Materials Science

Department Materials Science

Annual report 2024

Montanuniversität Leoben

Preface

Dear colleagues and friends of the Department of Materials Science!

We are proud to present the highlights of the year 2024 in the following pages of this annual report of the Department of Materials Science. We are committed to materials and are convinced that they are key to tackle future challenges, in particular those that are central to the aims of the Montanuniversität Leoben. That means combining research, study and innovation to put energy efficiency, climate neutrality, sustainability, zero waste and circular design into practice.

Our greatest asset is our people. Please take a look at the picture gallery displaying the various scientists, technicians and administrative staff. To keep our team at the forefront of research, we invested in new pieces of equipment last year, including a new multifunctional diffractometer, a rotation stage for the femtosecond-laser, a heating stage for the SEM/FIB, and a scanning electron microscope for micromechanical experiments. Furthermore, we have refurbished our mechanical testing equipment. Last but not least, the new high-performance computing cluster, acquired in 2023, became fully operational in 2024 and now provides a strong resource for virtualising materials and their processes - fostering innovation and accelerating developments in materials science.

The evolution of the Department's revenues over the recent years shows a stable progression. The excellent work and achievements of 2024 keep our expectations high and give us confidence for the years to come. An overview of our activities is provided through the description of key projects currently running at the Department. We also share the awards and prizes our research team has received. Furthermore, you will find selected examples of our scientific publications, theses and conference presentations, which highlight the value we return to society. To remove the barriers to accessing our research, we are increasingly adopting open access policies and also publishing the associated research data and software in appropriate repositories, in accordance with the FAIR data principles.

With regard to teaching, we continue to modernise and restructure our curricula. The new Bachelor's programme in Materials Science and Technology (MaWiTech) is now in its third year, and we expect the first Bachelor's graduates in 2025. The modularisation of the Master's programmes in Materials Science and in Advanced Materials Science and Engineering is ongoing and scheduled to commence in winter semester 2025. Furthermore, new exchange programs are being initiated in collaboration with European universities. With these initiatives, we are confident to attract more students to Montanuniversität Leoben and enhance its international visibility.

We invite you to enjoy the following pages and would like to thank our collaborators, industrial partners and our team members for their great support.

Prof. Dr. Raul Bermejo

Prof. Dr. Jürgen Eckert

Prof. Dr. Daniel Kiener

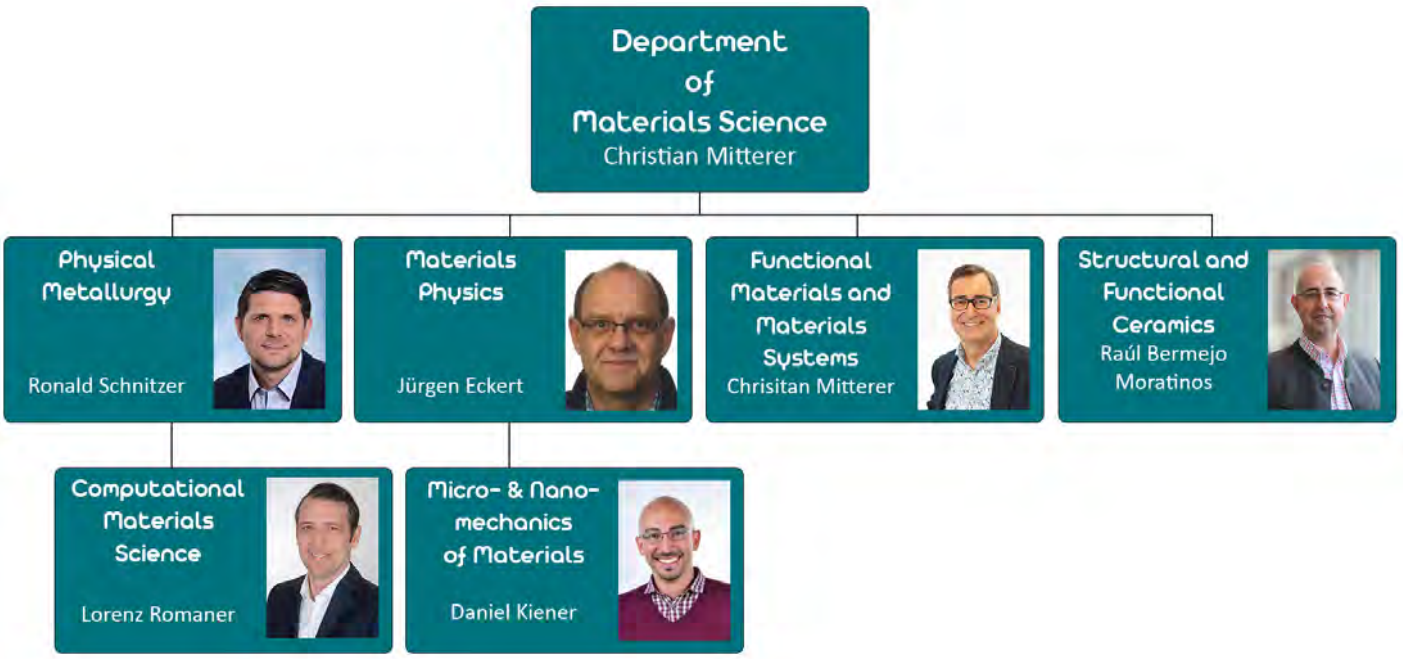
Prof. Dr. Christian Mitterer

Prof. Dr. Lorenz Romaner

Prof. Dr. Ronald Schnitzer

Table of content

Organigram


Department of Materials Science
Christian Mitterer
Physical Metallurgy
Ronald Schnitzer
Materials Physics
Jürgen Eckert
Functional Materials and Materials Systems
Chrisitan Mitterer
Structural and Functional Ceramics
Raúl Bermejo Moratinos
Computational Materials Science
Lorenz Romaner
Micro- & Nano-mechanics of Materials
Daniel Kiener

Personnel

Personnel

In 2024, 181 people were employed at the Department of Materials Science. The expenses for 60 employees were covered by federal funds, 121 employees were financed by third-party projects.

Head of Department

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Chair of Physical Metallurgy

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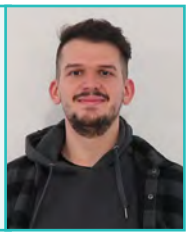

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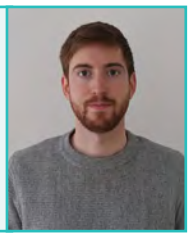

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em. o.Univ.-Prof. Dr.
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Empa Swiss Federal Laboratories for Materials Science and Technology, Switzerland

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Zhang, Jiyao
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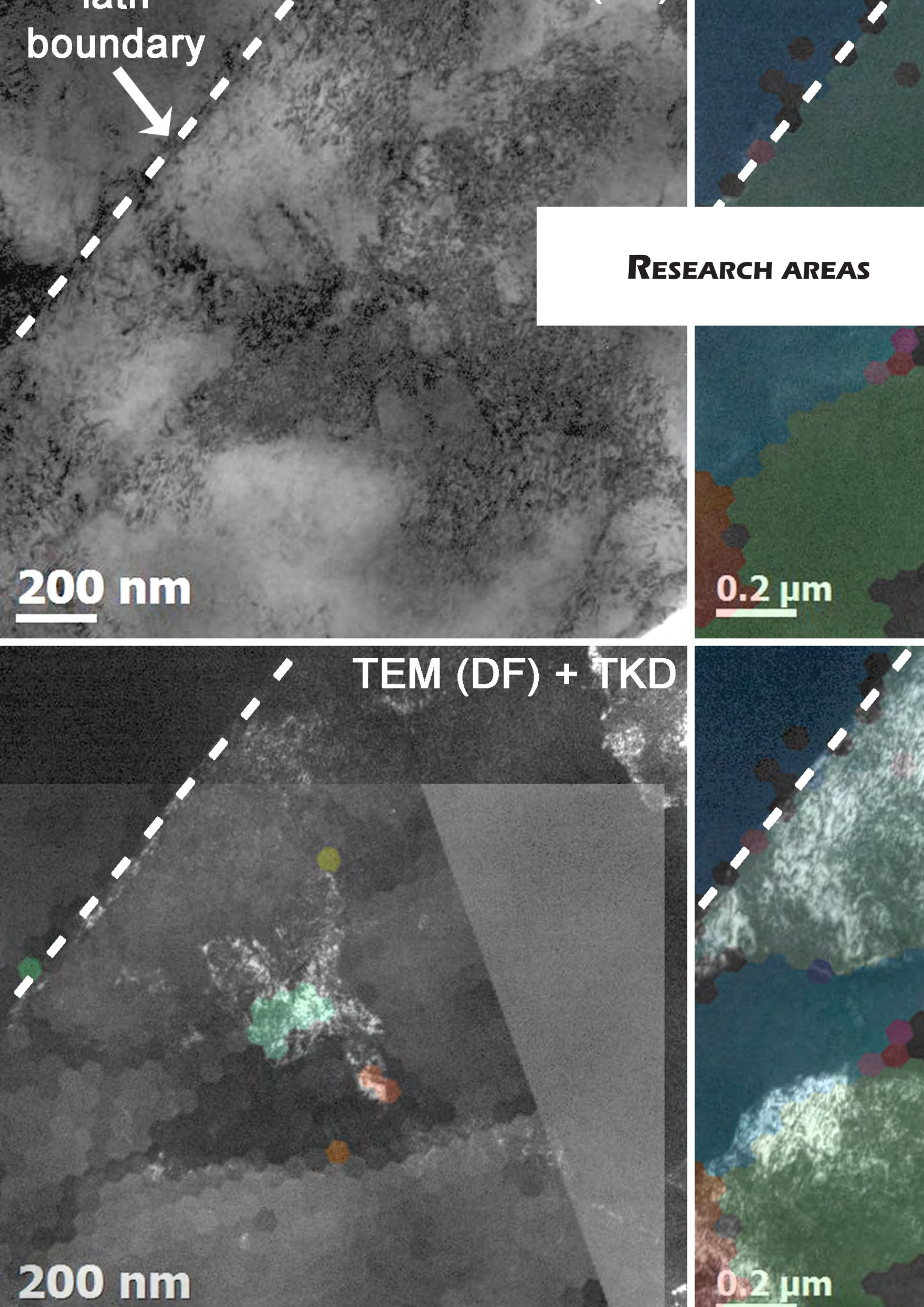


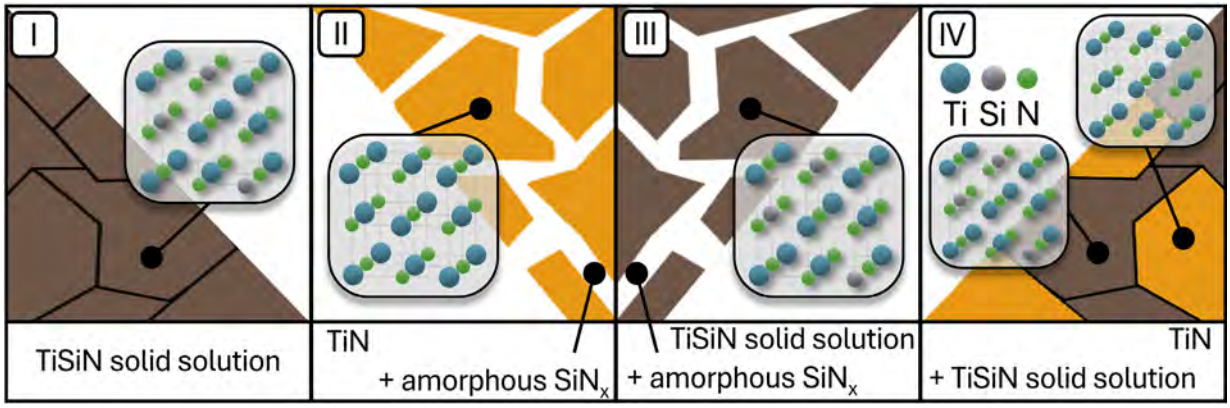
Research areas

Mission statement

Within the Department of Materials Science, research is done at the highest international level, to achieve a detailed understanding of the structure and the properties of materials and material systems. In teaching, students are integrated as early as possible in research activities, to gain new insights by joint research of supervisors and students. The obtained findings are transferred to the society via publications, to establish a solid knowledge basis for future applications. International visibility of the Materials Science area at Montanuniversität Leoben stems from a supercritical size, which necessitates the completeness in methods available to us and in the materials classes covered.

Chair of Functional Materials and Materials Systems

At the Chair of Functional Materials and Materials Systems, the following working groups with the respective group leaders are established: Advanced Surface Engineering (Nina Schalk), Materials for Microelectronics (Rostislav Daniel), Advanced Micro- and Nanostructure Characterization (Michael Tkadletz, group jointly operated with the Chair of Physical Metallurgy), and Scale Bridging Materials Testing under Extreme Conditions (Verena Maier-Kiener).
A particular research focus of the Chair is the design and synthesis of advanced functional materials and surfaces by surface activation, modification, and deposition of coatings, thin films and nanoparticles using plasma-assisted vacuum techniques. The Chair operates a unique portfolio of lab- to industrial scale vapor deposition systems, including sputter deposition (DC, pulsed DC, HiPIMS) and cathodic arc deposition for the synthesis of coatings and thin films, magnetron sputter inert gas condensation for the synthesis of nanoparticles, as well as plasma surface modification systems. This portfolio to develop functional materials is complemented by facilities for the investigation of microstructure and mechanical/tribological properties. The Chair operates a comprehensive spectrum of materials testing devices, bridging the gap from macro-mechanical testing under different loading conditions and temperatures to a unique set of micro- and nanomechanical testing systems, including various in-situ and operando nanoindenters enabling micromechanical tests ranging from -150 to 1000°C as well as under controlled electrochemical conditions. Furthermore, we apply various simulation tools for deposition processes and materials design. Additional methods for characterization and modelling are used in collaboration within the Department of Materials Science and other Chairs within Montanuniversität. Active research examples include tribological coatings for tools and components for automotive and aerospace applications, thin films for functional devices for microelectronics and displays, functional surfaces for energy conversion/storage and medical technology, as well as the development of advanced micromechanical testing methods for materials characterization under extreme conditions.
A highlight of the year 2024 was a publication in Acta Materialia, which fundamentally contributes to the ongoing scientific debate on the structure of TiSiN hard coatings. To illuminate the formation of a nanocomposite structure versus the formation of a $Ti_{1-x}Si_xN$ solid solution, a series of TiSiN coatings was synthesized using cathodic arc deposition. The influence of varying N_2 pressures and the addition of Ar to the deposition atmosphere on the structure of the TiSiN coatings was investigated by complementary application of several advanced and high resolution characterization methods. For all coatings, the presence of a crystalline $Ti_{1-x}Si_xN$ solid solution as well as an amorphous SiN_x phase fraction could be detected. However, at higher pressures more Si was incorporated into the $Ti_{1-x}Si_xN$ solid solution due to less energetic growth conditions, while the additional kinetic activation from Ar ions reduced the Si incorporation. The findings of the present study allow to gain a novel and previously not accessible insight into the complex correlation of deposition conditions and structure of TiSiN coatings, providing answers to open questions under debate for almost three decades.



Different nanostructures of TiSiN discussed in literature.

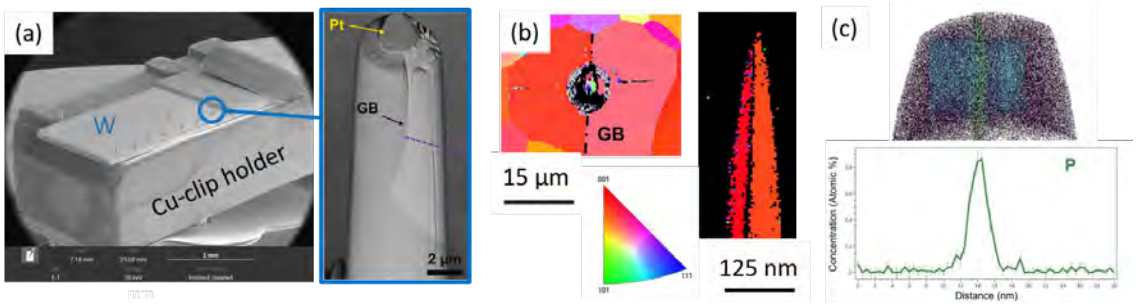
Chair of Physical Metallurgy

Research on structural materials at the Chair of Physical Metallurgy comprises the investigation of the processing-structure-properties relationship of metallic materials, with a focus on advanced steels, titanium alloys as well as refractory metals. High-resolution characterization methods such as atom probe tomography (APT) are used to obtain qualitative and quantitative information about the morphology, composition and distribution of phases. Moreover, the behavior of modern materials under process and application conditions is investigated by using specific diffraction and scattering methods.

Strong expertise in multiscale structural analysis of metallic materials is synergetically connected with modern computational materials science methods. The expertise of the chair lies in combining quantum-mechanical simulations, molecular dynamics simulations, thermokinetic modeling and machine learning to predict physical properties of bulk crystal phases, their extended defects such as grain boundaries, dislocations, or nanostructures.

Since mechanical and functional properties of materials are closely tied to the distribution of such defects and the local chemical composition surrounding them, correlative electron microscopy and APT are key techniques to understand and engineer defects at the near-atomic scale. However, the necessary site-specific specimen preparation (e.g., an APT tip containing a grain boundary of interest) to analyze the local chemical environment at defects is time consuming. Depending on the experience of the operator, about four hours of focused ion beam machining are necessary to prepare APT tips from a single grain boundary. For this reason, typically only one or two grain boundaries of interest are analyzed resulting on low statistics. Linking the solute excess of a single grain boundary to macroscopic properties, or comparing between individual samples, is thus highly challenging.

With the recent installation of a femtosecond (fs) laser ablation device at the Department, we, therefore, focused on a speed up of sample preparation workflows to improve the statistical relevance of APT datasets. Recently, we could demonstrate a robust workflow to use fs-laser ablation to site-specifically prepare APT tips in a high-throughput manner (see the image below). In contrast to focused ion beam workstations, fs-lasers allow to increase material removal rates by orders of magnitude, without inducing thermal effects to the specimen. Within the time used to prepare tips from a single grain boundary with the FIB, an atom probe coupon containing tips from eight individual grain boundaries was directly cut into the material with the fs-laser. Before the transfer to the atom probe and subsequent field evaporation, only a gentle final FIB polishing (20-30 minutes per tip) is necessary. This success could be recently published in Materials Characterization and is available open access (https://doi.org/10.1016/j.matchar.2024.114618). For the future, these developments will enable us to analyze the statistical nature of segregation at defects in a high-throughput manner, a pre-requisite to understand process-structure-properties relationships and deliberately engineer the relevant defects.



a) An APT coupon containing eight grain boundary tips was directly cut into the specimen (commercially pure tungsten) with the fs-laser. Final sharpening of these tips requires very limited FIB time. b) Colour inverse pole figure map of a selected grain boundary prior to fs-laser ablation and the corresponding final tip imaged using transmission Kikuchi diffraction. c) 3D reconstruction of the evaporated tip volume and a 1D line profile across this grain boundary, yielding a local phosphorous concentration of about 0.8 at.%. Images are taken from the published work (J. Tang et al., Materials Characterization 2025, 114618 - https://doi.org/10.1016/j.matchar.2024.114618).

Chair of Materials Physics

The activities of the Chair of Materials Physics are closely linked to its partnering Erich Schmid Institute (ESI) of Materials Science of the Austrian Academy of Sciences. Currently, eight research groups and one junior research group are active at both institutions.

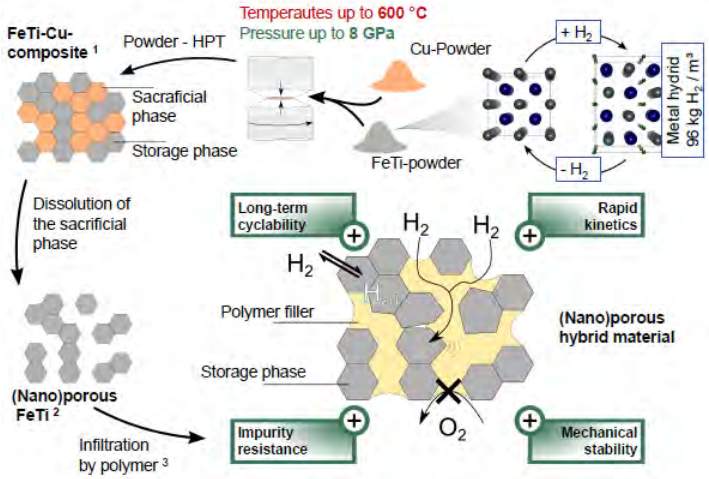
Our research activities encompass structural materials (e.g., steels, compositionally complex alloys, composites, and bioinspired materials), miniaturized material systems for information technology (flexible metal-polymer systems, advanced thin film metallization and functional ceramics), materials for energy and high temperature applications (high entropy alloys, refractory metals, intermetallic alloys), as well as nanocrystalline and amorphous bulk materials (nanocomposites, magnetic nanomaterials, nanoporous metals) for use in hydrogen storage or medical applications.

During the last year, research on interface properties of nano- and microscale materials in various systems (metallic, ceramic, organic) for application in flexible electronics or hard coatings were continued. Due to their attractive property combination, metallic glasses can cover a previously inaccessible niche. Thermoplastic forming of Ti-base metallic glasses enabled patterned surfaces on medical implants and patterned Pt-base metallic glasses as catalysts for hydrogen evolution reactions. Detailed tailoring of nano- and micro-structures is one of our most active research topics to improve mechanical and functional properties. This encompasses the magnetic performance or the hydrogen generation and storage properties of nanomaterials, tailored to the application needs, focusing on generating novel sustainable and responsible materials for green technologies.

To account for the ongoing demands for understanding material properties at all length scales, we address scale-bridging correlation of material nano- and microstructures with structural and functional properties from atomic level to bulk components by state-of-the-art structural and mechanical in situ characterization paired with computational techniques.

Furthermore, modern non-equilibrium processing such as severe plastic deformation, rapid quenching or additive manufacturing allow to create materials with unique properties. The related thermodynamic properties are studied by fast calorimetry at synchrotron beamlines at ESRF in Grenoble and DESY in Hamburg, correlated to locally resolved transmission electron microscopy, and backed-up by simulation and modelling. We exploit this for property and mechanism-based materials design, attempting to develop new materials with outstanding performance.

A current example tackling hydrogen storage in porous metal hydride-polymer hybrid materials is shown below. While metal hydrides hold promise as the superior storage option, many hurdles, including slow kinetics and insufficient stability, need to be surmounted. These are overcome by porous metal hydride-polymer composites designed for efficient solid-state hydrogen storage.



Concept of porous metal hydride-polymer composites: The storage material is blended with an immiscible sacrificial phase and refined to a nanoscale composite using high-pressure torsion at ambient or elevated temperatures. The sacrificial phase is subsequently removed selectively by wet-chemical dissolution. The resulting nanoporous structure, stabilized by a hydrogen permeable polymer, is beneficial for hydrogen absorption.

Chair of Structural and Functional Ceramics

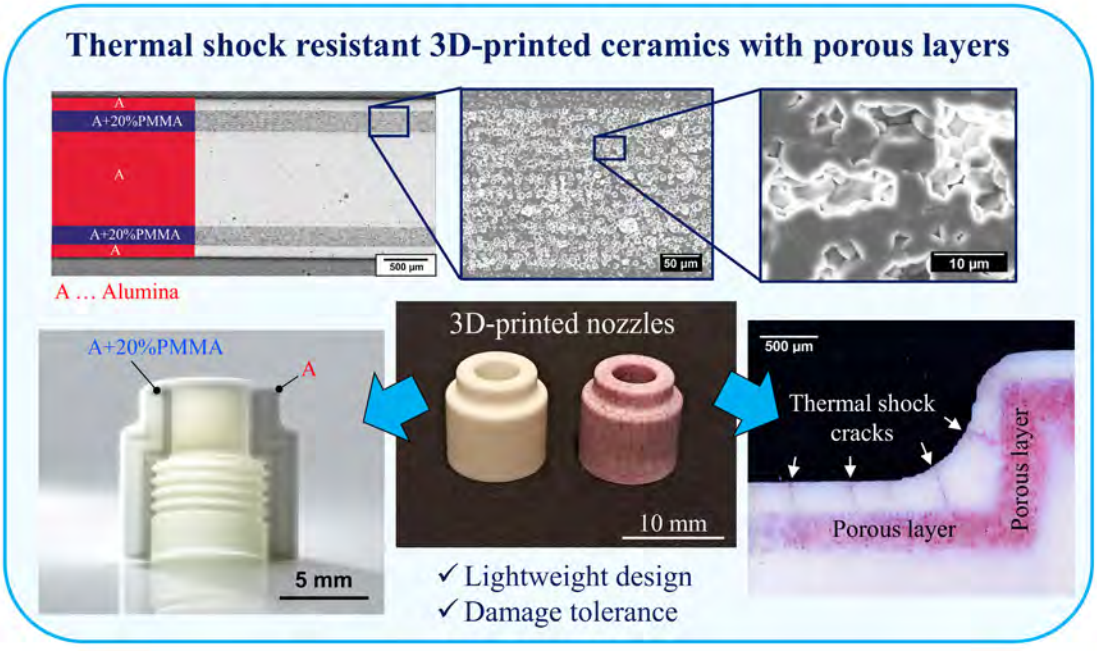
The Chair of Structural and Functional Ceramics aims to provide engineering solutions to the ceramic industry with primary focus on structural and functional applications. The research fields cover ceramic processing, material and system characterization as well as process simulation, with special focus on electro-ceramics. Student engagement in (fundamental / applied) research projects at the Chair and participation in national and international conferences is also a key educational aspect.

The work with industrial partners has evidenced the need for special testing techniques, e.g. for strength and toughness testing of thinner discs or plates, as well as small balls or cylinders (e.g. for roller bearings). A strong competence of the Chair is the development of testing methods for mechanical characterization of ceramics, which has led to several standards, that are today common practice in the ceramic industry. One example for such a special strength test is the ball-on-three-balls (B3B) test, which was developed at the Chair. This test enables the strength testing of particularly small and inexpensive samples.

The Chair is also well known for its work on fracture statistics, lifetime prediction and reliability analysis. Failure analysis of ceramic materials and components is one of the main topics investigated at the Chair. This includes brittle fracture, subcritical crack growth and creep, but also more specific types of failure such as edge chipping and thermal shock. The knowledge obtained from failure analyses and fractography of specimens represents often the starting point for further work.

The Chair's special methodological competences also lies in the electro-mechanical characterization of electro-ceramic components upon thermo-electrical loads, with special focus on understanding and modelling the non-linear behaviour of many ceramic components and systems. Models on different size scales - from atomic to macroscopic scales- have been developed and integrated to describe the component behaviour. Especially the results of this work has led to a completely new knowledge, e.g. about the behaviour of strongly non-linear electrical resistance in functional ceramics.

A new research line at the Chair has been encouraged by the ERC-Grant aiming to designing and manufacturing bio-inspired structures with high reliability. The working fields "Design and Manufacturing" and "Characterization of Multi-Material Systems" with a strong focus on microelectronics have gained importance in the research landscape of the Chair. Pioneer work in stereolithographic 3D-Printing of ceramics is a new feature at the Chair, which enables the fabrication of parts with tailored microstructure (see Figure) and opens new paths for the architectural design of ceramic composites with enhanced properties.



Investments

Investments

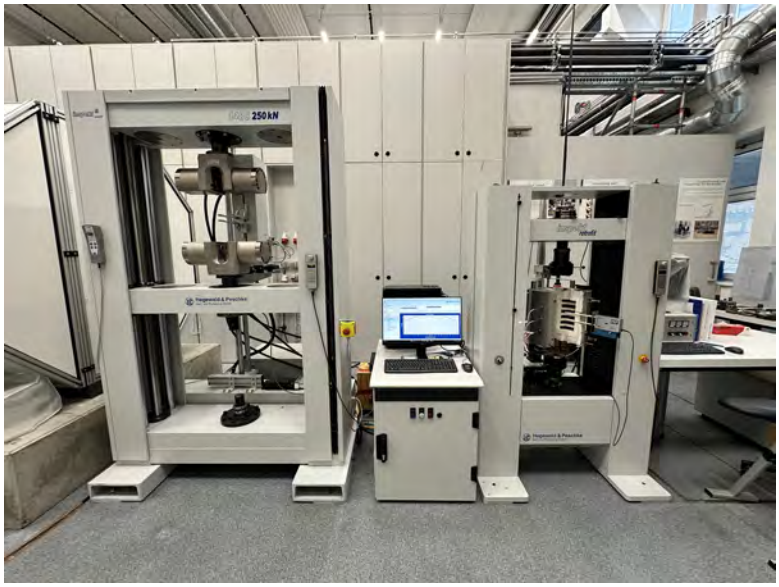
New multifunctional diffractometer

In the first half of 2024, a state-of-the-art 2D diffractometer (XRD²) of the type Bruker D8 Discover was put into operation at the Department. The XRD² impresses with its high flexibility and modularity, featuring various optics, an in-plane arm, and a central Eulerian cradle with motorized rotation and translation. This enables automated measurements and the mounting of various in-situ modules such as high-temperature chambers and mechanical load cells. A large cabinet provides ample space for additional equipment such as vacuum pumps and control devices. The XRD² opens up numerous new application areas and represents a significant advancement for the Department, as it is suitable for both standard applications and the complex demands of modern materials research. We are confident that this device will make a significant contribution to our research activities, and we look forward to the new possibilities it offers.

Refurbishment of universal testing machines

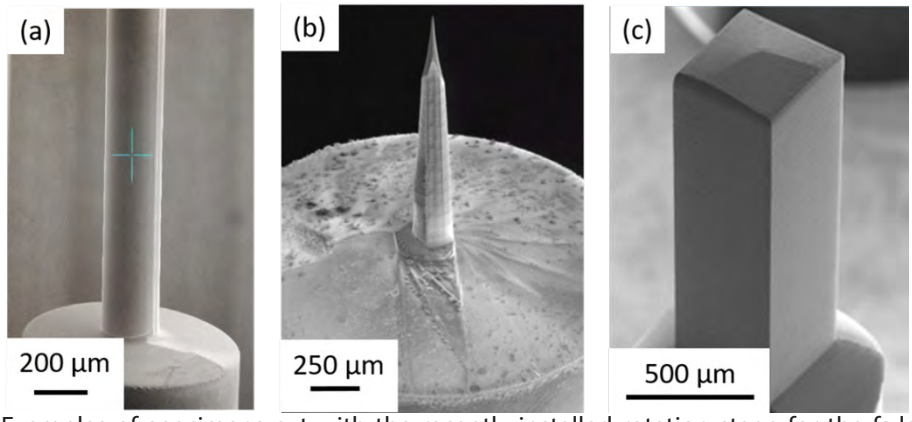
After more than 30 years in service, two universal testing machines had do undergo a well-deserved revision. The two machines with a maximum load of 250 and 50 kN, respectively, where picked up in February and transported to Hegewald & Peschke in Nossen, Germany. After a thorough revision, they were reinstalled in September, right before the start of the university semester.

A key improvement was the upgrade of the 50 kN unit with a furnace capable of reaching temperatures up to 1000°C, allowing for high-temperature material testing. These revisions now allow us to perform tensile, compression, and bending tests on both the macroscopic and the mesoscopic scale, significantly broadening our testing portfolio. This investment is essential not only for strengthening our research activities, but also for advancing our teaching capabilities to provide students the necessary hands-on experience in materials testing.



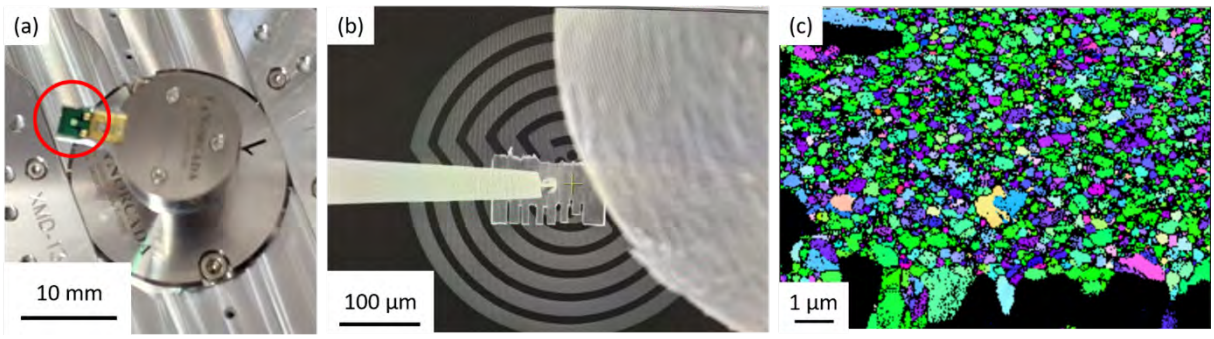
Rotation stage for the fs-laser microPREP and heating stage for the SEM/FIB

Two upgrades for the femtosecond laser (fs-laser) and the scanning electron microscope (SEM)/ focused ion beam workstation (FIB), respectively, could be realized and put in operation in 2024. For the fs-laser (microPREP PRO femto from 3D MICROMAC) an additional rotation stage allows now to rapidly process rotational symmetric specimens, such as used frequently for XRD-based tomography or microstructural analysis. Besides, also specimen holders for correlative investigations (e.g., electron microscopy and atom probe tomography) can now easily be prepared. Moreover, with the rotation stage the often unavoidable taper angle can be perfectly avoided, making it additionally interesting for local mechanical properties testing (see figure below).



Examples of specimens cut with the recently installed rotation stage for the fs-laser device at the Department. a) specimen for 3D-XRD microstructure mapping; b) pre-prepared atom probe tip; c) smaller-scale sample for a compression test.

For the SEM (TESCAN Clara) a membrane-based MEMS chip heating stage (Norcada, Canada) was purchased. The heating stage can be used inside the SEM as well as the FIB and can currently be operated up to 1200 °C (see figure below). Heating chips allowing for even higher temperatures are about to be released by Norcada. Due to the availability of different chips the heating stage can be flexibly used in transmission (TEM foils) and reflection, as well as for largely different sample sizes (from site-specific TEM lamella up to bulk samples with ~2 mm size). Another advantage to frequently available bulk heating stages is the extremely small and local power input, that limits signal noise for the detectors originating from thermal electrons. This has especially been a problem when acquiring secondary electron images. As the EBSD and EDX detectors were also equipped with infrared filters, in-situ heating experiments can now be routinely coupled with additional analytical measurements (see figure below). Here, the exceptional acquisition speed of ~6,000 fps of the EBSD camera is a clear asset to capture also crystallographic information of fast high-temperature processes. We thus expect fascinating in-situ insights into currently pending questions of the dynamics of interfaces.



a) Heating stage mounted to the SEM stage, with the actual heating chip circled; b) secondary electron image of a chip being loaded with a specimen in the FIB; c) colour inverse pole figure map of a PVD Au film taken at 400 °C.

Scanning electron microscope for micromechanical experiments

Recently, a new Zeiss LEO 1530 scanning electron microscope was installed at the Chair of Materials Physics. The microscope with field emission cathode is a high-resolution device that will be used to perform advanced in-situ micromechanical experiments and to develop new in-situ and in-operando methods. These experiments are crucial for understanding material behavior in small dimensions, which is important in many areas of materials science, especially in microelectronics and in the development of new materials.

The high-resolution imaging capabilities of this device will allow us to gain deeper insights into the deformation and fracture behavior of materials under stress at the micro- and nanometer scale.

The microscope is housed together with micromechanical testing equipment in our newly established in-situ laboratory. This allows us to prepare and carry out experiments in a single laboratory, which simplifies the workflow.

Budget

Revenues

At Austrian universities, revenues are structured as follows:

1. Global budget
2. Third-party funds
    a. Sponsored third-party funds
    b. Contract research

Global budget

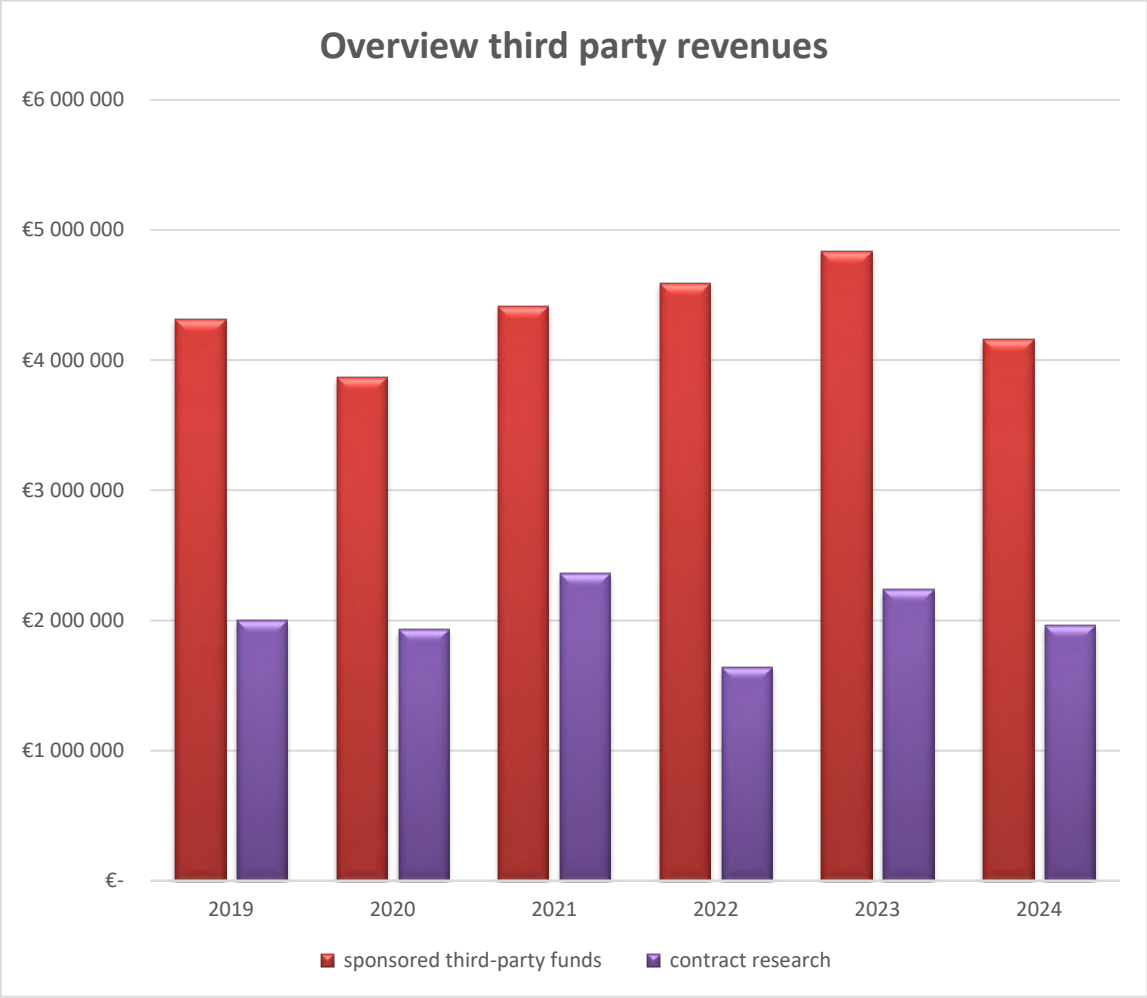
This endowment is to cover current operating expenses for research and teaching (incl. travel expenses, telephone, office supplies, copies for teaching and minor purchases for research operations; excl. university-funded positions)

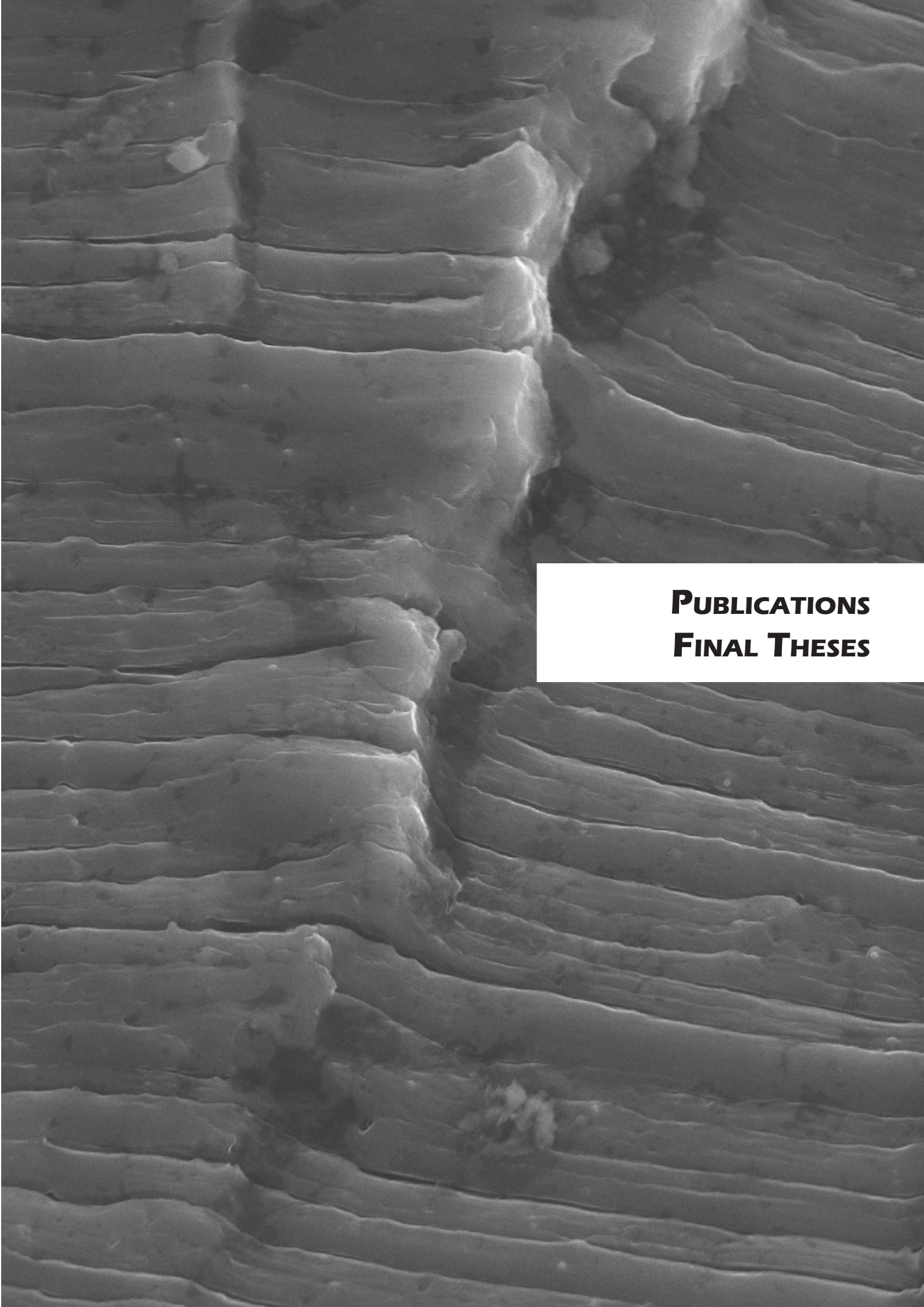
Third-party funds

Due to extensive third-party funding activities, the Department managed to keep the revenue of the budget year 2024 at a high level compared to previous years.

The budget from funded projects amounted to: € 4.157.800,-.

The budget from contract research amounted to: € 1.963.400,-.



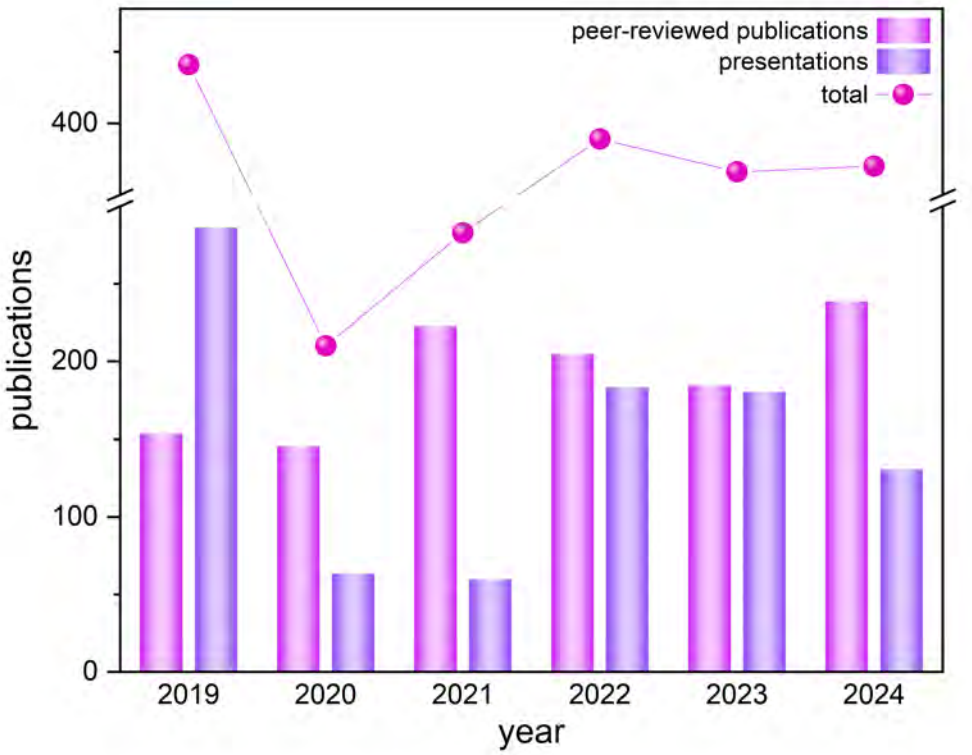


Publications
Final Theses

Publications and presentations

In line with the vision of the Department of Materials Science to conduct applied basic research of industrial relevance, it is a natural endeavor to publish the research results obtained in high-ranking journals and to present them at international conferences. In particular, this should also give young scientists the opportunity to present themselves to the international scientific community and to gain experience in publishing. Despite the Department‘s intensive cooperation with industrial partners, where often non-disclosure agreements are necessary, the research results obtained were made available to the public in 2024 in 239 articles in scientific journals and 131 presentations at scientific events. With this, the Department contributes significantly to the publication activity and thus to making the research activities of the Montanuniversität Leoben visible.

The following figure shows the development of publications and conference contributions over the last 6 years.



In the following a list of highlight publications is given. A detailed list of publications is available on the research portal of the Montanuniversität Leoben at “https://pure.unileoben.ac.at/portal/de/”.

Chair of Functional Materials and Materials Systems

Hans, M., Schneider, J. M., Matthews, A., Mitterer, C., Perspective on pathways towards responsible surface engineering, Surface & Coatings Technology 494 (2024) 131486.

Knabl, F., Gutnik, D., Patil, P., Bandl, C., Vermeij, T., Pichler, C. M., Putz, B., Mitterer, C., Enhancement of copper nanoparticle yield in magnetron sputter inert gas condensation by applying substrate bias voltage and its influence on thin film morphology, Vacuum 230 (2024) 113724.

Kölbl, L., Mehrabi, M., Griesser, T., Munnik, F., Mitterer, C., Lead-free dielectric thin films: Synthesis of $Ag(Nb_{1-x}Ta_x)O_3$ via reactive dc magnetron sputtering, Journal of Vacuum Science & Technology A 43 (2024) 1.

Konstantiniuk, F., Schiester, M., Tkadletz, M., Czettl, C., Schalk, N., Annealing activated substrate element diffusion and its influence on the microstructure and mechanical properties of CVD TiN/TiCN coatings, Surface & Coatings Technology 488 (2024) 131079.

Lumper, L., Fecher, J., Stark, A., Maier-Kiener, V., Investigation of phase transformations and ordering mechanisms in a Pd–Cu–Ag–Ru alloy, Advanced Engineering Materials 26 (2024) 2400255.

Schalk, N., Moritz, Y., Nayak, G. K., Holec, D., Hugenschmidt, C., Burwitz, V. V., Mathes, L., Schiester, M., Saringer, C., Czettl, C., Pohler, M., Mitterer, C.,Tkadletz, M., Nanocomposite versus solid solution formation in the TiSiN system, Acta Materialia 275 (2024) 120063.

Schiester, M., Waldl, H., Hans, M., Thuvander, M., Primetzhofer, D., Schalk, N., Tkadletz, M., Influence of multiple detection events on compositional accuracy of TiN coatings in atom probe tomography, Surface & Coatings Technology 477 (2024) 130318.

Sommerauer, M., Seligmann, B., Gottlieb, H., Hohenwarter, A., You, J.-H., Bostrom, N., Pippan, R., Siller, M., Maier-Kiener, V., Enhanced thermomechanical fatigue resistance in W10Re alloys: Microstructural and surface engineering approaches, Nuclear Materials and Energy 41 (2024) 101769.

Tkadletz, M., Schiester, M., Waldl, H., Schusser, G., Krause, M., Schalk, N., Fs-laser preparation of half grid specimens for atom probe tomography and transmission electron microscopy, Materials Today Communications 39 (2024) 108672.

Zeiler, S., Jelinek, A., Terziyska, V., Schwaiger, R., Mitterer, C., Brinckmann, S. & Maier-Kiener, V., A new approach for in situ electrochemical nanoindentation: Side charging as a promising alternative, Acta Materialia 276 (2024) 120113.

Chair of Physical Metallurgy

Glushko, O., Pippan, R., Şopu, D., Mitterer, C., Eckert, J., How to catch a shear band and explain plasticity of metallic glasses with continuum mechanics, Nature Communications (2024) 5601.

Pototschnig, U., Matas, M., Scheiblehner, D., Neuschitzer, D., Obenaus-Emler, R., Antrekowitsch, H., Holec, D., Predictive model for catalytic methane pyrolysis, Journal of Physical Chemistry 128 (2024) 9034-9040.

Reichmann, A., Tuchinda, N., Dösinger, C. A., Scheiber, D., Razumovskiy, V. I., Peil, O. E., Matson, T. P., Schuh, C. A., Romaner, L., Grain boundary segregation for the Fe-P system: Insights from atomistic modeling and Bayesian inference, Acta Materialia 279 (2024) 120215.

Reiners-Sakic, A., Schnitzer, R., Holec, D., Interplay between alloying and tramp element effects on temper embrittlement in bcc iron: DFT and thermodynamic insights, Acta Materialia 275 (2024) 120044.

Renk, O., Hohenwarter, A., Edalati, K., Kapp, M. W., Saturation of grain fragmentation upon severe plastic deformation: Fact or fiction? Advanced Engineering Materials 26 (2024) 12.

Rosenauer, A., Brandl, D., Ressel, G., Hönigmann, T., Stadler, M., Turk, C., Gammer, C., Wiessner, M., Gamsjäger, E., Stockinger, M., Schnitzer, R., Multiscale in-situ observations of the micro- and nanostructure of a PH 13-8 Mo maraging steel during austenitization, Materials Characterization 208 (2024) 113554.

Scheiber, D., Razumovskiy, V. I., Peil, O. E., Romaner, L., High-throughput first-principles calculations and machine learning of grain boundary segregation in Metals, Advanced Engineering Materials 26 (2024) 2400269.

Schrittwieser, D., Pahr, H., Musi, M., Landefeld, A., Glushko, O., Schnitzer, R., Revealing the embrittlement phenomena after post-weld heat treatment of high-strength weld metal using high-resolution microscopy, Journal of Materials Research and Technology 33 (2024) 5289-5298.

Taucher, L., Ramadan, Z., Hammer, R., Obermüller, T., Auer, P., Romaner, L., Machine learning assisted calibration of PVT simulations for SiC crystal growth, CrystEngComm 44 (2024) 6322-6335.

Zhang, D., Wang, J., Wu, Q., Du, Y., Holec, D., Ab initio study of oxygen vacancy filament formation at Ta/HfO_2 interface, Surfaces and Interfaces 49 (2024) 104418.

Chair of Materials Physics

Cai, F. F., Sarac, B., Akman, A., Londono, J. J., Gumrukcu, Eckert, J., Spieckermann, F., Enhanced hydrogen evolution via nanopatterned Pt-based metallic glass and dynamic copper oxide foam formation, Materials & Design 249 (2024) 113530.

Gammer, C., Issa, I., Minor, A. M., Ritchie, R. O., Kiener, D., Strain field around individual dislocations controls failure, Small Methods 8 (2024) 2400654.

Gao, Q., Kou, Z., Zhou, C., Liu, X., Zhang, J., Eckert, J., Exceptional strength-ductility synergy in a casting multiprincipal element alloy with a hierarchically heterogeneous structure, Materials Today 81 (2024) 70-83.

Glushko, O., Pippan, R., Sopu, D., Mitterer, C., Eckert, J. How to catch a shear band and explain plasticity of metallic glasses with continuum mechanics. Nature Communications, 15 (2024) 5601.

Hadibeik, S., Gingl, E., Schretter, L., Bochtler, B., Li, J., Schretter, L., Gammer, C., Hadibeik, S., Eckert, J., Hohenwarter, A., Spieckermann, F., Semi-analytical and experimental heat input study of additively manufactured Zr-based bulk metallic glass: Insights into nano- and global-scale relaxation and crystallization, Additive Manufacturing 89 (2024) 104295.

Kiener, D., Misra, A., Nanomechanical characterization, MRS Bulletin, 49 (2024) 214-223.

Liu, X., Song, K., Kou, Z., Gong, J., Chen, X., Ramasamy, P., Zhang, Z., Eckert, J., Synergistic grain boundary engineering for achieving strengthductility balance in ultrafine-grained high-Cr-bearing multicomponent alloys, International Journal of Plasticity 177 (2024) 103992.

Neumüller, D., Rafailovic, L.D., Pašti, I.A., Griesser, T., Gammer, C., Eckert, J., Revealing the role of Mo leaching in the structural transformation of NiMo thin film catalysts upon hydrogen evolution reaction, Small 20 (2024) 2402200.

Yildirim, C., Flatscher, F., Ganschow, S., Lassnig, A., Gammer, C., Todt, J., Keckes, J., Rettenwander, D., Understanding the origin of lithium dendrite branching in $Li_{6.5}La_3Zr_{1.5}Ta_{0.5}O_{12}$ solid-state electrolyte via microscopy measurements, Nature Communications 15 (2024) 8207.

Qu, Z., Zhang, Z., Liu, R., Xu, L., Zhang, Y., Li, X., Zhao, Z., Duan, Q., Wang, S., Li, S., Ma, Y., Shao, X., Yang, R., Eckert, J., Ritchie, R.O., Zhang, Z., High fatigue resistance in a titanium alloy via near-void-free 3D printing, Nature 626 (2024) 999–1004.

Chair of Structural and Functional Ceramics

Harrer, W., Gruber, M., Melcher, V., Tilz, A., Engelmayer, M., Wimmer, A., Bermejo, R., Ceramic materials as an alternative for conventional spark plug electrodes, International Journal of Applied Ceramic Technology 21 (2024) 4393-4403.

Jabr, A., Kuzmić, N., Škapin, S.D., Jantunen, H., Nelo, M., Spreitzer, M., Bermejo, R., Towards high strength $SrTiO_3$-based composites fabricated at room temperature, Journal of the European Ceramic Society 44 (2024) 116782.

Papšik, R., Sevecek, O., Schlacher, J., Bermejo, R., Prediction of thermal shock induced cracking in multi-material ceramics using a stress-energy criterion, Engineering Fracture Mechanics 303 (2024) 110121.

Salamon, D., Siddiqui, M., Scaffold microstructure evolution via freeze-casting and hydrothermal phase transformation of calcium phosphate, Journal of the American Ceramic Society 107 (2024) 7994-8006.

Sänger, J., Riechers, B., Pauw, B., Maass, R., Günster, J., Microplastic response of 2PP-printed ceramics, Journal of the American Ceramic Society 107 (2024) 6636-6645.

Schlacher, J., Bastos Mateus, L., Nohut, S., Schwentenwein, M., Bermejo, R., Thermal shock resistant 3D-printed ceramic components through spatially tailored porosity, Additive Manufacturing 96 (2024) 104582.

Schlacher, J., Geier, S., Schwentenwein, M., Bermejo, R., Towards 3D-printed alumina-based multi-material components with enhanced thermal shock resistance, Journal of the European Ceramic Society 44 (2024) 2294-2303.

Staudacher, M., Eggel, A., Supancic, P., Lube, T., The Ball-on-Three-Balls strength test: Effective volumes and surfaces for Weibull strength scaling, Journal of the European Ceramic Society 44 (2024) 173-183.

Staudacher, M., Scheithauer, U., Reichel, M., Lorenz, N., Schwentenwein, M., Lube, T., Strength testing of additive manufactured ceramics – A round robin using the CharAM-methodology, Open Ceramics 17 (2024) 100557.

Supancic, P., Maurer, F., Danzer, R., Biaxial bending strength testing of uniaxially curved thin plates using a modified ball on three balls test, Journal of Non-Crystalline Solids 639 (2024) 123067.

Special issues

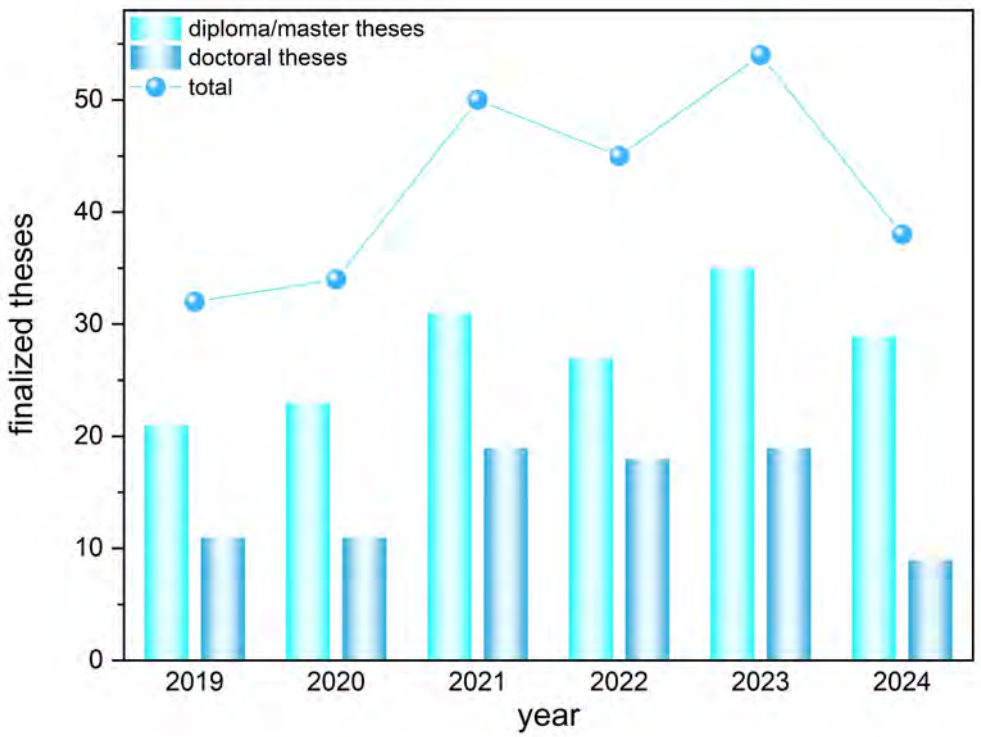
Chu, P., Martinu, L., Mitterer, C., Special Collection: Multifunctional coatings and surfaces, Journal of Vacuum Science & Technology A (2024).

Kiener, D., Hohenwarter, A., Editorial for the special issue on the occasion of Reinhard Pippan's 70th birthday: Celebrating a legacy of innovation and excellence in material science, Advanced Engineering Materials 26 (2024) 2401772.

Maier-Kiener, V., Clausner, A., Hoefnagels, J., EUROMAT23: Micro- and nano-mechanics – characterization and modelling, JOM – The Journal of The Minerals, Metals and Materials Society 76 (2024).

Master and doctoral theses

The following figure shows an overview of the completed diploma/master and doctoral theses of the last 6 years:



Master theses

In 2024, 29 students completed their theses.

Bauer, Nicolas Erwin
A laboratory total scattering approach for studying short-range order in a novel precipitation-strengthened compositionally complex alloy

Gindel, Theresa
$BiMg_{2/3}Nb_{1/3}O_3$-based thin films from chemical solution deposition - A study on the influence of the process parameters on the structure and the electrical properties

Gottlieb, Hannah Maria
Micromechanical characterisation of phase transitions

Graf, Maximilian
Hydrogen embrittlement in steels: state-of-the-art in theory and practice

Gruber, Fabian Ingo
Thermal treatment of continuous alumina fibers

Heim, Christopher
Local deformation behaviour of hipped molybdenum

Jahn, Marco Paul
Direct fabrication of tailored metal-carbon nanocomposites made by two-photon polymerization

Kaplan, Pia
Effects of processing conditions on electrical properties of cold sintered $BaTiO_3$

Kaufmann, Martina
NbC-Precipitates in a PH 15-5 steel

Kirchmair, Magdalena
Development of high entropy alloy thin films for hydrogen permeation barriers

Krammer, Klaus
Influence of ausforming on the microstructure of PH13-8 Mo maraging steels

Kuhn, Alexander
Development and automation of a bulge test procedure for polymer supported thin films

Ladinger, Lukas
Fabrication and mechanical characterisation of advanced alumino-borosilicate glasses

Luger, Thomas
High-resolution investigation of the Nb solubility in microalloyed steels

Moya Merino, Carlos
Multiphysics simulations of PVT process for SiC growth

Neumüller, Johannes
Electrical cycling and failure analysis of a lead-free piezoceramic

Payer, Philipp Emanuel
Functional magnetic composite materials with tuneable magnetic properties

Pferschy, Matthias
Characterization of the micro- and nanostructure of a high-alloy, martensitic Cr-steel

Prutti, Maria Theresa
Investigation of the lifetime of sintered interconnects in power electronics

Rechberger, Andreas
Impact of measurement errors on machine learning models in steel production

Rinnhofer, Nicole
Phase fraction and morphology of retained austenite in high-strength weld metal

Ruess, Leon
Impact of the wire arc additive manufacturing (WAAM) process on the distortion and residual stress state of rapidly rotating components in solid/liquid separation

Schiester, Maximilian
Advancements in elemental analysis of Ti(C,N) coatings using atom probe tomography

Stockinger, Lucia-Maria
Investigation of possible temper embrittlement in pearlitic steels with elevated levels of trace elements

Taurer, Gregor
Microstructural influences on bending resonance fatigue in nickel-based superalloy Rene‘88DT

Teuschl, Hanna
Segregation analysis of a temper embrittled 51CrV4 with elevated trace element content for green steel production

Verhoestraete, Emile
The anneal hardening phenomenon in the nanostructured Ti-Nb-Zr system

Waidbacher, Viktoria Anna
Determination of mechanical properties of a low temperature co-fired ceramic

Ziegler, Maximilian
Mechanical and electronic properties of monolayer TMDCs: A DFT study

Doctoral theses

In 2024, 9 doctoral students were awarded doctorates in montanistic sciences.

Böhle, Sandra Isabel
Effect of Cu on the carbide and nitride formation in steels for high-power density gears

Cai, Fei-Fan
Designability and versatility of thermoplastic forming for bulk metallic glasses

Gebhart, David
Metallic thin film fatigue dominated by the interface character

Knabl, Florian
Pathways towards the functionalization of three-dimensional substrates

Rosenauer, Andreas
Processing-structure-properties relationships of PH 13-8 Mo maraging steels

Schlacher, Josef Christian
Understanding the fracture behaviour of 2D/3D ceramic architectures with tailored microstructures

Schmuck, Klemens Silvester
Micro-mechanical approach to assess the strength of nanocrystalline tungsten-copper composites

Weissitsch, Lukas Emanuel
Microstructure and magnetic properties of high-pressure torsion synthesized hard magnetic materials

Zhang, Zequn
Microstructures and mechanical properties of CoCrFeNiAl-based high-entropy alloys

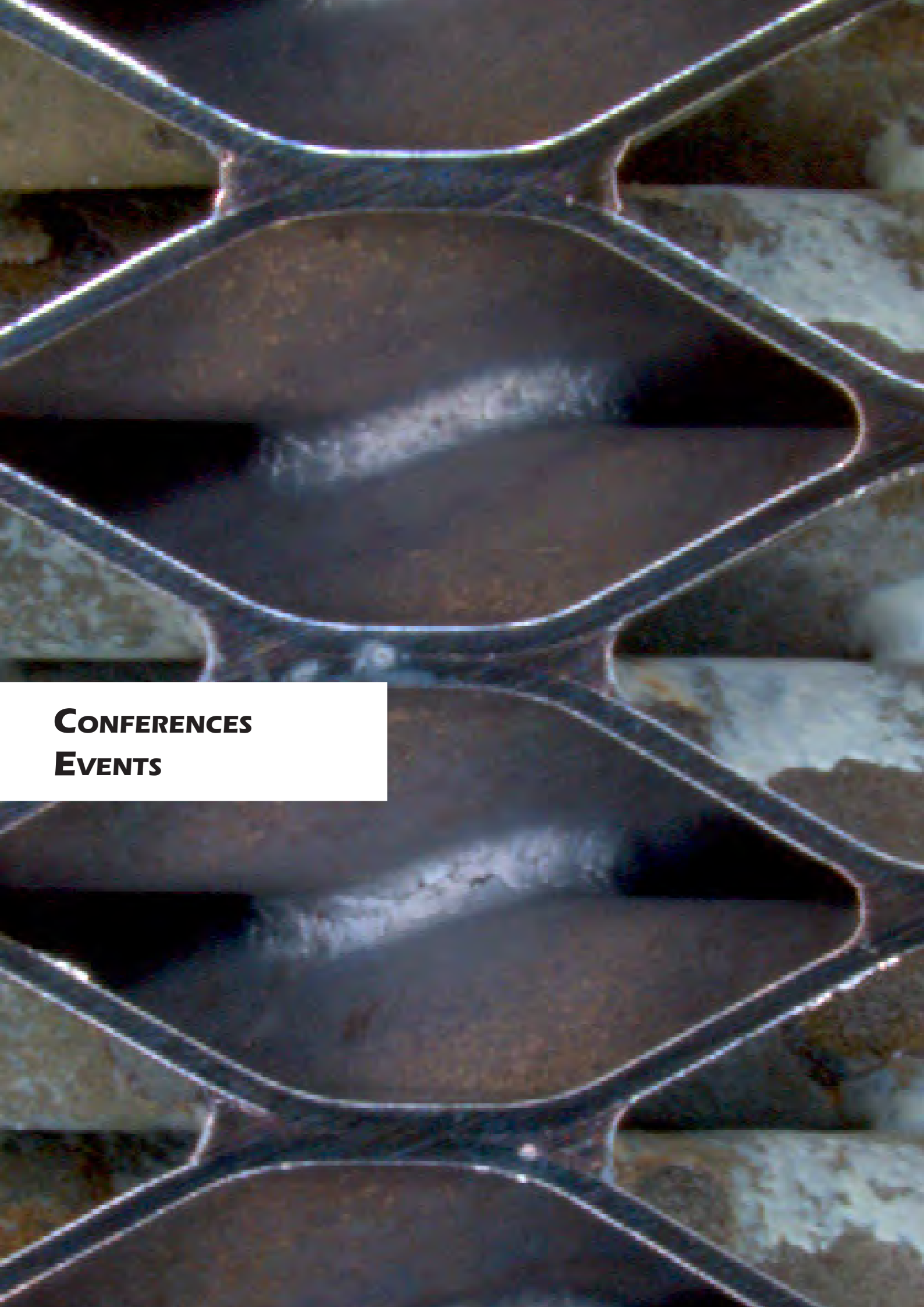
Habilitation

Tanja Lube, assistant professor at the Department of Materials Science at the Montanuniversität Leoben, Chair of Structural and Functional Ceramics, has successfully completed her habilitation. Her habilitation thesis is dedicated to the development and optimization of modern testing methods for evaluating the strength and fracture toughness of brittle materials, especially ceramic components.

Ceramic components have varying properties due to complex manufacturing processes, which is why precise and application-specific testing methods are essential in order to be able to make statements about the component behaviour. A particular challenge is that such components are often only a few millimetres in size. The results of Tanja Lube‘s work form the basis for the further development of modern testing methods, which play a central role in the additive manufacturing of ceramics in particular and support the development of more efficient materials.

About the person

Tanja Lube lives in Leoben and is mother of two now grown-up children. She studied materials science at the Montanuniversität Leoben and received her doctorate with distinction in 1999. Since then, she has worked at the Department of Materials Science, where she develops innovative test methods and standards for ceramics, including additively manufactured materials. She is also a member of numerous scientific societies, including the Austrian Ceramics Society and ESIS + ESIS Austria.



Conferences
Events

Conferences and events

Organization of conferences

Members of the Department were engaged in the organization of scientific conferences and other scientific events, as shown in the next pages.

4th German-Austrian Workshop "Computational Materials Science on Complex Energy Landscapes" (January 15 – 19, 2024, Kirchdorf, Austria)

After the Corona break, the Computational Materials Science group from the Department of Materials Science of the Montanuniversität Leoben together with the Max Planck Institute for Sustainable Materials have been able to revive the tradition of Austrian-German Workshops on "Computational Materials Science on Complex Energy Landscapes". The last year's edition took place during the week January 15 - 19, 2024, in a beautiful Hotel Gasteiger Jagdschlössl in Kirchdorf in Tirol. Over 50 researchers from Technische Universität Wien, ESI Leoben, Materials Center Leoben Forschung GmbH, University of Stuttgart, ICAMS and BAM Berlin enjoyed dense lecture programme, scientific discussions as well as an informal exchange of knowledge and ideas, both inside as well as outside.

153rd TMS Annual Conference (March 3 - 7, 2024, Orlando, Florida, USA)

With more than 4,000 attendees, the 153rd TMS Annual Meeting in Orlando, Florida, was a very successful highlight in the annual materials science calendar. Materials scientists from Leoben were well represented at this meeting and gave a number of well-attended scientific presentations in various symposia, but also enjoyed interacting with international colleagues and leaders in the field. The rocket launches that took place at night were a particular highlight. Special mention should be made of an invited lecture by Verena Maier-Kiener, who was also supported by the TMS through a Family Care Grant. Daniel Kiener, current chair of the Nanomechanical Materials Behavior Committee, served as co-organizer of the symposium “Mechanical Behavior at the Nanoscale VII“.

AM@MUL meeting at ISFK (March 14, 2024, Leoben)

On March 14, 2024, the Chair of Structural and Functional Ceramics, together with organizers of the AM@MUL group, invited participants to a lecture on additive manufacturing of multi-material ceramics. In a subsequent laboratory tour, processing laboratories and the 3D printer at the ISFK were shown.

AM@MUL is intended to enable an exchange about the activities of various working groups and chairs at the Montanuniversität in connection with additive manufacturing and, in addition to networking, also serves to find new cooperation opportunities. The organizers would like to thank all participants for their interest and lively exchange!

More information about AM@MUL can be found on www.addmanu.at.

3rd Materials Science Colloquium (68. Metallkunde-Kolloquium) (April 15 - 18, 2024, Lech am Arlberg)

From April 15 - 18, 2024, the 3rd Materials Science Colloquium (68th Physical Metallurgy Colloquium) was held in Lech am Arlberg. Organized by the entire Department of Materials Science, this year's event focused on "Advanced Micro- and Nanomechanical Analysis." With 32 engaging presentations, including contributions from esteemed international speakers from Germany, the colloquium fostered dynamic scientific discussions in a relaxed winter setting—leaving participants eager for more.

50th International Conference on Metallurgical Coatings & Thin Films (ICMCTF) (May 19 - 24, 2024, San Diego, USA)

In May 2024 the 50th anniversary of the ICMCTF was celebrated. For this special occasion also the structure of the conference was modified and a topical symposium on “Sustainable Surface Engineering” was added to the program, where Nina Schalk co-organized the session on “Circular Strategies for Surface Engineering” (TS5), which was very well received by the audience. David Holec co-organized the symposium “Advanced Characterization, Modelling, and Data Science for Coatings and Thin Films” (CM), where Barbara Putz and Michael Tkadletz chaired the session “Spatially-resolved and In-situ Characterization of Thin Films and Engineering Surfaces”. These sessions highlighted the most recent developments in the field of thin film and coating design, synthesis and advanced characterization and also the increasing importance of sustainability in the community.

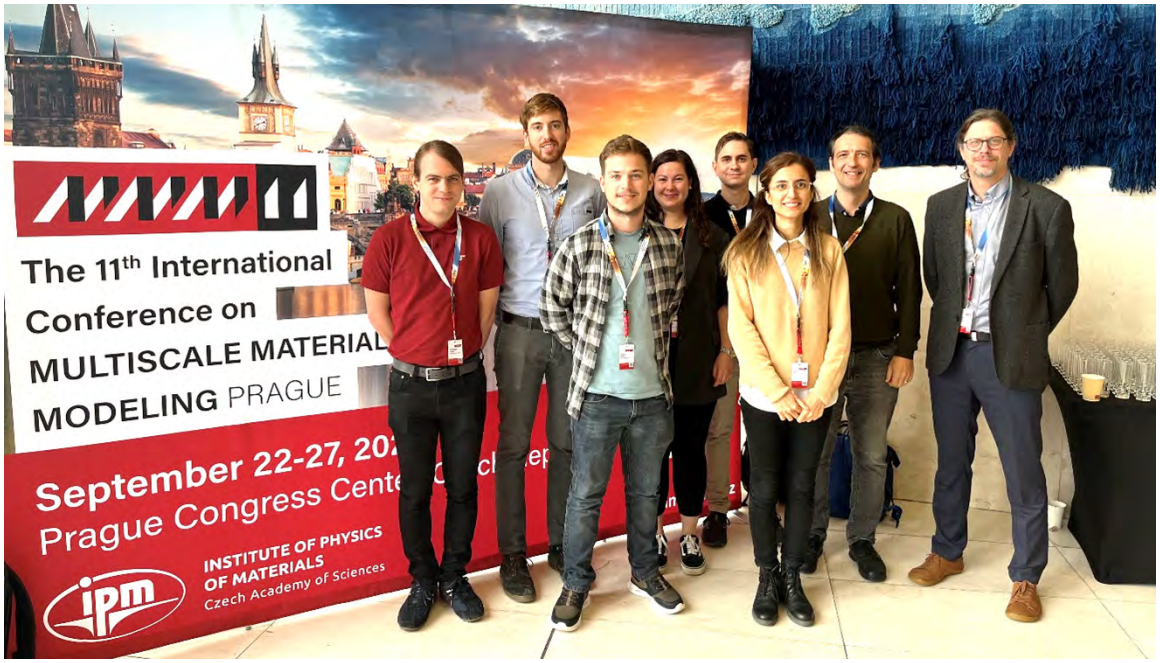
MecaNano 2nd General Meeting (May 1 - 3, 2024, Vienna, Austria)

TU Vienna welcomed the MecaNano network during the 2nd General Meeting (GM2) held in Vienna May 1 - 3, 2024. The event was kicked off by the MecaNano members and organizers Helmut Riedl (TU Vienna), Verena Maier-Kiener (Department Materials Science, MUL), and Megan Cordill (ÖAW-ESI, Leoben) with a session on some new developments in nanomechanical testing. The second day brought three more sessions on multiscale nanomechanical behavior, nanoindentation and machine learning approaches. Jürgen Stampfl, the keynote speaker from the TU Vienna Faculty of Mechanical and Industrial Engineering and an Alumni from Materials Science Leoben, talked about fracture toughness and thermomechanical behavior of 3D printed materials. After a lively poster session, participants boarded a dedicated tram for a trip through Vienna to the conference dinner location at a traditional Viennese Heurigen. On the final day, three more sessions on simulations, research data management, and size effects were presented. During the three-day event, five invited speakers presented along with 27 oral and 36 poster presentations to 94 MecaNano members from 27 countries.

The 11th International Conference on Multiscale Materials Modeling (September 22 - 27, 2024, Prague)

The International Conference on Multiscale Materials Modeling (MMM) series is the world's largest conference series focused on different aspects of MMM, including computational mechanics, computational biomechanics, and computational materials science. It combines existing and emerging methods from interdisciplinary fields to bridge phenomena occurring across different length and time scales that are common to complex material systems often inspired by nature.

The Computational Materials Science group has organized two symposia, "Quantum mechanical studies of structure and properties of materials", as well as "Machine learning assisted materials discovery".



Materials Science and Engineering (MSE) 2024 (September 24 - 26, 2024, Darmstadt, Germany)

Daniel Kiener was honored as a Plenary Speaker at the Materials Science and Engineering (MSE) 2024 Congress, held from September 24 - 26, 2024, in Darmstadt, Germany. This prestigious event brought together 1300 leading researchers and industry experts from 48 countries to discuss the latest advancements in materials science and engineering.

Daniel Kiener contributed to the conversation with a presentation on “Designing nanostructured materials for harsh environments by grain boundary engineering“, highlighting the premise of interface engineering utilizing only minor amounts of local doping elements in designing sustainable materials with outstanding functional and structural properties.

Furthermore, Anna Jelinek and Verena Maier-Kiener from the Department of Materials Science were involved in organizing the symposia “C08: Multi-Method High-Resolution Microscopy for Materials Science“ and “C05: In-situ mechanical testing and numerical modeling of small-scale mechanical behaviour – a COST MecaNano Symposium“, respectively.

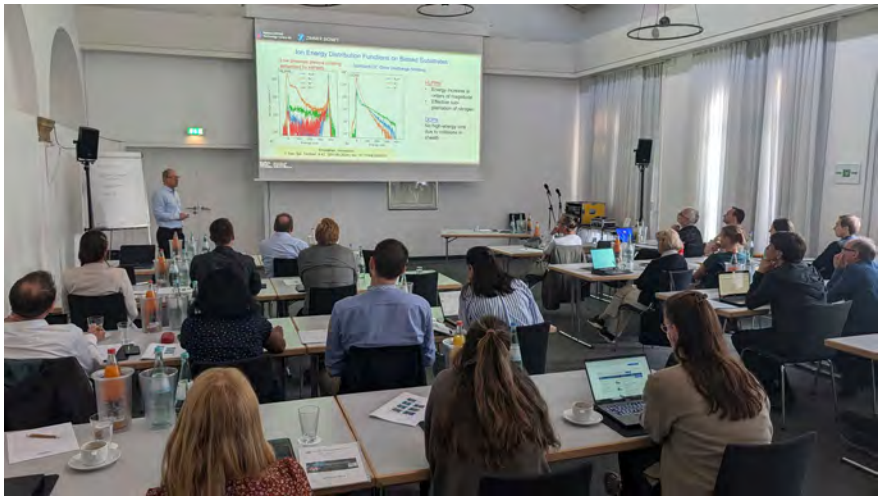
2024 Materials Science & Technology (MS&T2024) (October 06 – 09, 2024, Pittsburg, Pennsylvania, USA)

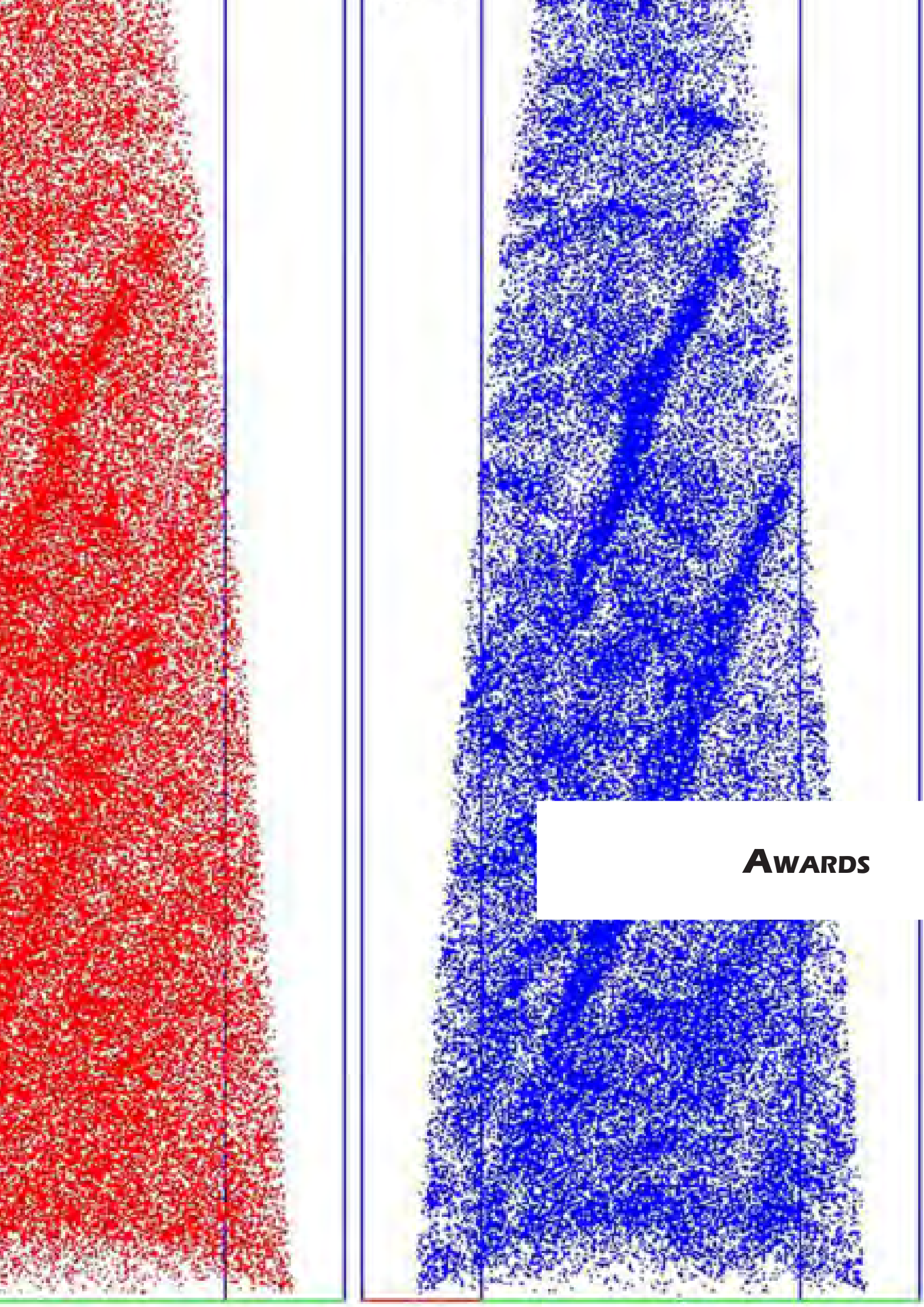
The 2024 Materials Science & Technology Technical Meeting and Exhibition (MS&T2024) organized by TMS, AIST and The American Ceramic Society took place in Pittsburgh, USA during October 6 - 9, 2024. Together with K.G. Prashanth (Tallinn University of Technology), Z. Wang (South China University of Technology, Guangzhou), J. Eckert organized a symposium on “Additive Manufacturing of Metals: Microstructure, Properties and Alloy Development“. The symposium extended over 3 days and included invited presentation as well as contributed talks by international experts working on additive manufacturing of advanced high performance materials. The topics covered materials and alloy development, processing, properties as well as microstructure correlations for different additive manufacturing processes, covering a broad range of materials spanning from steels to Al-, Cu-, Co-, Mg-based alloys, high entropy alloys, intermetallics, metallic glasses, metal matrix composites or ODS alloys. The scientific discussions and networking during the sessions was very lively, contributing to the success of the symposium.

100th IUVSTA Workshop – Rethinking Surface Engineering (October 27 – 31, 2024, Ludwigsburg, Germany)

The 100th IUVSTA workshop entitled “How Sustainable are Thin Films and Thin Film Processing? Pathways towards Responsible Surface Engineering” took place at the nestor hotel Ludwigsburg, Germany, from October 27 – 31, 2024. The workshop was sponsored by the International Union for Vacuum, Science, Technique and Applications (IUVSTA), with the goal to exchange, nucleate and promote research and development towards implementation of the Sustainable Development Goals into surface engineering and thin film deposition. In intensive discussions, the necessary changes in education as well as research and innovation strategies were formulated.

The workshop was organized by Dr. Marcus Hans (RWTH Aachen University, Germany), Prof. Grzegorz Greczynski (University of Linköping, Sweden), Prof. Claus Rebholz (University of Cyprus, Nicosia, Cyprus), and Prof. Sven Ulrich (Karlsruhe Institute of Technology, Germany), and Christian Mitterer (Montanuniversität Leoben).





Awards

Prizes and awards

The scientific work of the Department's employees met with a great response both nationally and internationally. It is gratifying to note that in particular numerous younger employees received awards for successful master's and doctoral theses. The following pages provide an overview of the awards received by members of the Department during the reporting period.

Several awards for Leoben scientists at the ECI conference

Several awards for Leoben scientists at the ECI conference "Nanomechanical Testing in Materials Research and Development IX" in Sicily, Italy. At this important conference for micro- and nanomechanics, which takes place every two years in the Mediterranean region, a large group of materials scientists from Leoben celebrated great successes.

Stefan Zeiler from the Chair of Functional Materials and Materials Systems took first place in the prize for the best presentation by a young scientist. He presented a new experimental setup for the in-situ loading of materials with hydrogen in a nanoindenter. This new setup improves and facilitates the simultaneous determination of material properties under the influence of hydrogen and thus boosts research in this pioneering field.

Lea Lumper-Wimler from the Chair of Functional Materials and Material Systems achieved, the second place in the same category. Her work deals with the combination of high-energy X-ray diffraction and nanoindentation to improve Cu-Pd-Ag alloys. These are an integral part of testing machines in the semiconductor industry for quality assurance of chips.

Gerald Schaffar, also from the Chair of Functional Materials and Material Systems, won prizes in two categories. His poster preview presentation - a 40-second rap about his research activity - took first place. The rap video can be found on the Department's Instagram channel: https://www.instagram.com/p/DA-kvQ_uzks/?igsh=MTk5aTF3b3RsMnA4eA. In addition, his poster on the high-temperature plasticity of silicon was awarded a shared second place in the best poster category. The research on plastic deformability using nanoindentation and micro pressure column compression is important to avoid rejects in semiconductor manufacturing.

Kevin Kutleša from the Chair of Materials Physics also achieved a shared second place in the category for the best poster for his work on the characterization of hard material layers using micromechanical tests and X-ray nanodiffraction. Such coatings are used in the metalworking industry in machining processes - literally "cutting edge" research.

In addition, Verena Maier-Kiener from the Chair of Functional Materials and Material Systems was honored for her outstanding contributions to micromechanics - especially nanoindentation - by being elected conference chair for 2026 by the steering committee.

New ESPRIT project for Markus Alfreider

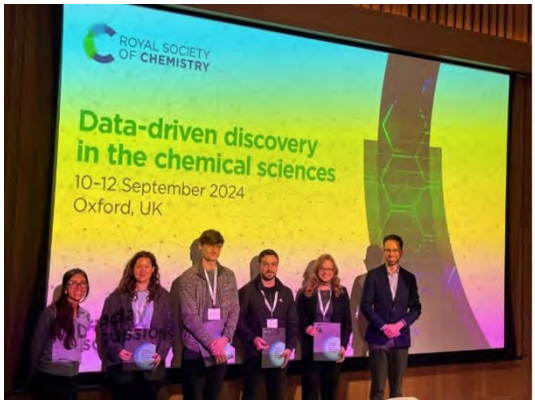
Markus Alfreider from the Chair of Material Physics has recently been awarded an ESPRIT project by the Austrian Science Fund (FWF) entitled “Individual grain boundary characterization via spectroscopy (INSPECT)“.
This project will be conducted in collaboration with research groups from TU Vienna (Prof. Michael Stöger-Pollach), Montanuniversität Leoben (Lorenz Romaner, Daniel Kiener) and Chalmers University of Technology (Prof. Mattias Thuvander).
Nearly all structural as well as functional materials are crystalline in nature, with individual crystallite (or grain) sizes ranging orders of magnitude from nanometers to millimeters depending on their purpose or use. The intersection of these grains, so-called grain boundaries (GBs) are the origin for a multitude of physical phenomena, such as mechanical response, magnetic coercivity, or thermal-/electrical conductivity, to name just a few. Therefore, altering the local geometrical or chemical structure of these GBs has become one of the go-to pathways to tailor and improve these properties in materials for modern applications. However, the process of such alterations is nearly always empirical, necessitating a large sweep of different synthesis parameter and subsequent experiments, without the fundamental knowledge of what exactly changed at these GBs.
The aim of the present project is to establish a framework to determine the actual atomistic characteristics of individual GBs in their native state. This will be addressed by a novel combination of a unique micromechanical spectroscopy technique in conjunction with spatially resolved valence electron energy loss spectroscopy, both capable of probing sub-micrometer sized volumes. Additional ab initio simulations and advanced chemical tomography will complement these experiments and lead to an in-depth understanding of the fundamental physics of GBs.

Physical Metallurgy Award 2024 awarded to Maximilian Graf

The Physical Metallurgy Award is awarded annually to young scientists from either one of the two chairs of Physical Metallurgy and Functional Materials and Materials Systems. In addition to outstanding academic achievement, the prerequisite for the award is a master’s thesis with a very good grade that was carried out at one of the two chairs. Furthermore, the award winner must also have started a dissertation at one of the two named chairs. The prize includes a benefit package that enables participation in next year’s 4th Materials Science Colloquium (69th Physical Metallurgy Colloquium) in Lech am Arlberg.

Marietta Blau Grant and poster prize for Celine Halkali

Celine Halkali from the Chair of Physical Metallurgy has been awarded a Marietta-Blau grant to carry out a one-year research stay to develop machine-learning interatomic potentials for silicon carbide and related doping elements. She will split the stay between the research group of Prof. Deringer at the University of Oxford and the group of Prof. R. Drautz at ICAMS, Ruhr-Universität Bochum. Furthermore, Celine Halkali has won a prize for her poster contribution entitled “Development of a machine learning-based interatomic potential for silicon carbide (SiC) using atomic cluster expansion (ACE)“ at the Faraday discussion on “Data-driven discovery in the chemical sciences“ taking place from September 10 - 12, 2024, Oxford, United Kingdom.



Best Paper Award from the Austrian Ceramic Society

On Thursday, April 4, the 12th Annual Meeting of the Austrian Ceramic Society (AuCerS) took place at the University of Technology Graz. Abdullah Jabr, doctoral student at the Chair of Structural and Functional Ceramics at the Montanuniversität Leoben, received the Best Paper Prize for his publication “Scaling up the cold sintering process of ceramics“. The award-winning work deals with technological aspects of the large-scale production of ceramics at low temperatures below 300°C (usually over 1000°C). This is achieved through an innovative sintering process. This significantly reduces energy consumption during production and enables the combination of different materials. An international panel of judges evaluated the contributions.

Brimacombe Medal winner

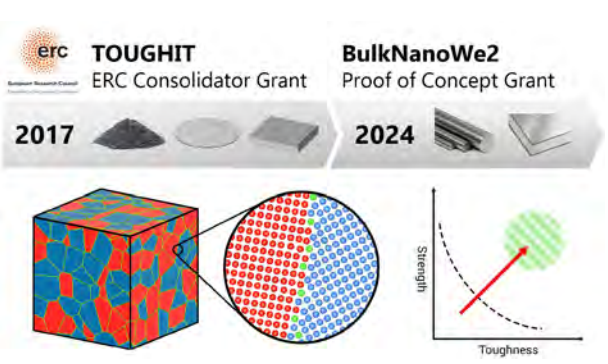
Daniel Kiener was honored by the Society as a Brimacombe Medal winner for his continued excellence in materials science and his pioneering work in the field of in-situ micro- and nanomechanical methods, which provide unique mechanistic insights into the mechanical behavior of materials.

Daniel Kiener was awarded the prestigious ERC (European Research Council) "Proof of Concept" grant

The ERC project TOUGHIT (Tough Interface Tailored Nanostructured Metals) uses advanced electron microscopy methods which, in combination with micro- and nanomechanical experiments, make it possible to correlate the mechanical behavior of the materials under investigation with the nanostructure of their interfaces. Together with the ab initio-based interface design, top-down and bottom-up synthesis enabled the production of novel materials with a unique combination of damage tolerance, strength and toughness.

During the ERC funding period, the research activities of three postdocs, three PhD students, three Master students and five Bachelor students were funded. This led to more than 80 publications in various recognized journals and several international awards.

The now awarded "BulkNanoWe2" Proof of Concept grant enables him and his research team to translate pioneering research into concrete solutions that promise applications in numerous branches of industry.



Lea Lumper-Wimler awarded Student Travel Grant and wins multiple awards at SWTest Conference in California/USA

Lea Lumper-Wimler was awarded a Student Travel Grant to attend the SWTest Conference in California for her research achievements in the field of semiconductor testing. At the conference, she also won the award for the Most Inspiring Presentation as well as the People's Choice Award. Lea Lumper-Wimler's dissertation at the Chair of Functional Materials and Materials Systems focuses on the characterization of copper-based alloys using nanomechanical and scattering methods. Her current work investigates a Cu-Pd alloy used in electronic applications, with a particular emphasis on exploring the structure-property relationships of these alloys. The recognition of her work underscores her significant contributions to materials science.

Young Scientist Best Lecture Prize awarded to Michael Meindlhumer

Michael Meindlhumer was awarded with the "Young Scientist Best Lecture Prize" for his presentation entitled "In situ X-ray Nanodiffraction Analysis of Multiaxial Stress-Strain Transfer across an Indenter-Sample Interface during in situ Indentation" held at the 12th European NESY Winterschool & Symposion on Neutron and Synchrotron Radiation.

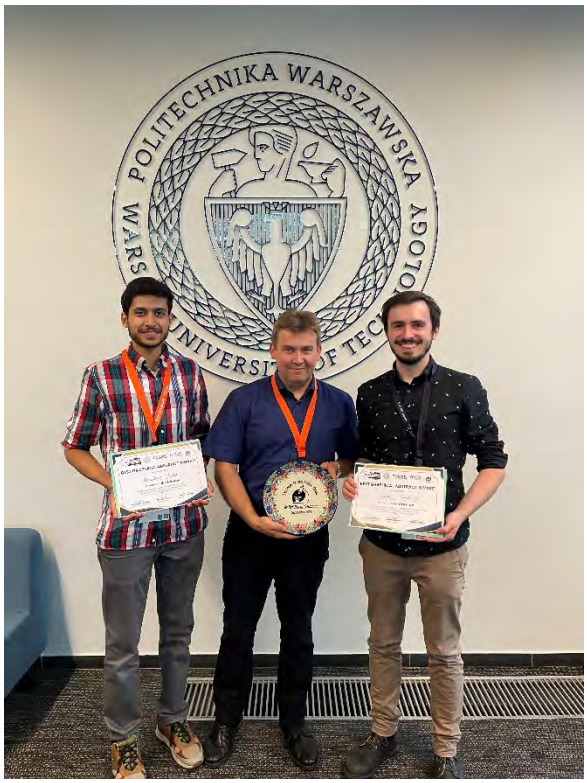
Christian Mitterer accepted as a full member of the ÖAW

The Austrian Academy of Sciences (ÖAW) elects its new members once a year, divided into honorary members, full members, corresponding members in Austria and abroad, and members of the Young Academy. The prerequisite for admission to the ÖAW is that the nominees meet the highest standards in terms of personality, scientific work and reputation in the scientific community and come from different disciplines. In this year's elections, Christian Mitterer was elected a full member of the mathematical-scientific class of the ÖAW for his pioneering work on the functionalization of surfaces for applications in tribology, microelectronics, energy and medical technology. With his election, the Montanuniversität Leoben is once again represented by an actively working full member of the ÖAW.

Promotion sub auspiciis Praesidentis for Sebastian Moser

During a festive academic ceremony on 16 February, 2024, Sebastian Moser received his doctorate in Materials Science "sub auspiciis Praesidentis rei publicae".
This makes him only the ninth person to receive this award at the Montanuniversität Leoben. Sebastian Moser was supervised by Megan Cordill of the Erich Schmid Institute of Materials Science of the Austrian Academy of Sciences through a collaboration with the Austrian microelectronics company Infineon Technologies Austria AG and the daughter company Kompetenzzentrum Automobil- und Industrieelektronik GmbH (KAI).
Only those who complete their upper secondary school and school-leaving examination with distinction, complete their bachelor's, master's and doctoral studies at university with distinction and complete all modules as well as their diploma thesis, dissertation and PhD defense with the best possible assessment are admitted as candidates for a sub-auspiciis doctorate. His doctoral thesis was dedicated to the topic of fatigue of metallization layers in microelectronic applications.

Two best graphical abstract awards from the Shaping 9 Conference and one award from the Polish Ceramic Society go to Leoben



From September 25 - 27, the 9th Shaping Conference of the European Ceramic Society (ECERS) took place in Warsaw. Just before the conference, a Summer School entitled "How to Shape Ceramic Ideas into Real Products – Laboratory Excellence versus Industrial Needs" was also held. As part of the conference and Summer School, there was a "Graphical Abstract Students Contest", where students and young researchers could submit a graphical summary of their respective research fields. The Montanuniversität Leoben was represented by four participants from the Chair of Structural and Functional Ceramics (ISFK). The Leoben participants had reason to celebrate right after the opening ceremony when the awards for the Graphical Abstract Contest were presented. Abdullah Jabr earned the 3rd prize in the Graphical Abstract Students Contest for his graphical abstract on "Understanding the Lower Fracture Resistance of Cold Sintered Ceramics". Tobias Prötsch won the 1st prize with his graphical abstract on "Tape Casting of Cr_2AlC MAX Phase for Multi-Material Designs". The graphical abstracts were evaluated by an international jury, and the authors were revealed only after the decision had been made. A special highlight was the award of the "Polish Ceramic Society Award" to David Salamon, in recognition of his contributions to the understanding and development of additive manufacturing.

Scientific Price for Montanistinnen awarded to Barbara Putz

Every year, the Montanuniversität Leoben awards the Science Prize for Women to female scientists and students for outstanding achievements in research. On this year's International Women's Day, the award in the PostDoc category went to Barbara Putz, Assistant Professor at the Department of Materials Science. Born in Leoben, she is researching the development of thin-film systems that can be used in both microelectronics and space travel. In everyday life, this technology is used in foldable cell phones or as insulation material for satellites, among other things. As part of Barbara Putz's research work, a unique coating system was used to produce metal/oxide nanolaminate films on flexible polymer substrates. Mechanical tests were carried out at the synchrotron to analyze the deformation behavior. It was found that the crack resistance of the films increases as the thickness of the oxide layer decreases. A biaxial yield stress model of the films was developed to describe the mechanical behavior under multiaxial loading conditions. This is of great importance for the application in various flexible carrier systems and load cases in electronics.

Early-Career Scientist Award to Parthiban Ramasamy

Parthiban Ramasamy was awarded with the "Early-Career Scientist Award" for his scientific achievement, innovation, and potential impact of the research in the field of Metastable, Amorphous, and Nanostructured Materials held at the 28th International Symposium on Metastable, Amorphous, and Nanostructured Materials, ISMANAM 28 (2024).

Poster Price for Lukas Schweiger

Lukas Schweiger from the Chair of Materials Physics received one of the Best Poster Awards at the 18th International Symposium on Metal-Hydrogen Systems. This event, bringing together researchers in the field of hydrogen storage, was held in Saint-Malo and featured over 200 posters and 160 talks. With the poster, Lukas Schweiger, presented his research on nanoporous metallic foams for hydrogen storage. Conducted at Montanuniversität Leoben in collaboration with the University of Vienna, this study developed a mesoporous FeTi foam with tunable pore size and surface area, addressing critical issues like mechanical stability and activation behavior. Part of the Strategic Core Research Area SCoRe A+ Hydrogen and Carbon, this research highlights the leading role of the Montanuniversität Leoben in the field of hydrogen technologies.

Successful women in cutting-edge research: Fereshteh Sourani wins FWF Career Programme Award

In 2023, a total of 59 female researchers were able to win their projects as part of the FWF career programs ESPRIT and Elise Richter.
Our colleague, Fereshteh Sourani was awarded the ESPRIT career funding for her project entitled “Investigation of a Novel Selective Laser Melted Bulk Metallic Glass for Knee Implants (SLM-BMG)“. This award impressively underlines the outstanding potential and excellence of women in science. The FWF is contributing to actively enhancing the network of excellent female researchers in Austria. The annual award and networking are part of numerous activities and measures to promote and make visible women in top research.

JECS-Trust Mobility Grant awarded to Maximilian Staudacher

In July 2024, Maximilian Staudacher from the Chair of Structural and Functional Ceramics received the JECS-Trust Mobility Grant, which is funded by the Journal of the European Ceramic Society. This grant enables a selected number of young scientists in the field of technical ceramics to spend several months at a renowned research institutions for several months. Maximilian Staudacher will use this funding to stay at the Fraunhofer IKTS in Dresden, Germany. There he will investigate the extent and origin of processing defects in ceramic materials fabricated through various additive manufacturing methods and work on developing new strength testing methods for such materials.

Teaching

Teaching

In addition to research, teaching is an important task of the university. It is the basis for the high quality education of our graduates, who will later not only contribute to the sustainable development of Austria as a location for industry and research, but will also successfully gain a foothold internationally.

Semester Hours (Hrs)
Winter- and summer semester

Chair	Compulsory subject (Hrs)	Elective subject (Hrs)	Free subject (Hrs)
Chair of Functional Materials and Materials Systems	51	5	37
Chair of Physical Metallurgy	57	18	33
Chair of Materials Physics	28,8	23	48
Chair of Structural and Functional Ceramics	48	9	0

Exams

Chair	Number of exams
Chair of Functional Materials and Materials Systems	616
Chair of Physical Metallurgy	481
Chair of Materials Physics	317
Chair of Structural and Functional Ceramics	250

Cooperations

Cooperations

NATIONAL CENTRE FOR SCIENTIFIC RESEARCH "DEMOKRITOS"

Northwestern University

THE UNIVERSITY OF SYDNEY

RUHR UNIVERSITÄT BOCHUM RUB

MAX PLANCK INSTITUTE FOR SUSTAINABLE MATERIALS

東京工業大学 Tokyo Institute of Technology

NEUTRONS FOR SCIENCE

Imperial College London

ÖAW Österreichische Akademie der Wissenschaften

TU Graz

RWTH AACHEN UNIVERSITY

IBS PAPER PERFORMANCE GROUP

DESY

University of Cyprus

MINES Saint-Étienne

JOANNEUM RESEARCH

TU WIEN TECHNISCHE UNIVERSITÄT WIEN Vienna University of Technology

ROMA TRE UNIVERSITÀ DEGLI STUDI

eman ta zabal zazu

Universidad del País Vasco Euskal Herriko Unibertsitatea

UNIVERSITEIT GENT

BERKELEY LAB Lawrence Berkeley National Laboratory

哈爾濱工業大學 Harbin Institute of Technology

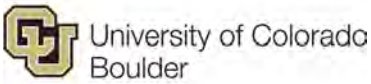
Helmholtz-Zentrum Geesthacht
Zentrum für Material- und Küstenforschung

LINKÖPINGS UNIVERSITET

HZDR

HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

Technische Universität München



Outlook

Our last year's outlook stated that 2023 marked the hottest ever documented year, and that the 2°C global warming goal would seem more challenging to reach than ever. Unfortunately, while still running, 2024 was declared to have broken this alarming record again in December. On top of that, ongoing conflicts persist to create unspeakable human pain and promote uncertainty in resources and energy supply, while new trends in AI challenge established industries and at the same time require massive amounts of energy. In the United States a newly elected president expresses plans not well aligned with most of the UN and EU consensus, while in Austria a new to be formed government considers lowering funding rates and dropping environmental measures to fix the national budget dept. And this is by no means a complete list, but just a few of the most prominent challenges we are facing these days.

Despite this seemingly no bright future, we are convinced that the Montanuniversität Leoben in general and the Department of Materials Science provide an excellent environment to contribute to many of these challenges for a better tomorrow. But this at the same time requires the brightest minds to come together and jointly work on these tasks. In that sense, we are glad that the student numbers are rising again, and we are looking forward to the appointment of a new professor for Computational Materials Design to further strengthen our theoretical capabilities. But 2025 will also mark the beginning of a new fully modular English Material Science Master program which will be offered with the beginning of October, allowing us to extend our reach and attract further international Master students to join forces with the excellent material scientists in Leoben.

The opening of the Hydrogen and Carbon Center in October 2024 marked another important cornerstone in positioning the Montanuniversität Leoben as an international gravity center for research and education focusing on sustainable solutions for the future. Reflecting this strategy in our broad spectrum of research activities, we will continue our efforts towards developing novel responsible materials and processes for extreme environments, energy storage and conversion, as well as product longevity and recyclability to contribute to a CO_2 neutral and energy efficient future.

Such developments not only require bright minds, but also the most modern experimental and computational equipment. In this sense, we look forward to the full operation of a novel cryo-plasma FIB for battery and hydrogen research, a dedicated in situ transmission SEM, a cryogen-free physical property measurement system, dedicated ovens for SiC crystal growth, and a high-end analytical equipped dual beam FIB/SEM. These large scale investments in conjunction with highly skilled people operating them are essential to remain competitive or even drive innovation in these global hot topics.

It remains our strong confidence that the manifold global challenges mentioned in the beginning can only be mastered by extensive efforts. We, as members of the Department of Materials Science, will continue to communicate to our students the inevitable necessity for a diversified higher education in materials science in conjunction with a respectful and inclusive mindset as a pre-requisite to peace and prosperity. Concomitantly, we are offering highest level multidisciplinary research competence to our industry partners. This combination places us in a top position to develop novel responsible materials that contribute to the socio-economic needs of our times and future generations to come.

We very much look forward to a successful cooperation in the year 2025!

Imprint

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