Materials Science

Department Materials Science

Annual report 2022

MONTAN UNIVERSITÄT LEOBEN

Preface

Dear partners and colleagues of the Department of Materials Science!

Due to the war in our neighbouring country, we believe, more than ever, that education is key to build and maintain a society which preserves human rights, respect and tolerance at a global level, above any political opinion, religion or cultural habits. Education is probably also the only mean to bring consciousness to our society about climate change and that "now" is the right time to act against it – education is sustainable par excellence! At the Materials Science Department, we feel obliged to commit to this undertaking through our teaching and research activities as well as through personal contact to our students.

Following the newly implemented Bachelor and Master studies at Montanuniversität Leoben in 2022, three main pillars have been consolidated as our teaching and research identity, namely "Advanced Resources", "Sustainable Processing", and "Smart Materials", all of them contributing to the implementation of a Circular Economy and to the United Nations Sustainable Development Goal 12 "Responsible Consumption and Production". The overarching role of Materials Science in the teaching portfolio of our university has resulted in the successful implementation of a new Bachelor study, "Materials Science and Technology" aiming to provide our students with solid fundamentals in materials science, covering aspects of diverse processing technologies (including recycling), materials design, characterization and testing, with the possibility of specialization either in metals, ceramics and functional materials, or in polymers and composites. At master level, the international flair of incoming students through the Erasmus Mundus Program "Advanced Materials Science and Engineering" (AMASE) to our Department has positively affected our students, bringing a multicultural environment and an appetite to go global!

With the farewell of our colleague Prof. Helmut Clemens, after a long dedicated career at the Department, two of the Chairs dealing to advanced metallic materials merged into the new Chair of Physical Metallurgy, under the leadership of Prof. Ronald Schnitzer. We celebrated the appointment of our colleague Dr. Daniel Kiener as Professor of Micro- and Nanomechanics of Materials, who has over the years achieved a worldwide recognition. We also welcomed the habilitation of Priv.-Doz. Nina Schalk in the research field of surface engineering. Outstanding research requires state-of-the-art facilities. Our Advanced Micro- and Nanostructure Characterization Group, jointly operated by the different Chairs within the Department, has expanded by the acquisition of new high end equipment, among which a new femto-laser ablation system for micro-machining, a 3D atom probe, and plasma-assisted systems for nanoparticle deposition and surface modification can be highlighted. Numerous publications in eminently respectable journals, such as Nature Communications, Science Advances, Acta Materialia or Additive Manufacturing, indicate the high quality of our Department's research activities during 2022. We are particularly proud of several conference prices received by our young undergraduate and graduate students, as well as distinguished awards for some of our Department researchers.

We would like to express thanks to our researchers as well as students of the Department and to all of our industrial partners for the support and for continuous motivation to jointly face future challenges. With this, we kindly invite you to read the following pages, which intend to provide a short overview of our activities in 2022.

Prof. Dr. Raul Bermejo Prof. Dr. Jürgen Eckert

Prof. Dr. Christian Mitterer Prof. Dr. Ronald Schnitzer

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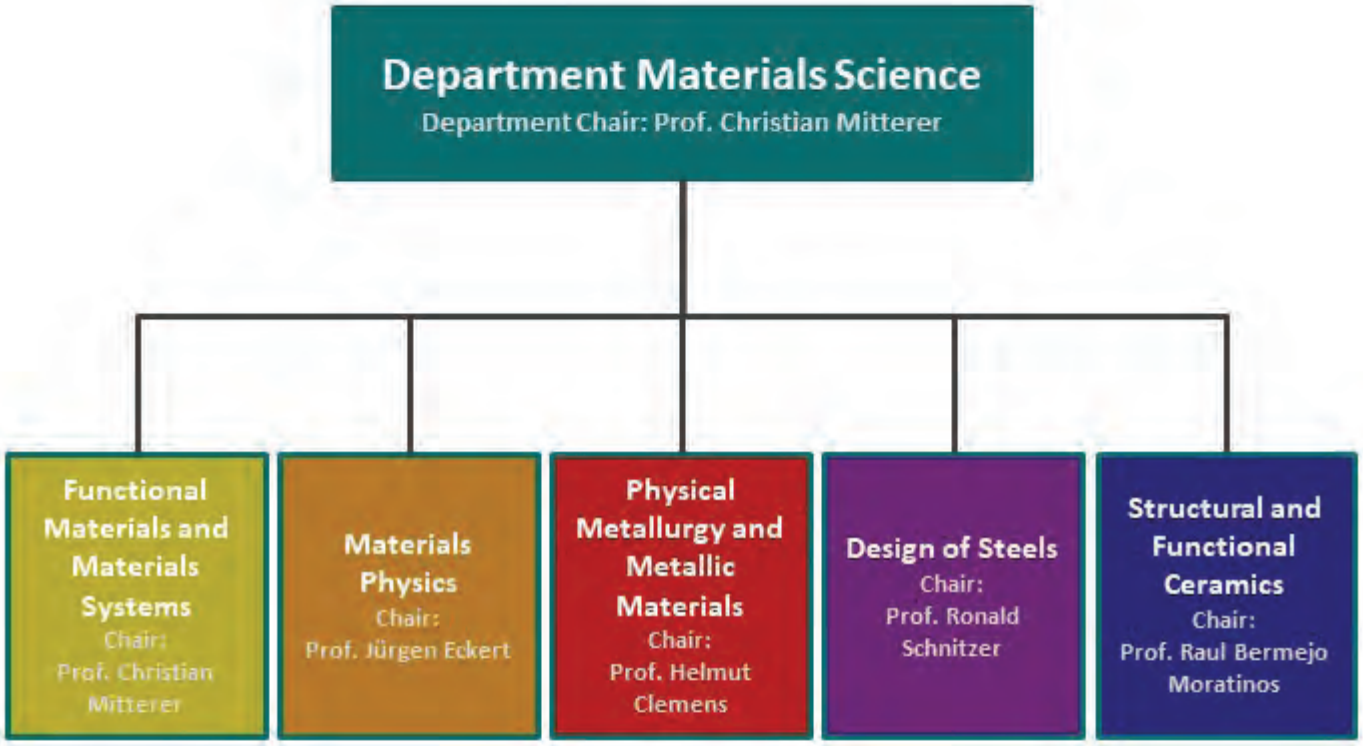
Organigram


Department Materials Science
Department Chair: Prof. Christian Mitterer
Functional Materials and Materials Systems
Chair:
Prof. Christian Mitterer
Materials Physics
Chair:
Prof. Jürgen Eckert
Physical Metallurgy and Metallic Materials
Chair:
Prof. Helmut Clemens
Design of Steels
Chair:
Prof. Ronald Schnitzer
Structural and Functional Ceramics
Chair:
Prof. Raul Bermejo Moratinos

Personnel

Personnel

In 2022, 184 people were employed at the Department Materials Science. The expenses for 66 employees were covered by federal funds, 118 employees were financed by third-party projects.

Head of department

Univ.-Prof. Dr.
Christian Mitterer
Chair of Functional Materials and Materials Systems

Chair

Univ.-Prof. Dr.
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Chair of Structural and Functional Ceramics

Univ.-Prof. Dr.
Helmut Clemens
(retired 09/2022)
Chair of Physical Metallurgy and Metallurgical Testing

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Jürgen Eckert
Chair of Materials Physics

Univ.-Prof. Dr.
Ronald Schnitzer
Chair of Physical Metallurgy and Metallurgical Testing /
Chair of Design of Steel

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Group leader

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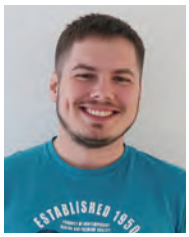

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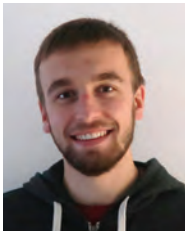

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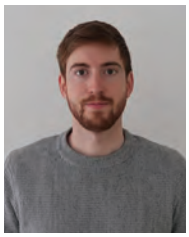

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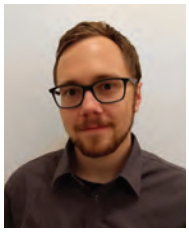

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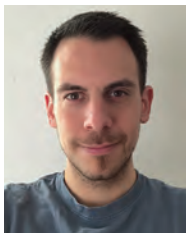

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Endowed Professorship and Chair of Design of Steels – BMK Professorship for Industry

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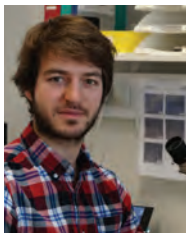

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Dipl. -Ing
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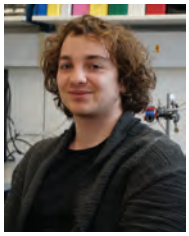

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Thomas Priet
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Dipl. Ing.
Josef Schlacher
PhD student

Dipl. Ing.
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Bsc.
Fabian Stücklberger
Graduate student

Bsc.
Andreas Vratanar
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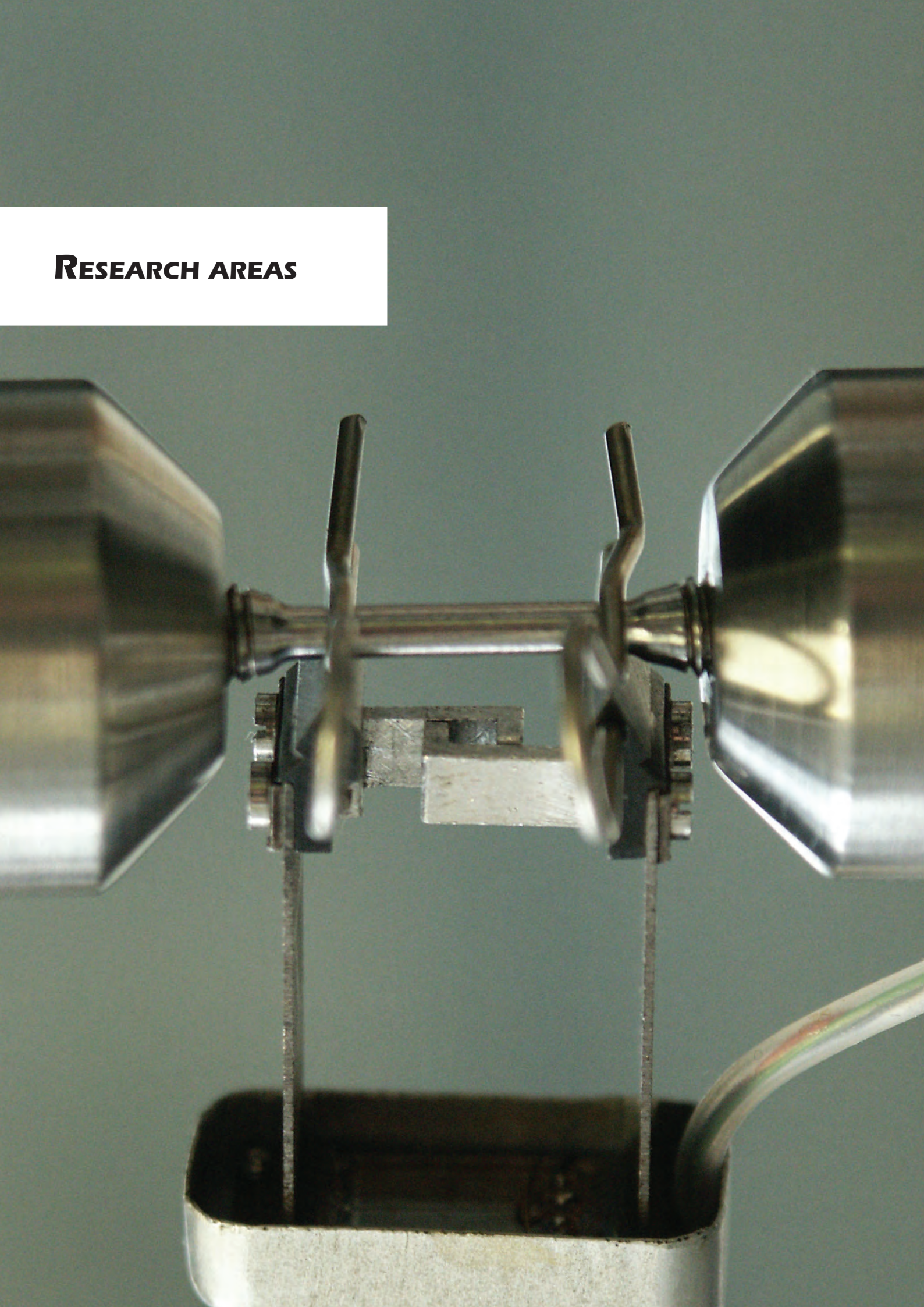
Retired / emeritus University professors

em. o.Univ.-Prof. Dr.
Robert Danzer

Univ.-Prof.i.R. Dr.
Albert Kneißl

Research areas

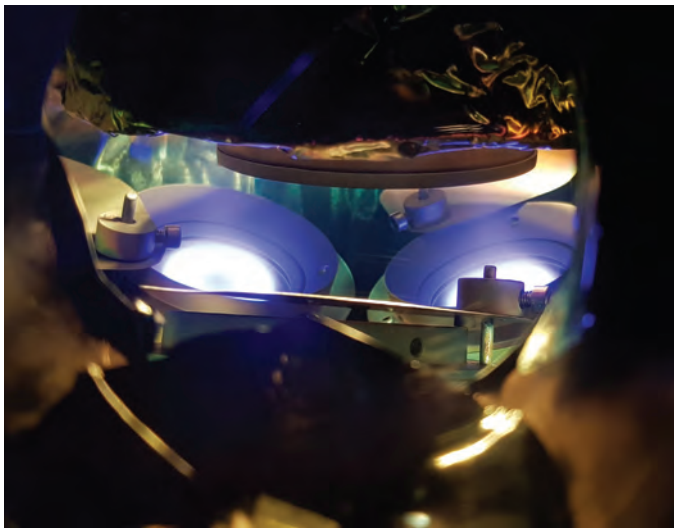


Mission statement

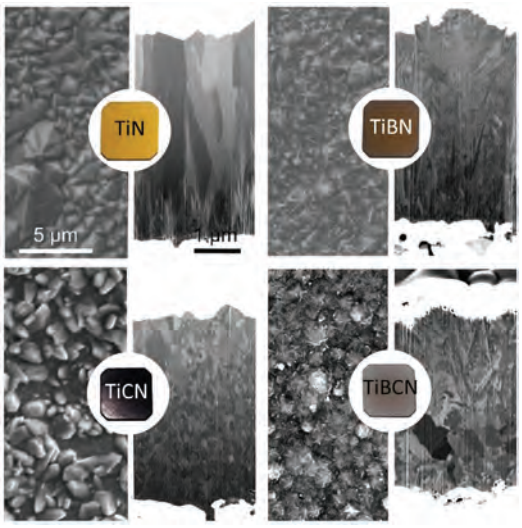
Within the Department of Materials Science, research is done at the highest international level, to achieve a detailed understanding of the structure and the properties of materials and material systems. In teaching, students are integrated as early as possible in research activities, to gain new insights 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 their group leaders added in parenthesis are established: Advanced Surface Engineering (Nina Schalk), Plasma and Surface Engineering (Robert Franz, until September 2022), Design and Architecture of Functional Materials Systems (Rostislav Daniel), and Advanced Micro- and Nanostructure Characterization (Michael Tkadletz, group operated jointly by the Chairs of Functional Materials and Materials Systems, Physical Metallurgy and Metallic Materials, and Steel Design).
Research at the Chair focuses on the functionalization of surfaces by their activation, modification, and the deposition of coatings, thin films and nanoparticles. For materials synthesis and surface modification, plasma-assisted vacuum techniques are used. The Chair operates a unique portfolio of vapor deposition systems, ranging from lab- to industrial scale, including sputter deposition (DC, pulsed DC, HiPIMS), cathodic arc deposition, and – implemented in 2022 – magnetron sputter inert gas condensation of nanoparticles as well as plasma modification. This portfolio for functionalization of surfaces is complemented by facilities for the investigation of microstructure and mechanical/ tribological properties. Further support is provided by various simulation tools for deposition processes and for materials design. Additional methods for materials characterization and modelling are used in collaboration within the Department of Materials Science and other Chairs within the Montanuniversität Leoben. Application-oriented research is done for tribological coatings for tools and components for automotive and aerospace application, for thin films for functional devices for microelectronics and displays, and for the functionalization of surfaces for energy conversion and storage.
A particular highlight of the year 2022 was an invited review paper focusing on hard coatings for cutting applications and future challenges for the coatings community, which was published in the journal Surface and Coatings Technology. In this work, the current state of research of hard coatings synthesized by physical and chemical vapor deposition, including the numerous pioneering contributions of the Chair of Functional Materials and Materials Systems, is summarized. In the style of a white paper, the last chapter is dedicated to raise awareness in the coatings community for current and future challenges related to climate change, energy transition and scarcity of resources and addresses potentials for a more responsible and sustainable design of both, synthesis processes and coating materials to ultimately meet the UN Sustainable Development Goals. The paper has been the most downloaded article of the journal Surface and Coatings Technology since April 2022.



Photograph of plasma inside a deposition system.



Scanning electron micrographs of surfaces and cross-sections of different CVD hard coatings.

Chair of Physical Metallurgy and Metallic Materials

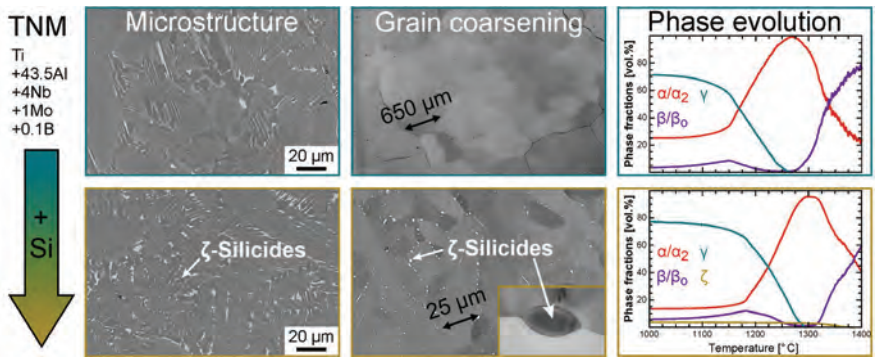
In the area of "Mechanical Properties and High-Performance Materials", the interaction of mechanical deformation behavior with the microstructure from room temperature to application-relevant conditions up to 1000°C and under non-ambient conditions, such as electrochemical charging, is investigated. For this purpose, local and correlative high-resolution characterization methods are mainly used in order to gain basic knowledge on materials mechanical and microstructural behavior, which can further be used specifically for advanced high performance alloy design. Moreover, an advanced nanoindentation techniques was developed for analyzing contact pressures in Si, which was further correlated with Raman spectroscopy. Together with HT materials testing, this helps to understand the high temperature deformation behavior of Si.

Intermetallic titanium aluminides and titanium alloys are used as structural materials in the next generation of aircraft engines and internal combustion engines. Through thermodynamic modeling and the use of the latest investigation and analysis methods, new alloy systems, e.g. for additive manufacturing, are developed together with industrial partners.

Methods from computational materials science are used to design and understand the structure and properties of materials. The group's expertise 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 or dislocations, or nanostructures. Recent highlights include predictions of alloying impact in TiAl-based alloys, steels, and nitride hard coatings, modelling-enabled interpretation of compositionally-induced trends in X-ray photoelectron spectroscopy, predictions of novel mechanism of doping in graphene grown on silicon substrates or reporting on magnetic properties of doped carbon quantum dots. Furthermore, multi-scale modeling approaches coupling density functional theory simulations with thermokinetic models have been developed for segregation and phase diagram predictions. The group is also active in developing software tools, for example the recently published and freely accessible tool for generating atomistic models of chemically disordered structures.

High-resolution characterization methods such as atom probe tomography and/or transmission electron microscopy are used to obtain qualitative and quantitative information about the morphology, composition and distribution of phases. The unique selling point in Austria are the two three-dimensional atomic probes. With this technique, the composition of the above-mentioned materials is analyzed down to the atomic level.

In order to better understand the behavior of modern materials under process and application conditions, specific diffraction and scattering methods are used. In-situ experiments using synchrotron radiation and neutrons allow e.g. the characterization of precipitation processes and phase changes in thermodynamic imbalance as well as the deformation behavior of materials on the level of the crystal lattice, as demonstrated in the following example.



Investigation of the influence of Si on β-solidifying γ-TiAl based alloys. Using complementary experimental methods, the changes to the microstructure, the grain coarsening behaviour and the phase transformations were assessed. Silicon causes the precipitation of ζ-Ti5Si3 silicides, which efficiently inhibit grain coarsening during high-temperature heat treatments. In-situ HEXRD experiments showed that Si furthermore stabilizes the γ phase at the expense of α2 at low temperatures and, in turn, the α phase at the expense of the β phase at high temperatures. For more details see https://doi.org/10.1016/j.mtla.2022.101475.

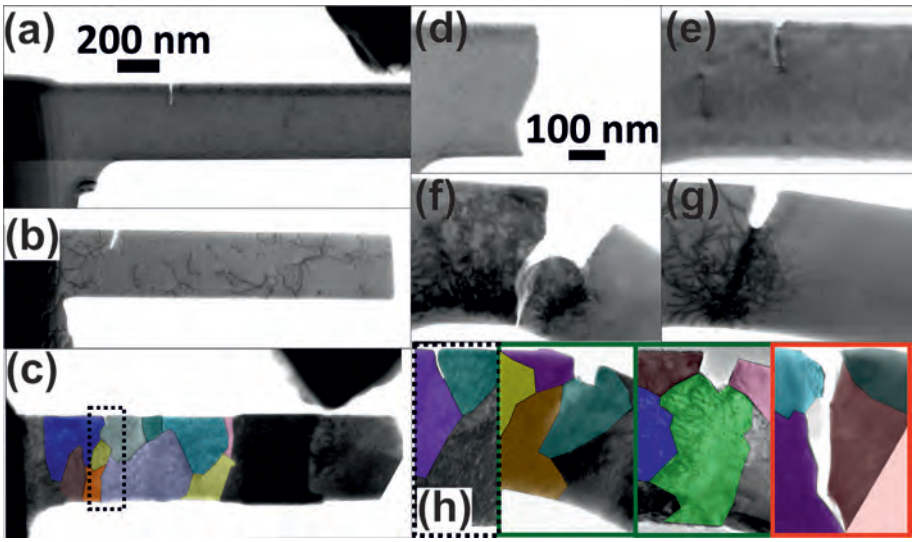
Chair of Materials Physics

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, four research groups are active at each of the respective institutions.

Research at the Chair of Materials Physics encompasses structural materials (e.g. steels, compositionally complex alloys, composites, as well as biological and bioinspired materials), miniaturized material applications for information technology (flexible metal-polymer systems, thin film structures, advanced metallization and functional ceramics for power electronics), materials for energy and high temperature applications (refractory metals, intermetallic alloys), as well as novel amorphous and nanocrystalline bulk materials (nanocomposites, magnetic nanomaterials, nanoporous metals) for use e.g. in hydrogen storage or medical applications.

During the last years, several research activities were initiated regarding interface properties of micro- and nanoscale multilayer systems spanning various material systems (organic, metallic, ceramic) for application in flexible electronics or hard coatings. In this aspect, due to their high hardness and good abrasion as well as corrosion resistance, metallic glasses can cover a previously inaccessible niche. Moreover, detailed tailoring of interface structures is an active research topic to improve strength, toughness and magnetic performance of nanomaterials to the application needs. Furthermore, modern processing techniques such as additive manufacturing require high heating and cooling rates, and ideally isotropic material properties. The related thermodynamic properties, e.g. of suited metallic glasses, are being studied using fast calorimetry at synchrotron beamlines at ESRF in Grenoble and DESY in Hamburg, and correlated to locally resolved transmission electron microscopy.

To account for the ongoing trends in integration and miniaturization in conjunction with associated demands for detailed understanding of related material size effects, Prof. Kiener was recently installed as new professor for Micro- and Nanomechanics of Materials at the Chair of Material Physics. His work encompasses a scale bridging correlation between material microstructures and structural as well as functional properties from atomistic details to bulk components using state-of-the-art structural and mechanical in-situ characterization techniques. A current example regarding this is depicted below. Using in-situ nanomechanical testing in the transmission electron microscope allowed to uncover the details of nanoscale fracture mechanisms in metallic materials for improving the ductility and fracture toughness of high performance materials.



In-situ response of cracked nanosamples: from brittle failure to ductile crack tip blunting. In-situ transmission electron microscopy images of cracks situated in (a) a dislocation free, (b) a dislocation containing crystal, or (c) at an interface. Crack tip processes can comprise (d) brittle cleavage or (e) dislocation emission, causing either (f) ductile fracture or (g) plastic blunting. (h) Interface cracks either support dislocation nucleation and crack tip blunting or cause intercrystalline fracture.

Chair of Design of Steels - Endowed Professorship for Industry

The Chair was founded within the framework of the FFG initiative “Production of the future”. The aim of the chair is the development of new and the optimization of existing high-performance steels. Research and development of steels as a high-performance material will make a decisive contribution to the key issues of the 21st century, such as sustainability, reduction of CO2 emissions, energy saving and recycling.

The research areas of the chair can be divided into three areas. The first includes low-alloyed high-strength steels, the second high-alloyed steels, and the third area welding of steels. One particular research area deals with PH 13-8 Mo maraging steels, which are widely used for safety-critical structural components in the aerospace industry. The extraordinary combination of high strength and remarkable toughness of these alloys stems from the complex microstructure consisting of a martensitic matrix embedded with nanometer-sized intermetallic β-NiAl precipitates and reverted austenite. Recently the focus was laid on applying multiscale in-situ techniques to investigate the martensite-to-austenite phase transformation and recrystallization. Atom probe tomography revealed that a significant amount of precipitates is already formed during continuous heating. However, these precipitates are not stable in the dual-phase field of martensite and austenite. Instead, a redistribution of the substitutional elements takes place, leading to Ni-enriched and -depleted regions, which even remain in the microstructure after the martensitic transformation. After full austenitization, the uneven distribution of substitutional elements is compensated, before recrystallization commences at temperatures slightly above 900°C. In contrast to most ferrous alloys, recrystallization in PH 13-8 Mo does not rely on cold deformation prior to heating. The reason for this rather odd behavior is the stored energy in low angle grain boundaries (LAGBs) inherited from the highly dislocated martensite. High temperature in-situ transmission electron microscopy experiments at temperatures up to 900°C ultimately proved the inheritance of LAGBs from martensitic lath boundaries in austenite.

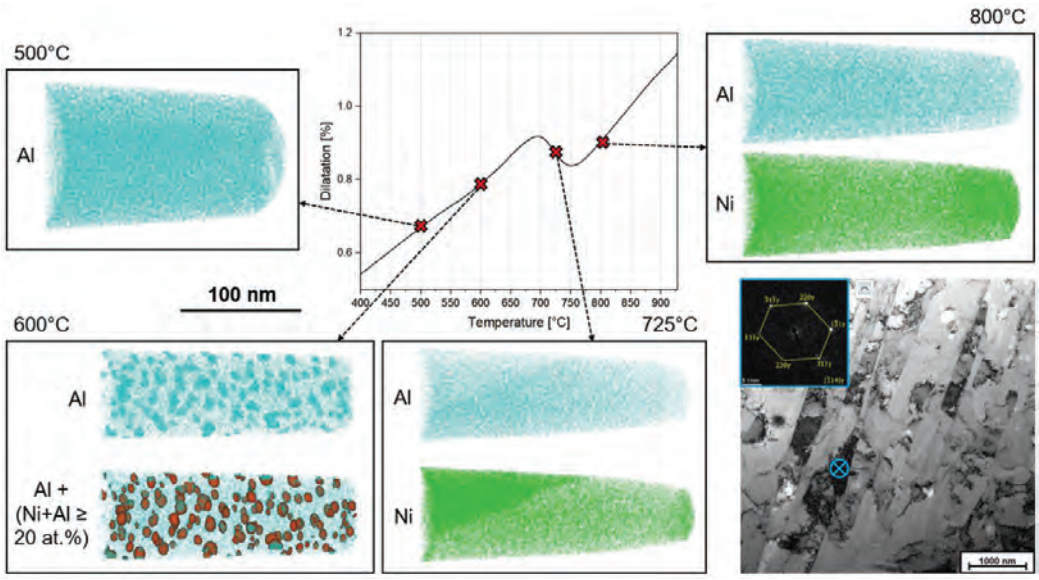


Figure: 3D reconstructions of PH 13-8 Mo samples quenched from different temperatures. β-NiAl precipitates are already formed during continuous heating, but are no longer present in the intercritical temperature region. Instead, a redistribution of Ni, Cr and Mo atoms between martensite and austenite takes place. After full austenitization, this uneven distribution is compensated, before inherited LAGBs form martensite (see HT-TEM image) trigger recrystallization of the austenitic microstructure.

Chair of Structural and Functional Ceramics

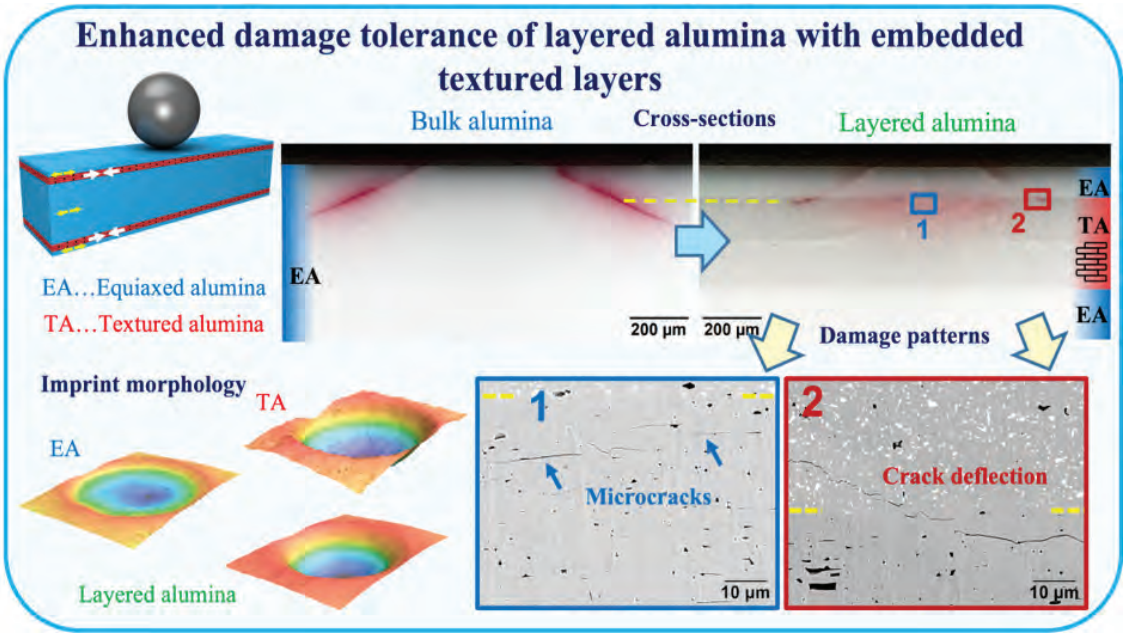
The Chair of Structural and Functional Ceramics (ISFK) aims at providing engineering solutions to the ceramic industry with primary focus on structural and functional applications. The research fields cover ceramic processing, material and system characterization as well as process simulation, with special 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 of ISFK.

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, 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 ISFK. This test enables the strength testing of particularly small and inexpensive samples.

The ISFK 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 ISFK. 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 lay 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 ISFK 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 ISFK. Pioneering 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

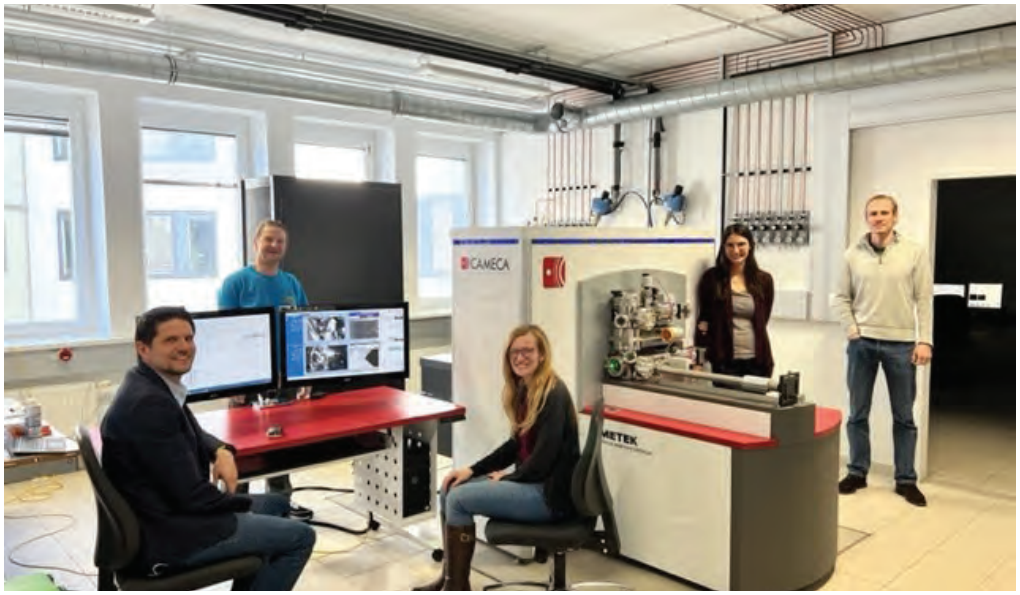
Investments

Successful installation of the new atom probe LEAP 5000 XR

In the course of the 3rd tender of the R&D infrastructure funding of the FFG, an atom probe of the so-called 3rd generation (LEAP 5000 XR) was purchased at the Department of Materials Science. The installation, commissioning and training was completed successfully and our first “own” ions were measured. This new generation of instruments is equipped with a UV laser, provides an increased detector efficiency of up to 50%, has novel software algorithms and allows significantly higher detection rates.

Using high-resolution atomic probe tomography, the atomic structure of materials can be investigated. In combination with correlative techniques such as transmission electron microscopy and ab-initio calculations, knowledge-based materials design and targeted property tuning are enabled.

With around € 2.6 million, it represents the highest laboratory equipment investment in the history of the Montanuniversität Leoben and at the same time entails a significant strengthening of Leoben as a research location. We are looking forward to the new opportunities available for us and to answering many exciting research questions.



The Leoben atom probe team (f.l.t.r Ronald Schnitzer, Michael Tkadletz, Anna Sophie Ebner, Helene Waldl, Stefan Kardos).

New deposition system for thin sputtered layer and Diener electronic Tetra 30 system

The already extensive capabilities of the Department for the deposition of thin films using plasma-assisted processes have been significantly expanded by a deposition system for thin sputtered layers and nanoparticles. This Moorfield MiniLab SN125M system is equipped with a conventional sputter source and a Nikalyte UHV/DX3 nanoparticle source. This source allows atoms from up to three magnetrons to be sputtered, agglomerated into small clusters, selected using a quadrupole mass filter, and then deposited onto substrates. These nanoparticles, with diameters ranging from 1 to 20 mm, can consist of metals and their alloys. Typical applications include the development of antibacterial or antiviral surfaces, self-cleaning surfaces, the functionalization of gas sensors, the activation of porous carbons for hydrogen storage, and the incorporation of nanoparticles as crack stoppers or as solid lubricants in hard coatings. Furthermore, a Diener electronic Tetra 30 system for the modification of surfaces in non-reactive and reactive plasmas was purchased. This system will be used for plasma exfoliation of graphite and for activation and functionalization of porous carbons. Potential applications include hydrogen storage, supercapacitors, selective gas separation, and water purification.

Plasma modification system

Nanoparticle Deposition System

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

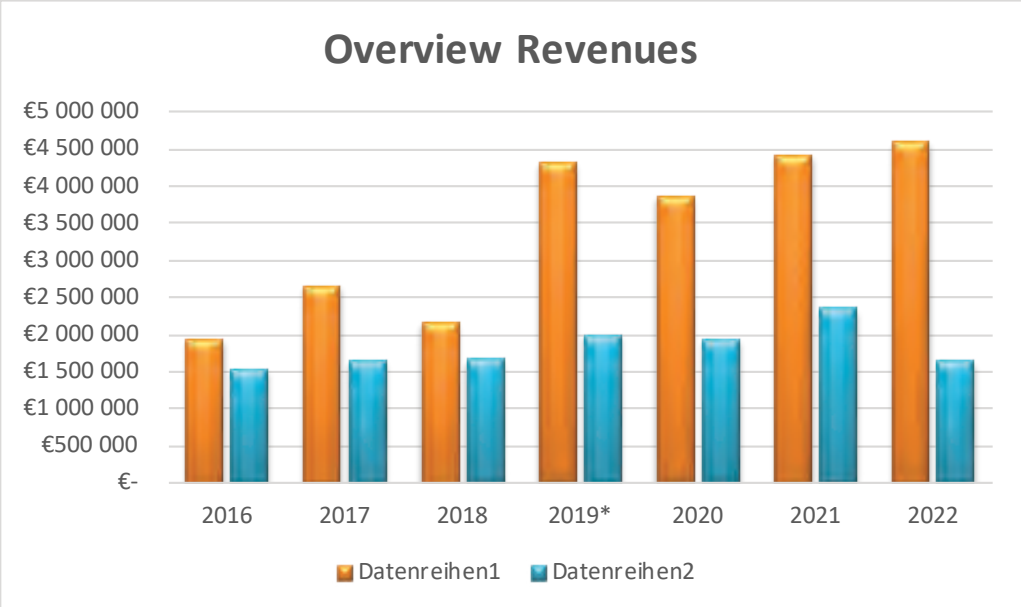
This endowment is to cover current operating expenses for research and teaching (incl. excursions, travel expenses, telephone, office supplies, copies for teaching and minor purchases for research operations; excl. university-funded positions)

Third-party funds

Due to extensive third-party funding activities, the Department managed to keep the revenue of the budget year 2022 at a high level compared to previous years.

The budget from funded projects amounted to: € 4.416.400,-.

The budget from contract research amounted to: € 2.359.500,-.



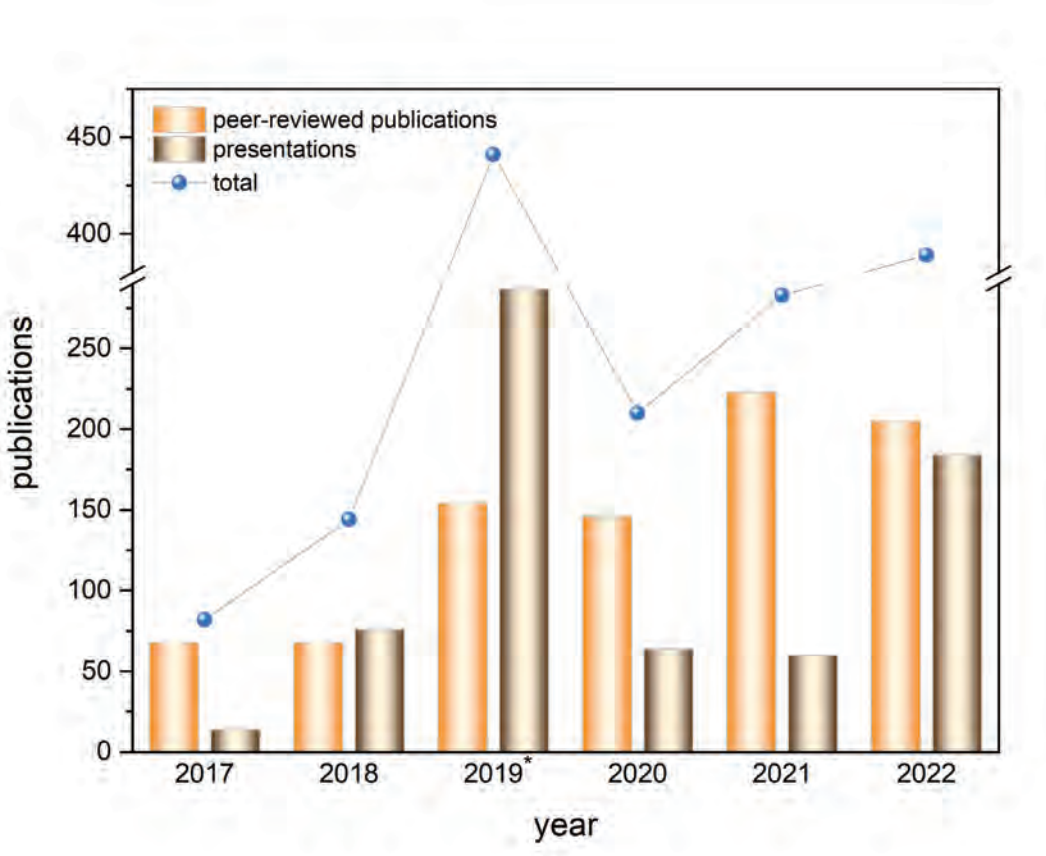
* Since the establishment of the Department of Materials Science in 2019, five chairs are included in this representation; prior to 2019, only three were included.

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 2022 in 205 articles in scientific journals and 184 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.



* Since the establishment of the Department of Materials Science in 2019, five chairs are included in this representation; prior to 2019, only three were included.

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

M. J. Cordill, P. Kreiml, C. Mitterer, Materials engineering for flexible metallic thin film applications, Materials 15 (2022) 926.

R. Daniel, J. Zalesak, I. Matko, W. Baumegger, A. Hohenwarter, E. P. George, J. Keckes, Microstructure-dependent phase stability and precipitation kinetics in equiatomic CrMnFeCoNi high-entropy alloy: Role of grain boundaries, Acta Materialia 223 (2022) 117470.

G. C. Gruber, A. Lassnig, S. Zak, C. Gammer, M. J. Cordill, R. Franz, Synthesis and structure of refractory high entropy alloy thin films based on the MoNbTaW system, Surface & Coatings Technology 439 (2022) 128446.

M. Gsellmann, D. Scheiber, T. Klünsner, J. Zálešák, Z. Zhang, H. Leitner, C. Mitterer, G. Ressel, L. Romaner, Bond strength between TiN coating and microstructural constituents of a high speed steel determined by first principle calculations, Acta Materialia 222 (2022) 117439.

N. Jäger, M. Meindlhumer, M. Zitek, S. Spor, H. Hruby, F. Nahif, J. Julin, M. Rosenthal, J. Keckes, C. Mitterer, R. Daniel, Impact of Si on the high-temperature oxidation of AlCr(Si)N coating, Journal of Materials Science & Technology, 100 (2022) 91-100.

L. Mitterhuber, V. Veerapandiyan, M. Deluca, S. Misture, J. Schaeperkoetter, M. Tkadletz, C. Mitterer, J. Spitaler, Anomalous thermal conductivity in amorphous niobium pentoxide thin films: A correlation study between structure and thermal properties, Materialia 26 (2022) 101601.

S. Rashid, G. M. Vita, L. Persichetti, G. Iucci, C. Battocchio, R. Daniel, D. Visaggio, M. Marsotto, P. Visca, E. Bemporad, P. Ascenzi, G. Capellini, M. Sebastiani, A. di Masi, Biocompatibility and antibacterial properties of TiCu(Ag) thin films produced by physical vapor deposition magnetron sputtering, Applied Surface Science 573 (2022) 151604.

N. Schalk, M. Tkadletz, C. Mitterer, Hard coatings for cutting applications: Physical vs. chemical vapor deposition and future challenges for the coatings community, Surface & Coatings Technology 429 (2022) 127949.

S. Stock, N. Kostoglou, J. Selinger, S. Spirk, C. Tampaxis, G. Charalambopoulou, T. Steriotis, C. Rebholz, C. Mitterer, O. Paris, Coffee waste-derived nanoporous carbons for hydrogen storage, ACS Appl. Energy Mater. 5 (2022) 10915−10926.

H. Waldl, M. Tkadletz, C. Czettl, M. Pohler, N. Schalk, Influence of multilayer architecture on microstructure and fracture properties of arc evaporated TiAlTaN coatings, Surface & Coatings Technology 433 (2022) 128098.

Chair of Physical Metallurgy and Metallic Materials

N. Abdoshahi, M. Dehghani, A. V. Ruban, M. Friák, M. Šob, J. Spitaler, D. Holec, On the energetics of the cubic-to-hexagonal transformations in TiAl+Mo alloys, Acta Materialia 240 (2022) 118268.

G. Graf, P. Spoerk-Erdely, P. Staron, A. Stark, F. Mendez Martin, H. Clemens, T. Klein, Quench rate sensitivity of age-hardenable Al-Zn-Mg-Cu alloys with respect to the Zn/Mg ratio: An in situ SAXS and HEXRD study, Acta Materialia 227 (2022) 117727.

V. Maier-Kiener, S. K. Lawrence, B. Merle, 30 Years of Oliver–Pharr: Then, now and the future of nanoindentation, JOM 74 (2022) 2177–2178.

M. Musi, H. Clemens, A. Stark, P. Staron, P. Spoerk-Erdely, Phase transformations and phase stability in the Ti–44 at.%Al–(0–7 at.%) Mo system, Intermetallics 143 (2022) 107484.

M. Musi, S. Kardos, L. Hatzenbichler, D. Holec, A. Stark, M. Allen, V. Güther, H. Clemens, P. Spoerk-Erdely, The effect of zirconium on the Ti-(42-46 at.%)Al system, Acta Materialia 241 (2022) 118414.

A. Sakic, C. Hofer, R. Schnitzer, D. Holec, Ab initio study of alloying impact on the stability of cementite in transformation-induced plasticity-assisted, Advanced Steels, Adv. Eng. Mater. 2022, 2200532.

G. J. K. Schaffar, J. Kappacher, D. Tscharnuter, V. Maier-Kiener, The phase transformation of silicon assessed by an unloading contact pressure approach, JOM 74 (2022) 2220–2230.

D. Scheiber, E. Povoden-Karadeniz, E. Kozeschnik, L. Romaner, Prediction of grain boundary chemistry in multicomponent Mo alloys with coupled precipitation and segregation kinetics simulations, Acta Materialia 224 (2022) 117482.

S. Zeisl, A. Landefeld, N. Van Steenberge, Y. Chang, R. Schnitzer, The role of alloying elements in NiAl and Ni3Ti strengthened Co-free maraging steels, Materials Science & Engineering A 861 (2022) 144313.

S. Zeisl, A. Lassnig, A. Hohenwarter, F. Mendez-Martin, Precipitation behavior of a Co-free Fe-Ni-Cr-Mo-Ti-Al maraging steel after severe plastic deformation, Materials Science & Engineering A 833 (2022) 142416.

Chair of Materials Physics

M. Alfreider, R. Bodlos, L. Romaner, D. Kiener, The influence of chemistry on the interface toughness in a WTi-Cu system, Acta Mater. 230 (2022).

Z. Chen, Y. Zheng, Y. Huang, Z. Gao, H. Sheng, M. Bartosik, P.H. Mayrhofer, Z. Zhang, Atomic-scale understanding of the structural evolution of TiN/AlN superlattice during nanoindentation— Part 1: Deformation, Acta Mater. 234 (2022).

M.J. Cordill, P. Kreiml, B. Putz, C.O.W. Trost, A. Lassnig, C. Mitterer, D. Faurie, P.O. Renault, Film thickness and architecture effects in biaxially strained polymer supported Al/Mo bilayers, Mater. Today Commun. 31 (2022).

M. Meindlhumer, T. Ziegelwanger, J. Zalesak, M. Hans, L. Löfler, S. Spor, N. Jäger, A. Stark, H. Hruby, R. Daniel, D. Holec, J.M. Schneider, C. Mitterer, J. Keckes, Precipitation-based grain boundary design alters Inter- to Trans-granular Fracture in AlCrN Thin Films, Acta Mater. 237 (2022).

R. Pippan, A. Hohenwarter, Crack propagation resistance of TiAl alloys, MRS Bull. 47 (2022).

B. Sarac, J. Eckert, Thermoplasticity of metallic glasses: Processing and applications, Prog. Mater. Sci. 127 (2022).

H. Sheng, D. Şopu, S. Fellner, J. Eckert, C. Gammer, Mapping Shear Bands in Metallic Glasses: From Atomic Structure to Bulk Dynamics, Physical Review Letters. 128 (2022) 245501.

F. Spieckermann, D. Şopu, V. Soprunyuk, M.B. Kerber, J. Bednarčík, A. Schökel, A. Rezvan, S. Ketov, B. Sarac, E. Schafler, J. Eckert, Structure-dynamics relationships in cryogenically deformed bulk metallic glass, Nat. Commun. 13 (2022).

L. Weissitsch, M. Stückler, S. Wurster, J. Todt, P. Knoll, H. Krenn, R. Pippan, A. Bachmaier, Manufacturing of Textured Bulk Fe-SmCo5 Magnets by Severe Plastic Deformation, Nanomaterials. 12 (2022).

Q. Xu, D. Şopu, X. Yuan, D. Kiener, J. Eckert, Interface-related deformation phenomena in metallic glass/high entropy nanolaminates, Acta Mater. 237 (2022).

Chair of Design of Steels - Endowed Professorship for Industry

F. Galbusera, A. G. Demir, J. Platl, C. Turk, R. Schnitzer, B. Previtali, Processability and cracking behaviour of novel high-alloyed tool steels processed by Laser Powder Bed Fusion, Journal of Materials Processing Tech. 302 (2022) 117435.

S. Monschein, N. Kostwein, K. S. Ragger, D. Zügner, J. Fasching, R. Schnitzer, Determination of the degree of recrystallization of a microalloyed HSLA steel by using metallographic methods, Pract. Metallogr. 59 (2022) 6.

S. Monschein, K. S. Ragger, J. Fasching, D. Zügner, R. Schnitzer, Microstructural, chemical, and crystallographic investigations of dynamic strain-induced ferrite in a microalloyed QT steel, Metals 12 (2022) 313.

S. Monschein, K. S. Ragger, D. Zügner, J. Fasching, R. Schnitzer, Influence of the Ti content on the grain stability and the recrystallization behavior of Nb-alloyed high-strength low-alloyed steels, steel research int. (2022) 2200094.

J. Platl, S. Bodner, C. Hofer, A. Landefeld, H. Leitner, C. Turk, M.-A. Nielsen, A. G. Demir, B. Previtali, J. Keckes, R. Schnitzer, Cracking mechanism in a laser powder bed fused cold-work tool steel: The role of residual stresses, microstructure and local elemental concentrations, Acta Materialia 225 (2022) 117570.

J. Platl, S. Bodner, H. Leitner, C. Turk, M.-A. Nielsen, J. Keckes, R. Schnitzer. Local microstructural evolution and the role of residual stresses in the phase stability of a laser powder bed fused cold-work tool steel, Materials Characterization 193 (2022) 112318.

A. Rosenauer, D. Brandl, G. Ressel, S. Lukas, S. Monschein, M. Stockinger, R. Schnitzer, Influence of delta ferrite on the impact toughness of a PH 13-8 Mo maraging steel, Materials Science & Engineering A 856 (2022) 144024.

H. Schönmaier, M. Musi, M. Albu, R. Krein, R. Schnitzer, Effect of post weld heat treatment on the interplay of microstructure, precipitates and properties of creep-resistant 2.25Cr-1Mo-0.25V weld metal, Materials Science & Engineering A 850 (2022) 143550.

D. Zidar, A. Landefeld, B. Gschöpf, R. Schnitzer, H. Zunko, W. Friesenbichler, Hardness Loss of Plastic Mold Steels: Phenomenon in Injection Molding, steel research int. (2022) 2200326.

Chair of Structural and Functional Ceramics

T.E.J. Edwards, N. Rohbeck, E. Huszár, K. Thomas, B. Putz, M.N. Polyakov, X. Maeder, L. Pethö, J. Michler, Thermally Stable Nanotwins: New Heights for Cu Mechanics, Advanced Science 34 (2022) 2203544.

M. Gruber, A. Leitner, D. Kiener, P. Supancic, R. Bermejo, Effect of crystal orientation on the hardness and strength of piezoelectric LiNbO3 substrates for microelectronic applications, Materials & Design 213 (2022) 110306.

A.-K. Hofer, A. Kocjan, R. Bermejo, High-strength lithography-based additive manufacturing of ceramic components with rapid sintering, Additive Manufacturing (2022) 103141.

A.-K. Hofer, J. Rabitsch, D. Jutrzenka-Trzebiatowska, M. Hofstetter, I. Gavalda-Velasco, J. Schlacher, M. Schwentenwein, R. Bermejo, Effect of binder system on the thermo-physical properties of 3D-printed zirconia ceramics, Applied Ceramic Technology 19 (2022) 174-180.

B. Kaufmann, P. Supancic, Theory of asymmetric and piezotronically modified double Schottky barriers, Journal of Applied Physics 132 (2022) 145702.

T. Lube, M. Staudacher, A.-K. Hofer, J. Schlacher, R. Bermejo, Stereolithographic 3D printing of ceramics: challenges and opportunities for structural integrity, Advanced Engineering Materials (2022) 2200520.

S. Nohut, S. Geier, I. Kraleva, M. Schwentenwein, R. Bermejo, Lithography-based additive manufacturing of porosity graded alumina, Additive Manufacturing Letters 3 (2022) 100060.

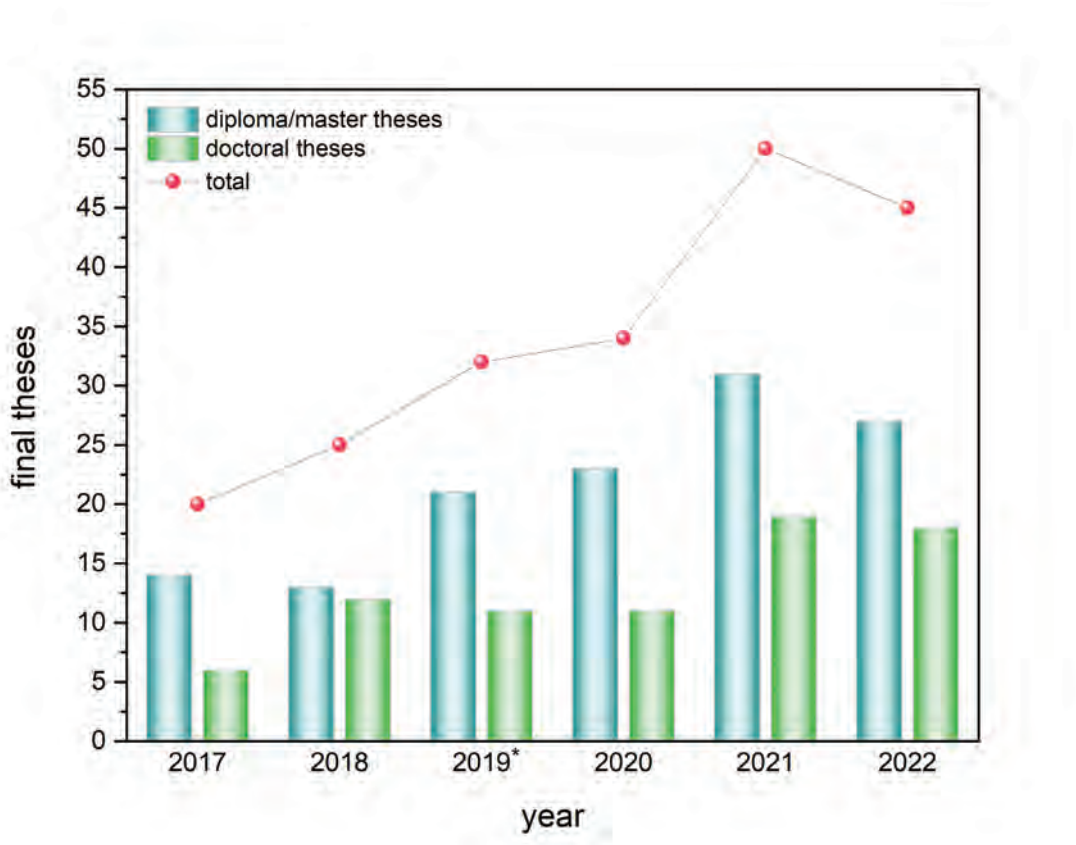
B. Putz, O. Milkovic, G. Mohanty, R. Ipach, L. Pethö, J. Milkovicova, X. Maeder, T.E.J. Edwards, P. Schweizer, M. Coduri, K. Saksl, J. Michler, Structural characterisation of Cu-Zr thin film combinatorial libraries with synchrotron radiation at the limit of crystallinity, Materials & Design 218 (2022) 110675.

D. Scheiber, M.N. Popov, P. Supancic, J. Spitaler, Understanding and controlling inversion boundaries in ZnO, Acta Materialia 229 (2022) 117804.

J. Schlacher, A. Jabr, A. Hofer, R. Bermejo, Contact damage tolerance of alumina-based layered ceramics with tailored microstructures, Journal of the American Ceramic Society (2022) 4387-4399.

Master and doctoral theses

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



* Since the establishment of the Department of Materials Science in 2019, five chairs are included in this representation; prior to 2019, only three were included.

Master theses

In 2022, 27 students completed their master's thesis.

Bechter, Johannes Ernst
Data-driven thermodynamic modelling and uncertainty quantification of the binary iron-carbon system

Becker, Maria-Theresia
Synthesis and characterization of B1-AlN containing superlattice structures

Buchebner, Nadine Susanne
Deformation behaviour of hexagonal closed packed zinc and magnesium with reference to size-effect and c/a-ratio

Byloff, Johanna Luise
Varistor grain boundary characterization by high resolution analytics

Donau, Moritz Robert Wilhelm
Thermal stability and structural evolution of a modified 2xxx alloy for an engine component application

Eschelbeck, Jakob
Grain growth and recrystallization behaviour of HSLA-steels

Glanznig, Alexander René
Qualification process of 3D printed high-performance polymer parts, for lam wet clean applications

Halkali, Celine
Development of a semi-automated molecular dynamics workflow for testing interatomic potentials against ab-initio data

Hatzenbichler, Lukas
Prediciting phase stability of TiAl-based high entropy alloys from first-principles

Käfer, Nicole
Additive manufacturing of nickel-base superalloys - crack formation, microstructural analysis and process optimization

Kapala, Joseph Munyika
Production of damage tolerant Ti-6Al-4V by laser powder bed fusion (L-PBF)

Kasalo, Manoel
Magnetoresistive behavior of nanocrystalline materials processed by high-pressure torsion

Käsznar, Katharina
Influence of processing parameters on the microstructure of cold heading steels during thermomechanical forming

Keckes, Julius
Probing local atomic strain of metallic glasses with nanometer resolution using TEM diffraction mapping

Kostwein, Nikolaus
Light optical and high-resolution characterization of thermomechanical rolled steel grades

Lichtenegger, Hannah Luise
Evaluation of the high cycle fatigue behaviour of high-strength MoRe alloys by means of rotary bending tests

Obersteiner, David
Thermomechanical processing and high-temperature behavior of spark-plasma-sintered near-α Ti-8242NbS alloy

Pock, Alexander Michael
Investigation of the influence of cyclic - thermal loading on the hardness and microstructure of plastic mold steels

Pogrielz, Thomas
About the productivity in laser powder bed fusion produced Ti-6Al-4V components

Reiter, Maximilian
Development of a wear-resistant cast steel alloy for hot work rolls with increased high temperature strength

Römer, Felix Josef
Investigation of the crystallization behavior of iron-based metallic glasses for electrical devices

Ruderes, Katharina
Reliability of copper-fiber reinforced laminates

Schrems, Sebastian
Substitution of silicon through aluminum in high-ductility steels

Schrittwieser, Daniel
Influence of alloying elements on the properties of low-alloyed creep-resistant CrMoV-weld metal

Seligmann, Benjamin
In-situ thermo-mechanical cycling of Si-TiW-Cu thin film structures

Taucher, Lorenz Johannes
Microstructural characterization and investigation of the high-temperature forming behavior of an (α+β) titanium alloy modified with boron

Zeitlhofer, Theresia
Material analysis of medical cannulas

Doctoral theses

In 2022, 18 doctoral students were awarded doctorates in montanistic sciences.

Alfreider, Markus
Locally resolved deformation and fracture processes near interfaces

Fleißner-Rieger, Christian
Titanium base alloys for laser powder bed fusion

Frank, Florian
ZrN-based hard coatings deposited by chemical and physical vapor deposition

Göbl, Michael Christian
Novel protection plates for automotive applications

Gsellmann, Matthias
Interfacial damage of TiN coated high speed steels under a realistic spectrum of shear- and normal loads

Haselmann, Ulrich
Atomic-scale study on dopant- and strain-effects in bismuth-ferrite thin films

Janda, Alexander Philipp
Alloy and process development of α+β titanium alloys for ballistic protection applications

Kickinger, Christoph
Development of high-strength quenching & partitioning steels

Löfler, Lukas
Defects and their influence on mechanical properties in nitrides: an atomistic study

Mayer, Michael
Temperature effect during mechanical alloying on the yttria evolution in the processing of an ODS FeCrMnNiCo alloy

Monschein, Stefan
Influence of microalloying elements and deformation parameters on the recrystallization behavior and microstructural evolution of HSLA steels

Moser, Sebastian
Thermo-mechanical fatigue of metallizations in microelectronic applications

Musi, Michael
Exploring phase transformations and phase stabilities in titanium aluminide based alloys

Platl, Jan Ingo
Cracking mechanisms of high-alloyed tool steels processed with laser powder bed fusion

Pfleger-Schopf, Bernd
Stability of retained austenite in a bainitic low alloyed steel and its response to mechanical and thermal loading

Schönmaier, Hannah
Microstructure-property relationships of creep-resistant 2.25Cr-1Mo-0.25V submerged-arc weld metal

Waldl, Helene
Development of TiAlN based hard coatings applying advanced characterization methods

Wurmshuber, Michael
Enhanced mechanical performance of nanostructured metals through systematically modified interfaces

Habilitation

Nina Schalk – Habilitation for surface engineering

Education and professional career

• Diploma studies in materials science (Graduation 2010), as well as subsequent doctoral studies (Doctorate 2013) at the University of Leoben.

• Since 2013 head of the research group „Advanced Surface Engineering“ at the Chair of Functional Materials and Material Systems.

• Since 2017 Head of the Christian Doppler Laboratory for advanced coated cutting tools.

Research focus

Functional thin films play an essential role in today‘s society. They allow tailoring of the surface properties for the respective application and thus significantly contribute to environmental protection and conservation of resources. Considering for example microelectronic components or displays many applications are only enabled by modern thin-film technologies.

Nina Schalk‘s research focuses on the deposition of multifunctional thin films by means of physical and chemical vapor deposition and the establishment of the synthesis-microstructure-properties-application behavior relationships. Where the characterization of the thin films, which are often only a few 10 nm to a few µm thick, is particularly challenging. In order to investigate the microstructure and multifunctional properties, the use of modern high-resolution methods such as electron backscatter diffraction, transmission electron microscopy, atomic probe tomography or micromechanical tests is necessary.

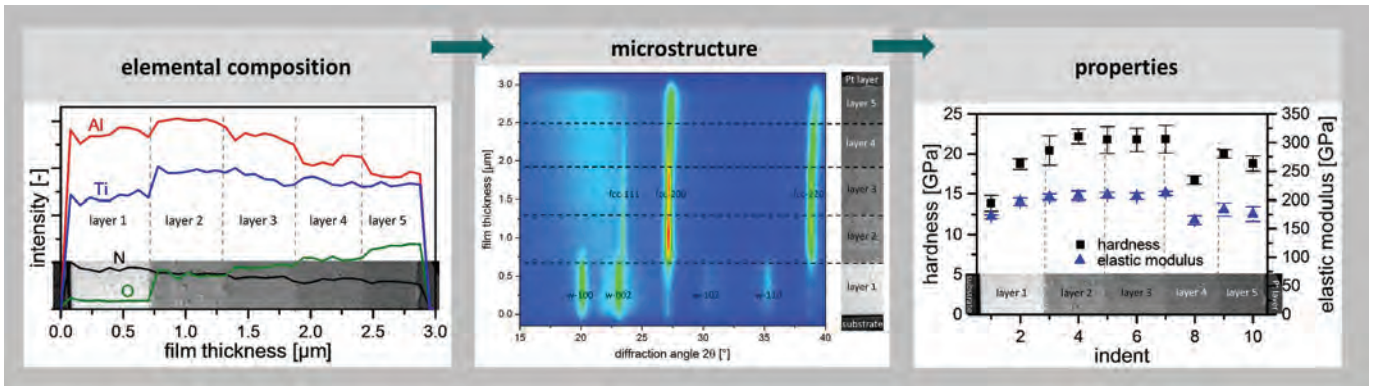
Awards and prizes

2014 Dr. Wolfang Houska Award, Top 10

2016 Forschungsförderungspreis of Styria

Personal Information

Nina Schalk likes to spend her free time traveling, hiking, biking and in winter skiing together with her family.



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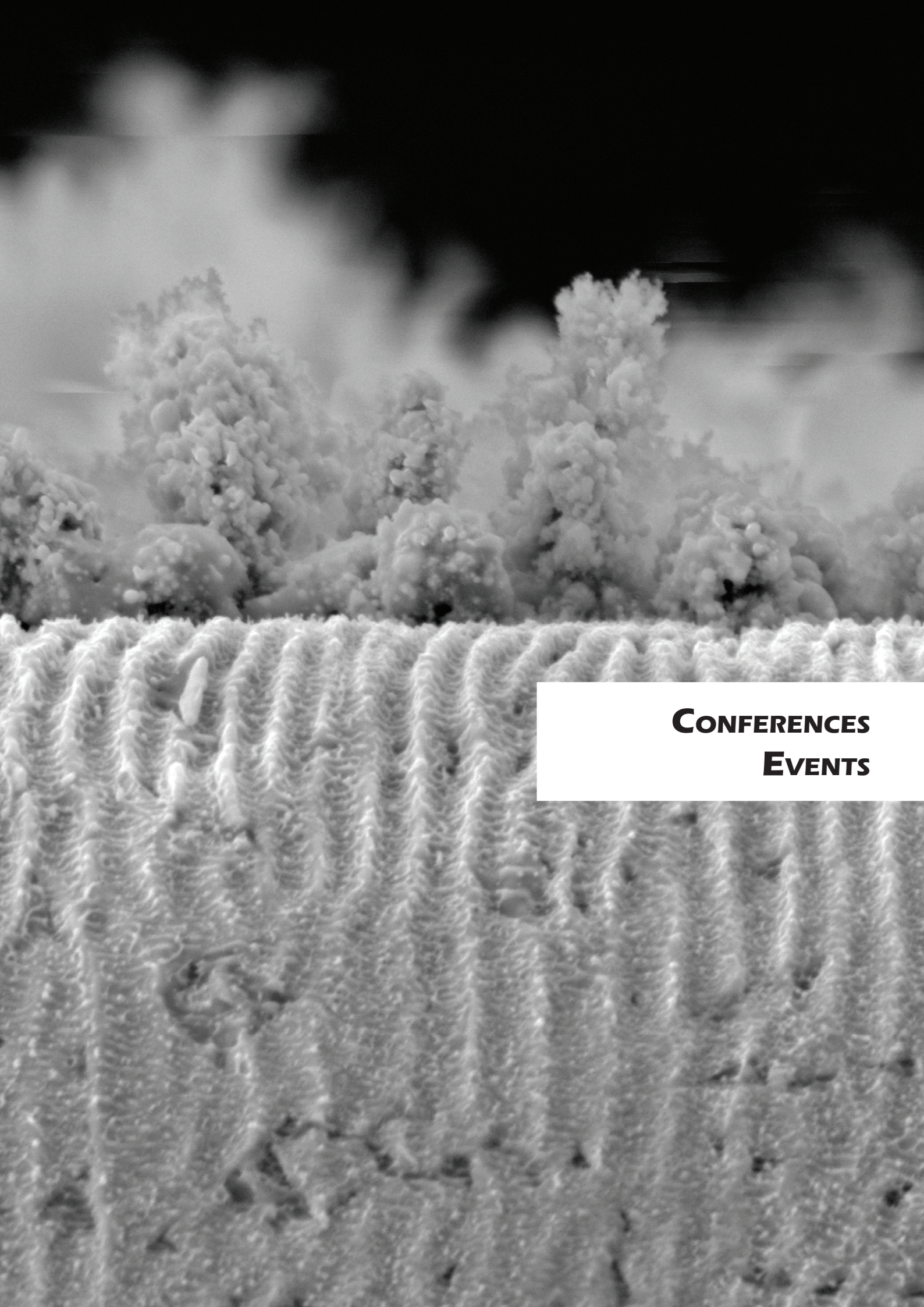


Conferences
Events

Conferences and events

Organization of conferences

Because of the outbreak of Covid-19 a lot of scientific events were canceled. However, there were still some conferences, seminars and other events the Department and its staff were actively involved. The following is an overview of the activities carried out.

1st Materials Science Colloquium (66. Metallkunde-Kolloquium) (19.04. - 22.04.2022, Lech am Arlberg)

From April 19-22, the 1st Materials Science Colloquium (66th Physical Metallurgy Colloquium) was held in Lech am Arlberg after a two-year break due to the pandemic. For the first time, the colloquium was held entirely in English, organized by the Department of Materials Science and included a highlight topic for one day on “Advanced ceramics and microelectronic systems”. Thus, an internationalization and successful extension of this traditional colloquium was achieved. The nearly 70 participants were able to discuss in-depth scientific talks and initiate new collaborations in a relaxed atmosphere.

48th International Conference on Metallurgical Coatings & Thin Films (ICMCTF) (22.05. - 27.05.2022, San Diego)

The traditional 'International Conference on Metallurgical Coatings and Thin Films (ICMCTF)' was held again in the Town and Country convention center in San Diego (CA, USA) during the last week of May of 2022. A meeting which attracts specialists from both academia and industry from around the globe with around 400 contributions including well-received talks from members of the Department of Materials Science. Next to multiple participations, the department was traditionally involved in the organization with four scientists serving as symposium chairs. Michael Tkadletz co-organized a session on "Spatially-resolved and In-Situ Characterization of Thin Films and Engineered Surfaces" within the symposium on "Advanced Characterization Techniques for Coatings, Thin Films, and Small Volumes", David Holec co-organized a session "In-Silico Design of Novel Materials by Quantum Mechanics and Classical Methods" within the symposium " New Horizons in Coatings and Thin Films", and Barbara Putz and Oleksandr Glushko co-organized a new topical symposium " Thin Films on Polymer Substrates: Flexible Electronics and Beyond".

Data Science Summer School 2022 (03.07. - 08.07.2022, Leoben)

The summer school was organized by the Data Science Hub at the Montanuniversität Leoben and the TU AUSTRIA and was taking place in Leoben from July 3-8. In an intensive five days of lectures, workshops and networking, the main concepts of machine learning (ML) and its application in engineering and physical sciences were introduced for PhD, Master, and advanced Bachelor students. The topics covered included an introduction to ML covering performance measures and testing, data preparation procedures, deep learning, autoencoders, ML in robotics and ML in materials science. The last topic was covered by Lorenz Romaner from the Department of Materials Science.

16th International Congress on Microscopy (MCM2022) (04.09. - 09.09.2022, Brno)

The 16th international congress on microscopy (MCM2022) was held in Brno, Czech Republic, from September 4- 9, connecting leading scientists and researchers in the field of microscopy. The conference featured presentations, workshops and exhibitions on the latest microscopy techniques and cutting-edge technological advancements. A team of researchers from the Montanuniversität Leoben had the opportunity to present their current work to an international community and network with experts in the field. Daniel Kiener descendants the honor to participate in the conference's scientific board and co-organized the session "Micro- and nanomechanical characterization of materials". His post-doctoral researcher, Michael Burtscher, had the opportunity to give an invited presentation on the current progress of his project.

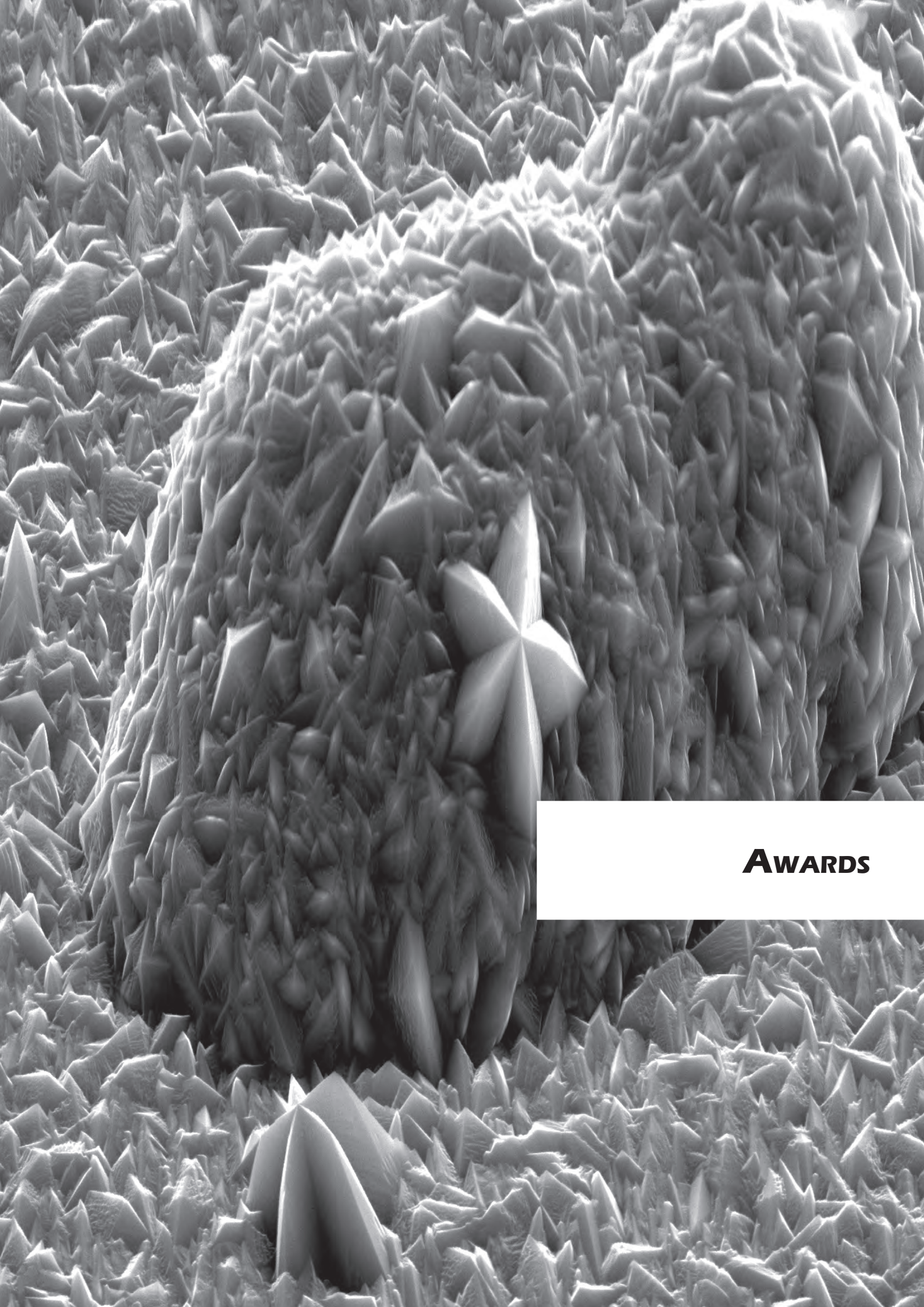
Opening celebration for the acquisition of the new atom probe at the Department Materials Science (03.10.2022, Leoben)

At the beginning of October, the opening celebration for the acquisition and successful commissioning of the new atom probe took place. The atom probe of the so-called 3rd generation (LEAP 5000 XR) was acquired within the framework of the 3rd tender of the R&D infrastructure funding of the FFG at the Department of Materials Science. With an investment volume of € 2.6 million it represents the highest laboratory equipment investment in the history of the Montanuniversität Leoben. With the help of high-resolution atom probe tomography, the atomic structure of materials can be investigated. In combination with correlative techniques such as transmission electron microscopy and ab-initio calculations, knowledge-based material developments and tuning of material properties are enabled.

With around 60 participants the event was very well attended and the newly acquired possibilities were presented through six expert talks. In addition to internal speakers, external speakers from the international research environment and the atom probe manufacturer Cameca (Madison, USA) illustrated the advantages of the new acquisition. After the presentations a laboratory tour and a visit to the atom probe took place, where the event ended with a buffet and interesting conversations. We are looking forward to the new opportunities now available for us and to answering many exciting research questions.

Materials Science & Technology Technical Meeting and Exhibition (MS&T2022) (09.10. - 12.10.2022, Pittsburgh)

The 2022 Materials Science & Technology Technical Meeting and Exhibition (MS&T2022) organized by TMS, AIST and The American Ceramic Society took place during October 9-12, 2022 in Pittsburgh. Together with K.G. Prashanth (Tallinn University of Technology) and Z. Wang (South China University of Technology, Guangzhou), Jürgen 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 and microstructure correlations for different additive manufacturing processes. Emphasis was placed on understanding the capabilities of the processes and the correlation between process conditions, process parameters, microstructure development and material properties, covering a broad range of materials spanning all the way from ferrous alloys including steels to Al-, Cu-, Co-, Mg-based alloys, high entropy alloys, intermetallics, metal matrix composites and ODS alloys. The main objective was to foster knowledge transfer and exchange of experiences among the delegates with academic or industrial background, and very lively discussions contributed to the success of the symposium.



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 numerous younger employees in particular 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.

Josef Krainer Appreciation Prize 2022 for Andrea Bachmaier

On Monday evening (May 23, 2022) the festive presentation of the Josef Krainer Prizes was on the program in the auditorium of the Old University in Graz. In the presence of numerous guests of honour, the memory of Josef Krainer Sr., who shaped the state as governor from 1948 to 1971 as a reformer, was honored. Provincial Governor Hermann Schützenhöfer and Gerald Schäfer, chairman of the Josef Krainer Memorial, awarded the Josef Krainer Appreciation Prize 2022 to Andrea Bachmaier, among others.

The Josef Krainer awards go to established personalities. Before making its decisions, the Scientific Advisory Board obtains reports from completely independent domestic and foreign experts. The Josef Krainer Appreciation Prize 2022 was awarded five times, and Andrea Bachmaier was one of the distinguished recipients.

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Andrea Bachmaier new member of the Young Academy

Andrea Bachmaier was elected as a new member of the Young Academy of the Austrian Academy of Sciences

In addition to the philosophical-historical and the mathematical-scientific classes, the Young Academy forms the third pillar of the Academy of Sciences. Consisting of excellent young scientists from all disciplines, it is actively involved in strengthening innovative research and promoting young researchers.

The members of the Young Academy are already established young scientists who are identified on the basis of important research funding awards or scholarships and are accepted by the Young Academy and confirmation by the Academy as a whole. Membership in the Young Academy is for a period of eight years.

Theodor Körner Award to Sandra Ebner

Sandra Ebner was awarded the Theodor Körner Prize 2020 for her dissertation entitled “Microstructural Evolution during Q&P Processing and Effects on the Mechanical Properties”. In her dissertation, which Sandra Ebner conducted at the Chair of Design of Steels, she dealt with novel third-generation Advanced High Strength Steels, which are used in automotive industry to enable weight savings while increasing personal safety. The focus of the doctoral thesis was on in-situ diffraction experiments using high-energy X-ray diffraction, which can be used to investigate time-resolved changes occurring in the material during heat treatment or mechanical loading. The presentation by Federal President Dr. Alexander van der Bellen, which was postponed due to the pandemic, was made up for in June 2022 at the Arbeiterkammer Wien.

f.l.t.r.: Arbeiterkammerpräsidentin Renate Anderl, Sandra Ebner, Federal President Alexander van der Bellen

Buehler Best Paper Award 2021 for the best publication of the year

The “Buehler Best Paper Award” recognizes the best papers from the journal “Praktische Metallographie / Practical Metallography” of the past year. In the evaluation of the 2021 contributions, the article of the Chair of Physical Metallurgy and Metallic Materials “An additively manufactured titanium alloy in the focus of metallography” under the leadership of Christian Fleißner-Rieger was chosen by the judging panel as the best publication. The selection was made by representatives of the editorial board of Practical Metallography, members of the Expert Committee for Metallography of the German Society for Materials Science (DGM) and Buehler staff. The prize was awarded on the occasion of the International Materialography Conference, which took place in Saarbrücken from September 21-23, 2022.

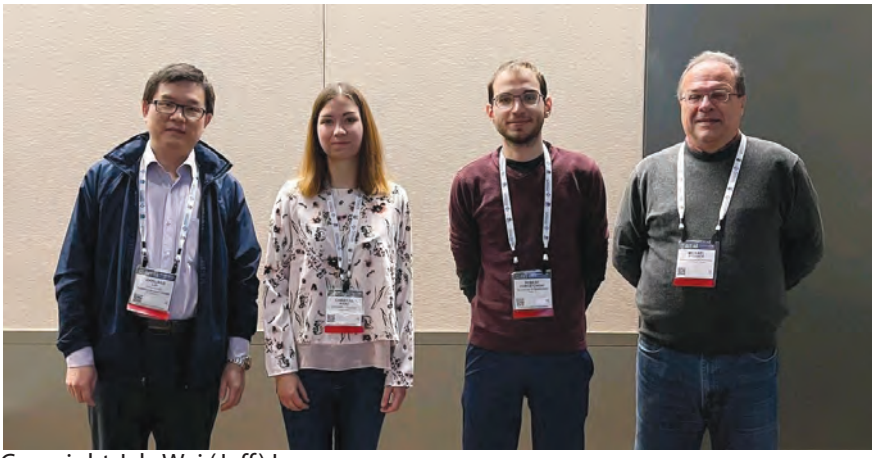
The award was accepted by Helmut Clemens (center). Left: Ronald Schnitzer; right: Prof. Dr. Frank Mücklich, the organizer of the International Materialography Conference in Saarbrücken.

Best Oral Presentation Award 2022 auf der Konferenz für „Young ceramists in additive manufacturing”

The 4th yCAM conference this year took place in Barcelona. yCAM stands for “young ceramists in additive manufacturing” and forms a network for young researchers in the field of ceramic 3D printing. During the conference, more than 30 presentations and numerous posters, mainly by PhD students, were given and exhibited on their current research topics. For the first time this year, an award was given for the best presentation and the best poster. The “best oral presentation award” went to the PhD student of the Chair of Structural and Functional Ceramics, Anna-Katharina Hofer. In her presentation, she showed her research on a new possible rapid sintering process of 3D-printed ceramic components, with which one can achieve a reduction of the process duration, the energy input and the targeted adjustment of microstructure and consequently mechanical properties.

AVS Young Investigator Award to Christina Kainz

Christina Kainz, postdoc in the Christian Doppler Laboratory for Advanced Coated Cutting Tools at the Chair of Functional Materials and Material Systems, received the Young Investigator Award during the 68th Symposium of the American Vacuum Society (AVS). The award, which is presented by the Advanced Surface Engineering Division of the AVS, recognizes the work of young researchers in the field of vacuum technology and thin film technology. The award was presented to Christina Kainz for her significant scientific contributions to design, synthesis and characterization of novel hard coatings with optimized thermal stability and superiors oxidation performance.



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Josef Krainer Promotion Award to Christina Kainz

In memory of the work of the Styrian governor Josef Krainer, the "Steirische Gedenkwerk" annualy awards prizes in the categories of the Josef Krainer Heimatpreis, the Josef Krainer Würdigungspreis and the Josef Krainer Förderungspreis. Christina Kainz, PostDoc in the Christian Doppler Laboratory Advanced Coated Cutting Tools at the Chair of Functional Materials and Materials Systems, was awarded one of the Josef Krainer Promotion Prizes 2021 in recognition of her research achievements in the field of materials science. In her award-winning doctoral thesis, Christina Kainz focused on the development and characterization of hard coatings for metal cutting applications. The award ceremony took place on February 17th 2022 in the auditorium of the old university in Graz.

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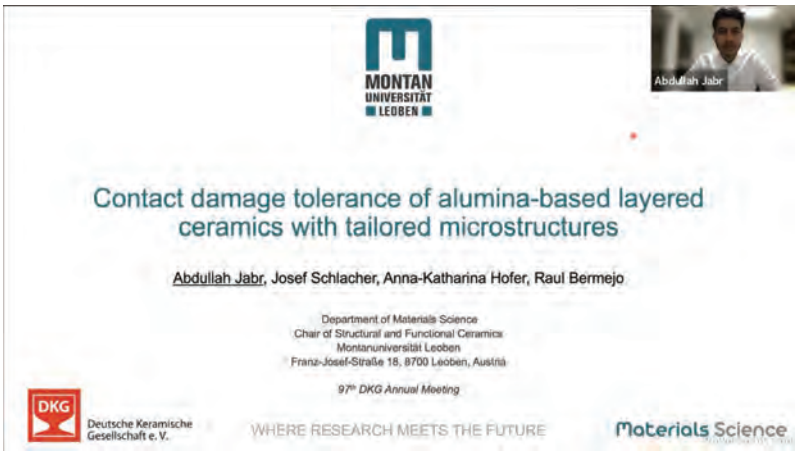
IUVSTA Prize for Science an Christian Mitterer

The triennial IUVSTA Prize for Science of the International Union for Vacuum Science, Technique and Applications was awarded in 2022 to Christian Mitterer, Professor of Functional Materials and Materials Systems, for his pioneering contributions to the materials science of protective coatings and thin films for flexible electronics and hydrogen storage. The Prize for Science, together with the Prize for Technology, represents IUVSTA's highest honors; they are awarded for recognition of outstanding and internationally recognized experimental and/or theoretical research results in subject areas relevant to IUVSTA. The prize is associated with a plenary lecture at the triennial IUVSTA International Vacuum Congress, which was held in Sapporo, Japan, September 11-16, 2022.

Two awards at the 97th annual conference of the DKG

As part of the 97th annual conference of the German Ceramic Society (DKG), two doctoral students from the Chair of Structural and Functional Ceramics were awarded.

Abdullah Jabr won the second place in the Hans-Walter-Hennicke lecture competition, which was sponsored by Morgan Advanced Materials Haldenwanger GmbH. The Hans-Walter-Hennicke Lecture Prize is awarded annually by the DKG to the best presentations by young scientists who have completed their thesis (bachelor's or master's thesis) in the field of ceramics. With his presentation "Contact damage tolerance of alumina-based layered ceramics with tailored microstructures", Abdullah Jabr convinced the jury by presenting the excellent contact damage tolerance of ceramic architectures with embedded textured layers.



Furthermore, Josef Schlacher was awarded with the second place of the JECS Trust Young Researcher Best Presentation Award for his invited presentation „Fracture toughness of textured alumina grains and grain boundaries determined by micro-cantilever bending tests". In this presentation, recent research results on the micro level of textured grains were discussed in order to better understand the macroscopic fracture behavior of layered ceramics.

Both works were carried out as part of the „CeraText" project of the ERC Consolidator Grant (Tailoring Microstructure and Architecture to Build Ceramic Components with Unprecedented Damage Tolerance).

Graduate Student Award for Yvonne Moritz

Yvonne Moritz, PhD student at the Christian Doppler Laboratory for Advanced Coated Cutting Tools at the Department of Materials Science, was awarded the Graduate Student Award Bronze at the International Conference on Metallurgical Coatings and Thin Films (ICMCTF 2022) in San Diego, USA, for her contribution entitled „New insights into microstructure, mechanical properties and thermal and oxidation stability of Ti(Al)SiN coatings using a combinatorial approach of advanced high resolution methods“. In this work, Yvonne Moritz studied the complex microstructure of Ti(Al)SiN nanocomposite coatings in detail by complimentary applying several advanced and high resolution characterization methods and correlated the microstructure with the mechanical properties as well as the thermal and oxidation stability.

©AVS Conference Photos, f.l.t.r.: Prof. Ivan Petrov (Chair of the Advanced Surface Engineering Division (ASED) Awards Committee), Andreas Kretschmer (TU Wien, Gold Finalist), Yvonne Moritz (Montanuniversität, Bronze Finalist), Damian Holzapfel (RWTH Aachen, Silver Finalist)

WKO - Research scholarships awarded to Maximilian Reiter and Anna Paulik for their master's theses at the Department of Materials Science

The research scholarships of the WKO Steiermark were awarded this year to two master students of the Department of Materials Science, to Anna Paulik from the Chair of Physical Metallurgy and Metallic Materials and Maximilian Reiter from the Chair of Design of Steels. Anna Paulik's thesis deals with the quantum mechanical calculation of the positioning of H in the crystal structure of NiTi shape memory alloys, which are to be used in medical technology in the future. That of Maximilian Reiter dealt with the development of a wear-resistant cast steel alloy for hot work rolls with increased high-temperature strength and was carried out in cooperation with the company Eisenwerk Sulzau-Werfen R. & E. Weinberger AG. The scholarships were awarded at a ceremony held by the WKO Steiermark in Graz on July 7.

©Foto Fischer: f.l.t.r.: WKO Kammerdirektor Dr. Karl-Heinz Dernoscheg, MBA, Anna Paulik, Maximilian Reiter, Anna Christine Krammer, Thomas Antretter.

Wissenschaftspreis für Montanistinnen 2022
Kategorie Junior Scientist: Anna Margarethe Paulik

Anna Paulik's work is in the area of atomistic simulations - specifically, she is using density functional theory methods to explore the structure and stability of a novel intermetallic nickel-titanium hydride phase. Her work makes a significant contribution to fundamental research in a field that is not fully accessible through experiments alone. Her simulations provide a deeper understanding of the material behavior of nickel-titanium, a shape memory material that is indispensable in today's modern medical technology. She not only collaborates with scientists from the University of Leoben, but as part of her research project, she is also networked with scientists from the Academy of Sciences of the Czech Republic in Brno.

SNF Ambizione - Grant for Barbara Putz

Barbara Putz has been awarded a € 850,000 Ambizione Grant from the Swiss National Science Foundation for her work in the field of stretchable hybrid materials at the atomic scale. In the course of the project, the potential of atomic and molecular layer deposition is used to selectively modify the microstructure and interfaces of thin films on flexible polymer substrates via artificial interlayers. Such materials are used, for example, in flexible microelectronics as well as in food packaging or satellite insulation.

The overall goal of the project is to contribute to an improved understanding of the metal-polymer interface, especially with respect to adhesion and cracking in the metal layer. Specifically, we will (i) investigate the mechanisms of natural interface formation during the coating process, and (ii) artificially recreate them at the atomic level to ensure good adhesion regardless of the material combination. In addition, we aim to (iii) use atomic-scale interfacial engineering to develop mechanisms and methods for selective separation of metal and polymer in the recycling phase.

The research is carried out in collaboration with Empa in Thun, Switzerland.

2nd place at the Dörrenberg StudienAWARD to Daniel Rainer

Daniel Rainer was awarded with the second place in the Dörrenberg StudienAWARD for his bachelor thesis entitled “Defect and microstructure characterization of a selectively laser-melted FeCoMo alloy”, which he carried out at the Chair of Design of Steels under the supervision of Ronald Schnitzer.

This prize competition organized by Dörrenberg Edelstahl GmbH, which includes a total endowment of € 10,000, awards prizes to student research projects in technical fields with a focus on materials technology. Project or bachelor’s theses, but not master’s or diploma theses, can be submitted. After submission, the candidates were evaluated and preselected for the final round, in which they presented their work with lectures in Engelskirchen near Cologne. The jury was made up of renowned professors from the Ruhr Universität Bochum, the RWTH Aachen and the FH Wels, as well as a representative of Dörrenberg Edelstahl GmbH, and was pleased to award the second place to Daniel Rainer’s work.

New scientific ground in metals research

f.l.t.r.: Gerhard Hackl (Executive Member of the Board ASMET), Franz Rotter (ASMET-President), Lorenz Romaner (Montanuniversität Leoben), Ursula Jakubek (Commerical Vice President FWF), Christof Gattringer (FWF-President).
© FWF/Daniel Novotny

The ASMET Prize, Austria's most highly endowed research prize in the field of metals research, has been awarded to Lorenz Romaner from the Montanuniversität Leoben. The prize, which amounts to 300,000 Euros, is funded by the Austrian Society for Metallurgy and Materials (ASMET) and awarded through the FWF, will enable the material scientist to use machine learning methods to improve the properties of metals. The project uses artificial intelligence methods to better simulate the properties of metals in particular their internal structure consisting of grains and grain boundaries. This research has great relevance for all industries that work with metal and electronic elements, such as metal manufacturers, the automotive industry, chemical companies or recycling centers. The complexity of the calculations is a great challenge and the ASMET Prize now offers Lorenz Romaner the opportunity to explore methods to circumvent this problem with machine learning. In this way, it may be possible to substitute complex physical calculations with surrogate models and explore possibilities to correct for errors associated with model approximations.

Lorenz Romaner (Montanuniversität Leoben), winner of the ASMET prize, is researching new approaches to improve the properties of metals using machine learning methods.
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LANGE NACHT
der FORSCHUNG
Eintritt frei!
20.5.
2022


Materials


Materials


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	21	4	26
Chair of Physical Metallurgy and Metallic Materials	49	12	50
Chair of Materials Physics	36,8	12	49
Chair of Design of Steels	16	0	12
Chair of Structural and Functional Ceramics	35	16	12

Exams

Chair	Number of exams
Chair of Functional Materials and Materials Systems	496
Chair of Physical Metallurgy and Metallic Materials	913
Chair of Materials Physics	493
Chair of Design of Steels	119
Chair of Structural and Functional Ceramics	453

Cooperations

Cooperations


NATIONAL CENTRE FOR SCIENTIFIC RESEARCH "DEMOKRITOS"


UNIVERSITY OF CAMBRIDGE


THE UNIVERSITY OF SYDNEY

RUHR UNIVERSITÄT BOCHUM RUB


Max-Planck-Institut für Eisenforschung GmbH


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


UNIVERSITEIT GENT


DESY


University of Cyprus


MINES Saint-Étienne


IBS PAPER PERFORMANCE GROUP


TU WIEN TECHNISCHE UNIVERSITÄT WIEN Vienna University of Technology


JOANNEUM RESEARCH


ROMA TRE UNIVERSITÀ DEGLI STUDI


eman ta zabal zazu
Universidad del País Vasco
Euskal Herriko Unibertsitatea


BERGAKADEMIE FREIBERG TECHNISCHE UNIVERSITÄT


UNIVERSITEIT GENT


BERKELEY LAB Lawrence Berkeley National Laboratory

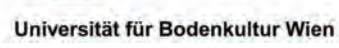

哈爾濱工業大學 Harbin Institute of Technology


Helmholtz-Zentrum Geesthacht
Zentrum für Material- und Küstenforschung


LINKÖPINGS UNIVERSITET


HZDR
HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

Cooperations



Outlook

Looking back, the last year was certainly again not what we were expecting a year ago. While one the one hand the pandemic was slowly turning into an epidemic and this aspect of life was considered to return to more normal, we were on the other hand abruptly faced with a terrible war in Ukraine and all the unmeasurable problems, loss and pain this brought to the people living there and abroad. But not only in Ukraine, in the whole world we evidence increasing numbers of conflicts, extreme weather phenomena, and scarcity of resources. Our efforts towards the Sustainable Development Goals of the United Nations will be valuable to mitigate and overcome these challenges.

Regarding an attractive education, we are very much looking forward to classes full of students and in person interactions, and are excited to see our new Materials Science and Technology study taking off. We also welcome back our international students and summer interns returning. Thus, while we expect our international student levels to be back to pre-pandemic levels, we still miss some of our national students and will do our best to make them return to Leoben and to attract additional students by intensified outreach activities.

In terms of research activities, we will continue our strong activities towards development of novel materials and processes for green energy harvesting, conversion and storage. But also the fields of transportation, microelectronics and information technology are of immanent importance, being it advanced metal alloys, novel semiconducting materials, accelerated material development by machine learning strategies, or issues raised by artificial intelligence gone wild. In this regards, we are very much looking forward to first scientific results from two newly started Christian Doppler laboratories on ‘Computer-aided Design of Crystal Growing Processes’ and ‘Knowledge-based Design of Advanced Steels’, respectively.

Being at the forefront of research does not come easy and requires state-of-the-art equipment and infrastructure going even beyond the currently possible. This encompasses the complementary fields of experiments, modeling, simulation, and data science required for a thorough understanding. As such, we are very much looking forward to the construction of the new Digitization Building of the Montanuniversität Leoben, a new high-performance computation cluster, and the erection of the Hydrogen Center with all the novel possibilities for joint research these facilities will enable. But we are also thrilled by the arrival of novel advanced instrumentation, such as two small-scale loading devices for scale-bridging in-situ fracture and fatigue investigations, a cryo-nanoindenter for hydrogen storage research, and a 2D X-ray diffractometer.

It remains our strong belief that, no matter how demanding and uncertain the global situation might become, by providing diversified higher education in materials science paired with a respectful global view to our students, and by offering highest level multidisciplinary research competences to our industry partners, we are in a top position to deliver significant contributions towards the societal needs of our times and the future generation to come.

We very much look forward to a successful cooperation in the year 2023!

Imprint

Montanuniversität Leoben
Department Materials Science

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