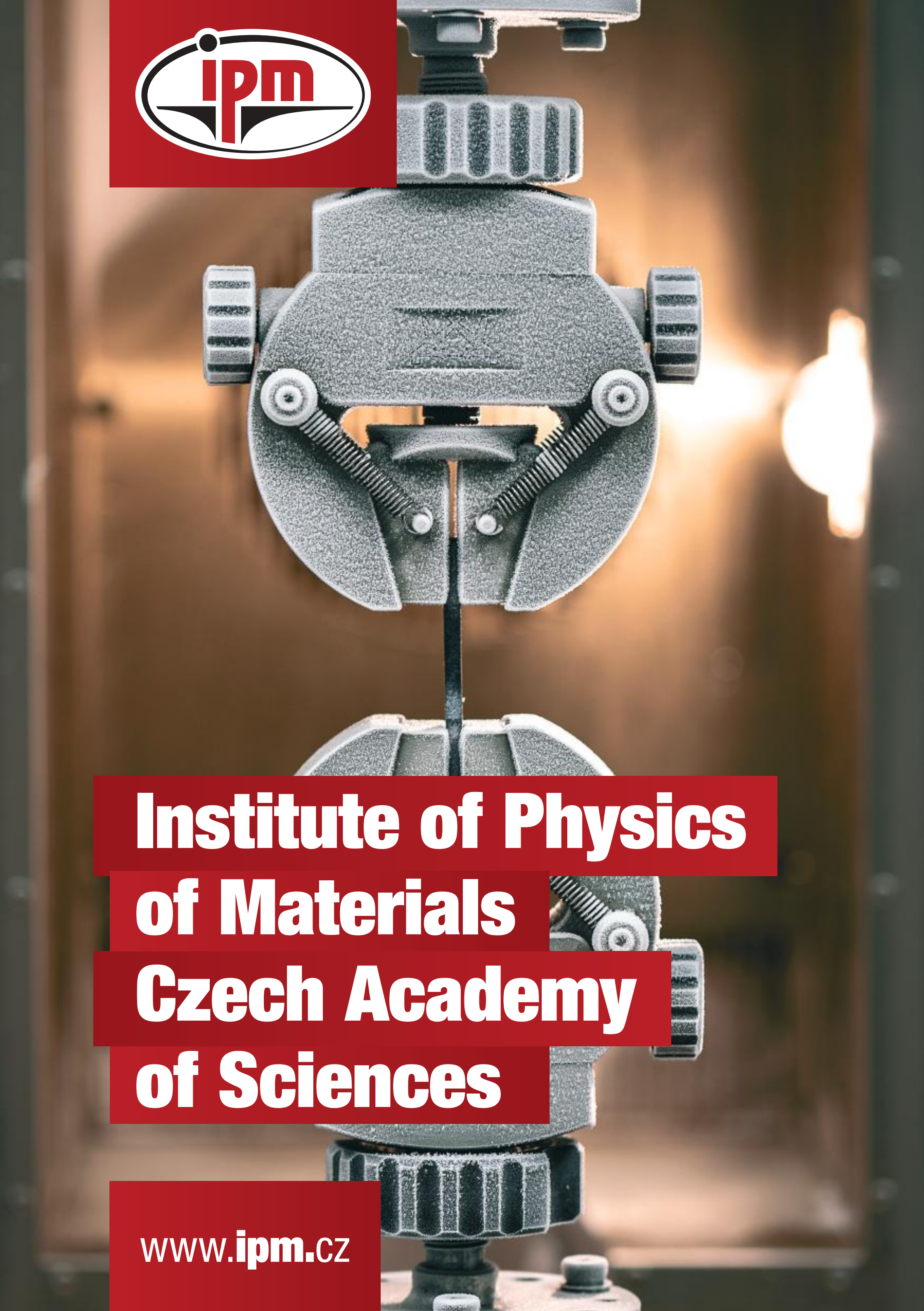
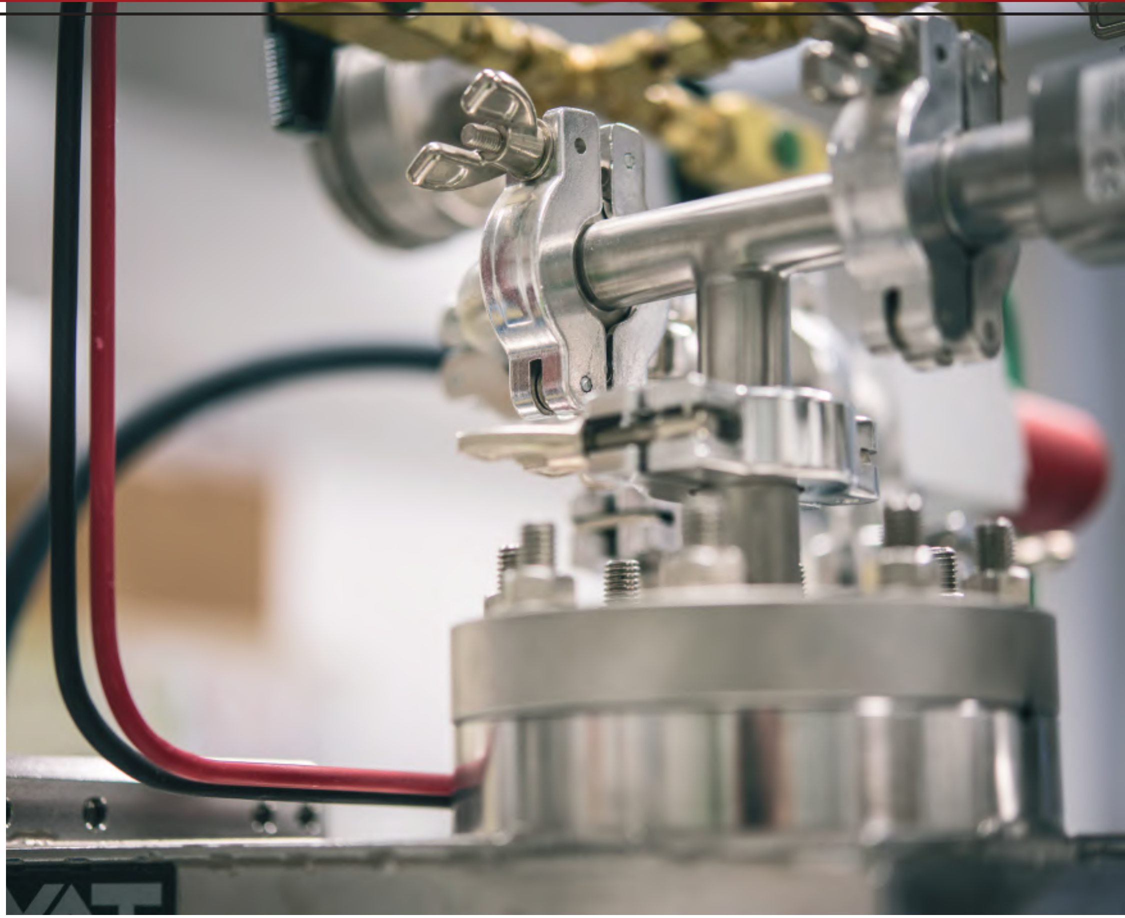


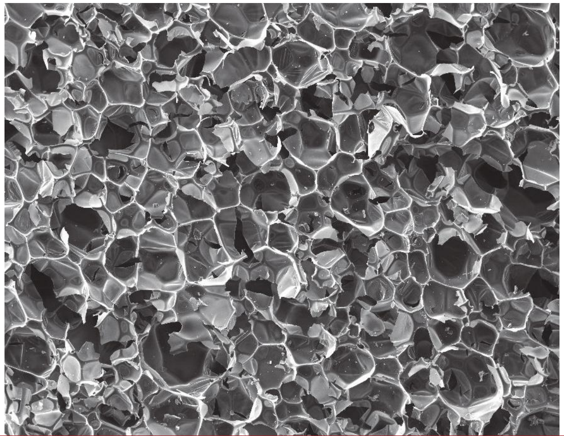
Institute of Physics of Materials Czech Academy of Sciences

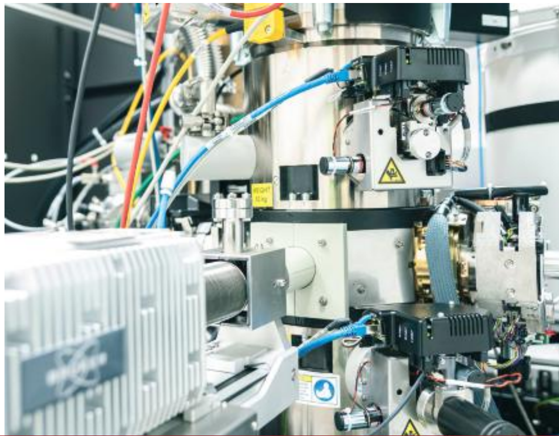
www.ipm.cz

ACTIVITIES OF THE INSTITUTE OF PHYSICS OF MATERIALS (IPM)

contribute to clarifying the relationship between the behavior and properties of materials and their structural and microstructural characteristics, with priority being given to the research of advanced materials based on metals, ceramics, and composites concerning their microstructure and method of preparation. The purpose of the research activity is to clarify and describe the physical properties of the examined materials with the potential to optimize their utility properties and predict their service life. The results of the basic and applied research of the IPM have enriched Czech and global scientific knowledge for more than 60 years. The results are shared with world experts and implemented into the educational process and practice through cooperation with universities and companies. Currently, **170** employees participate in the research activities of the Institute, of which **65** are researchers and **30** are PhD students.







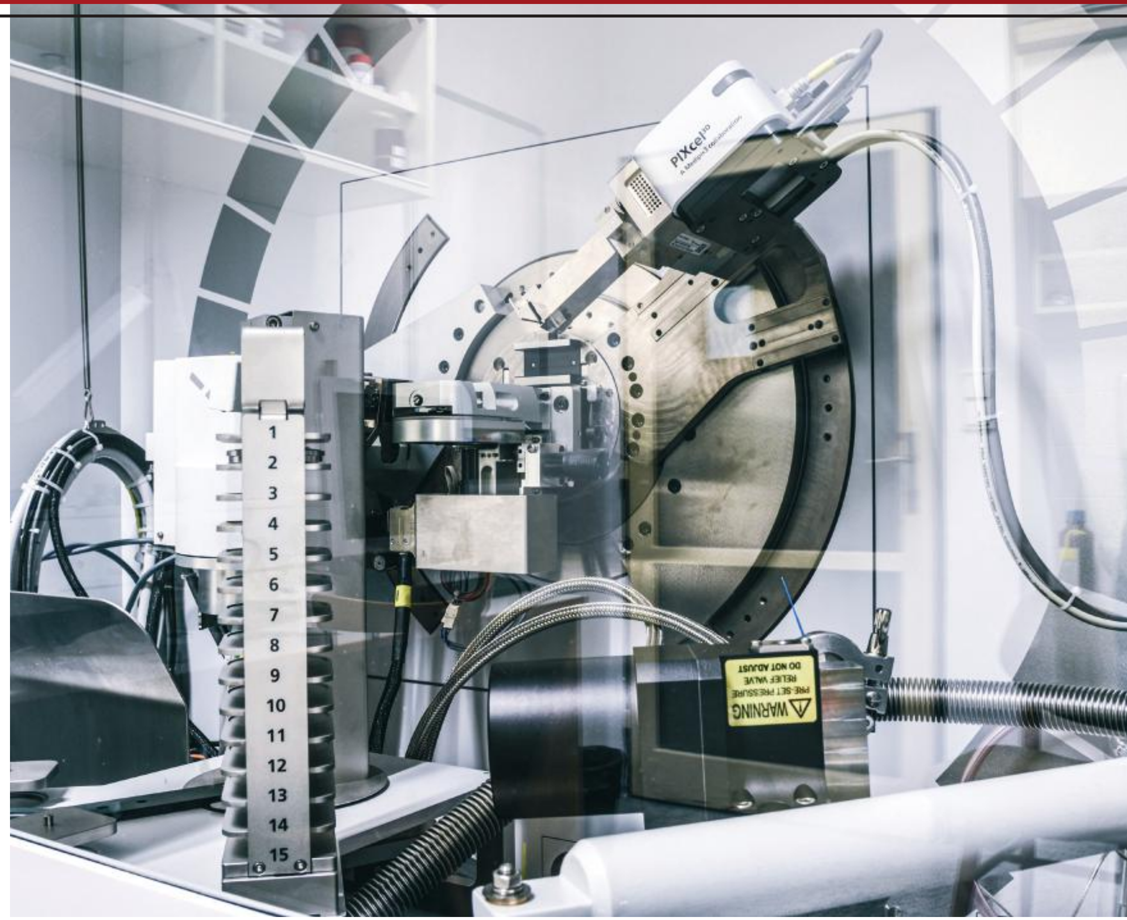
INSTITUTE OF PHYSICS OF MATERIALS

is one of the institutes of the Czech Academy of Sciences. It is a reliable partner for academic institutions and industrial enterprises implementing basic and applied research.

FOCUS OF THE INSTITUTE

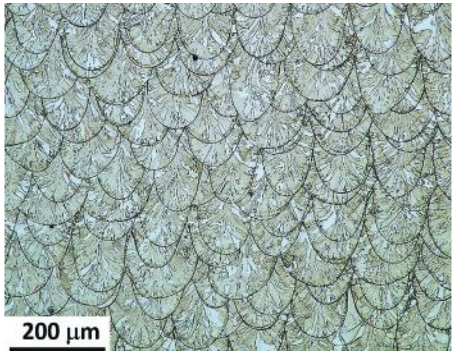
- METALLURGY AND MECHANICAL ENGINEERING
- TRANSPORTATION
- AEROSPACE INDUSTRY
- ENERGY
- AUTOMOTIVE INDUSTRY
- CONSTRUCTION AND CIVIL ENGINEERING
- POLYMERS
- PHARMACY AND HEALTHCARE

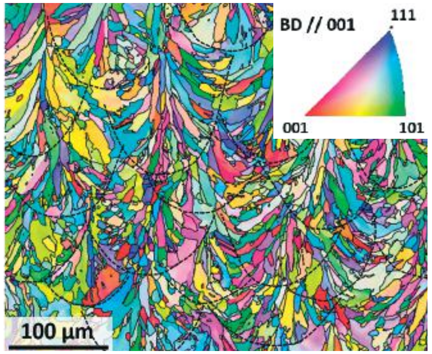
Currently, the Institute is dedicated to pioneering research in materials for the safe and ecological production of electrical energy, new materials for the automotive and aerospace industries, developing high-temperature materials, nanomaterials with unique properties, ceramic materials, composites, and polymers. Some of our major research topics are described in more detail on the following pages.



ADDITIVELY MANUFACTURED MATERIALS

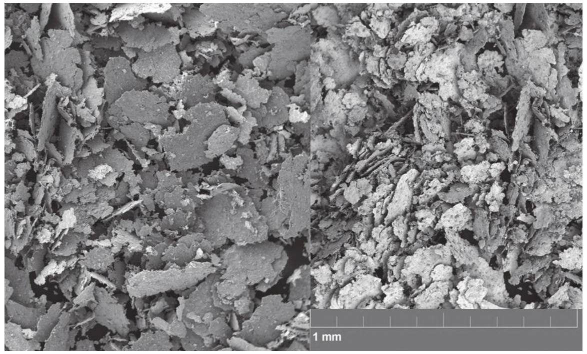
The development of additive technologies brings new, unprecedented possibilities not only in the area of design but also in terms of materials and their properties. Knowledge of the fundamental failure mechanisms allows the design of materials with specific structures as multi-component or gradient materials with improved response to loading and new functional properties. The research uses 3D printing methods for metals, ceramics, and polymer composites. For example, we deal with the development of metallic materials that can absorb significant damage without structural failure. By adapting the additive manufacturing process parameters, it is possible to modify the microstructure, crystallographic orientation, or even the active deformation mechanisms locally, making it possible to influence and improve the resistance to critical loads. These findings can then be used in designing individual components to produce industrial parts with significantly higher resistance to damage and long-term durability. For example, AISI 304L steel with an optimized gradient structure has been created by a gradual change in the process parameters of selective laser melting technology.





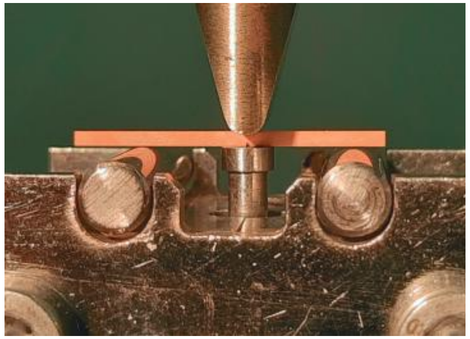
MATERIALS STRENGTHED BY OXIDE DISPERSION

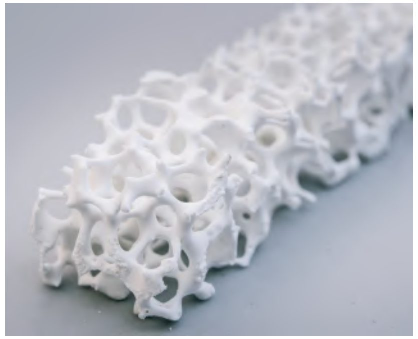
Materials strengthened by nano-dispersion of oxide particles, often based on Y_2O_3, have been known since the 1970s under the acronym ODS. The chemical and thermal stability of some oxides and their unique resistance to coarsening allow a long-term mechanical load of ODS materials at very high temperatures. In this way, the machine‘s operating temperature can be significantly increased and thus improve its thermal efficiency, directly reducing the amount of emissions produced. The excellent mechanical properties of ODS alloys, including high creep resistance, are due to the attractive interaction between oxides and dislocations. The Fe-10Al-4Cr-4Y_2O_3 material called FeAlOY was developed at the IPM. The result of our cutting-edge technology is an ODS alloy, which outperforms most known metallic materials in its high-temperature resistance. For example, the material has already been applied to the rods of high-temperature creep machines, which allows testing up to 1200 °C. High entropy alloys are another group of materials under development, strengthened by nano-dispersion. Finally, we also prepare ferritic steels strengthened with complex oxides, which lead to even better steel properties than material strengthened with conventional Y_2O_3.



ADVANCED PIEZOCERAMICS

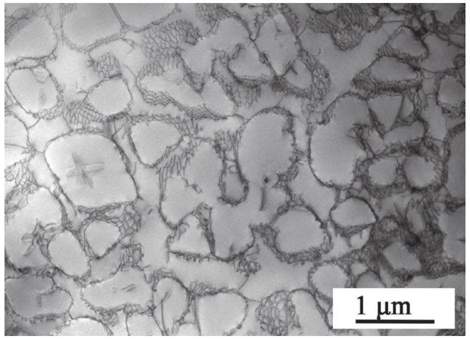
In the long term, we are also involved in developing, preparing and especially in the microstructural and mechanical characterization of advanced ceramic materials and their derived composites. In addition to studying the properties of monolithic ceramic materials or fiber-reinforced ceramic composites, we are focusing on functional, nature-friendly ceramic materials that exhibit piezoelectric behavior. Examples are materials with a perovskite structure based on $BaTiO_3$, which, unlike currently used materials, do not contain toxic lead. The disadvantage of these materials is, for the time being, less efficiency of deformation transformation into energy, lower stability temperature of the structure and brittleness, and the relatively low strength caused by it. That is why the development aimed at improving the utility properties is so necessary. Piezoceramic materials can be successfully applied in energy generators from oscillations caused, for example, by the operation of machinery. They can also serve in „smart“ multi-material composites as a functional component that controls the local mechanical response to the acting external load and reinforces or softens the material in the given area according to the actual need.

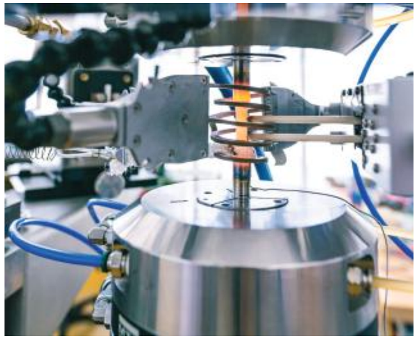




MECHANISMS OF LONG-TERM DAMAGE OF HIGH-TEMPERATURE MATERIALS

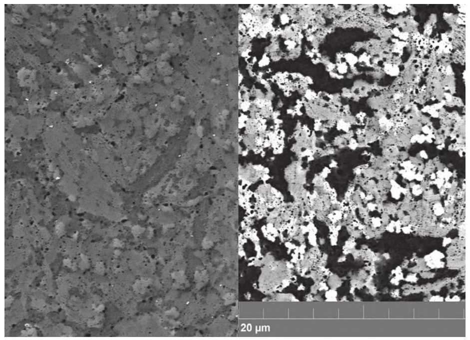
The constant demand for more powerful stationary and aircraft turbines, or turbochargers with increased efficiency and reliability, is challenging for material research. The most exposed components undergo several different working conditions during operation, and the resulting damage can be simplistically characterized as fatigue and creep. The former occurs due to turbine starts and shutdowns and superimposed vibrations. On the other hand, creep deformation is a time-dependent damage that degrades the material under nearly stable temperature and load conditions during the long-term operation of high-temperature equipment. The interaction of the two degradation mechanisms typically leads to a significant reduction in service life. Therefore, understanding their synergistic effect is necessary for material research with direct application impact. This can be documented by the successful collaboration with PBS Velká Bíteš, which led to optimizing the structure of precision castings of gas turbine blades and turbochargers from nickel-based superalloys, demonstrating the practical application of our research.

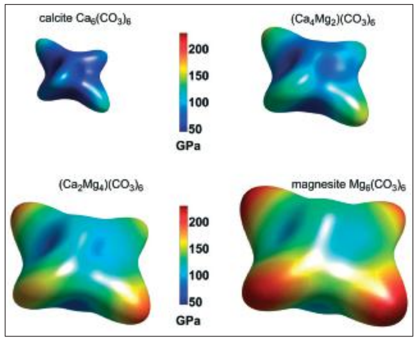




THEORY-DRIVEN MATERIALS DEVELOPMENT

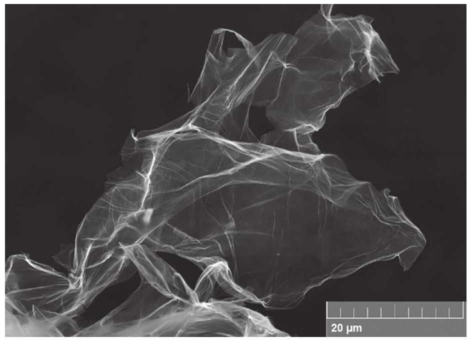
A modern alternative to traditional materials development, which is based on purely experimental procedures, is computer simulations. The effect of different chemical compositions of a material is at first predicted using theoretical methods; a few of the most promising compositions are selected, and only these are subsequently prepared. The development of new materials is thus considerably accelerated and streamlined. Using reliable computational methods such as quantum mechanical calculations (ab initio) at the atomic level is essential. The connection of ab initio calculations with the CALPHAD method used in studying thermodynamic properties and creating phase diagrams of complex multicomponent materials is an auspicious direction. The CALPHAD method is based on modeling binary and ternary systems using high-quality experimental data for simpler systems. When experimental data is missing, e.g., when studying multicomponent equilibrium states of ten or more elements, quantum mechanical calculations help. Various classes of advanced materials (e.g., lead-free solders, thermoelectric materials, new magnets, or hydrogen storage materials) are being developed within a broad international collaboration framework.

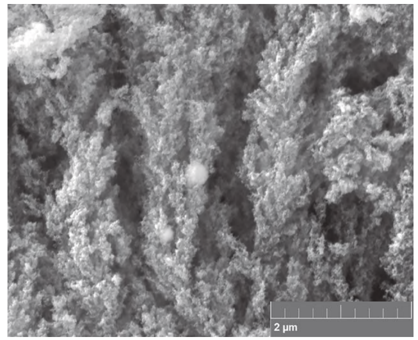




HYDROGEN STORAGE MATERIALS

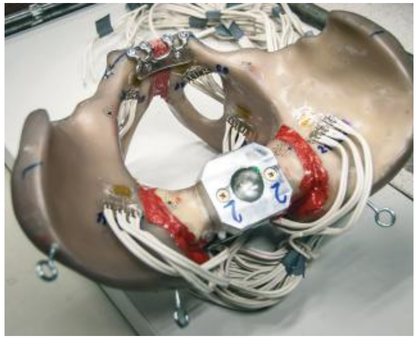
An important area of our research is the possibility of hydrogen storage in solids, representing an alternative to liquid or gaseous storage. We focus on improving the kinetics and thermodynamics of hydrogen sorption in the studied materials. Currently, research is directed at the study of hydrogen sorption in materials based on nanoconfined metal hydrides or 2D carbon structures, as well as the influence of nanocatalysts on the kinetics of sorption and the study of La-Ni-M and La-Ni-M-H alloys. The alloys mentioned are studied theoretically (CALPHAD method) and experimentally (studying the thermodynamic and kinetic behavior of the alloys and the hydrides themselves). Examples of experimental measurements include the p-c-T studies of the thermodynamic behavior of hydrogen in complex hydrides in adsorption/desorption modes, including kinetic cyclic experiments. The aim is to explain essential relationships between the studied sorption properties and the chemical composition of the material, its structure, and phases, even depending on temperature. Explaining these phenomena will allow for finding the most suitable material for hydrogen storage in solids, which is the most appropriate alternative from a safety point of view.





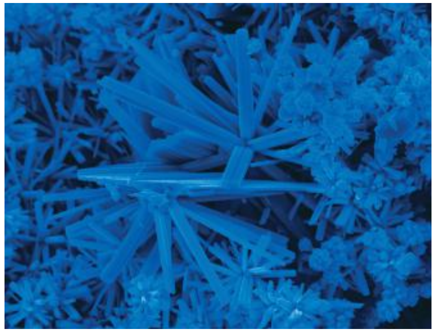
MATERIALS FOR BIO-APPLICATIONS

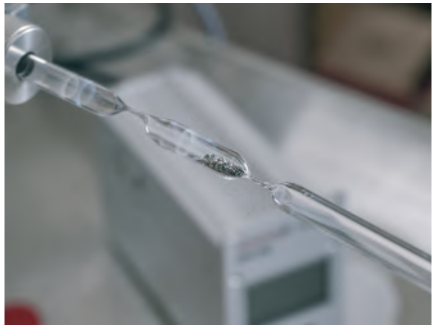
Our research also explores the potential of materials for bio-applications. We examine conventional materials (e.g., Ti-6Al-4V) used in medical practice and unconventional materials from the chemical composition or production process perspective. We use advanced methods for conventional materials to modify their structure (e.g., methods of intensive plastic deformation) and surface (e.g., water jet treatment or formation of particular surface layers), significantly impacting their resulting mechanical and biological properties. This allows, for instance, the geometry and surface of the resulting implant to be modified to minimize the burden on the human organism. Unconventional materials are prepared, for example, by modern 3D printing technologies, where the structure of the resulting material, its surface properties, and porosity can be changed using process parameters to allow better biocompatibility. We also study the interaction of the material with the biological environment and the feedback effect of this environment on mechanical properties and durability. Our research aims to determine the durability of biomedical implants at the design stage or to reveal the causes of their failure, inspiring optimism about the future of biomedical implants.



RESEARCH INFRASTRUCTURE OF THE IPM

is mainly focused on the study of advanced materials used in engineering applications. Its experimental equipment covers the field of mechanical tests (fatigue of materials, creep, and other material failures in a wide range of temperatures), characterization of material structure and its changes during loading, and determination of materials‘ thermodynamic, magnetic, electrical, and transport properties. In mathematical modeling, we cover the whole range of methods, from ab initio calculations through molecular dynamics to the method of finite elements.



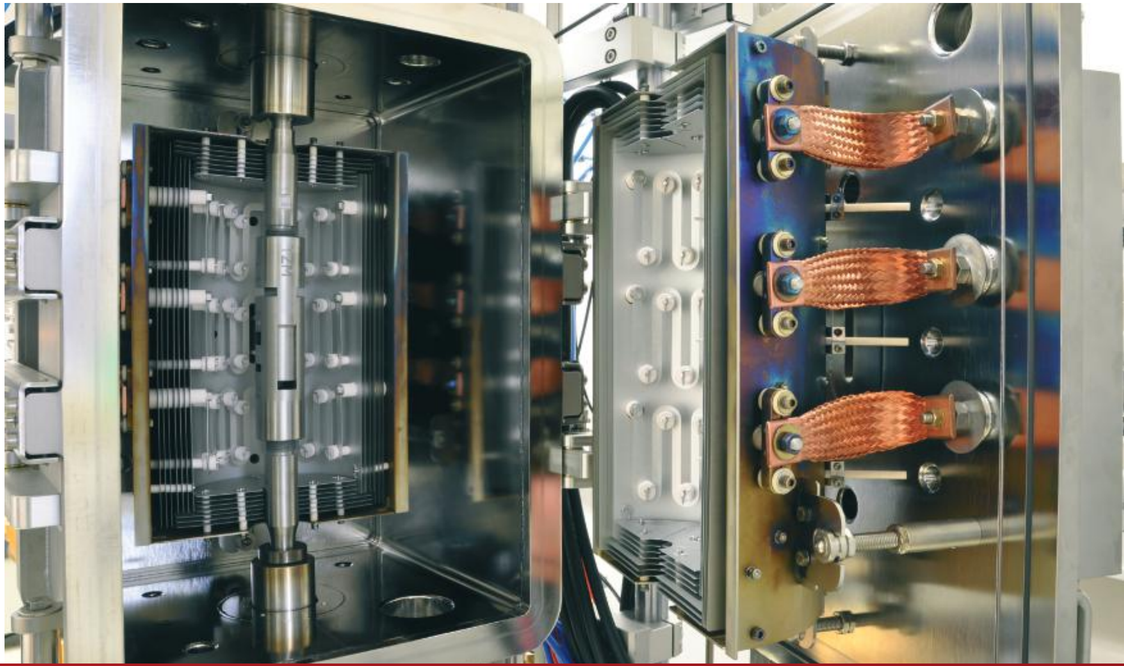


CREEP TESTS

- Creep tests in protective atmospheres or air with a continuous acquisition of deformation data in a temperature range from RT to 1000 °C.
- Creep tests in a vacuum or an Ar protective atmosphere with a continuous acquisition of deformation data at temperatures up to 1400 °C.
- Creep tests with extremely low deformation rates (lower limit 10^{-13} s^{-1} – typical for technical practice), temperature range up to 1000 °C.
- Torsion loading tests in the temperature range up to 1200 °C.

EQUIPMENT:

- 35× creep machines allowing a combination of two loading modes (tension/compression), each either using constant stress or constant force at temperatures up to 1000 °C (argon/hydrogen/hydrostar/air).
- 2× creep machines KAPPA (Messphysik) with a temperature capacity up to either 1200 °C or 1400 °C (vacuum/argon).
- 1× creep machine KAPPA DS 50 (Messphysik) with a loading capacity of 50 kN and a furnace up to 1200°C (air).
- 6× creep machines with a direct gravitational loading and advanced laser-based acquisition of the sample elongation data (tension/compression), furnace up to 1200 °C (air).
- 8× creep machines SATEC for experiments in the air with a temperature capacity up to 1000 °C.
- 2× creep machines for testing of helicoidal samples with a temperature capacity up to 1000 °C (argon).
- 1× creep machine for torsion loading with a temperature capacity up to 1200 °C.

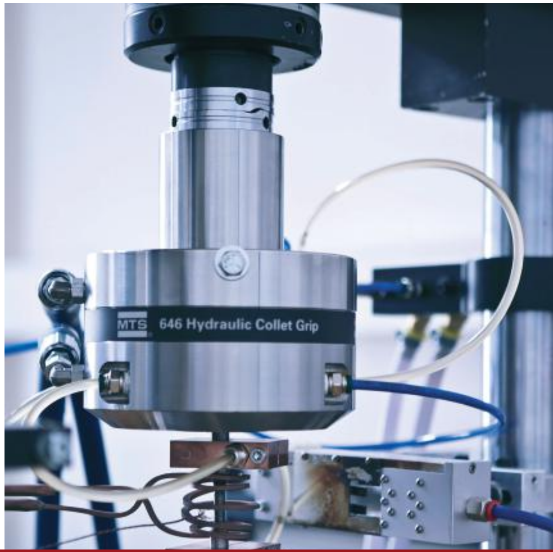


LOW CYCLE FATIGUE

- Fatigue properties of metallic, polymeric, and composite materials under tension/compression, torsion, or combined axial and torsional loading conditions. Properties can be measured in the temperature range from liquid nitrogen up to 1400 °C.
- Experimental determination of cyclic hardening/softening, cyclic stress-strain, Basquin, Manson-Coffin, and S-N curves.
- Identification of fatigue crack initiation sites and mechanisms and measurement of short fatigue crack propagation rates in traditional and advanced materials.
- Analysis of microstructure before and after fatigue loading and analysis of degradation mechanisms operating in studied materials.

EQUIPMENT:

- 3× servo-hydraulic testing machines MTS 880 and 810 with load capacity ± 100 kN, tension-compression, the possibility of low and high-temperature tests up to 1200 °C.
- 1× servo-hydraulic axial-torsion testing machine MTS 809, max. Force 100 kN, max. Torsional moment 1 100 Nm, temperature test range up to 1400 °C.
- 1× electrodynamic fatigue machine with linear motor, max. Force 12 kN, tension-pressure, equipped with an environmental furnace for tests from liquid nitrogen temperature up to 350 °C. Cycling frequency up to 100 Hz.
- Feritscope Fischer FMP 30 for non-destructive ferrite content measurement ranges from 0.1 to 110 FN or 0.1 to 80 % alpha Fe in austenitic and duplex steels.

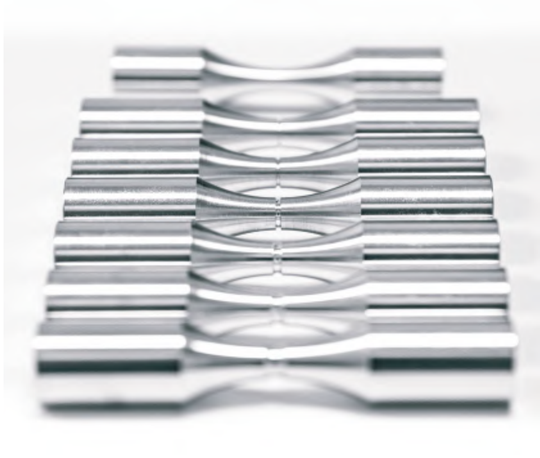


FATIGUE TESTS (HIGH CYCLE FATIGUE – GIGA CYCLE FATIGUE)

- Experimental determination of S-N curves, cyclic stress-strain curves, Goodman diagram, and fatigue crack propagation rates.
- Fractographic analysis of fracture surface, quantitative analysis of the role of defects and other stress concentrators on fatigue lifetime.
- Prediction of fatigue lifetime, numerical simulation of fatigue crack propagation, numerical prediction of residual lifetime in components with random load spectrum.
- Analysis of the microstructure before and after fatigue loading (visible light microscopy and electron microscopy), characterization of deformation mechanisms. Deformation analysis by DIC.
- Determination of residual stresses.
- Fatigue and fracture mechanics of composite and polymer materials.
- Determination of fatigue properties in giga cycle fatigue regimes (>10^9 cycles).

EQUIPMENT:

- 6× electromagnetic resonance fatigue testing machine with load range 1-100 kN, testing frequencies up to 150 Hz, possibility of tests at elevated temperatures up to 1200 °C.
- 2× servo-hydraulic universal testing machine Zwick/Roell Amsler HC25/ Instron 8872, axial loading up to 25 kN at testing frequencies up to 40 Hz.
- 4× universal dynamic testing machine with linear motor technology. Capacity of 0.1-20 kN, axial and torsion loading. Possibility of testing at temperatures of -80 °C + 350 °C.
- 3× special devices for gigacycle fatigue tests, axial loading at a testing frequency of 20 kHz, and fatigue tests up to 10^{10} loading cycles.



STRENGTH TESTS

- Tensile, compressive, bending, and shear tests under various loading conditions, including analysis of deformation and fracture processes focused mainly on fracture mechanics.
- The lab portfolio of experimental materials covers most metal, polymer, and ceramic materials, including their composites.
- The temperature range accessible for most tests is from -196 °C to 1200 °C in air and from room temperature up to 1500 °C in vacuum or argon.
- Tests can be carried out at loading speeds from 2 μm/h to 2 m/min with a machine capacity of up to 250 kN, except for the dynamic Charpy tests, where speeds up to 5m/s can be reached.
- Tests can be supplemented with instrumentation such as contact and non-contact extensometers, a high-speed camera, DIC, and analysis of acoustic-emission events.
- Basic material data can be supplemented with density measurements, thermal expansion, and elastic characteristics, all determined non-destructively.

EQUIPMENT:

- 3× universal electromechanical testing machine, max. load 50, 100, and 250 kN.
- 1× universal electromechanical machine with a high-temperature chamber up to 1500°C, max. load 20 kN.
- 1× universal electromagnetic machine for testing fibers, foils, and miniature samples, max. load 250 N.
- 1× system for measuring elastic properties using the resonance method up to a temperature of 1500 °C with a dilatometer.
- 3× instrumented Charpy hammer with a capacity from 0.5 J to 450 J with the possibility of a dynamic tensile test.
- 1× instrumented hardness tester for hardness tests up to 200 N.
- 1× instrumented nanomachine for hardness tests and scratch tests under loads up to 2 N.

DEVELOPMENT OF NEW MATERIALS

- Modelling phase diagrams of multicomponent materials using semiempirical methods and ab initio calculations.
- Preparation of new alloys by powder metallurgy, microalloying, and preparation of nanoparticle-strengthened structures in a controlled atmosphere.
- Preparation of new alloys by gravity casting in a vacuum induction furnace or an arc furnace, including vacuum casting.
- Development of new non-metallic inorganic materials such as geopolymer composites using low-temperature consolidation.
- Development and preparation of new types of nanoparticles based on iron or cerium oxides for medical applications.

EQUIPMENT:

- Multimaterial 3D printer with VAT Photopolymerisation printing method (stereolithography).
- 5× 3D printer with FDM or SLA filaments.
- Experimental furnaces allowing melting and heat treatment of samples in a vacuum or a controlled protective atmosphere.
- 2× planetary mill for high-energy milling of materials.
- 1× Fritsch Pulverisette 2 mortar mill.
- 1× Glove Box for powder handling in a protective atmosphere.
- 1× Vibrating sieve for homogenizing powder sizes.
- 1× Zetasizer Ultra Malvern powder size measuring device.
- 1× Ultrasonic Homogenizer.

THERMODYNAMIC AND THERMOPHYSICAL PROPERTIES OF MATERIALS

- Measurement of thermodynamic and temperature characteristics associated with phase transformations in materials – phase transition temperatures, transformation enthalpies, and heat capacities.
- Characterization of intermetallics, including measurement of specific heat capacity.
- p-c-T study of the thermodynamic behavior of hydrogen in solid materials for absorption/desorption regimes.
- Measurement of the rate of hydrogen sorption (possibly also of other gases) and evaluation of the activation energy of hydride formation, including kinetic cycling experiments.
- Measurement of adsorption/desorption characteristics of hydrogen (possibly other gases) in solid materials.

EQUIPMENT:

- Differential scanning calorimeter Netzsch DSC 204 F1 Phoenix for measuring transformation characteristics and specific heats in the temperature range -180 to 700 °C.
- Netzsch Pegasus DSC 404C calorimeter.
- Setaram PCT EVO for measuring gas sorption by the Sieverts method. The device is suitable for measuring the sorption kinetic and thermodynamic characteristics of selected gases (H_2, CO_2, CH_4, N_2, Ar, He) in solid samples (bulk, foil, powders) in the range of temperatures 20–400 °C and pressures 10^{-3} – 200 bars.
- Apparatus for determining parameters of thermal desorption of gases equipped with mass spectrometer QMG 250 M1, PrismaPro.
- Linesis PT1000 STA + Pfeiffer QMS – a device for simultaneous thermogravimetric and differential scanning calorimeter analysis, measures both heat flow and weight change of a sample as a function of temperature or time under a controlled atmosphere in the temperature range from RT to 1000 °C. This device is equipped with a quadrupole mass spectrometer, ThermoStar GSD 350 T1, with a mass range of 1-100u, for analysis of the composition of released gases, including hydrogen.

MATERIAL STRUCTURE ANALYSIS

- Analysis and description of the structure and substructure of materials, defects, surface and internal cracks, and analysis of the damage mechanism in the material operating under different loading conditions (tension, compression, bending, fatigue, creep).
- Measurement of the local chemical composition – EDS.
- Analysis of material phase composition, grain size, and texture – EBSD.
- Using focused ion beam to obtain information about material structure in subsurface regions and to prepare site-specific samples for transmission electron microscopy - FIB.
- Study of the structure of materials at the atomic level – transmission electron microscopy. Analysis of the atomic disorder (interstitial atoms, vacancies, dislocation structures), their motion, and the interaction of these defects with structural components of the material.

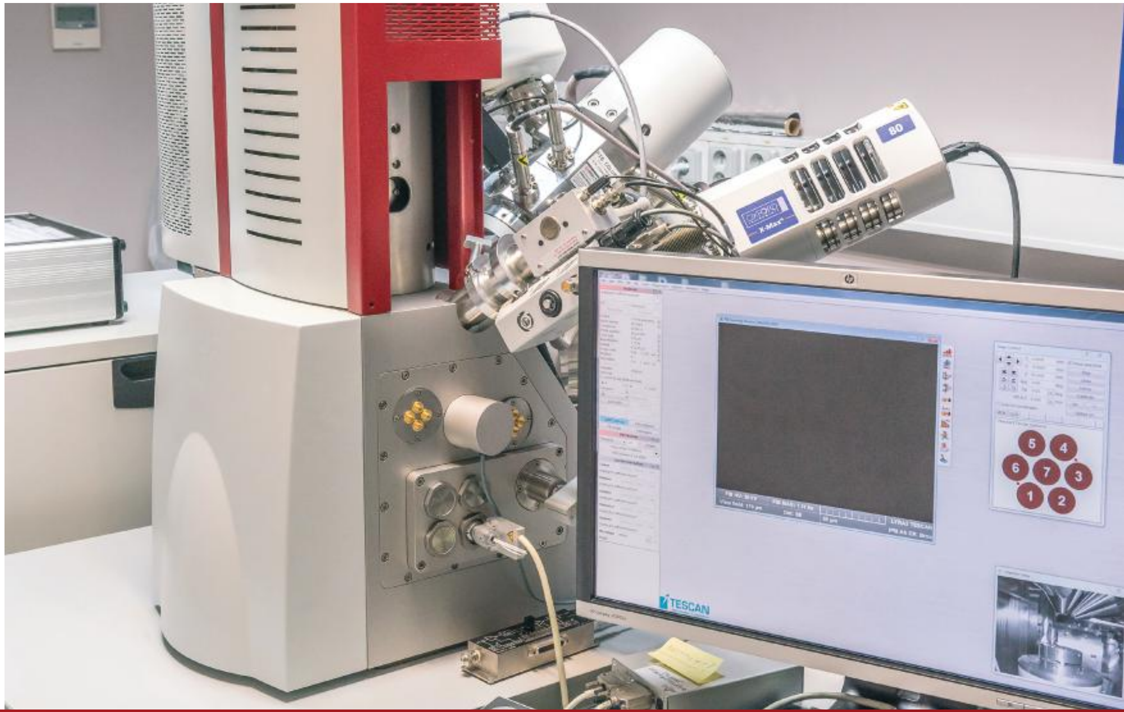
EQUIPMENT:

- Transmission electron microscope Talos 200i
  Techniques: TEM, HRTEM, SAED, CBD, NBD, (HR)STEM, EDS, DPC, iDPC, 4D STEM, Lorentz TEM, holography.

- JEOL JEM-2100F Transmission Electron Microscope
  Techniques: TEM, HRTEM, SAED, CBD, NBD, STEM, EDS.

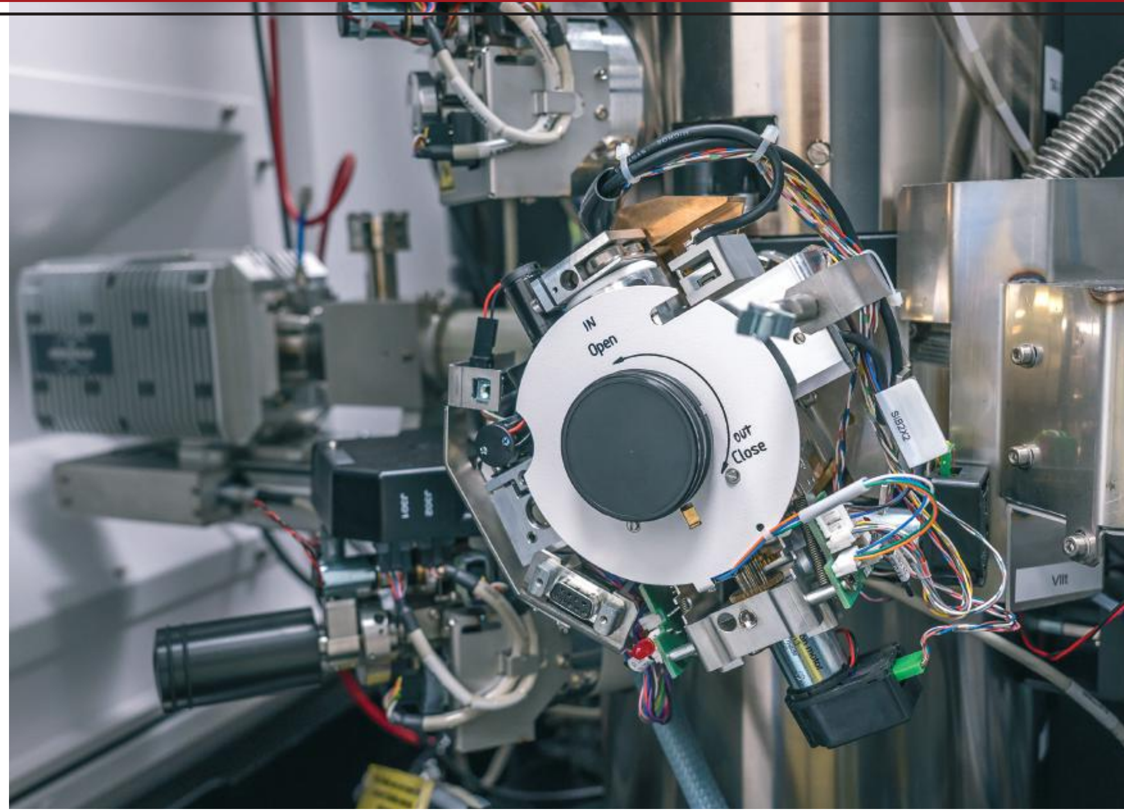
- 2× Tescan LYRA 3 XMU FEG/SEMxFIB scanning electron microscope
  Techniques: SE, BSE, EDS, EBSD, STEM (BF a DF), FIB, GIS.

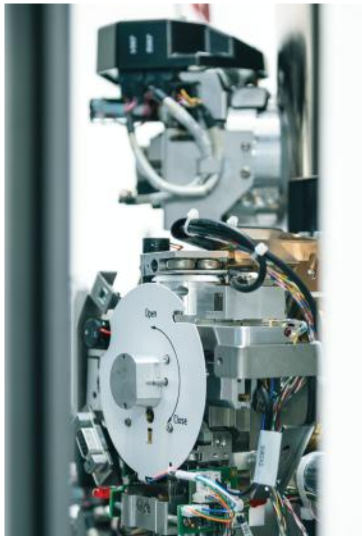
- Scanning Probe Microscope (SPM) LiteScopeTM (NenoVision) integrated into the scanning electron microscope
  Techniques: AFM, C-AFM, STM, MFM, KPFM, EBIC/EBAC.



TRANSMISSION ELECTRON MICROSCOPE TALOS F200I

The Talos F200i is a flexible transmission electron microscope (TEM) that enables fast and precise characterization of various materials. The device offers standard TEM and STEM modes, with sufficient resolution to image single atomic columns in both modes. TEM is an essential device of structural and phase analysis, and electron diffraction is an excellent tool for identifying the different structural parts present in a material. Combined with the measurement of local chemical composition using EDS detectors, the Talos F200i is an essential tool, for example, in developing new ODS materials. The description of interactions between strengthening particles and lattice defects down to the atomic level can serve as input for subsequent calculations, a better understanding of deformation mechanisms, and structure optimization. TEM in Lorenz mode and electron holography can image individual magnetic domains if they are present in materials or nanoparticles. Confirming the presence of individual magnetic domains and measuring their size is crucial in developing magnetic nanoparticles for cancer-fighting applications. Finally, the microscope is equipped with a rapidly developing 4D-STEM technique promising for many applications. One of the applications used is the measurement of local stresses in materials prepared by 3D printing.





NUMERICAL SIMULATIONS

- Calculations based on the quantum-mechanical description of materials, so-called ab initio methods. The research aims to study the electronic structure of materials, their magnetic properties, the structure of internal defects, and the development of new alloys. The quantum-mechanical methods are also combined with AI tools, such as neural networks and the newly emerging technology of quantum computers.
- Atomic-scale studies of materials are used, e.g., to clarify various failure mechanisms of metallic materials, such as slip and twinning models or grain boundaries‘ influence.
- Phase field models that enable a continuous description of microstructure characteristics in multiphase materials and, simultaneously, the spatial distribution of the dislocation substructure.
- Modeling of thermodynamic properties and phase diagrams using a combination of CALPHAD and ab initio methods.
- Modeling material behavior using crystal plasticity models to describe its mechanical behavior at the microstructure level.
- Modeling of crack propagation in various materials and composites.
- Structural calculations using the finite element method, determining the long-term life of critical components.

EQUIPMENT:

- 10× workstations for numerical modeling.
- Supercomputer with 260 CPUs and 1.6 TB RAM for computationally demanding simulations in computational materials science and theory-guided development of new alloys.
- Remote/cloud access to supercomputing centers in the Czech Republic and abroad (IT4I in Ostrava, METACENTRUM, and CERIT-SC in Brno, LUMI in Finland).
- Remote/cloud access to quantum computers of the IBM company in the USA.

MAGNETIC, ELECTRICAL AND TRANSPORT PROPERTIES

- Measurements of magnetic, electrical, and transport properties of materials are combined with the analysis of the structure and phase composition of materials.
- Tests of material properties at very low temperatures (down to -260 °C) and high temperatures (up to 800 °C).
- Complementing the experiments with advanced theoretical modeling (quantum-mechanical calculations) of observed phenomena and conditions that would be difficult/impossible to implement experimentally.

EQUIPMENT:

- EverCool II low-temperature measuring system enabling measurement of magnetic and electrical properties as well as heat transfer in the temperature range from -270 °C to 130 °C and in magnetic fields of up to 9 T.
- High-temperature vibrating magnetometer enabling the measurement of magnetic properties up to 800 °C.
- Automatic powder diffractometer X‘Pert PRO enabling the analysis of the structure of the investigated materials at low temperatures (down to -260 °C).
- Optical emission spectrometer GD-PROFILER 2 – high-resolution simultaneous spectrometer using a glow discharge radio frequency source for surface analysis, depth profile analysis, and volume analysis of electrically conductive and non-conductive samples and thin layers.
- Mössbauer spectrometers are used to accurately determine the phase composition of materials, most often steels and other iron-based materials, and local magnetic properties.

PREPARATION OF MATERIALS AND SAMPLES, METALLOGRAPHIC PREPARATION

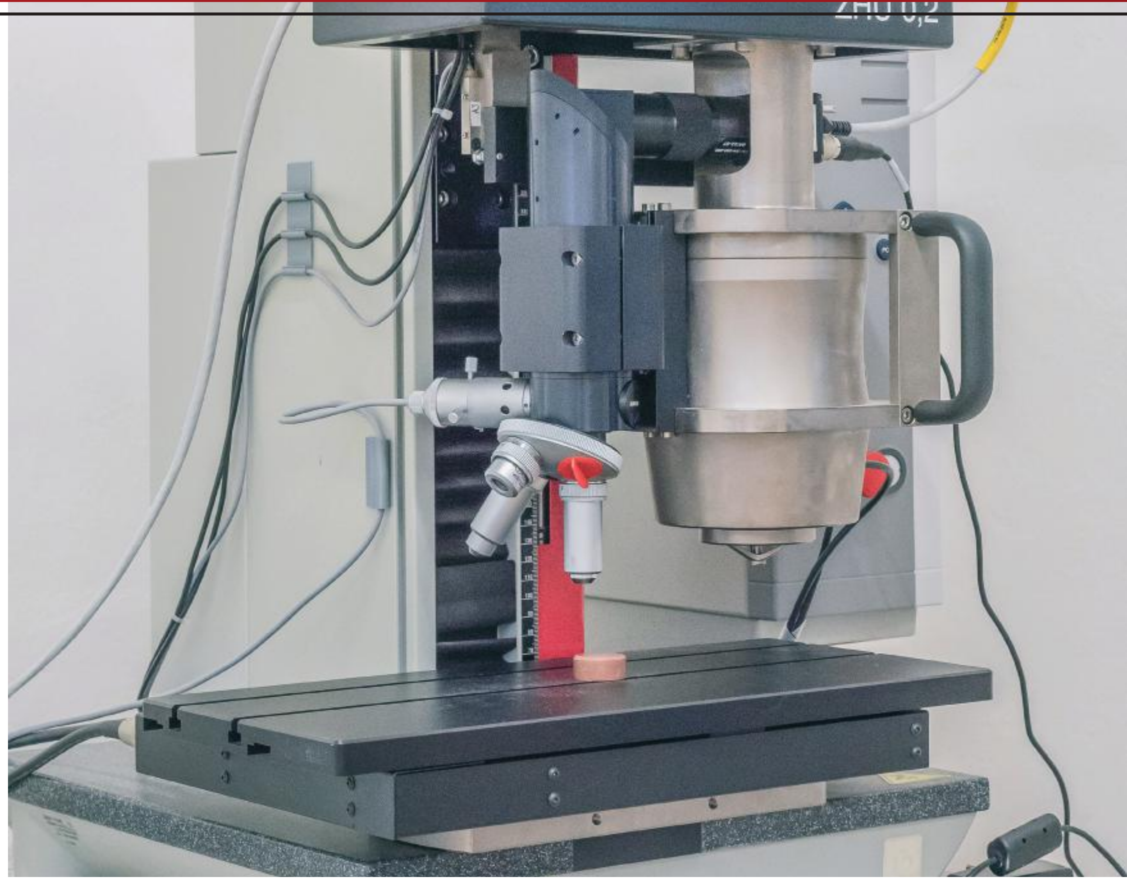
- The workshops and metallographic laboratory of the Institute are fully and well equipped for cutting and machining materials or preparation of test samples.
- Sampling, metallographic preparation, and characterization of all types of samples in terms of structure, porosity, hardness, or fracture surface analysis.
- Sample preparation meets all light, confocal, or electron microscopy requirements.

EQUIPMENT:

- Band saws, EDM cutter and drill, CNC lathe, conventional lathes and milling machines, grinders.
- Precision saws, metallographic mounting press, grinders and polishers, vibratory polisher, plasma cleaner.
- Optical light microscopes and a stereomicroscope.
- Hardness and micro-hardness testers.
- Sources for electropolishing/etching preparation even at low temperatures.

Zwick demo laboratory

In cooperation with Zwick/Roell, a demo laboratory was created. A DuraScan 70 G5 hardness tester and a Rockwell ZHR 8150 CLK universal hardness tester are placed in the laboratory on loan from the company. The DuraScan 70 G5 can automatically measure hardness waveforms and maps on several samples, even complicated shapes, in addition to basic manual measurements. The hardness tester automatically measures according to ISO 6507, ASTM E384, and ASTM E92 standards.



IN-HOUSE DEVELOPMENT OF CREEP MACHINES

- Development and production of creep machines with a direct gravitational loading.
- Successful tensile creep tests using the six new machines proved the design concept.
- The current version of the machine enables tests in air and offers a force capacity up to 1.5 kN.
- Test temperatures up to 1200 °C can be set with one-zone furnace FIBROTHAL RAC 70/500 TYPE A F-17.
- Test temperatures are measured by thermocouples attached to a sample and regulated by a CLASIC Ht 40 B controlling unit.
- Sample deformation is registered by a laser-based sensor MICROEPSILON optoNCDT 1320 sampling motion of the loading parts (extension range 10 or 25 mm).
- An original module-based software collects deformation data.
- Versatile sample shapes can be tested, including flat, threaded, or cylindrical geometries with a gauge length of 50 mm.
- Accuracy and reproducibility of measurements were proven by comparative tests on high-end commercial creep frames.
- The equipment can be tailored based on the requirements of customers. IPM administers sales, distribution, and services.

DEVELOPMENT OF OWN DEVICES FOR GIGA CYCLE FATIGUE TESTS OF MATERIALS

- Equipment for fully reverse tension-compression cycle loading.
- The device allows loading with or without static pre-stress.
- The operating frequency of 20,000 ± 500 Hz allows to achieve 10 million cycles in 8 minutes and 10 billion cycles in less than six days.
- Ultrasonic generator with the possibility of controlling the output amplitude of the signal.
- Horizontal configuration of the converter-booster-sonotrode-sample chain.
- Continuous control of the output amplitude of vibrations.
- Sets of used boosters and sonotrodes cover a wide range of output amplitudes of vibrations.
- Air cooling of the ultrasonic converter.
- Cooling of material samples with air or water.
- Efficient cooling by the closed water-cooling circuit.
- Optional induction heating for high temperatures (up to 800 °C) tests.
- The device can be modified according to the customer‘s wishes. ULTRATECH s.r.o. takes care of sales, distribution, and service.

Ultratech
ULTRASONIC TECHNOLOGY

INSTITUTE OF PHYSICS OF MATERIALS

is significantly involved in relevant research platforms such as the top research centers CEITEC, MEBIOSYS, and MATUR. Furthermore, the Institute of Physics of Materials participates in implementing partial projects of national competence centers of Technology Agency of the Czech Republic (NCK MESTEC and NCK ENGINEERING), which are more focused on cooperation with the industrial sphere.

CEITEC

The CEITEC centre realizes a common vision of creating a center of excellence in science whose results will improve the quality of life and human health. Masaryk University, Brno University of Technology, Mendel University in Brno, Institute of Physics of Materials, University of Veterinary Medicine in Brno, and Research Institute of Veterinary Medicine participate in this center. The International Science Centre has more than 1400 employees. Out of this number, there are more than 750 male and female scientists. CEITEC also runs its doctoral study programs within the CEITEC PhD School, which 400 male and female students attend. The joint research objectives are: elucidation of mechanisms of origin and spread of serious diseases, methods of their prevention, early diagnosis, and therapy; use of plant systems as renewable sources of materials and biologically active substances; development of advanced materials and functional nanostructures for medicine, energy, information and communication technologies; use of information and communication technologies for biomedicine.

The Center conducts cutting-edge research and provides advanced postgraduate and postdoctoral teaching. Installed advanced technologies will enable the synergistic study of objects of living and nonliving nature at all currently available levels of complexity, starting with individual atoms through molecules, molecular clusters, cells, and whole organisms. Thus, the joint use of advanced infrastructure, in addition to highly specialized research, also enables intensive interdisciplinary cooperation and a better background for teaching.

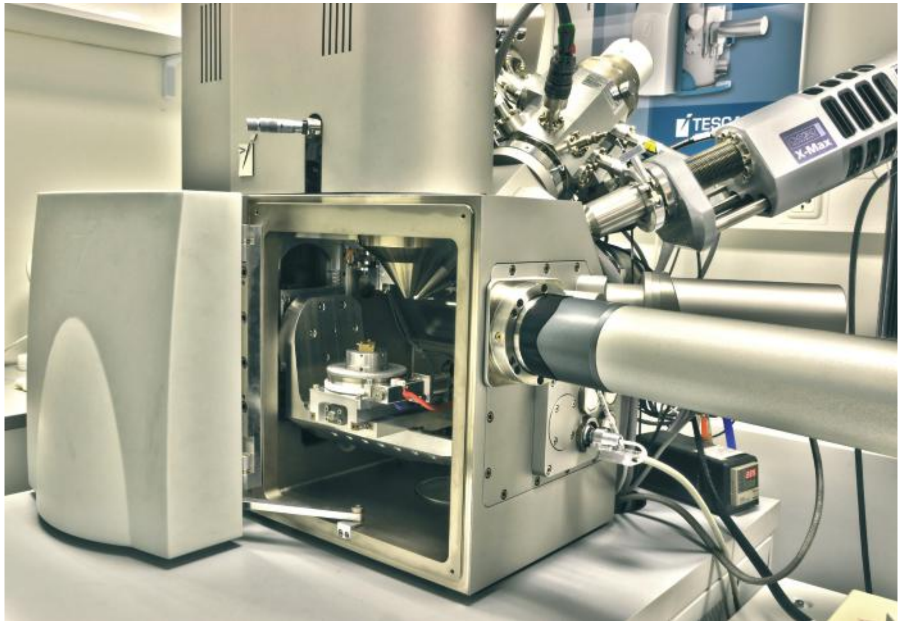
The Institute of Physics of Materials at the CEITEC center focuses on studying progressive materials applicable in energy, transport, and bio applications, theoretical description, and computer simulations of physical processes in materials at all levels, focusing on the microscopic and mesoscopic levels. In addition to cutting-edge research in materials physics and material sciences, it also educates university students of all grades in relevant courses at Masaryk University and Brno University of Technology, including the CEITEC PhD School.

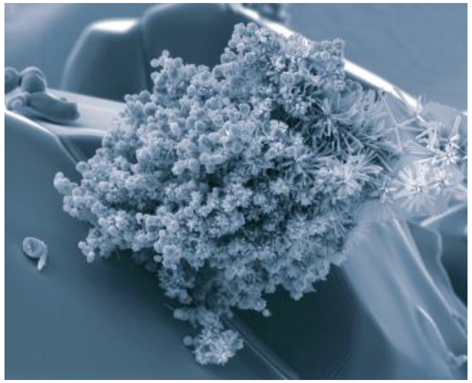
MEBIOSYS

The MEBIOSYS top research center aims to strengthen international cooperation, team development, and the implementation of cutting-edge research to develop a new generation of ground-breaking engineering products that result from the convergence of biological and technological evolution. The project solves the dual industrial transition issue and the EU's re-industrialization, especially for sophisticated production processes requiring advanced engineering products. Brno University of Technology leads the project, and the IPM is one of the key partners. The project also includes the development of internationalization in cooperation between research organizations, including mobility, modernization of technical equipment, and deeper integration of involved institutions into joint cutting-edge research. Within the framework of the MEBIOSYS center, the IPM carries out research in the field of bioinspired materials and metamaterial structures for use in industry and medicine.

MATUR

The MATUR top research center is based on the activities of an interdisciplinary research team focused on materials research for sustainable development. The Technical University of Ostrava leads the project, and the IPM is one of the key partners. The center is aimed at hybrid silicate materials, materials for high-temperature applications in the energy sector, materials and technologies reducing environmental impacts, and functional materials. The project also includes the development of international cooperation between research organizations, including exchanges between the involved partners. This center seeks closer links between materials engineering, civil engineering, physics, chemistry, mechatronics, and environmental engineering.





The project Mechanical engineering of biological and bio-inspired systems (MEBIO-SYS), reg. No. CZ.02.01.01/00/22_008/0004634 and the project Materials and Technology for Sustainable Development (MATUR) reg. No. CZ.02.01.01/00/22_008/000463, are co-funded by the European Union.

Co-funded by the European Union

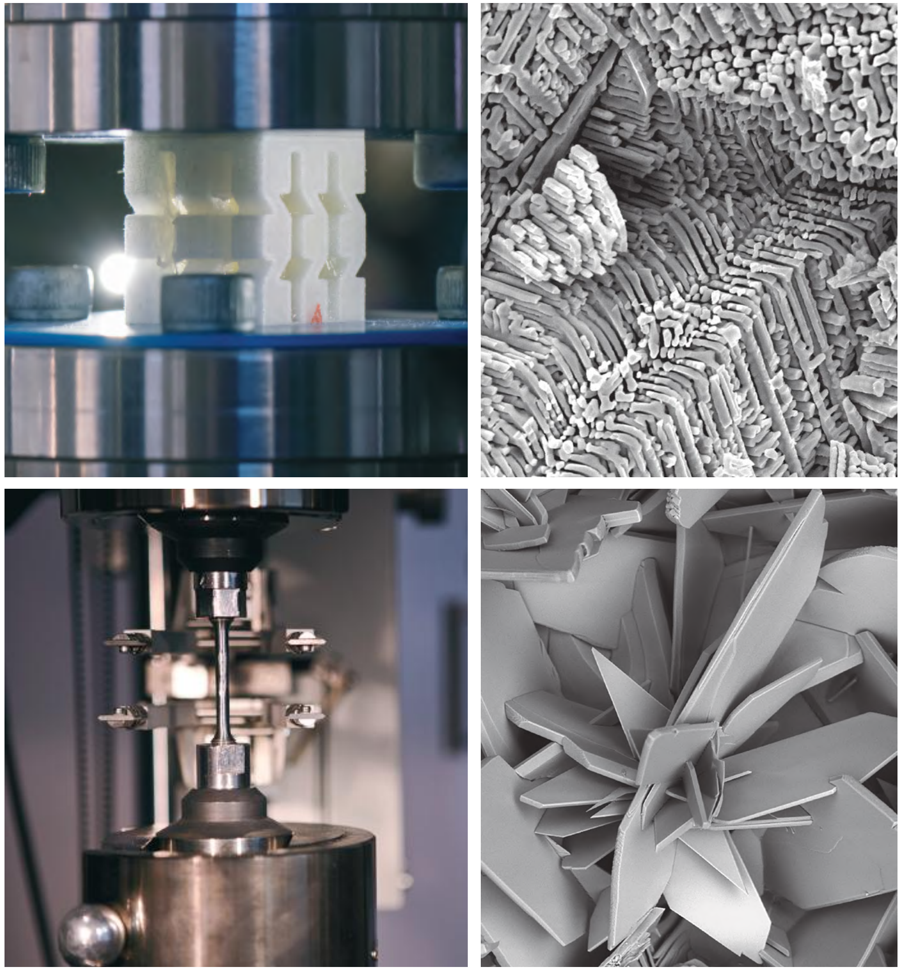
MINISTRY OF EDUCATION, YOUTH AND SPORTS

NCK MESTEC

The National Competence Centre of Mechatronics and Smart Technologies for Mechanical Engineering (NCK MESTEC) was established to concentrate the R&D capacities of individual departments and technologically oriented companies on implementing a joint research agenda. The Institute of Physics of Materials is an important partner. The focus of the center combines multidisciplinary research specializations (mechanical engineering, electrical engineering, chemistry, biology, material engineering, and virtual design), which are directed towards three interconnected technological areas, the application of which is focused primarily on engineering production for the 21st century. The center, led by Brno University of Technology, consists of 6 departments from research organizations and 19 development capacities of businesses.

NCK ENGINEERING

The National Competence Centre of Engineering (NCKS) is focused on research, development, and innovation activities necessary to enhance the competitiveness of the Czech engineering industry in the medium and light industry segments. The joint implementation of applied research and development aims to boost and further develop the cooperation of businesses and research organizations. The NCKS addresses issues and topics essential for future machinery innovations. The center is focused on increasing the performance and precision of machinery, reducing energy intensity, production process automation, and cost optimization, and reflecting the trends of Industry 4.0. VÚTS a.s. leads the consortium, and apart from Institute of Physics of Materials, it includes leading Czech technical universities and 22 development capacities of businesses.



National Competence Centre MESTEC, reg. No. TN02000010, and National Centre of Competence ENGINEERING, reg. No. TN02000018 is co-funded with the state support of the Technology Agency of the Czech Republic as part of the National Center of Competence Program.

SELECTED RESEARCH PARTNERS

Paul Scherrer Institute – *Switzerland*

Karlsruhe Institute of Technology – *Germany*

Politecnico di Milano – *Italy*

Massachusetts Institute of Technology – *USA*

University of Oxford – *UK*

Montanuniversität Leoben – *Austria*

RWTH Aachen – *Germany*

The Ohio State University – *USA*

EPFL – *Switzerland*

University of Cambridge – *UK*

SELECTED INDUSTRIAL PARTNERS

Thermofisher Scientific – *Czech Republic*

Aircraft industries – *Czech Republic*

Nenovision – *Czech Republic*

PBS Velká Bíteš – *Czech Republic*

Bonatrans group – *Czech Republic*

Hanon Systems Autopal – *Czech Republic*

MTU Aero Engines – *Germany*

IDIADA – *Czech Republic*

Hitachi Energy Switzerland – *Switzerland*

Sidenor – *Spain*

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