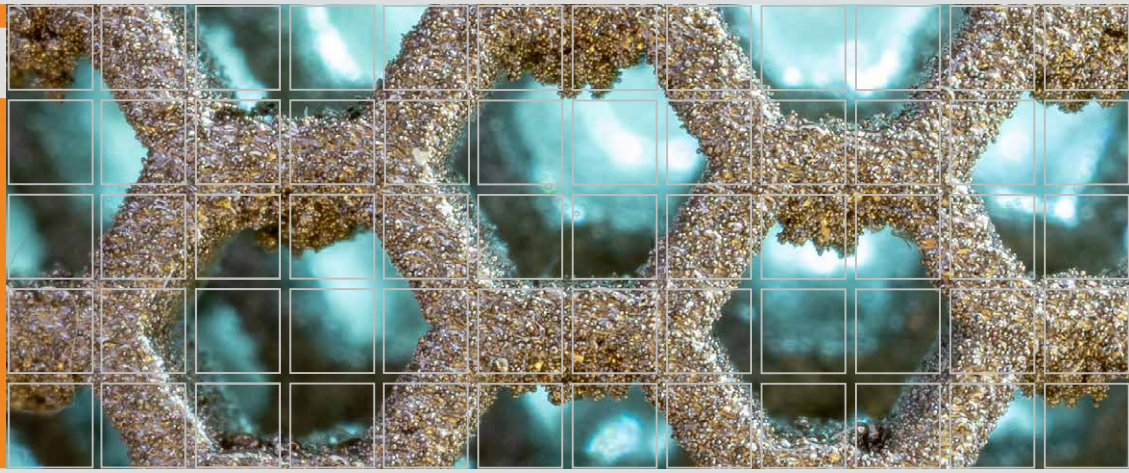
Institute of Materials Science, Joining and Forming
Univ.-Prof. Dipl.-Ing. Dr.techn. Christof Sommitsch

IMAT



Report 06.2021 - 06.2023

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9th November 2023

IMAT

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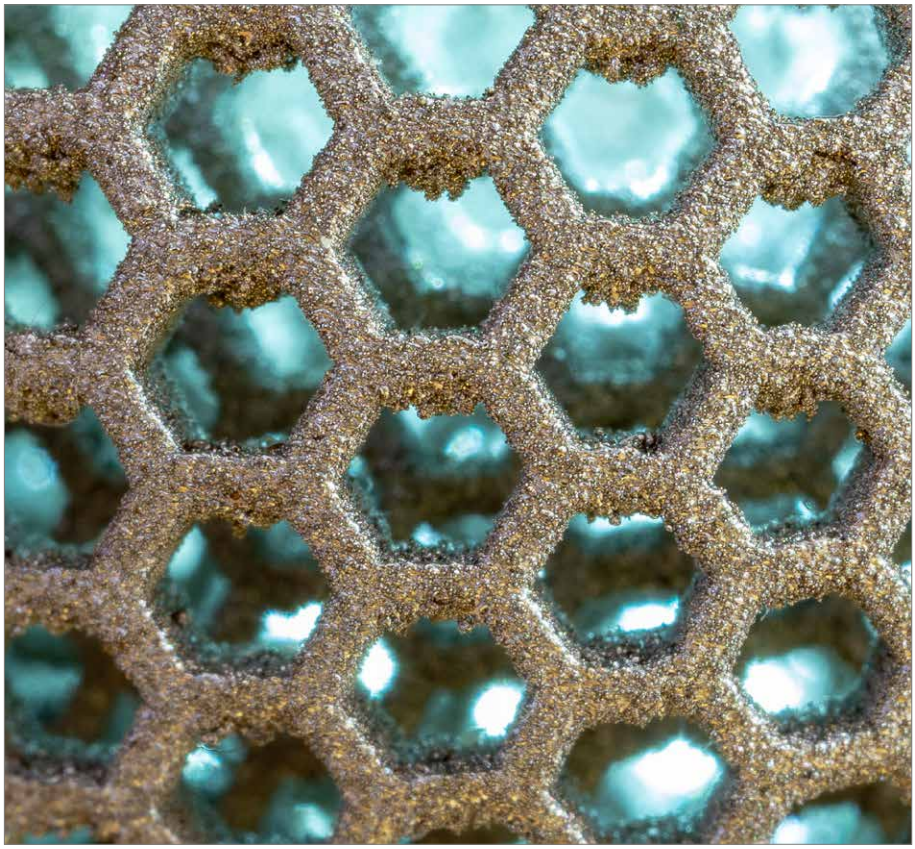

Cover:
"Detail of a complex additively manufactured part made of 316L stainless steel via laser powder bed fusion process" - Design: Coherent
Image: © TU Graz / IMAT - Fercher

Content

Introduction

Dear IMAT friends!

This performance report is issued on the occasion of the 16th Materials Conference at Graz University of Technology to describe the activities of the Institute of Materials Science, Joining and Forming in the period from July 2021 to June 2023.

The theme of this Materials Conference is Smart Materials and Processes, which is a cross-sectional research area in the IMAT working groups. Smart in this context means not only advanced but offering additional functional material properties and using intelligent means, such as physical-based materials modeling. IMAT's research focus is still on the design and modelling of high-performance and lightweight materials and their forming and joining. Considering today's challenges we incorporate environmental impact and circularity, where reasonable by digital means, machine learning and artificial intelligence approaches. We are happy to be a member of the Lead Project Porous Materials @ Work for Sustainability, in which we lead a subproject on Additive manufacturing of novel porous catalysts for sustainable fuel production.
After the pandemic, students returned to the classroom, however achievements and findings of accelerated digitalization in this period were integrated into the teaching plan.

At the beginning of March 2023, Prof. Sergio Amancio's professorship was perpetuated. Thus, his field of expertise on Additive manufacturing and joining of hybrid materials for lightweight application will be continued and strengthened in the future. In May 2023, we started a new tenure track position, for which Dr. Petra Spörk-Erdely was selected. She will focus on the behaviour of metallic materials under process and application conditions and will be Topic Leader Metal Additive Manufacturing at IMAT. Ass.Prof. Dr. Josef Domitner finished his habilitation in June 2023 on the subject of Materials Engineering and Lightweight Technologies.

Well educated students are the most important output of universities. The shrinking number of engineering students is a challenge and threat to both, us and the Austrian industrial location. With our ESP – IMAT Elite Student Programme for Materials Science, Joining and Forming we continuously try to attract the most promising high-potential students from different course programs.
Incoming and outgoing researchers' mobility is strongly promoted at IMAT.

Incoming and outgoing researchers' mobility is strongly promoted at IMAT. Assoc.Prof. Norbert Enzinger went for a 6 months research stay at the University West in Trollhättan, Sweden. In spite of pandemic, there have been several guest researchers at IMAT, among others Prof. Herman Nied from Lehigh University in Bethlehem, USA spent his Fulbright Scholarship at IMAT in 2021 and Ass.Prof. Shengjie Yao from the Harbin Institute of Technology at Weihai, China, stayed for one year as a guest researcher with us.

We have been busy in organizing and/or chairing international conferences and workshops. In September 2021, the Euromat Conference, which was planned to be held in Graz, was organized as a web conference,

however with live presentations. Our international three-years Seminar Numerical Analysis of Weldability was held in September 2022 in Seggau. Thermec Conference 2023 was organized successfully in Vienna in collaboration with TU Wien, hosting around 1150 participants from 40 countries. After Covid, the community was happy to meet up and discuss again in person. For the second time we jointly performed a PhD Seminar with Prof. Peter Mayr, this time hosted by TU München.

In the area of the Life-Long Learning program, about 200 welding specialists have graduated successfully and left the University to work in industry over the last 22 years.

Due to your support, our many eager international institute members and colleagues, and the support from Graz University of Technology, the promotion agencies, and the industrial partners, the coming years will bring cutting-edge research projects and a continuous education of our students at the highest level.

Christof Sommitsch

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Univ.-Prof. Dipl.-Ing. Dr.techn. Christof Sommitsch
Head of Institute

2023 DGM Award to
Sergio Amancio and Ricardo Buzolin

The Institute

Mission

Passionate Lecturers and Researchers

We ensure a maximum of freedom for each staff member and student, supporting them as they acquire and deepen their subject area knowledge to the highest international standards. We provide an exciting and stable working environment, the result of our uncompromising commitment in teaching as also in cooperation with academic and industrial partners.

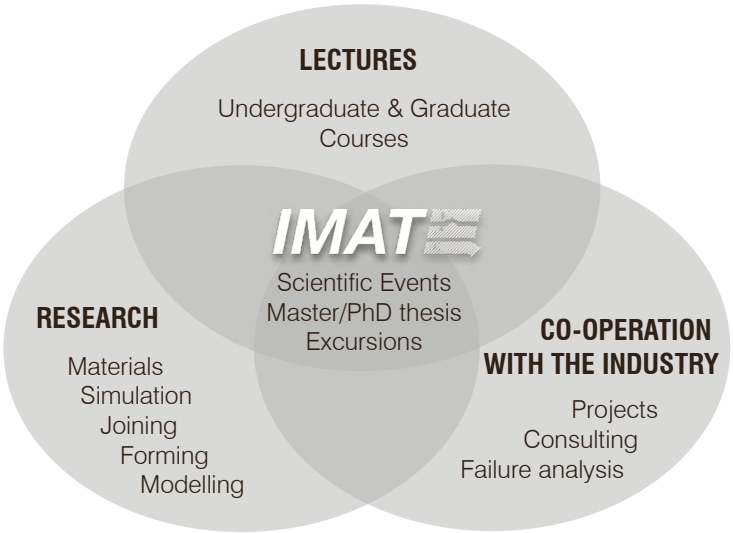
Vision

Materials Science for a Modern Society

We are an internationally recognized institute developing, modelling, joining and forming high-performance structural and functional materials. We address socially and environmentally relevant topics, focusing on green and disruptive materials and technologies.

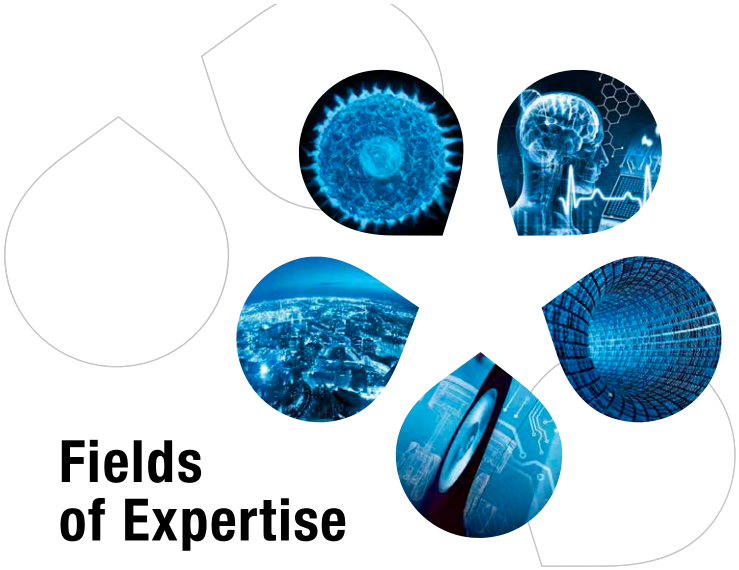
Operation Areas

The IMAT operation areas include academic education, research and cooperation with the industry.
We make important contributions to several undergraduate, graduate and post graduate degree programmes. In research, we focus on materials development, joining, forming, modelling and process simulation, passing on our knowledge in lectures. We cooperate with the industry in applied research and failure case analysis.



Fields of Expertise FoE

IMAT is active in 3 of 5 trend-setting areas in research and teaching, referred to as Fields of Expertise at Graz University of Technology.



- Advanced Materials Science
- Mobility & Production
- Human & Biotechnology

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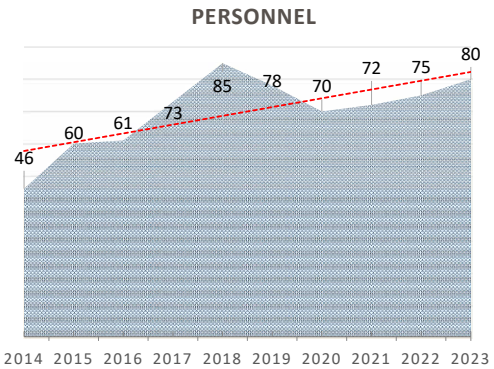
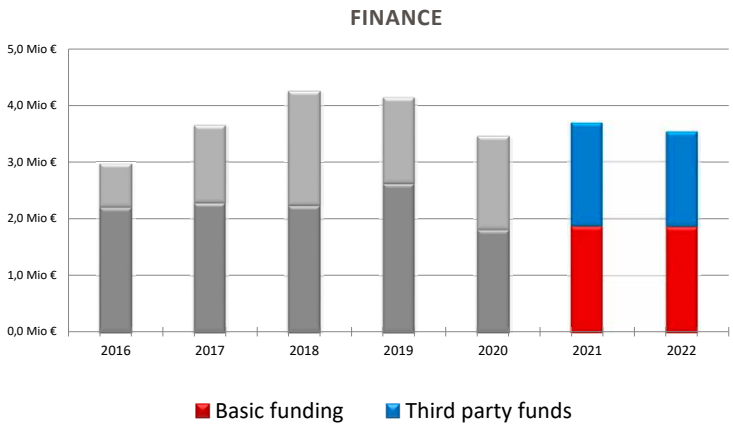
https://www.tugraz.at/en/research/forschungsschwerpunkte-5-fields-of-expertise/overview-fields-of-expertise/

Financial Aspects

IMAT has acquired major external funding for contractual work with industry and government-funded research.
Basic funding was increased by a FFG Endowed Professorship for Aviation and recently by a new tenure track position.



Number of employees



Head of Institute

From left to right: Josef Domitner, Sergio Amancio, Christof Sommitsch, Cecilia Poletti and Norbert Enzinger

Univ.-Prof. Dipl.-Ing. Dr.techn. Priv.-Doz. Christof Sommitsch is full Professor and has been head of the Institute since 2009. He has worked in the steel industry, e.g., Böhler Edelstahl from 1999 to 2004 and served as the deputy head of the Chair of the Metal Forming at the Montanuniversität Leoben until 2009. He was Dean of the Faculty of Mechanical Engineering and Economics Sciences in the period from 2012 to 2015. He has been on the Board of Directors of the Field of Expertise Advanced Materials Science at TU Graz since 2016.
The focus of his research is on materials development of high-strength and high-temperature, as well as electrical steels, and on powder-based metal additive manufacturing and joining and forming of metals. His research has been funded both by industry and the state as well as under European research programs. He has co-authored close to 600 publications on these topics.
https://orcid.org/0000-0002-6854-4851

Assoc.Prof. Dr.techn. Maria Cecilia Poletti studied Chemical Engineering at the Universidad Nacional del Comahue in Argentina. She received her doctorate in 2005 at TU Wien and completed her post-doctorate work. In 2011, she obtained a tenure track position at TU Graz, where she now teaches and researches. Poletti received the Venia Docendi in “Materials Science” in 2012 and has held an Associate Professor position there since 2014.
She researches the development and processing of high-performance alloys using materials models and simulations supported by experimental evidence. Poletti has been the head of the Christian Doppler Laboratory for the design of high-performance alloys by thermomechanical processing since May 2017. Her scientific records are listed here https://orcid.org/0000-0002-4776-920X. Poletti is a member of the DGM, ASMET and SAM Materials societies.

Poletti also gives lectures at the Universidad Nacional del Comahue (ARG), in Recrystallisation Summer schools (France-CNRS) and in the framework of Blended International Lectures (Erasmus+). She is involved in university committees committed to teaching, such as the Senate (deputy head) and the Advanced Materials Science Study Commission (head).

Assoc.Prof. Dipl.-Ing. Dr.techn. Norbert Enzinger has worked at the Institute intermittently since 1996, holding various positions. He habilitated in the area of Welding and Failure Case Analysis and is head of the Joining Group. He is passionate about one-to-one teaching and supervision within application-related research projects. Additionally to materials science, basics in welding, fracture mechanics and failure case analysis are his main teaching activities covering different subjects at the master's level of mechanical engineering and advance materials science at TU Graz.
Beyond teaching activities at TU Graz he was appointed as a visiting professor at Peter the Great St.Petersburg Polytechnic University for "Trends in Welding" in 2019 and for "Welding Metallurgy" at University West in Trollhättan, Sweden in 2020. Numerous publications in international and peer-reviewed journals (https://orcid.org/0000-0003-0051-9518) as well as reviewing activities (https://www.webofscience.com/wos/author/record/1137058) are part of his contribution to the international welding and research community. He is an active member of the International Institute of Welding (IIW) leading subcommission IX-L dealing with weldability of low alloyed steel. In 2023 he was appointed a fellow of IIW.

Univ.-Prof. Dr.-Ing. Sergio de Traglia Amancio Filho has been a full professor for aviation materials and manufacturing techniques at TU Graz since 2018. He was the chair of the 'Austrian Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) Endowed Professorship for Aviation' from 2018 to 2023. The focus of Prof. Amancio's work has been on the correlation between processing, microstructure and material properties with the aim of developing, understanding and optimizing additive manufacturing and joining techniques for lightweight engineering structures. He has a bachelor's degree in Materials Engineering with a specialization in Polymers and a master of science in Metallurgy from the Federal University of São Carlos (Brazil). During his PhD in Materials Science and Joining Technology at Hamburg University of Technology (TU Hamburg), and post-doctoral studies at Helmholtz-Zentrum Geesthacht in Germany, he developed and patented new joining and additive manufacturing techniques for polymer-metal hybrid structures. Before joining TU Graz, Prof. Amancio was a Helmholtz-Young Investigator group leader at Helmholtz-Zentrum Geesthacht and assistant professor for Joining Technology at the Institute of Polymer Composites of Hamburg University of Technology (TU Hamburg, Germany). He has been awarded 22 patents, co-published over 300 technical publications, co-edited the world´s first technical book on joining of metal-polymer structures (John Wiley & Sons Inc., USA, 2018), and more recently a book in metal additive manufacturing (Elsevier-Woodhead Publishing, 2022). Prof. Amancio is a recipient of several national and international awards, including the 'DGM-Prize 2022' German Society for Materials Science (DGM), for his contribution to the materials science of hybrid materials, and the 'Yoshiaki Arata Award 2023' from the International Institute of Welding (IIW) for his career contribution to joining techniques and correlate techniques. He was a Visiting Professor in joining technology at Peter the Great St. Petersburg Polytechnic University, Russia from 2020 to 2021, and is currently Adjunct Professor at Ohio State University, in the Welding Engineering Program of the Department of Materials Engineering and Science. https://orcid.org/0000-0002-1886-1349

Ass.Prof. Priv.-Doz. DDDipl.-Ing. Dr.mont. Josef Domitner studied Mechanical Engineering, Metallurgy, and Industrial Management at the Montanuniversität Leoben. He received his PhD from the Montanuniversität in the field of Modeling and Simulation of Metallurgical Processes in 2014. He gained his first scientific experience as a young researcher at the Materials Center Leoben (MCL) and at the Competence Center of Light Metals Technologies Ranshofen (LKR). He joined the IMAT in 2017 and is head of the Research Group of Lightweight and Forming Technologies (former Tools and Forming group). His main research activities include forming and joining of lightweight materials for transportation applications with a focus on numerical process modelling and hydrogen effects in materials. Moreover, he has spent several months as an invited guest researcher at universities in Sweden, Germany and Slovenia. In 2023 he was habilitated in the research field of Materials Engineering and Lightweight Technologies. https://orcid.org/0000-0002-6023-7216

New tenure track position at IMAT

picture Stefan Fortmüller / IMAT

Dipl.-Ing. Dr.mont. Petra Spörk-Erdely

Petra Spörk-Erdely, born in Graz, Austria, studied materials science at the Montanuniversität Leoben. In 2018, she successfully defended her PhD thesis in the field of intermetallic high-temperature alloys at the Chair of Physical Metallurgy and Metallic Materials, making her the seventh person and first woman at the Montanuniversität to receive their doctorate sub auspiciis Praesidentis. After four years of experience as senior scientist and group leader of the recently established Neutron and X-ray Team (NEXT) in Leoben, Petra Spörk-Erdely joined the Institute of Materials Science, Joining and Forming as a university assistant with doctorate (tenure track) in May 2023.

Petra Spörk-Erdely looks back on more than ten years of experience in the field of diffraction and scattering experiments at large-scale research facilities. In particular, she is specialized in the characterization of advanced materials using synchrotron X-rays, the interpretation of synchrotron data backed by suitable conventional lab-scale techniques, in-situ experiments, and the development and optimisation of materials and manufacturing routes for lightweight construction, high-performance application, and medical technology. Fundamental investigations on phase transformations, microstructure evolution, and materials behaviour under load form the very core of her research. As a junior topic leader for metal-based additive manufacturing (AM) at IMAT, Petra Spörk-Erdely is looking forward to making use of the fundamental discoveries by her group in the development and microstructural design of advanced AM-fabricated materials.

Dr. Petra Spörk-Erdely holds a tenue track position aiming for both, habilitation, and associate professorship at TU Graz. We are very happy having her as a new scientific team member at the institute focusing on additive manufacturing of advanced and smart metals and alloys.

In addition, she will strengthen our research area of high-temperature materials, especially of intermetallics. Her broad and strong experience in diffraction and scattering analyses will help to understand microstructure and its evolution during processing for a variety of advanced lightweight and high-strength materials. *Christof Sommitsch*

Team Status 30.06.2023

emeritus professor
Em.Univ.-Prof. Dipl.-Ing. Dr.mont. Horst H. **Cerjak**

honorary and habilitated Professors
Univ.-Prof. Dipl.-Ing. Dr.techn. Ernst **Kozeschnik**
Hon.-Prof. Dr. Omer **Pasic**
Hon.-Prof. Univ.-Doz. Dipl.-Ing. Dr.techn. Dieter **Vollath**

university assistants
Dipl.-Ing. Siegfried **Arneitz**
Dipl.-Ing. Dr.mont. Andreas **Drexler**
Dipl.-Ing. Lic. Talina **Terrazas Monje**
Dipl.-Ing. Sebastian **Fritsche,** IWE
Arash **Shafiee Sabet**, Fogh-lis. Lis.
Dr.techn. Gean Henrique **Marcatto de Oliveira**

university assistant with doctorate (tenure track)
Dipl.-Ing. Dr.mont. Petra **Spörk-Erdely**

senior scientist
Dr.techn. Fernando Gustavo **Warchomicka**
Dipl.-Ing. Dr.techn. Rudolf **Vallant**, IWE

scientific staff
Hamdi **Ahmed Elsayed**, Bsc. Msc**.**
Awais **Awan**, B.Sc. M.Sc.
Dr.techn. Ricardo Henrique **Buzolin**, Eng. Mestr.
Dipl.-Ing. Marlene **Eichlseder**
Dipl.-Ing. Eva **Graf**
Dipl.-Ing. Stefan **Fortmüller**
Dipl.-Ing. Emir **Hodzic**
Dipl.-Ing. Andreas **Hütter**
Franz **Miller Branco Ferraz**, Eng.
Dipl.-Ing. Matthias **Moschinger**, IWE
Dipl.-Ing. Florian **Pixner**, IWE
Dipl.-Ing. Zahra **Silvayeh**
Saham Sadat **Sharifi**, Fogh-lis.
Esmaeil **Shahryari**
Peng **Wang**, M.Eng.

student project employees
Maialen **Aguirregoicoa Ocerin,** MU Grda
Peter **Auer**, BSc.
Dipl. inz. str. David **Gomboc**
Ing. Michael **Hochrainer**, BSc.
Stefan **Herbst**, BSc.
Karlo **Maček,** dipl. inz.
Markus **Maßwohl**
Lejla **Muratovic**
Felix **Meixner,** BSc.
Helmut **Riedl**
Felix **Schindler**

laboratory staff
Heinz Karl **Fasching**
Ing. Thomas **Friedl**
Leander **Herbitschek**
Ing. Kurt **Kerschbaumer**
Julian **Koch** *(apprentice)*
Nino **Müllner**
Ing. Herbert **Penker**
Ing. Meister Thomas **Staubmann**
Gernot **Stöfan**

secretary / administration
Eva **Keinrath** *(deputy of administration)*
Mag.phil. Isabella **Knollseisen**
Manuela **Prader** *(head of administration)*
MMag.phil. Dr.phil. Bettina **Schreiner-Fößl**
Claudia **Schwinzerl**
Sandra **Wesener**

tutors
Fabian **Bobner**
Simon **Elmiger,** Bsc.
Max Philip **Friedrich**
Michael **Hochrainer**, BSc. Ing.
Lisa **Minkowitz,** BSc.
Lejla **Muratovic**
Lena **Neidhart**, BSc.
Igor **Puljarevic**
Daniel **Radowski**, BSc.
Helmut **Riedl**
Jennifer **Stippich,** Bakk.rer.soc.oec.
Tobias **Walder**

External Lecturer (academic years 21/22 - 22/23)

Dipl.-Ing. Dr. Lambert **Bösch**	Non-destructive Testing Methods
Dipl,-Ing. Helmut **Brunner**	Materials and Environment
Dipl.-Ing. Philipp Emanuel **Brunner**	Basic Laboratory for Advanced Materials Science
Dipl.-Ing. Dr.techn. Peter **Brunnhofer**	Materials Science Laboratory
Dipl.-Ing. Christoph **Derler**	Design and Calculation of Welded Structures
Assoc.Prof. Dipl.-Chem. Dr.rer.nat Berhard **Gollas**	Basic Laboratory for Advanced Materials Science
Univ.-Prof. Ph.D. Peter **Hadley**	Materials Production and Processing
Dr.-Ing. Matthias **Harsch**	Economic and Ecological Technology Management
Assoc.Prof. Dipl.-Ing. Dr.techn. Mario **Hirz**	Materials and the Environment
Prof. Dipl.-Ing. Dr.mont. Thomas **Karall**	Plastics and Composites in Mechanical Engineering
Ass.Prof. Dipl.-Ing. Dr.techn. Markus **Kettler**	Design and Calculation of Welded Structures
Dipl.-Ing. Dr.techn. Siegfried **Kleber**	Materials Technology of Steels / Steels for Advanced Materials Science
Mag.rer.nat. Martin **Klein**	Materials Technology of Steels / Steels for Advanced Materials Science
Ao.Univ.-Prof. Dr. Joachim **Krenn**	Basic Laboratory for Advanced Materials Science
Dipl.-Ing. Dr.mont. Friedrich **Krumphals**	Materials Technology 1 (Powder Metallurgy) Basic Laboratory for Advanced Materials Science
Dipl.-Ing. Dr.techn. Ernst **Letofsky**	Special Welding Processes / Welding of Non-ferrous Metals and Plastics
Dipl.-Ing. Udo **Pappler**	Plastics and Composites in Mechanical Engineering
Dipl.-Ing. Dr.techn. Rainer **Prader**	Quality Assurance in Welding Technology / Applied Welding Technology
Dipl.-Ing. Dr.techn. Gerhard **Posch**	Welding Processes
Ao.Univ.-Prof. Dipl.-Ing. Dr.techn. Klaus **Reichmann**	Materials Production and Processing / Basic Laboratory for Advanced Materials Science
Assoc.Prof. Dipl.-Phys. Dr.rer.nat. Wolfgang **Sprengel**	Materials and the Environment
Dipl.-Ing. Dr.techn. Markus **Stütz**, IWE	Design and Calculation of Welded Structures
Univ.-Prof. Dipl.-Ing. Dr.techn. Bernhard **Sonderegger**	Introduction to Modelling and Simulation / Modelling and Simulation for Advanced Materials Science / Modelling and Simulation in the Production Technology
Univ.-Prof. Dipl.-Ing. Dr.techn. Gregor **Trimmel**	High-performance Materials and Composites
Univ.-Prof. Dipl.-Ing. Dr.techn. Harald **Unterweger**	Design and Calculation of Welded structures
Dipl.-Ing. Dr.techn. Thomas **Weinberger**	Welding Processes
Dipl.-Ing. Dr.techn. Wolfgang **Weiß**	Process Simulation of Manufacturing Technologies
Dipl.-Ing. Peter **Zaucher**	Plastics and Composites in Mechanical Engineering

Former Employees 2021 - 2023

In the period under report the following people have left the institute. *(period employee until *)*

Visiting professor

Dr. Silvana Andrea **Sommadossi** **November 2021*
Dr. Fernando Diego **Carazo** **November 2022*

Scientific staff

Dr. Mohammad **Ahmadi** **December 2021*
Fatemeh **Iranshahi**, Fogh-lis. Lis. **October 2021*
Mohammad Bager **Nasiri**, Fogh-lis.**October 2021*
Dipl.-Ing. Christian **Hoflehner** **August 2021*
Dipl.-Ing. Jakob **Hinum-Wagner** **July 2021*
Dipl.-Ing. Dr. techn. Pedro **Effertz** **August 2022*
Carlos **Belei**, MSc. **July 2022*
Dipl.-Ing. Maxim **Honea** **June 2022*
Wilian **Carvalho**, MSc. **December 2022*
Rafael **Paiotti**, MSc. **Nov 2022*
Dipl.-Ing. Mirjam **Spuller** *September 2022*
Dipl.-Ing. Bernhard **Fercher** **May 2023*
Dipl.-Ing. Florian **Riedlsperger** **June 2022*
Dr. Gerold **Zuderstorfer** **June 2022*
Dipl.-Ing. Clemens **Jechtl** **February 2022*
Dipl.-Ing. Simon **Schönegger** **June 2023*
Dipl.-Ing. Kasyap **Pradeep** **December 2021*
Dipl.-Ing. Rene **Wang** **October 2021*

Apprentice

Chayenne **Robol** **January 2023*

Student project employees

Francesco **Marzemin** **August 2021*
Marius **Müller** **December 2021*
Besim **Helic** **June 2022*
Maria-Ilinca **Badulescu** **July 2022*
Julian **Sonderegger** **December 2022*
Lisa **Minkowitz** **May 2023*
Thomas **Mayr** **January 2023*
Patrick **Neubauer** **December 2021*
Mehran **Abdi** **January 2022*

Technical staff

Wolfgang **Steinbäck** **August 2022*
Alexander **Vujic** **December 2022*

Tutors

Robin **Aydinonat** **June 2022*
Marius **Müller** **June 2021*
Alexander **Lattner** **June 2021*
Laurenz **Hartmann** **June 2021*
Hesam **Estilaei**, Karsh. **January 2023*

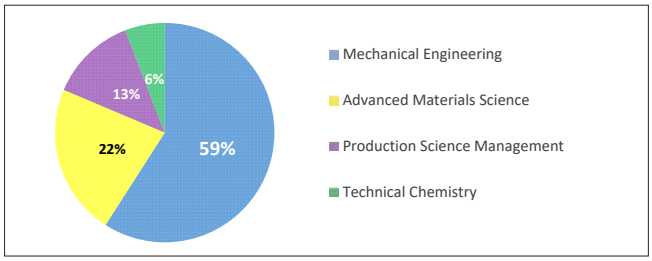
Academic Education

Teaching

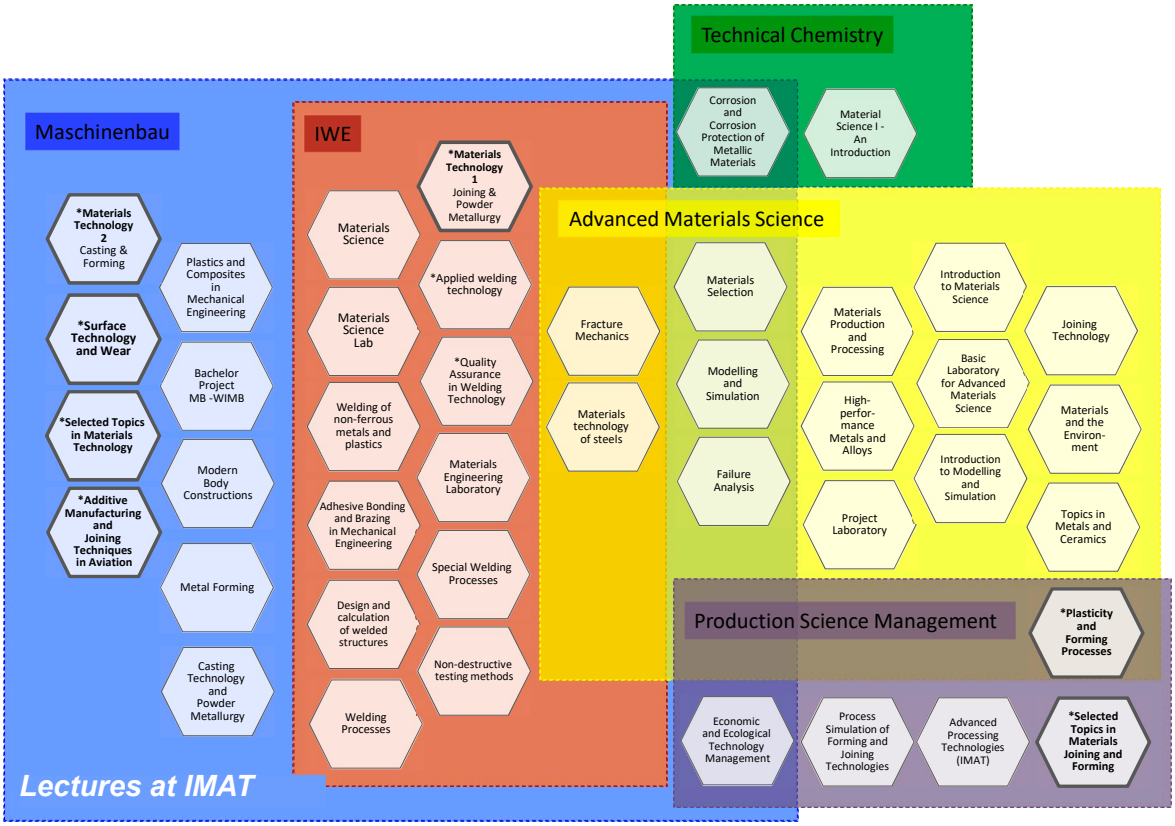
Teaching is one of the most important tasks of a university and therefore makes up a significant share of the institute's duties. Currently, **23** university staff members and **17** external experts teach **69** different bachelor's, master's and PhD's lectures at IMAT.

In the academic year 2022/23, there were approximately **470** registrations for bachelor's degree courses, **730** for master's degree courses and **50** for doctoral degree courses at IMAT.

In the bachelor's degree progamme Mechanical Engineering and Business Economics and in the master's degree programme Advanced Materials Science and Technical Chemistry, the lectures about fundamentals of ***Materials Science*** are compulsory. A total of around **330** students attended this course last year. In the bachelor's degree programme, the course is supplemented with a ***Laboratory Course.*** A fixed number of students can take laboratory courses at IMAT each semester. Almost **140** students attended a laboratory tutorial class in the academic year 2022/23.



Percentage distribution of master's degree students at IMAT in the academic year 2022/23



Special Letures

Blended Lectures - BIP

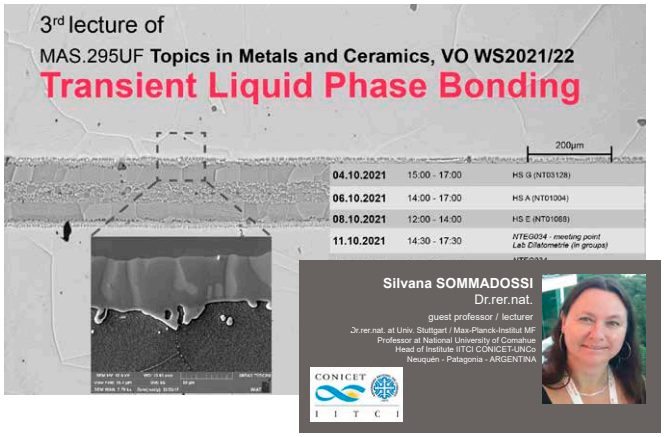
In the summer semester of 2023, we gave the lecture **Fundamentals and Practice of Sheet Metal Tool Design“** in the framework of the Blended Intensive Program (BIP). Together with universities from four countries, around 25 students learnt the fundamentals of Plasticity, Tool Design and Sheet Metal Forming online. They spent one week on-site at John von Neumann University (H) for practical work and excursions. The universities that participated in this international lecture were TU Graz (A), University of Slavonski Brod (HR), Sapientia Hungarian University of Transylvania (RO) and the coordinator John von Neumann University (H).
For more information: https://ijat.hu/eng/education/bip

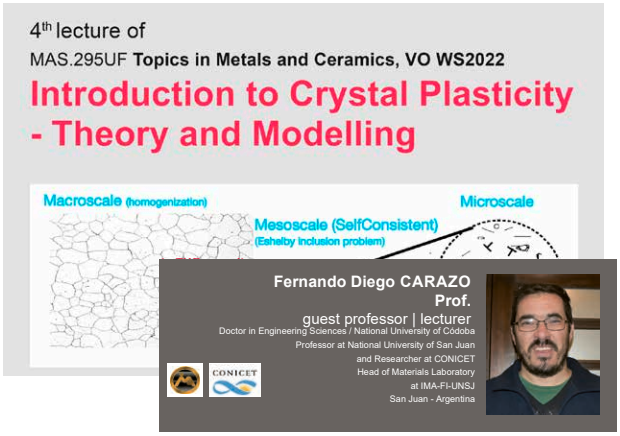
Topics in Metals and Ceramics

Two specific topics from the elective lecture "Topics in Metals and Ceramics" from the Advancecd Material Science curriculum were held in the reporting period.

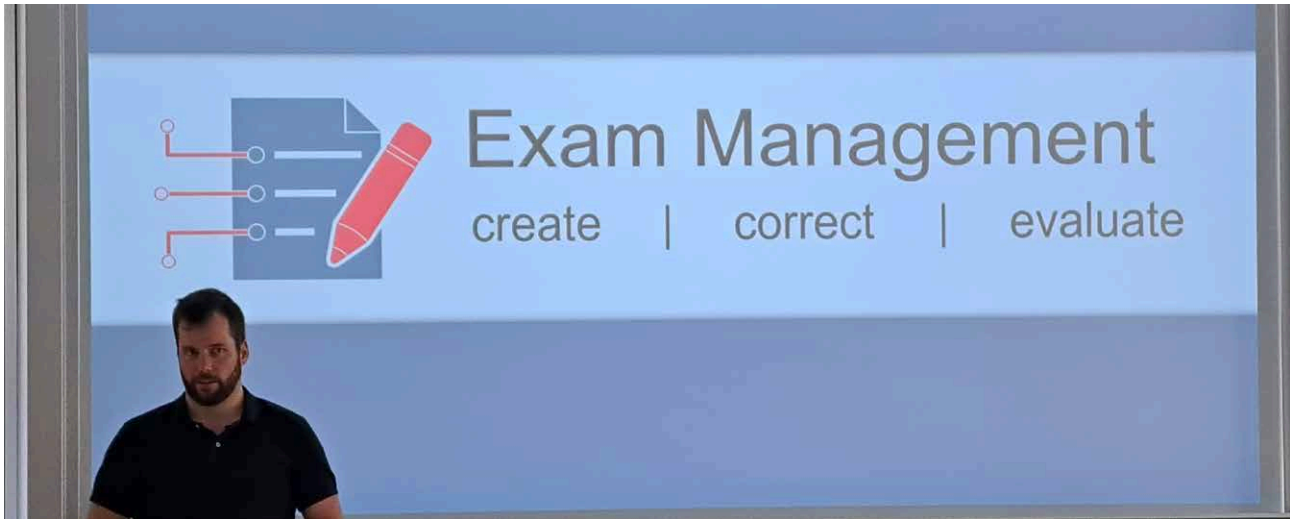
+ Topics in Metals and Ceramics: Transient Liquid Phase Bonding in winter 2021 by Prof. Dr. Silvana Sommadossi, visiting professor from Comahue University, Argentina. This course aims for students to apply general knowledge in Materials Science and Engineering to understand the TLPB technological process. The lecture consisted of a theoretical part that considered the thermodynamic and diffusive aspects of the phase transformations in the metallurgical bond zone and a practical part where students built and analysed their own bonds. PhD and master's students received the lecture with enthusiasm.

+ Topics in Metals and Ceramics: Introduction to Crystal Plasticity - Theory and Modelling in winter term 2022 by Prof. Fernando Diego Carazo, visiting professor from the University of San Juan, Argentina. The lecture familiarised the students with crystal plasticity tools, continuum mechanics and finite element simulations. The courses taught by Prof. Carazo were very well received by master's and doctoral students. Prof. Carazo presented the theoretical framework of plasticity and implemented these concepts in practical examples.





TEL Pilot project – Exam Management

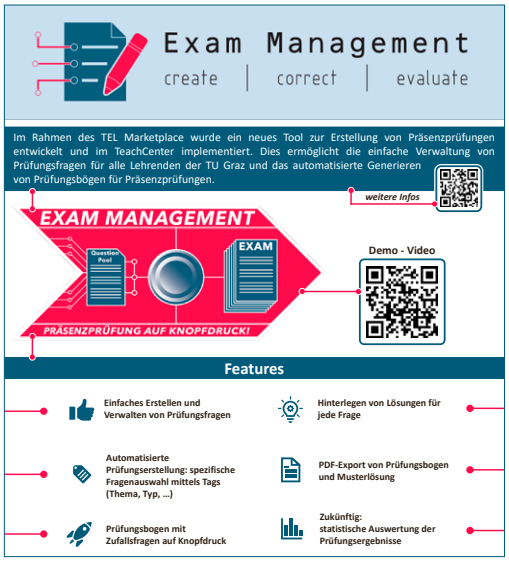


Sebastian Fritsche presented the results of the project at the f2f Marketplace event .

Checking exam attendance at the push of a button

After one and a half years of development, the time had come. At TU Graz, as part of the Technology Enhanced Learning Marketplace – or TEL for short – we have developed a new tool "Exam Printer" for creating in-person examinations in cooperation with the Institute for Machine Elements and Development Methodology, the Institute of Innovation and Industrial Management and the organisational unit Educational Technology. On September 13, 2023 we were able to present the project at the f2f Marketplace 2023. Lecturers at Graz University of Technology can now easily manage their exam questions in the TeachCenter (Moodle 4.1) and automatically generate exam sheets for in-person examinations.

► DEMO-video | E-Poster | Digitale TU Graz Marketplace



This has the following advantages:

- Easily create and manage exam questions for your course in the TeachCenter.
- Use tags to automatically create exam sheets according to specific requirements (level of difficulty, question type, etc.).
- Create an exam just once, then generate EXAM SHEET WITH RANDOM QUESTIONS AT THE PRESS OF A BUTTON for each exam date.
- Record solutions for every question and export sample solutions as PDF files.

The ProjectTEAM:
IMAT: Sebastian Fritsche, Norbert Enzinger, Daniel Radowski
IME: Stefan Kollegger, Michael Bader, Emre Enis Ketan
IIM: Matthias Wolf
LLT: Maria Haas, Josef Wachtler

LIFE LONG LEARNING at TU Graz

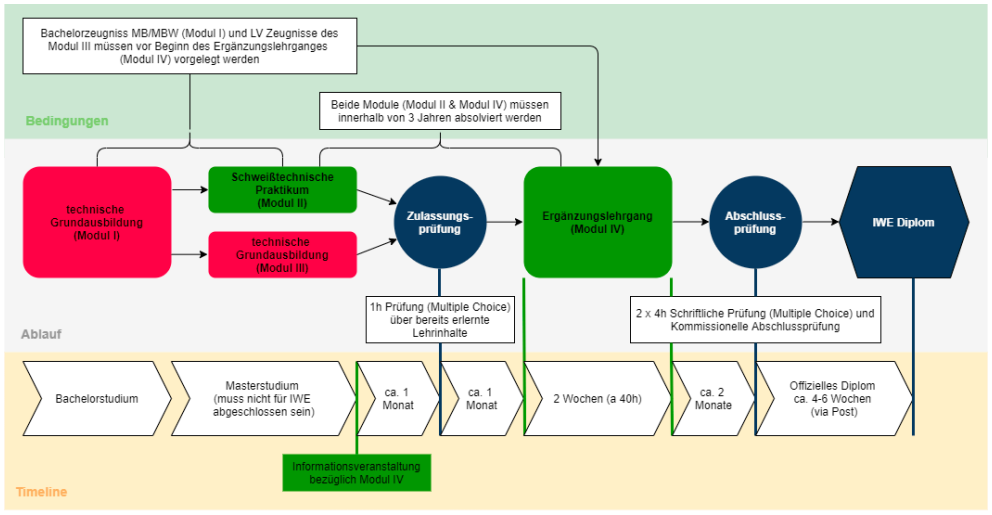
IWE - International Welding Engineer

© Lunghammer - TU Graz

For more than twenty years now, the IWE has been offered at IMAT as an additional qualification for students of mechanical engineering. This not only expands knowledge in the field of welding technology but also qualifies these students to supervise and monitor welding management in industrial companies. This diploma offers a great benefit for both students and industry as the IWE is required in many areas of welding.

To guarantee the quality of such an education, it is necessary to constantly compare the required teaching content with the lectures held by the Institute. Here we work closely with the SZA as well as with the WIFI Styria.

In recent years, the training has been evaluated and adapted to new requirements. In 2023 an entrance examination for the final supplementary course was introduced. This apparent extra effort is not only intended to review knowledge, it also serves to repeat the subject-specific basics learned so far. These can then be discussed in detail and supplemented in the subsequent supplementary course with practicing IWEs in industry. The current IWE training can be found below:



IWE - training overview

ESP - Elite Student Programme

new ESP students 2022/2023 (in the left picture from left to right): Lukas Perz and Max Friedrich

ESP students 2021/2022 (in the right picture from left to right):
Stefan Lintner, Robin Aydinonant, Markus Maßwohl, Markus Schneidhofer and Richard Oberkofler

There is a great demand faced by all academic institutions to attract the best students to collaborate in research projects. As a consequence, the ESP – IMAT Elite Student Programme for Materials Science, Joining and Forming has been running very successfully since the academic year 2016/17 with the aim of enabling high-potential students to take part in this interesting programme.
The programme was developed mainly for students of the bachelor's and master's degree programmes in Mechanical Engineering, Mechanical Engineering-Economic Sciences, Production Science and Management as well as Advanced Materials Science. They are required to have passed the exams in Materials Science, the laboratory Materials Science, or the exam Introduction to Materials Science as well as the integrative laboratory with very good grades. Furthermore, our elite students need to have a specific talent and enthusiasm for Materials Science and Technology, Joining and Forming.
Thirty students have already participated in this programme and actively contributed to the Institute's research activities.

Admission to the ESP gave me the opportunity to get very good insights into the Institute of Materials Science, Joining and Forming, as I was able to work as a project assistant and write my bachelor's thesis in the field of joining technologies for hybrid materials. This experience sparked my interest in gaining further knowledge in materials science, and when Prof. Amancio offered me the chance to go to Canada to conduct research not only for a semester but for a whole year and write a paper, and my master's thesis, I immediately said yes. ...

Stefan Herbst, ESP student since 2020

ESP students receiving their awards at the annual IMAT Christmas party. In the picture ESP student Stefan Herbst with Josef Domitner and Christof Sommitsch, 2021

Exchange - Short report



by Stefan Herbst

... Working together with Prof. Sergio Amancio and Dr. Philip Bates at the **Royal Military College of Canada in Kingston** was the perfect chance for me to gain initial experiences of scientific research within materials science. Not only do I hope that this paper will be great for my future career, but also that it will be the foundation of future cooperations between TU-Graz and the RMC.

The scope of this research was to gain a fundamental understanding of the vibration welding process for automotive applications. This process is used to join various polymer-based parts of modern-day cars. The results of this welding process are well known and were often reported by various researchers including Dr. Bates. However, there was a knowledge gap with regard to a process step that is vital for many applications that needed to be closed. Since hardly any research focused on the first period of the welding process, we took this as an opportunity and started our investigations. Since this research was focusing on automotive suppliers and applications, injection molding grade polypropylene was used for all the parts. All steps necessary for the whole investigation were made in-house at the RMC. The goal was to understand the joining behavior and the ongoing mechanisms between the two parts during the first fraction of a second. Analyzing various parameter combinations, geometries, welding directions and materials gave us the results we hoped for. In addition, I had the opportunity to operate and analyze my samples with the RMC's equipment and even their SEM. Since all the investigations are concluded, the next step will be to publish an article and finalize my thesis "Quantitative fibril and debris analysis of vibration welded thermoplastics for automotive applications".

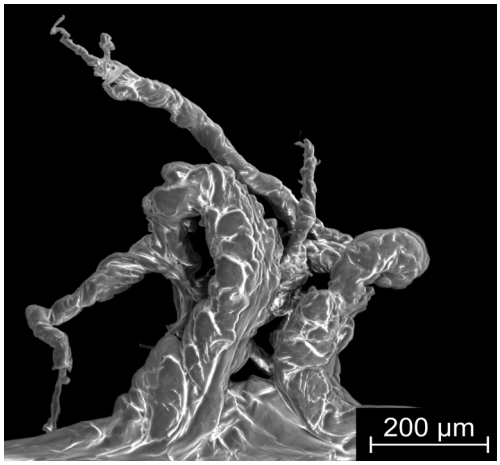


Figure: SEM image of unreinforced PP fibril

However, it is important to point out that not only the academic part was of great importance to me, but also immersing myself into the Canadian culture and lifestyle. Throughout this whole year I met so many great people, got to know their way of living and saw so many beautiful places around Canada. The big contrast between the astonishing Rocky Mountains with its magnificent mountains and the Grasslands National Park with its wild bison will definitely be remembered. Summing up my experience I can only say that I am so thankful that I got the opportunity to live in such a great country for a year. This experience will definitely be the perfect base for my future work in materials science.

Master's theses

in progress

Basta Michael (483) Hot Deformation Behaviour of Metastable Beta Ti12Mo

Elmiger Simon (445) Drahtbasierte additive Fertigung von NiBas Inconel mit Elektronenstrahl

Ferrari Ruben (445) Realisation and Validation of Additively Manufactured Sensor and Thermal Management Components for Advanced Automotive Measurement Solutions

Görges Sven (445) Influence of the additive manufacturing process on the mechanical properties of Ti-6Al-4V

Grünwalder Leonhard Georg (511) Investigation of Hydrogen Induced Cracking (HIC) of austenitic and ferritic steels by in-situ H-loading during Slow Strain Rate Tests

Gsodam Fabian (511) Dynamic recrystallization of AISI 304L during hot Plastic deformation

Herbst Stefan (482) Quantitative fibril and debris analysis of vibration welded thermoplastics for automotive applications

Jaritz Paul (445) Untersuchung des Verschleißverhaltens beim Refill FSSW Prozess

Maier Stefan (511) Correlation between prior austenite grain size and martensitic substructure size in a low-carbon steel

Martins Gomes Felipe (483) Thermomechanical welding of S 700 MC

Minkowitz Lisa (445) Additive Fertigung einer Kollektorelektrode für ein ionenwindangetriebenes Flugobjekt in Leichtbauweise

Mohamed Ahmed Sobhy Abdelhady (483) Multiphysics Simulation of High-Performance Type 6 Hydrogen Direct Injection Engines Piston using Additive Manufacturing

Patrick Neubauer (445) Konstruktiver Entwurf eines Prüfaufbaus für die Ermittlung von Reibungskoeffizienten

Platzer Alexander (482) Commissioning the prototype of a dual-gate hot runner system for thixomolding of magnesium alloys

Prutej Sebastian (482) Optimierung der zeitlichen Anfahrtverluste einer Rohrschweißanlage

Reinbacher Stefan (445) Additive Fertigung von Al-Cu-Si mittels Zweidraht-Plasmaschweißen

Shahryari Esmaeil (511) Improvement of predictability of hot deformation models of alloys

Schlögl Christoph (491) Pickling behavior of high strenght steel grades

Schindler Felix (445) Dissimilar RFSSW Joints of wrought Aluminium to Copper

Schneeberger Patrick (445) Experimentelle Analyse des Verschleißverhaltens ausgewählter Walze-Rohr-Werkstoffkombinationen in der Schrägwalzenrichtmaschine

Thoralf Horst Maria (511) Recrystallization and grain growth behavior of S700MC

Vujic Aleksandar (491) Analysis of H uptake during galvanic coating of timer screws and evaluation on the mechanical behaviour

Walder Tobias (482) H-Versprödung hochfester Stahl-Verbindungselemente für den Motorenbau. Kurzzeittests auf Anfälligkeit gegenüber H-Versprödung / Konstruktion, Fertigung und Aufbau einer elektrochemischen Prüfzelle für die H-Beladung während des Zugversuches

List of all completed Master's theses at IMAT

2023

Estilaei Hesam (445) Modeling the effect of elastoplastic material behavior on the thermomechanical wear of rolls

Gruber Thomas (445) Elektronenstrahlschweißen im Schienenfahrzeugbau

Helic Besim (483) The influence of forming on the hydrogen uptake and the hydrogen embrittlement susceptibility **of indus-**trial dual phase steels

Mayr Thomas (511) Influences of the welding position in plasma-based additive manufacturing

Rauchdobler Bettina (511) The Effect of Heat Treatments on the Transformation Temperature and Superelastic Response of Ni-rich NiTi Parts Manufactured by Electron Beam Freeform Fabrication

Schönegger Simon (445) Erstellung eines Simulationsmodelles für das PWAAM an Eisenbahnrädern

Todorovic Srdjan (445) Untersuchung der statischen Belastbarkeit einer Aluminium-Holzfurnier-Schraubverbindung bei unterschiedlichen Lastrichtungen

2022

Abdi Mehran (445) Numerical study of interfacial instability driven by magnetohydrodynamic forces in aluminium reduction cells

Barišić Luka (483) Improving the wire feed system implemented in the electron beam welding machine

Eichlseder Marlene (511) Influence of Cu content on the corrosion behaviour of AlSiMgCuX alloys

Graf Eva Maria (511) On the printability and superelasticity of NiTi shape memory alloys fabricated by laser powder bed fusion with Ni-rich elementally blended powder

Hartbauer Nikolas (482) Additive Manufacturing-enabled Embedding of Optical Fibers for an Advanced Automotive Fuel Cell Measurement Device

Hussein Omar (511) Rotary Friction Welding of a S700MC steel pipe to a S420MC steel plate

Khaled Hassan Aly Mohamed, Mohamed (483) Laser powder bed fusion and U-Joining parameters optimization for additively manufactured Ti-6Al-4V/PEEK-20CF hybrid joints

Marzemin Francesco (511) Optimization of fused filament fabrication process parameters for 20% short-carbon-fiber reinforced poly-ether-ether-ketone

Patil Samiksha Jagannath (483) Modelling of texture evolution during deformation of aluminum alloys using the VPSC method

Ralon-Rosales Felipe (511) Material Compatibility Analysis of 316L, AlSi10Mg, AW 6063 and CuAl10Fe5Ni5 alloys in PEM Fuel Cell System Application

Sinha Ankit (483) Methoden zur Systemspezifikation - Entwicklung automatisierter Systeme (Grundlagen, Normen, Anwendungen - Schwerpunkt Intralogistik)

Szałowski Bartłomiej Konrad (483) Effect of Thermomechanical Welding on the Austenitic Stainless Steel

Terrazas Monje Talina (511) Topology optimization of additively manufactured 316L stainless steel connectors for ultrasonic joining

2021

Breitenberger Lukas (445) Fügen von artfremden, dickwandigen Zylindern mittels EBW

Deutsch Christian (482) Bestimmung von temperaturabhängigen mechanischen Kennwerten an CuSn20

Fink Stefan (482) Untersuchung zur Wasserstoffversprödung von Gasrohrleitungen

Jechtl Clemens (482) Numerical Simulations of Wire-Based Additive Manufacturing

Puđa Marko (483) Comparison of MAG vs. CMT in Wire Arc Additive Manufacturing (WAAM)

Reiter Markus (483) Sensor Embedding in Additively Manufactured Metal Components for Innovative Automotive Instrumentation and Test Systems

Zubčák Martin (511) Investigation of Al-B4C metal matrix composites (MMCs) produced by Friction Stir Additive Processing (FSAP)

434, 511 Master programme: Advanced Materials Science
445 Master programme: Mechanical Engineering
461 Master programme: Technical Physics
482 Master programme: Mechanical Engineering and Business Economics
483 Master programme: Production Science and Management

Bachelor's theses

in progress

Baumgartner Niklas Charakterisierung von LTT- Schweißzusatzmaterial für die additive Fertigung

Ber Matthias Nachhaltigkeit von Fügeprozessen

Crnovčić Danijela Untersuchung der AA6082 Legierung nach thermomechanischen Behandlungen

Gruber Andreas Einfluss des induktiven Richtens auf die Eigenschaften hochfester Stähle

Hochrainer Michael Verschleißtests von verschiedenen Schweißzusatzmaterialien

Knogler David Finite Element-Methode (FEM), Simulation der thermomechanischen Behandlung von AA 6082 durch direkte Widerstandserwärmung

Lintner Stefan Optimierung einer AA5024 Legierung durch in-situ Legieren für Anwendung in L-PBF Verfahren für die Luftfahrt

Pierer Stefan Warmverformung der metastabilen Beta Titanlegierung Ti18Mo in ß-Bereich

Pirhofer Fabian Analyse des Richtprozesses

Riedl Helmut Vergleich verschiedener Punktschweißverfahren zum Schweißen von Aluminiumlegierungen

Scholte van Mast Philip Zerstörungsfreie Untersuchung von historischen Hakenbüchsen

Sonderegger Julian Untersuchungen zum anisotropen Drucken in einer magnetischen Fe-Cr-Co Legierung

Vallazza Mathias Mechanische Charakterisierung von Schweißzusätzen für die additive Fertigung

Widlroither Florian Metallographische Untersuchung von historischen Hakenbüchsen

Witzlinger Georg Prozessentwicklung für Feststoffraketenantriebe

2023

Kerschenbauer Elias Feasibility of mechanical testing in porcine vocal folds

Maßwohl Markus Thermomechanische Untersuchung einer nickelbasierten Hochentropielegierung

Suppan Patrick Experimentelle Analyse der Steifigkeit und Festigkeit eines Carbon Monocoques

Trzesniowski Markus Implementierung eines 3D-Scanners für die Additive Fertigung

2022

Costantini Sara Metallographische Analyse von niedriglegierten Titanwerkstoffen zum Nachweis von Ti-Hydriden nach potentiostatischen Korrosionstests

Markovic Srdjan Halbhohlstanznieten von Stahl-Polymer- Sandwichblechen für Leichtbauanwendungen

Preissegger Benedikt Mechanical interlocking investigation of double-sided selfe pierce Riveting using Finite Element Analysis

Radowksi Daniel ZTU Diagramm eines Schweißzusatzes für die additive Fertigung

Schindler Felix Werkzeugverschleiß beim Rührreibpunktschweißen von Aluminium

Storr Julian Stefan Geometry investigation and its influence on the mechanical interlocking of double-sided self pierce Riveting (DSSPR)

2021

Herbst Stefan Ernst Topology optimization and characterization of 316L lattice structures by laser powder bed fusion for U-Joining application

Platzer Alexander Entwicklung eines Mehrfach-Heißkanalsystems für Thixomolding-Maschinen

Walder Tobias Planung, Konstruktion, Fertigung und Installation einer Korrosionsprüfzelle (KPZ) für Zugprüfmaschinen PSA und RMC zur Durchführung von CLT, SSRT und ISLT

PhD candidates

in progress

Arneitz Siegfried, Additive Manufacturing of magnetic materials: Influence of printing conditions on the magnetic properties of FeCrCo, an anisotropic Fe-Co α1-phase based magnetic material
Supervisor: Christof Sommitsch

Avbar Matija, Materialmodifikationen mit kohlenstoffbasierten Additiven
Supervisor: Sergio Amancio

Awan Awais, Ultrasonic Joining of Wood-(Polymer/Metal) for Lightweight Hybrid Structures
Supervisor: Sergio Amancio

Bakhtiari Saeid, Thermomechanical modeling of hot ductility during continuous casting of low alloy steels
Supervisor: Christof Sommitsch

Batistao Bruna Fernanda (Cotutelle PhD), Surface functionalization of the AA2017 aluminum alloy powder for use in Additive Manufacturing
Supervisor: Sergio Amancio

Belei Feliciano Carlos Alberto, Additive Manufacturing of Metal/Polymer Hybrid Structures
Supervisor: Sergio Amancio

Boskovic Vladimir, Difficulties during cold forming of AHSS parts in the automotive industry
Supervisor: Christof Sommitsch

David Daniel, Legierungsentwicklung eines lufthärtenden Schmiedestahls auf der Basis eines MedMn-Stahls
Supervisor: Christof Sommitsch

Davoodi Jooneghani Hamed, Modeling of fatigue crack growth in severely deformed pearlitic steel
Supervisor: Cecilia Poletti

Eichlseder Marlene, Additive manufacturing of porous metallic structures for catalytic applications
Supervisor: Christof Sommitsch

Fercher Bernhard, Development and Optimization of Welded Joints of Damage-tolerant Aluminium Alloys for Aerospace Applications.
Supervisor: Sergio Amancio

Fortmüller Stefan, Influence of Cu on the corrosion resistance and mechanical performance of Al-cast alloys
Supervisor: Cecilia Poletti

Fritsche Sebastian, Welding of additive manufactured metals to wrought alloys
Supervisor: Sergio Amancio

Giedenbacher Jochen, Einfluss der Prozessparameter auf Verarbeitbarkeit von Pulverwerkstoffen mit höherem Kohlenstoffgehalt (C>0,3%) mittels Laserschmelzen
Supervisor: Christof Sommitsch

Godavarthy Anantha Venkata Ranganada Kasyap Pradeep, Creep resistance optimization of Ni-based alloys
Supervisor: Cecilia Poletti

Graf Eva Maria, On the formability of wood-based hybrid components and their virtual description by Finite Element Analysis for potential use cases in the mobility and mechanical engineering sector
Supervisor: Christof Sommitsch

Hinterer Andreas, Thermisches Fügen von metallischen Mischverbindungen mit Hilfe von atmosphärischen Plasmaspritzschichten
Supervisor: Norbert Enzinger

Hodzic Emir, Experimentelle und numerische Untersuchung der Tiefziehbarkeit neuer Aluminiumlegierungen
Supervisor: Christof Sommitsch

Kresser Simona, Optimierungsansätze für N-legierte martensitische Stähle
Supervisor: Christof Sommitsch

Paiotti Marcondes Guimaraes Rafael, 4D printing of Shape Memory Alloys
Supervisor: Sergio Amancio

Pixner Florian, Wire based Additive Manufacturing of tool components
Supervisor: Norbert Enzinger

Putz Andrea, Entwicklung eines Duplex-Fülldrahtes
Supervisor: Norbert Enzinger

Martins Freitas Brenda Juliet (Cotutelle PhD), Microstructure, corrosion and wear resistance of a boron-modified duplex stainless steel produced by LPBF
Supervisor: Sergio Amancio

Meier Benjamin, Strukturoptimierte additiv gefertigte Leichtbaustrukturen aus Titanlegierungen
Supervisor: Christof Sommitsch

Miller Branco Ferraz Franz, Thermomechanical processing of titanium alloys
Supervisor: Cecilia Poletti

Mehic Bakir, Entwicklung additiv gefertigter aktiver Tiefziehwerkzeuge für den Einsatz im mehrstufigen Tiefziehprozess
Supervisor: Christof Sommitsch

Moschinger Matthias, PWAM of train wheels in overhead position
Supervisor: Norbert Enzinger

Neundlinger Lukas, Next Generation E-mobility Grades
Supervisor: Christof Sommitsch

Oberlercher Hannes, Experimentelle und modellhafte Betrachtung eines Konsolidierungsprozesses in der additiven Fertigungstechnik von Endlosfaserverbundbauteilen mit Polyamid-6 (PA-6) Matrix
Supervisor: Sergio Amancio

Rieger Martin, Betriebsfestigkeitsauslegung beim Leichtbau von Fahrwerkskomponenten für Schienenfahrzeuge
Supervisor: Norbert Enzinger

Rojas Arias Nicolas (Cotutelle PhD), Tailoring the composition of AA2017 aluminum alloy to reduce cracking susceptibility during selective laser melting
Supervisor: Sergio Amancio

Silvayeh Zahra, Joining of steel and aluminium alloys for multi-material car body design
Supervisor: Christof Sommitsch

Sales de Carvalho Willian, Ultrasonic joining of additively manufactured composite-metal hybrid parts
Supervisor: Sergio Amancio

Shahryari Esmaeil, Thermomechanical processing of metastable beta Ti-xMo (x=12,15,18) alloys
Supervisor: Cecilia Poletti

Shafiee Sabet Arash, Tribology in Aluminium Sheet Forming
Supervisor: Christof Sommitsch

Sharifi Saham Sadat, Crystal plasticity and mesoscale models to describe plastic deformation of metallic materials
Supervisor: Cecilia Poletti

Silmbroth Mathias, Modifikation von Aluminiumbauteilen durch Wire Arc Additive Manufacturing
Supervisor: Norbert Enzinger

Stummer Maximilian, Enabling dissimilar joints by use of plasma interlayers
Supervisor: Norbert Enzinger

Terrazas Monje Talina, Thermomechanical treatment of AA6082 aluminium alloy
Supervisor: Cecilia Poletti

Wallner Matthias, Entwicklung von 3. Generation AHSS-Stählen für den Feuerverzinkungs- und Galvannealingprozess
Supervisor: Christof Sommitsch

Wang Peng, Flow instabilities and flow localization in alloys
Supervisor: Cecilia Poletti

Wang Rene, Heat treatments of Al-Si alloys and mechanical response
Supervisor: Cecilia Poletti

Weingrill Leonhard Andreas, Hochleistungsschweißen von Schienen
Supervisor: Norbert Enzinger

Wild Norbert, Einfluss der Prozessparameter auf die Werkstoffeigenschaften von mittels Laser-Auftragschweißen gefertigten Warmarbeitsstählen
Supervisor: Christof Sommitsch

The following candidates received a PhD in technical sciences (Dr.techn.) between 2021 and 2023

Christian Hoflehner

Dipl.-Ing. Dr.techn. Christian Hoflehner
Investigation of second ductility minimum of continuously cast micro alloyed steels.

Supervisor: Christof Sommitsch
Reviewer: Christian Bernhard (MUL - Montanuniversität Leoben)
10.09.2021

Fatemeh Iranshahi

Dr.techn. Fatemeh Iranshahi
Microstructure Modification in Biocompatible Magnesium Alloys to Control the Degradation Rate.

Supervisor: Christof Sommitsch
Reviewer: Silvia Spriano (Politecnico di Torino)
06.07.2022
Graduation with distinction

Simone Kaar

Dipl.-Ing. Dr.techn. Simone Kaar
Influence of Q&P processing on the microstructural evolution and mechanical properties of lean medium Mn steels.

Supervisor: Christof Sommitsch
Reviewer: Ronald Schnitzer (MUL)
10.02.2022
Graduation with distinction

Florian Riedlsperger

Dipl.-Ing. Dr.techn. Florian Kerem Riedlsperger
Microstructurally based creep modelling of selected martensic Cr-steels and Ni-based alloys.

Supervisor: Bernhard Sonderegger
Reviewer: Ernst Kozeschnik (TU Wien)
14.10.2022
Graduation with distinction

Marina Melo Gontijo

Dr.techn. Marina Melo Gontijo
Hot Ductility Behavior of Continuously Cast Microalloyed Steels

Supervisor: Christof Sommitsch
Reviewer: Christian Bernhard (MUL)
30.11.2022
Graduation with distinction

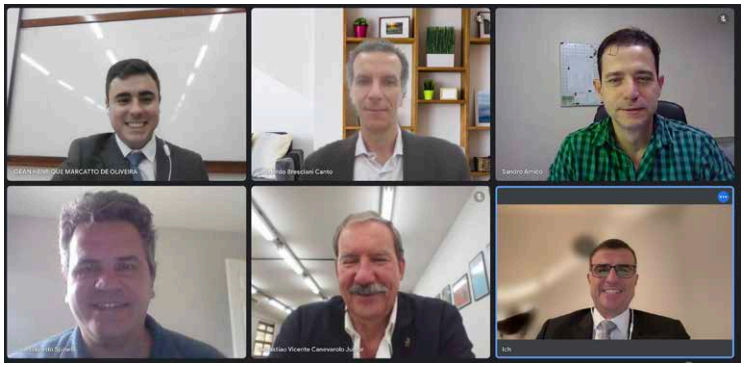
Mohammad Bagher Nasiri

Dr.techn. Mohammad Bagher Nasiri
Analytical Solution to Heat Flow Problem in Welding

Supervisor: Norbert Enzinger
Reviewer: Ernst Kozeschnik (TU Wien)
22.03.2022

Dr.techn. Gean Henrique Marcatto de Oliveira (Cotutelle PhD*)*
Injection overmolding of polycarbonate-aluminum alloys hybrid structures

Supervisors: Sergio Amancio (IMAT) and Leonardo Bresciani Canto (Universidade Federal de São Carlos - UFSCar)
Reviewers: Sebastião Vicente Canevarolo Junior and José Eduardo Spinelli (UFSCar, Brazil), Sandro Campos Amico (UFRGS, Brazil), the first PhD within the Cotutelle PhD between UFSCar and the IMAT
24.03.2023, online
Graduation with distinction



Gean Henrique Marcatto de Oliveira

Cotutelle de thèse PhD at IMAT

My experience as a Cotutelle PhD student at TU Graz

by Gean Marcatto

My research stays in Graz took place during the critical time of the Covid pandemic lockdown. Almost all countries closed their borders, and universities had to cancel classes and laboratory activities. However, Graz University of Technology pioneered online classes and implemented safety procedures for accessing laboratories, allowing foreign exchange researchers and PhD students to come to Austria. In this context, I had the opportunity to begin a double-degree doctorate within the framework of the Cotutelle program between my home university, the Federal University of Sao Carlos – UFSCar (Brazil), and TU Graz. The PhD work was carried out under the joint supervision of Prof. Sergio Amancio (TU Graz) and Prof. Leonardo B. Canto (UFSCar).

This choice led to my first time abroad, allowing me to be exposed to with a different language and culture and live on my own. Despite the challenges related to Covid restrictions, it was a very enriching experience to get to know Graz and other cities in Austria. This experience contributed to an exponential evolution in my personal life.

Apart from its high-level technical courses and research facilities, TU Graz made it possible for me to experience the academic environment. Many students and young people in Graz create an enjoyable atmosphere with a high quality of life, an ideal situation for a perfect work-life balance. As the first student within the Cotutelle agreement at the Faculty of Mechanical Engineering, I had to set the path and assist with drawing up documents and internal procedures at TU Graz, from day one until the PhD defense. I am happy to have successfully completed this process and contributed to helping other PhD candidates with Cotutelle agreements based on the steps I helped to establish.

I finished my doctoral thesis entitled "Injection overmolding of polycarbonate-aluminum alloys hybrid structures" shortly after my return to Brazil. After the PhD., I had the opportunity to return as a postdoctoral senior university assistant at IMAT, to continue my academic and research career. I look forward to contributing even more to the institute and TU Graz!

Sergio Amancio

"Dr. Gean Marcatto was my first co-PhD candidate within the double-degree Cotutelle PhD program with UFSCar (Brazil). This international collaboration with a leading university in materials science and engineering in South America is an important milestone for IMAT's international collaboration network. Meanwhile, I am co-supervising another three Cotutelle PhD candidates in the area of additive manufacturing of structural metal alloys. The complementary expertise of both universities led to unique synergies in science and technology, allowing us to create high-level scientific and engineering outputs in form of publications."

Reviews of external PhD's theses between 2021 and 2023

Schönmaier Hannah, „Microstructure-property relationship of creep-resistant 2.25Cr-1Mo-0.25V submerged-arc weld metal"
Montanuniversität Leoben, Reviewer and examiner: Norbert Enzinger 19.05.2022

Seyyed Mohammad Ali Noori Rahmin Abadi, "Laser metal fusion and deposition using wire feedstock: Process modelling and CFD simulation"
University West, SE, Examiner: Norbert Enzinger 02.11.2022

Amin Ebrahimi, "Molten Metal Oscillatory Behaviour in Advanced Fusion-based Manufacturing Processes"
Technische Universiteit Delft, NL, Examiner: Norbert Ezinger, 30.03.2022

Andreas Schwarz-Gsaxner, "Process development for manufacturing ultrafine-grained aluminum semi-finished products"
Montanuniversität Leoben, Reviewer: Sergio Amancio, 29.07.2022

Florian Dominik Staab, „Verbundeigenschaften, Mikrostruktur und Prozessanalyse ultraschallgeschweißter Leichtmetall/CFK-Verbunde"
Albert-Ludwigs-Universität Freiburg, DE, Reviewer: Sergio Amancio, 09.06.2022

Martin Malý, „Processing of metal materials using Selective Laser Melting technology at elevated temperatures"
Brno University of Technology, CZ, Reviewer: Sergio Amancio, 07.03.2023

Matheus Garilio, "A multiscale study of microstructural evolutions in hot deformed two-phase titanium alloys"
University MINES ParisTech, FR, Reviewer and examiner: Cecilia Poletti, Feb 2023

Alexander Janda, "Legierungs- und Prozessentwicklung von (α+β)-Titanlegierungen für ballistische Schutzanwendungen"
Montanuniversität Leoben, Reviewer: Ceclilia Poletti, Nov 2022

Chiara Confalonieri, "Composite Phase Change Materials based on thermally activated immiscible alloys: from design to functional characterization"
Politecnico di Milano, Reviewer and examiner: Cecilia Poletti, Oct 2022

Konstantin Prabitz, "Multi-physical modelling of resistance spot welding with assessing the risk of liquid metal embrittlement"
Montanuniversität Leoben, Reviewer: Ceclilia Poletti, May 2022

Arnab Chakraborty, "On the Design of Microstructures in Low Carbon Microalloyed Steels"
The University of New South Wales, Australia, Reviewer: Christof Sommitsch, 24.08.2022

Ryan DeMott, "Characterization of Alpha Variant Selection and Morphology in Additively Manufactured Ti-6Al4V via 3D-EBSD"
The University of New South Wales (UNSW), Australia. Reviewer: Fernando Warchomicka, August 2021

Jan Suchý "Processing of magnesium alloys by selective laser melting method"
Brno University of Technology, Reviewer and examiner: Fernando Warchomicka, July 2022

Elena Mora Serrano "Applicability of a Dynamic Recrystallization Model for an Open Die Forging Process for the As-Cast Superaustenitic Stainless Steel Alloy 28"
Mondragon Unibertsitatea, Spain. Reviewer: Fernando Warchomicka, March 2022

Reviews for habilitation procedures between 2021 and 2023

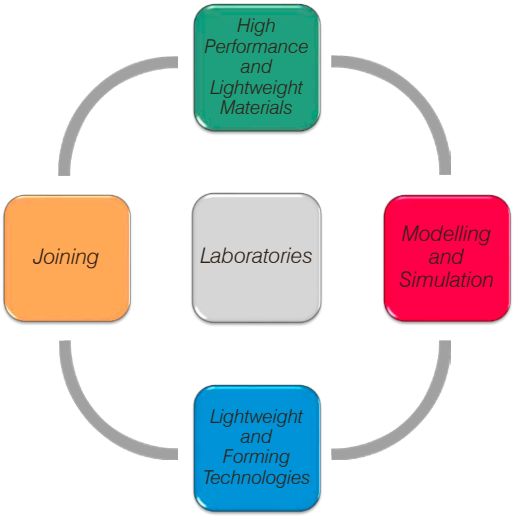
Peter Minárik, in the Area of "Materials"
Charles University, Prague, Assessment Committee member: Cecilia Poletti, April 2022

Josef Stratsky, in the Area of "Materials"
Charles University, Prague, Committee member: Cecilia Poletti, March 2022

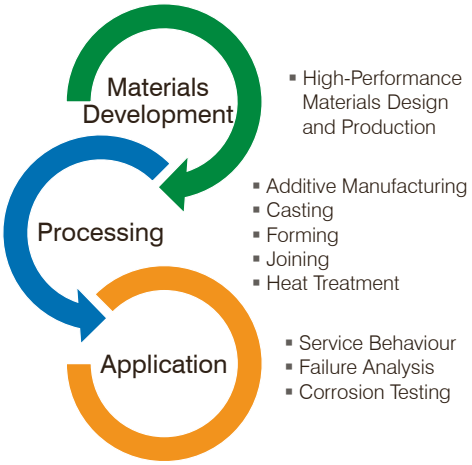
Fields of Research

Research at the Institute of Materials Science, Joining and Forming is carried out by four main groups, supported by the laboratories. The group leader and the deputy ensure that work is done efficiently by organising different tasks, improving the information flow within the team and representing the working group externally. These internal and external networking activities enable an excellent scientific and technological output.

Working Groups at IMAT



Material behaviour is thus investigated and developed along the life cycle based on its properties.



Materials

From left to right: Felix Schindler (master student), Fabian Bobner (master student), Helmut Riedl (bachelor student), Marlene Eichlseder (PhD student), Sebastian Fritsche (university assistant), Benjamin Meyer (PhD student), Christof Sommitsch (group leader), Felix Meixner (master student), Siegfried Arneitz (PhD student), Petra Spörk-Erdely (university assistant, topic leader Metal Additive Manufacturing), Gean Marcatto de Oliveira (university assistant), Sergio Amancio (group leader), Awais Awan (PhD student), Saeid Bakhtiari (PhD student)
Not in the picture: Fernando Warchomicka (senior scientist, topic leader Biobased Materials), Stefan Herbst and Lisa Minkowitz (ESP and master student) and following PhD students: Wilian Carvalho, Hannes Oberlercher, Rafael Paiotti, Carlos Belei, Matja Avbar, Simona Kresser, Matthias Wallner, Norbert Wild, Daniel David, Hamdi Elsayed, Bruna Fernanda Batistao (Cotutelle PhD), Bernhard Fercher, Brenda Juliet Martins Freitas (Cotutelle PhD), Lukas Neundlinger and Nicolas Rojas Arias (Cotutelle PhD)

The *Materials Group* is an interdisciplinary team working on materials development and the optimisation of production and processing technologies of high-performance metallic and composite materials. The latter especially includes additive manufacturing of dissimilar parts and joining them using highly advanced methods.
Our activities aim at characterising, understanding and modelling the relationships between microstructure and mechanical properties for optimising the material properties under service conditions.

The main research topics in this group are:

- Design of high-strength automotive steels, electrical steels and creep-resistant steels
- Experimental analysis and modeling of high-temperature ductility and strength of steels during continuous casting
- Development, surface structuring and testing of implant materials
- Metal additive manufacturing by selective laser melting and in-situ alloying
- Joining of dissimilar additive manufactured parts

Design of electrical steels for e-mobility with improved mechanical and magnetic properties

Electrical steels are commonly used as stacked laminations of rotors and stators in electric vehicles. In order to achieve the best performance of the engine, Non-Grain Oriented Electrical Steels need the best possible magnetic properties. Another important aspect is mechanical strength, which is needed to withstand the centrifugal forces created by high rotational speed in high frequency applications. The aim of this project is the investigation of new alloying concepts and processing methods that allow an improvement of both magnetic and mechanical properties. Figure 1 shows a TEM image of a new alloy concept in which fine precipitations are observed.

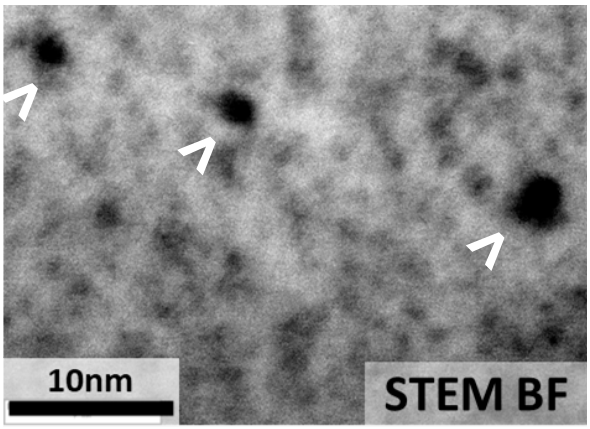


Figure 1: TEM-image of an electrical steel with fine precipitations (average size 2-3 nm), picture © Lukas Neundlinger

Influence of alloying on the producibility and processability of galvanized Q&P steels

Third generation AHSS steels such as Quenching and Partitioning (Q&P) steels are characterized by a balanced ratio of global and local formability with high strength, which is due to their fine-grained microstructure combined with metastable retained austenite. This enables the implementation of lightweight design concepts in automobiles, leading to a reduction in fuel consumption while maintaining or improving crash safety. In addition to their moderate galvanizability, a major disadvantage of these steels is the risk of zinc-induced liquid metal embrittlement (LME) and the associated cracking during spot welding (see Figure 2). This phenomenon is intensified in these steels by the alloying element Si, which is required to stabilize the retained austenite due to its carbide retarding effect. In this work, the influence of an adaptation of the alloying concept on LME susceptibility and the mechanical properties of Q&P steels is investigated. Another accompanying research focus throughout this work was the manufacturability of Q&P steels via continuous hot dip galvanizing lines with a galvannealing unit, where austenite decomposition at higher temperature is a particular problem.

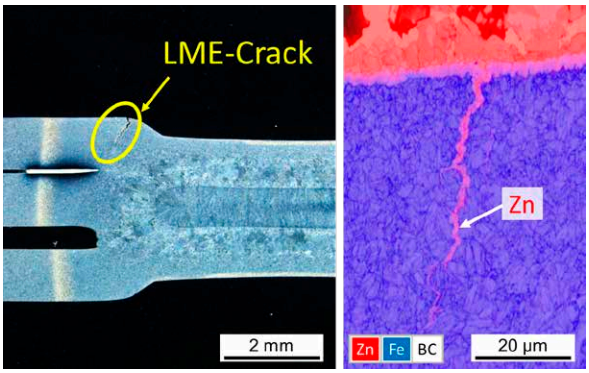


Figure 2: LME crack in the deformed, uncooled shoulder region of a spot weld (left) and EBSD band contrast image with superimposed EDX mapping of the Zn and Fe signal of an (intergranular) LME crack (right), picture © Matthias Wallner

Optimisation approaches for N-alloyed martensitic stainless steels

Quenching and partitioning (Q&P) is a well-established heat treatment mainly used on low-alloy steels. In this project, the potential of the Q&P process was investigated on martensitic stainless steels. The presence of retained austenite (RA) in the final structure is generally undesirable in these steels.

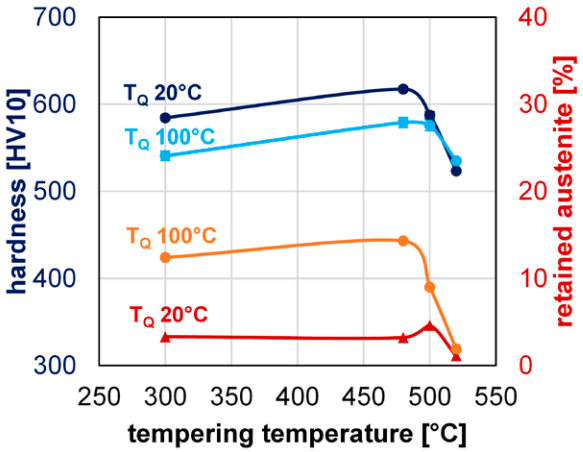


Figure 3: Hardness and retained austenite values after quenching at two different quenching temperatures (TQ) and subsequent tempering twice at the respective tempering temperature for 2h

However, the RA strongly stabilized with carbon in the Q&P process could have a positive effect on the mechanical properties, especially toughness. It was found that nitrogen has a similar effect to carbon during Q&P. Figure 1 shows that at a partitioning temperature of 300°C, an increased quenching temperature (TQ) of 100°C results in significantly more RA and thus that hardness is lower compared with the sample cooled to 20°C. Even at the high tempering temperatures, where Cr-rich carbides/nitrides are already precipitated, the partitioning effect has an influence. There is a shift in the RA drop and the secondary hardness maximum for the sample with a TQ of 100°C. The aim of this project is to develop a model to describe these processes and optimize the mechanical properties.

Biocompatible alloys – optimization of properties

The performance of a material used for implants is not only given by the degree of compatibility with the body but also by the bulk and surface properties. The mechanical properties help to achieve stability, while the surface of the material has the function of interacting with the surrounding tissue to ensure good corrosion and wear resistance.

Investigations in bulk properties focused on the thermomechanical process of titanium and magnesium alloys to improve the mechanical strength and control the corrosion rate of biodegradable alloys. Activities in metastable beta titanium alloys aim to understand the mechanism of restoration, refinement of grains and phase formation to correlate with mechanical properties. In the case of biocompatible magnesium alloys, controlling precipitates and grain size depends on the chemical composition and the micro-galvanic corrosion mechanism. Multiscale topography by electron beam technique helped to expand the field of research. International cooperation in surface engineering has recently brought to us a new research field in biocorrosion resistance. Plasma electrolytic oxidation (PEO) treatment was carried out at the surface of structured titanium alloys (Figure 4), observing an outstanding reproduction of the topography by the coating. The type of electrolyte and the treatment time influence the morphology of the pores, the thickness of the coating and the Ca/P ratio similar to the hydroxyapatite.

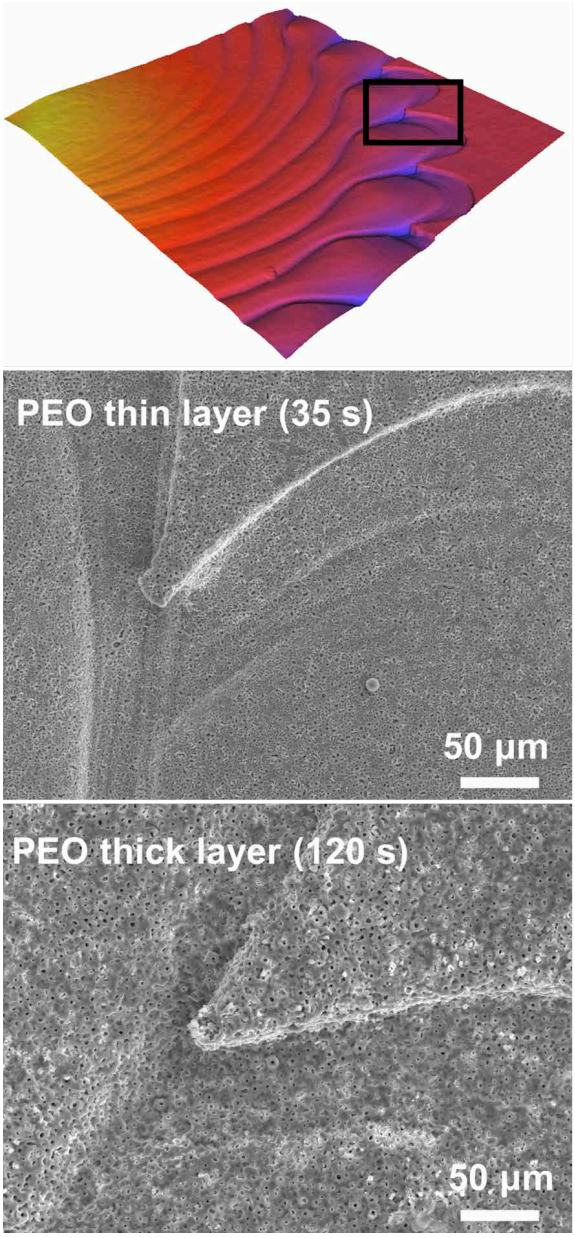


Figure 4: Topography reproduction of a PEO treatment in electron beam structured Ti-6Al-4V. Above: 3D reconstruction of the topography, center: thin coating layer (2.5 µm thickness, Ca/P ~ 0.6), bottom: thick coating layer (9.7 µm thickness, Ca/P ~ 1.1)

New FWF project: Deformation-phases-strength interaction in ß-Ti alloys (BETI)

Investigation of the interplay between deformation, phase transformations and mechanical properties in metastable β titanium alloys

Near beta titanium alloys are promising for structural applications due to their high specific strength, good hardenability and good fatigue behaviour. The performance of these alloys depends mainly on the type of microstructure, which can be engineered by thermomechanical processing. The use of non-toxic alloying elements can suit them as a good alternative for implant materials. Based on the assumption that the beta stabilizer elements affect phase transformation and plastic deformation, the description of deformation behaviour and subsequent microstructural changes by thermal activation in binary Ti-Mo alloys with different Mo content is still unclear.

The expertise of IMAT in hot deformation and microstructure modelling and the experience in phase transformation of titanium alloys of the Department of Physics of Materials at Charles University in Prague (Czech Republic) contributed to preparing and realising a unique research project. The project entitled “Deformation-phases-strength interaction in ß-Ti alloys” (BETI) was funded by Austrian Science Fund (FWF) and the Czech Science Foundation (GACR) for three years. The aim of BETI is the analysis and detailed description of deformation mechanisms operating at moderate and large plastic deformations at high temperatures and the effect on subsequent heat treatments in three high pure Ti-Mo alloys: Ti-12Mo, Ti-15Mo and Ti-18Mo. Scientific activities in IMAT are:

- Deformation of Ti-Mo alloys by a wide range of strains at different temperatures and using various strain rates. These experiments help to describe the deformation behaviour depending on the stability of the β phase (i.e., on the Mo content) and the deformation parameters.
- Implementation of a microstructure-based model to gain insights into the mechanisms of restoration and how they affect the phase transformation kinetics of β-Ti alloys during subsequent heat treatment.

The scientific group at Charles University concentrates their research on the characterization of the phase transformations and microstructural changes occurring depending on Mo content and the previous deformation state.

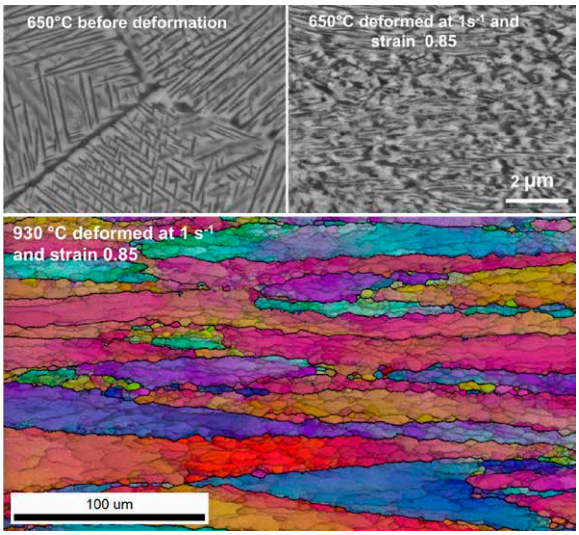


Figure 5: Hot deformation of Ti-12Mo. Above: SEM images before and after deformation in the alpha + beta field, observing dynamic globularization of the alpha phase: Below: EBSD image (IPF Map) observing dynamic recovery by deformation in the beta field

TU Graz

Charles University

FWF Der Wissenschaftsfonds.

GACR GRANTOVÁ AGENTURA ČESKÉ REPUBLIKY

Information

Project:
I 5818 - Deformation-phases-strength interaction in ß-Ti alloys
Project leader (Austria): Fernando Warchomicka
Duration: 2022 - 2025
Partner:
Department of Physics of Materials - Charles University (Prague, Czech Republic)
Funded Agencies:
Austrian Science Fund (FWF) and the Czech Science Foundation (GACR)

Additive Manufacturing

Functional materials

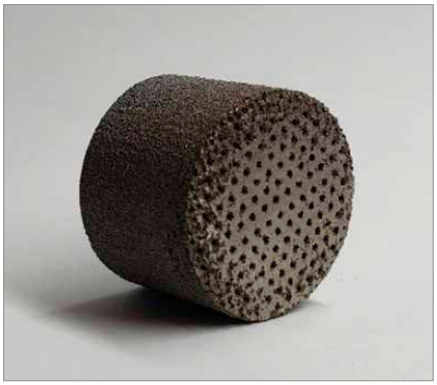


Figure 6: Catalyst fabricated by means of LPBF.

Catalytic reactions are vital in many industrial processes. With regard to heterogeneous catalysts, the active surface area, pore volume, and pore size distribution represent major morphological characteristics. In the framework of the three-year project "Additive manufacturing of novel porous catalysts for sustainable fuel production", which started in late 2022 as part of the Lead Project **"Porous Materials@Work for Sustainability"** at Graz University of Technology, researchers at IMAT strive to exploit the AM process of laser powder bed fusion (LPBF) not only to create complex-shaped parts with large surface areas (Fig. 6), but also to generate porous (micro-)structures. By carefully adjusting the printing parameters, ways of introducing pores on several length scales are explored, while simultaneously guaranteeing a sufficient mechanical stability for handling and catalyst application (Fig 7). In the past year, materials systems based on Ni-Al (in particular 76Ni24Al), Fe, and Cu-Zn were investigated. In the case of Ni-Al, in-situ alloying was followed by a dedicated heat treatment to homogenize the microstructure and promote the formation of the catalytically active phases (Fig. 8). The aim is to establish the catalytic properties using reformer testbeds in a collaboration with the Institute of Thermal Engineering. In a collaboration with the Institute of Materials Physics, the de-alloying of in-situ alloyed AM structures is currently being studied on catalytic Ni-Al alloys, but also on other binary alloys.

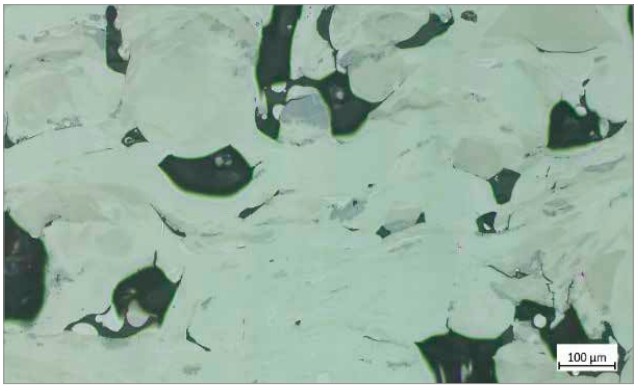


Figure 7: In-situ alloyed 76Ni24Al microstructure with a high pore fraction.

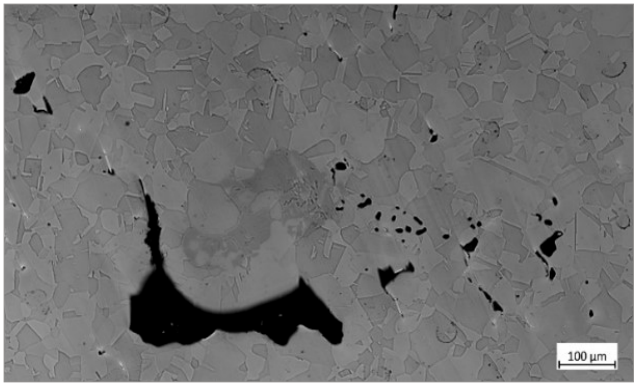


Figure 8: Porous 76Ni24Al microstructure after a two-step homogenization heat treatment.

In the field of magnetic materials, a strong research focus has been placed on the further development of the LPBF printing process for Fe-Co based spinodal alloys. In this context, one notable achievement has been successful manufacturing of magnetic structures with an inherent chemical gradient. The base material was manufactured with gradients of different alloying elements that were known to influence the magnetic properties. It was subsequently proven that it is possible to produce a structure with a gradient in its magnetic properties (Fig. 9).

Additionally, research has continued on the AM of Nd-Fe-B, one of the strongest permanent magnets currently on the market. With regard to manufacturing this material, two problems have arisen previously, which proved detrimental to strong and stable AM Nd-Fe B magnets: first, the formation of free iron phases due to an improper solidification path arising from slower cooling rates, and, secondly, the instability of the parts due to an insufficient heat input. Since a greater heat input is usually concomitant with slower cooling rates, these two problems initially appeared diametrical.

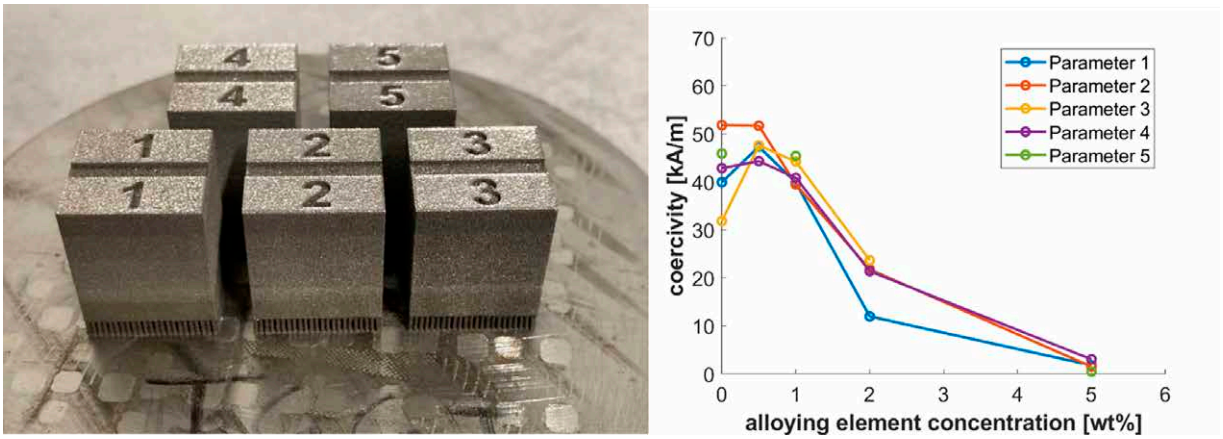


Figure 9: Graded LPBF specimens and coercivity as a function of the alloying element concentration for different sets of printing parameters.

However, in the course of a careful investigation of the printing process, new sets of printing parameters have been discovered which yield stable parts with a very small amount of free iron phases. The successful selection of parameters also reflected in the magnetism inherent to the printed samples right after dismounting them from the printing bed (Fig. 10). In a collaborative project with AVL in the course of the AddMag project, these AM magnetic parts are currently being tested for their applicability.

Figure 10: As-printed Nd-Fe-B samples which magnetically attract surrounding powder particles.

Smart materials and sensor integration

In the field of AM of smart materials, the successful collaboration with AVL has been continued. Two master's theses have been completed. While Markus Reiter investigated possibilities of embedding sensors in AM metal components for innovative automotive instrumentation and test systems, Nikolas Hartbauer introduced optical fibers as strain and temperature sensors into AM 316L structures. The embedding principle for the optical fibers shown in Fig. 11 permits a possible sensor application in smart bipolar plates for fuel cell applications, in which optical fibers acting as strain sensors are mechanically connected to the parts, whereas temperature sensors are embedded in such a way as to ensure free expansion upon temperature change.

Further information about the Additive Manufacturing Laboratory and equipment at: *https://www.tugraz.at/institute/imat/services/laboratory-main-fields/addlab*

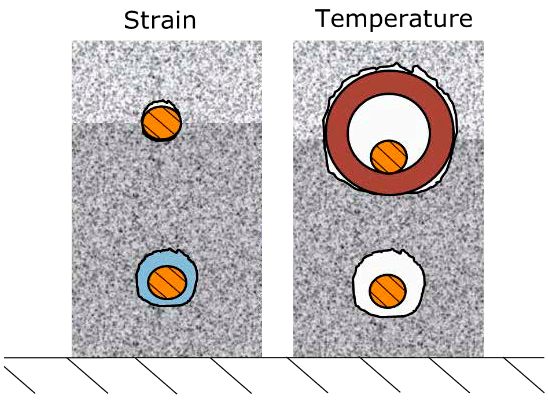


Figure 11: Schematic of the embedding principle for optical fibers as sensors for strain or temperature.[1]

[1] *N. Hartbauer, S. Arneitz, S. Karanovic, A. Klug, C. Sommitsch, „Additive Manufacturing-enabled Embedding of Optical Fibers for Innovative Automotive Instrumentation", Poster of the Master's thesis, 2022.*

Innovative Materials and Manufacturing Techniques in Aviation

The Aviation Team has been working on innovative and novel engineering approaches in joining and additive manufacturing technologies to produce lightweight and high-performance metal-composite hybrid structures. Our unique R&D methodology combines materials science and engineering knowledge, advanced joining and new additive manufacturing routes, which are supported by process optimization, modelling and simulation tools. Innovative friction-based joining techniques are combined with additive manufacturing of metals and engineering thermoplastics composites to produce metal-thermoplastic composites hybrid structures (MTC-HS). These hybrid structures have high strength-to-weight performance, improved damage tolerance and crashworthiness, and good repairability (e.g., by thermal joining or welding); they are easier to disassemble and recycle as thermoplastic composite matrix can be remelted by heat.

These R&D efforts have been mainly accomplished within the scope of the BMK Endowed Professorship for Aviation (Federal Ministry Republic of Austria, FFG, voestalpine, Diamond Aircraft, Fuchshofer Präzisionstechnik and TCM, 2018 - 2023). The very good technical-scientific output of junior and senior scientists and engineers working in this project enabled an overall excellent evaluation of the project: 153 technical peer-reviewed publications (49 JCR-papers, 104 conference papers and abstracts, and posters). Moreover, four book chapters and three co-edited technical books were also published. An applied patent in the area of Friction-based Materials Recycling, and three prepared invention disclosures in the area of additive manufacturing of hybrid materials and wood, and joining of wood-hybrid materials, have also set the path for the Aviation Team's future R&D work on green materials and manufacturing techniques. The quality of the work has been also recognized by the invitation to deliver 23 invited lectures in different countries, such as the USA, Germany, Brazil, Russia, Finland, Romania and Austria. Furthermore, a total of 27 academic theses and undergraduate papers (two post-docs, six PhD, nine MSc and ten BSc) have been successfully concluded so far in the framework of this project, with another six theses (three PhD, three MSc) expected to be finished in 2024.

The co-workers of the Endowed Professorship also won nine awards and prizes in recognition of their academic performance and contribution to science and technology. The research work on manufacturing of hybrid lightweight structures has recently received the second place in the prize Energy Globe STYRIA AWARD 2022 in the category "Research". This award established in 1999 honors outstanding, sustainable projects with a focus on resource conservation, energy efficiency and the use of renewable energies. The technical-scientific relevance of our research on hybrid materials has been recently recognized with the DGM-Prize 2022 of the German Society for Materials Science (DGM) awarded to Prof. Amancio. This is one of the most prestigious research prizes in Europe for Materials Scientists. The DGM Prize is awarded to a mid-career scientist for outstanding scientific or scientific-technical achievements that represent a breakthrough in materials science and engineering, documented by publications, or that have opened up a new field of research. This prize was presented for the first time to a scientist currently working in an Austrian university. Prof. Amancio also won the Yoshiaki Arata Award 2023 from the International Institute of Welding (IIW). This award recognizes individuals who have realized extraordinary achievements in fundamental research in welding science and technology and its allied areas, which have been recognized as significant contributions to the progress of welding engineering and related fields. This was the second time IMAT has received this prestigious prize, showing the continued relevance of the work in welding and joining initiated with Prof. Horst Cerjak (awardee from 2007).

[1] S.T. Amancio-Filho, L. Blaga, Joining of Polymer-Metal Hybrid Structures: Principles and Applications, John Wiley & Sons Inc, USA. 416p, ISBN-10: 1118177630, 2018, USA.

[2] S.T. Amancio-Filho*, P. Effertz, C. Sommitsch, F. Haas, G.P Cipriano, "Waste Fraction Processing Friction Extruder Unit" European patent registration number 21203669.3

International Collaboration and Networking

A new doctorate Cotutelle (double-degree) program between TU Graz and Federal University of Sao Carlos (UFSCar, Brazil) was launched in 2022. Four doctoral candidates (Bruna F. Batistão, Nicolas R. Arias, Brenda Martins, and Gean H. O. Marcatto) with full scholarships financed by the Brazilian government. Following professors are part of this collaboration: UFSCar: Prof. Leonardo B. Canto, Prof. Piter Gargarella and Prof. Bolfarini; TU Graz: Prof. Amancio. UFSCar is one of best universities in the area of Materials Engineering in South America. In this academic collaboration, the synergetic contribution of UFSCar in metal powder alloy development for additive manufacturing (AM) and polymer processing, as well as the strong expertise of IMAT in process development and materials science of AM metals and hybrid parts, is already bearing fruit. Two JCR papers (https://doi.org/10.1002/pen.26244 and https://doi.org/10.1016/j.matlet.2022.133378) have already been published, along with various conference papers. Moreover, the first PhD defense within this collaboration was by Dr. Gean Marcatto in February 2023. The three other Cotutelle PhDs have had their one-year research stay at TU Graz in 2022-2023. They are currently finishing their PhD experiments at their home university.

Sebastian Fritsche has been working on his doctoral thesis since 2021 in the field of solid-state joining of AM and wrought aircraft alloys. His doctoral thesis is being conducted within the scope of the Matched-PhD programme between TU Graz and the University of Strathclyde (UoS). As UoS is a key player in the area of modelling of solid-state welding, Prof. Toumpis and Prof. Galloway are supporting the modelling activities of this academic. So far two JCR papers have been published (https://doi.org/10.1016/j.jmrt.2023.08.305 and https://doi.org/10.1016/j.mfglet.2022.09.010)

Prof. Amancio has been further confirmed as “Adjunct Professor” in the Department of Materials Science and Engineering at The Ohio State University (OSU), USA. IMAT’s collaborating partners Prof. Antonio Ramirez and Prof. Avi Benatar have hosted IMAT’s PhD candidate Willian Carvalho in 2022 at Ohio for realizing experiments on vertical vibration ultrasonic joining. Based on various talks at technical conferences, a direct output of this collaboration is a manuscript (https://doi.org/10.3390/met13020319) with citations and over 1175 online views.

Work and Publication Highlights

One main motivation driver for the research in “Innovative Materials and Manufacturing Techniques in Aviation“ is the possibility to contribute to fulfilling the goals of the European Union's Clean Aviation program that aims to achieve zero emissions by 2050 by harnessing the use of cleaner propulsion technologies and lightweight materials.

[3] https://www.energyglobe.at/steiermark

[4] https://dgm.de/dgmtag/2022/preistraeger/dgm-preis-2022

[5] https://dgm.de/en/about-dgm/honors-and-awards/dgm-prize

Additive Manufacturing of aircraft functional structural alloys.

a) Development of metal powders for Laser Powder Bed Fusion (L-PBF) by *in situ* alloying.

Preliminary work has shown potential to reduce L-PBF costs for NiTi-shape memory alloys[7]. While 10 kg of NiTi pre-alloyed costs an average of 8500 euros (TLS Technik Spezialpulver[8], Germany), the same *in situ* alloyed powder has a cost of only 840 euros, while displaying comparable printability and mechanical properties. Figure 12 shows the morphology of the produced powder. The AM feasibility of this alloy has been performed with the aid of design of experiments (DoE) and statistical analysis. Crack-free specimens have been produced. A deeper understanding of the correlations between *in situ* alloying, L-PBF parameters, microstructure and printed part mechanical properties will be a focus of the research in the coming years.

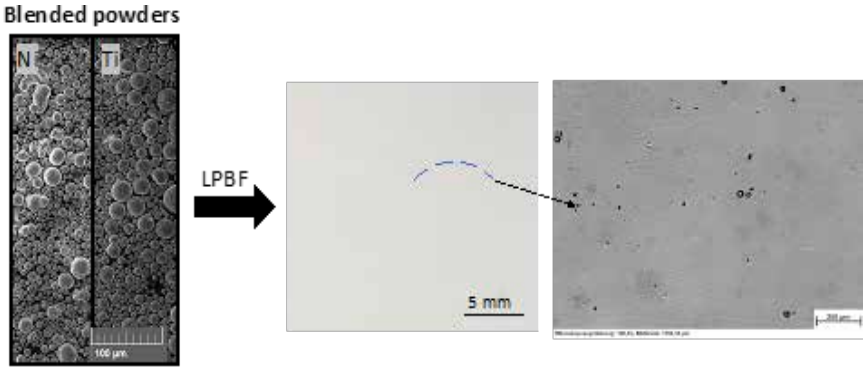


Figure 12. Ni and Ti powders blended to produce in situ alloyed NiTi with over 98% density.

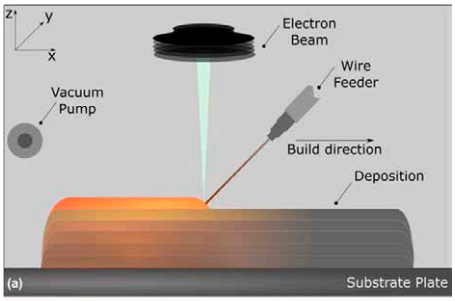
b) Wire-Based Electron Beam Additive Manufacturing (w-EBAM) of shape-memory alloys (SMA).

Alloys displaying shape memory – i.e., these alloys can be trained to react to external stimuli, such as temperature - these are generally high-strength alloys difficult to be processed by conventional subtractive and formative processes due to their superlastic behaviour. An example of a potential application in aircraft for SMAs is the combination to polymer composites to form smart lightweight hybrid structures, such as in smart metallic hinge connectors for thermoplastic composite wing ailerons. The first wire-Based Electron Beam Additive Manufacturing (w-EBAM), NiTi shape memory alloy (Figure 13) has been demonstrated recently at IMAT in a project led by the Aviation Team in cooperation with the Joining and Materials Modelling groups. Two publications were published in the reporting period (https://doi.org/10.1177/1464420720975059; https://doi.org/10.1177/14644207231184787).

[6] https://www.clean-aviation.eu/ accessed on April 20, 2022

[7] S.T. Amancio-Filho, M. Skalon, R. Buzolin, R. Paiotti, S. Arneitz, L. Minkowitz, P. Effertz, C. Belei, B. Meier, W. Carvalho, C. Sommitsch, Advances on the LPBF of Structural Materials : microstructure, processing and material strength. In Proc.: Lasers in Manufacturing 2021, Munich, Germany, June 21 - 24, 2021,

[8] TLS Technik Spezialpulver was purchased by ECKART



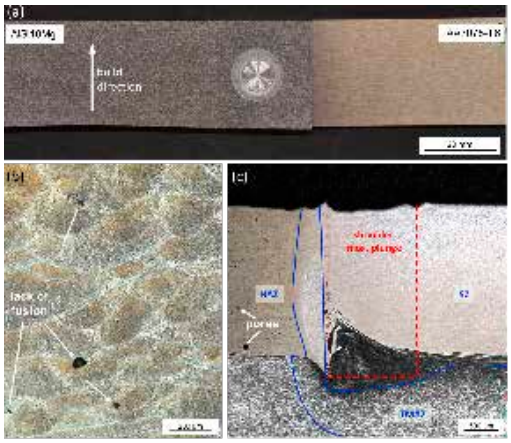


Figure 13 (left) (a) The schematics of the Wire-Based Electron Beam Additive Manufacturing (w-EBAM) (Figure R. Paiotti, 2021); (b) Example of different w-EBAM NiTi shape memory additively manufactured specimens (Image: C. Hoflehner / R. Paiotti, IMAT, 2021)

Figure 14 (right). RFSSW single-lap joint between LPBF AlSi10Mg and rolled AA7075-T6. a) surface appearance of the weld; b) Microstructure of as-built LPBF AlSi10Mg; c) half of a cross-section in the center of the weld (center of the spot weld is on the right-hand side of the figure). Lack of fusion in b) and pores in c) are a result of the LPBF and can be minimized or fully eliminated by means of 3D printing process optimization.

The study of the fundamental weldability of AM metals to wrought and casting alloys.

Different large aircraft parts with complex geometry are machined down out of larger billets. By printing smaller parts with complex geometries by LPBF and integrating them by welding in machined or formed larger parts, initial material waste can be reduced; therefore, the buy-to-fly ratio of the final part is also decreased. However, unknown challenges related to welding AM materials to state-of-the-art materials may arise due to their dissimilarity in properties, such as different textures and residual stresses. We have investigated for the first time in the literature the refill-friction stir welding (RFSSW) on laser-powder bed fusion (L-PBF) AlSi10Mg - rolled AA7075 dissimilar welds. The main goal of this academic work being carried out in collaboration with the University of Strathclyde in Scotland is to investigate the influence of process parameters on the microstructure, mechanical behavior and corrosion properties of these welds. Published preliminary results showed that RFSSW is feasible to produce strong spot welds between AM and wrought aluminum alloys (https://doi.org/10.1016/j.mfglet.2022.09.010). Figure 14 shows the microstructural features of these welds. Figure 15 shows the mechanical strength and fracture surface of exemplary RFSSW dissimilar welds.

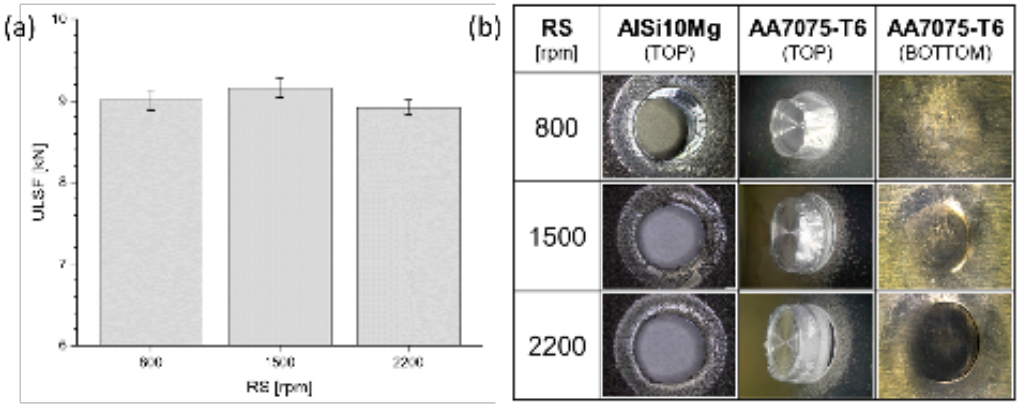


Figure 15. Lap shear testing results for RFSSW LPBF AlSi10Mg - rolled AA7075-T6 welds produced with different rotational speeds (RS). a) The ultimate lap shear force of produced joints; b) Fracture types observed for samples in a).

Additive Manufacturing and Joining of AM metal-polymer hybrid structures.

a) AddJoining of fully additive manufactured AlSi10Mg/PC lap joints.

AddJoining uses fused filament fabrication (FFF) to hybridize metals – i.e. to form the polymeric/composite part around the metal parts. Hence, the parts can be produced with complex 3D geometries by depositing extruded material layer by layer on a metallic substrate (e.g. in extruded, rolled, machine or additively manufactured metals). The innovative manufacturing route has been successfully demonstrated for different combinations of materials. These include ABS with aluminum 2024[9], unreinforced, continuous-carbon-fiber reinforced PA6 with aluminum 2024[10] and Ti64[11], as well as short-fiber-reinforced PA 6 with rolled[12] and laser-powder bed fusion additively manufactured Ti64[13]. We recently demonstrated the feasibility of fully additive manufactured AlSi10Mg/PC Add-joints (https://doi.org/10.1016/j.matlet.2022.133378). In this work Laser-Powder Bed Fusion was chosen to produce metal parts with engineered submilimetrical bio-inspired surface elements, to be infiltrated by the printed polymer during hybridization via AddJoining. The addition of these bio-inspired structures led to an increase in lap shear strength of the hybrid joints. A demonstrator part was produced to evaluate the scaling-up effect (Figure 16). AddJoining's manufacturing times are in the scale of minutes in comparison with the typical several hours in state-of-the-art composite lamination processes. No molds are required, while robotic application will be possible in the near future.

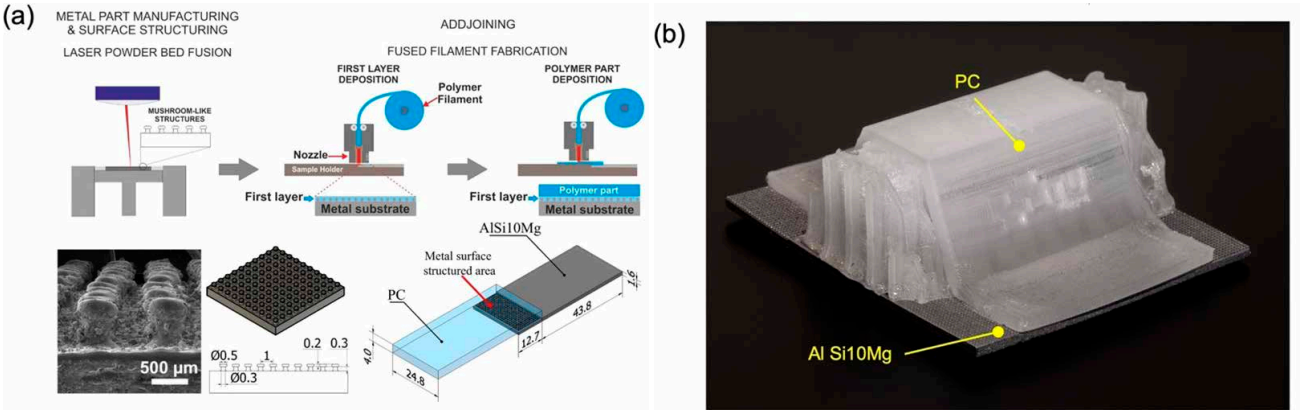


Figure 16. (a) Additive manufacturing steps for the production of PC/AlSi10Mg hybrid joints: Mushroom-shape metal surface structuring by L-PBF production of single-lap PC/ AlSi10Mg Addjoints. All dimensions are given in millimeters (reproduced with authorization from [58]); (b) An example of skin-stringer component produced with the manufacturing approach and materials shown in (a).
Foto: G. Marcatto, B. Fercher / IMAT, 2023).

[9] R. Falck, J.F. dos Santos, S.T. Amancio-Filho (https://doi.org/10.3390/ma12060864).

[10] R. Falck, J.F. dos Santos, S.T. Amancio-Filho (https://doi.org/10.1016/j.matlet.2018.01.021).

[11] C. Belei, S.T. Amancio-Filho, Additive Manufacturing of Metal-Polymer Hybrid Parts: Relevant Aspects and Potential Techniques – A Review (AM-151). In Proc.: LightMat 2019 3rd Conference & Exhibition on Light Materials – Science and Technology, 5th-7th November 2019, Manchester, United Kingdom.

[12] C. Belei, R. Pommer, S.T. Amancio-Filho, (https://doi.org/10.1016/j.matdes.2022.110776).

[13] C. Belei et al., Preliminary study on the AddJoining process over additively-manufactured metallic parts, Advanced Materials Day 2019, TU Graz, 29th September 2019, Graz, Austria.

b) Understanding and optimizing AddJoining process using machine learning (ML).

An example of how simple ML models can be used to understand and optimize the mechanical performance of AM metal-polymer hybrid joints has been recently investigated in the Aviation team. Fully AM carbon-fiber-reinforced polyamide/L-PBF Ti-Al6-V4 dissimilar joints (Figures MM) were produced and optimized via a combined approach using DoE and simple ML models (Figure 17). The influence of as-printed laser-powder-bed fusion (L-PBF) surface roughness on the quasi-static joint strength (three-point bending testing) was determined and modelled in a good manner by using this DoE/ML approach combined with materials characterization. A manuscript describing this work has been published in 2023 (https://www.frontiersin.org/articles/10.3389/fmats.2023.1202281/full).

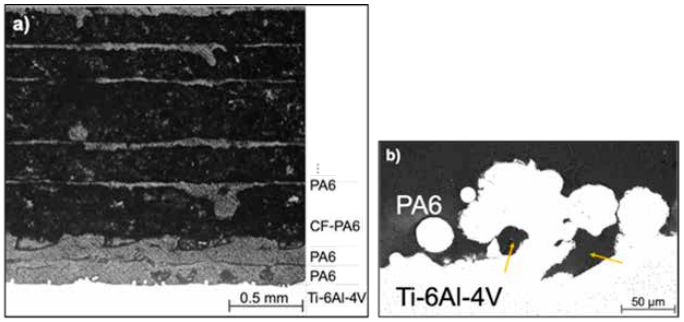


Figure MM. Example of Add-joints: a) CF-Polyamide 6 and Ti-6Al-4V printed with laser powder bed fusion; b) detail of the interface of specimen in a) (Photos: C. Belei, 2022 / IMAT);

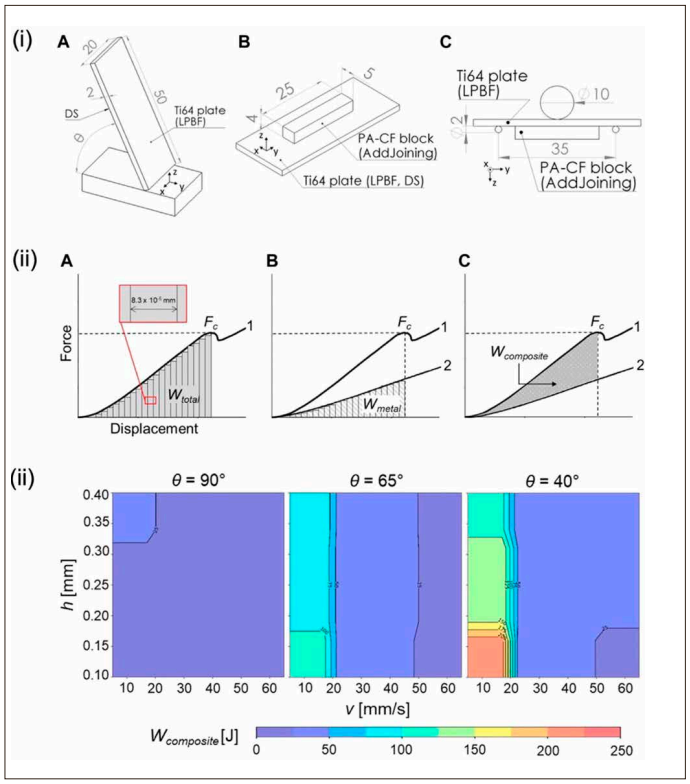


Figure 17. The influence of as-printed laser-powder-bed fusion (L-PBF) surface roughness on the joint strength (three-point bending testing method based on ISO 14679:1997) of Ti- 6Al-4V/PA-CF joints produced by AddJoining. I) (A) Schematics of the Ti-6Al-4V substrates printed by L-PBF. Z denotes the build direction; (B) Schematics of the PA-CF block 3D-printed on L-PBF substrates using the AddJoining approach. Z denotes the build direction; (C) Schematics of the three-point bending test, based on ISO 14679:1997. Ti64 denotes Ti-6Al-4V. Dimensions in mm; ii) Summary of the sequence used for the calculation of the total resilience of the substrate-block system up to the detachment, Wtotal. Step (A) integral of Force x Displacement curve for hybrid specimen (1) calculated up to Fc (Wtotal); Step (B) integral of average curve for standalone substrates (2) calculated up to Fc (Wmetal); Step (C) Wmetal is subtracted from Wtotal, resulting in Wcomposite, visualized as the area between curves 1 and 2; iii) Gradient boosting Regression (GBR) results showing contour plots for layer height h and printing speed v at different inclination angle θ levels, adopting Wcomposite as a response. Reproduced with authorization from [52] (© 2023 Belei, Effertz, Meier and Amancio-Filho. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY)).

[14] W.S. Carvalho, S.T. Amancio-Filho, Ultrasonic joining of additively manufactured metal-polymer lightweight hybrid structures. In: Annual Technical Conference - ANTEC, Conference Proceedings (Code 186181) Society of Plastics Engineers, SPE ANTEC 2022 Vol. 1, p. 289-296, Charlotte, NC, USA (2022).

c) Weight Reduction by topology optimization, AM and combined AM and joining techniques.

An example of a skin-stringer-bracket MTC-HS produced via U-Joining using AM for the metallic and polymeric (unreinforced and fiber-reinforced) parts (Figure 18) has been recently published in an international conference proceeding indexed by Scopus[14]. In this study the topology optimization and elimination of fasteners and adhesive led to weight decreases of up to 64% compared with the full metallic-bolted structure. Another two examples for fully AM hybrid joints have been published recently: for laser-powder bed fusion (L-PBF) Ti64 / FFF PA-CF (https://www.mdpi.com/2075-4701/13/7/1262) leading to weight reductions of 40% to 45% in comparison with full-metallic component Addjoints (see Figure 19).

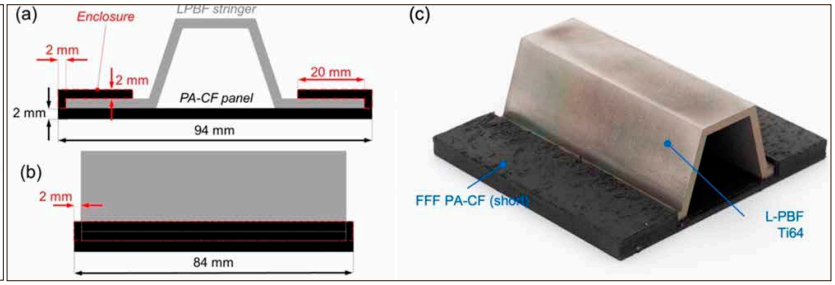
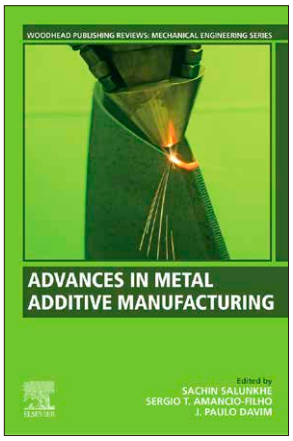


Figure 18 (left) Skin-stringer-bracket L-PBF 316L stainless steel (dark gray colour) -FFF PEEK-CF (black) hybrid structure produced via AM and U-Join

Figure 19 (right) Schematics of the full metal-polymer technology demonstrator 2. (a) Front view; (b) side view. Gray regions represent the Ti-6Al-4V L-PBF stringer, black ones represent the PA-CF panel. Red dashed lines represent PA-CF areas used as enclosure. Image not in scale; (c) The AM component. Reproduced with authorization from [37] (© 2023 by the authors. Licensee MDPI, Basel, Switzerland. An open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license).



Technical book "Advances in Metal Additive Manufacturing"

(Elsevier-Woodhead Publishing)[15] (co-edited by Prof. Amancio). This book (Figure 20 reviews current research results in powder-bed fusion (PBF) and directed energy deposition (DED) additive manufacturing process. The book published in 2022 has met with a positive response among the community. IMAT has coordinated the writing of two large chapters in this book indexed by Scopus (https://doi.org/10.1016/B978-0-323-91230-3.00003-2; https://doi.org/10.1016/B978-0-323-91230-3.00006-8) .

[15] S. Salunkhe, S.T. Amancio-Filho, J. Paulo Davim, Advances in Metal Additive Manufacturing, Elsevier-Woodhead Publishing, England. 250p, paperback ISBN: 9780323912303 https://www.elsevier.com/books/advances-in-metal-additive-manufacturing/salunkhe/978-0-323-91230-3. 1st edition publication on 10 October 2022

Ongoing projects

- AddMag - Additive manufacturing of permanent magnet materials (FFG, ERA-NET, 2022 - 2025)
- SCREW-HISCC - Hydrogen-induced stress corrosion cracking of self-tapping timber screws (FFG, Schmid Schrauben Hainfeld GmbH, Stiegler GesmbH, 2020 - 2023)
- Dissertation Kresser - N-alloyed martensitic steels (voestalpine Böhler Edelstahl GmbH & Co KG, 2019 - 2023)
- Dissertation Neundlinger - Next Generation E-mobilty Grades (voestalpine Stahl GmbH, 2021 - 2023)
- Dissertation Wallner - Conventional and medium-Mn Q&P steels suitable for the GIGA process (voestalpine Stahl GmbH, 2020 - 2023)
- FWF - BETI - Deformation-phases-strength interaction in ß-Ti alloys (FWF, WEAVE, 2022 - 2025)
- K1-MET P1.4 - Sustainable continuous casting process (FFG, COMET - K1, MET, 2023 - 2027)
- MedMnSteel - Development of medium-Mn forged steel (voestalpine Stahl Donawitz GmbH, 2022 - 2023)
- Porous Materials @ Work for Sustainability (BioTechMed, Lead Project, 2022 - 2025)
- RFSSW - RFSSW tools development (STIRtec GmbH, 2022 - 2023)
- SCREW_HISCC - Hydrogen-induced stress corrosion cracking of self-tapping timber screws (FFG, Bridge, 2020 - 2023)
- Thermomechanical modlling of continuous casting and hot rolling (K1 Met, 2019 - 2023)
- Machbarkeitsstudie von Ultraschallverbindungen (Miba Gleitlager Austria GmbH, 2022)
- Machbarkeitsstudie von FSW-Mischverbindungen (Miba Gleitlager Austria GmbH, 2022)
- Dissertation Avbar - Materialmodifikationen mit kohlenstoff-basierten Additiven (Glock Technology, 2021 - 2025)
- Diissertation Batistao - Surface functionalization of the AA2017 aluminum alloy powder for use in Additive Manufacturing (Cotutelle UFSCar / TU Graz, 2021 - 2025)
- Dissertation Arias - Tailoring the composition of AA2017 aluminum alloy to reduce cracking susceptibility during selective laser melting (Cotutelle UFSCar / TU Graz, 2020 - 2024)
- Dissertation Freitas - Microstructure, mechanical properties and corrosion resistance of boron-modified stainless steels processed by additive manufacturing (Cotutelle UFSCar / TU Graz, 2019 - 2023)

Completed projects

- IonAS 2 - Ionic wind propulsion system for aircrafts, part 2 (FFG, FH JOANNEUM Gesellschaft mbH, 2021 - 2022)
- K1-Met P2.3 - Thermomechanical modelling of continuous casting and hot rolling (FFG, K1-MET GmbH, 2019 - 2023)
- IBM-Sys - Intelligent coating systems on multi-metallic composite structures for automotive production (FFG, CEST - Kompetenzzentrum für elektrochemische Oberflächentechnologie GmbH, 2021 - 2022)
- BMK Endowed Professorship for Aviation (Federal Ministry Republic of Austria, FFG, voestalpine, Diamond Aircraft, Fuchshofer Präzisionstechnik and TCM, 2018 - 2023)
- HISCC UHSS bolts - Improvement of hydrogen induced stress corrosion cracking resistance of ultra-high strength steel screws and fasteners (CEST, 2018 - 2021)
- Dissertation Oberlercher - Thermo-mechanical consolidation of 3D-printed polymer composites (Carinthia University of Applied Sciences / TU Graz, 2018-2022)
- Dissertation Marcatto - Injection overmolding of polymer-metal hybrid structures (Cotutelle UFSCar / TU Graz, 2020-2023)
- HISCC UHSS bolts - Improvement of hydrogen induced stress corrosion cracking resistance of ultra-high strength steel screws and fasteners (CEST, 2018 - 2021)

Joining

From left to right: Tobias Walder (bachelor and ESP student), Andreas Gruber (master student), Fabian Gsodam (master student), Michael Hochrainer (bachelor student), Aleksandar Vujic (master student), Rudolf Vallant (co-group leader), Andreas Hütter (scientific staff), Matthias Moschinger (PhD student), Norbert Enzinger (group leader) and Peng Wang (PhD student).
Not in the picture: Daniel Radowski (student) and following PhD students: Maximilian Stummer, Leonhard Weingrill, Andreas Hinterer, Andrea Putz, Florian Pixner, Martin Rieger, Mathias Silmbroth and Oğuzhan Eroğlu.

The *Joining Group* deals with various welding processes and their influence on the properties of welded joints. The focus of this working group is on arc welding, friction welding and electron beam welding. Processes and material behaviour during welding and subsequent operations are investigated both experimentally and by means of numerical and physical simulation. In addition to traditional joining processes and surface modifications by welding, additive manufacturing is a hot topic in welding research. This is also shown by its share in our research group: Several master's and doctoral theses focus on wire-based additive manufacturing. Our equipment allows us to consider not only WAAM but also EBAM processes.

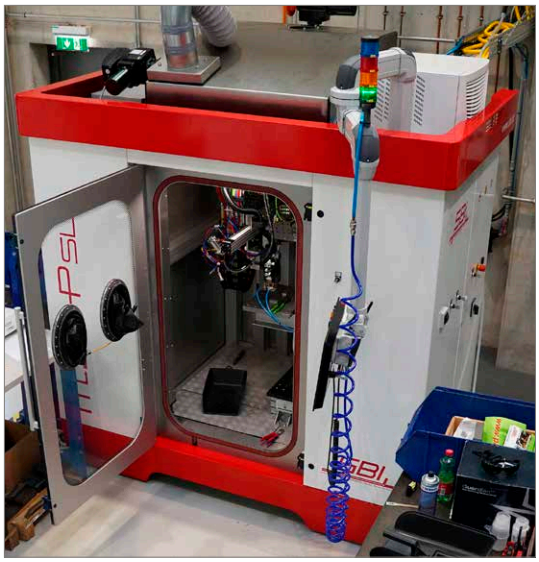
In beginning of 2022 a brand-new research device was installed in our lab. With M3DP-SL from company SBI GmbH it is possible to do plasma based additive manufacturing and welding in a closed chamber in defined inert atmosphere. It includes the possibility to feed two different wires and control their feeding speed independently. Therefore, even in-situ alloying is possible, which is a part of an ongoing master thesis.

Another interesting option is Wire-based electron beam additive manufacturing (EBAM), because the mandatory vacuum atmosphere combined with the deflectable electron beam enables the production of near-net shape AM specimens made even from very reactive materials. In the frame of a currently running project the wire feeding system in our pro-beam device is updated to improve accuracy and control of the wire feed enabling to build even more sophisticated structures.

Within "We3D - Wire-based additive manufacturing – materials and technologies – for 3D metal structures of the future" (FFG COMET K-Project) under the leadership of AIT - LKR a very interesting project in cooperation with different company partner is ongoing in the field of additive manufacturing and maintenance. This experimental work is accompanied with numerical simulation using Simufact Welding and the respective validations.

Other topics in this research cooperation are insitu-alloying of Al-Cu-Si alloy and in-depth characterization and comparison of Ti64 structures made using different wire-based AM processes like CMT, Plasma and Electron beam.

In 2021 AMAG donated a Gefertec 3D Printing device to IMAT and IFT - Institute of Production Engineering (Prof. Franz Haas). In 2022 after some intensive planning a cooperation with AVL enabled the installation of this device at AVL. Currently, combined efforts are undertaken to start some research activities with this device.



SBI Plasma Welidng, picture from Matthias Moschinger / IMAT

In a project with voestalpine Böhler welding the hot cracking susceptibility of different alloys is systematically investigated. Therefore, self-restraint samples are welded, characterized using dye penetrant testing and subsequently investigated using different metallographic methods. Similarly, dissimilar joints produced using electron beam welding are characterized using micro-CT and thereafter with a target-preparation metallographically investigated in more detail.

In the reporting period also, different projects were successfully finished. “3DWelding - Additive Manufacturing of Structural Steel Elements” as well as "NAT - New developments in anchor technique" were closed after some year of intense collaboration at TU Graz and beyond. Several publications in different media report about different aspects of 3D Printing and special joining processes for very specific applications. The results enable completely new approaches and solutions in civil engineering. However, sometimes one also has to accept limits of physics and consider alternative solutions to overcome such boundaries. This gives room for further fundamental research and further development.

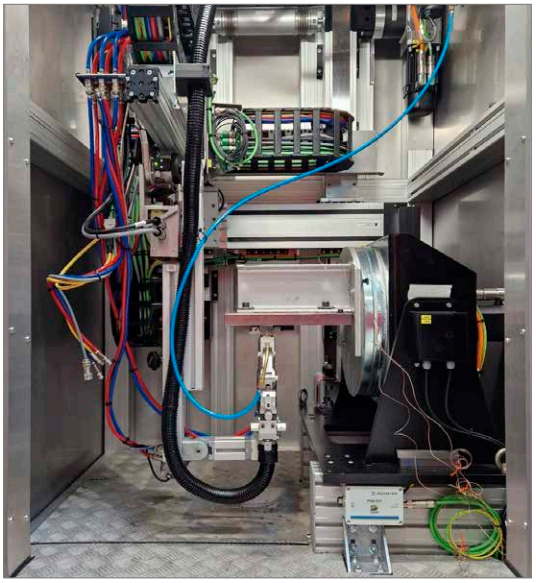
Figure 1: shear force connection for civil engineering application based on wire based additive manufacturing.
Holzinger, Christoph: Additive Fabrication of Structural Steel Elements. PhD Thesis 2022, TU Graz, ITE
picture: © Christoph Holzinger / TU Graz - ITE

We3D - Wire-based additive manufacturing - materials and technologies - for 3D metal structures of the future

A subproject in We3D deals with the additive reconstruction of typical tempering steel. To be able to do this economically, the aim is to investigate whether it is possible to rebuild structures by welding in the overhead position. Not only the overhead position but also the materials used to pose a challenge, as they are widely considered difficult or impossible to weld. Since the Plasma Wire Arc Additive Manufacturing (PWAAM) process is a welding process, the connection to the used components is a big challenge. Due to high carbon content of the substrate, traditionally high preheat temperatures are required, which for final application must be minimised as well.

Since high technical demands are placed not only on the connection but also on the manufactured structures and layers following standards, the materials, and mechanical properties of these must be designed accordingly. The challenge in this project is to control the microstructure with the help of the process itself to avoid a post-heat treatment and the associated additional economic impact.

Due to good preparations, the M3DP-SL additive manufacturing machine from SBI GmbH could be integrated quickly into the existing infrastructure of TU Graz and "Arc on" is reported in May 2022. Special welding consumables from Voestalpine Böhler Welding are used in this project. First studies in the flat position (PA) as well as in the overhead position (PE) are performed to gain experience regarding the processability of the materials in different positions. The findings from these studies form the basis for further investigations. An optimised setup for subsequent experiments was realized by improved clamping possibilities but also adjustments to the wire feeding system.



Experimental setup for overhead position

Welding CCT diagrams were determined for a potential filler material. These data provide important information to plan the AM process considering the filler material and thus to optimize path planning. However, not only the used filler metals and their properties are of interest, but also the used base materials. Studies have also been conducted to better understand the structural changes in the substrate caused by the process and the resulting properties. For example, the effect of multiple thermal cycles caused by the AM process of single-track structures on the heat-affected zone in the substrate and the heat treatment of the new layers has already been investigated.

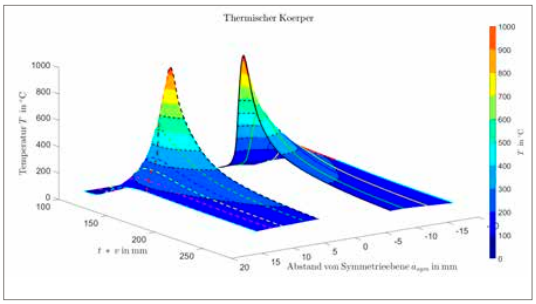


Figure 3: thermal body due to AM comparison of simulation and experiment

Additionally to the experiments, a numerical simulation of certain aspects was performed. A validated thermal body was generated (Figure 3), which represents the quasi steady state process properly and can be used for further modelling activities. Figure 4 shows a distortion simulation. Its results corresponded well with reality. However, welding residual stresses remain challenging; material model, temperature and phase dependent properties must be determined.

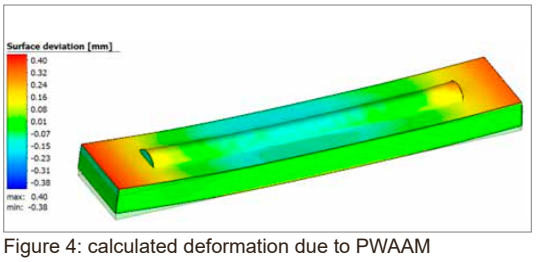


Figure 4: calculated deformation due to PWAAM

Ongoing projects

- We3D - Wire-based additive manufacturing – materials and technologies – for 3D metal structures of the future, (FFG, COMET- K-Project, 2021 - 2025)
- TMW - Thermomechanical Welding (FWF, 2019 - 2024)
- We3D - Wire-based additive manufacturing – materials and technologies – for 3D metal structures of the future (FFG COMET K-Project, Amt der Steiermärkischen Landesregierung, LKR Leichtmetallkompetenzzentrum Ranshofen GmbH, 2021 - 2025)
- Green welding for H_2 - Green Welding for hydrogen economy (voestalpine Böhler Welding Austria GmbH, 2021 - 2023)

Completed projects

- IBM-Sys - Intelligent coating systems on multi-metallic composite structures for automotive production (CEST - Kompetenzzentrum für elektrochemische Oberflächentechnologie GmbH, FFG, 2021 - 2022)
- AM Tool - Wire based Additive Manufacturing of tool components (FFG COMET K-Project, MCL, 2018 - 2021)
- HPW - High Performance Wire für ressourceneffiziente Mobilität und High End Oil & Gas Products (voestalpine Wire Rod Austria GmbH, 2019 - 2022)
- NAT - New developments in anchor technique (FFG, 2019 - 2021)
- TIRL - Thermally induced load (Dobeneck-Technologie-Stiftung, 2020 - 2021)
- 3DWelding - Addtive Manufacturing of Structural Steel Elements (FFG, ABB AG, Fronius International GmbH, voestalpine Böhler Welding GmbH, Wirtschaftskammer Österreich - Fachverband Metalltechnische Industrie, Zeman Bauelemente, 2020 - 2022)
- HISCC UHSS bolts - Improvement of hydrogen induced stress corrosion cracking resistance of ultra-high strength steel screws and fasteners (CEST - Kompetenzzentrum für elektrochemische Oberflächentechnologie GmbH; voestalpine Wire Rod Austria GmbH, 2018 - 2021)
- EBW thick walled cylinder (INNIO Jenbacher, Dobeneck-Technologie-Stiftung, 2020 - 2021)
- AMNibas - Wire based additive fabrication of NiBas Inconel with electron beam (Dobeneck-Technologie-Stiftung, 2021 - 2022)
- Research on electron beam weldability of hard to join dissimilar materials WTZ project Slovakia / Austria "hard to weld materials" OeaD, 2021 - 2023)

Editorial tasks

- Welding International, Associate Editor: Norbert Enzinger
- Welding in the World, Member of Editorial Board: Norbert Enzinger
- Journal of Welding and Joining (JWJ, South Korea), International Editorial Staff: Norbert Enzinger

Lightweight and Forming Technologies

From left to right: Nino Müllner (technician), Arash Shafiee Sabet (PhD student), Josef Domitner (group leader), Emir Hodzic (PhD student), Eva Keinrath (secretary), David Gomboc (student employee), Zahra Silvayeh (PhD student), Patrick Schneeberger (master student), Eva Graf (PhD student), Theodor Felser (apprentice), Lejla Muratovic (student employee), Peter Auer (scientific staff).
Not in the picture: Andreas Drexler (deputy group leader), Maialen Aguirregoicoa Ocerin (student employee), Heinz Fasching (technician), Jennifer Stippich (student employee)

In order to highlight the key research areas the Tools and Forming Research Group was be renamed in 2022 as the *Research Group for Lightweight and Forming Technologies*.

The main research areas of the *LFT Lightweight and Forming Technologies* Research Group include lightweight technologies, metal forming technologies, mechanical joining processes, hydrogen effects in materials and tribology in forming processes. The investigations are performed both experimentally and numerically using finite element (FE) simulations. The research projects are usually conducted in close collaboration with partners from the metallurgical, metal working and automotive industries. In the field of hydrogen research we collaborate with the HyCentA GmbH and with the Austrian steel industry.

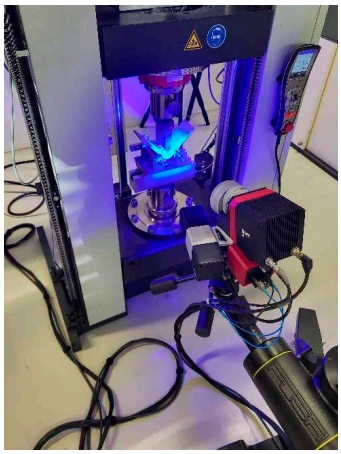
The result of this is that we have very strong key competences in the fields of

- Lightweight technologies
- Hot and cold forming technologies with a focus on deep drawing
- Mechanical joining processes
- Hydrogen in materials
- Tribology in forming processes

CARpenTiER - Modelling, Production and Processing of Eco-hybrid Structures and Materials

In the automotive sector the demand for sustainable lightweight materials that are able to replace conventional steels is steadily increasing. Hybrid components of wood-based materials offer a high potential for automotive lightweight applications due to their high strength-to-weight ratio. Nevertheless, the high variability of mechanical properties due to the natural growth of wood has resulted in a lack of data regarding forming and joining. The CARpenTiER project wants to overcome these obstacles by investigating conventional forming and joining technologies on metal-wood components. Additionally, the aim is to implement a function-oriented process control system and suitable finite element models (FEM) capable of predicting the components' behaviour.

To investigate the bending behavior of hybrid aluminum-wood components, three-point bending tests were carried out. Since the mechanical properties of wood are highly influenced by moisture and temperature, the components were tested in different conditions. The bending behavior was evaluated in terms of maximum bending force, bending angle and strain field measurements. The strain field during the bending test was determined on the basis of a digital image correlation (as shown in Figure 6). Additional finite element models (FEM) by the Virtual Vehicle Research GmbH with input parameters previously determined in several material tests were implemented. As illustrated in Figure 7, the model was able to predict the strain fields for hybrid aluminum-wood components quite well.



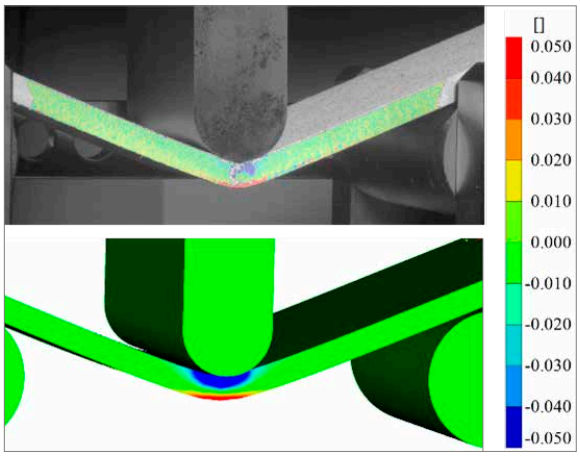


Figure 6: Three-point bending test with simultaneous optical strain field measurement based on digital image correlation (DIC).

Figure 7: Comparison of strain fields evaluated (a) in the real experiment with DIC and (b) in the FE model.

Regarding the joining of metal and wood, different conventional joining technologies were tested. For example, self-pierce riveting, adhesive and screw bonding between aluminum alloy sheets and cross-laminated wood veneers (as shown in Figure 8) were investigated in terms of static and dynamic mechanical performance.

Figure 8: Cross-section of an adhesive and screw-bonded aluminum-wood component.

TS-Geotexous - Development of deep-drawing and punching tools with optimized geometries, textured surfaces and ultrasonic support

Finite element modeling of forming and cutting processes is nowadays very important in the industry. Modeling of high-speed forming processes is still elaborate because strain rate-dependent and temperature-dependent material properties are required for creating accurate process models. Therefore, the flow curves of technically pure aluminum, deep drawing steel and high-strength steel at different strain rates were determined between room temperature and 300 °C by means of quasi-static and high-speed tensile tests. The flow curves generated from these tests were employed in finite element simulations of deep drawing and cutting processes. The results of the simulations were compared with the geometry of deep-drawn / punched industrial components that were captured with a 3D scanner. A significant improvement of the simulation results was achieved by using the experimentally determined flow curves at different strain rates and temperatures for each of the three materials.

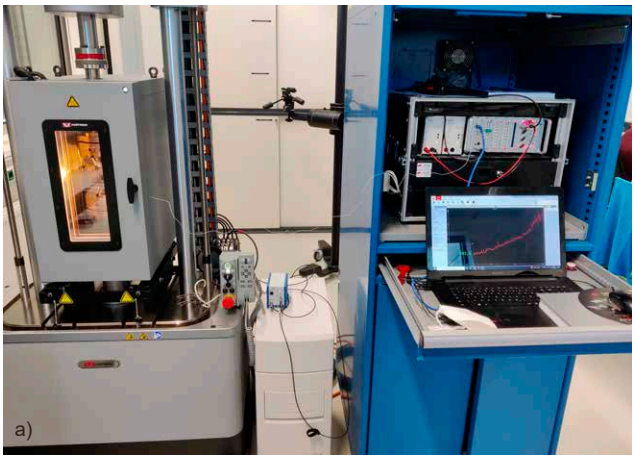


Figure 4: Instron ELECTROPULS® E10000 – tensile tests up to 300°C and strain rates from 0.001 to 1 [1/s]

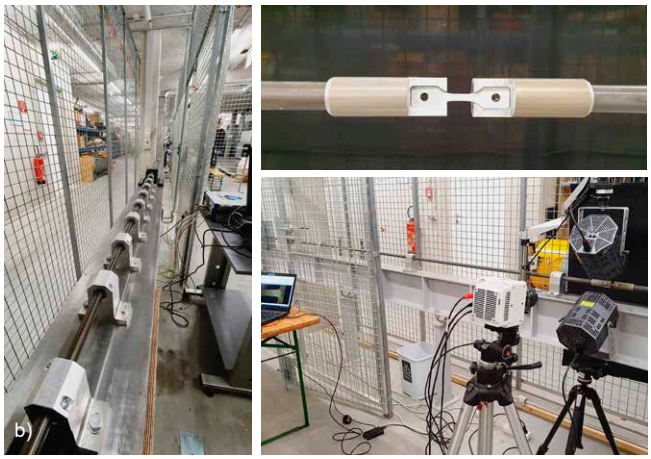


Figure 5: Universal Split Hopkinson Testing Machine [@VSI] – tensile tests at RT/100°C and up to strain rates of 1000 [1/s]

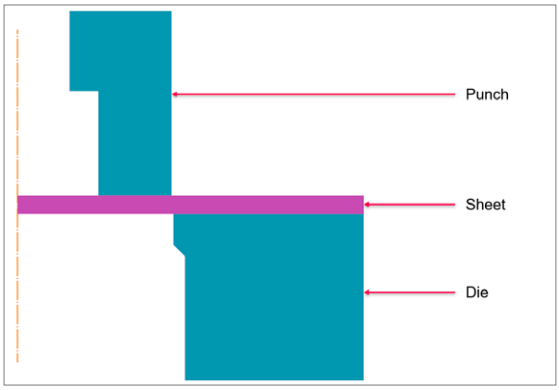


Figure 6: 2D-FEM-Simulation model of a simple punching process using DEFORM-2D simulation software

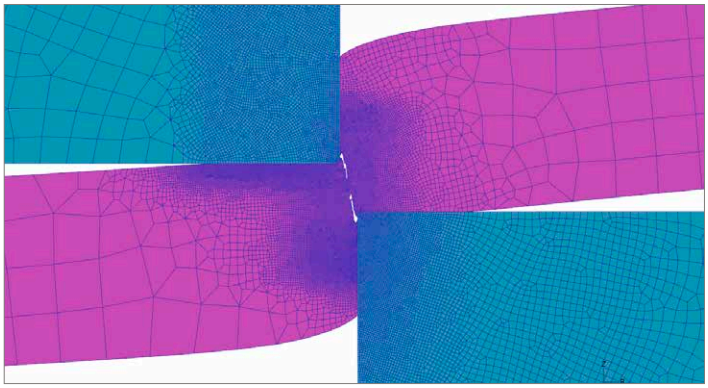


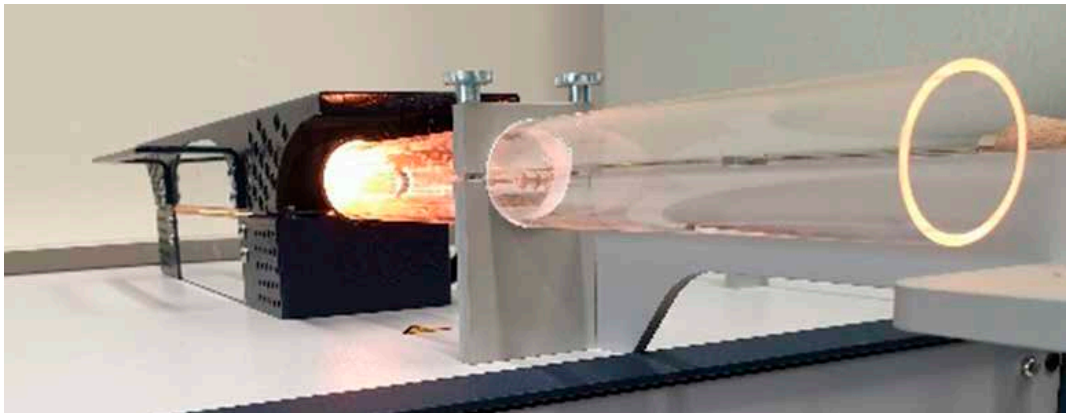
Figure 7: Detail of 2D-FEM-Simulation of a simple cutting process using DEFORM-2D

Ongoing projects

- AluEx - Expertises in Aluminum Forming, AMAG rolling GmbH (2020 - 2023)
- HySteel - Hydrogen Embrittlement of Steels for the Energy Industry, voestalpine Grobblech GmbH (2023 - 2023)
- HyWeld - Numerical Simulation of Hydrogen Diffusion in Pipeline Welds, BAM Bundesanstalt für Materialforschung und -prüfung (DE), (2023 - 2025)
- XRoll - Investigation of Roll Wear on a Cross-roll Straightening Machine, voestalpine Tubulars GmbH (2023 - 2024)
- TS-Geotexous - Development of deep-drawing and punching tools with optimized geometries, textured surfaces and ultrasonic support (FFG, Mark Metallwarenfabrik GmbH, (2021 - 2024)
- CARpenTiER - Modelling, Production and Processing of Eco-hybrid Structures and Materials (FFG, SFG, Innovationszentrum W.E.I.Z., W.E.I.Z. Forschungs & EntwicklungsGmbH, 2021 - 2025)

Completed projects

- AluForm - Experimental and Numerical Investigations on the Deep-Drawability of New Aluminum Alloys (AMAG rolling GmbH, 2020 - 2023)
- Sunrise - Wear Investigations on New Roll Materials (Sunrise - Wear Investigations on New Roll Materials, 2020 - 2023)
- Rollprüfstand (Eisenwerk Sulzau-Werfen, 2018 - 2021)
- AluTribo - Tribologie in der Aluminiumblech-Umformung (Magna COSMA, 2019 - 2022)
- AluFric - Friction Modelling in Aluminum Sheet Forming (Cosma Engineering Europe GmbH, 2021 - 2022)



G8 Brucker Galileo H analyzer for quality control and research

Modelling and Simulation

From left to right: Saham Sadat Sharifi (PhD student), Michael Basta (master student), Esmail Shahryari (PhD student), Danijela Crnovčić (bachelor student), Cecilia Poletti (group leader), Stefan Pierer (bachelor student), Stefan Fortmüller (PhD student), Markus Maßwohl (elite student), Franz Miller Branco Ferraz (PhD student), David Knogler (bachelor student), Talina Terrazas Monje (university assistant and PhD student)
The following PhD students are not in the picture: Kasyap Pradeep, Peng Wang, Hamed Davoodi

The *modelling and simulation group* is constituted to provide basic knowledge in the field of materials science and to support the other groups at IMAT as well as external partners with the interpretation of physical phenomena by the use of models, experimental validation and computing simulations. The group is prepared to integrate multiscale materials models to simulate the response of workpieces during industrial processes.

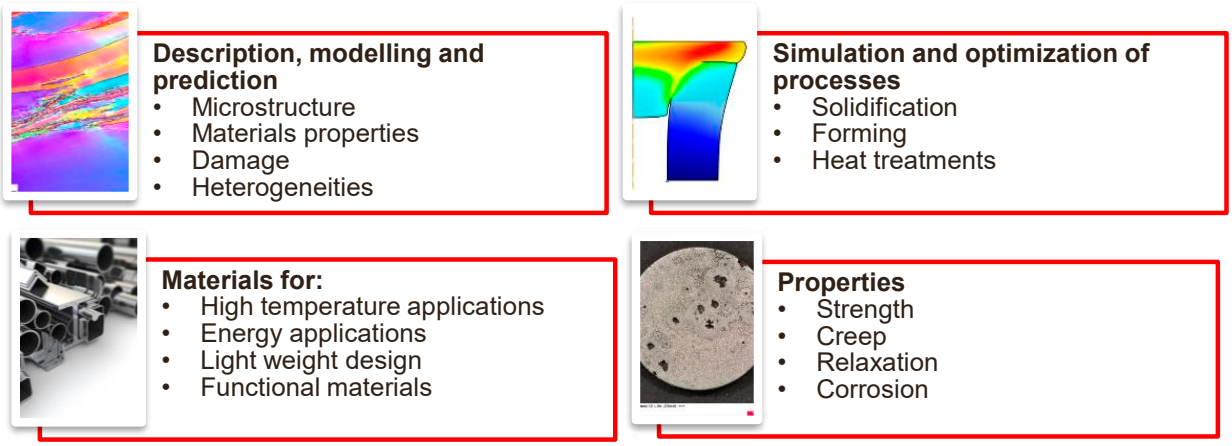


Figure 1. Main topics covered by the Modelling and Simulation Group

The Modelling and Simulation Group focuses on the description, modelling and simulation of materials microstructures and properties of materials under different processing routes. Our main goal is to understand and describe the **microstructural evolution** during **processing** and **service** and link it to the **materials properties**, such as strength, plastic deformation, volume changes and heat flow. We support internal and external projects (grey in the figure below). The *Christian Doppler Laboratory for Design of High-Performance Alloys by Thermomechanical Processing* and the mobility project OeAD WTZ India, led by Cecilia Poletti, belong to the research group.

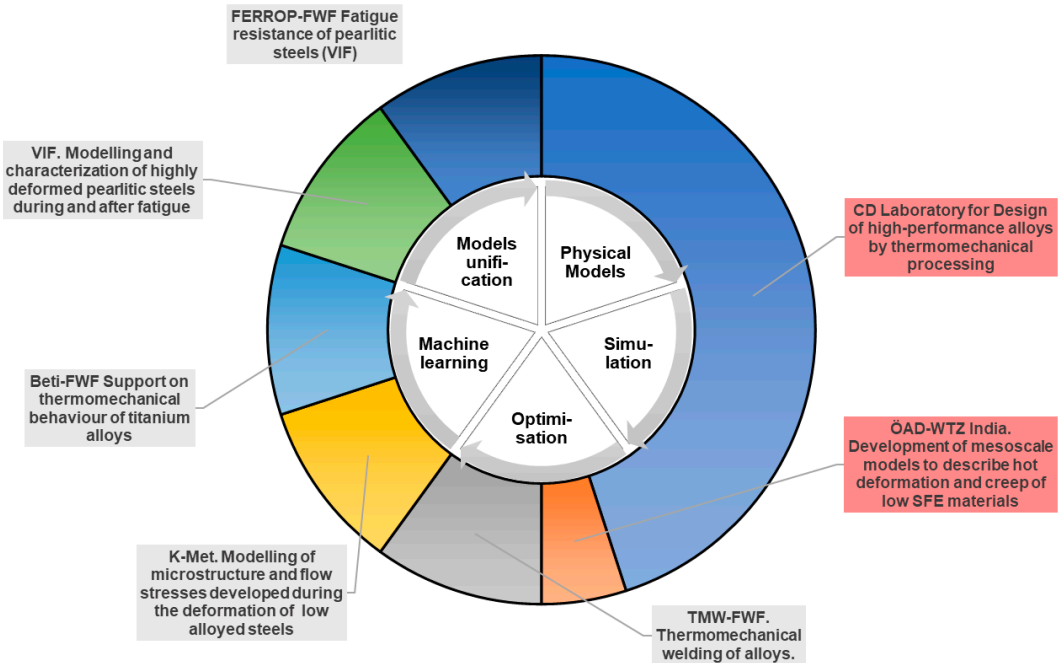


Figure 2. Acquired projects (red) and participation in projects (grey)

Activities 2022-2023 and highlights.

In the past years, the group was active in the following topics:

Development of **mesoscale physically based models** to describe the microstructure evolution during

- hot deformation of wrought titanium, aluminium and high entropy alloys, as well as low alloyed steels
- cold deformation of aluminium alloys and pearlitic steels
- relaxation of cast aluminium alloys during ageing
- creep of nickel-based superalloys and Cr-steels
- heat treatments of all the alloys mentioned above

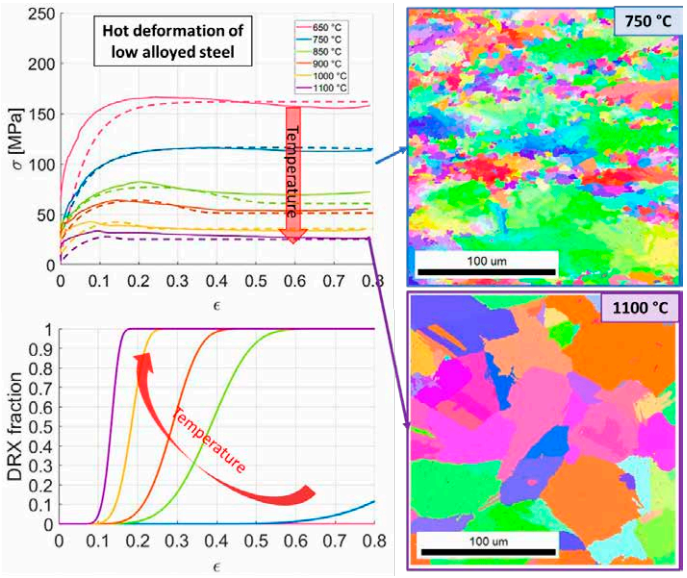


Figure 3. Modelling and characterisation of the dynamic recrystallisation in low carbon steels (Saham Sadat Sharifi)

- Coupling of thermodynamic, microstructural and mechanical models to account for heterogeneities during the processing of metallic materials
- Implementation of flow localization models in finite element simulations to predict flow localization and microstructure evolution during hot forming of titanium alloys
- Determination and prediction of phase transformation kinetics in titanium alloys and steels
- Characterization and simulation of precipitation kinetics in cast aluminium alloys using MatCalc
- Validation of models using experimental thermal/mechanical testing and microstructural characterization
- Development of corrosion-resistant aluminium cast alloys and processing of newly developed high entropy alloys

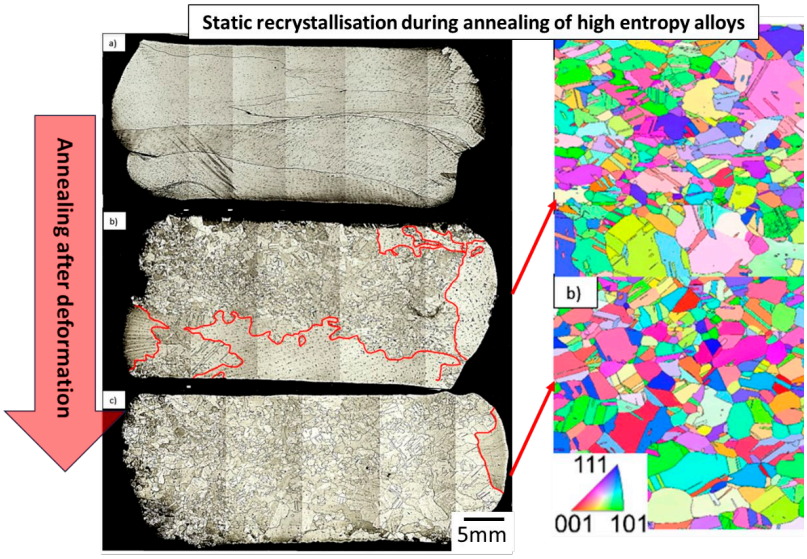


Figure 4. Processing High Entropy Alloys to refine the grains from casting (Markus Maßwohl)

International exchanges are part of the culture of our group. We host researchers and students and enjoy being abroad.

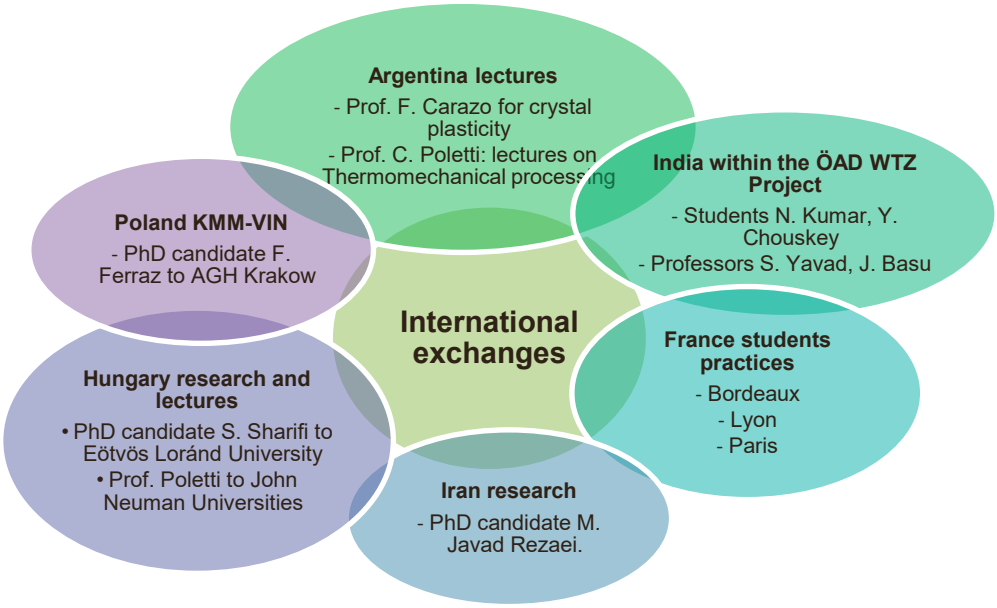


Figure 5. Highlights of exchanges for lectures and research work

Ongoing projects

- FWF - FERROP - Fatigue crack growth in severely shear-deformed pearlite (FWF, 2022 - 2025)
- Software Development - Software Development on Dislocation Creep in Alloys (FWF, project no. P 31374-N36, 2018 - 2022)
- CD Laboratory for Design of high-performance alloys by thermomechanical processing (Christian Doppler Forschungsgesellschaft, 2017 - 2024)
- OeAD-WTZ India. Development of mesoscale models to describe hot deformation and creep of low SFE materials

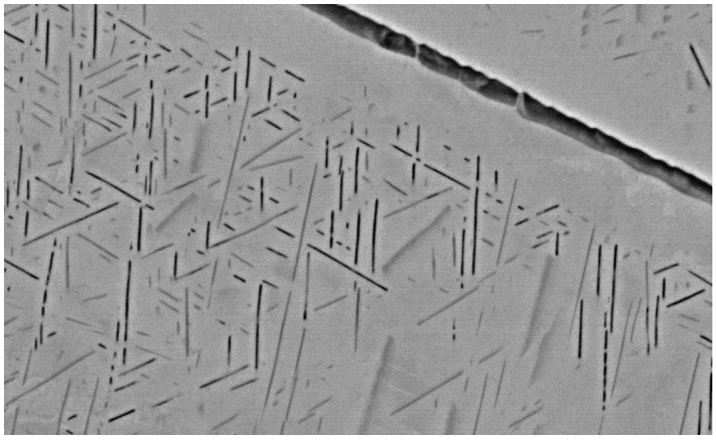
Participation in projects

- TMW-FWF. Support on thermomechanical behaviour of alloys
- K-Met. Modelling of microstructure and flow stresses developed during the deformation of austenitic and ferritic phases in low alloyed steels
- Beti-FWF Support on thermomechanical behaviour of titanium alloys
- VIF. Support on modelling and characterization of highly deformed pearlitic steels during and after fatigue
- FERROP-FWF external project (VIF)

Editorial tasks

- MDPI Special Issue "Microstructure Characterization and Design of Alloys". Editors: Silvana Sommadossi, Cecilia Poletti and Ricardo Buzolin.
- Key Engineering Materials. Editor in Chief: Cecilia Poletti

For the scientific activities of the CD-Laboratory in detail, please check the corresponding chapter in this report.



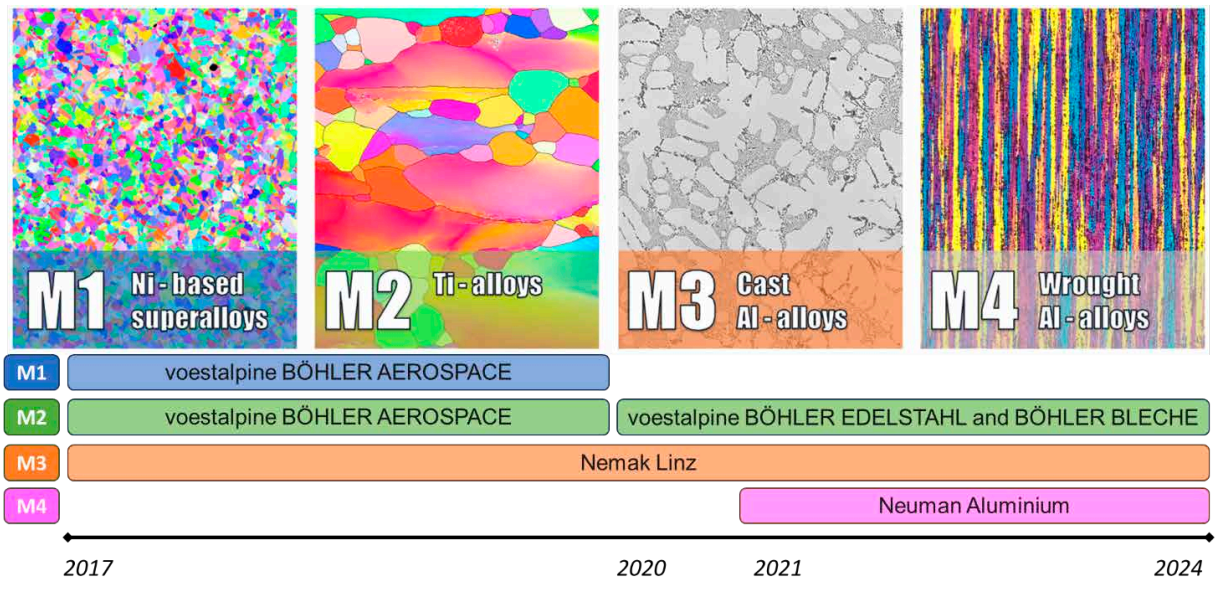
Microstructure of a near beta titanium alloy before hot deformation.
picture: Esmaeil Shahryari

Christian Doppler Laboratory

CD-Lab Team, from left to right: Stefan Fortmüller (PhD student), Danijela Crnovčić (bachelor student), Michael Basta (master student), Cecilia Poletti (leadership), Markus Maßwohl (elite and bachelor student), Manuela Prader (secretary), Leander Herbitschek (technician) Franz Ferraz (PhD student), Talina Terrazas Monje (university assistant and PhD student).

Progress within the CD Laboratory for Design of high-performance alloys by thermomechanical processing

The CD-Laboratory, active since the 1st of May 2017 under the leadership of Prof. Maria Cecilia Poletti, is reaching its last year. Our aim is to collaborate with processing industries to answer technological questions with a scientific approach. The Laboratory comprises **4 Modules** focused on optimising thermomechanical processes for high-performance materials.

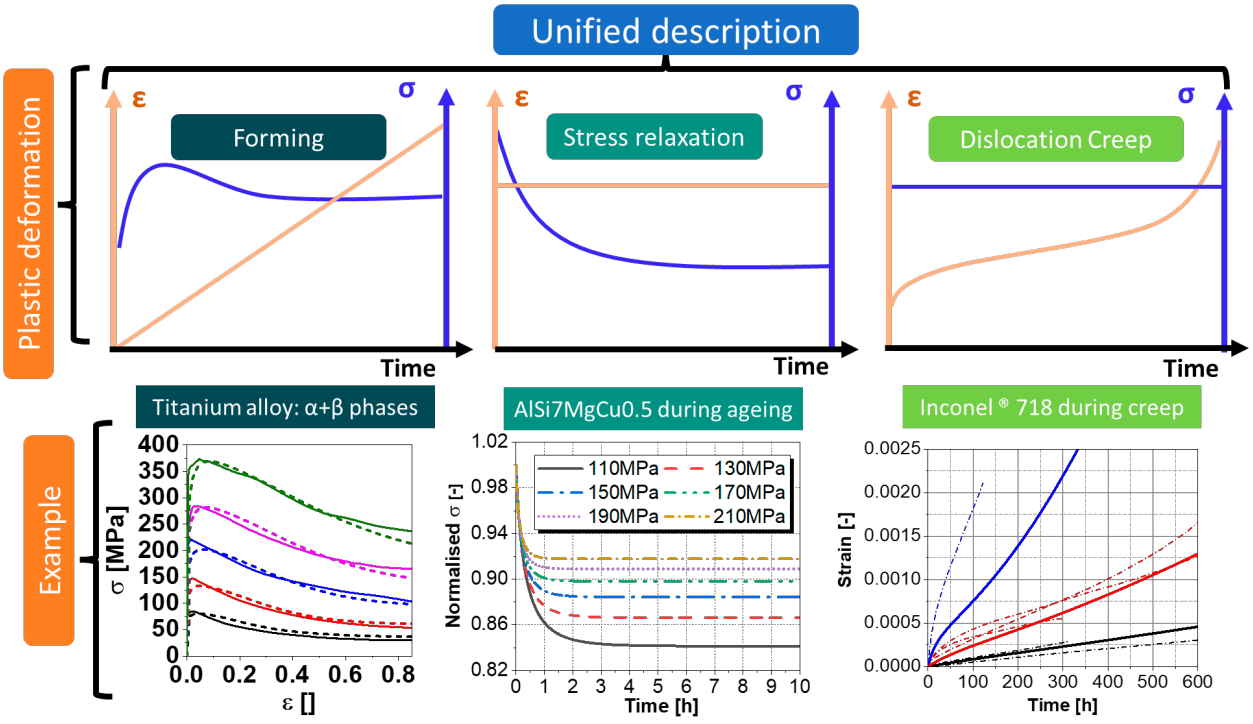


About the group

The strength of this CD-Lab lies in the people who contributed with their work, experience, and commitment.
The contribution of students and post-docs is essential to tackle complex scientific questions, challenging experiments and intricate models. They are the post-docs Friedrich Krumphals and Ricardo Buzolin (the latter is also a PhD candidate), the **PhD candidates** Kashyap Pradeep, René Wang, Franz Ferraz, Stefan Fortmüller and Talina Terrazas Monje, the **master students** Franco Lizzi, Desirée Weiß, Emilia Guntsche, Dinesh Ram, Carolina Gonzalez and Marlene Eichlseder and the **bachelor students** Markus Maßwohl, Danijela Crnovcic, Thomas Stamer and David Knogler. Over the years, we also had the scientific support of Mariana Poliserpi, Peng Wang and Mohammed Nasiri.
Leander Herbitschek takes care in the laboratory of **technical aspects** related to samples and the proper functioning of the machines, while Manuela Prader is in charge of the **office**.

Main scientific achievements

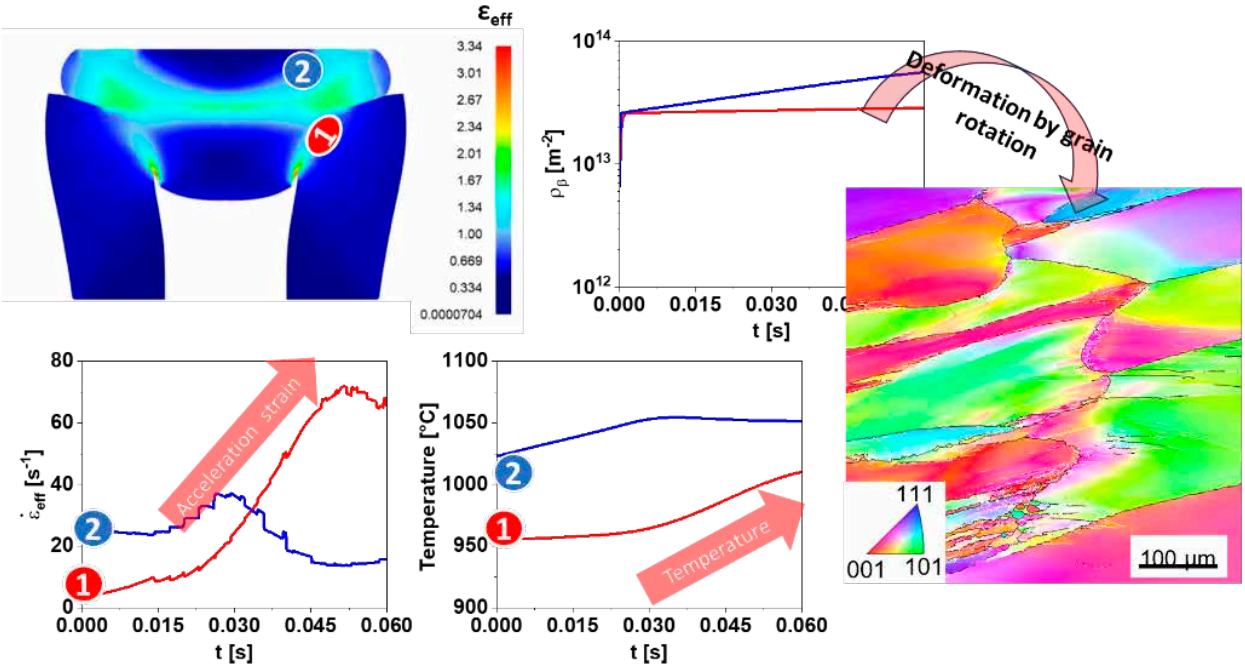
Over the years, we have dealt with the behaviour of high-performance alloys under thermal and thermomechanical loads. These multiphase alloys modified their microstructure during processing and service.
We are able to: » describe and predict **creep, stress relaxation,** and **hot deformation** of alloys using the same physical rules.
We developed a model based on dislocation densities, grain boundaries and secondary phases that also works for materials with allotropic phase transformations.



» use high-quality **experimental data** for supporting and elucidating physical descriptions. Apart from traditional methods for materials testing and characterisation, we also used methods together with our scientific partners:

- Difference dilatometer to follow restoration mechanisms in aluminium alloys (Institute of Materials Physics),
- Split-Hopkinson tests to reach deformation rates above 1000s-1 (Vehicle Safety Institute)
- TEM to identify phases in aluminium alloys (FELMI)
- Kelvin probe microscopy to localise electrochemical potential differences that affect corrosion resistance in aluminium cast alloys (Universidad Autónoma de Madrid)
- Synchrotron XRD measurements to determine dislocation densities (Desy-Hamburg).

» implement physical models in FEM to simulate the microstructural evolution under **heterogeneous processing conditions** within industrial workpieces.



» determine the **phase transformation and precipitation kinetics** in cast aluminium alloy during solidification and heat treatments: solid solution heat treatment, ageing and continuous heating.
» determine the **phase kinetics** in Transient Liquid Bondings.
» explore the **hot-forming routes** of high entropy alloys and explain their behaviour under thermomechanical loads.

Output in numbers

Publications
- 20 journal papers
- 7 conference papers
- 30 oral presentations
- 8 conference posters

PhD theses
- 1 finished
- 1 external finished
- 5 in progress

Master/Bachelor theses
- 6 master theses
- 1 bachelor thesis
- 2 bachelor theses in progress

Industrial relevance

Determining the correlation between the process and mechanical properties is one of the most exciting topics in Materials Science. We derive our motivation for scientific study from industrial processes and requirements. As a counterpart, we provide cutting-edge knowledge that supports the development of products with improved or new properties and optimise industrial processes. Finally, our models allow industries to predict the mechanical properties of metallic parts conventionally processed by forging, extrusion, rolling and casting. The basic knowledge can also support the development of new alloys and processing methods.

National and international cooperation

Our group's geographical position and international and interdisciplinary characteristics provide an excellent national and international cooperation framework.

FELMI: TEM for precipitates and phases

MTF STU: Dislocations and precipitates

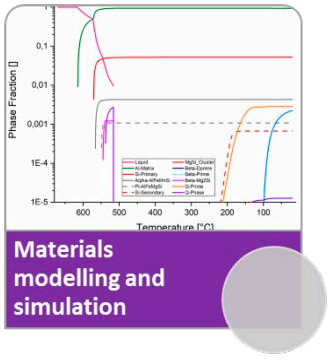
University of Tokyo: Confocal laser microscopy

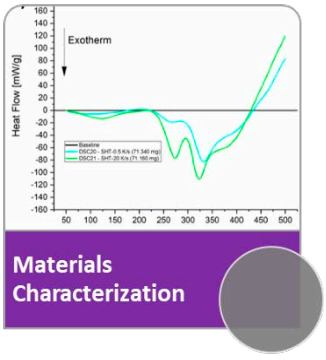
Comahue National University: production of new joins

Łukasiewicz - Krakow Institute of Technology: High entropy alloys

TU Vienna: MatCalc for Alu precipitation

AGH and TU Graz (Electrotechnics): Metamodelling, Model parametrization and optimization





UBC: Laser ultrasound for microstructural characterization

TU Graz (Physics): Positron annihilation, dilatometry, µCT

TU Graz (Chemistry): Differential scanning calorimetry

Publications and scientific output

You can find all our publications at this link:

► https://www.tugraz.at/institute/imat/research/research-groups/cdl-christian-doppler-laboratory

EUROPEAN JOURNAL OF MATERIALS
https://doi.org/10.1080/26889277.2022.2125350

Topological aspects in the microstructural evolution of AA6082 during hot plastic deformation

Ricardo Henrique Buzolin[a,b], Friedrich Krumphals[c], Maria Cecilia Poletti[a,b]

ABSTRACT

Journal of Alloys and Compounds 956 (2023) 170310

Contents lists available at ScienceDirect

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Research Article

Thermomechanical treatments for a dual phase cast high entropy alloy

Ricardo Henrique Buzolin [a,b,*], Markus Masswohl [a,b], Franz Miller Branco Ferraz [a,b], Konrad Chrzan [c], Tomasz Dudziak [c], Maria Cecilia Poletti [a,b]

crystals

MDPI

Article

Stress Relaxation during Artificial Aging of an $AlSi_7Cu_{0.5}Mg$ Cast Alloy

René Wang [1,2,*], Dinesh Ram [1,3,4], Bernhard Stauder [5], Ricardo Fernández Gutiérrez [5], Elisabetta Gariboldi [6] and Maria Cecilia Poletti [1,2]

Materials Science & Engineering A 872 (2023) 144931

Contents lists available at ScienceDirect

Materials Science & Engineering A

journal homepage: www.elsevier.com/locate/msea

Microstructure refinement of a cast high entropy alloy by thermomechanical treatments

Ricardo Henrique Buzolin [a,b,*], Markus Masswohl [a,b], Franz Miller Branco Ferraz [a,b], Konrad Chrzan [c], Tomasz Dudziak [c], Maria Cecilia Poletti [a,b]

Materials Today Communications 35 (2023) 106148

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Metamodelling the hot deformation behaviour of titanium alloys using a mean-field approach

Franz Miller Branco Ferraz [a,b,*], Łukasz Sztangret [c], Fernando Carazo [e,f], Ricardo Henrique Buzolin [a,b], Peng Wang [a], Danuta Szeliga [c], Pedro dos Santos Effertz [g], Piotr Maciol [c], Alfred Krumphals [d], Maria Cecilia Poletti [a,b]

ARTICLE INFO

Keywords:
Hot deformation
Metamodel
Artificial neural network
Decision-tree regression
Titanium alloys
Mean-field model

ABSTRACT

During the thermomechanical processing of titanium alloys in the β-domain, the β-phase undergoes restoration phenomena. This work describes them by a mean-field physical model that correlates the flow stress with the microstructural evolution. To reduce the computational time of process simulations, metamodels are developed for specific outputs of the mean-field physical model using Artificial Neural Network (ANN) and Decision Tree Regression (DTR). The performance of the obtained metamodels is evaluated in terms of the coefficient of determination (R^2), the root-mean-square error (RMSE), and the mean relative error (MRE). No significant difference was observed between $R^2_{training}$ and $R^2_{testing}$, meaning that all the metamodels correctly generalise the overall behaviour of the outputs for a wide range of inputs. The evolution of the metamodel outputs is compared with the model predictions in two different situations: 1) at a constant strain rate and temperature, and 2) during

Laboratories and Workshops

From left to right: Theodor Felser (apprentice), Gerhard Kukutschki (external lecturer and failure case expert), Nino Müllner, Heinz Karl Fasching (group leader LFT), Thomas Staubmann, Herbert Penker, Leander Herbitschek, Kurt Kerschbaumer (group leader), Gernot Stöfan (deputy), Thomas Friedl, Julian Koch (apprentice)

In August 2022, a second-hand Charpy pendulum impact tester from Zwick/Roell was added to the laboratory equipment available at IMAT for mechanical materials testing. Thomas Staubmann (Ing.) took over from his predecessor Corinna Mühlak on 1 October 2021, taking charge of the laboratory activities Teaching Metallography, Mechanical Materials Testing and Spark Optical Emission Spectrometry.

The new plasma welding machine from SBI was officially taken into operation at the LFT laboratory with a presentation on 13 May 2022. A SafanDarley guillotine shear was also purchased for the workshop area of the LFT in Inffeldgasse in 2022. The old machine used for cutting metallographic samples was replaced with the new Labotom 20 cutting machine in September 2022. Julian Koch began a materials engineer traineeship at IMAT at the same time. Wolfgang Steinbäck, chemist and operator of our corrosion laboratory, left IMAT on 31 August 2022. A new “Uranos” welding power supply was donated to the welding laboratory by Voestalpine Böhler Welding in January 2023. Tensile testing of samples in a corrosion cell began in April 2023 with the aim of investigating the influence of hydrogen on corrosion.

new in the **Main fields**

- Corrosion *- In-situ Electrochemical Hydrogen Charging Cell*
- Metallography *- Pendulum 450J*
- Microscopy
- Physical testing
- Joining *- Plasma Welding*
- Creep
- Heat treatment
- Tools and Forming *- Guillotine shears SafanDarley*
- addLab

www.tugraz.at/institute/imat/services/laboratory/

www.tugraz.at/institute/imat/research/research-groups/lightweight-and-forming-technologies

Investments

450J Pendulum impact testing machine

In August 2021, IMAT bought the second-hand Zwick/Roell RP450 pendulum impact testing machine from TÜV Süd in Munich to replace the existing 300-joule pendulum from Otto Wolpert – Werke without an enclosure. This enables Charpy impact tests up to 450 joules. The measuring unit connected to the machine can send the measured impact energy to a computer. Thanks to the protective enclosure, the motorised hammer lift and the electrical trigger mechanism, it is now possible to perform Charpy impact tests with significantly improved safety for both project and research work, as well as when teaching to a large group of students.

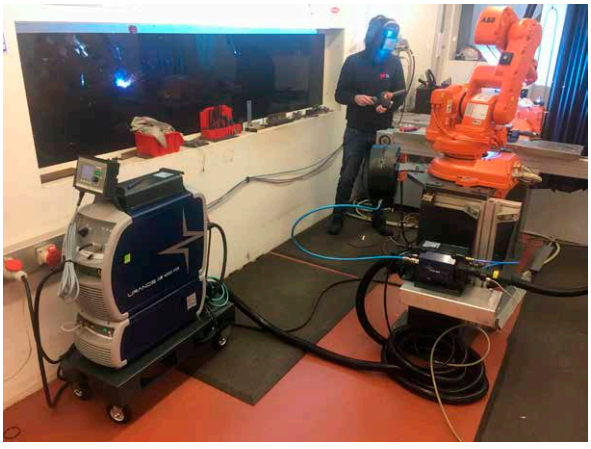
Pendulum impact testing machine

Labotom20 cutting machine

This cutting machine was purchased in September 2022 as a replacement for the existing WOCO Top machine. It is a significant improvement for cooled precision cutting of large workpieces and particularly hard materials.

Voestalpine Böhler Welding power supply

Voestalpine Böhler Welding, the global market leader for welding technology and a long-standing cooperation partner of IMAT, provided us with a Uranos NX 4000 PSR power supply for our research and teaching activities. It went into operation in January 2023.



Voestalpine Böhler Welding power supply

Corrosion cell

A corrosion cell was developed and commissioned on the servo-hydraulic PSA testing machine in April 2023 for physical testing of samples under the influence of hydrogen. This allows us to perform CLT, SSRT and ISLT tests under defined electrochemical conditions.

*IEHCC = In-situ Electrochemical Hydrogen Charging Cell

In order to expedite the energy transition by using hydrogen as a source of energy, there is a great demand when it comes to testing metal materials efficiently and economically with regard to their resistance to hydrogen embrittlement (HE) – particularly the need to test HE under tensile or fatigue stress.

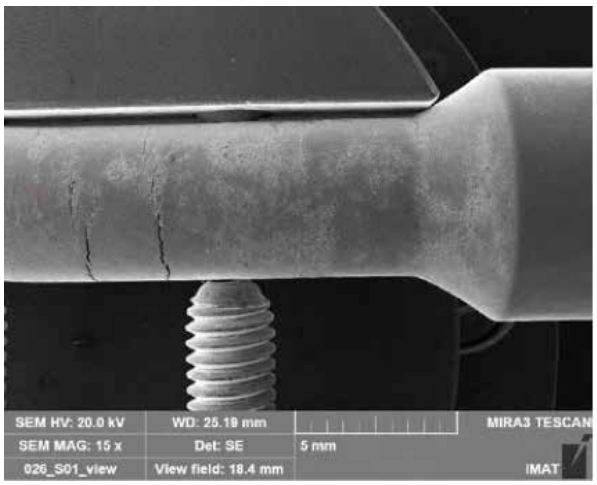
The IEHCC* system that has been developed enables testing of a tensile specimen at very small elongation rates, under constant tension/elongation or fatigue stress with simultaneous hydrogen charging. The latter is effected by polarisation in an electrolyte (saline solution/acid/alkali solution) surrounding the tensile specimen by means of the counter electrode or reference electrode.

This method of testing offers a number of advantages:

- Testing of HE-resistant materials (austenitic steels, Al, etc.)
- Efficient shortening of testing time by increasing polarisation
- Testing for stress corrosion cracking of anodic polarisation (Al, Ti, brass, etc.)
- Testing of inhomogeneous specimens (weld metals, AM components) and metallic coatings
- Testing of materials under fatigue stress
- In-situ hydrogen charging prevents falsification of results (hydrogen loss during external charging)
- Can replace charging with compressed hydrogen (up to 1000 bar H2 pressure)

Installed IEHCC at the PSA hydraulic tensile test machine


IEHCC test of a zinc-coated timber screw in salt-solution / counter electrode above



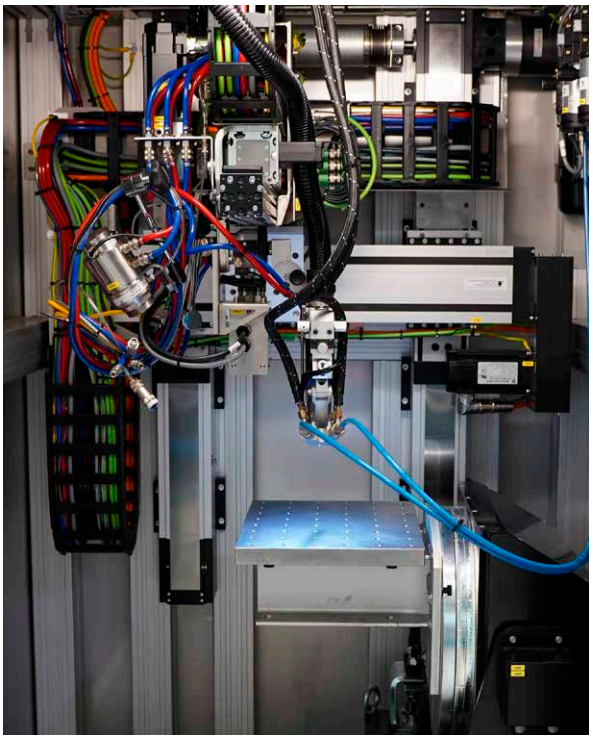
SEM image of hydrogen cracks in a tensile specimen after slow strain rate IEHCC test

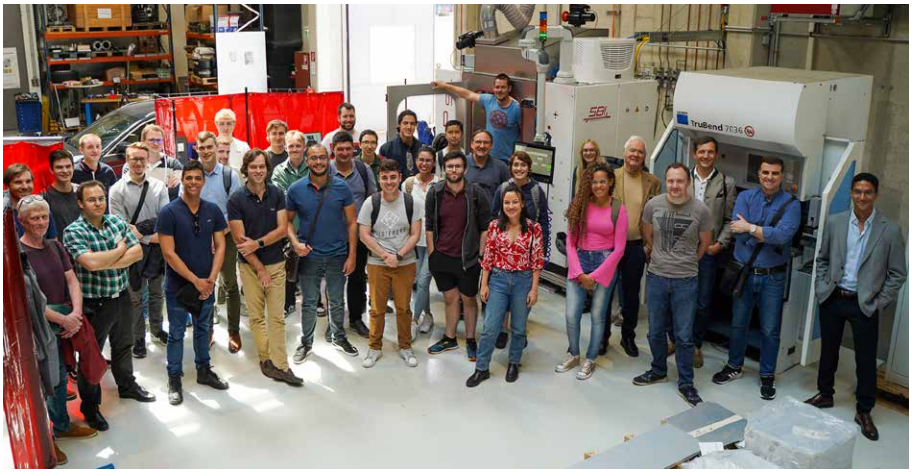
Plasma Welding - SBI M3DP-SL

At the beginning of April 2022, the Institute received the long-awaited M3DP-SL plasma printer from SBI GmbH as part of the COMET project We3D. This not only represents an expansion of the machine park but also strengthens the group of joining technology in the areas of plasma welding and wire-based additive manufacturing. The Institute was already involved in the initial planning phases to design a machine that could cater for the widest possible range of research topics. Thus, in addition to different variations in the process, such as two different welding filler wires at the same time, working in different welding positions and atmospheres, the M3DP-SL also offers the possibility of comprehensive measurement or monitoring methods. Especially in additive manufacturing, detecting and maintaining temperatures is an important factor. The M3DP-SL has several connections for thermocouples and a pyrometer. These can be easily queried in the machine controller or recorded with the rest of the machine data. This data recording is supplemented by the possibility of video recording using Arc-CAM, which offers the possibility of process monitoring. Also, a strain gauge module was installed, which allows the strain in the structure to be welded to be measured during the process.
Also, thanks to an infrastructure investment grant from the university, a laser line scanner was purchased, which was integrated into the machine with the help of SBI.

But in the beginning, the M3DP-SL had to be integrated into the existing infrastructure of the University. This had already been prepared in advance so that the necessary supply lines could be laid and connected immediately after delivery. For example, it was possible to use an existing gas supply of the process gas, which made additional complex safety concepts for gas storage unnecessary. To be able to guarantee a legally compliant exhaust air filtration, an exhaust air filtration system with an associated conveying fan was already planned and designed in the construction phase of the M3DP-SL in cooperation with the company AIGNER GmbH.

Plasma Welding SBI

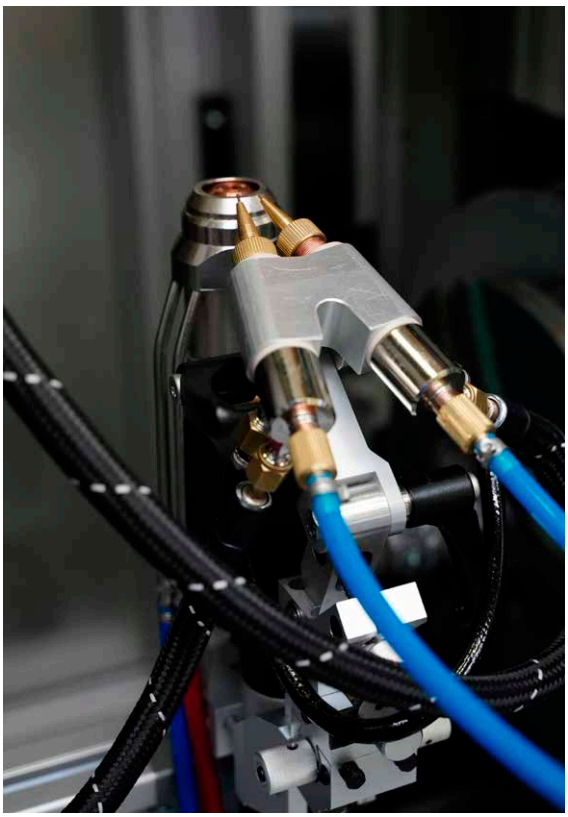

Interior of welding chamber



Official inauguration of the plasma welding SBI machine, 13.05.2022

With the addition of some consumables and supplies, within a few days of delivery of the M3DP-SL on IMAT,

we are able to say **ARC-ON!**



Torch in overhead position with two wire feeds

The cooperation with SBI GmbH did not end with the handover of the M3DP-SL to IMAT and is still continuing. Just as IMAT was involved in the planning of the M3DP-SL from the beginning, SBI GmbH will supervise further work with the M3DP-SL to ensure the greatest possible exchange of experience and to create the best possible synergy between research and industry. Therefore, the experiences from the application will also flow back to SBI GmbH and will find their way into the further development of similar systems.

Technical data:

- 350 A power source (450 A plasma torch)
- different welding modes DC-, DC+, pulsed
- hotwire with two wire feeds
- working envelope 400m-400mm-400mm (X-Y-Z)
- floodable working chamber (work in inert atmosphere)
- welding in different positions PA/PE

Different measurement systems inside the chamber:

- 6 type-K thermocouples, 1 type-S
- pyrometer
- 1 strain gauge
- arc cam
- 3D scanner

Guillotine shears SafanDarley M-Shear 205-6

In July 2022, the LFT working group purchased a guillotine shear from SafanDarley - model: M-Shear 205-6. This will allow us to cut large sheets to a maximum width of 2 meters. This machine allows us to prepare our blanks for deep drawing on our hydraulic press.

Technical data:

- Cutting capacity: 6 mm
- Bending length : 2050 mm
- Motor power : 11 kW
- No. of strokes/min (stroke length max. cutting edge): 32
- No. of strokes/min (stroke length min. cutting edge): 84
- max. cutting angle (°): 2
- Backgauge reach: 1000 mm
- Number of hold-down pads: 14

Guillotine shear

GEFERTEC

On 15 March 2022, AMAG Austria Metall AG donated a combined WAAM (Wire-Arc-Additive-Manufacturing) facility from Gefertec GmbH to Graz University of Technology. It is an integrated part of the **addLab**, which is driven by IFT (Prof. Haas) and IMAT (Prof. Sommitsch).

After the WAAM process, parts can be measured optically and then finished by subtractive manufacturing.

The facility is used jointly by TU Graz and AVL List GmbH in Graz, where it is situated. Multi-firm project proposals are planned in the area of high-strength lightweight materials and electric mobility.

► https://www.amag-al4u.com/media/pressemitteilungen


from left to right: Harald Kainz, Rector of TU Graz; Dr. Helmut Kaufmann, Chief technology officer of AMAG Austria Metall AG and Prof. Christof Sommitsch, after the signing of the donation contract at the TU Graz

© Lunghammer – TU Graz

The cutting-edge titanium machine for additive manufacturing of components

© AMAG

IMAT as partner of the µCT-lab

Since 2022, TU Graz has been running a micro-computer tomography laboratory (µCT) which expands the possibility of characterizing materials. The laboratory was funded by the Austrian Research Promotion Agency – FFG and an inter-university Graz consortium, which our Institute is part of.

The laboratory has two scanners to cover a wide range of spatial resolution with the possibility of mounting in-situ experiments:

+ **TESCAN UniTOM HR** has a nano-focus X-ray source that enables sub-micron resolution imaging (below 600 nm) by continuous sample rotation and scanning.

+ **TESCAN UniTOM XL** is capable of measuring to measure larger samples up to 100 cm in height with optimal resolution (> 3 µm), with real-time zooming for better observation of a specific volume.

IMAT applies this non-destructive technique to monitor and optimize weld joints, identify defects within the component, pore formation during additive manufacturing, and intermetallic phase evolution in cast aluminium-based alloys, among other applications.

Technical information about the scanners:
► https://www.tugraz.at/projekte/gmct/infrastructure/tescan-unitom/technical-description

Figure. µCT measurement carried out with Tescan UniTOM XL. Pore distribution of a wire arc additive manufactured aluminium alloy (We3D project). Left: Setup of the measurement. Right: Spatial distribution of pores within the sample.

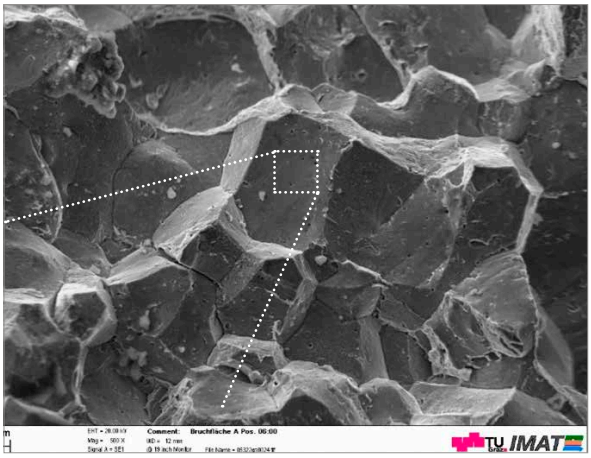
Materials consulting and failure analysis

When a customer comes to our laboratory with a damaged material part, our scientific and laboratory staff first seek to evaluate the entire damage case history and to establish a reliable quotation for the analysis work, including issues such as a SEM fracture surface and metallographic microstructure analyses, testing of strength, hardness and toughness; furthermore thermomechanical simulation (GLEEBLE 3800), welding and AM tests (Arc, Laser, FSW, EBW, Ultrasonic), residual stress measurements, long- and short-time corrosion tests (electrochemical simulation), hydrogen loading and H-content measurements (G8 Galileo) are also possible as a means of finding out the primary cause of damage.

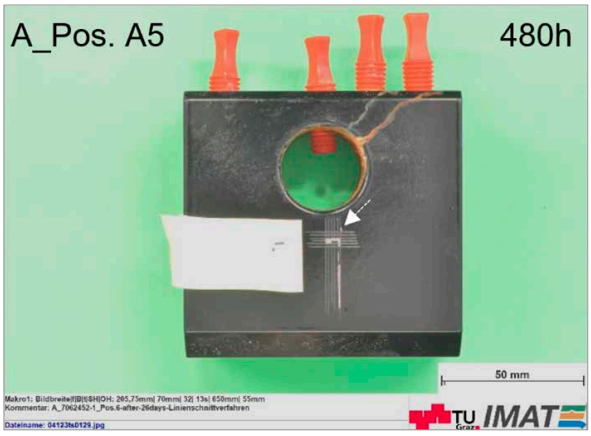
The following are the most frequent causes of damage to metallic materials:

- poor manufacturing (wrong or no heat treatment, high residual stresses, joining and coating imperfections, tinting colours etc.),
- lack of alloying elements (e.g. insufficient Cu in brass used for water installation valves, insufficient nickel in steel) or excessive impurities (e.g. P and S in steel, Fe in Al, Pb in brass),
- mechanical and corrosive overloading as well as wrong choice of material and filler metal (e.g. braze alloys),
- poor construction and incorrect calculation and simulation leading to unexpected loads.

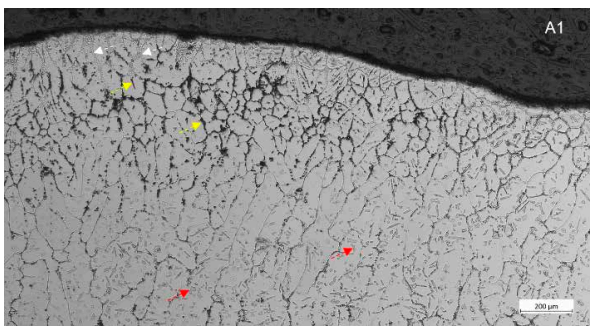
All of these problems occur even more frequently today due to the price competition of products on the global market.
Besides this, we offer theoretical analysis in performing literature research, modelling and simulation as well as selection of materials (CES data base). Our Institute benefits from a remarkably extensive experience and data base in recognizing similarities of failure cases, in close cooperation with several TU Graz institutes and also from building up good relationships for potential further research projects together with our customers. We are proud to perform around 80 failure case and laboratory analyses every year for some 45 different national and international customers from various industries (energy, construction, mobility, manufacture, chemical, surgical, etc.), for companies and courts. Always striving to support the companies in their development and to avoid future damage costs.



Martensitic stainless steel screw - brittle fracture surface due to hydrogen induced cracking (HIC) / SEM SE image



Cross-cut test (ISO 2409, s. arrow) of a polymer powder coating on a steel part - after 480 hours in salt spray chamber (ISO 9227).



Step grate of a pellet heating system (800-900 °C): Wear of a heat-resistant cast steel GX40CrSi28, different carbides (s. arrows).

Networks and Committees (Selection)

A2LT - Austrian Advanced Lightweight Technology
- Christof Sommitsch (Speaker since 2023)

AMAG - Austria Metall GmbH
- Christof Sommitsch (Member of the Science and Technology Advisory Board)

ASM International - The Materials Information Society
- Christof Sommitsch (Member)

ASMET - The Austrian Society for Metallurgy and Materials, Leoben (Austria)
- Christof Sommitsch (Member of the Management Board)
- Norbert Enzinger (Member)
- Cecilia Poletti (Member)

CEST - Austrian competence centre for electrochemical surface technology
- Christof Sommitsch (Member of the General Assembly)
- Rudolf Vallant (Member of the Strategy Board)

Club Scientifica - the Competence Network for Female Scientists
- Cecilia Poletti (Member)

CDG - Christian Doppler Forschungsgesellschaft
- Cecilia Poletti (Head of the CD Laboratory for Design of high-performance alloys by thermomechanical processing“ 01.05.2017 - 30.04.2024)

DGM - Deutsche Gesellschaft für Materialkunde
- Christof Sommitsch (Member)
- Cecilia Poletti (Member)
- Sergio Amancio (Member)
- Ricardo Buzolin (Member)

DVS – Deutscher Verband für Schweißen
- Sergio Amancio (Member)

FTI - Research, Technology and Innovation Strategic Advisory Board for the Austrian Aviation Sector
- Sergio Amancio (Member)

Hauptverband der allgemein beeideten und gerichtlich zertifizierten Sachverständigen
- Christof Sommitsch (Member)
- Rudolf Vallant (Member)

HPS - Research Initiative High Performance Sailing TU Graz
- Christof Sommitsch (Board Member since 2016)

IIW - International Institute of Welding, Genua (Italy)
IIW - Commission III: resistance welding, solid state welding and allied joining processes
- Sergio Amanico (Expert)

IIW - Commission XVI: Polymer and Adhesive Technology
- Sergio Amanico (Vice Chairman and member of the Austrian Delegation)

IIW - Commision IX: Behaviour of metals subjected to welding
- Christof Sommitsch (Austrian Delegate)

IIW - General Assembly
- Christof Sommitsch (Austrian Delegate)

KMM-VIN - The European Virtual Institute of Knowledge-based Multifunctional Materials
- Christof Sommitsch (Chairman of Working Group 2 - Materials for Energy)

MCL - Materials Center Leoben, (Austria)
- Christof Sommitsch (Member of the Board of Directors)
- Norbert Enzinger (Member of the Programme Committee)

ÖGS - Österreichische Gesellschaft für Schweißtechnik
- Norbert Enzinger (Member of the Board)
- IMAT (Corporate Membership)

OeWGP - Österreichische Wissenschaftliche Gesellschaft für Produktionstechnik
- Christof Sommitsch (Founding Member)

PNSIF - International Federation of Physical and Numerical Simulation of Materials Processing
- Christof Sommitsch (Member)

SAM - Argentiniean Society of Materials
- Cecilia Poletti (Member)

SPE - Society of Plastic Engineers
- Sergio Amancio (Member)

Research Center Smart Production Graz
- Christof Sommitsch (Speaker since 2015)

voestalpine Böhler Welding Group GmbH, Düsseldorf
- Christof Sommitsch (Member of the Board of Directors since 2014)

TMS - The Minerals, Metals & Materials Society (USA)
- Christof Sommitsch (Member)

University Council of Technische Universität Wien
- Christof Sommitsch (Member 2018 - 2023)

Committees of Graz University of Technology:

Academic Senate - Graz University of Technology
- Cecilia Poletti (Deputy Head 01.10.2022 - 30.09.2025)

WG Curricular Committee for the Field of Studies Advanced Materials Science
- Cecilia Poletti (Head 01.01.2020 - 31.12.2025)

Field of Expertise “Advanced Materials Science“
- Christof Sommitsch (Chair 2016 - 2023)

Scientific Exchange - Research stay abroad (Outgoing)

John von Neumann University, HU
Cecilia Poletti (Teaching)
in the framework of the BIP Blended Lecture
26 May 2023

ELTE - Eötvös Loránd University, HU
Cecilia Poletti (Teaching)
Saham Sadat Sharifi (Visitor)
18 April 2023

ELTE - Eötvös Loránd University, HU
Saham Sadat Sharifi (Visitor)
12 Jun 2023 → 30 Jun 2023

Technical University of Darmstadt, DE
Saham Sadat Sharifi (Visitor)
6-7 Jun 2023

Lehigh University, Betlehem, US
Christof Sommitsch (Visitor)
17 Apr 2023 → 19 Apr 2023

The Slovak academy of sciences
Institute of materials and machine mechanics, SK
Christof Sommitsch (Visitor)
Cecilia Poletti (Visitor)
Ricardo Buzolin (Visitor)
27 Feb 2023

The University of Tokyo, JP
Christof Sommitsch (Visitor)
28 Oct 2022 → 30 Oct 2022

Kyoto University of Advanced Science, JP
Christof Sommitsch (Visitor)
31 Oct 2022 → 2 Nov 2022

TUM - Technical University Munich, DE
Sergio de Traglia Amancio Filho (Visitor)
Maria Cecilia Poletti (Visitor)
Andreas Drexler (Visitor)
Ricardo Henrique Buzolin (Visitor)
Franz Miller Branco Ferraz (Visitor)
Saham Sadat Sharifi (Visitor)
Siegfried Arneitz (Visitor)
23 Jun 2022 → 24 Jun 2022

IMAT PhD students at TU Darmstadtt

Prof. Christof Sommitsch and Prof. Herman Nied at Lehigh University in US

Prof. Christof Sommitsch and Prof. Franz Haas at University of Tokjo, JP

Prof. Christof Sommitsch and Prof. Franz Haas at Kyoto University of Advanced Science KUAS, JP

Centro Universitário de Ourinhos, BRA
Sergio de Traglia Amancio Filho (Visitor)
8 Nov 2022

BAM - Bundesanstalt für Materialforschung und -prüfung, DE
Andreas Drexler (Visitor)
1 Jul 2021 → 27 Aug 2021
4 Jul 2022 → 15 Jul 2022

Universidade Estadual de Campinas, BRA
Sergio de Traglia Amancio Filho (Visitor)
18 Oct 2022

University of Strathclyde UoS, Glasgow, UK
Sebastian Fritsche (Visitor)
within the framework of the Matched PhD programme
7 Sept 2022 → 27 Sept 2022

AGH University of Science and Technology, PL
Franz Miller Branco Ferraz (Visitor)
1 Sept 2021 → 30 Sept 2021

The Ohio State University, US
Sergio de Traglia Amancio Filho (Visitor)
6 Dec 2021

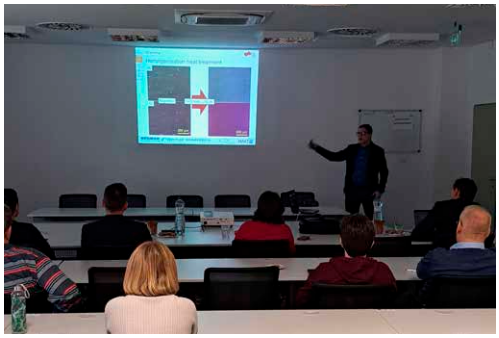
University of Maribor, SI
Josef Domitner (Visitor)
Zahra Silvayeh (Visitor)
1 Aug 2021 → 31 Oct 2021

Peter the Great St. Petersburg Polytechnic University, RU
Sergio de Traglia Amancio Filho (Visitor)
14 Oct 2021 → 9 Dec 2021

BBU - Babes-Bolyai University, RO
Sergio de Traglia Amancio Filho (Visitor)
22 Apr 2021

CNRS - Institut Néel Grenoble, FR
Christof Sommitsch (Visitor)
Siegfried Arneitz (Visitor)
23 Nov 2021 → 25 Nov 2021

Krakowski Instytut Technologiczny, PL
Ricardo Henrique Buzolin (Visitor)
1 Oct 2021 → 31 Oct 2021


Ricardo Buzolin at the meeting at Slovak Academy of Sciences, SK


Prof. Nelson Guedes, Prof. Sergio Amancio and Prof. Claudemiro Bolfarini at UFSCar in São Carlos


Christof Sommitsch, Sophie Rivoirard from CNRS and Siegfried Arneitz in Grenoble, France

Scientific Exchange - Scientific Guests (Incoming)

Ing. Martin Balog, Dr. Martin Nosko, Kateryna Kamyshnykova, Peter Krizik, Moara Marques de Castro
Visiting researchers, SAS - The Slovak academy of sciences, IMMM - Institute of materials and machine mechanics, SK
15 May 2023

Paul-Antoine Solbes, François-Régiskessler, Alan Thibaudeau
Erasmus students, Universite de Brest, FR
Apr - Jun 2023

Mohammad Javad Rezai, PhD
Visiting researcher, University of Science and Technology Iran, IR
Feb - Sep 2023

Guilaume Nenert, Arthur Robin, Julienne Mendes, Antoiné Labe, Yann Ltaste
Bachelor Students, University of Bordeaux, FR
Jan - March 2023

Sergio Pastore, Prof. Marco Ormellese, Prof. Fabio Bolzoni
Visiting researchers, Politecnico di Milano, IT
6 - 7 Jun 2023

Surya Yadav, Nilesh Kumar, Jiysurya Basu,
Visitng researcher, IIT (BHU), Varanasi, IN
1 - 14 Jul 2023

Santiago Noriega Franco, Alejandro Torres Marques
Erasmus students, Instituto Tecnológico de Estudios Superiores de Monterrey, Mexico, MX
Oct 2022 - Feb 2023

M.E. PhD. Ganesan Gunasekaran
Visiting researcher, IIT Bombay,
Indian Institute of Technology Bombay, IN
10 - 14 Jul 2023

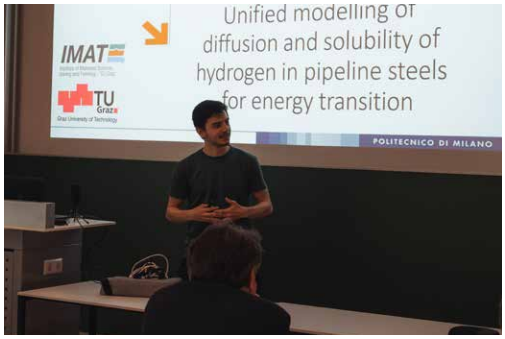
Flora Henri
Student, Université Paris Cité, FR
22 May- 28 Jul 2023

Thibaut Paty
Erasmus student, Institut National des Sciences Appliquées de Lyon - INSA Lyon, FR
Oct 2022 - Feb 2023

Jiří Kozlík, PhD
Visiting researcher, Charles University, Department of Physics of Materials, Prague, PL
16 Aug - 30 Sep 2022


SAS - IMMM and IMAT - Meeting in Graz, 2023

Ganesan Gunasekaran, researcher from IIT Bombay



Sergio Pastore, master student from Politecnico di Milano

Yogendra Chouksey, PhD, Nilesh Kumar, PhD
Visiting researchers, OeAD, IIT (BHU), Varanasi, IN
7 Jul - 26 Aug 2022

Prof. Fernando Diego Carazo
Visiting professor, teaching and research, National University of San Juan, AR
30 Sept – 31 Nov 2022

Prof. Iman Danaee
Visiting researcher, Petroleum University of Technology, Abadan, IR
2 - 29 Jul 2022

Prof. Elisabetta Gariboldi
Visiting researcher, Politecnico di Milano, IT
29 Jun - 2 Jul 2022

Haila Carolina Dias dos Santos
IAESTE student, FEDERAL UNIVERSITY OF OURO PRETO (UFOP - Universidade Federal de Ouro Preto), BR
1 May - 31 Aug 2022

Dr. Marta Orlowska
Visiting researcher, Warsaw University of Technology, PL
25 - 29 Apr 2022

Nicolas Hing, Adnan Chisty, Adrian Brindejonc
Erasmus students, Universite de Paris, FR
April - June 2022

Luc Pascal
Bachelor student, University of Bordeaux, FR
20 Apr - 24 Jun 2022

Amaury Ruffloch, Arnaud Le Moine
Bachelor students, Brest University, FR
9 Apr - 11 Jun 2022

Prof. Jozef Predan
Visiting researcher, University of Maribor, SI
30 March - 19 May 2022

Jokin Elustondo Azkue
Erasmus student, Mondragon University, ES
March - June 2022

Fernando Diego Carazo, guest professor from NUSJ, Argentinia

Heila Carolina Dias dos Santos, IAESTE student from UFOP Brasil

IMAT modelling group with guests: Silvana Sommadossi, guest professor and Dalibor Preisler (Post Doc from University of Charles, Prag)

Scientific Exchange - Scientific Guests (Incoming)

Johnathan Draper, PhD
Visiting researcher, University of Strathclyde UoS, Glasgow, UK
9 March - 2 Apr 2022

Paolo Gainnasi
Master student, Politecnico di Milano, IT
2021

Crowin Guillaume, Claire Guillemin
Erasmus student, INSA – Institut National des Sciences Appliquées, Lyon, FR
Nov 2021 - Feb 2022

Dalibor Preisler, PhD
Charles University Prag, CZ
20 Sep - 19 Nov 2021

Dr. Hugo Mora Sánchez
Visiting researcher, Universidad Complutense Madrid, ES
KMM-Vin Post Doc research fellowship
6 Sep - 20 Oct 2021

Prof. Dr. Silvana Sommadossi
Visiting professor, teaching and research, Comahue National University, AR
1 – 31 Oct 2021

Dr. Anton Naumov, Dr. Oleg Panchenko
Visting researchers
Peter the Great St. Petersburg State Polytechnical University, RU
4 - 8 Oct 2021

Ass.Prof. Sophie Primig
Visiting researcher
School of Materials Science & Engineering, Sydney, AU
August - November 2021

Sophie Rivoirard, Robin Vallereau
Visiting researchers, CNRS / Institut Néel, Grenoble, FR
September 2021

Anton Naumov, Sophie Primig, Cecilia Poletti, Florian Pixner and Oleg Panchenko

Sophie Primig, Assoc.Prof from Australia

Silvana Sommadossi and Fernando Warchomicka

Scientific Exchanges - Short Reports

Matched PhD – University of Strathclyde meets TU Graz

Karin Weinberger, Sebastian Fritsche and Johnathan Draper at TU Graz

For the first time, IMAT is participating in the Matched PhD programme, which is part of a strategic cooperation between TU Graz and the University of Strathclyde (UoS) in Glasgow, Scotland. As part of this programme, one PhD student at each university is working on a similar task. In this case, Sebastian Fritsche (IMAT) and Jonathan Draper (UoS) are both working on friction stir spot welding (RFSSW) of aluminium. While research at UoS is focused more on the area of FEM simulation, IMAT deals with experimental research and testing. In this way, it is possible to optimise synergies.

During his three-week research stay at IMAT in March 2022, Jonathan Draper carried out validation tests for his FEM simulations and was able to learn more about the welding system and the process. In September 2022, Sebastian Fritsche then stayed at UoS for three weeks and, among other things, was able to use their research infrastructure to conduct fatigue tests. This cooperation has already resulted in several publications and conference contributions.

Silvana Sommadossi
Visiting Professor at TU Graz

Dr. Silvana Sommadossi is a visiting professor at IMAT. She is a researcher at the National Council for Scientific and Technical Research (CONICET) and is a professor at the National University of Comahue (UNCo). She is also Director of the Institute of Research and Engineering Sciences (IITCI CONICET-UNCo) in Neuquén, Patagonia, Argentina. She has been holding courses during the winter semester at TU Graz since 2015, approximately every 2 years, on dissimilar material joining technologies for industrial applications and on Liquid Phase Transition Bonding (TLPB). TLPB is an alternative joining technology for gas & oil, energy power plants, electronics, aerospace and medical application fields.

The courses include experiences in the laboratory and the theory of basic phenomena, models, diffusion-reaction binary couples, driving force, the influence of manufacturing parameters influence on the microstructure, thermal and chemical gradients, as well as bond characterization techniques and mechanical testing.

Silvana Sommadossi in the IMAT lab.

Partners (Selection)

Scientific Partners

AC2T research GmbH, A
Academy of Sciences of the Czech Republic, CZ
AGH University of Science and Technology, PL
Aalto University, FI
Austrian Institute of Technology, A
Bioengineering Research and Development Center, SBR
Brno University of Technology, CZ
Comahue National University, ARG
Centro Sviluppo Materiali S.p.A., I
CEST Centre for Electrochemistry and Surface Technology Gmbh, A
Chalmers University of Technology, SE
Charles University, Faculty of Mathematics and Physics, CZ
Chemnitz University of Technology, D
Christian Doppler Forschungsgesellschaft, A
Cranfield University, UK
Deakin University, AUS
Dobeneck-Technologie-Stiftung, D
Ecole nationale supérieure des Mines de Saint-Etienne, F
École polytechnique fédérale de Lausanne, CH
Eötvös Loránd University, HU
Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa, PRT
Federal Institute for Materials Research and Testing, D
Engineering Academy of Armenia, ARM
Elettra - Sincrotrone Trieste S.C.p.A., I
ÉTS - École de technologie supérieure, CAN
Federal University of Sao Carlos, UFSCar, BRA
FELMI-ZFE - Austrian Centre for Electron Microscopy and Nanoanalysis, A
FFG - Die Österreichische Forschungsförderungsgesellschaft, A
FH Joanneum - University of Applied Sciences, A
FH Kärnten - University of Applied Sciences, A
FH Oberösterreich - University of Applied Sciences Upper Austria, A
Forschungszentrum Jülich GmbH, D
Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., D
Friedrich-Alexander-Universität Erlangen-Nürnberg, D
Georgian technical University, GEO
Grundig Akademie, A
Harbin Institute of Technology, CHN
Helmholtz-Zentrum Geesthacht - Centre of Materials and Coastal Research, D
Henan Polytechnic University, CHN
Indian Institute of Technology Roorkee, IND
Institut National des Sciences Appliquées Lyon, FR
International Institute of Welding (IIW), FR
Joanneum Research Forschungsgesellschaft mbH, A
Johannes Kepler University Linz, A
KTH - Royal Institute of Technology, SE
LKR Leichtmetallkompetenzzentrum Ranshofen GmbH, A
Loughborough University, UK
MCL Materials Center Leoben, A
Medical University of Graz, A

Montanuniversität Leoben, A
Materials Testing Institute University of Stuttgart, D
National Physical Laboratory, UK
National Technical University of Ukraine, UKR
Northwestern Polytechnical University Xian, CHN
Nuclear Physics Institute ASCR, CZ
ÖGS Österreichische Gesellschaft für Schweißtechnik, A
Ohio State University, USA
Peter the Great St. Petersburg Polytechnic University, RU
Politecnico di Torino, I
Politecnico di Milano, I
Polytechnic University of Timisoara, RU
RWTH Aachen University, D
Southwest University of Sciene and Technology, Mianyang,Sichuan, China
Slovak Welding Research Institute, SK
Slovak Academy of Sciences, SK
Slovak University of Technology, SK
Schweißtechnische Zentralanstalt Wien, A
The Leibniz Institute of Photonic Technology, D
The University of Tokyo, J
Technische Universität für Bergakademie Freiberg, D
Technical University of Danemark, DK
Technical University of Darmstadt, D
Technische Universität Hamburg, D
Technische Universität Ilmenau, D
Technische Universität München, D
Technische Universität Wien, A
Technical University of Liberec, CZ
Toyohashi University of Technology, J
The University of British Columbia, CAN
The Welding Institute Cambridge, UK
Universidade Federal do Rio Grande do Sul, BRA
Università di Bologna, I
Universidad Complutense Madrid, ES
Unversidade Federal de Sao Carlos, BRA
University of Kragujeva, SBR
University of Maribor, SVN
University of Rijeka, HR
University West, SE
Virtual Vehicle Research Center, A
Wright State University Dayton, USA

Industrial Partners

ANP Systems GmbH
APB Apparatebau Schweißtechnik GmbH
4a technology GmbH
ACE Apparatebau construction & engineering GmbH
Air Liquide
AMAG Austria Metall AG
ANDRITZ AG
Anton Paar GmbH
Aperam - Stainless Services & Solutions France, FR

ASMET - The Austrian Society for Metallurgy and Materials
Applied Ultrasonics Australia
AVL List GmbH
BHDT GmbH
BMW Group
Böhler Welding
Branson Ultrasonics
Breitenfeld Edelstahl AG
Brünner ZT GmbH
CLST Cryo Life Science Technologies GmbH
Cosma Engineering Europe
Diamond Aircraft Industries
Doka GmbH
Doosan Babcock Ltd.
DSI Underground Austria GmbH
DynaWeld GmbH
EBW Lex GmbH
Ebner Industrieofenbau GmbH
ECKART GmbH
ECO Schadenservice e.U.
ECOP Technologies GmbH
easE-Link GmbH
Eisenwerk Sulzau-Werfen R. & E. Weinberger AG
Emerson Automation Solutions
Embraer
EMCO-TEST Prüfmaschinen GmbH
Energie Steiermark Wärme GmbH
Erne Fittings GmbH
Ernst Stibel GmbH
Fronius International GmbH
Froxx-Global GmbH
Fuchshofer Präzisionstechnik GmbH
GE Power
Geoconsult ZT
Glavassevich Wintergärtner GmbH
GLOCK Ges.m.b.H.
GODSPEED Sail Racing Academy
Grassmayr Glockengießerei GmbH
Hans Künz GmbH
INOCON Technologie Gesellschaft m.b.H.
INNIO Jenbacher GmbH & Co OG
J. Pichler GmbH
Kanzler Verfahrenstechnik GmbH
Keller Grundbau Ges.mbH
Klaus Raiser GmbH
Knapp AG
Krankenanstalten Immobiliengesmbh
Kristl Seibt & Co GmbH

Leitz GmbH & Co. KG
Lorch Schweißtechnik GmbH
Mach ROTEC GmbH
Magna International Inc.
Mark Metallwarenfabrik
MatCalc Engineering
Mondi SCP a. s.
Nemak Linz GmbH
NIDEC Corporation
Outokumpu
Palfinger
Peak Technology
Pengg Austria GmbH
pewag Austria GmbH
Plansee SE
Plasma Industrietechnik GmbH
pro-beam AG & CO. KGaA
Rina Consulting
RECENDT GmbH
Salzburger Aluminium Group
Samsung SDI Battery Systems GmbH
Sappi Austria Produktions-GmbH & Co KG
Schindler Aufzüge und Fahrtreppen GmbH
Schmidt + Clemens Gruppe
Schuler AG
SBI GmbH
Sebring Technology GmbH
Siemens AG
Simufact Engineering GmbH
Space-Lock-Dynamics GmbH
Stahl- und Walzwerk Marienhütte GmbH
SteelCERT GmbH
Steiner Nautic Bootsbau
Siempelkamp GmbH & Co KG
STIRtec GmbH
Talum
TailSiT GmbH
TBE-Anlagendiagnostik GmbH
TCM International
TE-PRO d.o.o.
TRUMPF Maschinen Austria GmbH + Co. KG
TÜV Austria Gruppe
thyssenkrupp Presta AG
Thyssen Krupp Bilstein
VENTREX Automotive GmbH
voestalpine AG
Volkswagen
Welser Profile AG
WISCO TAILORED BLANKS GmbH
ZF Lemförder Achssysteme Ges.m.b.H.
Zwick Roell GmH & Co. KG

Scientific Events

2023

Habilitation lecture "Leichtbau von Karosserien" by Josef Domitner
27 June 2023
Within the framework of his habilitation process Josef Domitner gave an exciting lecture on lightweight design of modern car bodies. He presented basic principles of modern car body design, applications of lightweight materials in the automotive industry and examples of state-of-the-art and future cars. The lecture was concluded by an lively discussion with the audience.

Habilitation lecture Josef Domitner, 27.06.2023

WORKSHOP for the Christian Doppler Laboratory for "Design of High-Performance Alloys by Thermomechanical Processing"
On the 16th of February of 2023, Poletti and her Group organised a hybrid workshop to discuss with colleagues the main results obtained during six years of CD-Laboratory.
The presenters Ricardo Buzolin, Franz Ferraz, Stefan Fortmüller and Talina Terrazas Monje gave an overview of the studies on the thermomechanical treatment of titanium, nickel and aluminium alloys and their performance during service. The presenters also integrated the contributions of the previous members Friedrich Krumphals, René Wang and Kashyap Pradeep into their presentations. Manuela Prader played a vital role in organising
the workshop.
The workshop counted more than 50 participants from academia and industry. The project partners from voestalpine, Nemak and Neuman Aluminium Industries supported the discussions with their experience in processing and their inquiries about materials development. Scientists from other faculties of TUGraz and Johannes Kepler Universität Linz, Politecnico di Milano and Virtual Vehicle Research GmbH contributed questions and ideas.

► https://www.tugraz.at/institute/imat/research/research-groups/cdl-christian-doppler-laboratory

CD-Laboratory workshop led by Cecilia Poletti, 16.02.2023


© IMAT
CD-Laboratory, workshop with partners from universities, research centers and industry

2022

Advanced Materials Poster Day, 2022
22 April 2022
Advanced Materials Day is the yearly meeting where the members of the FoE Advanced Materials Science interdisciplinary network at TU Graz present their latest results.
37 institutes from 6 faculties are presently involved.
The 2022 AMS Poster Day was held in person and more than 50 posters were presented.

2021

15th Materials Day
AULA - TU Graz
The motto of the 15th Materials Day held on Nov. 18th 2021 was "Additive Manufacturing of high-performance and hybrid structures". Rector Harald Kainz and Dean Franz Haas welcomed around 90 participants from science and business. Twelve presentations from guests and IMAT members covered the field of wire-based, powder based and hybrid structures.

The research groups at IMAT cover a wide variety of scientific topics relating to additive manufacturing, dealing with process development of wire- and powder-based additive manufacturing and material development. Efficient tools used for experimentation include in-situ alloying, numerical simulation and material modelling. Hybrid AM of metallic and polymer materials for lightweight construction as well as the production of functional materials such as magnetic alloys and shape memory alloys complement structural AM using tool steels, high-strength steels as well as titanium alloys. The attendees followed the interesting presentations, contributed to lively discussions and enjoyed the gathering during the breaks. Finally, a guided lab tour was offered and many guests visited the new infrastructure at IMAT.

► https://go.tugraz.at/Materials-Day

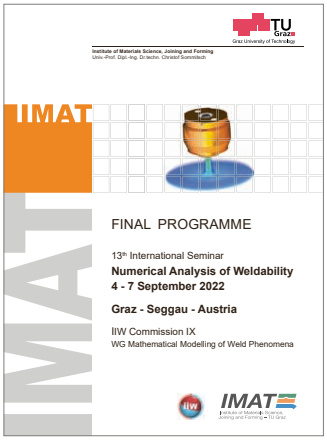
15th Materials Day, 2021 - Dean Prof. Franz Haas and Prof. Christof Sommitsch


15th Materials Day, 2021 - Opening speech by Rector Harald Kainz

Exhibitors and sponsors on site (from left to right): Monika Schuler (ZwickRoell) Thomas Weinberger (STIRtec) Georg Engl (proBeam) and Peter Ruchti (Zwick-Roell)

The 13th International Seminar Numerical Analysis of Weldability

4 - 7 September 2022
Graz - Seggau - Austria



Scientific Committee
Chairman: Christof Sommitsch (TU Graz, IMAT)
Vice Chairmen: Norbert Enzinger (TU Graz, IMAT)
and Peter Mayr (Technical University Munich, TUM)
Honorary Chairman: Horst Cerjak (TU Graz, IMAT)

Seggau'2022, In the very inspiring setting of Seggau Castle, 70 participants from 12 countries met to exchange the latest results in numerical modelling in the field of welding and to foster friendship and partnerships, which in some cases is also a starting point for future successful cooperation. Once more, this seminar was organized by IMAT in cooperation with the IIW working group "mathematical modelling of weld phenomena" of commission IX.

In total 37 oral presentations and 3 posters were discussed. Different aspects of modelling in welding research were covered and organized in ten topical sections:

I. additive manufacturing
II. arc welding, melt pool phenomena, solidification
III. artificial intelligence
IV. laser and electron beam welding
V. residual stresses and distortion
VI. microstructural modelling in weld metal and the heat affected zone
VII. cracking phenomena and hydrogen effects
VIII. modelling tools and computer programs
IX. solid state and friction stir welding
X. special joining processes.


Seggau conference


Prof. Christof Sommitsch, Prof. Patricio F. Mendez and Prof. Herman Nied

Finally, 32 contributions to the seminar are published in the book Mathematical Modelling of Weld Phenomena 13, which is also electronically available – full papers are open access documents.
DOI 10.3217/978-3-85125-968-1

After an extra-long break of 4 years it was possible again to have a face-to-face informal and friendly exchange during a Styrian evening after enjoying wine tasting, roast chestnuts and a glass of hearty Sturm around a warming bonfire. On that evening, the Kenneth Easterling best paper award was again given to the contribution "*A numerical study on the suppression of a detrimental weld pool profile in wire feed laser beam welding by magnetohydrodynamic technique"* by Xiangmeng Meng, Antoni Artinov, Marcel Bachmann, Ömer Üstündağ, Andrey Gumenyuk, Michael Rethmeier.

Overall, this event can be seen as a huge success, both scientifically and socially, and we look forward to the

14th International Seminar Numerical Analysis of Weldability on 21 - 24 September 2025

► www.tugraz.at/events/seggau/

Prof. Antonio Ramirez

Xiangmeng Meng, BAM

Kenneth Easterling best paper Award to Xiangmeng Meng

Internal / External Seminars - Visiting Lecturers

Guest lecturers at IMAT: Dr. Armin Paar (left) from ESW Eisenwerk Suzlau-Werfen and Prof. Antonio J. Ramirez (right) from Ohio State University

Knowledge exchange and knowledge sharing is a big part of our culture. In our monthly IMAT Seminar students and professors from TU Graz as well as visting lectures from all over the world give their expertise in form of a presentation, which is rounded off by a well conducted round of discussion.

2023

164th internal IMAT seminar, 15.06.2023
Master and bachelor presentations

163rd - IMAT external seminar, 07.06.2023
from Politecnico di Milano
“Electrochemical charging of carbon steel and low alloy steel”
Prof. Marco Ormellese and Prof. Fabio Bolzoni

“Unified modelling the high-pressure and low temperature hydrogen solubility of X70 pipeline steel“
Sergio Pastore

162nd - IMAT external seminar / 15.05.2023
Institute of materials and machine mechanics, The Slovak academy of sciences - IMMM SAS
“Overview of research activities at IMMM SAS”, Martin Nosko

“Structural Al-AlN MMC for high temperature use", Martin Balog

“Small punch test technique for creep testing”, Peter Krizik

„Fully biodegradable Zn-ZnO MMC for stents“, Moara Marques de Castro

„Design, processing and properties of precipitation hardenable complex concentrated alloys resistant to hydrogen embrittlement”, Kateryna Kamyshnykova

“Development and characterisation of alloys and in-situ composites based on TiAl with the enhanced high-temperature capability”, Kateryna Kamyshnykova

161st - IMAT seminar / 11.05.2023
Master and bachelor presentations

160th - IMAT seminar / 17.04.2023
Master and bachelor presentations

159th - IMAT seminar / 09.03.2023
Master and bachelor presentations

158th - IMAT seminar / 06.02.2023
Master and bachelor presentations

guest lecture, 30.01.2023
"Warm- und Kaltwalzen in der Blechherstellung: Anforderungen, Werkstoffe und Herstellungsprozesse für moderne Walzen"
Dr.techn. Armin Paar, MSc., Head of Quality Management at ESW Eisenwerk Suzlau-Werfen R. & E. Weinberger AG

157th - IMAT seminar / 13.01.2023
Master and bachelor presentations

2022

guest lecture, 28.11.2022
"Highlights from 30 years of experience in welding thermal turbine rotors and hydro generators"
Sorin Keller, Manager Welding & Brazing Technology – GE Power Switzerland, President of IIW International Institute of Welding

156th IMAT seminar / 02.12.2022
Master and bachelor presentations

155th IMAT seminar / 04.11.2022
"Computational modeling applied to material processing"
Prof. Fernando Diego Carazo
National University of San Juan and Researcher at CONICET, Head of Materials Laboratory at IMA-FI-UNSJ - Institute of Materials Science, San Juan - Argentina

154th IMAT seminar / 04.10.2022
„Fatigue behaviour and fatigue limits of weldments“
PhD. Eng. Mirco Daniel Chapetti, Department of Mechanical Engineering of the National University of Mar del Plata, Argentina.

guest lecture, 01.09.2022
"Research on Materials Joining and Additive Manufacturing at the Ohio State University and Ma2JIC (Manufacturing and Joining Innovation Center)"
Prof. Antonio J. Ramirez, Ohio State University

153rd IMAT seminar / 01.07.2022
“Phase arrangement effects in the thermal response of composite Phase Change Materials”
Prof. Elisabetta Gariboldi. Politecnico Milano, Department of Mechanical Engineering

152nd IMAT seminar / 03.06.2022
Master and bachelor presentations

151st IMAT seminar / 13.05.2022
Master and bachelor presentations

guest lecture, 27.04.2022
"Welding and repair solutions for damaged large components in turbomachinery"
Sorin Keller, Manager Welding & Brazing Technology – GE Power Switzerland, President of IIW

150th IMAT seminar / 01.04.2022
“A numerical and experimental approach to the development of Refill Friction Stir Spot Welding tools”
Jonathan Draper, University of Strathclyde, Glasgow

149th IMAT seminar / 04.03.2022
Master and bachelor presentations

148th IMAT seminar / 14.01.2022, virtual
Master and bachelor presentations

The 1st joint PhD seminar took place from 12 to 13 February 2020 at Grundlsee in Styria and was organised by IMAT. Twelve PhD students presented their results, which were then discussed in detail with the professors and senior researchers.

This time the follow-up **2nd joint PhD Seminar** with 15 PhD students was organised by our partner Prof. Peter Mayr, Head of the Institute for Materials Engineering of Additive Manufacturing at TU Munich and took place from 22 to 24 June 2022 in Munich. In addition, a social programme in Munich intensified networking between the institutes. A follow-up is planned for 2024, once again in Styria.

„Influence of partitioning effects on the retained austenite content and properties of a martensitic stainless steel“ | Simona Kresser

„Effect of Si and Al on retained austenite stabilization during Q&P and galvannealing process“ | Matthias Wallner

„High temperature aging of laser-welded copper – aluminium joints for E-mobility“ | Clemens Obergfell

„Wire-based electron beam additive manufacturing of Ni-rich NiTi alloy“ | Rafael Paiotti

„Multi-fidelity modeling for material properties of support structures" | Claudia Geitner

„Additive manufacturing of functional magnetic materials“ | Siegfried Arneitz

"Build-up strategies in cold spray additive manufacturing and 3D plasma metal deposition" | Julius Arnhold

"Thermomechanical processing of titanium alloys" | Franz Miller Ferraz

„Heat affected zone and tensile properties investigation of coated and uncoated 12%Cr steel using a thermophysical simulation system“ | Fabian Dittrich

„Hot ductility behavior of continuously cast microalloyed steels" | Marina Melo Gontijo

„Mesocale models to describe plastic deformation of metallic materials“ | Saham Sadat Sharifi

"Simulating multi-stage hot deformation behavior of an Al-Cu-Mg-Zr alloy“ | Guowei Bo

"Designing a deep-drawing tool for the formability characterization of aluminum alloys“ | Emir Hodzic

"Amending high strength aluminum alloys for additive manufacturing via microstructure control” | Graham Matheson

2021

147th IMAT seminar / 26.11.2021, virtual

guest lecture, 23.11.2021
"Welding and Brazing technology, as key processes in the manufacturing of power generation components"
Sorin Keller, Manager Welding & Brazing Technology –
GE Power, Switzerland

146th online IMAT seminar / 05.11.2021
„Interaction between the sheet segments' springback during simple bending of tailor welded blanks“
Gábor J. Béres PhD,
John von Neumann University, Hungary
GAMF Faculty of Engineering and Computer Science, Department of Innovative Vehicles and Material

"Research of new beta-Ti alloys at Charles University - from oxygen effects to hip implants"
Dalibor Preisler, PhD
Charles University Prag

143rd online IMAT seminar / 08.10.2021
„Characterization of TLPBonding for inconel-718“
Prof. Silvana Sommadossi,
National University of Comahue, Argentinia

„Corrosion and surface modification of Additive Manufacturing lightweight alloys“
Hugo Mora Sanchez
Universidad Complutense de Madrid, Spain

‘Wire arc addtive manufacturing“
Prof. Oleg Panchenko,
St. Petersburg Polytechnic University, Russia

"Friction Stir welding“
Prof. Anton Naumow,
St. Petersburg Polytechnic University, Russia

"Microstructure Control during metal additive manufacturing"
Sophie Primig, Scientia Associate Professor
School of Materials Science & Engineering, Sydney, Australia

142nd IMAT seminar / 21.09.2021 virtual
Dr. Sophie Rivoirard and Romain Caniou
CNRS/ Institut Néel, Grenoble France

141st online IMAT seminar / 06.09.2021
Master and bachelor presentations

Awards *2021 - 2023*

© DGM

Dr. Ricardo Buzolin

Prof. Sergio Amancio

all pictures © Deutsche Gesellschaft für Materialkunde e.V

We are very honored that two prestigious prizes from the **DGM - Deutsche Gesellschaft für Materialkunde e.V.** were awarded to our Institute. The presentation of the awards took place at the DGM Day on September 26, 2022 in Darmstadt.

"DGM Nachwuchspreis 2021" to Ricardo Buzolin

Every year, the DGM awards the "DGM Young Investigator Award" to doctoral students or postgraduates in the field of materials science and materials engineering for the above-average study and work results of four talented young researchers.
https://dgm.de/dgmtag/2022/preistraeger/dgm-nachwuchspreis-2021

"DGM Preis 2022" to Sergio Amancio

The DGM Prize is awarded to an excellent mid-career scientist for outstanding scientific or scientific-technical achievements that represent a breakthrough in materials science and engineering that are documented by publications or that have opened up a new field of research.
DGM: *... The German Society for Materials Science e.V. awards Univ.-Prof. Dr.-Ing. Sergio Amancio the DGM Award 2022 for his fundamental and innovative contributions to nanomechanics and plasticity of complex materials.*
Materials engineer and materials scientist Univ.-Prof. Dr.-Ing. Sergio Amancio has been working on the materials science and manufacturing processes of metal-fiber composite hybrids since the early 2000s. The focus of his highly successful research career has been on the development of more energy-efficient as well as effective joining and additive manufacturing processes for hybrid materials. For his extensive engineering achievements, Prof. Amancio has been recognized not only by the scientific community but also by the industry with over 100 Scopus-referenced publications, 22 patent grants and 17 awards. These outstanding achievements, which Sergio Amancio can already show in the middle of his research career, point to a promising scientific future and make him an outstanding candidate for this year's DGM Award.

https://dgm.de/dgmtag/2022/preistraeger/dgm-preis-2022

Emir Hodžić and Dr. Werner Fragner

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Norbert Enzinger (supervisor of the master's thesis) accepted the award on behalf of Matthias Moschinger.

Florian Pixner; IIW Award 2021

AMAG Innovation 2023

Emir Hodžić was awarded the AMAG Innovation Prize in the category Best Paper "technological" on April 26, 2023 at the "AMAG Innovation, CIP and Social Award Presentation 2023" event for his publication:
Influence of alloy composition and lubrication on the formability of Al-Mg-Si alloy blanks.
https://doi.org/10.1016/j.jmapro.2022.11.029
in: the "Journal of Manufacturing Processes", No. 85, p. 109-121, 6 Jan 2023
as part of his PhD thesis and recently received the prize from Dr. Werner Fragner, Head of AMAG Corporate Technology.

Franz Leitner Award 2023

to Matthias Moschinger

As part of the ASMET Forum for Metallurgy and Materials Technology, the Franz Leitner Prize 2023 was awarded for outstanding achievements in the field of welding technology. The prize was awarded for the best master's thesis entitled: ***Electron Beam Welding of thin-walled aluminum liner.***

KMM-VIN Fellowship 2022

research grant to Florian Pixner on 28 March 2022 from the granting organisation working group 2 - Materials for Energy of KMM-VIN, Brussels (Belgium) for the project: ***AMNibas - Wire based additive fabrication of NiBas Inconel with electron beam***

Welding in the World Best Paper Award 2021

to Florian Pixner

sponsored by the IIW International Institute of Welding at the 75th IIW Annual Assembly in Tokio 2022 http://www.iiw2022.com/
in the Category A: Welding Processes and Additive Manufacturing in recognition of his outstanding research paper: ***Contactless temperature measurement in wire-based electron beam additive manufacturing Ti-6Al-4V***
in: Welding in the World, vol. 65, No. 7, p. 1307-1322, July 2021
https://doi.org/10.1007/s40194-021-01097-0
Co-authors: Ricardo Buzolin, Sebastian Schönfelder from pro beam additive GmbH, Gilching, David Theuermann, Fernando Warchomicka and Norbert Enzinger.

© _johannes_gellner

Wilian Sales Carvalho, Christof Sommitsch, Sergio Amancio, Carlos Belei and Christian Purrer

Landespreis "Energy Globe STYRIA AWARD 2022"

awarded to the project team at IMAT: Willian Sales de Carvalho, Carlos A. Belei, Sergio T. Filho Amamcio and Christof Sommitsch was awarded for the project: ***GreENJOINable - Enabling next-generation green aircraft structures*** in the research category and is nominated for the international Energy Globe Award in the AIR category.

Content: Innovative composite materials and efficient ultrasonic joining technology reduce CO_2 emissions through lower aircraft weight.

The prize was presented by Mr. Christian Purrer, spokesman of the board of Energie Steiermark AG in the auditorium of the Old University in Graz on July 7, 2022.

teiermark.at/cms/beitrag/12879196/154271055/

http://www.energyglobe.at/ueber-energy-globe

Gean Henrique Marcatto de Oliveira (right)

KMM-VIN Best Poster Presentation

2nd place to Gean Henrique Marcatto de Oliveira

on the occasion of the event "12th KMM-VIN Industrial Workshop - Advanced Materials for Energy: Challenges and Opportunities", on 12 May 2023 at the Politecnico di Torino in Italy.

for the poster presentation: ***Fully additive manufacturing of PC/AlSi10Mg hybrid joints with surface structured substrate: a promissing approach for lightweight applications.***

© ÖGS

Matthias Moschinger and Guido Reuter (ÖGS)

Richard Marek Award 2021

to Matthias Moschinger

The award was handed over by the speaker of the board of the ÖGS, Mr. Guido Reuter. The prize was given for innovative solutions in welding technology.

Elektronenstrahlschweißen dünnwandiger Aluminium Liner / Electron Beam Welding of thin-walled aluminum liner.

from left to right: Sergio Amancio, Christof Sommitsch, Pedro Effertz and Mohammad Reza Ahmadi

IMAT Best Paper Award 2022 to Florian Pixner

IMAT Best Paper Award 2021 to Ricardo Buzolin

Inventor of the TU Graz

On the occasion of the event "From Science to Innovation" on 9th November 2021 at the Karl-Franzens University the Graz University of Technology honors its inventors. The award was given to Sergio T. Amancio Filho, Christof Sommitsch, Pedro Effertz and Mohammad Reza Ahmadi for their groundbreaking inventions in the field of materials science:

Method and equipment to produce metallic wire and polymeric filament using friction energy" - with a focus on materials recycling and repurposing for additive manufacturing

Ferritic steel for service temperatures from 650 to 700°C

Development of post heat treatment for ferritic creep resistant steels containing 15% Chromium

Additive manufacturing powders for use in additive manufacturing processes resulting in improved stability of steel melt-track

IMAT Best Paper Award

Award for the paper with the highest impact factor of all the publications produced by the Institute of Materials Science and Welding.

IMAT Best Paper Award 2022

awarded to Florian Pixner

at the Christmas party on 15 Dec 2022

Tailoring the alloy composition for wire arc additive manufacturing utilizing metal-cored wires in the cold metal transfer process

https://doi.org/10.1016/j.matdes.2022.110453

in: Materials and Design, Volume 215, 2022, 110453.

IMAT Best Paper Award 2021

awarded to Ricardo Buzolin

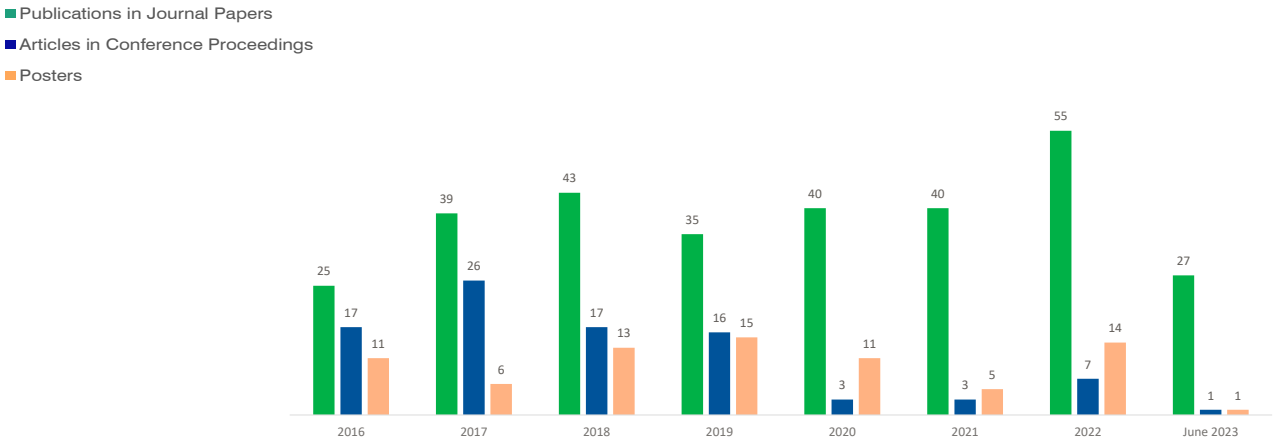
at the Christmas party on 17 Dec 2021

Hot deformation and dynamic α-globularization of a Ti-17 alloy: Consistent physical model

https://doi.org/10.1016/j.matdes.2021.109627

in: Materials and Design, Volume 197, 2021, 109627.

Publications



Journal Papers (published in *)

2023

Additive manufacturing of metal-polymer hybrid parts: the influence of as-printed LPBF surface roughness on the joint strength
Belei, C., Effertz, P. S., Meier, B. & Amancio-Filho, S. T., 26 May 2023,
* Frontiers in Materials. 10, 1202281.
https://doi.org/10.3389/fmats.2023.1202281

Effect of wire-arc directed energy deposition on the microstructural formation and age-hardening response of the Mg-9Al-1Zn (AZ91) alloy
Graf, G., Spörk-Erdely, P., Maawad, E., Burtscher, M., Kiener, D., Clemens, H., Klein, T.
* Journal of Magnesium and Alloys, Vol. 11, p. 1944-1958, 26 May 2023
https://doi.org/10.1016/j.jma.2023.05.012

Effects of temperature on friction and degradation of dry film lubricants during sliding against aluminum alloy sheets
Shafiee Sabet, A., Domitner, J., Ristić, A., Öksüz, K., Rodríguez Ripoll, M., Sommitsch, C.
* Tribology International, Vol. 180, 108205, 2023
https://doi.org/10.1016/j.triboint.2022.108205

High Temperature Tensile Strength of TI6AL4V Processed by L-PBF—Influence of Microstructure and Heat Treatment
Meier, B., Warchomicka, F. G., Petrusa, J., Kaindl, R., Waldhauser, W. & Sommitsch, C.
* Berg- und hüttenmännische Monatshefte. 168, 5, p. 247–253, 25 May 2023
https://doi.org/10.1007/s00501-023-01346-3

Hot deformation mechanisms of dual phase high entropy alloys
Buzolin, R. H., Masswohl, M., Branco Ferraz, F. M., Chrzan, K., Dudziak, T. & Poletti, M. C., 30 Jun 2023,
* Materials Science and Engineering: A. 878, 145235, 30 Jun 2023
https://doi.org/10.1016/j.msea.2023.145235

Influence of alloy composition and lubrication on the formability of Al-Mg-Si alloy blanks
Hodzic, E., Domitner, J., Thum, A., Shafiee Sabet, A., Müllner, N., Fragner, W. & Sommitsch, C.
* Journal of Manufacturing Processes. 85, p. 109-121, 6 Jan 2023
https://doi.org/10.1016/j.jmapro.2022.11.029

Influence of microstructure on degradation of cast graphitic high-speed steel
Aigner, M., Pellizzari, M., Domitner, J., Elizondo, L., Fischbacher, M., Laubichler, I., Paar, A., Reiter, M., Trickl, T. & Sommitsch, C.
* Wear. 522, 12 p., 204702, 1 Jun 2023
https://doi.org/10.1016/j.wear.2023.204702

Influence of thermomechanical treatments on the microstructure and mechanical properties of AISI 304L welds
Wang, P., Szalowski, B., Vallant, R., Poletti, M. C., Enzinger, N.
* Welding International, Vol. 37, No. 2, p. 79-90, 2023
https://doi.org/10.1080/09507116.2023.2182728

Influence of natural aging on the formability of Al-Mg-Si alloy blanks
Hodzic, E., Domitner, J., Thum, A., Shafiee Sabet, A., Müllner, N., Fragner, W. & Sommitsch, C.
* Journal of Manufacturing Processes. 94, p. 228-239, 1 April 2023
https://doi.org/10.1016/j.jmapro.2023.03.021

Influence of thermomechanical treatments on the microstructure and mechanical properties of AISI 304L welds
Wang, P., Szalowski, B., Vallant, R., Poletti, M. C. & Enzinger, N.
* Welding International. 37, 2, p. 79-90, 2023
https://doi.org/10.1080/09507116.2023.2182728

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2023

In-situ consolidation of additively manufactured continuous fiber reinforced material: Technical approach and results
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2023

Fully additive manufacturing of PC/AlSi10Mg hybrid joints with surface structured substrate: a promissing approach for lightweight applications.
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2022

Computer-aided topology optimization of through-the-thickness reinforcements for metal-composite hybrid joints produced via U-Joining.
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Dissimilar joints of additive manufactured and wrought aluminium alloy produced by refill friction stir spot welding.
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High entropy alloys produced by laser powder bed fusion assisted by in-situ alloying.
Arneitz, S., Sharifi, S. S., Palcevski, T., Auer, P., Domitner, J., Poletti, M. C., Amancio-Filho, S. T., Sommitsch, C., Buzolin, R. H. H
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Injection overmolded polymer-metal hybrid structures.
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Modelling the hot deformation of a microalloyed steel.
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Physical upset butt welding simulation for high performance Q&T steels.
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The effect of an in-situ consolidation process on the microstructure of additive manufactured continuos carbon fiber reinforced polyamide 6 material.
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Ultrasonic joining parameters optimization and surface corrosion behavior of additively manufactured 316L and PEEK-20CF hybrid structures.
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Wire-based electron beam additive manufacturing of NiTi shape memory alloy: influence of heat treatment on the functional behaviour.
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2021

Effect of stain rate on hot ductility of a Ti-Nb microalloyed steel.
Hoflehner, C., Sommitsch, C., Melo Gontijo, M., Six, J., Ilie, S.
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Influence of volumetric flow on the mechanical properties of short carbon fiber-reinforced polyamide parts printed by Fused Filament Fabrication.
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On the feasibility of Ultrasonic Joining of 3D-printed PEEK to rolled AISI 304 stainless steel reinforced with cold metal transfer welded pins.
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Overview of different consolidation models in additive manufacturing of continuous fiber composites their development and initial results.
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Using raw LPBF surfaces to improve the strength of metalpolymer hybrid joints produced by Additive Manufacturing.
Belei Feliciano, C. A., Meier, B., Amancio-Filho, S. T.
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Lectures (presented at *)

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LightMAT 2023, Talina Terrazas Monje (Speaker)

2023

Heterogeneous microstructural evolution of AA6082 during plastic deformation
Talina Terrazas Monje (Speaker)
Christian-Doppler Laboratory for Design of High-Performance Alloys by Thermomechanical Processing
* 5th International Conference on Light Materials: LightMAT 2023, Trondheim, Norway
21/06/2023 → 23/06/2023

Microstructure design of beta annealed Ti-15Mo using thermo-mechanical processing
Esmaeil Shahryari (Speaker)
* World Titanium Conference 2023, Edinburgh, UK
12/06/23 → 16/06/23

The role of the α-phase in the hot deformation behaviour of a Ti-17 alloy
Franz Miller Branco Ferraz (Speaker)
* Institute of Materials, London, UK
15/06/2023

Causes of flow localization in a Ti17 alloy during hot forming, and its consequences for the microstructure
Maria Cecilia Poletti (Speaker)
* World Titanium Conference 2023, Edinburgh / UK
12/06/23 → 16/06/23

Hot deformation and recrystallization refine the microstructure of as cast FCC-high entropy alloys
Markus Maßwohl (Speaker)
* 32nd International Conference on Metallurgy and Materials: Metal 2023, Brno, Czech Republic
17/05/23 → 19/05/23

Recrystallization and recovery of micro-alloyed steel during thermomechanical processing: Modelling and experiments
Saham Sadat Sharifi (Speaker)
* K1 MET – Competence Center for Excellent Technologies in Advanced Metallurgical and Environmental Process Development (98414)
11/04/2023 → 12/04/2023

Joining of LPBF-printed AlSi10Mg to AA7075-T6 wrought alloy by Refill Friction Stir Spot Welding
Sebastian Fritsche (Speaker)
* 34nd AeroMat Conference and Exposition: AeroMat 2023 Fort Worth, Texas, US
14/03/23 → 16/03/23

Thermal history due to plasma wire arc additive manufacturing and its influence on high carbon steel substrate
Matthias Moschinger (Speaker)
* IIW intermediate meeting IIW IX-L, Munich, Germany
6/03/23 → 8/03/23

A dislocation-based model for the microstructure evolution and the flow stress of near-B titanium alloys
Ricardo Henrique Buzolin (Speaker)
* International Conference on Plasticity, Damage, and Fracture 2023, Punta Cana, Dominican Republic
3/01/23 → 9/01/23

2022

Additive Fertigung in PE mittels Plasmaprozess
Thomas Mayr (Speaker)
* ASMET - The Austrian Society for Metallurgy and Materials, Leoben, Austria
16/12/2022

Wire-based electron beam additive manufacturing of NiTi alloy
Rafael Paiotti Marcondes Guimaraes (Speaker)
* Metal Additive Manufacturing Conference 2022: MAMC 2022, Graz, Austria
26/09/22 → 28/09/22

On the printability and superelasticity of NiTi shape memory alloys fabricated by laser powder bed fusion with Ni-rich elementally blended powder
Rafael Paiotti Marcondes Guimaraes (Speaker)
* Metal Additive Manufacturing Conference 2022: MAMC 2022, Graz, Austria
26/09/22 → 28/09/22

FEM study of thermomechanical welding of austenitic stainless steel and experimental validation
Peng Wang (Speaker)
* 13th International Seminar "Numerical Analysis of Weldability", Graz Seggau, Austria
4/09/22 → 7/09/22

Influence of copper on the artificial ageing of secondary AlSi10Mg casting alloys
Stefan Fortmüller (Speaker)
* 18th International Conference on Aluminium Alloys: ICAA 2018, Toyama, Japan
4/09/22 → 8/09/22

Modelling and Simulation of diffusion driven pore formation in metals during creep
Felix Meixner (Speaker)
* 3rd International Congress on Advanced Materials Sciences and Engineering: AMSE 2022, Opatija, Croatia
21/07/22 → 25/07/22

Recent advances in the ultrasonic joining process of additively manufactured metal-composite hybrid structures
Willian Sales de Carvalho (Speaker)
* 75th Annual Assembly, International Institute of Welding, Tokyo, Japan
16/07/22 → 22/07/22

Influence of energy distribution on porosity during EBW of thin walled aluminum components.
Matthias Moschinger (Speaker)
* 75th IIW Annual Assembly and International Conference: IIW 2022, Tokyo, Japan
16/07/22 → 22/07/22

Effect of local deformation during TIG welding of austenitic stainless steel on the microstructure and hardness
Rudolf Vallant (Speaker)
* ESSC & DUPLEX 2022, Verona, Italy
15/06/22 → 17/06/22

Application of Machine Learning on the Additive Manufacturing of AlSi10Mg
Pedro Effertz (Speaker)
* 33rd AeroMat Conference and Exposition: AeroMat 2022, Pasadena, CA, US
15/03/22 → 17/03/22

Application of additive manufacturing to improve the joinability of 316L stainless steel – PEEK-20CF hybrid joints produced by Ultrasonic Joining
Willian Sales de Carvalho (Speaker)
* 33rd AeroMat Conference and Exposition: AeroMat 2022, Pasadena, CA, US
15/03/22 → 17/03/22

Friction Riveting of Aviation Thermoplastics and Composites
S.T. Amancio (Speaker)
* 33rd AeroMat Conference and Exposition: AeroMat 2022, Pasadena, CA, US
15/03/22 → 17/03/22

Disruptive metal-composite hybrid structures for and space applications: Combining joining and manufacturing
S.T. Amancio (Speaker)
* 1st International Conference on Advanced Manufacturing for Air, Space and Land Transportation: ICAM 2022, Virtual
7/03/22 → 10/03/22

Influence of energy distribution on porosity during EBW of thin walled aluminum components
Matthias Moschinger (Speaker)
* Advanced Materials Day 2022, Graz, Austria
22/04/22


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15th Materials Day 2021, Siegfried Arneitz (Speaker)

2021

Additive manufacturing to improve joinability of hybrid structures
Willian Sales de Carvalho (Speaker)
* 15th Materials Day, Graz, Austria
18/11/21

Elektronenstrahlschweißen dünnwandiger Aluminium Liner
Matthias Moschinger (Speaker)
* General Meeting of the ÖGS, Vienna, Austria
28/10/21

Additive manufacturing of metal/polymer hybrid parts – The AddJoining Technique
Carlos Alberto Belei Feliciano (Speaker)
* 15th Materials Day, Graz, Austria
18/11/21

Artificial Intelligence – a key tool in additive manufacturing
Pedro Effertz (Speaker)
* 15th Materials Day, Graz, Austria
18/11/21

Einsatz der additiven Fertigung zur Optimierung der Fügbarkeit von Hybridstrukturen
Willian Sales de Carvalho (Speaker)
* 15th Materials Day, Graz, Austria
18/11/21

Herstellung von Bauteilen mittels WAAM ohne Nachbearbeitung
Norbert Enzinger (Speaker)
Florian Pixner (Speaker)
* 15th Materials Day: Additive Fertigung von performanten und hybriden Strukturen, Graz, Austria
18/11/21

Influence of Cu on the phases of secondary Al10SiMg alloys after heat treatments
Stefan Fortmüller (Speaker)
* LightMAT 2021: 4th International Conference on Light Materials
2/11/21 → 4/11/21

Application of a physically-based dislocation creep model to P92 for constructing TTR diagrams
Florian Kerem Riedlsperger (Speaker)
* 5th International ECCC Creep & Fracture Conference
19/10/21 → 20/10/21

Additive Manufacturing as Enabler for Embedded Sensor Technology and Innovative Components
Christof Sommitsch (Speaker)
* AVL ITS R&T Research Networking Day 2021, Austria
4/10/21

Artfremde Verbindungen auf Basis von Plasma Zwischenschichten
Norbert Enzinger (Speaker)
* Innovative und simulationsbasierte Prozess- und Fertigungsplanung von Schweißkonstruktionen, Graz, Austria
29/09/21 → 30/09/21

Numerische Simulation der Perlitbildung beim Schweißen von Schienen
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* Innovative und simulationsbasierte Prozess- und Fertigungsplanung von Schweißkonstruktionen, Graz, Austria
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Analytische Berechnung der Temperaturverteilung einer Kehlnahtschweißung
Norbert Enzinger (Speaker)
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29/09/21 → 30/09/21

Rotational friction welding of high strength steel anchor strands
Christian Hoflehner (Speaker)
* 2021 European Congress and Exhibition on Advanced Materials and Processes: EUROMAT 2021, virtual
13/09/21 → 17/09/21

Integrated modelling tools to simulate the evolution of the microstructure in titanium alloys along the production chain
Ricardo Henrique Buzolin (Speaker)
* 2021 European Congress and Exhibition on Advanced Materials and Processes: EUROMAT 2021, virtual
13/09/21 → 17/09/21

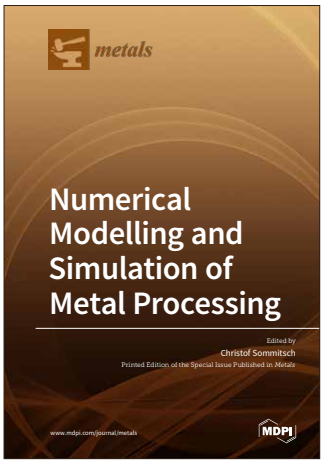
Prediction of microstructure gradient distribution of Ti alloys during thermomechanical treatment
Franz Miller Branco Ferraz (Speaker)
* 2021 European Congress and Exhibition on Advanced Materials and Processes: EUROMAT 2021, virtual
13/09/21 → 17/09/21

Mechanical performance optimization of additively-manufactured 316L stainless steel – PEEK hybrid joints produced by Ultrasonic Joining
Willian Sales de Carvalho (Speaker)
* 74th Annual Assembly, International Institute of Welding
7/07/21 → 21/07/21

Optimization of single-lap PA6-15CF/Ti-6Al-4V hybrid joints produced by Additive
Carlos Alberto Belei Feliciano (Speaker)
https://iiw2021.com/
* 74th Annual Assembly, International Institute of Welding
7/07/21 → 21/07/21

Books

Numerical Modelling and Simulation of Metal Processing: A special issue of Metals



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Advances in Metal Additive Manufacturing

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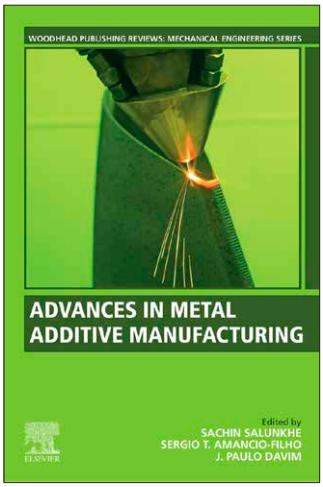

Powder bed fusion processes: main classes of alloys, current status, and technological trends

written by
Rafael Paiotti M. Guimaraes, Lisa Minkowitz, Siegfried Arneitz, Christof Sommitsch, Marcel Müller, Aziz Huskic, Norbert Wild, Ricardo Henrique Buzolin, Benjamin Meier, Mateusz Skalon, Franz Haas, Sergio T. Amancio-Filho
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Directed energy deposition processes and process design by artificial intelligence

written by
Rafael Paiotti M. Guimaraes, florian Pixner, Norbert Enzinger, Carlos Alberto FeicianoBelei, Pedro dos Santos Effertz, Sergio T. Amancio-Filho
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MDPI Special Issue "Microstructure Characterization and Design of Alloys"

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Silvana Sommadossi, Cecilia Poletti and Ricardo Buzolin.
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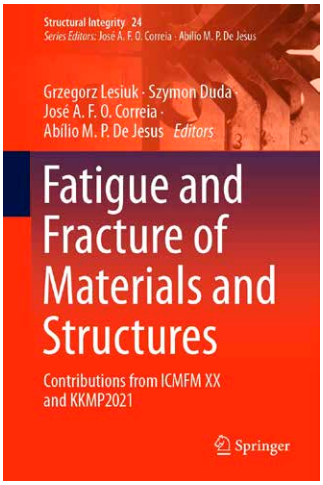
Contributions to books



Influence of Different Surface- and Heat Treatments; Elevated Temperature, Orientation on the Fatigue Properties of Ti6Al4V Processed by L-PBF for Controlled Powder Properties
written by
Benjamin Meier, Fernando Warchomicka, Reinhard Kaindl, Christof Sommitsch, Wolfgang Waldhauser
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Microstructurally Based Modeling of Creep Deformation and Damage in Martensitic Steels
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Christof Sommitsch, Bernhard Sonderegger, Mohammad Ahmadi, Florian Riedlsperger, Felix Meixner, Josef Mergl and Bernhard Krenmayr
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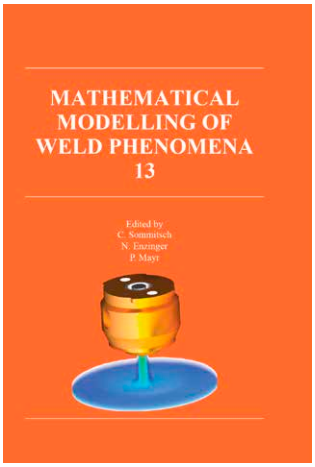
From the Edited Volume: Failure Analysis - Structural Health Monitoring of Structure and Infrastructure Components [Working Title], Dr. Gobinath Ravindran and Dr. Vutukuru Mahesh, 21 April 2022
https://doi.org/10.5772/intechopen.104381

Mathematical Modelling of Weld Phenomena issue 1 - 12, period 1992 - 2019

Conference Proceedings

Mathematical Modelling of Weld Phenomena 13

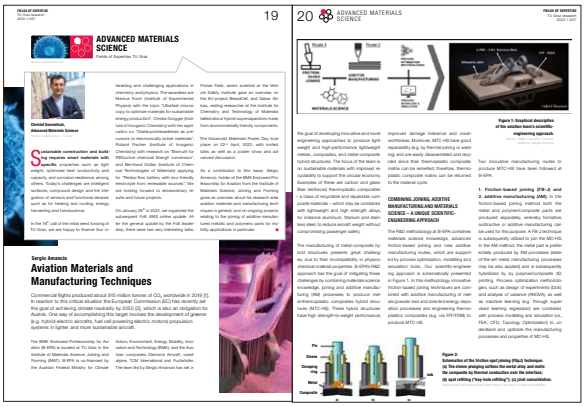


contains the papers presented at the 13th International Seminar 'Numerical Analysis of Weldability" in Sept 2022. This meeting was organised by the Institute and the International Institute of Welding (IIW). The academic aim of these meetings is to publish authoritative, well-written, refereed and edited articles, which are presented in sufficient depth to enable the ready reproduction of the work and to serve as reference as well as teaching material.
edited by
Christof Sommitsch, Norbert Enzinger, Peter Mayr.
Verlag der Technischen Universität Graz
ISBN: 978-3-85125-969-8, ISSN: 2410-0544
DOI 10.3217/978-3-85125-968-1
published 2023

Press

Aviation Materials and Manufacturing Techniques

Sergio Amancio
TU Graz research #27, 2022-1
https://epaper.tugraz.at/paper/88/8/desktop



TU Graz research #27

Smart Products from Smart Factories

If we think today about the factory of the future, robots, artificial intelligence, resource-efficient production methods and new materials have a firm place in it. At TU Graz, research is being carried out to turn this vision into reality.
Christof Sommitsch and Sergio Amancio
TU Graz research #28, 2022-2, by Birgit Baustädter
https://epaper.tugraz.at/paper/94/1/desktop

TU Graz research #28

Talk Science To Me

The science podcast of TU Graz
Interviewed by Birgit Baustädter:

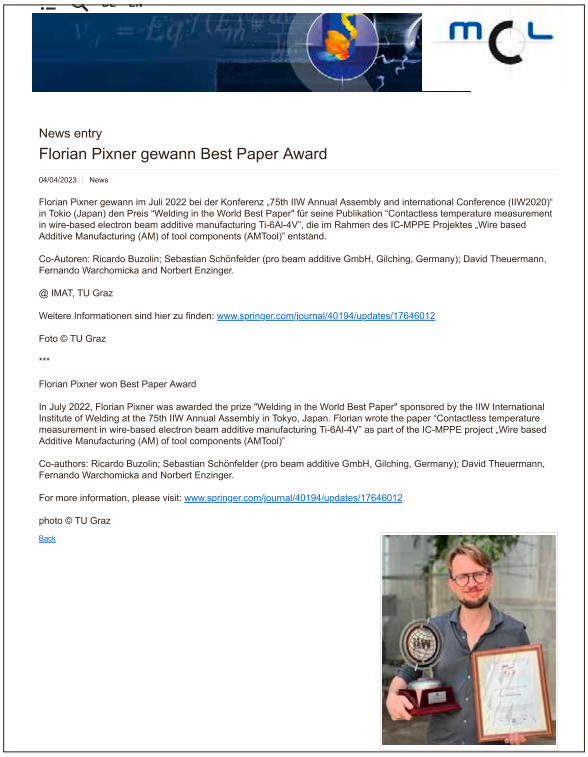
- podcast#6 Christof Sommitsch on smart production
- podcast#7 Franz Haas on future production
- podcast#8 Rudolf Pichler the smartfactory@tugraz
- podcast#9 Sergio T. Amancio Filho on new joining techniques

https://www.tugraz.at/en/tu-graz/services/news-stories/talk-science-to-me/all-episodes

Florian Pixner won Best Paper Award

75th IIW Annual Assembly and International Conference in Tokyo
Florian Pixner, by MCL, News Entry
04/04/2023, online

https://www.mcl.at/en/presse-news-media/news/news/florian-pixner-gewann-best-paper-award/



News entry
Florian Pixner gewann Best Paper Award

04/04/2023 | News

Florian Pixner gewann im Juli 2022 bei der Konferenz „75th IIW Annual Assembly and international Conference (IIW2020)" in Tokio (Japan) den Preis "Welding in the World Best Paper" für seine Publikation "Contactless temperature measurement in wire-based electron beam additive manufacturing Ti-6Al-4V", die im Rahmen des IC-MPPE Projektes „Wire based Additive Manufacturing (AM) of tool components (AMTool)" entstand.

Co-Autoren: Ricardo Buzolin; Sebastian Schönfelder (pro beam additive GmbH, Gilching, Germany); David Theuermann, Fernando Warchomicka and Norbert Enzinger.

@ IMAT, TU Graz

Weitere Informationen sind hier zu finden: www.springer.com/journal/40194/updates/17646012

Foto © TU Graz

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Florian Pixner won Best Paper Award

In July 2022, Florian Pixner was awarded the prize "Welding in the World Best Paper" sponsored by the IIW International Institute of Welding at the 75th IIW Annual Assembly in Tokyo, Japan. Florian wrote the paper "Contactless temperature measurement in wire-based electron beam additive manufacturing Ti-6Al-4V" as part of the IC-MPPE project „Wire based Additive Manufacturing (AM) of tool components (AMTool)"

Co-authors: Ricardo Buzolin; Sebastian Schönfelder (pro beam additive GmbH, Gilching, Germany); David Theuermann, Fernando Warchomicka and Norbert Enzinger.

For more information, please visit: www.springer.com/journal/40194/updates/17646012

photo © TU Graz

Back

MCL - News, 2023

"I just loved knowing what things are made of"

Ricardo Buzolin has received the DGM Prize for Young Talent of the German Materials Society for his work.
Ricardo Buzolin
Planet research / FoE Andvanced Materials Science / Young Talents, by Birgit Baustädter
21/09/2021, online

https://www.tugraz.at/tu-graz/services/news-stories

addLab - video

Our AddLab was presented during the 11th Conference of Learning Factory on 1-2 July 2021 in Graz.
https://www.tugraz.at/events/clf2021/home/

https://www.tugraz.at/institute/imat/home

AddLab video, Prof. Ramsauer with Prof. Sommitsch, 2021

TU Graz
Graz University of Technology

SCIENCE PASSION TECHNOLOGY

Planet Research:
"I just loved knowing what things are made of."

09/21/2022 | Planet research | FoE Advanced Materials Science | Young Talents
By Birgit Baustädter

This sentence comes from TU Graz researcher Ricardo Buzolin. The 30-year-old is actually a mechanical engineer, but switched to materials science because "every machine is made of materials".

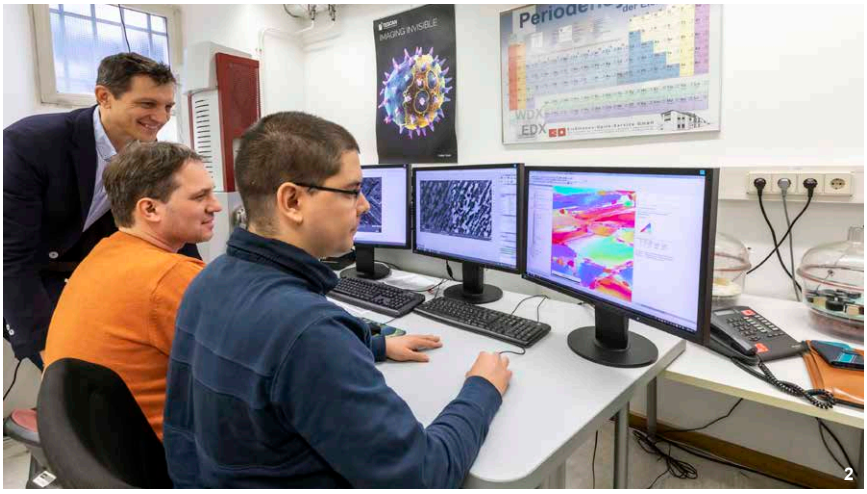
Ricardo Buzolin is working on the properties of metallic materials. Source: Lunghammer - TU Graz

"My father used to have a motorbike," Ricardo Buzolin says, only to correct himself with a laugh: "Or rather, he once had a motorbike." Because Ricardo Buzolin loved to take things apart as a young man in order to know, how they were made. But, in the case of the motorbike, he even had permission to do so. "My father had this old motorbike. It no longer worked. Instead of throwing it away, he used it to entertain his son for several months," he says with a broad smile. "We took the bike apart together piece by piece and looked at everything. I loved that."

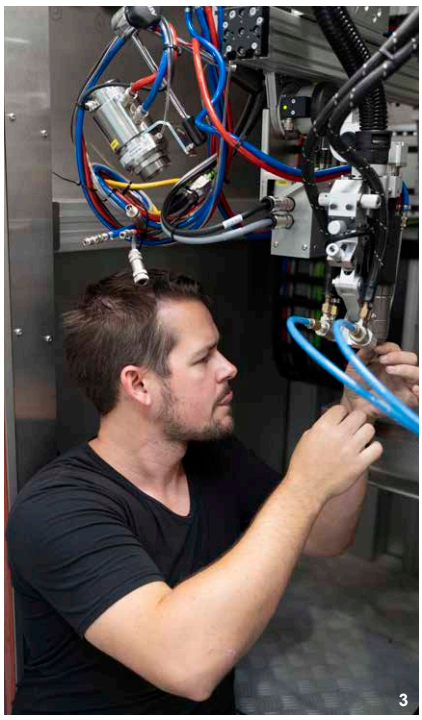
My father used to have a motorbike...

TU Graz - Planet Research, 2022

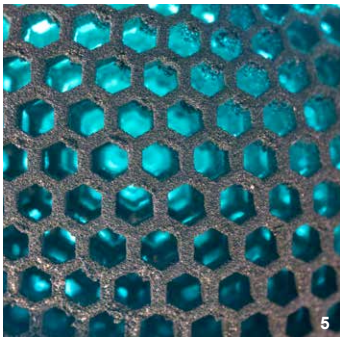
Impressions 2021 - 2023

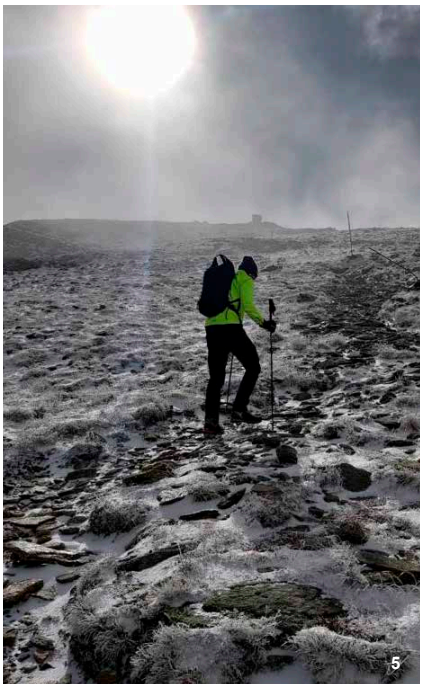


pictures 1, 2: © Lunghammer / TU Graz



1. REM - scanning electron microscope
2. Christof Sommitsch, Fernando Warchomicka and Ricardo Buzolin at the REM
3. Matthias Moschinger working on the SBI plasma welding machine, 2022
4. The Making of - photo shooting by Bernhard Fercher, 2023
5. AM part of 316L Stainless steel, 2023
6. Hybrid electrode out of aluminium alloy and Carbon fibre-reiforced polymer for possible aerofoil, 2023
7. PhD defense from Florian Riedlsperger, 2022
8. Guided tour in Landeszeughaus Graz, 2022



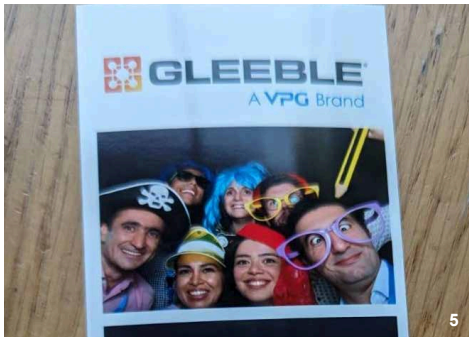


1. IMAT hiking tour to Zirbitzkogel, IMAT at the top, 2022
2. IMAT hiking tour Zirbitzkogel, 2022
3. Zirbitzkogel: Nikolas Rojas, Thomas Staubmann and Rudolf Vallant
4. Zirbitzkogel
5. Prof. Sommitsch on the way up, Zirbitzkogel, 2022
6. Prof. Sommitsch visited Prof. Herman Nied an Kathleen Nied in US, 2023
7. Sorin Keller visited IMAT, 2021

Impressions

1. Thermec'2023 opening, Prof. Christof Sommitsch, Sabine Seidler (Rector of the TU Wien) and Prof. Ernst Kozeschnik, 2023
2. Samples EBAM Electron Beam Additive Manufacturing
3. IMAT Pizza day with Sebastian Fritsche and Matthias Moschinger, 2022
4. IMAT maroon roasting, 2022
5. Night of Networking, Thermec'2023
6. Modelling Group, Hiking Day, 2022
7. AddMag Meeting in Grenoble, 2023

picture 2: © Lunghammer / TU Graz



1. IMAT skiing day, Sebastian Fritsche - also authorized ski instructor - is awarding the IMAT absolut beginner skiers, 2023
2. IMAT skiing day in Lachtal, 2023
3. IMAT barbecue with guests, 2022
4. IMAT skiing day, with french interchange students from University of Bordeaux, 2023
5. Doctoral seminar IMAT and TUM in Munich, 2022
6. IMAT skiing day - alternativ programme tobogganing, 2023

Upcoming Events

International Conference on Processing & Manufacturing of Advanced Materials
Thermec´2025
in Tours, France
https://go.tugraz.at/thermec

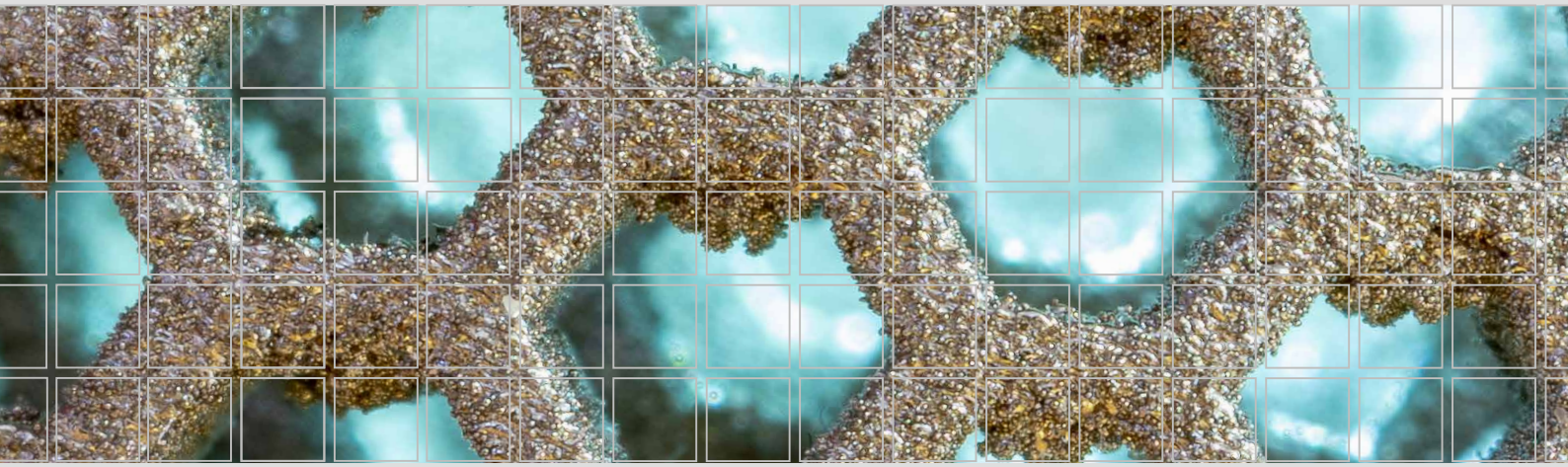
14th International seminar
Numerical Analysis of Weldability
21 - 24 September 2025 in Seggau, Austria
https://go.tugraz.at/seggau

Issue 14 - 2023, Reporting period: 06.2021 - 06.2023

Editorial: Sandra Wesener

Univ.-Prof. Dipl.-Ing. Dr.techn. Christof Sommitsch (Publisher)
Graz Universitiy of Technology
8010 Graz - Austria, Kopernikusgasse 24/I

SCIENCE ▪ PASSION ▪ TECHNOLOGY



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