities and consulting service for industrial partners, technological and knowledge transfer, education activities in accordance with requirements of industry and dissemination of results together with popularization of the Centre.

The main areas of research are:

- Research and development of advanced steels, alloys, ceramics, powder metallurgy materials and products and hard coatings.
- Research and development of materials and technologies for biomedical and environmental applications.
- Materials for ICT technologies and cryotechnologies.
- Research and development of new magnetic materials.

Core Facilities

- Advanced technologies – Spark plasma sintering, microwave sintering, micro-fiber production technology, melt spinning and art melting, laser technology, PVD technologies, hot pressing, single crystal technology, nano-powder preparation technology, etc.
- Facilities for microstructure and chemical analyses – TEM/HRTEM, FIB, AFM, SEMs, GDOS, X-rays from – 180°C to 1800°C, Raman spectroscopy, Confocal and optical microscopies, etc.
- Facilities for mechanical, tribological and corrosion tests – Universal testing machines up to 1500°C, nanoindentation up to 500°C, nano/micro/macro tribology up to 800°C, corrosion facilities, etc.
- Facilities for functional and thermal tests – Ultra high vacuum STM, Cryo-free 14 T magnet equipped with high temperature furnace, SQUID, etc.

INSTITUTE OF MATERIALS RESEARCH OF SLOVAK ACADEMY OF SCIENCES

FIVE YEAR REPORT *2020 - 2024*

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