

**Department
Werkstoffwissenschaft**

Annual report 2021



**MONTAN
UNIVERSITÄT
LEOBEN**

PREFACE

Dear partners and colleagues of the Department of Materials Science!

The implementation of new teaching and working strategies during this pandemic year 2021 has allowed our Department to successfully increase the number of master and graduate students, enter new study programs, commission state-of-the-art equipment and further improve our multidisciplinary research competences.

More than ever, an important focus has been set to increase the international recognition of the Montanuniversität and the visibility of its materials science study programs. In this context, the Erasmus Mundus Program “Advanced Materials Science and Engineering” (AMASE) together with five other European partner universities started in Leoben in fall, hosting the first international students coming from five different countries.

The first full year of the newly introduced Professorship for Computational Materials Science, focusing on interface modelling and virtual materials design, has shown to provide valuable opportunities to connect experiments with modeling across all length scales and round up the existing teaching and research activities concerning atomistic modelling at our Department.

With the incorporation of Ass.-Prof. Barbara Putz for the “Synthesis and Characterization of Materials and Systems for Microelectronics”, along with new partnerships in place with international companies in the field, our research driven teaching portfolio in microelectronics shall be strengthened in the upcoming years.

The 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 the new atom probe tomography system LEAP 5000, a high-temperature laser confocal microscope and a Raman microscope with in-situ capabilities up to 1500°C can be highlighted.

Numerous publications in eminently respectable journals indicate the high quality of our department’s research activities during 2021, showing a 25 % increase with respect to the previous year. We are particularly proud of several conference prizes received by our young graduate students as well as distinguished awards for some of our department researchers.

A big “Thank You” for the support and for continuous motivation to jointly face future challenges goes to all our researchers as well as students of the department and to all of our industrial partners.

We invite you to read the following pages, which intend to provide a short overview of our activities in 2021.

Prof. Dr. Raul Bermejo

Prof. Dr. Helmut Clemens

Prof. Dr. Jürgen Eckert

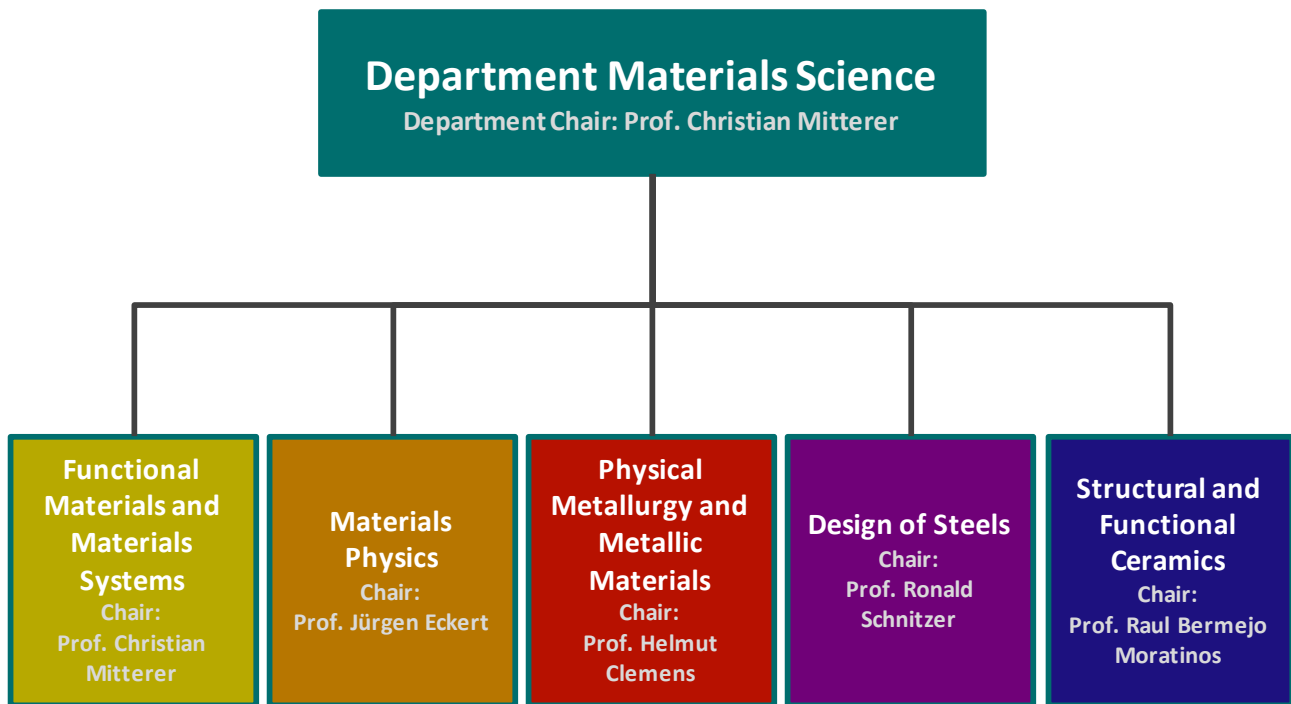
Prof. Dr. Christian Mitterer

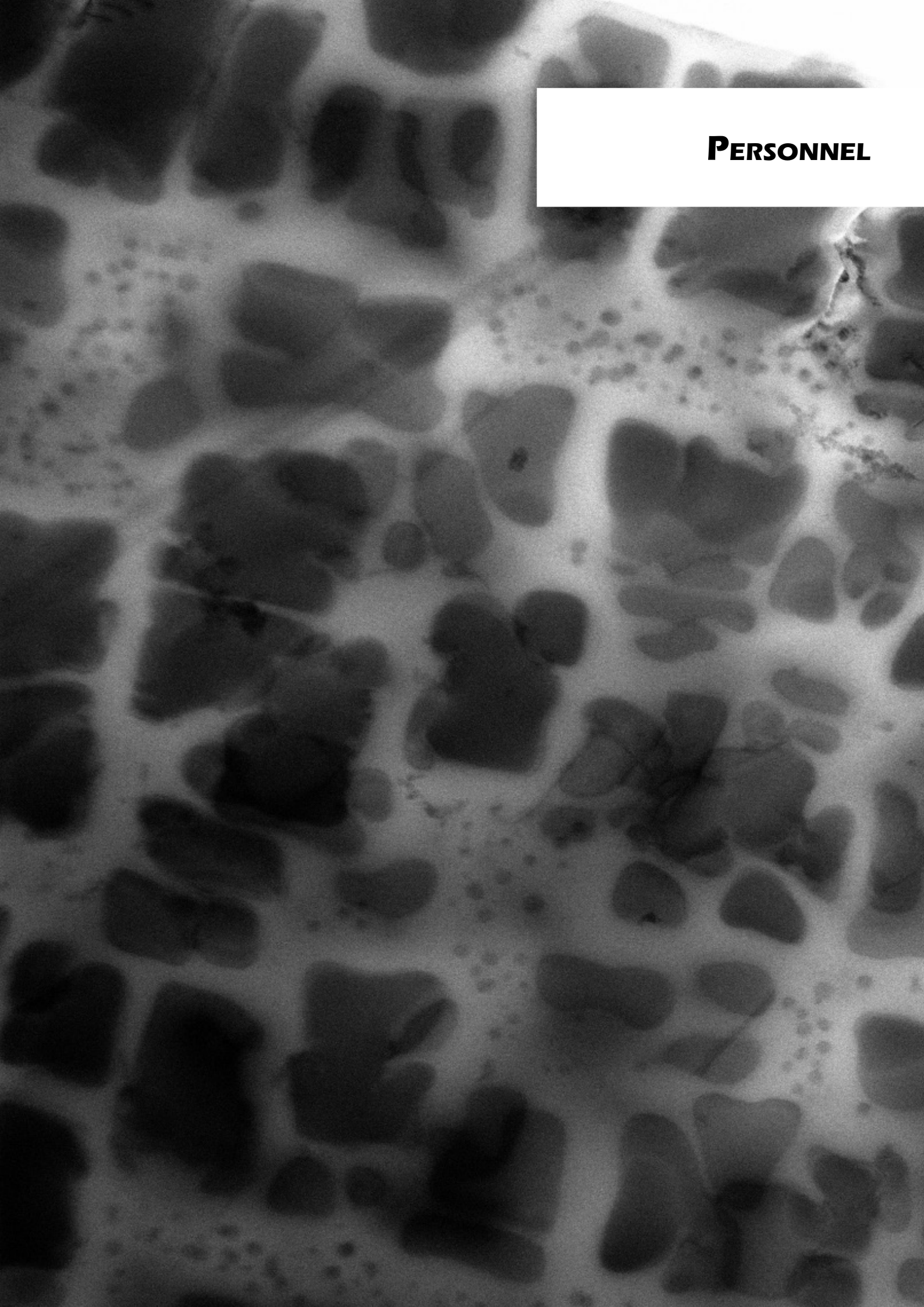
Prof. Dr. Ronald Schnitzer

TABLE OF CONTENT

Preface.....	1
Table of content.....	3
Organigram.....	4
Personnel.....	6
Mission statement.....	29
Investments.....	36
Revenues.....	41
Publications and presentations.....	43
Master and doctoral theses.....	47
Conferences and events.....	53
Prizes and awards.....	58
Teaching.....	69
Cooperations.....	71
Outlook.....	73

ORGANIGRAM





PERSONNEL

PERSONNEL

In 2021, 201 people were employed at the Department Materials Science. The expenses for 52.5 employees were covered by federal funds, 148.5 employees were financed by third-party projects.

Head of department

Univ.-Prof. Dr.
Christian Mitterer



Chair/Deputy

Univ.-Prof. Dr.
Raul Bermejo Moratinos



Univ.-Prof. Dr.
Helmut Clemens



Univ.-Prof. Dr. Dr.h.c.
Jürgen Eckert



Univ.-Prof. Dr.
Ronald Schnitzer



Chair of Functional Materials and Materials Systems

Chair

Univ.-Prof. Dr.
Christian Mitterer



Deputy chair

Assoz. Prof. Dr.
Rostislav Daniel
Group leader



Group leader

Dr.
Robert Franz



Dr.
Nina Schalk



Dr.
Michael Tkadletz



Office management

Regina Kranz



Cornelia Schnedl



Susanne Strasak,
Bakk.phil.



Angelika Tremmel, MA



Technicians

Sabrina Hirn
Surface engineering



Ing.
Karl Heinz Pichler
Electrical engineering



Scientific staff

Ioannis Athanasopoulos
Graduate student



Dr.
Matthias Bartosik
PostDoc



Maria-Theresia Becker
Graduate student



Dipl.-Ing.
Aydan Cicek
PhD student



Isabella Eichbauer
Student staff



MSc.
Florian Frank
PhD student



MSc.
Mehran Golizadeh
PhD student



Dipl.-Ing.
Georg Gruber
PhD student



David Haselsteiner
Student staff



Dr.
Anna Hofer-Roblyek
PostDoc



Dipl.-Ing.
Nikolaus Jäger
PhD student



Dr.
Christina Kainz
PostDoc



Magdalena Kirchmair
Student staff



Dipl.-Ing.
Florian Knabl
PhD student



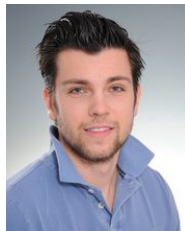
Edyta Kobierska, inz.
PhD student



Dipl.-Ing.
Lukas Kölbl
PhD student



Dipl.-Ing.
Fabian Konstantiniuk
PhD student



Dr.
Nikolaos Kostoglou
PostDoc



Alexandra Lechner
Student staff



Mahdieh Mehrabi
Student staff



Dipl.-Ing.
Yvonne Moritz
PhD student



Daniel Rainer
Graduate student



Dr.
**Marisa Rebelo
de Figueiredo**
PostDoc



Thomas Resch
Student staff



Personnel

Neus Sala
Student visitor



Dr.
Christian Saringer
PostDoc



Maximilian Schiester
Student staff



Michael Tabelander
Graduate student



Mag.
Velislava Terziyska
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Dipl.-Ing.
Helene Waldl
PhD student



Lisa Marie Weniger
Graduate student



Liying Wu
Student visitor



Michael Wurmitzer
Student staff



Dr.
Michal Zitek
PostDoc



Chair of Physical Metallurgy and Metallic Materials

Chair

Univ.-Prof. Dr.
Helmut Clemens



Deputy chair

Assoz.Prof. Dr.
Svea Mayer
Group leader
(until 9/2021)



Group leader

Priv.-Doz. Dr.
David Holec



Priv.-Doz. Dr.
Verena Maier-Kiener



Dr.
Francisca Mendez Martin



Dr.
Boryana Rashkova



Univ.-Prof. Dr.
Lorenz Romaner
Deputy Chair
(since 10/2021)



Dr.
Petra Spörk-Erdely



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Regina Kranz



Cornelia Schnedl



**Susanne Strasak,
Bakk.phil.**



Angelika Tremmel, MA



Technicians

Alfred Gajsek
Workshop



Gerhard Hawranek
*Scanning electron
microscopy*



Walter Kopper
Materials testing



**Ing.
Bruno Krajnc**
Materials testing



**Ing.
Alfons Lontschar**
IT administration



Silvia Pölzl
Metallography



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Graduate student



Nadine Buchebner
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Johanna Byloff
Student staff



Lukas Dettela
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**Dr.
Anna Sophie Ebner**
PostDoc



**Dipl.-Ing.
Christian Fleißner-Rieger**
PhD student



Benjamin Galy
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Daniel Gass
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Dominik Gehringer**
PhD student



Cristian Ghibaudo
Student visitor



Jürgen Glettler
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Hannah Gottlieb
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Gloria Graf
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Dipl.-Ing.
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Lorenz Taucher
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Sebastian Teusl
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Antonio Vukusic
Student staff



Dipl.-Ing.
Reinhold Wartbichler
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Graduate student



Dipl.-Ing.
David Wimler
PhD student



Dip.-Ing.
Stefan Zeisl
PhD student



Chair of Materials Physics

Chair

Univ.-Prof. Dr. Dr.h.c.
Jürgen Eckert



Deputy chair

Univ.-Prof. Dr.
Jozef. Keckes



Group leader

Dr.
Anton Hohenwarter



Assoz.Prof. Dr.
Daniel Kiener



Office management

Sabine Wilfling



Technician/Non-scientific staff

Gabriele Felber
TEM preparation



Ing.
Herwig Felber
*Technic/
Electrical engineering*



Manuela Karner
Cleaning



Silke Kaufmann
*Metallography
(maternity leave)*



Melissa Suschetz
Metallography



Scientific staff

Dipl.-Ing.
Markus Alfreider
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Atacan Asci
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mag.
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Jitka Holcova
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Inas Issa
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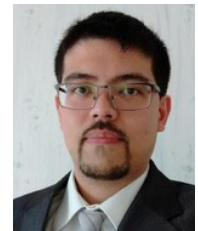
Nicole Käfer
Student staff



Manoel Kasalo
Student staff



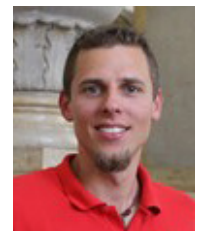
Dr.
Patrice Kreiml
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Dipl.-Ing.
Arthur Lintner
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Christoffer Müller
Graduate student



Dipl.-Ing.
Daniela Neumüller
PhD student



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Lidija Rafailovic
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Lukas Schweiger
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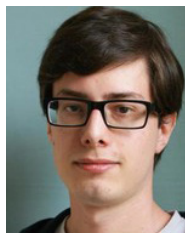
Benjamin Seligmann
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Dr.
Florian Spieckermann
PostDoc



Dr.
Juraj Todt
PostDoc



Dipl.-Ing.
Michael Wurmshuber
PhD student



Dr.
Jakub Zalesak
PostDoc



Tobias Ziegelwanger
Graduate student



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

Chair

Univ.-Prof. Dr.
Ronald Schnitzer



Deputy Chair

Dr.
Christina Hofer
Group leader



Office management

Regina Kranz



Cornelia Schnedl



Susanne Strasak,
Bakk.phil.



Angelika Tremmel, MA



Technician

Ing.
Thomas Fischer
*Dilatometrie, DSC,
HT-LSCM*



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Graduate student



Jakob Eschelbeck
Graduate student



Dipl.-Ing.
Michael Göbl
PhD student



Veronika Job
Graduate student



Lorena Juarez Perez
AMASE Student staff



Dipl.-Ing.
Stefan Kardos
PhD student



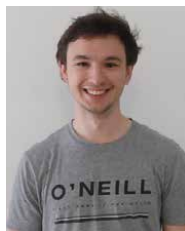
Dr.
Johann Kappacher
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Katharina Käsznar
Graduate student



Nikolaus Kostwein
Graduate student



Klaus Krammer
Student staff



Dr.-Ing.
Andreas Landefeld
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Student staff



Dipl.-Ing.
Jan Platl
PhD student



Alexander Pock
Graduate student



Armin Proyer
Graduate student



Maximilian Reiter
Graduate student



Dipl.-Ing.
Andreas Rosenauer
PhD student



Dipl.-Ing.
Amin Sakic
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Hannah Schönmaier
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Daniel Schrittwieser
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Dipl.-Ing.
Manfred Stadler
PhD student



Theresia Zeitlhofer
Graduate student



Chair of Structural and Functional Ceramics

Chair

Univ.-Prof. Dr.
Raul Bermejo Moratinos



Deputy Chair

Ass.-Prof. Dr.
Tanja Lube



University lecturer

Ao.Univ.-Prof. Dr.
Peter Supancic



Office management

Judith Sifkovits
Study administrations
Personnel management
Financial management



Technicians

Sarah Kohlbacher
IT administration



Ing.
Ronald Binder
Workshop



Scientific staff

Dipl.-Ing.
Thomas Billovits
Graduate student



Luisa Bastos-Mateus
AMASE student



Christoph Bleicher
Graduate student



Dipl.-Ing.
Johanna Byloff
Graduate student



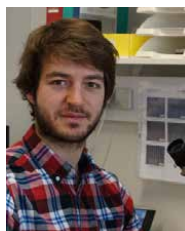
Juan Cardenas-Velasco
AMASE student



Dr.
Manuel Gruber
Senior Scientist



Viktor Haipl
Student staff



Dr.
Walter Harrer
Senior Scientist



Dipl.-Ing.
Anna-Katharina Hofer
PhD student



BSc.
Abdullah Jabr
Graduate student



Dr.
Benjamin Kaufmann
PhD student



Dipl.-Ing
Irina Kraleva
Senior Scientist



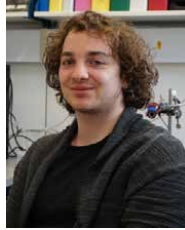
Dr.
Josef Kreith
Senior Scientist



Verena Melcher
Student staff



Maximilian Munz
Student staff



Johannes Neumüller
Student staff



Ing.
Roman Papsik
PhD student



Tobias Prötsch
Student staff



Ass.-Prof. Dr
Barbara Putz
Senior Scientist



Elija Ribul
Student staff



Dipl. Ing.
Josef Schlachter
PhD student



Dipl. Ing.
Maximilian Staudacher
PhD student



Andreas Vratanar
Student staff



Marlies Wratschko
Graduate student



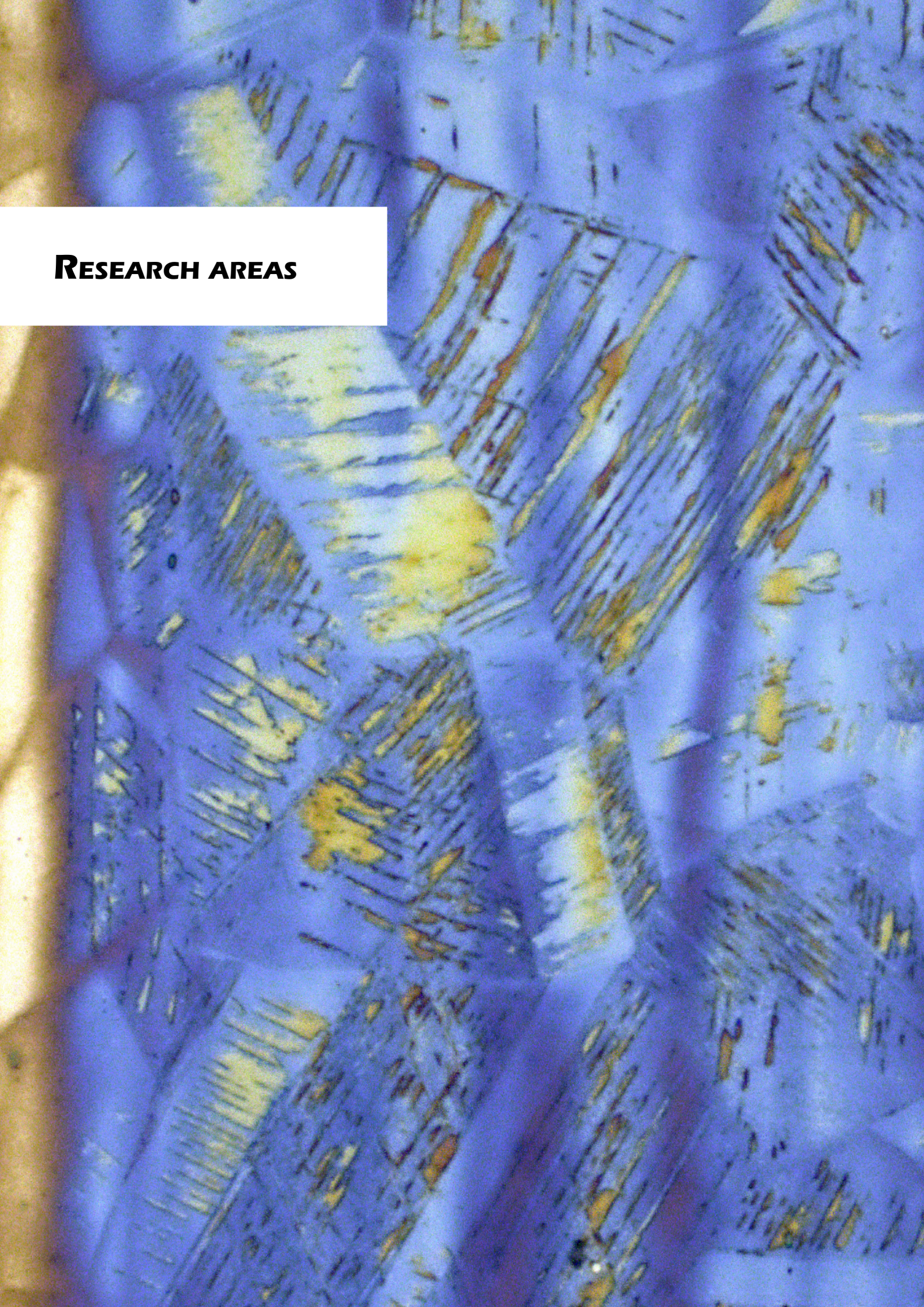
Retired / emeritus University professors

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



Univ.-Prof.i.R. Dr.
Albert Kneißl



The background of the image is a close-up of a fabric with a blue and yellow plaid pattern. The pattern consists of intersecting horizontal and vertical bands of different shades of blue and yellow, creating a complex, textured appearance. The lighting is slightly uneven, with some areas appearing brighter than others, emphasizing the texture of the material.

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.

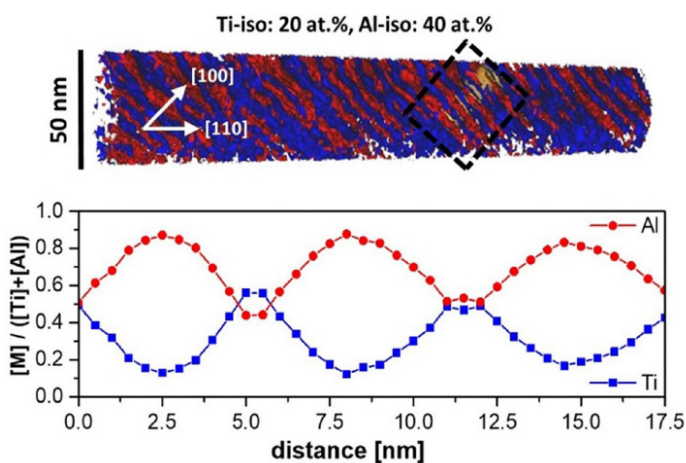


Chair of Functional Materials and Materials Systems

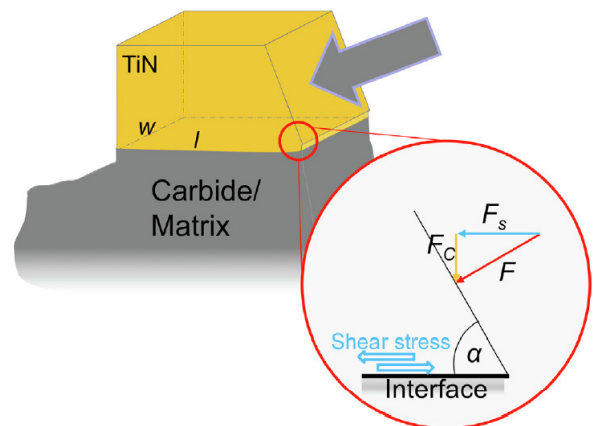
At the Chair of Functional Materials and Materials Systems, the following working groups with their group leaders added in parenthesis are established: Plasma and Surface Engineering (Robert Franz), Multifunctional Thin Films (Nina Schalk), Design and Architecture of Functional Materials Systems (Rostislav 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 coatings, thin films and nanoparticles. For material synthesis, plasma-assisted vapor deposition 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 evaporation, and – with installation starting in 2021 and finalization planned in early 2022 – magnetron sputter inert gas condensation of nanoparticles. This portfolio for the synthesis of functional materials 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 and Institutes within 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.

Recent breakthroughs have been achieved in the design, synthesis, characterization and testing of interfaces. Such interfaces determine the performance of e.g. coated cutting tools. While the available high-resolution methods like 3D atom probe tomography and transmission electron microscopy enable an unprecedented insight into such interfaces, micromechanical methods have been developed to test the interface strength. In a recent approach, Al-rich face-centered cubic $\text{Ti}_{1-x}\text{Al}_x\text{N}$ coatings grown by chemical vapor deposition have been investigated by atom probe tomography, revealing the formation of a nano-lamellar microstructure consisting of Al-rich and Ti-rich areas. A novel micro shear compression test has been developed to assess the strength of interfaces between hard coating and the respective phases within high-speed steels. So for the first time, a ranking of interface strength ($\text{MC/TiN} > \text{M}_6\text{C/TiN} > \text{martensite/TiN}$) could be established.



Fluctuations of chemical composition in an Al-rich CVD $\text{Ti}_{1-x}\text{Al}_x\text{N}$ hard coating revealed by 3D atom probe tomography



Schematics of a micro-shear compression specimen with load F applied by a flat punch indenter acting at the interface while testing with its shear and compression components

Chair of Physical Metallurgy and Metallic Materials

The chair is divided into the following research areas: “High-resolution materials analysis” (Francisca Mendez-Martin and Boryana Rashkova), “Mechanical properties and high-performance materials” and “Materials testing” (Verena Maier-Kiener), “Phase transformations and high-temperature materials” (Svea Mayer), “Material behavior under process and application conditions” (Petra Spörk-Erdely) and “Computational Materials Science” (David Holec and Lorenz Romaner) .

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 is investigated. For this purpose, local high-resolution characterization methods are mainly used in order to gain basic knowledge of material behavior, which can then be used specifically for further alloy design.

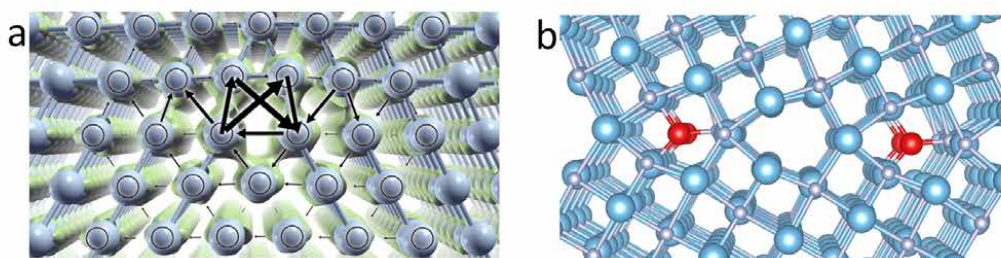
Intermetallic titanium aluminides and titanium alloys are used as structural materials in the next generation of aircraft engines and internal combustion engines. Through thermodynamic modeling and the use of the latest investigation and analysis methods, new alloy systems, e.g. for additive manufacturing,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

Methods from computational materials science are used to design and understand the structure and properties of materials. Simulation methods combining quantum mechanical simulations, molecular dynamics simulations, thermokinetic modeling and machine learning predict physical properties of bulk crystal phases, their extended defects such as grain boundaries or dislocations (see Figure), or nanostructures. These simulations allow investigating elastic and plastic deformation mechanisms of metallic alloys or superlattice coatings, investigating interfacial embrittlement phenomena, studying phase transformation in TiAl alloys, steels and refractory metals and understanding 2D carbon-based materials with a particular focus of their H-storage capability.

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.

In the field of materials testing the focus is on the correlation of microstructure and mechanical properties



Atomistic design of crystallographic defects: a) View into the dislocation core of a M111 dislocation in a bcc metal. b) Zoom on a TiN grain boundary with boron (red) as a segregant.

Chair of Materials Physics

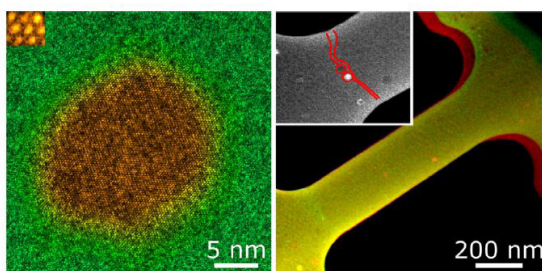
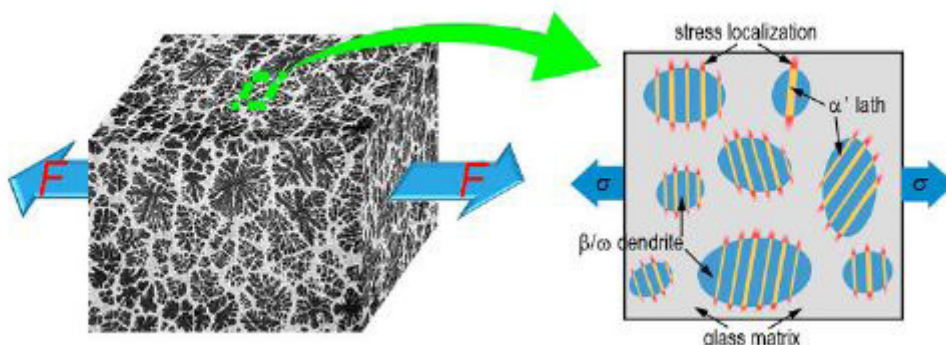
The activities of the Chair of Materials Physics are closely linked to its partnering Erich Schmid Institute (ESI) of Materials Science of the Austrian Academy of Sciences. Currently, four research groups are active at each of the respective institutions.

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 for 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, the respective structural and mechanical characterization capabilities at the Chair of Material Physics are at the international fore front. This allows for a scale bridging correlation between material microstructures and structural as well as functional properties from atomistic details to bulk components. A current example regarding this is depicted below. Using in-situ structure investigations and nanomechanical testing in the transmission electron microscope in combination with atomistic simulations allowed to uncover the details of nanoscale deformation mechanisms in metallic glass composites for improving the ductility of such otherwise brittle materials.

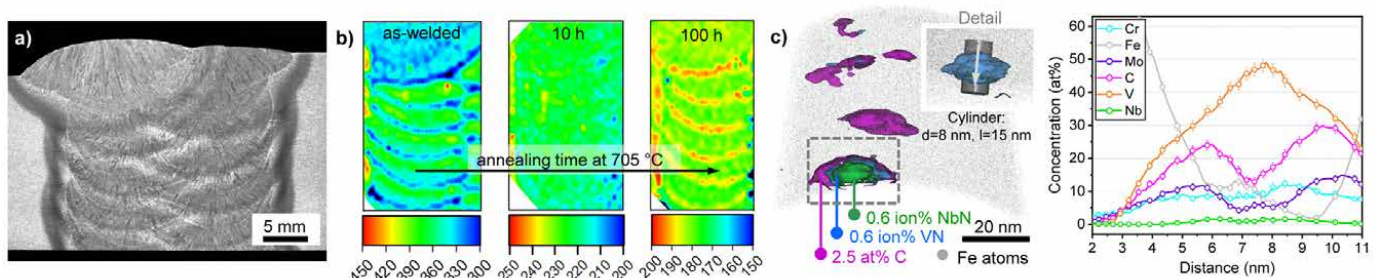


Schematic representation (top) and in-situ observation (bottom) of the deformation processes governing deformation in metallic glass composites.

Chair of Design of Steels - Endowed Professorship for Industry

At the beginning of 2016, the new chair for steel design was established at the Montanuniversität Leoben. The Chair was founded within the framework of the FFG initiative “Production of the future” and focuses on applied basic research in the form of industry-related collaborations and research projects. The aim of the chair is the development of new and the optimization of existing high-performance steels. With around 1.8 billion tons a year produced worldwide, steel is still by far the most important construction material. 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 submerged-arc welded 2.25Cr-1Mo-0.25V steel. Creep-resistant CrMoV steel is usually applied where high pressures and temperatures of up to 470 °C are prevalent. Hence, the weldments and base metal need a beneficial combination of creep strength and toughness for ensuring a safe application over several years. To develop a strategy for improving the mechanical properties, in-depth knowledge of the relationships between processing, microstructure, and properties is required. 2.25Cr-1Mo-0.25V steel is usually multi-layer welded, which severely influences the hardness distribution over the weld metal's cross-section, see Fig a) and b). The inhomogeneous hardness after welding homogenizes after 10-12 h of annealing at 705 °C and becomes inhomogeneous again for annealing times > 12 h, as the heat-affected zones (HAZ) in-between the weld beads exhibit a higher temper resistance. The slower softening of the HAZs within the multi-layer weld metal is mainly related to a smaller grain size from reaustenitization and a higher fraction of carbides at grain boundaries. Besides the hardness distribution, multi-pass welding substantially impacts the precipitate formation. Atom probe tomography (APT) measurements on various positions within the weld metal's cross-section revealed that multiple times of reheating in the course of multi-layer welding is required for the formation of nano-sized MX carbonitrides which are crucial for high creep resistance. Fig c) depicts an APT tip with multiple MX carbonitrides and the 1D concentration profile of a larger one displaying mainly enrichment in V, Nb, C and N.



a) Macroscopic image and (b) HV1 hardness mappings of the weld metal's cross-section in the as-welded condition and after 8 h and 100 h of annealing at 705 °C, as well as c) atom probe investigation revealing nano-sized V-, Nb-, C- and N-rich MX carbonitrides formed during multi-layer welding.

Chair of Structural and Functional Ceramics

The Chair of Structural and Functional Ceramics (ISFK) 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 of ISFK.

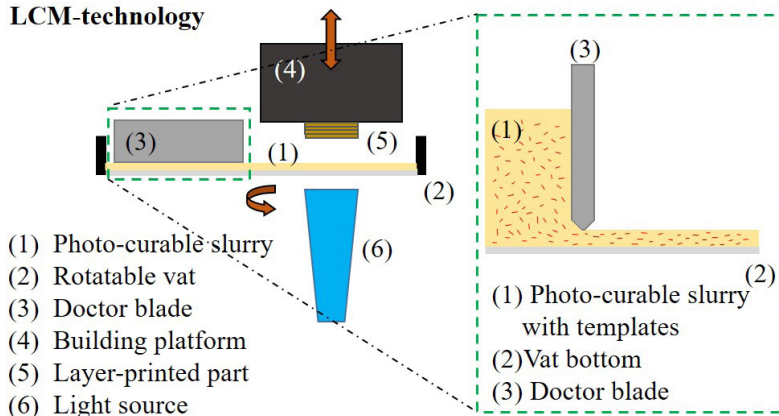
The work with industrial partners has evidenced the need for special testing techniques, e.g. for strength and toughness testing of thinner discs or plates, as well as small balls or cylinders (e.g. for roller bearings). A strong competence of the Institute is the development of testing methods for mechanical characterization of ceramics, which has led to several standards, which 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 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 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.

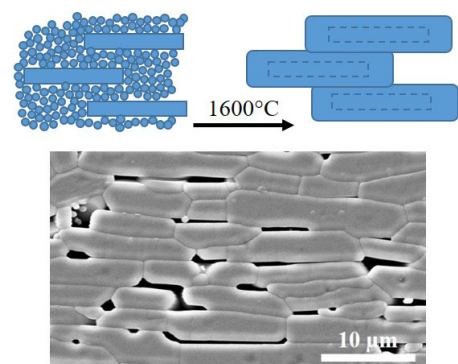
The chair's special methodological competences also lay in the electro-mechanical characterization of electro-ceramic components upon thermo-electrical loads, with special focus on understanding and modelling the non-linear behaviour of many ceramic components and systems. Models on different size scales - 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.

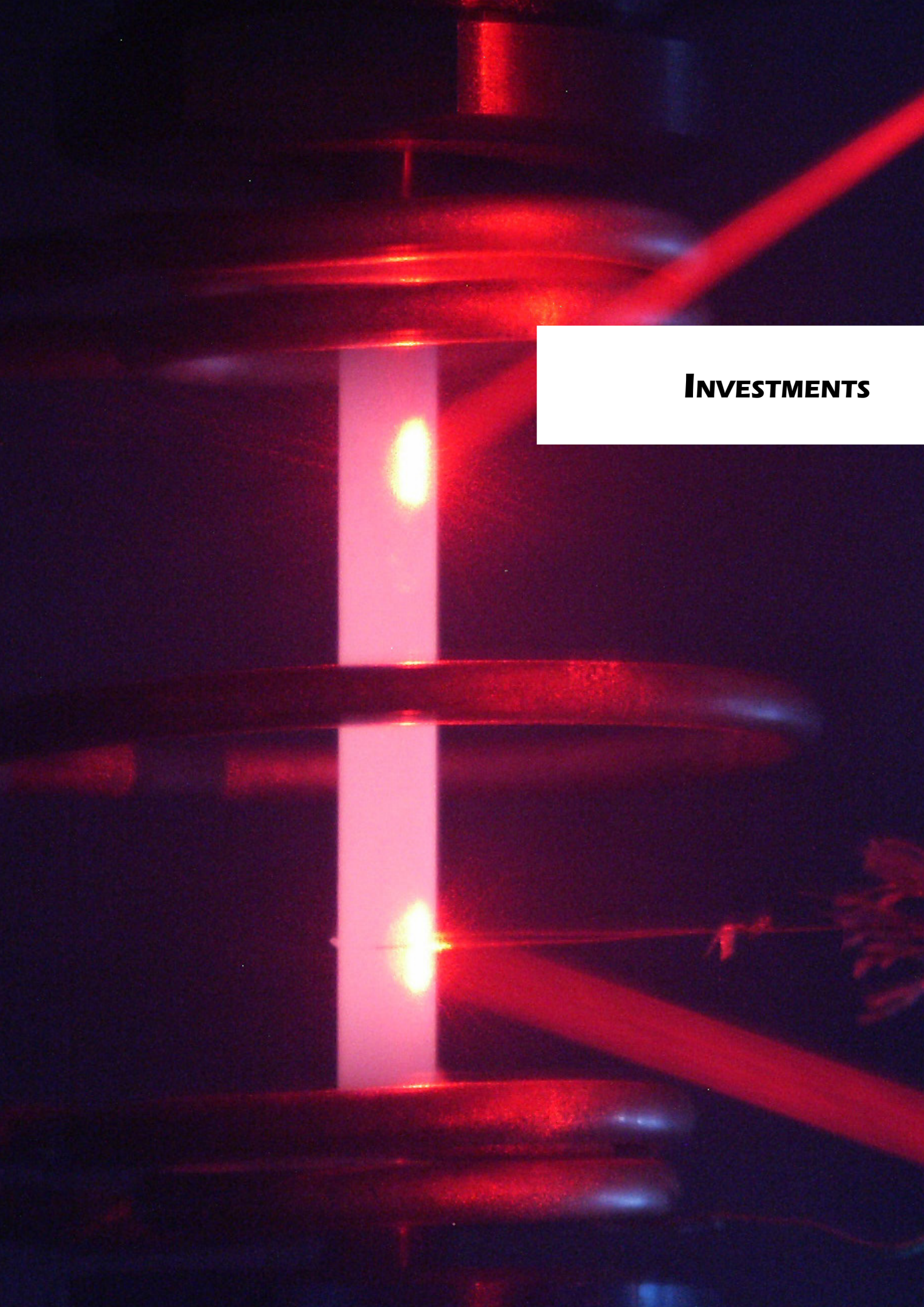
A new research line at the ISFK has been encouraged by the ERC-Grant aiming to designing and manufacturing bio-inspired structures with high reliability. The working fields "Design and Manufacturing" and "Characterization of Multi-Material Systems" with a strong focus on microelectronics have gained importance in the research landscape of the 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.

LCM-technology



Templated Grain Growth process





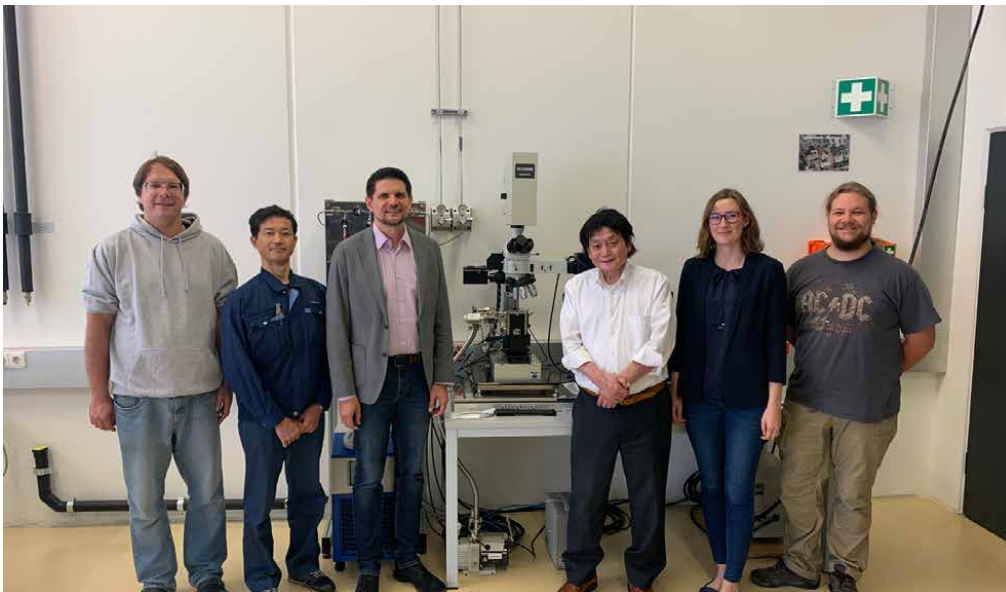
INVESTMENTS

INVESTMENTS

High-Temperature Laser Confocal Microscope

Funds from the Montanuniversität Leoben's R&D Infrastructure Impulse Program were used to purchase a high-temperature laser confocal microscope, which was put into operation at the Department of Materials Science in October 2021. High-temperature laser confocal microscopy allows the direct observation and recording of microstructural changes while performing heating and cooling cycles up to peak temperatures of 1800 °C. High-temperature laser confocal microscopy allows to obtain a comprehensive understanding of microstructural changes relevant to materials science, such as grain coarsening, recrystallization processes or even phase transformations (such as martensite and bainite formation). The recording of videos during the experiments facilitates a detailed temporal evaluation of the live observed microstructural changes.

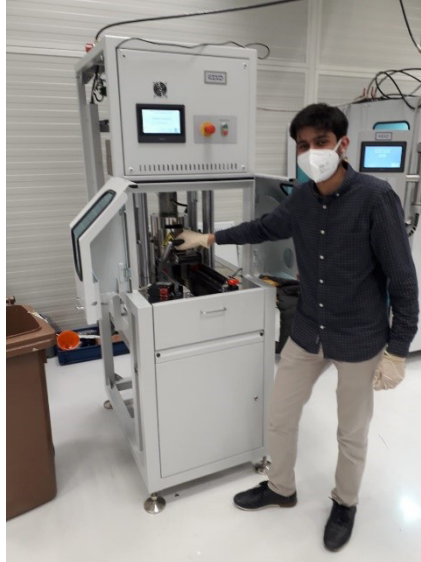
The commissioning of the new microscope took place after installation and training by representatives of the Japanese manufacturer Yonekura in the new laboratory "Thermomechanical Analysis" in the building IZW. The instrument has already been used successfully for first measurements and we are looking forward to the new possibilities available and to answering many exciting research questions.



LTR: Thomas Fischer (Chair of Design of Steel), Masafumi Fukuda (Yonekura), Ronald Schnitzer (Chair of Design of Steel), Mayumi Nakamura (Yonekura), Hannah Schönmaier (Chair of Design of Steel) and Gerald Schaffar (Chair of Physical Metallurgy and Metallic Materials) in front of the new high-temperature laser confocal microscope.

Cold Sintering Press

As part of the ERC grant from Prof. Bermejo, a cold sintering press TPR-IJS1 (KEKO) was purchased at the ISFK for processing of ceramics. With the hydraulic press pellet, cylinders and pressing plates can be fabricated. The maximum working pressure for the pellets is 500 MPa, the maximum working temperature is 400°C.



Raman Microscope

Funded by the hydrogen infrastructure program of the Montanuniversität Leoben, a Witec alpha300R Raman microscope was purchased at the Materials Science Department and it was installed in December 2021. The device combines the possibilities of conventional light microscopy with Raman spectroscopy. The underlying Raman effect is based on the inelastic scattering of the light from a laser on the molecules within a sample. Thus, the chemical fingerprint of the sample can be characterized both laterally and depth resolved. Using the attached heating chamber allows to investigate the material behavior in-situ up to a temperature of 1500°C. Within the hydrogen focus of the Montanuniversität, the Raman microscope will be used for the characterization of functionalized nanoporous carbons for hydrogen storage. Furthermore, Raman microscopy will be applied for the characterization of chemical bonds, phase changes or oxidation processes of construction and functional materials.



Tensile/Compression Deformation Dilatometer

With funds from the endowed professorship for steel design and from the MUL's impulse program for R&D infrastructure, the purchase of a tensile/compression deformation dilatometer was undertaken and the device was delivered to the Department of Materials Science in May 2021. The new machine is a DIL805A/D/T quenching and forming dilatometer with tension/compression adapter from TA Instruments. The possible measuring range covers 20°C to 1700°C with heating and cooling rates up to 100 K/s. The possible deformation degree for compression forming tests is in the range of 0.05 - 1.2 with deformation rates from 0.001 s⁻¹ to 20 s⁻¹ and a possible resolution of the length change of 50 nm, as well as a maximum force of up to 20 kN. Flat and round tensile specimens can be tested at tensile deformation rates of 0.001 s⁻¹ to 2 s⁻¹, a forming degree of 0.05 to 1.2, and a maximum force of 10 kN.

The fully automated dilatometer thus enables the analysis of phase transformations and the recording of flow curves at elevated temperatures of a wide variety of metallic materials researched at the department.

The commissioning of the new forming dilatometer and the relocation of the quenching dilatometer to the new "Thermomechanical Analysis" laboratory have already been completed and the instrument has been successfully used for the first measurements. Now, three dilatometers, two DSC systems (up to max. 1500°C and 2400°C, respectively), four creep test benches and a high-temperature laser confocal microscope are available in this new laboratory. We are looking forward to the new possibilities available and to answering many exciting research questions.

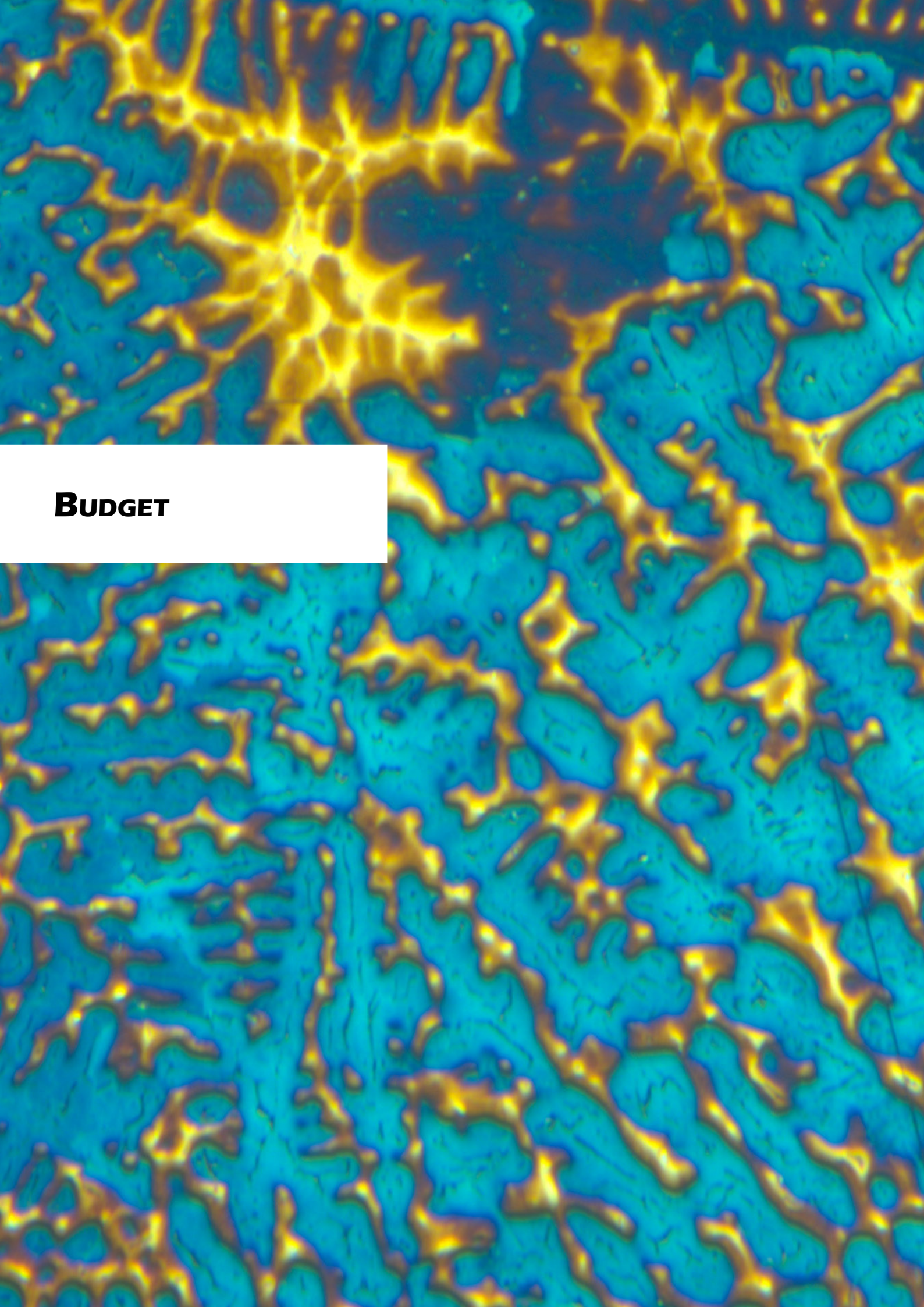


Thomas Fischer and Ronald Schnitzer

Universal Testing Machine

In the last year an environmental chamber for our modern universal testing machine was purchased. With this chamber, tensile, compressive and bending experiments can be performed in a temperature range between -80°C and 600°C . Simultaneously, there is also the possibility to adjust the atmospheric conditions in certain ranges.





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

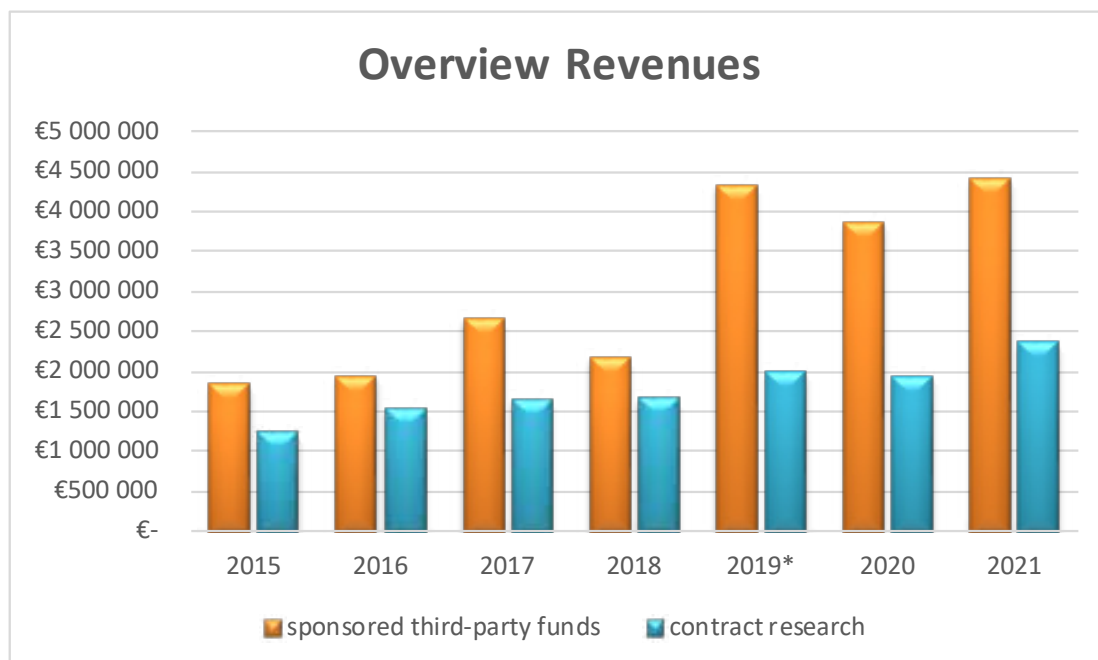
This endowment is to cover current operating expenses for research and teaching (incl. excursions, travel expenses, telephone, office supplies, copies for teaching and minor purchases for research operations; excl. university-funded positions)

Third-party funds

Due to extensive third-party funding activities, the Department managed to keep the revenue of the budget year 2021 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,-.



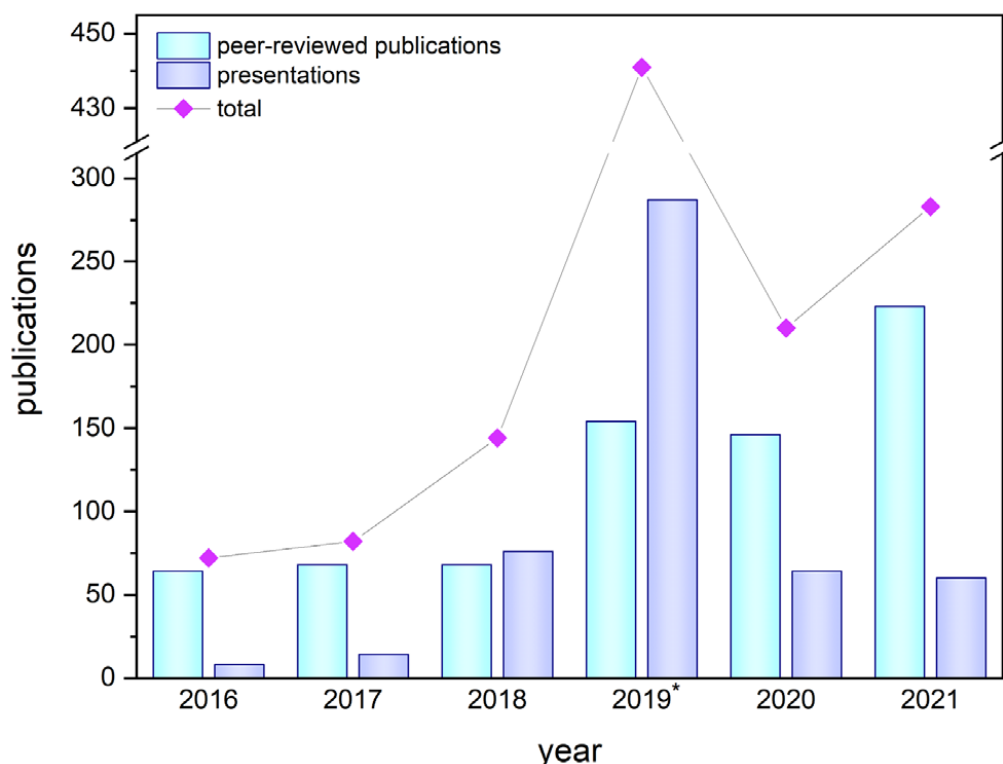
* Since the establishment of the Department of Materials Science in 2019, five chairs are included in this representation; prior to 2019, only three were included.

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 2021 in 223 articles in scientific journals and 60 presentations at scientific events. Not surprisingly, the Covid-19 pandemic with many conferences and workshops being cancelled or postponed caused a significant drop in oral and poster presentations. Even with this drop of presentation numbers, 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

N. Schalk, C. Saringer, A. Fian, V.L. Terziyska, J. Julin, M. Tkadletz, Evolution of the microstructure of sputter deposited TaAlON thin films with increasing oxygen partial pressure, *Surf. Coat. Technol.* 418 (2021) 127237.

C. Saringer, M. Tkadletz, J. Thurner, C. Czettl, N. Schalk, Influence of the deposition parameters on the nanolamella periodicity of chemical vapor deposited $\text{Ti}_{1-x}\text{Al}_x\text{N}$, *Mater. Lett.* 305 (2021) 130819.

M. Golizadeh, F. Mendez Martin, S. Wurster, J. P. Mogeritsch, A. Kharicha, S. Koloszvari, C. Mitterer, R. Franz, Rapid solidification and metastable phase formation during surface modifications of composite Al-Cr cathodes exposed to cathodic arc plasma, *J. Mater. Sci. Technol.* 94 (2021) 147-163.

A. Drnovšek, H.T. Vo, M. Rebelo de Figueiredo, S. Kolozsvári, P. Hosemann, R. Franz, High temperature fracture toughness of single-layer CrAlN and CrAlSiN hard coatings, *Surf. Coat. Technol.* 409 (2021) 126909.

M. Meindlhumer, L.R. Brandt, J. Zalesak, M. Rosenthal, H. Hruby, J. Kopecek, E. Salvati, C. Mitterer, R. Daniel, J. Todt, J. Keckes and A.M. Korsunsky, Evolution of stress fields during crack growth and arrest in a brittle-ductile CrN-Cr clamped-cantilever analysed by X-ray nanodiffraction and modelling, *Mater. Design* 198 (2021) 109365.

S. Rashid, M. Sebastiani, M.Z. Mughal, R. Daniel, E. Bemporad, Influence of the silver content on mechanical properties of Ti-Cu-Ag thin films, *Nanomaterials* 11 (2021) 435.

M. Gsellmann, T. Klünsner, C. Mitterer, M. Krobath, M. Wurmshuber, H. Leitner, W. Ecker, S. Marsoner, V. Maier-Kiener, D. Kiener, G. Ressel, Strength ranking for interfaces between a TiN hard coating and microstructural constituents of high speed steel determined by micromechanical testing, *Mater. Design* 204 (2021) 109690.

N. Kostoglou, C.-W. Liao, C.-Y. Wang, J.N. Kondo, C. Tampaxis, T. Steriotis, K. Giannakopoulos, A.G. Kontos, S. Hinder, M. Baker, E. Bousser, A. Matthews, C. Rebholz, C. Mitterer, Effect of Pt nanoparticle decoration on the H_2 storage performance of plasma-derived nanoporous graphene, *Carbon* 171 (2021) 294-305.

Chair of Physical Metallurgy and Metallic Materials

G. Graf, J. Rosigkeit, E. Krohmer, P. Staron, R. Krenn, H. Clemens, P. Spoerk-Erdely, In-situ investigation of the rapid solidification behavior of intermetallic γ -TiAl based alloys using high-energy X-ray diffraction, *Advanced Engineering Materials* 23 (2021) 2100557.

P. Spoerk-Erdely, P. Staron, J. Liu, N. Kashaev, A. Stark, K. Hauschildt, E. Maawad, S. Mayer, H. Clemens, Exploring structural changes, manufacturing, joining, and repair of intermetallic γ -TiAl based alloys: Recent progress enabled by in situ synchrotron X-ray techniques, *Advanced Engineering Materials* 23 (2021) 2000947.

J. Kappacher, O. Renk, D. Kiener, H. Clemens, V. Maier-Kiener, How grain boundary characteristics influence plasticity close to and above the critical temperature of ultra-fine grained bcc Ta2.5W, *Acta Materialia* 216 (2021) 117110.

A.S. Ebner, S. Jakob, H. Clemens, R. Pippan, V. Maier-Kiener, S. He, W. Ecker, D. Scheiber, V.I. Razumovskiy, Grain boundary segregation in Ni-base alloys: A combined atom probe tomography and first principles study, *Acta Materialia* 221 (2021).

L. Romaner, T. Pradhan, A. Kholobina, R. Drautz, M. Mrovec, Theoretical investigation of the 70.5° mixed dislocations in body-centered cubic transition metals, *Acta Materialia*, 217 (2021) 117154.

A. Ahmadian, D. Scheiber, X. Zhou, B. Gault, CH. Liebscher, L. Romaner, G. Dehm, Aluminum pletion induced by co-segregation of carbon and boron in a bcc-iron grain boundary, *Nature Communications*, 12 (2021) 6008.

G.K. Nayak, M.N. Popov, D. Holec, Pressure- and temperature-dependent diffusion from first-principles: A case study of V and Ti in a TiN matrix, *Surf. Coat. Technol.* 422 (2021) 127491.

D. Holec, N. Abdoshahi, D. Gehring, L. Hatzenbichler, A. Sakic, H. Clemens, Electrons meet alloy development: a γ -TiAl-based alloys showcase, *Adv. Eng. Mater.* (2021).

D. Wimler, K. Käschnar, M. Musi, C. Breuning, M. Markl, J. Keckes, H. Clemens, C. Körner, S. Mayer, How electron beam melting tailors the Al-sensitive microstructure and mechanical response of a novel process-adapted γ -TiAl based alloy, *Materials and Design* 212 (2021) 110187.

V. I. Razumovskiy, W. Ecker, D. Wimler, F. D. Fischer, F. Appel, S. Mayer, H. Clemens, An atomistic view on oxygen, antisites and vacancies in the γ -TiAl phase, *Computational Materials Science* 197 (2021) 110655.

Chair of Materials Physics

I. Issa, C. Gammer, S. Kolitsch, A. Hohenwarter, P. Imrich, R. Pippan, D. Kiener, In-situ TEM investigation of toughening in Silicon at small scales, *Materials Today*, 47 (2021) 1369-7021.

A. Lassnig, B. Putz, S. Hirn, D. M. Toebebens, C. Mitterer, M. J. Cordill, Adhesion evaluation of thin films to dielectrics in multilayer stacks: A comparison of four-point bending and stressed overlayer technique, *Mater. Des.*, 200 (2021) 109451.

K. Nomoto, A. Ceguerra, C. Gammer, B. Li, H. Bilal, A. Hohenwarter, B. Gludovatz, J. Eckert, S. P. Ringer, J. J. Kruzic, Medium-range order dictates local hardness in bulk metallic glasses. *Materials Today*, 44 (2021) 48-57.

B. Sarac, T. Karazehir, E. Yuce, M. Muehlbacher, A. S. Sarac, J. Eckert, Porosity and thickness effect of Pd-Cu-Si metallic glasses on electrocatalytic hydrogen production and storage. *Mater. Des.*, 210 (2021) 110099.

M. Stoica, B. Sarac, F. Spieckermann, J. Wright, C. Gammer, J. Han, P. F. Gostin, J. Eckert, J. F. Löffler, X-ray Diffraction computed nanotomography applied to solve the structure of hierarchically phase-separated metallic glass. *ACS Nano*, 15 (2) (2021) 2386-2398.

Chair of Design of Steels - Endowed Professorship for Industry

S. Ebner, R. Schnitzer, E. Maawad, C. Suppan, C. Hofer, Influence of partitioning parameters on the mechanical stability of austenite in a Q&P steel: A comparative in-situ study, *Materialia* 15 (2021) 101033.

M. Hofinger, B. Seisenbacher, A. Landefeld, M. Ognianov, C. Turk, H. Leitner, R. Schnitzer, Influence of thermomechanical fatigue loading conditions on the nanostructure of secondary hardening steels, *Materials Science & Engineering A* 802 (2021) 140672.

S. Monschein, M. Kapp, D. Zügner, J. Fasching, A. Landefeld, R. Schnitzer, Influence of microalloying elements and deformation parameters on the recrystallization and precipitation behavior of two low-alloyed steels, *steel research international* 2021, 2100065.

C. Kicking, C. Suppan, T. Hebesberger, R. Schnitzer, C. Hofer, Microstructure and mechanical properties of partially ferritic Q&P steels, *Materials Science and Engineering A* 815 (2021) 141296.

M. Stadler, R. Schnitzer, M. Gruber, K. Steineder, C. Hofer, Microstructure and Local Mechanical Properties of the heat-affected zone of a resistance spot welded medium-Mn steel, *Materials* 14 (2021) 3362.

C. Hofer, M. Stadler, T. Kurz, V. Maier-Kiener, A. Mayerhofer, T. Hebesberger, R. Schnitzer, Bending Behavior of Zinc-Coated Hot Stamping Steels, *steel research international* 2021, 2100149.

H. Schonmaier, C. Fleißner-Rieger, R. Krein, M. Schmitz-Niederau, R. Schnitzer, On the impact of post weld heat treatment on the microstructure and mechanical properties of creep resistant 2.25Cr–1Mo–0.25V weld metal, *Journal of Materials Science* 56 (2021) 20208-20223.

Chair of Structural and Functional Ceramics

A.-K. Hofer, I. Kraveva, R. Bermejo, Additive manufacturing of highly textured alumina ceramics, *Open Ceramics* 5 (2021) 100085.

J. Schlacher, A.-K. Hofer, S. Geier, I. Kraveva, R. Papšik, M. Schwentenwein, R. Bermejo, Additive manufacturing of high-strength alumina through a multi-material approach, *Open Ceramics* 5 (2021) 100082.

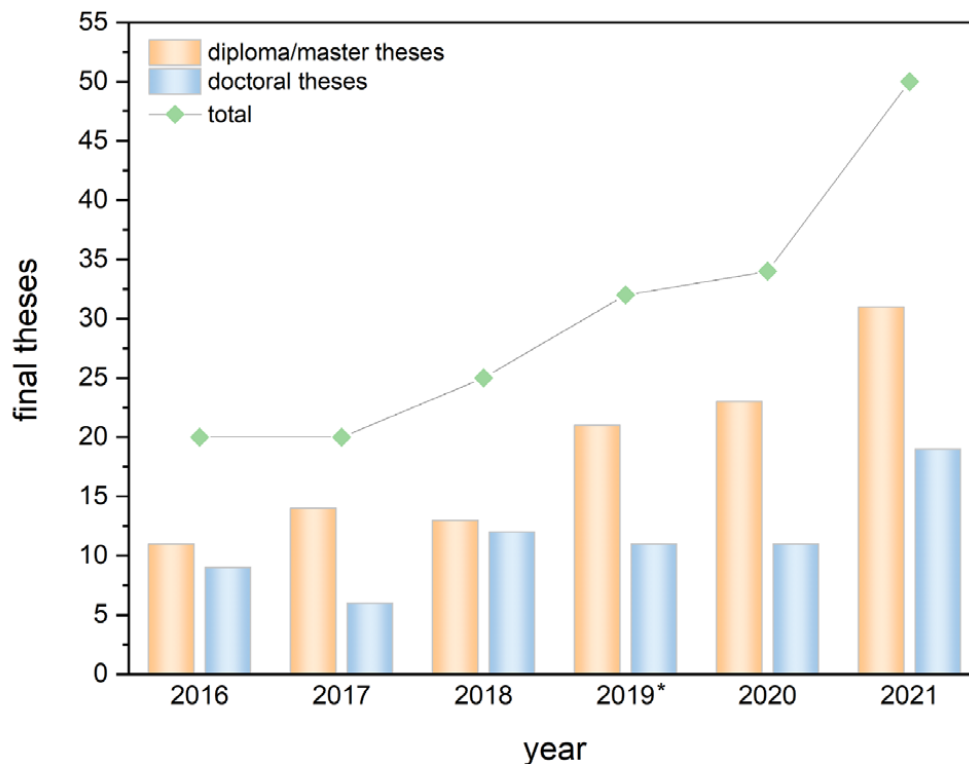
T. Billovits, P. Supancic, Measurement of the piezotronic effect on single grain boundaries in Zinc Oxide Varistors, *Open Ceramics* 6 (2021) 100125.

M. Staudacher, T. Lube, J. Schlacher, P. Supancic, Comparison of biaxial strength measured with the ball-on-three-balls- and the ring-on-ring-test, *Open Ceramics* 6 (2021) 100101.

R. Bermejo, Subcritical Crack Growth: Modelling of the v–K curve in different eEnvironments, M. Pomeroy (Ed.), *Encyclopedia of Material: Technical Ceramics and Glasses*, Elsevier, Oxford (2021) 811-817.

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 2021, 31 students completed their master's thesis.

Baumegger, Walter

Correlation of process conditions, microstructure and mechanical properties of magnetron sputtered equiatomic CrMnFeNiCo alloys

Bleicher, Christoph

Mechanical properties of varistor ceramics

Blumauer, Stefan

Sputter deposited TiAlN/AlTiN and CrAlN/TiAlN - multilayer coatings

Cui, Charlotte

Precipitation evolution of a laser powder bed fused FeCoMo alloy with atom probe tomography

Endt, Sebastian Zacharias

Characterization of an additively manufactured zirconia ceramic for dental and implant applications

Erlacher, Georg

Tribological performance of different material pairings of exhaust valve and valve seat under impact-sliding conditions

Feichtenschlager, Lukas

Effect microstructure of explosion hardened Hadfield steel on the propagation of surface acoustic waves

Fellner, Simon

A multiscale structural investigation of metallic glass composites with advanced electron microscopic methods

Gruber, Paul Harald

Effects of metallic Y and Ti addition on the dispersion and solubility behaviour of added Y_2O_3 in an ODS FeCrMnNiCo HEA during mechanical alloying

Gschöpf, Boris

Softening of plastic mould steels during injection moulding

Jabr, Abdullah

Contact damage of alumina-based layered ceramics with tailored microstructure

Jechtl, Tobias

Assessment of various DFT-based methods for predicting temperature dependence of elastic constants

Kardos, Stefan

The influence of 2 at.% to 4 at.% zirconium on phase equilibria in γ -based Ti–Al alloys

Leiner, Thomas

Impact of the stacking sequence on the stability of transition-metal diborides

Lukas, Thomas

Study on stabilization of α -case in Ti-6Al-4V

Lumper, Lea Andrea

Mechanical constitution of stable and metastable phases in Cu₂₀Sn

Paulischin, Alexander Benedikt

Magnetostrictive behavior of severe plastically deformed, nanocrystalline materials

Proyer, Armin

Atom probe tomography investigation of the diffusion of Si, Mn, and Cr in a pearlitic steel

Pürstl, Fabian

Development of a tailored heat treatment route for SLM manufactured γ -TiAl high-temperature components

Rockenschaub, Martin Horst Gerhard

Influence of explosive depth hardening on the formation of craze cracks in Hadfield steels

Schretter, Lukas

Analysis of the strain information from nanodiffraction data

Schwendenwein, Philipp Peter

Simulation of ballistic tests on hot-rolled Ti-6Al-4V plates with different microstructures

Sommerauer, Michael

Impact of conditioning processes on the performance of rotating anodes

Spuller, Mirjam

Selective laser melting of a Zr-based bulk metallic glass for medical applications

Tropper, Florian

Technology innovation in direct fastening on concrete and steel

Walch, Lukas

Damage initiation in hard-coated hard metal substrates under normal and tangential loads at elevated temperature

Wasenbelz, Fabian

Cathodic arc evaporated high-entropy alloy-based metallic and nitride coatings

Weniger, Lisa-Marie

Structural, electrical and mechanical properties of AgAuSi thin film metallic glasses on polymer substrates

Wratschko, Marlies Tabea

Processing and characterization of alumina – zirconia textured ceramics

Zeiler, Stefan

Microstructural influence on threshold behavior and fracture toughness of additively manufactured γ -Titanium Aluminides

Ziegelwanger, Tobias

Microstructural and mechanical properties of Si-alloyed AlCrN hard coatings: Grain boundary segregation engineering by CrN precipitation

Doctoral theses

In 2021, 19 doctoral students were awarded doctorates in montanistic sciences.

Abdoshahi, Neda

Ab initio study of martensitic and ordering transformations in intermetallic TiAl-alloys

Chen, Zhuo

Study on the interface structure of transition metal nitride thin films by advanced electron microscopy

Ebner, Anna Sophie

Advanced in-situ electrochemical nanoindentation for investigating hydrogen-materials interactions

Golizadeh Najafabadi, Mehran

Towards knowledge-based design of multi-element cathodes for cathodic arc deposition processes

Gruber, David

Cross-sectional characterisation of thin films for the knowledge-based design of hard coatings

Grünbichler, Hannes

Electro-mechanical characterisation of multilayer piezoelectric actuators

Jakob, Severin

Investigation into the mechanical character of grain boundaries in technically pure and micro-doped molybdenum

Kaliyaperumal Veerapandiyan, Vignaswaran

Raman spectroscopy of barium titanate based relaxor ferroelectric ceramics

Kappacher, Johann

High temperature nanoindentation as a versatile tool to examine thermally activated deformation mechanisms

Kaufmann, Benjamin

Microscale characterisation and modelling of the highly nonlinear electrical behaviour of zinc oxide varistors

Kunter, Karlheinz

Simulation of crack propagation during crash

Maier, Kathrin

Damage indicators for early failure detection under cyclic loading considering creep strain of WC-Co hardmetals at 700°C and 800°C

Massone, Agustina

In-situ investigations of hydrogen-material interaction

Schwarz, Katharina Theresia

Microstructure evolution and fracture behaviour of lamellar material produced by high pressure torsion

Siller, Maximilian

Surface damage of rotating anodes and the impact on the x-ray emission

Souli, Imane

Stress engineering to reduce mechanical loading in Cu-based metallizations

Stadler, Manfred

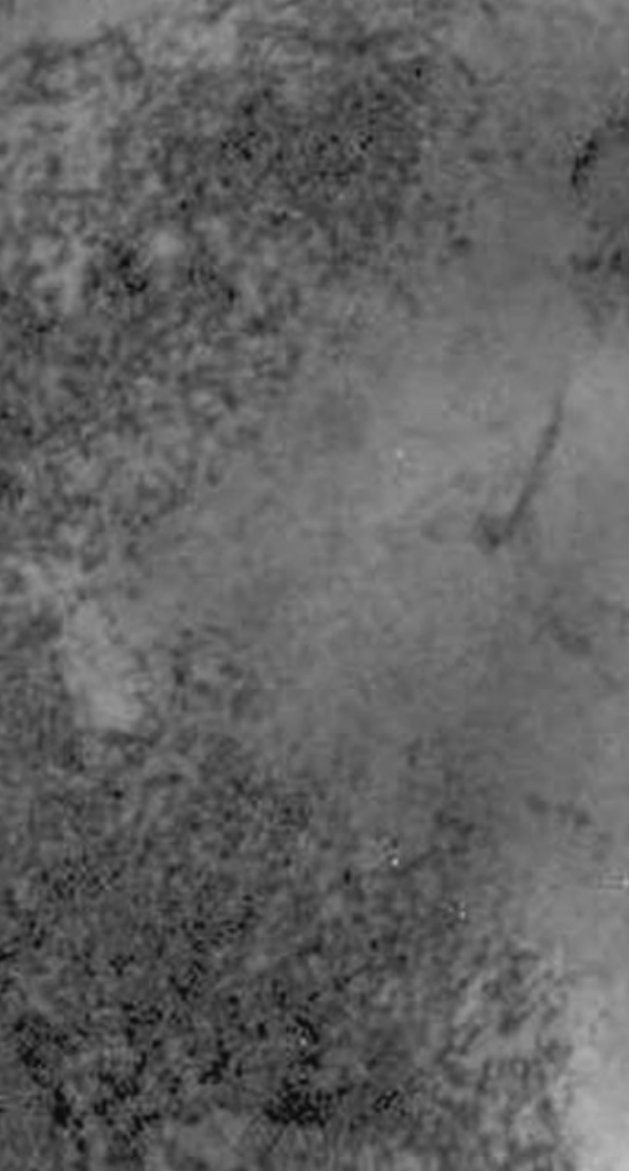
Resistance spot welding of third generation advanced high strength steels

Stückler, Martin

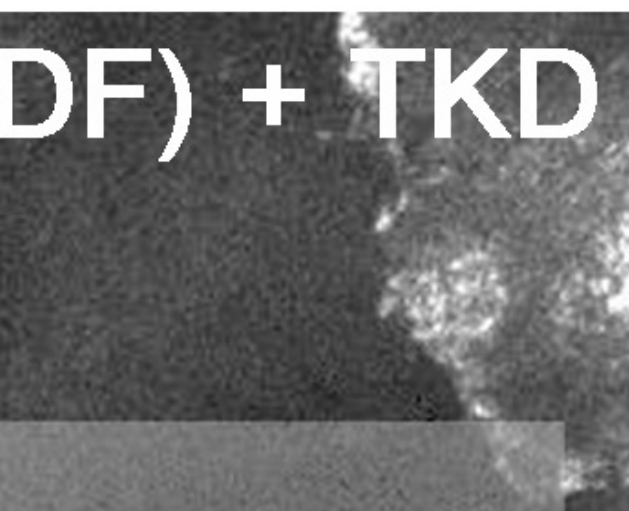
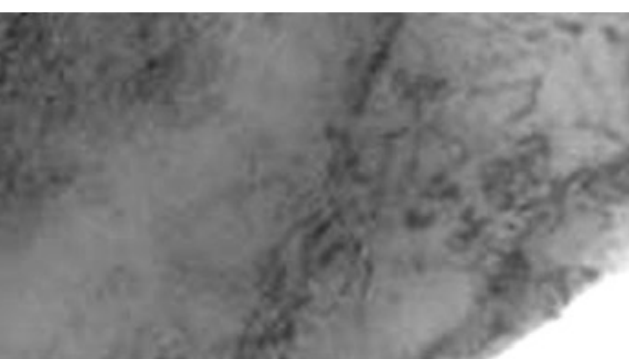
Nanoscaled magnetic materials with tunable properties

Wimler, David

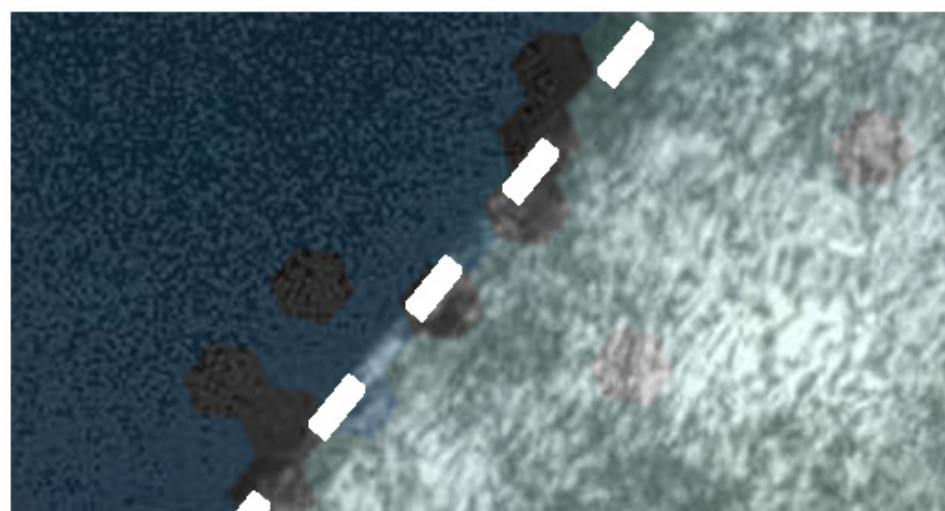
Development of TiAl alloys on the demand of additive manufacturing and high-temperature application



**CONFERENCES
EVENTS**



DF) + TKD



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.

International Conference on Metallurgical Coatings and Thin Films (ICMCTF) (26.-30.04.2021, Virtual)

After canceling the 2020 edition of the traditional International Conference on Metallurgical Coatings and Thin Films (ICMCTF), the 2021 was held in a virtual format during the last week of April 2021. The Department was traditionally involved in the organization with two scientists serving as symposium chairs (David Holec co-organized the TS3 symposium on “In-Silico Design of Novel Materials by Quantum Mechanics and Classical Methods” and Oleksandr Glushko co-organized the TS5 symposium “Thin Films on Polymer Substrates: Flexible Electronics and Beyond”).

The meeting attracted specialists from both academia and industry from around the globe with around 400 contributions. More than 20 of these were also from the Department of Materials Science, Montanuniversität Leoben, including the invited talk of Verena Maier-Kiener titled “Local Deformation Mechanisms under Ambient and Non-ambient Conditions Tested via Advanced Nanoindentation”.



EUROMAT 2021 (13.-17.09.2021, Virtual)

The Department of Materials Science was intensely involved in the organization of the EUROMAT 2021 conference. Ronald Schnitzer served as organizer for Area B – Structural Materials within the scientific committee and Helmut Clemens contributed with a plenary talk entitled ‘Intermetallic TiAl based alloys – from fundamental research to application’ to the success of the conference. It was the 1st virtual EUROMAT conference, which brought together more than 1500 experts from 46 countries online and more than 1250 oral presentations in 16 parallel rooms over 5 days were given. The conference is the premier international congress in the field of materials science and technology in Europe. The main objective was to foster knowledge transfer and exchange of experiences among delegates with academic and industrial backgrounds.

In addition five symposia were organized by the members of the Department:

The symposium D6: Atomic Scale Modelling of Advanced Materials – Ab Initio, Molecular Dynamics and Monte-Carlo Simulations, co-organized by Lorenz Romaner, was about theoretical tools for simulations of materials properties at the atomic scale for the knowledge-based design of advanced materials.

Symposium D3: Micro- and Nano-mechanics – Characterization and Modelling, co-organized by Verena Maier-Kiener presented a large group of talks on small scale mechanical testing as well as the corresponding materials behavior analysis.

The Symposium B4: Advanced Structural Ceramics, co-organized by Raul Bermejo, covered aspects dealing with correlations between processing, microstructures and component performance/reliability under service conditions/environment, with special focus on novel manufacturing technologies (such as 3D-printing) and its implication in the end properties of technical ceramics.

The B9 Symposium: Theory-guided Development of Structural Materials, co-organized by David Holec was topically similar to D6. Scale-bridging methods ranging from electronic structure calculations to phase-field modeling were presented on examples applied to structural alloys (steels, TiAl-alloys, Mg-alloys) as well as functional materials (protective ceramic coatings or permanent magnets).

Symposium C 14: Thermomechanical Processing, Severe Plastic Deformation & Nanostructuring, co-organized by Daniel Kiener, Andrea Bachmaier and Heinz-Werner Höppel, focused on the processing of metallic materials in order to achieve superior nanocrystalline or ultra-fine grained microstructures by advancing Process-Microstructure-Properties correlations. Strategies to enhance microstructural stability, as well as new developments of tailoring/grading and functionalization of materials by these processes were covered.



EUROMAT 2021
EUROPEAN CONGRESS AND EXHIBITION
ON ADVANCED MATERIALS AND PROCESSES

WWW.EUROMAT2021.FEMS.EU
SEPTEMBER 13-17, 2021
VIRTUAL

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THE AUSTRIAN SOCIETY FOR
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FEMS 30
FEDERATION OF EUROPEAN
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ÖGV-Seminar 2021 (24.09.2021, Vienna)

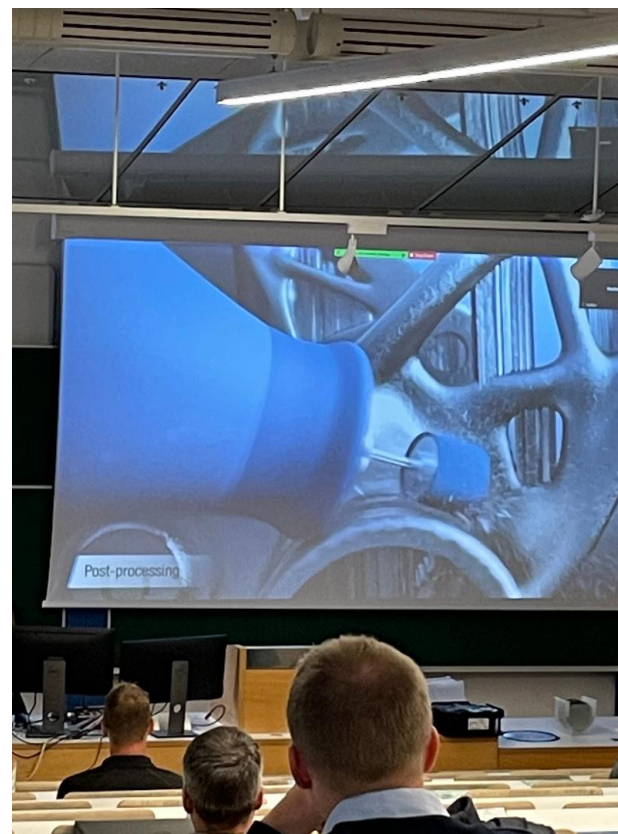
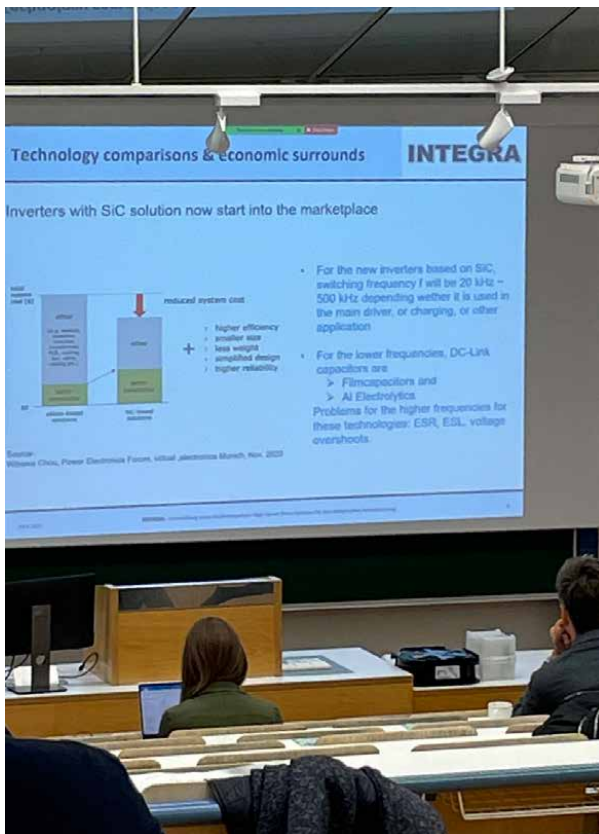
The ÖGV-Seminar 2021 by the Austrian Vacuum Society (ÖGV) was held for the first time at TU Wien on 24 September. The seminar was established to provide a forum for Austrian research groups and companies active in the field of vacuum technology and the synthesis and characterization of thin films. It was organised by Helmut Riedl-Tragenreif and Christoph Eisenmenger-Sittner from TU Wien and Robert Franz from Montanuniversität Leoben. In total 10 presentations were given by PhD students on a wide variety of topics which were well received and discussed by the audience and enabled the exchange of results and ideas from current research in the field. The organisers were very pleased with the strong participation from industrial partners, who, in addition to getting to know details about various research topics, had the chance to meet potential future employees and colleagues. A highlight of the seminar was the plenary talk by André Anders on “Energy considerations in plasma-based deposition of thin films” where he summarised in a clear and descriptive way the importance of different energy contributions to the film growth conditions and how they can be influenced and/or exploited in an optimum way.

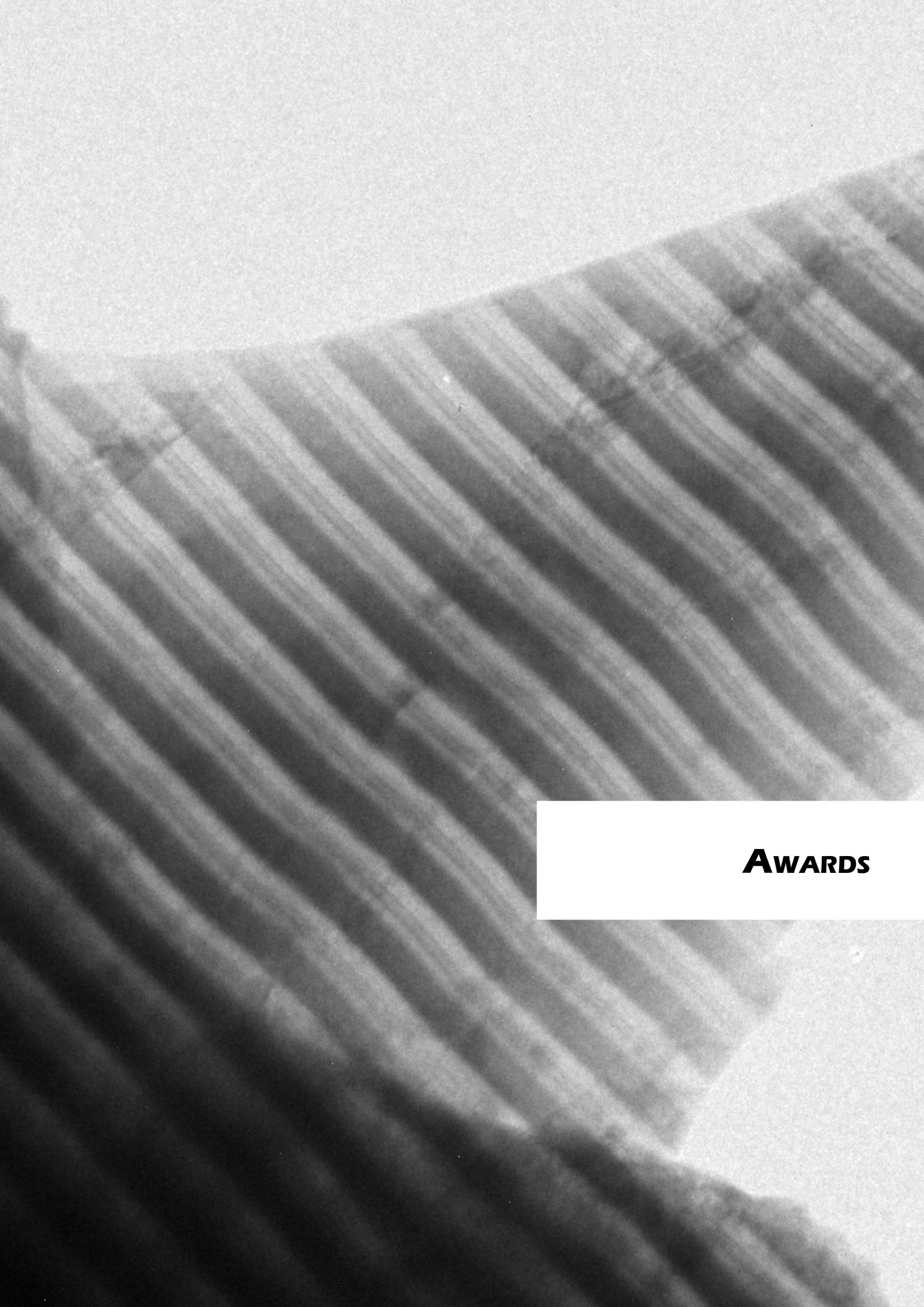
Future seminars are planned to take place annually at different Austrian universities with the next edition to be held on 11 July 2022 at Montanuniversität Leoben. All interested parties are cordially invited to attend this and all other future seminars!



2. INTEGRA-Workshop, Montanuniversität Leoben (29.09.2021, Leoben)

On September 29th 2021, a workshop was held at the MUL as part of the INTEGRA (FFG-project: "Entwicklung eines hochkompakten High-Speed-Drive Systems für den elektrischen Antriebsstrang"). 28 plus 14 virtual participants were welcomed to the 9 presentations. The workshop, which was open to MUL students, offered a good opportunity to show the University's networking with Austrian industry in cutting-edge research issues.





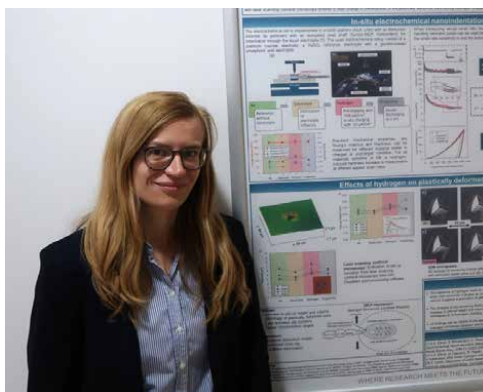
AWARDS

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.

Poster Award to Anna Sophie Ebner in the course of the online conference Nanobridges 2021

For her poster, with the title "Advanced in-situ electrochemical nanoindentation testing for understanding hydrogen-materials interactions", Anna Sophie Ebner won the Poster Award at the online conference "Nanobrücken 2021". Ms. Ebner is working at the Chair of Physical Metallurgy and Metallic Materials and during her PhD in a COMET project in collaboration with the Materials Center Leoben, she developed and optimized an innovative setup for measuring mechanical properties using micromechanical methods and, in particular, nanoindentation under electrochemical in-situ conditions. This method can be used to directly determine hydrogen-material interactions in order to develop future materials that, for example, exhibit high resistance to hydrogen embrittlement and can therefore make a decisive contribution in the field of hydrogen storage as well as for alternative hydrogen-based mobility concepts.



1st prize of the Fahrzeugverband-Jubiläumsstiftung 2020 to Sandra Ebner

Sandra Ebner was awarded the 1st prize of the Fahrzeugverband-Jubiläumsstiftung 2020 for her research achievements in the field of third-generation „Advanced High Strength Steels“. Understanding the complex microstructure of these high-strength steels for the automotive industry is essential for further development in terms of lightweight construction combined with increased safety. Sandra Ebner's focus of her doctoral thesis at the Chair of Steel Design was on material characterization using atom probe tomography and in-situ synchrotron radiation. The award ceremony took place at TU Graz in October 2021.



THERMEC'2021 Distinguished Award presented to Jürgen Eckert

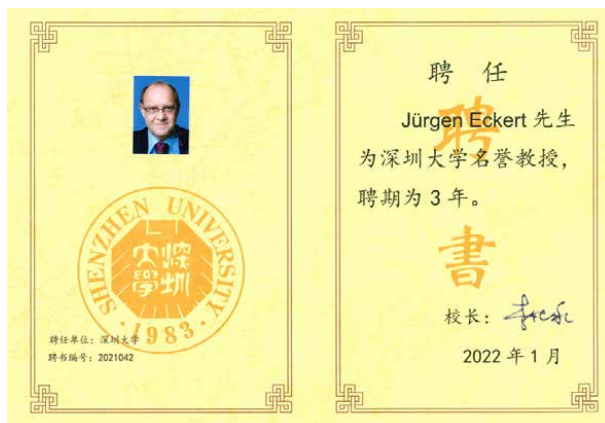
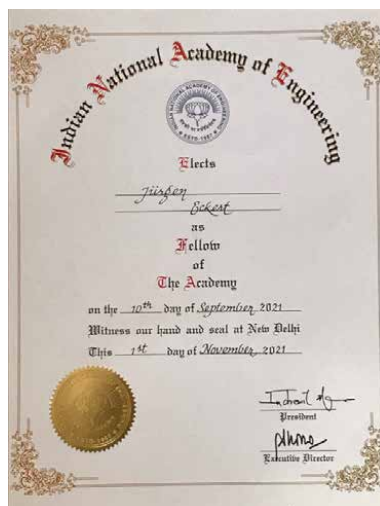
Jürgen Eckert was awarded the THERMEC'2021 Distinguished Award of the International Conference on Processing and Manufacturing of Advanced Materials. This was in recognition of his research achievements in the development of new high-performance materials and his commitment to the advancement of materials science in Austria.

The THERMEC Conference Series is an International Conference Series that has been held every two years for more than 20 years and is typically attended by more than 1000 participants from all over the world. Due to the Covid-19 pandemic, the event originally planned for 2020 in Vienna has now been held as an online event from 1st to 5th June. The next meeting of this conference series is scheduled to take place in June 2023, then hopefully under normal circumstances, again in Vienna.



Awards for Jürgen Eckert

Jürgen Eckert has been elected Foreign Fellow of the Indian National Academy of Engineering (INAE). This award represents the highest honor bestowed by the INAE and is given to scientists who have rendered outstanding services to the advancement of science, collaboration with Indian scientists, as well as the promotion of young scientists. Due to Covid-19 restrictions, the award was presented at the INAE annual meeting via video conference. In addition, Jürgen Eckert was awarded the European Advanced Materials Award of the International Association of Advanced Materials and appointed Honorary Professor at Shenzhen University, China.



DOC Scholarships for Dominik Gehringer and Michael Musi

In mid-May, two PhD students of the Chair of Physical Metallurgy and Metallic Materials were awarded with a coveted DOC scholarships of the Austrian Academy of Sciences (ÖAW). Michael Musi, from the group of Svea Mayer, deals in his dissertation with the improvement of the high-temperature properties of intermetallic TiAl alloys. Dominik Gehringer (group of David Holec) is working on the coupling of classical and quantum mechanical simulation methods in order to better investigate crystal defects in metallic materials. The DOC funding program of the ÖAW supports highly qualified PhD students from all fields of research. This research funding is awarded exclusively to outstanding young scientists in a highly competitive, two-stage selection process.



Fritz-Grasenick-Award 2020 for Inas Issa

Inas Issa, a scientist working at the Department of Materials Sciences (Montanuniversität Leoben), received the “Fritz-Grasenick-Preis 2020” of the Austrian Society for Electron Microscopy (ASEM), and delivered an invited award speech during the 11th ASEM workshop (20th-21st of May 2021).

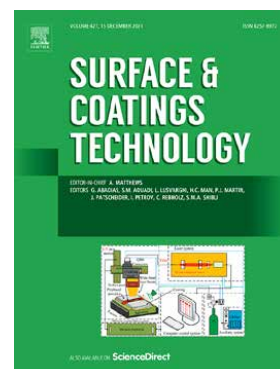
In the work entitled “In-situ TEM Investigation of Silicon at small scales”, Inas Issa and co-authors reported pioneering insights demonstrating the remarkable toughening and a connected dramatic shift in the brittle-to-ductile transition temperature of a highly brittle yet indispensable model material, namely silicon, solely by geometrical miniaturization. This was rationalized via quantitative nanoscale fracture experiments performed in-situ in the transmission electron microscope in conjunction with advanced in-situ nanoscale strain mapping and detailed Finite Element Method simulations.

The Austrian Society for Electron Microscopy (ASEM) has been awarding the Fritz-Grasenick-Award to young scientists in the field of electron microscopy since 2007. Also, the award’s purpose is to remember one of the pioneers of electron microscopy in Austria, Dr. Fritz Grasenick (1916-2003), the founder of the Center for Electron Microscopy in Graz.

The image shows a presentation slide titled "In-situ TEM Investigation of Toughening in Silicon at Small Scales" by Inas Issa et al. The slide includes logos for ÖAW, MONTAN UNIVERSITÄT LEOBEN, and ERC Grant 771146 TOUGH IT. It also lists the authors: Inas Issa¹, Christoph Gammer², Stefan Kolitsch^{2,3}, Anton Hohenwarter¹, Peter J. Imrich¹, Reinhard Pippan², and Daniel Kiener¹. The slide mentions the Fritz-Grasenick-Award 2020 from the Austrian Society for Electron Microscopy (ASEM) and provides a citation: I. Issa et al., In-situ TEM Investigation of Toughening in Silicon at Small Scales. Materials Today (2021). <https://doi.org/10.1016/j.mattod.2021.03.009>. A video call window in the bottom right corner shows Inas Issa speaking.

ECAB: Christina Kainz appointed into the Early Career Advisory Board of the journal Surface and Coatings Technology

Christina Kainz, post doctoral researcher within the scope of the Christian Doppler Laboratory for Advanced Coated Cutting Tools at the Chair of Functional Materials and Material Systems, has been accepted as a member of the Early Career Advisory Board of the journal Surface and Coatings Technology (Elsevier). The focus of this international journal is on the engineering of surfaces and interfaces with the aim of modifying and improving their properties and functionality. The journal with an impact factor of 4,158 is one of the leading publications in the field of surface and coating technology; the submitted manuscripts undergo a rigorous review process. Early Career Board members are appointed for a two-year period following a selective selection process.



Scholarship of the Hans List Fonds to Christina Kainz

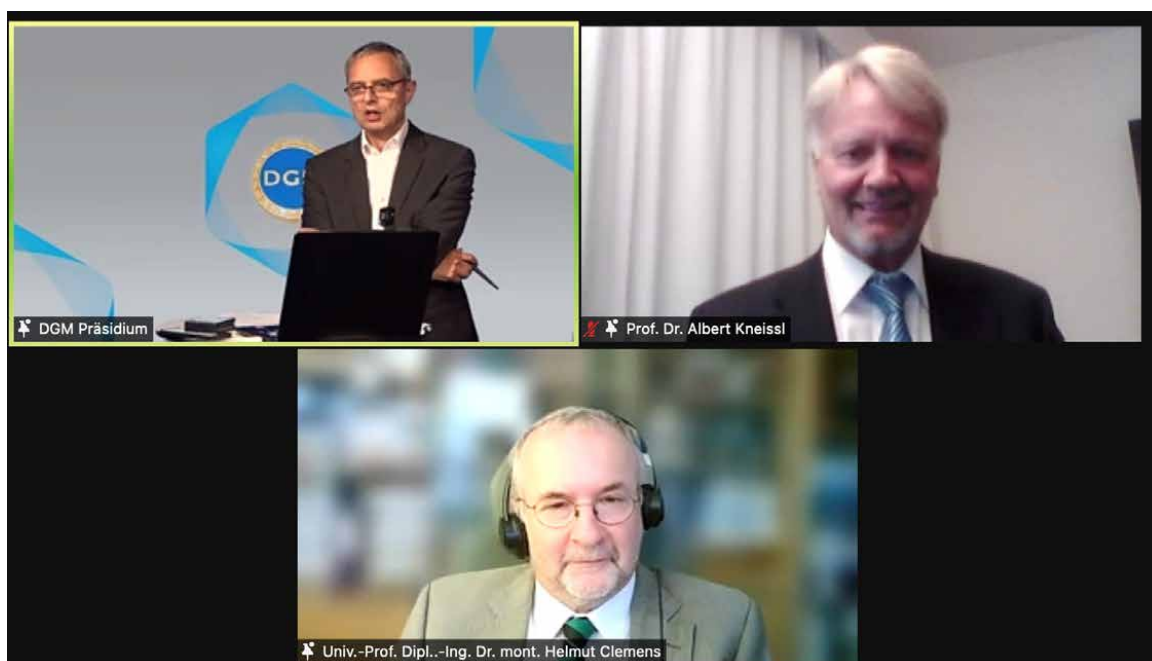
Christina Kainz was awarded the Scholarship of the Hans List Fonds for her dissertation entitled „Chemical Vapor Deposition of Hard Coatings in the System Ti-B-C-N“. The dissertation was carried out within the framework of the Christian Doppler Laboratory for Advanced Coated Cutting Tools at the Chair of Functional Materials and Material Systems under the supervision of Nina Schalk and Christian Mitterer. In her work, Christina Kainz focused on the production, characterization and optimization of hard coatings used for metal cutting applications. Sophisticated characterization techniques, such as in-situ synchrotron X-ray diffraction or micromechanical bending tests were applied to allow for a better understanding of the structure-property relationship of the coatings. The award ceremony took place on October 14th 2021 at AVL List GmbH in Graz.



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DGM Honorary Membership 2021 to Univ.-Prof. i.R. Dr. mont. Albert Kneißl

Due to his achievements in the field of physical metallurgy and metallography as well as in appreciation of his active work in the technical committee Materialography and in other expert committees, the German Society for Materials Science e.V. has awarded Prof. Dr. Albert Kneißl the honorary membership 2021. The award ceremony took place on September 6 during the DGM Day, which was held virtually due to the pandemic. The laudation was given by Helmut Clemens.



from top left clockwise: Prof. Dr. Gerhard Schneider, DGM Präsidium, Prof. Dr. Albert Kneißl, Helmut Clemens.

Nikolaos Kostoglou appointed Editorial Board Member of the Journal of Advanced Materials Science and Technology

Nikolaos Kostoglou from the Chair of Functional Materials and Material Systems was appointed Editorial Board Member of the Journal of Advanced Materials Science and Technology, published by Omniscient publishing house (Singapore), in September 2021. The Journal of Advanced Materials Science and Technology is an international and interdisciplinary open access journal; the submitted manuscripts undergo a rigorous review process. The journal covers the synthesis, properties and applications of new materials related to energy, environment, physics, chemistry, engineering, biology and medicine.



Female Scientists of the Montanuniversität Leoben 2020

On the occasion of this year's International Women's Day 2021 on March, 8th, three female materials scientists from Leoben were awarded the Female Science Award for Women 2020 (Wissenschaftspreis für Montanistinnen) for their outstanding scientific achievements. Since this year, the prize is awarded in 3 different categories; DI Malina Jop (former student at Chair of Physical Metallurgy and Metallic Materials, now PhD student at the Department of Physics) received it as Junior Scientist, Sabine Bodner (Chair of Materials Physics) in the category PraeDoc and Verena Maier-Kiener (Chair of Physical Metallurgy and Metallic Materials) was awarded as PostDoc. All three scientists are distinguished by outstanding research achievements for their comparatively young scientific age and all have several international publications and awards to their credit. With these awards, the MUL aims to promote the work of young female researchers at the MUL and to strengthen women in the STEM subjects.



LTR: Malina Jop, Sabine Bodner, Verena Maier-Kiener

Graduate Student Award for Michael Meindlhumer

Michael Meindlhumer, former PhD Student at the Christian Doppler Laboratory for Advanced Synthesis of Novel Multifunctional Coatings at the Department of Material Science, now at the Erich-Schmid Institute for Materials Science, was awarded the Graduate Student Award Bronze at the International Conference on Metallurgical Coatings and Thin Films (ICMCTF 2021 Virtual Conference, 26.-30. of April 2021) for his work entitled "Nanoscale Synchrotron Characterization of Microstructure and Stress Evolution in Thin Films using Millisecond X-ray Diffraction". In his work, Dr. Meindlhumer investigated several aspects of the stress and microstructure variations accumulated in thin films accompanying thermal and mechanical loading.



Award of Excellence

Michael Meindlhumer was rewarded with the “Award of Excellence” (Staatspreis für die besten Dissertationen) for his dissertation entitled “Cross-sectional and High-Temperature Structure-Property Relationships in Nanocrystalline Thin Films” by the Federal Ministry for Education, Science and Research. This prize is awarded annually to 40 selected, outstanding, and best-rated dissertations. The award ceremony had to be cancelled due to the current situation.



Christian Mitterer appointed to the Senate of the Christian Doppler Society

The Christian Doppler Society (CDG) has appointed Christian Mitterer as a member of the Senate. One of the main goals of the CDG is to promote application-oriented basic research, jointly be done by universities and companies. The Senate is the CDG’s scientific advisory body that shapes the scientific framework of the funding programs, reviews applications for the establishment of CD Laboratories and evaluates their research progress. The Senate is composed of highly qualified individuals from science and industry. Following the passing of Prof.

Buchmayr, the Montanuniversität Leoben is now once again represented by two members in the CDG Senate, Christian Mitterer and Prof. Johannes Schenk.

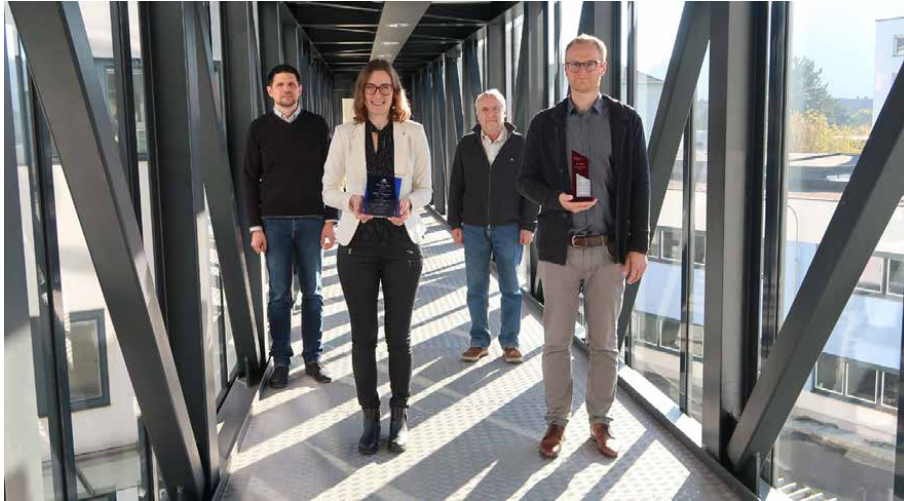
Poster Award to Josef Schlacher

Josef Schlacher, PhD-student at the Chair of Structural and Functional Ceramics, won the first place in a poster competition with 31 participants at the „17th European Inter-Regional Conference on Ceramics (CIEC17)” on 27th Nov. 2021. The work „Micro-scale fracture toughness of textured alumina grains and grain boundaries”, done in collaboration with the Institute of Materials Research of the Slovak Academy of Science in Košice, investigated the micromechanical behaviour of textured alumina for a better understanding of the macroscopic fracture of layered ceramic architectures. Funding for this research is provided by the ERC Consolidator Grants (Tailoring Microstructure and Architecture to Build Ceramic Components with Unprecedented Damage Tolerance) within the project „CeraText”.



Several awards at the 55th Metallography Conference

Hannah Schönmaier, Magdalena Pölzgutter and Ronald Schnitzer from the Chair of Steel Design were awarded the “Buehler Best Paper Award 2020” at this year’s Virtual Metallography Conference. Their article “Etching Methods for the Microstructural Characterization of a Heat Resistant 2.25Cr-1Mo-0.25V Weld Metal”, published in the journal Practical Metallography, achieved the 1st place. The achievements of Christian Fleißner-Rieger from the Chair of Physical Metallurgy and Metallic Materials were also outstanding. At the same conference, he was awarded 1st place in the photo competition and was honoured in the category “Best Lecture”.



LTR: Ronald Schnitzer, Hannah Schönmaier, Helmut Clemens, Christian Fleißner-Rieger

Presentation of the Ring of Honor of the Republic of Austria to Petra Spörk-Erdely

Almost three years after her doctoral examination and about one year after her sub auspiciis doctorate, Petra Spörk-Erdely received the Ring of Honor of the Republic of Austria on November 25, 2021. The award ceremony was held in the smallest of settings by Magnificence Wilfried Eichlseder, with the participation of the two vice rectors, Dr. Martha Mühlburger and Prof. Peter Moser, as well as the doctoral supervisor, Helmut Clemens.



LTR: Prof. Peter Moser, Rector Wilfried Eichlseder, Petra Erdely-Spörk, Dr. Martha Mühlburger, Helmut Clemens

Josef Krainer Promotion Prize 2020 awarded to Petra Spörk-Erdely with a time delay

In memory of the work of the Styrian Governor Josef Krainer, the Styrian Commemorative Work has been awarding prizes in the categories of the Great Josef Krainer Prize, the Josef Krainer Appreciation Prize and the Josef Krainer Promotion Prize since 1993. During the award ceremony, Petra Spörk-Erdely, who heads a research group at the Chair of Physical Metallurgy and Metallic Materials, was awarded one of the Josef Krainer Promotion Prizes 2020 in recognition of her research achievements in the field of materials science. In her doctoral thesis, which was awarded the prize, Ms. Spörk-Erdely dealt with the development and characterization of intermetallic titanium aluminide alloys using diffraction and scattering techniques. The award ceremony was originally scheduled for March 20, 2020, but could not be held until May 12, 2021, due to the Covid-19 pandemic. The award ceremony was held under strict conditions and could be followed live via streaming.



LTR: Em.o.Univ.-Prof. DDr. Gerald Schöpfer, Petra Spörk-Erdely, Georg Krainer und LH Hermann Schützenhöfer (Photo: Kommunikation Land Steiermark/Fischer).

1st Price at the student speech contest of the European Ceramic Society

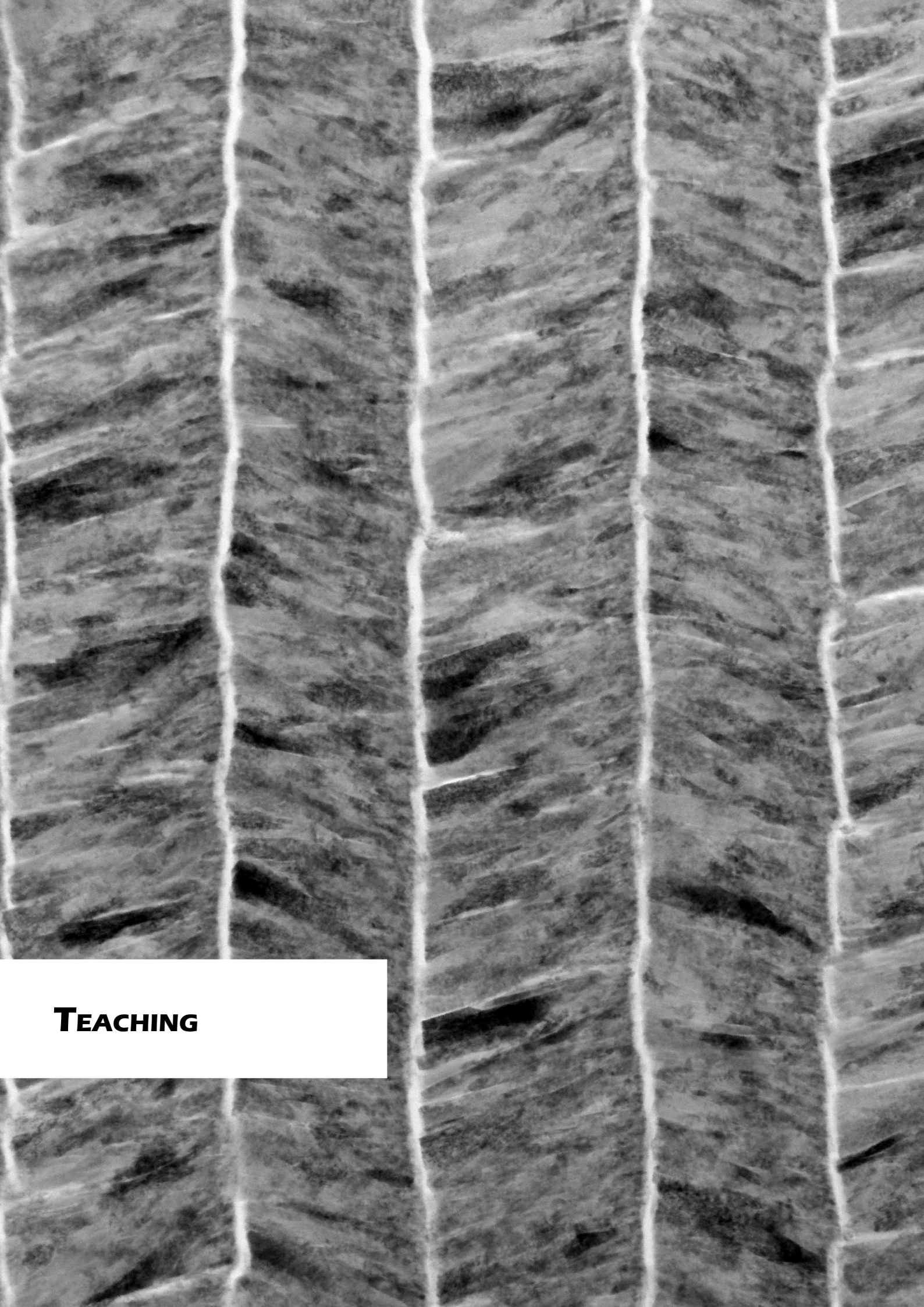
Maximilian Staudacher has won the bi-annual student speech contest of the European Ceramic Society (ECerS). This contest took place during the “14th Ecers Conference for Young Scientists in Ceramics” from 20.-23.10.2021 in Novi Sad, Serbia. With his presentation titled “The Ball-on-Three-Balls-Test: Comparison with the Ring-on-Ring-Test for Ceramics”, he managed to outperform 18 other candidates. In order to qualify for this contest, each contestant had to win their respective national contests, which Maximilian Staudacher did at the Austrian student speech contest in March 2021. Currently, he is a PhD-Student at the Chair of Structural- and Functional Ceramics and is working on testing methods for additive manufactured specimens or specimens with exceptional geometries. By winning this international competition, he will have the opportunity to perform as an invited speaker at the 17th Conference of the ECerS titled “Ceramics in Europe 2022” from 10.-14.7.2022 in Krakow, Poland, which is the most important European conference within the ceramic field.



Best Poster Award of Intermetallics 2021 to Reinhold Wartbichler

During Intermetallics 2021, which took place from October 4-8, 2021 at the Banz Monastery, Bad Staffelstein, Germany, as an international hybrid conference, Reinhold Wartbichler, Chair of Physical Metallurgy and Metallic Materials, was awarded the “Best Poster Award”. The awarded work deals with the elucidation of the microstructure evolution of an intermetallic titanium aluminide alloy during additive manufacturing by electron beam melting. The investigations were carried out as part of the EU project NEWTEAM, in which Italian research institutes and the company Avio Aero are partners.





TEACHING

TEACHING

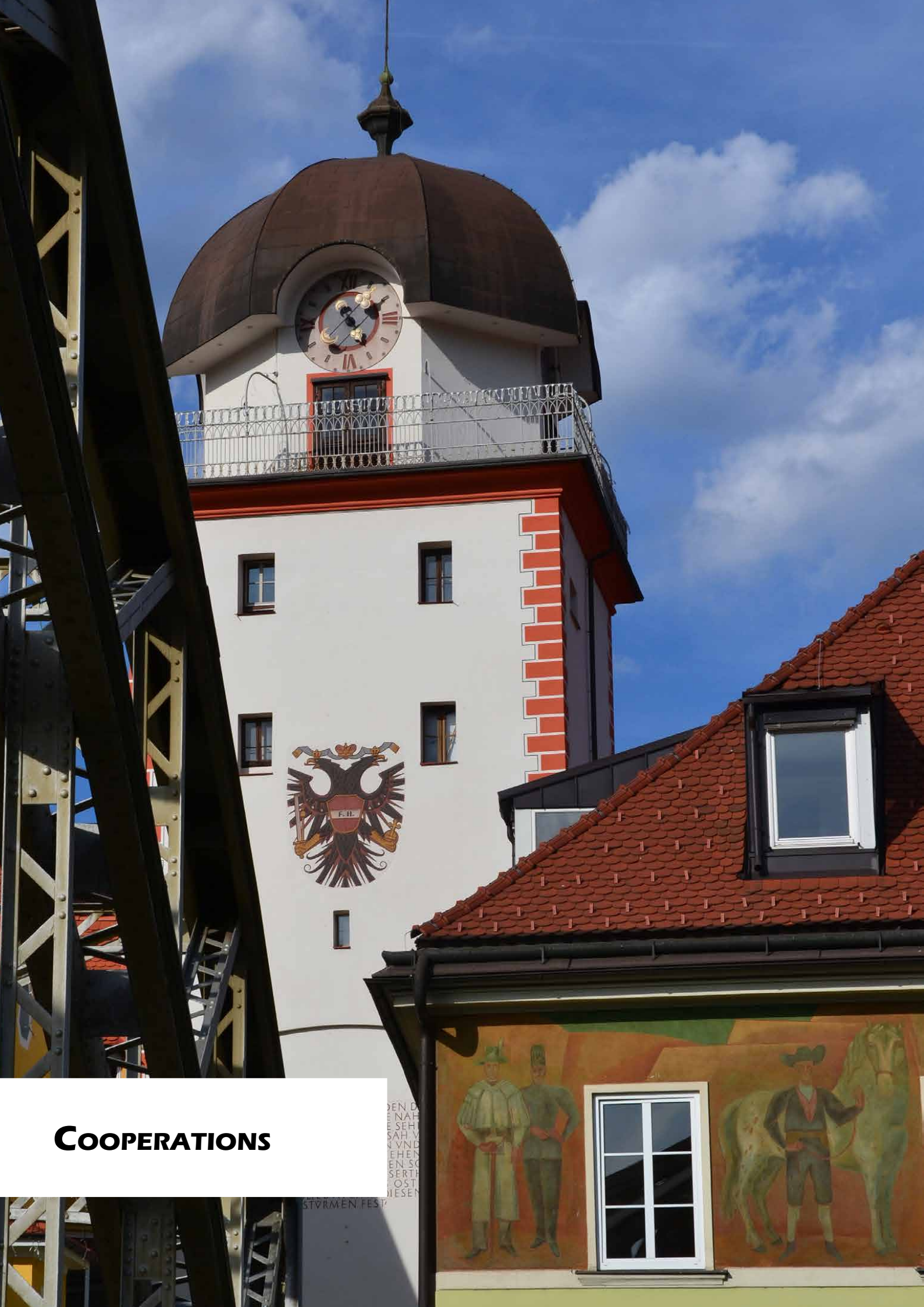
In addition to research, teaching is an important task of the university. It is the basis for the high quality education of our graduates, who will later not only contribute to the sustainable development of Austria as a location for industry and research, but will also successfully gain a foothold internationally.

Semester Hours (Hrs) Winter- and summer semester

Chair	Compulsory subject (Hrs)	Elective subject (Hrs)	Free subject (Hrs)
Chair of Functional Materials and Materials Systems	18	4	27
Chair of Physical Metallurgy and Metallic Materials	40	19	49
Chair of Materials Physics	25	25	47
Chair of Design of Steels	16	2	12
Chair of Structural and Functional Ceramics	27	16	15

Exams

Chair	Number of exams
Chair of Functional Materials and Materials Systems	461
Chair of Physical Metallurgy and Metallic Materials	824
Chair of Materials Physics	491
Chair of Design of Steels	194
Chair of Structural and Functional Ceramics	311



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of Cyprus



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Vienna University of Technology



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RESEARCH



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Euskal Herriko
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Harbin Institute of Technology



Helmholtz-Zentrum
Geesthacht
Zentrum für Material- und Küstenforschung



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HELMHOLTZ
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ROSSENDORF

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MUNI

Masaryk
University



Max Planck Institute
of Colloids and Interfaces

FAU

FRIEDRICH-ALEXANDER
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CTU
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UNIVERSITY
IN PRAGUE



COMTES FHT
Complete Technological Service - Forming, Heat Treatment



a QSIL company



ESRF
The European Synchrotron



Karlsruher Institut für Technologie



Universität für Bodenkultur Wien



OAK
RIDGE
National Laboratory



Deutscher Verband für
Materialforschung und -prüfung e.V.



EXCELENCIA
MARÍA
DE MAEZTU



Technical University
of Denmark



Queen Mary
University of London



PURDUE
UNIVERSITY



KARL-FRANZENS-UNIVERSITÄT GRAZ
UNIVERSITY OF GRAZ



Technische Universität München



University of Colorado
Boulder



CEMES



THE UNIVERSITY
of EDINBURGH



Univerza v Mariboru



TECHNION
Israel Institute
of Technology



PennState



EINDHOVEN
UNIVERSITY OF
TECHNOLOGY



OUTLOOK

Looking back, the last year was again a challenging one we did not expect a year past. We had to again cope with a pandemic that globally affected education and research. But this time, we were already prepared and adopted our research and teaching activities swiftly when situations were getting more difficult. Looking forward, this seems to remain a common theme, whether we like it or not. But now we can state that we are prepared, safety measures and procedures are in place and our online, remote and hybrid skills are continuously improving.

In terms of an attractive education, we are very much looking forward to our new bachelor study Materials Science & Technology ("MaWiTech"). After hundreds of hours spent in designing this new modern study concept, we are very much looking forward to putting it in place starting this October. There will certainly be challenges, as always when stepping from conceptualization to realization, but we are convinced the outcome will be a very exciting and internationally compelling study. In a practical sense, we hope to meet and interact with our students back in class, since we of course manage online or hybrid meetings, but the spirit of Leoben lives in the close personal interaction between students and academic staff. That is where we excel and make a difference, and this is what we would like to offer to our students if the pandemic situation allows.

In terms of research activities, there are already strong activities towards development of novel materials and processes for green energy generation and storage. Given the current global situation, we will further enhance our efforts to strengthen and promote these undertakings. This will involve, for example, resource efficiency, alternative energy sources and storage media, as well as modern reuse and recycling concepts to extend the end of life of components. But also classical fields such as steel technology will enter a new era, and we will see the first glimpses of this torch carried on in Leoben.

Of course, such advances do not come easy, since many variables are at play, which requires state-of-the-art infrastructure in the complementary fields of experiments, modeling, simulation, and data science for a thorough understanding. Several novel high-end instruments, e.g. for creating and characterizing nanostructured or nanoporous materials, just arrived or are in the acquisition process. In addition, the capabilities in materials simulation and digitalization are being expanded for example in the new FWF project "Hybrid modeling of grain boundary chemistry", and also transferred into new courses within the Materials Science master curriculum.

In such demanding and uncertain times, with war raging within the European borders, we are nonetheless confident that, by providing diversified higher education in Materials Science and a tolerant global picture 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 2022!

Imprint

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