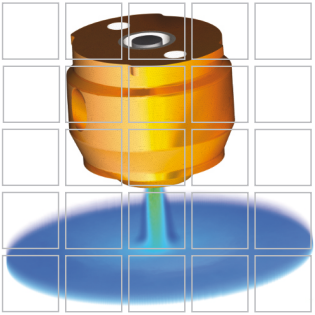
TU Graz
Graz University of Technology

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

IMAT



FINAL PROGRAMME

13th International Seminar

Numerical Analysis of Weldability

4 - 7 September 2022

Graz - Seggau - Austria

IIW Commission IX
WG Mathematical Modelling of Weld Phenomena

IMAT
Institute of Materials Science, Joining and Forming – TU Graz

Welcome note

13th International Seminar
Numerical Analysis of Weldability
Chairman: C. Sommitsch
Co-Chairmen: N. Enzinger, P. Mayr
Honorary Chairman: H. Cerjak

With the 13th International Seminar „Numerical Analysis of Weldability“, a tradition of successful meetings will be continued. Since the first of these events in 1991, this seminar series has developed to be a world leading conference in the growing field of the development of methods for predicting the microstructure and properties of welds. It is both, of practical importance and academic interest and it supports the philosophy of computer modelling, which helps to optimise welding processes and consumables as well as the service behaviour of welded components. Leading experts in this field attend the seminar and present their latest results in the calm atmosphere of an ancient castle. The seminar is organized by the Institute of Materials Science, Joining and Forming of Graz University of Technology.

The following items (among others) of development and application of numerical analysis shall be discussed:

- Arc Welding, Melt Pool and Solidification
- Microstructural Modelling in Weld Metal and Heat Affected Zone
- Microstructure and Mechanical Properties
- Residual Stresses and Distortion
- Cracking Phenomena and Hydrogen Effects
- Solid State and Friction Stir Welding
- Laser & Electron Beam Welding
- Special Joining Processes
- Modelling Tools and Computer Programmes
- Additive Manufacturing
- Artificial Intelligence

Publication

After a peer review process, the contributions will be published as a book. Furthermore, all papers can be published as open access articles.

IIW Kenneth Easterling Best Paper Award

This IIW award, which is sponsored by the Institute for Materials Science, Joining and Forming of Graz University of Technology as well as by the Metals Journal, will be awarded for the eighth time.

It is given to the paper *“which is valued by an international committee as the best contribution made over the three years proceeding on the advancement of knowledge or practice in respect of mathematical modelling of weld phenomena“*.

The programme at a glance

Sunday, 4th September 2022	**Arrival day**	
	19:00	**Welcome reception** **&** **Dinner at Schloss Seggau**
Monday, 5th September 2022	08:30 - 08:45	**Welcome address and introduction**
	08:45 - 16:10	**Presentations**
	18:30	**Bus departure to dinner location**
	19:15	**Dinner at Winery Pichler-Schober**
Tuesday, 6th September 2022	08:30 - 16:15	**Presentations**
	17:30 - 18:30	**Guided tour through Schloss Seggau**
	19:00	**Wine tasting and styrian evening (Buffet)** **Best paper award ceremony**
Wednesday, 7th September 2022	08:30 - 11:40	**Presentations**
	11:40 - 12:00	**Farewell**

Scientific committee

Chairman: Christof Sommitsch, Graz University of Technology - IMAT, Austria
Vice Chairmen: Norbert Enzinger, Graz University of Technology - IMAT, Austria
Peter Mayr, Technical University of Munich, Germany
Honorary Chairman: Horst Cerjak, Graz University of Technology - IMAT, Austria

Murugaiyan Amirthalingam, Indian Institute of Technology Madras, India
Thomas Böllinghaus, BAM - Federal Institute for Materials Research and Testing Berlin, Germany
Jesper Hattel, Technical University of Denmark, Denmark
Toshihiko Koseki, Kyoto University of Advanced Science, Japan
Ernst Kozeschnik, TU Wien, Austria
Tobias Loose, Dr. Loose GmbH, Germany
Wenya Li, Northwestern Polytechnical University, P.R. China
Stephen Liu, Colorado School of Mines, USA
Patricio F. Mendez, University of Alberta, Canada
Suck Joo Na, Xian Jiaotong University, P.R. China
Uwe Reisgen, RWTH Aachen University, Germany
Michael Rethmeier, Technische Universität Berlin, Germany
Kazuyoshi Saida, Osaka University, Japan
Gleb A. Turichin, Saint Petersburg State Polytechnical University, Russia
John Turner, The University of Tennessee, USA
ChuanSong Wu, Shandong University, Jinan, China

Monday, 5th September 2022

08:30 - 08:45 **Welcome address and introduction**
Christof SOMMITSCH, Graz University of Technology - IMAT, Austria

I Additive Manufacturing

Chairman: C. Sommitsch

08:45 - 09:10 **KEYNOTE**
High-fidelity numerical analysis of metal deposition in wire-arc additive manufacturing
EBRAHIMI Amin, RICHARDSON Ian M., HERMANS Marcel J.M.
Department of Materials Science and Engineering, Delft University of Technology, The Netherlands

09:10 - 09:30 **High-fidelity numerical modelling and experimental investigation of hot and cold spatter formation during laser powder bed fusion of 316-L stainless steel**
BAYAT Mohamad (1), BARTELS Dominic (2), SCHMIDT Michael (2), HATTEL Jesper H. (1)
1: Department of Mechanical Engineering, Technical University of Denmark (DTU), Denmark
2: Institute of Photonic Technology, Friedrich-Alexander-University Erlangen-Nürnberg, Germany

09:30 - 09:50 **Comparison between green and infrared laser in laser powder bed fusion of pure copper through high fidelity numerical modelling at meso-scale**
ALPHONSO Wayne Edgar, BAYAT Mohamad, HATTEL Jesper Henri
Technical University of Denmark (DTU), Denmark

09:50 - 10:10 **Simulation of microstructure evolution during WAM process**
KRONSTEINER Johannes (1), DREXLER Hugo (1), HOVDEN Sindre (1), HAUNREITER Fabian (1), O'TOOLE Patrick (2), MOLOTNIKOV Andrey (2), EASTON Mark (2)
1: LKR Light Metals Technologies, Austrian Institute of Technology, Austria
2: RMIT University, Melbourne, Australia

10:10 - 10:30 **Numerical prediction of bead formation and build-up toward WAAM process optimization**
BEN Hamouda Haithem (1), FELICE Igor (2), OLIVEIRA João Pedro(2), ANTONISSEN Joachim (1)
1: Guaranteed BV, Zelzate, Belgium
2: Department of Mechanical and Industrial Engineering FCT NOVA, ,Lisbon, Portugal

10:30 - 11:00 COFFEE BREAK

II Arc Welding, Melt Pool, Solidification

Chairman: E. Kozeschnik

11:00 - 11:25 **KEYNOTE**

Physical mechanisms governing deposition rate in arc welding with a consumable electrode

MENDEZ Patricio

University of Alberta, Edmonton, AB, Canada

11:25 - 11:45 **Numerical study on the formation of a bulging region in partial penetration laser beam welding**

ARTINOV Antoni (1), MENG Xiangmeng (1), BACHMANN Marcel (1), RETHMEIER Michael (2,1,3)

1: BAM Federal Institute for Materials Research and Testing, Germany

2: Institute of Machine Tools and Factory Management, Technische Universität Berlin, Germany

3: Fraunhofer Institute for Production Systems and Design Technology, Germany

11:45 - 12:05 **Modelling of the melt pool behaviour during a pulsed TIG welding operation in a narrow groove**

CADIOU Stephen (1), BAUMARD Anais (1), BROSSE Alexandre (1), BRUYERE Vincent (2)

1: Framatome-DTIM, Lyon, France

2: SIMTEC, Grenoble, France

12:05 - 12:25 **A numerical study on the suppression of a detrimental weld pool profile in wire feed laser beam welding by magnetohydrodynamic technique**

MENG Xiangmeng (1), ARTINOV Antoni (1), BACHMANN Marcel (1), ÜSTÜNDAĞ Ömer (1), GUMENYUK Andrey (1), RETHMEIER Michael (1,2)

1: BAM Federal Institute for Materials Research and Testing, Germany

2: Technische Universität Berlin, Germany

12:25 - 13:40 LUNCH

13:40 - 14:00 **Numerical analysis of the dependency of the weld pool shape on turbulence and thermodynamic activity of solutes in laser beam welding of unalloyed steels**

ARTINOV Antoni (1), KISING Pascal (1), BACHMANN Marcel (1), MENG Xiangmeng (1), RETHMEIER Michael (2,1,3)

1: BAM Federal Institute for Materials Research and Testing, Germany

2: Institute of Machine Tools and Factory Management, Technische Universität Berlin, Germany

3: Fraunhofer Institute for Production Systems and Design Technology, Germany

14:00 - 14:20 **FEM study of thermomechanical welding of austenitic stainless steel and experimental validation**

WANG Peng (1), SZALOWSKI Bartlomiej (1), ELUSTONDO AZUKE Jokin (2), VALLANT Rudolf (1), POLETTI Cecilia (1), ENZINGER Norbert (1)

1: Institute of Materials Science, Joining and Forming at the Graz University of Technology, Graz, Austria

2: Faculty of Engineering at the Mondragon University, Arrasate, Gipuzkoa, Spain

III Artificial Intelligence

Chairman: J. Inoue

14:20 - 14:40 **Optimization of the laser beam welding process using combination of physical based and data driven AI models**
ILIN Alexander, STRITT Peter
Robert Bosch GmbH, Germany

14:40 - 15:00 **Study of resistance spot welding via experimental, numerical and advanced analytical methods**
GAO He, ZWART Remco, vd AA Ellen, vd VELDT Tony
Tata Steel Europe, The Netherlands

15:00 - 15:30 COFFEE BREAK

IV Laser & Electron Beam Welding

Chairman: M. Bachmann

15:30 - 15:50 **Establishing an automated heat-source calibration framework**
RISSAKI Dimitra (1), VASILEIOU Anastasia (1), SMITH Mike (1), MURÁNSKY Ondrej (2), BENARDOS Panorios (3), VOSNIAKOS George (3)
1: The University of Manchester, Manchester, United Kingdom
2: ANSTO, Australia
3: National Technical University of Athens, Athens, Greece

15:50 - 16:10 **Numerical analysis of the influence of an auxiliary oscillating magnetic field on suppressing the porosity formation in deep penetration laser beam welding of alluminum alloys**
YANG Fan (1), MENG Xiangmeng (1), BACHMANN Marcel (1), ARTINOV Antoni (1), NUGRAHA PUTRA Stephen (1) RETHMEIER Michael (2,1,3)
1: BAM Federal Institute for Materials Research and Testing, Berlin, Germany
2: Technical University Berlin, Institute of Machine Tools and Factory Management, Berlin, Germany
3: Fraunhofer Institute for Production Systems and Design Technology, Berlin, Germany

18:30 Bus departure to dinner location

TUESDAY, 6TH SEPTEMBER 2022

V Residual Stresses and Distortion

Chairman: N. Enzinger

08:30 - 08:55 **KEYNOTE**

Simulation of residual stresses during the wire arc additive manufacturing (WAAM) process

ALRUMAYH Abdulrahman A. (1), NIED Herman F. (2)
1: Qassim University, Qassim, Saudi Arabia
2: Lehigh University, Bethlehem, PA, United States of America

08:55 - 09:15 **Numerical analysis of welding process for distortion prediction of pipe structures for aerospace industry**

RASCHE Stefan (1), FISCHER Moritz (2), HILDEBRAND Jörg (1), BERGMANN Jean Pierre (1)
1: TU Ilmenau, Ilmenau, Germany
2: PFW Aerospace GmbH, Speyer, Germany

09:15 - 09:35 **Effect of phase- and temperature-dependent strain-hardening slopes on the calculated welding residual stresses in S235 steel**

SUN Jiamin, NITSCHKE-PAGEL Thomas, DILGER Klaus
TU Braunschweig, Germany

09:35 - 09:55 **A new alloy type agnostic solidification cracking susceptibility criteria**

RAMIREZ Antonio, GIORJAO Rafael, BRIZES Eric
The Ohio State University, United States of America

09:55 - 10:25 **COFFEE BREAK**

Chairman: H. Nied

10:25 - 10:45 **Validation of welding structure simulations**

LOOSE Tobias (1), GIRRESSER Tobias (2), GOLDAK John (3)
1: Dr. Loose GmbH, Walzbachtal, Germany
2: Technologie-Institut für Metall & Engineering GmbH (TIME), Wissen (Sieg), Germany
3: Goldak Technologies Inc., Ottawa, Canada

10:45 - 11:05 **Numerical simulation of l-pbf additive manufacturing of medium-manganese steel for automotive crash applications**

ABBURI VENKATA Kiranmayi (1), SCHOB Bernd (2), KASPROWICZ Marcin (3)
1: Simufact Engineering part of Hexagon, Hamburg, Germany
2: Technische Universität Chemnitz, Chemnitz, Germany
3: Wadim Plast Sp. z o. o., Reguły, Poland

11:05 - 11:25 **A variability assessment of commercially available material data for welding and directed energy deposition simulations**

DANTIN Matthew J, FISHER Charles R
Naval Surface Warfare Center, Carderock Division, West Bethesda, Maryland, United States of America

11:25 - 11:45 **On the influence of cyclic plasticity on the residual stress state in welded high-alloy steels**
HEMPEL Nico (1,2), NITSCHKE-PAGEL Thomas (3), REBELO KORNMEIER Joana (2), DILGER Klaus (2)
1: Technical University of Munich, TUM School of Engineering and Design, Chair of Materials Engineering of Additive Manufacturing, Garching, Germany
2: TU Braunschweig, Institute of Joining and Welding, Braunschweig, Germany
3: Heinz Maier-Leibnitz Zentrum (MLZ), Technical University of Munich, Garching, Germany

11:45 - 12:05 **A simulation approach for series production of plasma-based additive manufacturing of Ti-6Al-4V components**
BIELIK Martin (1), NEUBAUER Erich (1), KITZMANTEL Michael (1), NEUBAUER Ingo (2), KOZESCHNIK Ernst (3)
1: RHP-Technology GmbH, Austria
2: Simufact Engineering GmbH, Germany
3: TU Wien, Austria

12:05 - 13:20 LUNCH

VI Microstructural Modelling in Weld Metal and Heat Affected Zone

Chairman: P. Mayr

13:20 - 13:40 **Extraction of process-structure-property linkage using deep learning methods**
INOUE Junya, NOGUCHI Satoshi
The University of Tokyo, Japan

13:40 - 14:00 **A general steel tempering model for prediction of resistance spot welding heat-affected zone hardness**
BRIZES Eric, RAMIREZ Antonio
The Ohio State University, Columbus-OH, United States of America

14:00 - 14:20 **Microstructure evolution subroutine for finite element analysis**
SHAN Yao V., VIERNSTEIN B., KOZESCHNIK E.
TU Wien, Austria

14:20 - 14:40: **Stress-strain properties of HSS steel welded joint heterogeneous structure: Experimental and numerical evaluation**
TOMERLIN Damir (1), KOZAK Dražan (2), GUBELJAK Nenad (3), MAGIĆ KUKULJ Marija (1)
1: DOK-ING Ltd., Zagreb, Croatia
2: Mechanical Engineering Faculty, University of Slavonski Brod, Slavonski Brod, Croatia
3: Faculty of Mechanical Engineering, University of Maribor, Maribor, Slovenia

14:40 - 15:10 COFFEE BREAK

VII Cracking Phenomena & Hydrogen Effects

Chairman: N. Gubeljak

15:10 - 15:35 **KEYNOTE**

Analysis of solidification cracking considering mechanical and metallurgical factors

MAEDA Shintaro, KATO Takuya, IKUSHIMA Kazuki, SHIBAHARA Masakazu
Graduate school of engineering, Osaka Metropolitan University, Japan

15:35 - 15:55 **Numerical simulation of gleeble tensile testing for analysis of liquid metal embrittlement**

SEITZ Georg (1), BIEGLER Max (1), SCHREIBER Vincent (4), MEYERDIERKS Martin (4), JÜTTNER Sven (4), RETHMEIER Michael (3,1,2)
1: Fraunhofer Institute of Production Systems and Design Engineering (IPK), Berlin, Germany
2: Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany
3: Institut für Werkzeugmaschinen und Fabrikbetrieb IWF, Technische Universität Berlin, Berlin, Germany
4: Institut für Werkstoff- und Fügetechnik IWF, Otto von Guericke Universität Magdeburg, Magdeburg, Germany

15:55 - 16:15 **Numerical study of the Tekken welding test**

PAGET Alexandre (1,2), ROBIN Vincent (2,4), DRAUP Jefri (3), HENDILI Sofiane (2), UFARTE Rafaël (2), KHAN Talha (3,1), DELMAS Josselin (2), SMITH Michael C. (1)
1: The University of Manchester (MaSC), Manchester, United-Kingdom
2: EDF R&D (PRISME), Chatou, France
3: EDF Energy R&D UK Center (MaSC), Manchester, United-Kingdom
4: EDF Direction Technique, Lyon, France

17:30 - 18:30 **Guided tour through Schloss Seggau (optional - please register by 12:30 pm)**

19:00 **Wine tasting and Styrian evening (with Styrian Buffet) at Schloss Seggau, Best paper award ceremony**

Wednesday, 7th September 2022

VIII Modelling Tools and Computer Programs

Chairman: T. Loose

08:30 - 08:50 **Assessment of fatigue behaviour of UHSS steel butt-welded joints by means of a fracture mechanics methodology**
STEIMBREGER Ceferino (1,2), GUBELJAK Nenad (3), VUHERER Tomaž (3), ENZINGER Norbert (4), ERNST Wolfgang (5), CHAPETTI Mirco Daniel (2)
1: National University of Comahue, Neuquén, Argentine Republic
2: National University of Mar del Plata - CONICET, Institute for Material Science and Technology (INTEMA), Mar del Plata, Argentina
3: University of Maribor, Faculty of Mechanical Engineering, Maribor, Slovenia;
4: Graz University of Technology, Institute for Materials Science and Welding, Graz, Austria
5: voestalpine Stahl GmbH, Linz, Austria

08:50 - 09:10 **Efficient numerical analysis of directed energy deposition processes**
ELSNER Beatrix A. M. (1), NEUBAUER Ingo (1), RABERGER Lukas (2)
1: Simufact Engineering, Hamburg, Germany
2: Fronius International GmbH, Thalheim bei Wels, Austria

09:10 - 09:30 **Prognose der Nahtgeometrie beim Laserstrahlschweißen**
SCHWARZ Christian, PUSCHMANN Markus, MAUERMANN Reinhard
Fraunhofer IWU, Chemnitz, Germany

IX Solid State and Friction Stir Welding

Chairman: N. Hempel

09:30 - 09:50 **Numerical analysis of ultrasonic vibration enhanced friction stir welding of dissimilar Al/Mg alloys**
YANG Chunliang (1,2), WU Chuansong (1), BACHMANN Marcel (2), RETHMEIER Michael (2, 3, 4)
1: Shandong University, China
2: Bundesanstalt für Materialforschung und -prüfung, Germany
3: Technische Universität Berlin, Germany
4: Fraunhofer Institute for Production Systems and Design Technology, Germany

09:50 - 10:10 **A process modelling approach to the developement of lap welding procedures**
LEWIS Mike (1), SMITH Simon (2)
1: FTS Engineering Answers Ltd, United Kingdom
2: Transforming Stress Ltd, United Kingdom

10:00 - 10:40 COFFEE BREAK

10:40 - 11:00 **Mechanical performance prediction of friction stir welded joint of rolled homogeneous armor steel**
GIORJAO Rafael, LYDA Paul, RAMIREZ Antonio
The Ohio State University, United States of America

X Special Joining Processes
Chairman: A. Ramirez

11:00 - 11:20 **Impact of activation in projection welding with capacitor discharge using multiphysics simulation and a process-integrated transition resistance measurement**
KOAL Johannes, BAUMGARTEN Martin, ZSCHETZSCHE Jörg, FÜSSEL Uwe
Technische Universität Dresden, Chair of Joining Technology and Assembly, Germany

11:20 - 11:40 **Simulation model for laser hardening of small-diameter holes**
EVDOKIMOV Anton (1), JASIEWICZ Filip (2), DOYNOV Nikolay (1), OSSENBRINK Ralf (1), MICHAILOV Vesselin (1)
1: Brandenburg University of technology, Germany
2: Scansonic MI GmbH

11:40 - 12:00 Farewell
Christof SOMMITSCH

End of Seminar

Sponsors of the seminar

POSTERS

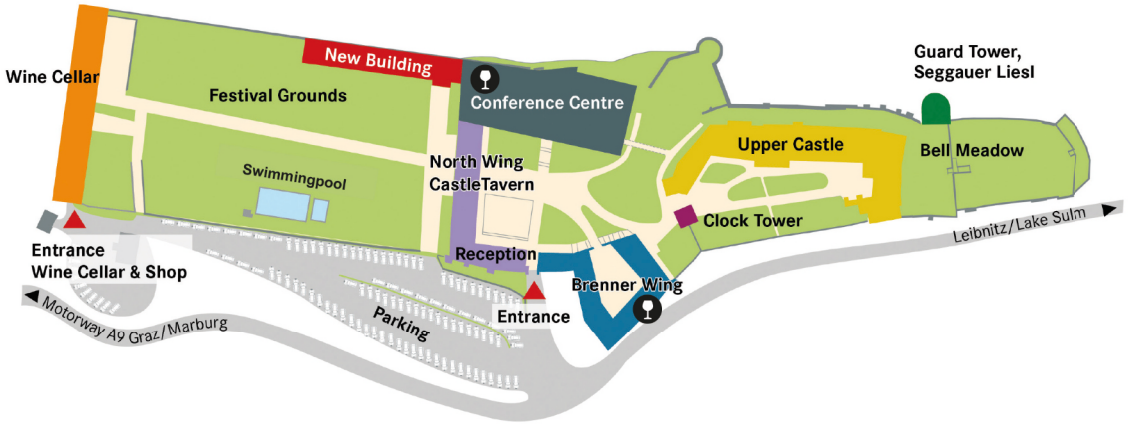
The posters are accessible during the whole seminar. Please place your poster on Monday morning. Coffee breaks are served in the poster session rooms. All authors are kindly asked and invited to stay with their posters during the breaks.

Simulation of laser assisted double wire deposition welding with two different approaches with eulerian (FVM) and lagrangian (SPH) methods
REISGEN Uwe (1), SHARMA Rahul (1), MOKROV Oleg (1), EMADMOSTOUFI Sobhan (1), KRUSKA Jan (1), HERMSDORF Jörg (2), LAMMERS Marius (2), BOKELMANN Tjorben (2)
1: Institute for joining and welding, RWTH-Aachen University, Aachen, Germany
2: Laser Zentrum Hannover (LZH), Hannover, Germany

Numerical simulation of a multi-layer MIG welding process on an aluminium alloy 6082
REICH Michael, WIECHMANN Philipp, KESSLER Olaf
University Rostock, Germany

Prediction of welding deformation of large-scale structure using inherent deformation computed by using machine learning
KATO Takuya, MAEDA Shintaro, IKUSHIMA Kazuki, SHIBAHARA Masakazu
Osaka Metropolitan University, Japan

Notes



Upper Castle

Ground floor: Managing Directors office, Administration, Toilets
1st floor: Castle Chapel, Castle Meeting Rooms 1–3, Rooms 12, 13, 14, Toilets
2nd floor: Episcopal Chambers, Gallery, Castle Meeting Rooms 4+5, Rooms 6–10

North Wing

Ground floor: Reception, Castle Tavern, Meeting room „Spielsaal"
1st floor: Rooms 4-101 – 4-113
2nd floor: Rooms 4-201 – 4-218

New Building

Ground floor: Dining Rooms 1–3
1st floor: Rooms 3-101 – 3-113

Conference Centre

Basement: Conference-Hall, Lower Lobby, Toilets
Ground floor: Styria-Hall, Meeting Rooms 1–3, Upper Lobby, Wardrobe
3rd floor: Drinks & Snack Corner

Brenner Wing

Ground floor: Brenner Meeting Rooms 1–3, Michael's Chapel, Rooms 5-111 – 5-113
1st floor: Rooms 5-101 – 5-110, Drinks & Snack Corner
2nd floor: Rooms 5-201 – 5-204

Wine Cellar

Basement: Episcopal Wine Cellar, Seggau Wine Shop
Ground floor: Orangery

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Venue

The 13th International Seminar „Numerical Analysis of Weldability“ will take place at Schloss Seggau, the former bishop residence in the Styrian wine area 40 km south of Graz, Austria.

How to reach Graz

Graz has currently direct scheduled flight connections from Amsterdam, Ankara, Antalya, Düsseldorf, Frankfurt, Lissabon, Munich, Palma de Mallorca, Vienna, Zurich and many others. For more information please visit the website Graz Airport http://www.flughafen-graz.at/en/home.

Seminar Organisation

Graz University of Technology, Institute for Materials Science, Joining and Forming and
IIW Commission IX, Working Group „Mathematical Modelling of Weld Phenomena“

Chairman: Prof. Christof Sommitsch
Institute of Materials Science, Joining and Forming
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