

**30. MEDNARODNA KONFERENCA O MATERIALIH  
IN TEHNOLOGIJAH**

15.–17. oktober 2025, Portorož, Slovenija

**30<sup>th</sup> INTERNATIONAL CONFERENCE ON MATERIALS  
AND TECHNOLOGY**

15–17 October 2025, Portorož, Slovenia

**PROGRAM IN KNJIGA POVZETKOV**

**PROGRAM AND BOOK OF ABSTRACTS**

30. MEDNARODNA KONFERENCA O MATERIALIH IN TEHNOLOGIJAH /  
30<sup>th</sup> INTERNATIONAL CONFERENCE ON MATERIALS AND TECHNOLOGY

PROGRAM IN KNJIGA POVZETKOV / PROGRAM AND BOOK OF ABSTRACTS

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**30<sup>th</sup> INTERNATIONAL CONFERENCE ON MATERIALS AND TECHNOLOGY,  
15–17 OCTOBER, 2025**

**Wednesday, 15.10.2025**

9:00	<b>OPENING CEREMONY – Chair of the Conference Matjaž Godec, ADRIA HALL</b>		<b>MEDITERANEA HALL PERMANET workshop</b>		
9:15	<b>PLENARY LECTURE - Orlov</b>	10:00	Opening - P. Padilla		
9:55	<b>PLENARY LECTURE - D'Elia</b>	10:10	Hub 1 - P. Flemming		
10:35	Kubasek	10:25	Hub2 - L. Itani		
10:55	Thermo Fisher	10:40	Hub3 - T. Tulio		
<b>11:15</b>	<b>Coffee Break</b>	11:00	Panelists		
11:45	MR session opening	12:00	Q&A and wrap-up - P. Padilla		
12:00	Kalaczynski - Nuhanović				
12:20	Nečas - Smilgevicius				
<b>12:30</b>	<b>LUNCH</b>				
	<b>ADRIA HALL – Young Researchers Session</b>				
14:00	Blažek - Kratochvil				
14:20	Tome - Velikajne				
14:40	Prijatelj - Pokorny				
15:00	Lesar - Lucchini Huspek				
15:20	Močnik				
<b>15:30</b>	<b>Coffee Break</b>				
16:00	Gonzalez - Tomc				
16:20	Šadl - Thurlova				
16:40	Zielinska - Gudžulić				
<b>17:30 – 19:30</b>	<b>POSTER SESSION IN MEDITERANEA HALL</b>				

## Thursday 16.10.2025

	ADRIA HALL	EMERALD HALL
09:00	<b>PLENARY LECTURE - Pašti</b>	<b>10:00 - 13:00</b> <b>Slovenian industrial meeting SRIP MATPRO</b>
09:40	Gutić	
10:00	Hodnik	
10:20	Bele	
10:40	Suhadolnik	
<b>11:00</b>	<b>Coffee Break</b>	
11:40	Bestetti	
12:00	Abdelghany	
12:20	Järvenpää	
12:40	Westman	
<b>13:00</b>	<b>LUNCH</b>	
	<b>ADRIA HALL</b>	
14:20	Kevorkijan	
14:50	Kovačec	
15:10	Sedlaček	
15:30	Podgornik	
15:50	Burja	
16:10	Žužek	
<b>16:30</b>	<b>Coffee Break</b>	
17:00	Yarasu	
17:20	Mede	
17:40	Mohd Radzuan	
18:00	Zgonc	
18:20	Prusa	
<b>20:00 - 23:00</b>	<b>Social event – Hotel Histrion Arcade Club</b>	

## Friday 17.10.2025

	ADRIA HALL		
09:00	<b>PLENARY LECTURE - Chiavari</b>		
09:40	Otmačić Ćurković		
10:00	Kosec		
10:20	Gartner		
10:40	Hren		
<b>11:00</b>	<b>Coffee Break</b>		
11:30	Bozziini		
11:50	Legat		
12:10	Garcia		
12:30	Godec		
12:50	Loncnar		
13:10	Oprčkal		
<b>13:30</b>	<b>Closing ceremony</b>		
<b>13:30</b>	<b>Lunch</b>		
<b>15:35</b>	<b>Workshops</b>		

**PROGRAM 30. MEDNARODNE KONFERENCE O MATERIALIH IN TEHNOLOGIJAH  
30<sup>th</sup> INTERNATIONAL CONFERENCE ON MATERIALS AND TECHNOLOGY: PROGRAM**

<b>Wednesday 15.10.2025 ADRIA HALL</b>	
	<b>Predsedujoči – Chairs:</b> Matjaž Godec , Anna Dobkowska
	<b>ADRIA HALL</b>
<b>9:00</b>	<b>ODPRTJE – OPENING CEREMONY – Matjaž Godec</b>
Plenary 9:15	<b>Atomic-Scale Mechanisms of Mg Oxidation</b> <u>Dmytro Orlov</u> Division of Mechanics, Materials and Component Design, Department of Industrial and Mechanical Sciences, LTH, Lund University
Plenary 9:55	<b>From design to functionality: Engineering biodegradable metals as durable implants through powder bed fusion – laser beam processing</b> <u>Francesco D'Elia</u> Uppsala Universitet, Department of Materials Science and Engineering
10:35	<b>Powder Metallurgy of Zinc Alloys for High Strength and Retained Ductility</b> <u>Jiří Kubásek</u> <sup>1</sup> , <u>Selase Torkornoo</u> <sup>2*</sup> , <u>David Nečas</u> <sup>1</sup> , <u>Anna Boukalová</u> <sup>1</sup> , <u>Ingrid McCarroll</u> <sup>2</sup> , <u>Baptiste Gault</u> <sup>2,3</sup> , <u>Črtomir Donik</u> <sup>4</sup> , <u>Irena Paulin</u> <sup>4</sup> , <u>Jaroslav Čapek</u> <sup>1</sup> <sup>1</sup> University of Chemistry and Technology in Prague, Faculty of Chemical Technology, Department of Metals and Corrosion Engineering, Prague, Czech Republic, <sup>2</sup> Department of Microstructure Physics and Alloy Design, Max-Planck-Institut für Nachhaltige Materialien GmbH, Max-Planck-Straße 1, 40237 Düsseldorf, Germany, <sup>3</sup> Department of Materials, Imperial College London, Royal School of Mines, Exhibition Road, London SW7 2AZ, UK, <sup>4</sup> Institute of Metals and Technology, Department of Physics and Chemistry of Materials, Ljubljana, Slovenia, E-mail: <a href="mailto:kubasekj@vscht.cz">kubasekj@vscht.cz</a>
10:55	<b>Advances in 3D Characterization Using Focused Ion Beam (FIB) Technology</b> <u>Nicolas A. Rivas</u> Thermo Fisher Scientific
<b>11:15</b>	<b>Coffee Break</b>
11:45	<b>MR session opening; Predsedujoči – Chairs:</b> Miran Čeh, Bojan Podgornik, Kristina Žagar, Elena Tchernychova, Dorota Moszczyńska, Francesco D'Elia
12:00	<b>Influence of HIP on the properties of the LPBF manufactured austenitic ODS steels</b> <u>Hubert Kalaczyński</u> <sup>1</sup> , <u>Anna Dobkowska</u> <sup>1</sup> , <u>Jakub Ciftci</u> <sup>2</sup> , <u>Irena Paulin</u> <sup>3</sup> , <u>Črtomir Donik</u> <sup>3</sup> , <u>Jiří Kubásek</u> <sup>4</sup> , <u>Matjaž Godec</u> <sup>3</sup> , <u>Jarosław Mizera</u> <sup>1</sup> <sup>1</sup> Faculty of Materials Science and Engineering, Warsaw University of Technology, 00-661 Warsaw, Poland, <sup>2</sup> AMAZEMET Sp. z o. o. [Ltd.], Al. Jana Pawła II 27, 00-867 Warsaw, Poland <sup>3</sup> Department of Physics and Chemistry of Materials, Institute of Metals and Technology, 1000 Ljubljana, Slovenia, <sup>4</sup> Department of Metals and Corrosion Engineering, Faculty of Chemical Technology, University of Chemistry and Technology in Prague, 160 00 Prague, Czech Republic E-mail: <a href="mailto:hubert.kalaczynski.stud@pw.edu.pl">hubert.kalaczynski.stud@pw.edu.pl</a>
12:10	<b>Versatile Applications of Scanning Electrochemical Microscopy: From Localized Corrosion Analysis to Electrocatalysis in Metals and Alloys</b> <u>Mejrema Nuhanović</u> , <u>Léonard Moriau</u> , <u>Milutin Smiljanić</u> , <u>Nejc Hodnik</u> Department of Materials Chemistry, National Institute of Chemistry, Hajdrihova 19, 1000 Ljubljana, Slovenia, E-mail: <a href="mailto:mejrema.nuhanovic@ki.si">mejrema.nuhanovic@ki.si</a>

12:20	<p><b>In-Situ Formation of Y<sub>2</sub>O<sub>3</sub> Particles in 316L ODS Steel Using YH<sub>2</sub></b>  Jan Pokorný<sup>1</sup>, Jiří Kubásek<sup>1</sup>, Anna Dobkowska<sup>2</sup>, Irena Paulin<sup>3</sup>, Črtomir Donik<sup>3</sup>, Matjaž Godec<sup>3</sup>,  David Nečas<sup>1</sup></p> <p><sup>1</sup>University of Chemistry and Technology in Prague, Faculty of Chemical Technology, Department of Metals and Corrosion Engineering, Prague, Czech Republic, <sup>2</sup>Warsaw University of Technology, Faculty of Materials Science and Engineering, Warsaw, Poland, <sup>3</sup>Institute of Metals and Technology, Department of Physics and Chemistry of Materials, Ljubljana, Slovenia, E-mail: <a href="mailto:necasd@vscht.cz">necasd@vscht.cz</a></p>
12:30	<p><b>Anti-Corrosive Protection of Aircrafts unstainable Coatings Based on Biomass Waste: Local Lignin Valorization for high Technology</b>  T.V. Smilgevicius, J.C. Dupin, J. Allouche</p> <p>University of Pau et des Pays de l'Adour, IPREM CNRS UMR5254, Hélioparc 2 Av. du Président Pierre Angot, 64000 PAU, FRANCE, E-mail: <a href="mailto:t.smilgevicius@univ-pau.fr">t.smilgevicius@univ-pau.fr</a></p>
12:40	<p><b>LUNCH</b></p>
	<p><b>Predsedujoči – Chairs:</b> Miran Čeh, Bojan Podgornik, Kristina Žagar, Elena Tchernychova, Dmytro Orlov, Francesco D'Elia</p> <p><b>ADRIA HALL – Young Researchers Session</b></p>
14:00	<p><b>Microstructural Evolution and Mechanical Properties of Ti–25Nb–8Sn–4Ta Beta Titanium Core–Shell Structures Fabricated by Ball Milling and Spark Plasma Sintering</b>  Jan Blažek, David Nečas, Jiří Kubásek</p> <p>University of Chemistry and Technology in Prague, Faculty of Chemical Technology, Department of Metals and Corrosion Engineering, Prague, Czech Republic, E-mail: <a href="mailto:blazekb@vscht.cz">blazekb@vscht.cz</a></p>
14:10	<p><b>Enhancing mechanical properties of CoCrFeNiMn high-entropy alloy with carbon waste materials</b>  Petr Kratochvíl<sup>1</sup>, Jan Riedl<sup>1</sup>, František Růžička<sup>1</sup>, Tomáš Vrba<sup>1</sup>, Jafar Fathi<sup>2</sup>, Filip Průša<sup>1</sup></p> <p><sup>1</sup> University of Chemistry and Technology, Technická 5, 166 28 Prague, Czech Republic  <sup>2</sup> Institute of Plasma Physics of the Czech Academy of Sciences, U Slovanky 2525/1a, 182 00 Prague, Czech Republic, E-mail: <a href="mailto:kratochs@vscht.cz">kratochs@vscht.cz</a></p>
14:20	<p><b>AISI H13 Hot Work Tool Steel Produced by Laser Powder Bed Fusion</b>  Samo Tome, Irena Paulin, Danijela Skobir Balantič, Matjaž Godec</p> <p>Institute of Metals and Technology, Lepi pot 11, SI-1000 Ljubljana, Slovenia  E-mail: <a href="mailto:samo.tome@imt.si">samo.tome@imt.si</a></p>
14:30	<p><b>Effects of the addition of silicon to EN AW 7075 aluminum alloy on solidification behaviour</b>  <sup>1,2</sup>Nejc Velikajne, <sup>2</sup>Jožef Medved, <sup>1</sup>Črtomir Donik, <sup>1</sup>Matjaž Godec, <sup>1</sup>Irena Paulin</p> <p><sup>1</sup>Institute of Metals and Technology, Lepi pot 11 Ljubljana, Slovenia, <sup>2</sup>University of Ljubljana, Faculty of Natural Sciences and Engineering, Aškerčeva cesta 12 Ljubljana, Slovenia  E-mail: <a href="mailto:nejc.velikajne@imt.si">nejc.velikajne@imt.si</a></p>
14:40	<p><b>Monitoring galvanic corrosion between copper and steel</b>  Klara Prijatelj<sup>1</sup>, Aleš Nagode<sup>2</sup>, Tadeja Kosec<sup>1</sup></p> <p><sup>1</sup>Slovenian National Building and Civil Engineering Institute, Dimičeva 12, 1000 Ljubljana, Slovenia  <sup>2</sup>University of Ljubljana, Faculty of Natural Sciences and Engineering, Aškerčeva 12, 1000 Ljubljana, Slovenia  E-mail: <a href="mailto:klara.prijatelj@zag.si">klara.prijatelj@zag.si</a></p>
14:50	<p><b>Corrosion Resistance of AISI 316L ODS Steel Strengthened by In-Situ Formed Y<sub>2</sub>O<sub>3</sub> Particles</b>  Jiří Kubásek<sup>1</sup>, Anna Boukalová<sup>1</sup>, David Nečas<sup>1</sup>, Anna Dobkowska<sup>2</sup>, Črtomir Donik<sup>3</sup>,  Irena Paulin<sup>3</sup>, Matjaž Godec<sup>3</sup>, Jan Pokorný<sup>1</sup></p> <p><sup>1</sup>University of Chemistry and Technology in Prague, Faculty of Chemical Technology, Department of Metals and Corrosion Engineering, Prague, Czech Republic, <sup>2</sup>Warsaw University of Technology, Faculty of Materials Science and Engineering, Warsaw, Poland, <sup>3</sup>Institute of Metals and Technology, Department of Physics and Chemistry of Materials, Ljubljana, Slovenia, E-mail: <a href="mailto:pokorny@vscht.cz">pokorny@vscht.cz</a></p>

15:00	<p><b>SEM and EDS characterization of 316L Stainless Steel exposed to <i>P. fluorescens</i> and <i>S. aureus</i> in a rich growth media</b></p> <p>Aleksander Lesar<sup>a</sup>, Mojca Blaznik<sup>b</sup>, David Stopar<sup>b</sup>, Barbara Šetina<sup>a</sup>, Matej Hočevar<sup>a</sup>  <sup>a</sup>Institute of Metals and Technology, Ljubljana, Slovenia, <sup>b</sup>Biotechnical faculty, University of Ljubljana, Ljubljana, Slovenia, E-mail: <a href="mailto:aleksander.lesar@imt.si">aleksander.lesar@imt.si</a></p>
15:10	<p><b>Surface Finishing of 17-4PH Steel Produced via Binder Jetting: a Comparison Between Mass Finishing and Electron Beam Techniques</b></p> <p>A. Lucchini Huspek<sup>1</sup>, M. Pozzi<sup>1,2</sup>, S. Navarro Martinez<sup>1</sup> and M. Bestetti<sup>1,3</sup>  <sup>1</sup>Polytechnic University of Milan, Department of Chemistry, Materials and Chemical Engineering “Giulio Natta”, Via Luigi Mancinelli 7, 20131 Milan (Italy), <sup>2</sup>Rösler Italiana S.r.l., Via Elio Vittorini 10, 20863 Concorezzo (Italy), <sup>3</sup>Tomsk Polytechnic University, The Weinberg Research Center, Lenin Ave 30, 634050 Tomsk (Russia), E-mail: <a href="mailto:andrea.lucchinihuspek@polimi.it">andrea.lucchinihuspek@polimi.it</a></p>
15:20	<p><b>Extraction of Kinetic Corrosion Parameters of Passivating Metals Using Electrochemical Impedance Spectroscopy With an Upgraded Point Defect Model Framework</b></p> <p>Miran Gaberšček, Aleksandra Kocijan, Črtomir Donik, Nejc Močnik          Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, E-mail: <a href="mailto:nejc.mocnik@imt.si">nejc.mocnik@imt.si</a></p>
15:30	<p><b>Coffee Break</b></p>
16:00	<p><b>Study for corrosion behavior in vitro of in-cast Zn-1Mg and Zn-1Mg-1Ag (wt.%) under different simulated body fluid conditions and first insights of antibacterial activity</b></p> <p>Marlene González<sup>1</sup>, Diana Martínez<sup>1</sup>, Anna Dobkowska<sup>1</sup>, Monika Staniszewska<sup>2</sup>, Wojciech Świążkowski<sup>1</sup>  <sup>1</sup>Faculty of Materials Science and Engineering, Wołoska 141, 02-507, Warsaw, Poland.  <sup>2</sup>Centre for Advanced Materials and Technologies, Poleczki 19, 02-822, Warsaw, Poland.          E-mail: <a href="mailto:marlene.gonzalez.dokt@pw.edu.pl">marlene.gonzalez.dokt@pw.edu.pl</a></p>
16:10	<p><b>Identical Location SEM on a Case Example of Copper Degradation During Electrochemical CO<sub>2</sub> Reduction</b></p> <p>Blaž Tomc<sup>1,2</sup>, Marjan Bele<sup>1</sup>, Nejc Hodnik<sup>1,2,3</sup>, Matic Plut<sup>1</sup>, Luka Suhadolnik<sup>1</sup>  <sup>1</sup>Laboratory for Electrocatalysis, Department of Materials Chemistry, National Institute of Chemistry, Ljubljana 1000, Slovenia, <sup>2</sup>University of Nova Gorica, Nova Gorica 5000, Slovenia, <sup>3</sup>Institute of Metals and Technology, Ljubljana 1000, Slovenia, E-mail: <a href="mailto:blaz.tomc@ki.si">blaz.tomc@ki.si</a></p>
16:20	<p><b>Corrosion Behaviour of Reinforced Steel in LC3 and OPC Simulated Pore Solutions</b></p> <p>Sara Šadl, Miha Hren          Slovenian National Building and Civil Engineering Institute, Dimičeva 12, 1000 Ljubljana, Slovenia          E-mail: <a href="mailto:sara.sadl@zag.si">sara.sadl@zag.si</a></p>
16:30	<p><b>Microstructure and Mechanical Properties of Co-28Cr-6Mo for Medical Applications: Casting vs. Additive Manufacturing</b></p> <p>Hana Thürlová, Dalibor Vojtěch          University of Chemistry and Technology Prague, Technická 5, Praha, 166 28          E-mail: <a href="mailto:thurlovh@vscht.cz">thurlovh@vscht.cz</a></p>
16:40	<p><b>Corrosion and cytotoxicity properties of ultralight Mg-8Li-0.5Ca alloys produced by laser powder bed fusion</b></p> <p>A. Zielińska<sup>1</sup>, A. Dobkowska<sup>1</sup>, J. Kubasek<sup>2</sup>, F. D’Elia<sup>3</sup>, Irena Paulin<sup>4</sup>, M. Godec<sup>4</sup>, W. Świążkowski<sup>1</sup>  <sup>1</sup>Faculty of Materials Science and Engineering, Warsaw University of Technology, Warsaw, Poland  <sup>2</sup>University of Chemistry and Technology, Prague, Czech Republic, <sup>3</sup>Department of Materials Science and Engineering, Uppsala University, Sweden, <sup>4</sup>Institute of Metals and Technology, Ljubljana, Slovenia, E-mail: <a href="mailto:aleksandra.zielinska3.dokt@pw.edu.pl">aleksandra.zielinska3.dokt@pw.edu.pl</a>, <a href="mailto:anna.dobkowska@pw.edu.pl">anna.dobkowska@pw.edu.pl</a></p>

Govorni prispevki – Oral

16:50	<p><b>A Comparative Study of Conventional TEM and FIB Sample Preparation Techniques for High-Entropy Alloys</b> Tara Gudžulic<sup>1,2</sup>, Lara Einfalt<sup>2,3</sup>, Aleksander Učakar<sup>1,2,3</sup>, Saša Kos<sup>1</sup>, Gregor Kapun<sup>2,4</sup> and Miran Čeh<sup>1,2,3</sup> <sup>1</sup>Center for Microscopy and Microanalysis, Jožef Stefan Institute, 1000 Ljubljana, Slovenia <sup>2</sup>Jožef Stefan International Postgraduate School, 1000 Ljubljana, Slovenia <sup>3</sup>Department for Nanostructured Materials, Jožef Stefan Institute, 1000 Ljubljana, Slovenia <sup>4</sup>National Institute of Chemistry, Department of Materials Chemistry, 1000 Ljubljana, Slovenia Jožef Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia E-mail: <a href="mailto:tara.gudzulic@ijs.si">tara.gudzulic@ijs.si</a></p>
17:30 – 19:30	Poster Session in Mediteranea Hall

<b>Thursday 16.10.2025</b>	
	<b>Predsedujoči – Chairs:</b> Nejc Hodnik, Mirjam Bajt Leban
	<b>ADRIA HALL</b>
Plenary 9:00	<b>Electrochemical Realism in Single-Atom Catalysis</b> <u>Igor A. Pašti</u> University of Belgrade – Faculty of Physical Chemistry, Studentski trg 12-16, 11158 Belgrade, Serbia; Serbian Academy of Sciences and Arts, Kneza Mihaila 35, 11000 Belgrade, Serbia E-mail: <a href="mailto:igor@ffh.bg.ac.rs">igor@ffh.bg.ac.rs</a>
9:40	<b>Corrosion, Electrocatalysis, Biofilms: The Role of Local Electrochemistry in Materials Science</b> Sanjin J. Gutić University of Sarajevo – Faculty of Science, Zmaja od Bosne 33-35 71000 Sarajevo, Bosnia and Herzegovina, E-mail: <a href="mailto:sgutic@pmf.unsa.ba">sgutic@pmf.unsa.ba</a>
10:00	<b>Microstructural Engineering Ni-Based Alloy Surfaces for Enhanced OER Performance</b> Luka Suhadolnik, Črtomir Donik, Blaž Tomc, Mejrema Nuhanović, Martin Šala, Marjan Bele, Matjaž Finšgar, Matjaž Godec, <u>Nejc Hodnik</u> National Institute of Chemistry, Hajdrihova 19, SI-1000 Ljubljana, Slovenia; Institute of Metals and Technology, Lepi pot 11, SI-1000 Ljubljana, Slovenia; Faculty of Chemistry and Chemical Engineering, University of Maribor, Smetanova 17, SI-2000 Maribor, Slovenia; University of Nova Gorica, Vipavska 13, SI-5000 Nova Gorica, Slovenia., E-mail: <a href="mailto:nejc.hodnik@ki.si">nejc.hodnik@ki.si</a>
10:20	<b>Advanced Electroactive Materials for Sustainable Energy: Innovations in Electrocatalyst Design via the Nano Lab Concept</b> <u>Marjan Bele</u> <sup>1</sup> , Luka Suhadolnik <sup>1</sup> , Leonard Moriau <sup>1,3</sup> , Primož Jovanovič <sup>1</sup> , Francisco Ruiz-Zepeda <sup>1</sup> , Gorazd Koderman Podboršek <sup>1,3</sup> , Goran Dražić <sup>1,3</sup> , Blaž Tomc <sup>1</sup> , Ana Rebeka Kamšek <sup>1,2</sup> , Miran Gaberšček <sup>1,2</sup> , Nejc Hodnik <sup>1,3,4</sup> <sup>1</sup> National Institute of Chemistry, Hajdrihova 19, SI-1000 Ljubljana, Slovenia, <sup>2</sup> Faculty of Chemistry and Chemical Technology, University of Ljubljana, Večna pot 113, Ljubljana SI-1000, <sup>3</sup> Jožef Stefan International Postgraduate School, Jamova 39, SI-1000 Ljubljana, Slovenia, <sup>4</sup> Institute of Metals and Technology, Lepi pot 11, SI-1000 Ljubljana, Slovenia. E-mail: <a href="mailto:marjan.bele@ki.si">marjan.bele@ki.si</a>
10:40	<b>Electrocatalyst Discovery through Advanced Synthesis, Characterization, and Data Integration</b> <u>Luka Suhadolnik</u> , <sup>1</sup> Marjan Bele, <sup>1</sup> Goran Dražić, <sup>1,3</sup> Blaž Tomc, <sup>1</sup> Milutin Smiljanić, <sup>1</sup> Črtomir Donik, <sup>2</sup> Irena Paulin, <sup>2</sup> Matjaž Godec, <sup>2</sup> Martin Šala, <sup>3</sup> Jakob Starec Oman, <sup>1</sup> Miha Osredkar, <sup>1</sup> Samuel Brhane Alemayohu, <sup>1</sup> Matjaž Finšgar, <sup>4</sup> Mejrema Nuhanović, <sup>1</sup> Ana Rebeka Kamšek, <sup>1</sup> Andraž Mavrič, <sup>5</sup> Iztok Arčon, <sup>5</sup> Nejc Hodnik <sup>1,2</sup> <sup>1</sup> National Institute of Chemistry, Hajdrihova 19, SI-1000 Ljubljana, Slovenia, <sup>2</sup> Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenia, <sup>3</sup> Department of Analytical Chemistry, National Institute of Chemistry, Hajdrihova 19, SI-1000 Ljubljana, Slovenia, <sup>4</sup> Faculty of Chemistry and Chemical Engineering, University of Maribor, Smetanova 17, 2000 Maribor, Slovenia <sup>5</sup> University of Nova Gorica, Vipavska 13, SI-5000 Nova Gorica, Slovenia E-mail: <a href="mailto:luka.suhadolnik@ki.si">luka.suhadolnik@ki.si</a>
<b>11:00</b>	<b>Coffee Break</b>
	<b>Predsedujoči – Chairs:</b> Elena Tchernychova, Luka Suhadolnik
11:40	<b>Low-Energy High-Current Electron Beam Surface Pretreatment to Improve the Anodizability of Al-Si Foundry Alloys</b> A. Lucchini Huspek <sup>1</sup> and <u>M. Bestetti</u> <sup>1,2</sup> <sup>1</sup> Polytechnic University of Milan, Department of Chemistry, Materials and Chemical Engineering “Giulio Natta”, Via Luigi Mancinelli 7, 20131 Milan (Italy), <sup>2</sup> Tomsk Polytechnic University, The Weinberg Research Center, Lenin Ave 30, 634050 Tomsk (Russia) E-mail: <a href="mailto:massimiliano.bestetti@polimi.it">massimiliano.bestetti@polimi.it</a>

12:00	<p><b>Effects of Laser Power, Scan Speed, and Heat Treatment on Microstructure and Hardness of PBF-LB Inconel 718</b>  <u>Ahmed W. Abdelghany</u><sup>1,2</sup>, Matias Jaskari<sup>1</sup>, Sami Westman<sup>3</sup>, Ilkka Poutiainen<sup>3</sup>, Antti Järvenpää<sup>3</sup>  <sup>1</sup>Future Manufacturing Technologies (FMT), Kerttu Saalasti Institute, University of Oulu, Nivala 85500, Finland, <sup>2</sup>Design and Production Engineering Dept., Faculty of Engineering, Ain Shams University, Cairo 11535, Egypt, <sup>3</sup>Laser processing and additive manufacturing, Mechanical Engineering Department, School of Energy Systems, Lappeenranta-Lahti University of Technology LUT, P.O. Box 20, FI-53851, Lappeenranta, Finland  E-mail: <a href="mailto:ahmed.abdelghany@oulu.fi">ahmed.abdelghany@oulu.fi</a></p>
12:20	<p><b>The Effect of Material Strength and Internal Defects on Fatigue Performance of LPBF Metals</b>  <u>Antti Järvenpää</u><sup>1</sup>, Ilkka Poutiainen<sup>1</sup>, Ahmed W. Abdelghany<sup>2</sup>, Timo Rautio<sup>2</sup>  <sup>1</sup>Laser processing and additive manufacturing, Mechanical Engineering Department, School of Energy Systems, Lappeenranta-Lahti University of Technology LUT, P.O. Box 20, FI-53851, Lappeenranta, Finland, <sup>2</sup>Future Manufacturing Technologies (FMT), Kerttu Saalasti Institute, University of Oulu, Nivala 85500, Finland</p>
12:40	<p><b>Additive Manufacturing of Architected Inconel 718 Structures: Exploring the Strength and Failure of Lattice Structures</b>  <u>Sami Westman</u><sup>1</sup>, Ahmed W. Abdelghany<sup>2,3</sup>, Lari Rajala<sup>1</sup>, Ilkka Poutiainen<sup>1</sup>, Antti Järvenpää<sup>1</sup>  <sup>1</sup>Laser processing and additive manufacturing, Mechanical Engineering Department, School of Energy Systems, Lappeenranta-Lahti University of Technology LUT, P.O. Box 20, FI-53851, Lappeenranta, Finland, <sup>2</sup>Future Manufacturing Technologies (FMT), Kerttu Saalasti Institute, University of Oulu, Nivala 85500, Finland, <sup>3</sup>Design and Production Engineering Dept., Faculty of Engineering, Ain Shams University, Cairo 11535, Egypt  E-mail: <a href="mailto:sami.westman@lut.fi">sami.westman@lut.fi</a></p>
13:00	<b>LUNCH</b>
	<p><b>Predsedujoči – Chairs:</b> Jiri Kubasek, Anna Dobkowska</p>
	<b>ADRIA HALL</b>
14:20	<p><b>30 Years of Industrial Research and Development in Light Metals and Composites</b>  <u>Varužan Kevorkijan</u>  Impol Aluminium Industry, Partizanska 38, 2310 Slovenska Bistrica, Slovenia,  E-mail: <a href="mailto:varuzan.kevorkijan@impol.si">varuzan.kevorkijan@impol.si</a></p>
14:50	<p>Melt Refining of Wrought Aluminium Alloy Al-Mg-Si with Increased Fraction of External Scrap  <u>Uroš Kovačec</u><sup>1,2</sup>, Franc Zupanič<sup>1</sup>  <sup>1</sup> University of Maribor, Faculty of Mechanical Engineering, Smetanova ulica 17, SI-2000, Maribor, Slovenia, <sup>2</sup> Impol 2000 d.d., Partizanska ulica 38, SI-2310 Slovenska Bistrica, Slovenia  E-mail: <a href="mailto:uros.kovacec@impol.si">uros.kovacec@impol.si</a></p>
15:10	<p><b>Influence of hydrogen charging on fatigue life of additive manufactured austenitic stainless steel AISI 304 and martensitic stainless steel AISI420</b>  <u>Marko Sedlaček</u><sup>1</sup>, Barbara Šetina Batič<sup>1</sup>, Bojan Zajec<sup>2</sup>, Andraž Legat<sup>2</sup>, Irena Paulin<sup>1</sup>, Frantz Martin Franz<sup>3</sup>, Bojan Podgornik<sup>1</sup>  <sup>1</sup>Institute of Metals and Technology, Lepi pot 11, Ljubljana, Slovenia, <sup>2</sup>Slovenian National Building and Civil Engineering Institute, Dimičeva ulica 12, Ljubljana, Slovenia, <sup>3</sup>Université Paris-Saclay. CEA. Service de Recherche en Corrosion et Comportement des Matériaux. 91191 Gif Sur Yvette. France  E-mail: <a href="mailto:marko.sedlacek@imt.si">marko.sedlacek@imt.si</a></p>
15:30	<p><b>Performance of AM Stainless Steels in Hydrogen Rich Environments</b>  <u>B. Podgornik</u><sup>1</sup>, M. Sedlaček<sup>1</sup>, B. Šetina-Batič<sup>1</sup>, I. Paulin<sup>1</sup>, B. Zajec<sup>2</sup>, M. Bajt Leban<sup>2</sup>, F. Martin<sup>3</sup>  <sup>1</sup>Institute of Metals and Technolog, Ljubljana, 1000, Slovenia; <sup>2</sup>Slovenian National Building and Civil Engineering Institute, Ljubljana, 1000, Slovenia; <sup>3</sup>CEA ISAS, Paris-Saclay,91191, France Institution  E-mail: <a href="mailto:bojan.podgornik@imt.si">bojan.podgornik@imt.si</a></p>

Govorni prispevki – Oral

15:50	<p><b>Increasing Microbiological Corrosion Resistance of Hydropower Turbine Blade Steel</b>  <u>Jaka Burja</u>, Borut Žužek, Barbara Šetina Batič  Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenija, E-mail: <a href="mailto:jaka.burja@imt.si">jaka.burja@imt.si</a></p>
16:10	<p><b>Failure Analysis of leakage in NEK Reactor Cooling System</b>  <u>Borut Žužek</u><sup>1</sup>, Barbara Šetina Batič<sup>1</sup>, Jaka Burja<sup>1</sup>, Stanko Manojlovič<sup>2</sup>, Arash Parsi<sup>3</sup>, Catherine Cmar<sup>3</sup>  <sup>1</sup>Institute of Metals and Technology, Lepi pot 11, Ljubljana, Slovenia, <sup>2</sup>Nuclear Power Plant Krško, Vrbina 12, 8270 Krško, Slovenia, <sup>3</sup>Westinghouse Electric Company, 1332 Beulah Road, Churchill, PA, USA  E-mail: <a href="mailto:borut.zuzek@imt.si">borut.zuzek@imt.si</a></p>
16:30	<p><b>Coffee Break</b></p>
	<p><b>Predsedujoči – Chairs:</b> Bojan Podgornik, Borut Žužek</p>
17:00	<p><b>Role of Cryogenic Cycle Design in Tailoring Mechanical Performance of D2 Tool Steel</b>  <u>Venu Yarasu</u>, Bojan Podgornik, Marko Sedlacek  Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenia  E-mail: <a href="mailto:venu.yarasu@imt.si">venu.yarasu@imt.si</a></p>
17:20	<p><b>Powder Particle Velocity at the Nozzle Outlet in Directed Energy Deposition</b>  <u>Tijan Mede</u><sup>1</sup>, Andrej Jeromen<sup>2</sup>, Michael Mallon<sup>3</sup>, Edvard Govekar<sup>2</sup>, Matjaž Godec<sup>1</sup>  <sup>1</sup>Institute of Metals and Technology, Lepi pot 11, Ljubljana, Slovenia, <sup>2</sup> Faculty of Mechanical Engineering, University of Ljubljana, Aškerčeva cesta 6, Ljubljana, Slovenia, <sup>3</sup> Materials and Processes Section, Structures, Mechanisms and Materials Division, Mechanical Department, ESA-ESTEC, Keplerlaan 1, 2201 AZ Noordwijk, The Netherlands  E-mail: <a href="mailto:tijan.mede@imt.si">tijan.mede@imt.si</a></p>
17:40	<p><b>3D-Printed Polylactic Acid Reinforced Carbon Fibre in Bulk and Triply Periodic Minimal Surfaces (TPMS) Lattice Structure: A Mechanical Properties Analysis Comparative Study</b>  <u>Nabilah Afiqah Mohd Radzuan</u>  Advanced Manufacturing Research Group, Department of Mechanical &amp; Manufacturing Engineering, Faculty Engineering &amp; Built Environment, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia  E-mail: <a href="mailto:afiqah@ukm.edu.my">afiqah@ukm.edu.my</a></p>
18:00	<p><b>SIQUAL 6368 – Development of a High-Strength, Nickel-Enhanced Steel for Pressure Vessel Applications</b>  Matic Bernik, Jan Foder, <u>Dejan Zgonc</u>  SIJ Acroni d.o.o., Cesta Borisa Kidriča 44, 4270 Jesenice, Slovenia, E-mail: <a href="mailto:dejan.zgonc@acroni.si">dejan.zgonc@acroni.si</a></p>
18:20	<p><b>Enhanced NiTi-TiC Composites for Ballistic Protection: Effect of Reinforcement Origin and Milling Strategy</b>  <u>Filip Prusa</u>, Jaroslav Zima, František Ruzicka, Petr Kratochvil, Tomas Vrba, Ilona Vonavkova, Jafar Fathi  University of Chemistry and Technology Prague, Department of Metals and Corrosion Engineering, Technická 5, 166 28 Prague, Czech Republic, E-mail: <a href="mailto:prusaf@vscht.cz">prusaf@vscht.cz</a></p>
20:00 – 23:00	<p><b>Social event – Hotel Histrion Arcade Club</b></p>

Govorni prispevki – Oral

<b>Friday 17.10.2025</b>	
	<b>Predsedujoči – Chairs:</b> Tadeja Kosec, Helena Otmačič Čurković
	<b>ADRIA HALL – Material Degradation and Corrosion: Heritage, Innovation, and AI</b>
09:00	<b>New safeguarding strategies for outdoor CH facing Climate Change</b> Cristina Chiavari, Elena Bernardi, Carla Martini University of Bologna, Department of Cultural Heritage, Via degli Ariani, 1 - 48121 Ravenna - Italy E-mail: <a href="mailto:cristina.chiavari@unibo.it">cristina.chiavari@unibo.it</a>
09:40	<b>Electrochemical and Spectroscopic Characterization of Patinated Bronze Sculptures</b> Angela Kapitanović, Dajana Mikić, <u>Helena Otmačič Čurković</u> University of Zagreb Faculty of Chemical Engineering and Technology, Marulićev trg 19, 10 000 Zagreb, Croatia, E-mail: <a href="mailto:hotmac@fkit.unizg.hr">hotmac@fkit.unizg.hr</a>
10:00	<b>Surface Evolution and Hydrophobicity of Sulphide Patinas on Bronze: Linking Chemistry, Morphology, and Corrosion Behavior</b> <u>Tadeja Kosec</u> <sup>1</sup> , Erika Švara Fabjan <sup>1</sup> , Marjan Bele <sup>2</sup> , Matjaž Finšgar <sup>3</sup> <sup>1</sup> Slovenian National Building and Civil Engineering Institute, Dimičeva ulica 12, SI-1000 Ljubljana <sup>2</sup> National Institute of Chemistry, Hajdrihova ulica 19, SI-1001 Ljubljana, <sup>3</sup> University of Maribor, Faculty of Chemistry and Chemical Engineering, Smetanova ulica 17, SI-2000 Maribor E-mail: <a href="mailto:Tadeja.kosec@zag.si">Tadeja.kosec@zag.si</a>
10:20	<b>Assessing and mitigating corrosion in historic concrete: the NUK case study</b> <u>Nina Gartner</u> <sup>1</sup> , Nal Trobec <sup>1</sup> , Tadeja Kosec <sup>1</sup> , Miha Hren <sup>1</sup> , Zala Žarkovič <sup>1</sup> , Sabina Dolenc <sup>1,2</sup> <sup>1</sup> Slovenian National Building and Civil Engineering Institute, Dimičeva ulica 12, SI-1000 Ljubljana <sup>2</sup> University of Ljubljana, Faculty of Natural Sciences and Engineering, Department of geology, Aškerčeva cesta 12, SI-Ljubljana E-mail: <a href="mailto:nina.gartner@zag.si">nina.gartner@zag.si</a>
10:40	<b>Corrosion data acquisition in the wake of artificial intelligence</b> <u>Miha Hren</u> , Tadeja Kosec and Andraž Legat Slovenian National Building and Civil Engineering Institute, Dimičeva 12, 1000 Ljubljana, Slovenia E-mail: <a href="mailto:miha.hren@zag.si">miha.hren@zag.si</a>
<b>11:00</b>	<b>Coffee Break</b>
	<b>Predsedujoči – Chairs:</b> Tadeja Kosec, Katarina Marušič
	<b>ADRIA HALL</b>
11:30	<b>Electrochemical Demolition: a green and sustainable recovery process for hardmetal scrap</b> <u>Benedetto Bozzini</u> <sup>1</sup> , Fransisca Pirone <sup>2</sup> , Sandra Tedeschi <sup>2</sup> , Mirjam Bajt Leban <sup>3</sup> and Gian Pietro De Gaudenzi <sup>2</sup> <sup>1</sup> Dipartimento di Energia, Politecnico di Milano, via Lambruschini 4, 20156 Milano – Italy <sup>2</sup> OMCD TEK HUB SpA, via Megolo, 28877 Anzola d'Ossola (VB) – Italy <sup>3</sup> ZAG Zavod za gradbeništvo Slovenije, Dimičeva ulica 12, 1000 Ljubljana – Slovenia E-mail: <a href="mailto:benedetto.bozzini@polimi.it">benedetto.bozzini@polimi.it</a>
11:50	<b>Corrosion Sensing Beyond Electrochemistry</b> <u>Andraž Legat</u> , Bojan Zajec, Miha Hren, Simon Pavlič, Tadeja Kosec Slovenian National Building and Civil Engineering Institute, Dimičeva 12, SI-1000 Ljubljana, Slovenia E-mail: <a href="mailto:andraz.legat@zag.si">andraz.legat@zag.si</a>

Govorni prispevki – Oral

12:10	<p><b>Molecularly Imprinted Polymers Nanoparticles for Antibiotic Detection in Aqueous Systems</b>  <u>Yadiris García</u><sup>1</sup>, Katerina Medrano<sup>1,2</sup>, and Verónica A. Jiménez<sup>2</sup>  <sup>1</sup>Departamento de Química Analítica e Inorgánica, Facultad de Ciencias Químicas, Universidad de Concepción, Edmundo Larenas 129, Concepción, Chile, <sup>2</sup>Departamento de Ciencias Químicas, Facultad de Ciencias Exactas, Universidad Andres Bello, Autopista Concepción-Talcahuano 7100, Talcahuano, Chile  E-mail: <a href="mailto:ygarcia@udec.cl">ygarcia@udec.cl</a></p>
12:30	<p><b>High-Temperature Stability of PBF-LB/M Processed AISI 316L ODS Steel with Micrometre-Sized Y<sub>2</sub>O<sub>3</sub> Additions</b>  <u>Matjaž Godec</u><sup>1</sup>, Črtomir Donik<sup>1</sup>, Anna Dobkowska<sup>2</sup>, Jiří Kubásek<sup>3</sup>, Jarosław Mizer<sup>2</sup>, Bojan Podgornik<sup>1</sup>, Francisco Ruiz Zepeda<sup>1,4</sup>, Irena Paulin<sup>1</sup>  <sup>1</sup>Institute of Metals and Technology, Ljubljana, Slovenia, <sup>2</sup>Faculty of Materials Science and Engineering, Warsaw University of Technology, Warsaw, Poland, <sup>3</sup>Department of Metals and Corrosion Engineering, University of Chemistry and Technology, Prague, Czech Republic  <sup>4</sup>National Institute of Chemistry, Ljubljana, Slovenia  E-mail: <a href="mailto:matjaz.godec@imt.si">matjaz.godec@imt.si</a></p>
12:50	<p><b>Mining the Technosphere</b>  <u>Primož Oprčkal</u>, Ana Mladenovič, Alenka Mauko Pranjič  Slovenian National Building and Civil Engineering Institute, Dimičeva 12, 1000 Ljubljana, Slovenia  E-mail: <a href="mailto:primoz.oprckal@zag.si">primoz.oprckal@zag.si</a></p>
13:40	<p><b>Higher precision in orthopaedic oncology: the role of computer-assisted navigation</b>  <u>Aljaž Merčun</u>, David Martinčič, Rok Vojković, Blaž Mavčič  University Medical Center Ljubljana, Zaloška cesta 9, 1000 Ljubljana, E-mail: <a href="mailto:aljaz.mercun@kclj.si">aljaz.mercun@kclj.si</a></p>
14:00	<p><b>Project SMARTChain: Steps towards digital integration in the NGO electrical steel value chain</b>  <u>Mojca Lončnar</u><sup>1</sup>, Kristjan Cuznar<sup>2</sup>, Aljoša Vister<sup>2</sup>, Aleks Kobentar<sup>2</sup>, Ermina Pašić Imamović<sup>1</sup>, Anton Jaklič<sup>2</sup>  <sup>1</sup>SIJ Acroni d.o.o., Cesta Borisa Kidriča 44, 4270 Jesenice, Slovenia, <sup>2</sup>SIJ Storitve d.o.o., Koroška cesta 14, Ravne na Koroškem, 2390 Ravne na Koroškem  E-mail: <a href="mailto:mojca.loncnar@acroni.si">mojca.loncnar@acroni.si</a></p>
14:20	<b>Closing Ceremony, LUNCH</b>
14:55	<b>Lunch</b>
15:35	<b>Workshops</b>

POSTER SESSION

Wednesday 15.10.2025 (18:00 – 20:00)

1	<p><b>Large area SEM analysis of Sintered Strontium Hexaferrite in different atmospheres</b>  <u>Aleksander Učakar</u><sup>2,3</sup>, Miran Čeh<sup>1,2</sup>, Andraž Kocjan<sup>2,3</sup>, Tara Gudžulić<sup>1,3</sup> and Petra Jenuš Belec<sup>2</sup>  <sup>1</sup>Center for Microscopy and Microanalysis, Jožef Stefan Institute, 1000 Ljubljana, Slovenia  <sup>2</sup>Department for Nanostructured Materials, Jožef Stefan Institute, 1000 Ljubljana, Slovenia</p>
2	<p><b>Formation of microstructure during hot compression of Inconel 625 superalloy</b>  Boštjan Arh, Franc Tehovnik, Simon Malej, Franci Vode  Institute of Metals and Technology, Lepi pot 11, Ljubljana, Slovenia</p>
3	<p><b>Corrosion Dynamics of Magnesium Barrier Membrane used in Regenerative Periodontology: Comparative In-vitro Study</b>  <u>Mirjam Bajt Leban</u><sup>1</sup>, Domen Kanduti<sup>2,3</sup>, Nataša Resnik<sup>4</sup>, Anton Sculean<sup>5</sup>, Boris Gašpirc<sup>2,3</sup>, Marija Đurić<sup>1</sup>, Tadeja Kosec<sup>1</sup>  <sup>1</sup>Department of Materials, Slovenian National Building and Civil Engineering Institute, Slovenia  <sup>2</sup>Department for Oral Diseases and Periodontology, Faculty of Medicine, University of Ljubljana, Slovenia, <sup>3</sup>Department for Oral Diseases and Periodontology, University Medical Centre Ljubljana, Slovenia, <sup>4</sup>Institute of Cell Biology, Faculty of Medicine, University of Ljubljana, Slovenia  <sup>5</sup>Department of Periodontology, School of Dental Medicine, University of Bern, Switzerland</p>
4	<p><b>Thermophysical Characterization of Some Ni-Cr-based Superalloys Used in the Manufacture of Gas Turbines</b>  <u>Mihai Branzei</u><sup>1,2</sup>, Mihai Ovidiu Cojocaru<sup>1,2</sup>, Gheorghe Matache<sup>2,3</sup>, Constantin Romica Stoica<sup>1</sup>, Adrian Bibis<sup>2</sup>  <sup>1</sup>National University of Science and Technology POLITEHNICA Bucharest, 313 Splaiul Independentei, 060042-Bucharest, ROMANIA, <sup>2</sup>Technical Science Academy of Romania, Dacia Av., no.26, 030167-Bucharest, Romania, <sup>3</sup>National Research and Development Institute for Gas Turbines (COMOTI), Iuliu Maniu Av., no.220, 061126-Bucharest, Romania  E-mail: <a href="mailto:mihai.branzei@upb.ro">mihai.branzei@upb.ro</a></p>
5	<p><b>Effects of Laser Texturing and Sandblasting on Surface and Corrosion Properties of Magnesium</b>  <u>Marjetka Conradi</u>  Institute of metals and technology, Lepi pot 11, 1000 Ljubljana, Slovenia  E-mail: <a href="mailto:marjetka.conradi@imt.si">marjetka.conradi@imt.si</a></p>
6	<p><b>TiB<sub>2</sub>-modified 316L steel: correlation between reinforcement concentration, corrosion resistance, and mechanical properties</b>  Hubert Kalaczyński<sup>1</sup>, Anna Dobkowska<sup>1</sup>, Dorota Moszczyńska<sup>1</sup>, Irena Paulin<sup>3</sup>, Črtomir Donik<sup>3</sup>, Jiří Kubásek<sup>2</sup>, Matjaž Godec<sup>3</sup>, Jarosław Mizera<sup>1</sup>  <sup>1</sup> Faculty of Materials Science and Engineering, Warsaw University of Technology, 00-661 Warsaw, Poland, <sup>2</sup> Department of Physics and Chemistry of Materials, Institute of Metals and Technology, 1000 Ljubljana, Slovenia, <sup>3</sup> Department of Metals and Corrosion Engineering, Faculty of Chemical Technology, University of Chemistry and Technology in Prague, 160 00 Prague, Czech Republic  E-mail: <a href="mailto:anna.dobkowska@pw.edu.pl">anna.dobkowska@pw.edu.pl</a></p>
7	<p><b>TEM Characterization of Fe<sub>3</sub>O<sub>4</sub>-Au Hybrid Nanostructures Prepared by Coprecipitation and Ultrasonic Spray Pyrolysis</b>  <u>Darja Feizpour</u><sup>1</sup>, Lan Kresnik<sup>2</sup>, Peter Majerič<sup>2,3</sup>, Klementina Pušnik Črešnar<sup>2,4</sup>, Rebeka Rudolf<sup>2,3,5</sup>  <sup>1</sup> Institute of Metals and Technology (IMT), 1000 Ljubljana, Slovenia, <sup>2</sup> Faculty of Mechanical Engineering, University of Maribor, 2000 Maribor, Slovenia, <sup>3</sup> Zlatarna Celje d.o.o., 3000 Celje, Slovenia, <sup>4</sup> Faculty of Chemistry and Chemical Engineering, University of Maribor, 2000 Maribor, Slovenia, <sup>5</sup> Pomurje Science and Innovation Centre, 9000 Murska Sobota, Slovenia  E-mail: <a href="mailto:darja.feizpour@imt.si">darja.feizpour@imt.si</a></p>

8	<p><b>Comprehensive Material Characterization and Reliable Biocompatibility Testing as Steps Toward the Standardized Evaluation of Metallic Biomaterial Surfaces</b></p> <p><u>Matej Hočevar</u>, Barbara Šetina Batič Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana E-mail: <a href="mailto:matej.hocevar@imt">matej.hocevar@imt</a></p>
9	<p><b>Sustainable Alkali-activated Composites from Industrial Byproducts and Waste Keratin Fibres</b></p> <p>Barbara Horvat<sup>1</sup>, Nadja Železnik<sup>1</sup>, Lara Petrič<sup>2</sup>, Sara Tominc<sup>3</sup> <sup>1</sup>Milan Vidmar Electric Power Research Institute, Hajdrihova 2, 1000 Ljubljana, Slovenia, <sup>2</sup>University of Ljubljana, Biotechnical Faculty, Ljubljana, Slovenia, <sup>3</sup>Slovenian National Building and Civil Engineering Institute, Dimičeva ulica 12, 1000 Ljubljana, Slovenia E-mail: <a href="mailto:barbara.horvat@eimv.si">barbara.horvat@eimv.si</a>, nadja.zeleznik@eimv.si, lp46225@student.uni-lj.si, sara.tominc@zag.si</p>
10	<p><b>Microstructure, Corrosion Resistance and Mechanical Properties of Additively Manufactured Ti-6Al-4V alloy: A Comparative Study of Powder Bed Fusion, Directed Energy Deposition and Hybrid Techniques</b></p> <p>Aleksandra Kocijan, Simon Malej Institute of Metals and Technology, Ljubljana, Slovenia, E-mail: <a href="mailto:aleksandra.kocijan@imt.si">aleksandra.kocijan@imt.si</a></p>
11	<p><b>Optimization and Wear Properties of Titanium Metal Matrix Composite Built by Direct Energy Deposition</b></p> <p><sup>1,2</sup>Simon Malej, <sup>1</sup>Irena Paulin, <sup>1</sup>Marko Sedlaček, <sup>1</sup>Črtomir Donik, <sup>1</sup>Matjaž Godec, <sup>3</sup>Matija Bizjak <sup>1</sup>Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenia, <sup>2</sup>Balmar d.o.o., Kidričeva 24A, 3000 Celje, Slovenia, <sup>3</sup>EMO - Orodjarna d.o.o., Bežigradska 10, 3000 Celje, Slovenia E-mail: <a href="mailto:simon.malej@imt.si">simon.malej@imt.si</a></p>
12	<p><b>Evaluation of Protective Layers on Weathering Steel in Diverse Environmental Conditions</b></p> <p>Petra Močnik<sup>1</sup>, Tadeja Kosec<sup>1</sup>, Katarina Marušič<sup>2</sup>, Helena Otmačič Čurkovič<sup>3</sup> <sup>1</sup>Slovenian National Building and Civil Engineering Institute, Dimičeva 12, 1000 Ljubljana, Slovenia <sup>2</sup>Ruđer Bošković Institute, Division of Materials Chemistry, Laboratory for Precipitation Processes, Bijenička cesta 54, 10 000 Zagreb, Croatia, <sup>3</sup>Faculty of Chemical Engineering and Technology, University of Zagreb, Savska cesta 16, 10000 Zagreb, Croatia E-mail: <a href="mailto:petra.mocnik@zag.si">petra.mocnik@zag.si</a></p>
13	<p><b>Fabrication of austenitic ODS steels with TiB<sub>2</sub> addition: effect mechanical alloying time on microstructure and mechanical properties</b></p> <p>Hubert Kalaczyński<sup>1</sup>, Anna Dobkowska<sup>1</sup>, <u>Dorota Moszczyńska</u><sup>1</sup>, Mirosław Jakub Kruszewski<sup>1</sup>, Irena Paulin<sup>2</sup>, Črtomir Donik<sup>2</sup>, Jiří Kubásek<sup>3</sup>, Matjaž Godec<sup>2</sup>, Jarosław Mizera<sup>1</sup> <sup>1</sup>Faculty of Materials Science and Engineering, Warsaw University of Technology, 00-661 Warsaw, Poland, <sup>2</sup>Institute of Metals and Technology, 1000 Ljubljana, Slovenia, <sup>3</sup>Department of Metals and Corrosion Engineering, Faculty of Chemical Technology, University of Chemistry and Technology in Prague, 160 00 Prague, Czech Republic E-mail: <a href="mailto:dorota.moszczyńska@pw.edu.pl">dorota.moszczyńska@pw.edu.pl</a></p>
14	<p><b>Application of Spark Image Analysis and Artificial Intelligence for Predicting Carbon Content in Steels</b></p> <p><u>Goran Mundar</u><sup>1</sup>, Rok Knupleš<sup>1</sup>, Miha Kovačič<sup>2,3,4</sup>, Uroš Župerl<sup>1</sup> <sup>1</sup>Faculty of Mechanical Engineering, University of Maribor, 2000 Maribor, Slovenia, <sup>2</sup>ŠTORE STEEL, d.o.o., 3220 Štore, Slovenia, <sup>3</sup>Faculty of Mechanical Engineering, University of Ljubljana, 1000 Ljubljana, Slovenia, <sup>4</sup>College of Industrial Engineering Celje, 3000 Celje, Slovenia E-mail: <a href="mailto:goran.mundjar@um.si">goran.mundjar@um.si</a></p>
15	<p><b>High-Entropy Oxide Catalyst for Durable Anion Exchange Membrane Seawater Electrolysis</b></p> <p><u>Thi Xuyen Nguyen</u>, Ting-You Shih, Jyh-Ming Ting Department of Materials Science and Engineering, National Cheng Kung University, 1 University Road, Tainan 701 Taiwan E-mail: <a href="mailto:nguyenxuyen1511@gmail.com">nguyenxuyen1511@gmail.com</a></p>

16	<p><b>Production of ODS steels via additive manufacturing for demanding environments</b>  <u>Irena Paulin</u><sup>1</sup>, Nejc Velikajne<sup>1</sup>, Samo Tome<sup>1</sup>, Črtomir Donik<sup>1</sup>, Jiří Kubásek<sup>2</sup>, Anna Dobkowska<sup>3</sup>, Borut Žužek<sup>1</sup>, Matjaž Godec<sup>1</sup>  <sup>1</sup>Institute of Metals and Technology, 1000 Ljubljana, Slovenia, <sup>2</sup>University of Chemistry and Technology Prague, Faculty of Chemical Technology, Department of Metals and Corrosion Engineering, Praha, Czech Republic, <sup>3</sup>Faculty of Materials Science and Engineering, Warsaw University of Technology, Warsaw, Poland  E-mail: <a href="mailto:irena.paulin@imt.si">irena.paulin@imt.si</a></p>
17	<p><b>Enhanced NiTi-TiC Composites for Ballistic Protection: Effect of Reinforcement Origin and Milling Strategy</b>  <u>Filip Prusa</u>, Jaroslav Zima, František Ruzicka, Petr Kratochvil, Tomas Vrba, Ilona Vonavkova, Jafar Fathi  University of Chemistry and Technology Prague, Department of Metals and Corrosion Engineering, Technická 5, 166 28 Prague, Czech Republic, E-mail: <a href="mailto:prusaf@vscht.cz">prusaf@vscht.cz</a></p>
18	<p><b>Impact of Surface Preparation on the UCI Hardness Measurements</b>  <u>Rok Rezar</u>, Borut Žužek, Marko Sedlaček  Institute of Metals and Technology (IMT), Lepi pot 11, 1000 Ljubljana, E-mail: <a href="mailto:rok.rezar@imt.si">rok.rezar@imt.si</a></p>
19	<p><b>Microstructural Evolution of Plasma-Nitrided Additively Manufactured AISI 316L, 18Ni300, and IN625</b>  <u>Danijela A. Skobir Balantič</u>, Črtomir Donik, Aleksandra Kocijan, Bojan Podgornik, Matjaž Godec  Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenia, <a href="mailto:danijela.skobir@imt.si">danijela.skobir@imt.si</a></p>
20	<p><b>Accurate Measurement of Coating Thickness on Fully-Finished Non-Oriented Electrical Steels Using FIB-SEM</b>  Črtomir Donik<sup>1</sup>, Ajdin Šeper<sup>2</sup>, <u>Darja Steiner Petrovič</u><sup>1</sup>  <sup>1</sup>IMT, Ljubljana, Lepi pot 11, Slovenia, <sup>2</sup>SIJ Acroni d.o.o., Jesenice, Cesta Borisa Kidriča 44, Slovenia  E-mail: <a href="mailto:darja.steiner@imt.si">darja.steiner@imt.si</a></p>
21	<p><b>Carbon Capture and Storage of Glowing Flaming Plant Induced by Photosynthetic Efficiency for Vein-absorbed Graphene Quantum Dot</b>  <u>Yen-Hsun Su</u>, Yun-Liang Chien, Chia-Wei Chang, Shu-Mei Wang  1. Department of Materials Science and Engineering, National Cheng Kung University  2. Department of Bio-Industry Communication and Development, National Taiwan University  E-mail: <a href="mailto:yhsu@mail.ncku.edu.tw">yhsu@mail.ncku.edu.tw</a></p>
22	<p><b>Electrocatalyst Discovery through Advanced Synthesis, Characterization, and Data Integration</b>  <u>Luka Suhadolnik</u>,<sup>1</sup> Marjan Bele,<sup>1</sup> Goran Dražić,<sup>1,3</sup> Blaž Tomc,<sup>1</sup> Milutin Smiljanić,<sup>1</sup> Črtomir Donik,<sup>2</sup> Irena Paulin,<sup>2</sup> Matjaž Godec,<sup>2</sup> Martin Šala,<sup>3</sup> Jakob Starec Oman,<sup>1</sup> Miha Osredkar,<sup>1</sup> Samuel Brhane Alemayohu,<sup>1</sup> Matjaž Finšgar,<sup>4</sup> Mejrema Nuhanović,<sup>1</sup> Ana Rebeka Kamšek,<sup>1</sup> Andraž Mavrič,<sup>5</sup> Iztok Arčon,<sup>5</sup> Nejc Hodnik<sup>1,2</sup>  <sup>1</sup> National Institute of Chemistry, Hajdrihova 19, SI-1000 Ljubljana, Slovenia, <sup>2</sup> Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenia, <sup>3</sup> Department of Analytical Chemistry, National Institute of Chemistry, Hajdrihova 19, SI-1000 Ljubljana, Slovenia, <sup>4</sup> Faculty of Chemistry and Chemical Engineering, University of Maribor, Smetanova 17, 2000 Maribor, Slovenia  <sup>5</sup> University of Nova Gorica, Vipavska 13, SI-5000 Nova Gorica, Slovenia  E-mail: <a href="mailto:luka.suhadolnik@ki.si">luka.suhadolnik@ki.si</a></p>
23	<p><b>Tensile Behaviour of Laminated Wood and Aluminium-Reinforced Composites: An Experimental and ARAMIS-Based Analysis</b>  <u>Sanja Šolić</u><sup>1</sup>, Karlo Murković<sup>1</sup>, Zdravko Schauerl<sup>2</sup>, Vlado Tropša<sup>1</sup>  <sup>1</sup>University North, Department of Mechanical Engineering, J. Križanića 31b, 42000 Varaždin, Croatia  <sup>2</sup>Faculty of Mechanical Engineering and Naval Architecture, I. Lučića 5, 10000 Zagreb, Croatia  E-mail: <a href="mailto:ssolic@unin.hr">ssolic@unin.hr</a></p>

24	<p><b>Low-carbon decorative concrete floor tile strengthened by carbonation curing</b>  Katarina Šter<sup>1,2</sup>, Mateja Golež<sup>1</sup>, Sabina Dolenc<sup>1,3</sup>  <sup>1</sup>Slovenian National Building and Civil Engineering Institute (ZAG), Ljubljana, Slovenia  E-mail: <a href="mailto:katarina.ster@zag.si">katarina.ster@zag.si</a>  <sup>2</sup>Jožef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana, Slovenia  <sup>3</sup>University of Ljubljana, Faculty of Natural Sciences and Engineering, Department of geology, Aškerčeva ulica 12, 1000 Ljubljana, Slovenia</p>
25	<p><b>Effect of a <math>\text{La}_{0.07}\text{Ba}_{0.93}\text{SnO}_3</math> Interlayer on Epitaxial <math>\text{Li}_4\text{Ti}_5\text{O}_{12}</math> Anodes for All-Solid-State Batteries</b>  Tchernychova Elena<sup>a</sup>, Žuntar Jan<sup>b,c</sup>, Jaklič Blaž<sup>b,c</sup>, Kapun Gregor<sup>a</sup>, Spreitzer Matjaž<sup>b</sup>, Dominko Robert<sup>a,d,e</sup>  <sup>a</sup>National Institute of Chemistry, Hajdrihova 19, 1000 Ljubljana, Slovenia, <sup>b</sup>Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia, <sup>c</sup>Jožef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana, Slovenia, <sup>d</sup>Faculty of chemistry and chemical technology, University of Ljubljana, Slovenia, <sup>e</sup>ALISTORE-European Research Institute, Amiens, France  Email: <a href="mailto:elena.tchernychova@ki.si">elena.tchernychova@ki.si</a></p>
26	<p><b>Nidrides and carbides in 2101 lean duplex stainless steels</b>  F. Tehovnik, B. Arh, F. Vode, T. Sever  Institute of Metals and Technology, Lepi pot 11, Ljubljana, Slovenia  E-mail: <a href="mailto:franc.tehovnik@imt.si">franc.tehovnik@imt.si</a></p>
27	<p><b>Enhancing the Hydrogen Evolution Reaction in Anion Exchange Membrane Water Electrolyzer Using De-alloyed and Platinum Decorated Catalyst</b>  Chia-Chi Hsu, Jyh-Ming Ting  Department of Materials Science and Engineering, National Cheng Kung University  1 University Road, Tainan 701 Taiwan  E-mail: <a href="mailto:jting@mail.ncku.edu.tw">jting@mail.ncku.edu.tw</a></p>
28	<p><b>Impact of hydrogen charging parameters on the hydrogen embrittlement of conventional and 3D printed (AM) austenitic stainless steel</b>  Bojan Zajec<sup>1</sup>, Mirjam Bajt Leban<sup>1</sup>, Bojan Podgornik<sup>2</sup>, Marko Sedlaček<sup>2</sup>, Irena Paulin<sup>2</sup>, Barbara Šetina Batič<sup>2</sup>, Frantz Martin<sup>3</sup>  <sup>1</sup>Slovenian National Building and Civil Engineering Institute (ZAG), Dimičeva 12, Ljubljana, Slovenia, <sup>2</sup>Institute of Metals and Technology (IMT), Lepi pot 11, Ljubljana, Slovenia  <sup>3</sup>Université Paris-Saclay, CEA, Service de Recherche en Corrosion et Comportement des Matériaux, Gif Sur Yvette, France  E-mail: <a href="mailto:bojan.zajec@zag.si">bojan.zajec@zag.si</a></p>
29	<p><b>Stabilization Strategies for Prussian Blue Electrodes in Polyamine Sensing Applications</b>  Neža Sodnik<sup>1,2</sup>, Giulia Della Pelle<sup>1,2</sup>, Kristina Žagar Soderžnik<sup>1,2</sup>  <sup>1</sup>Department for Nanostructured Materials, Jožef Stefan Institute, Jamova cesta 39, SI-1000 Ljubljana, Slovenia, <sup>2</sup>Jožef Stefan International Postgraduate School, Jamova cesta 39, SI-1000 Ljubljana, Slovenia  E-mail: <a href="mailto:kristina.zagar@ijs.si">kristina.zagar@ijs.si</a></p>
30	<p><b>Comparison of Microstructure and Properties of Austenitic ODS Steel Produced LPBF and Plasma Sintering</b>  Črtomir Donik<sup>a</sup>, Irena Paulin<sup>a</sup>, Matjaž Godec<sup>a</sup>, Jiri Kubasek<sup>b</sup>, Anna Dobkowska<sup>c</sup>  <sup>a</sup>Institute of Metals and Technology, Ljubljana, Slovenia  <sup>b</sup>University of Chemistry and Technology, Prague, Czech Republic  <sup>c</sup>Faculty of Materials Science and Engineering, Warsaw University of Technology, Warsaw, Poland  E-mail: <a href="mailto:crtomir.donik@imt.si">crtomir.donik@imt.si</a></p>

# Effects of Laser Power, Scan Speed, and Heat Treatment on Microstructure and Hardness of PBF-LB Inconel 718

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This study investigates the combined influence of laser powder bed fusion (LPBF) parameters and post-build heat treatment on the microstructure and hardness of Inconel 718. Cylindrical specimens were produced using an EOS M290 system under varied combinations of laser power and scanning speed to assess the impact of process-induced microstructural variations. Four conditions were analysed: the as-built state, the standard EOS heat treatment and two modified regimes featuring solution annealing at 954 °C and 980 °C, respectively, followed by double ageing. Microstructural characterisation was performed using electron backscatter diffraction (EBSD), focusing on grain refinement, recrystallisation, and texture evolution. Hardness measurements were correlated with microstructural features to evaluate the effectiveness of each heat treatment route. The results demonstrate that tailored thermal post-processing can enhance mechanical performance and provide viable alternatives to conventional schedules. This work contributes to the optimisation of AM IN718 for critical aerospace and energy applications.

# 3D-Printed Polylactic Acid Reinforced Carbon Fibre in Bulk and Triply Periodic Minimal Surfaces (TPMS) Lattice Structure: A Mechanical Properties Analysis Comparative Study

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Focusing on producing lightweight yet maintaining their mechanical integrity at utmost levels made triply periodic minimal surfaces (TPMS) lattice structure one of the promising structures can be applied [1]. Therefore, this study investigates the mechanical performance of polylactic acid (PLA) reinforced with 15wt.% carbon fibre (CF), in both bulk and TPMS lattice. Filaments were fabricated in-house and printed using fused deposited modelling. Results indicated that the 15wt.% bulk structure exhibited a 60% increase in tensile modulus compared to pure PLA when tested between 30°C and 80°C, indicating effective stress distribution within the fibre networks. Further analysis of gyroid and honeycomb TPMS lattice revealed a 56% difference in compressive strength compared to the bulk structure. These findings highlight the potential of TPMS structure in enhancing mechanical performance while reducing weight and having the used of sustainable polymeric composites [2,3]. The experimental setups for compression test are shown in Figure 1, with the digital camera positioned in front of the specimens to record the deformations.

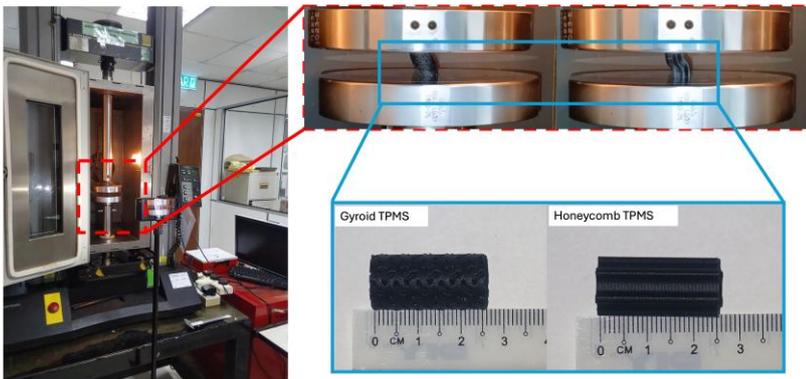


Figure 1: The compression test setups for both bulk and TPMS lattice structure samples.

## **Formation of microstructure during hot compression of Inconel 625 superalloy**

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Inconel superalloy have excellent corrosion resistance and strength at elevated temperatures. Alloy 625 is widely utilized in a number of industries such as chemical processing, automotive transportation and marine oil extraction. The alloy also exhibits good resistance to irradiation assisted stress corrosion cracking and combination of these properties have led to it a candidate material for nuclear applications.

During the hot deformation of metals, material flow behaviors are often very complex, and the control of microstructure is of great importance to optimize the final mechanical properties. Studies show that the work hardening, dynamic recovery and dynamic recrystallization often occur in the metals and alloys with low stacking fault energy during hot deformation. Generally dynamic recrystallization is not only an important softening mechanism, but also an effective method to refine coarse grain size and reduce the hot deformation resistance. The nickel-based superalloy, one typical precipitation strengthened steel, is widely used in modern aero engines and gas turbine. This presentation provides an overview of the structural changes that occur during the hot compression tests of Inconel 625 superalloy were conducted using a deformation dilatometer at different strain between 1000 °C and 1200 °C with a different strain rate. Optical microscope were employed to investigate the microstructure evolution.

# Corrosion Dynamics of Magnesium Barrier Membrane used in Regenerative Periodontology: Comparative In-vitro Study

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The growing demand for advanced biomaterials highlights the limitations of conventional options such as stainless steel and titanium. Stainless steel often exhibits poor biocompatibility, degradation risks and insufficient multifunctionality. More and more research shows that titanium also degrades over time and release toxic ions that accumulate in our body. Magnesium (Mg) and its alloys have emerged as promising candidates for next-generation temporary biomaterials and bioalloys in periodontology oral, cardiovascular and orthopaedic surgery due to their biodegradability. Biocompatible materials should have also sufficient mechanical integrity and a modulus of elasticity comparable to bone. These advances improve patient care, reduce healthcare costs and enable patient-centred care. Due to its light weight and biocompatibility, Mg is not only used in dentistry but also in various other industries such as aerospace and automotive.

Periodontitis is chronic inflammatory disease that affects the supporting tissues around teeth. For complete tissue regeneration, barrier membranes are an important element in regenerative treatment as they allow separation of bone and soft tissue components of periodontal defect. They can be used with or without bone graft, depending on the bone defect anatomy. Nowadays magnesium-based bio-alloys emerged with favourable degradation rates, enhanced biocompatibility and favourable effect on bone regeneration and bone healing.

Corrosion is a main factor for Mg materials that determines their service life and activity in tissue. Compared to other metallic biomaterials, it degrades rapidly in the physiological environment and leaves no traces other than harmless magnesium ions, which are an essential element of the body. Under certain circumstances, however, the corrosion reaction proceeds too quickly and causes side effects. One of the most problematic is the development of hydrogen and the resulting reduced healing effect. The aim of this study was to perform corrosion characterisation of commercially available pure magnesium membranes when exposed to the MEM (Minimum Essential Medium) solution and to compare their corrosion development once the cells are attached to their surface. The corrosion rate and mechanism will be investigated by electrochemical tests such as open circuit potential measurements, linear polarisation, electrochemical impedance spectroscopy and potentiodynamic polarisation before and after cell adhesion. In addition, ion release tests are performed to monitor the leaching of magnesium ions into the MEM solution under the same conditions over an extended period of time required for partial dissolution of the material.

# Advanced Electroactive Materials for Sustainable Energy: Innovations in Electrocatalyst Design via the Nano Lab Concept

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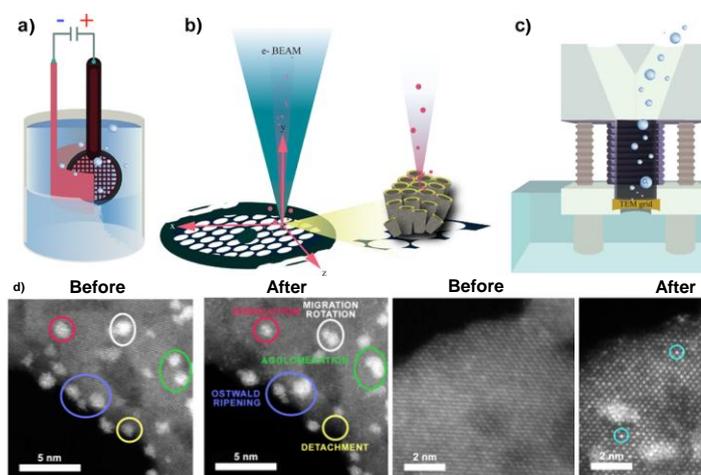
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As the global community faces the urgent global challenge of climate change, the search for sustainable energy solutions becomes critical. At the centre of this search is the innovation of technologies for energy storage and conversion. Our research introduces a novel approach to optimising catalysts for the oxygen evolution reaction (OER) using the Nano-Lab concept<sup>1,2</sup> (Fig. 1), an integrated experimental platform that provides insights into the relationships between synthesis, structure and performance at the atomic level. We focus on nanostructured titanium oxynitride ( $\text{TiO}_x\text{N}_y$ ) substrates, prepared via anodic oxidation (AO) and subsequent nitridation, which provide a high-surface-area and electrically conductive support for immobilized iridium nanoparticles. Leveraging strong metal–support interactions (SMSI), these catalysts demonstrate exceptional performance and stability while drastically reducing noble-metal loading<sup>1</sup>. A distinctive feature of our work is the implementation of identical-location electron microscopy (IL-TEM, IL-SEM) on dedicated TEM grids throughout all synthesis and electrochemical steps. Combined with floating electrode electrochemical characterization, Raman spectroscopy, and XPS, this setup enables direct tracking of morphological, compositional, and structural changes at the nanoscale. We report dynamic transformations of both the Ir nanoparticles and the  $\text{TiO}_x\text{N}_y$  support during electrochemical operation, including the formation of atomically dispersed Ir species. Our results illustrate the path towards robust, cost-effective electrocatalysts that are essential for the transition to a carbon-neutral hydrogen economy.



**Fig. 1:** Nano Lab integrates multiple advanced characterization techniques: (a) AO of the TEM grid, (b) IL-TEM technique, (c) electrochemical characterization and d) two sequences of identical location STEM–HAADF image of the  $\text{TiO}_x\text{N}_y$ –Ir sample before electrochemical degradation and after it - the left pair showing all the possible degradation processes and the right pair showing Ir nanoparticles as well as the formation of Ir single atoms<sup>2</sup>.

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2. M. BELE, et al., *ACS applied nano materials*, **2023**, 6 (12), 10421–10430

# Low-Energy High-Current Electron Beam Surface Pretreatment to Improve the Anodizability of Al-Si Foundry Alloys

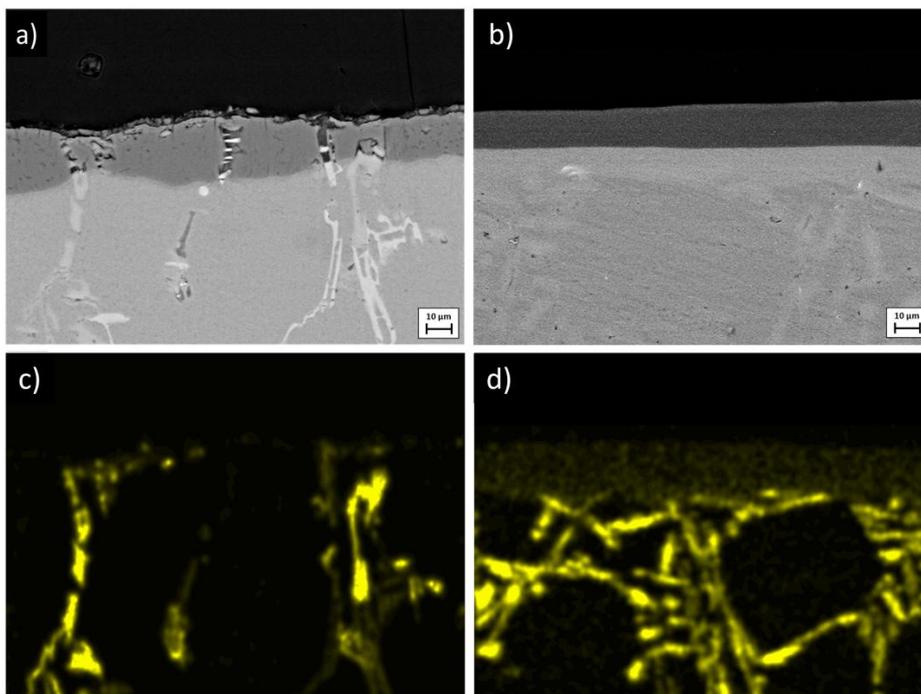
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Aluminum-silicon (Al-Si) alloys are widely used across engineering sectors such as aerospace, automotive, marine, and construction due to their low density, high strength-to-weight ratio, excellent thermal and electrical conductivity, good castability, and recyclability. To improve corrosion resistance and hardness, anodic oxidation is commonly employed. However, the anodizability of Al-Si alloys is negatively influenced by the presence of silicon particles (eutectic structure and primary Si).

This study explores the use of Low-Energy High-Current Electron Beam (LEHCEB) irradiation as a surface pretreatment to enhance the anodizability of Al-Si alloys. The rapid melting and solidification induced by LEHCEB promotes silicon redistribution and refinement, leading to a more uniform microstructure. The effects of varying energy densities (2-5 J/cm<sup>2</sup>) and number of pulses (4-32) were investigated. Subsequent anodic oxidation was carried out in sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) at 0°C for durations of 15, 30, and 45 minutes. Figure 1 shows the SEM morphology and EDX silicon elemental map of anodic oxide formed on a pristine (a, c) and LEHCEB pretreated (b, d) hypoeutectic Al-Si alloy.



**Figure 1.** SEM cross section morphology and EDX silicon elemental map of anodic oxide formed on a pristine (a, c) and LEHCEB pre-treated (b, d) hypoeutectic Al-Si alloy.

# Microstructural Evolution and Mechanical Properties of Ti–25Nb–8Sn–4Ta Beta Titanium Core–Shell Structures Fabricated by Ball Milling and Spark Plasma Sintering

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Beta titanium alloys have gained significant attention in biomedical and structural applications due to their unique combination of properties. They exhibit a low elastic modulus, closely matching that of human bone, which helps to reduce the stress shielding effect in medical devices. Additionally, their excellent corrosion resistance and biocompatibility ensures long-term stability in physiological environments further enhancing their suitability for medical devices and orthopaedic implants. Furthermore, the core–shell structures enhance mechanical properties by increasing strength while maintaining a good plasticity.

Core–shell structures composed of coarse-grained  $\beta$ -phase cores surrounded by ultrafine-grained  $\alpha+\beta$ -phase shells were successfully prepared by combining mechanical milling and spark plasma sintering (SPS). In these materials, the degree of deformation of the powder precursors affected the volume fraction of the fine-grained phase, which significantly contributed to the increase in both flexural and compressive strength ( $\sigma_{\gamma C} = 950 \pm 28$  MPa) as well as hardness ( $290 \pm 17$  HV<sub>1</sub>), compared to the reference material prepared solely by SPS ( $\sigma_{\gamma C} = 712 \pm 6$  MPa and  $194 \pm 8$  HV<sub>1</sub>). Increased oxygen content and embedded deformation promoted the nucleation of fine-grained (<1  $\mu\text{m}$ )  $\alpha$ -Ti along  $\beta$ -Ti matrix grains, as revealed by EBSD, SEM, and EDX analyses. With a higher content of fine-grained regions, which serve as the primary sites for crack propagation during bending tests, the ductility decreases. Overall, the Ti-25Nb-8Sn-4Ta core–shell structures were successfully prepared, but the results indicate that processing parameters must be carefully optimized to balance the trade-off between strength and ductility.

This research was funded by project "Mechanical Engineering of Biological and Bio-inspired Systems", funded as project No. CZ.02.01.01/00/22\_008/0004634 by Programme Johannes Amos Comenius, call Excellent Research.

## Electrochemical Demolition: a green and sustainable recovery process for hardmetal scrap

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Recycling of Critical Raw Materials (CRMs) / Strategic Raw Materials (SRMs) such as tungsten and cobalt is mandatory for the European industrial economy. Electrochemical methods to recover those metals from hardmetal scrap, although widely studied, never reached the productivity level of common industrial processes. In recently published work [1,2], we demonstrated – at laboratory scale – an innovative and eco-friendly electrochemical recovery process - that is the object of a recent MESCEL EIT-Raw Materials funded project - to circumvent hardmetal pseudopassivation with alloy-bounded corrosion-resistant grades. As verifying the validity of the protocol in non-laboratory conditions is important to fully assess its potential for industrial applications, in this work the protocol is applied with a realistic electrochemical cell configuration, extending the approach from dedicated laboratory samples to objects that mimic real-life scrap, including edges and irregular surface variations. The results show that productivity increases, although the presence of edges introduces mechanical instability in the surface rejuvenation process and uneven current density lines distribution, preventing uniform material extraction across the entire surface. These results highlight the protocol validity and lay the foundation for further optimization towards pilot plant implementation.

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# Thermophysical Characterization of Some Ni-Cr-based Superalloys Used in the Manufacture of Gas Turbines

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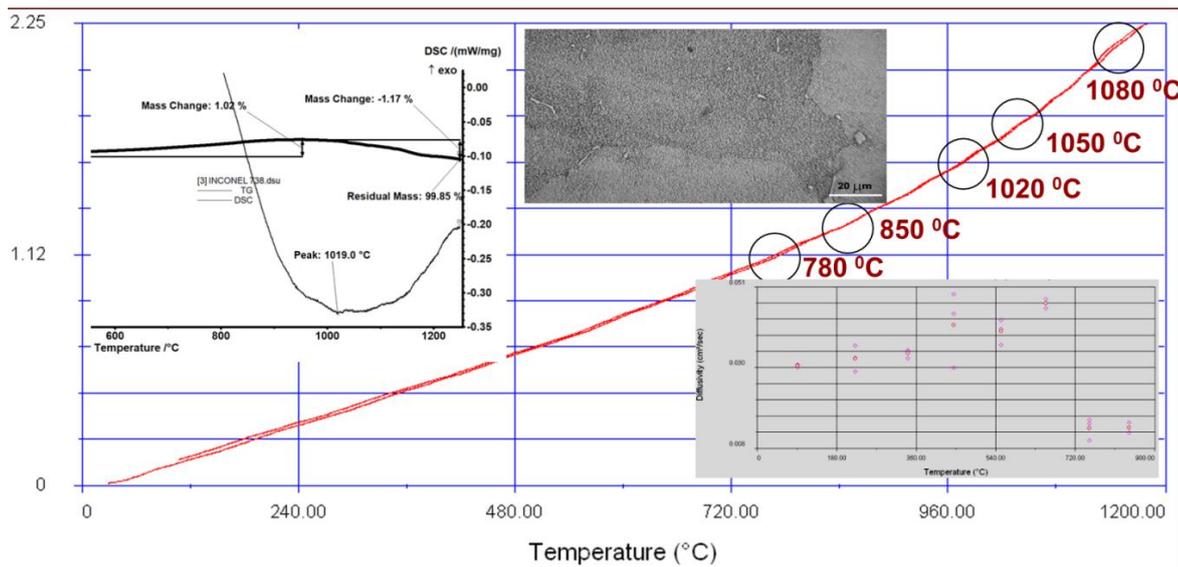
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Alloys like Inconel 625 / 718 / 738, Udimet 720 and RENE 41 are Ni-Cr-based high temperature superalloys extensively used in gas turbines [1]. The use of these engines for longer service and increasingly higher temperatures requires a more detailed knowledge of the thermal stability phases. The microstructures of these superalloys were studied by optical microscopy (OM) and have been correlated with thermal properties like thermal expansion (TE), differential scanning calorimetry (DSC) and thermal diffusivity/conductivity (TD/TC).



Such an example is given in the above figure for the Inconel 738 alloy. The curve shows from 720 °C upwards some inflection points, which mark, in order, the beginning and the end of the following IMCs solubilization:  $M_{23}C_6$  carbides (850 °C÷1020 °C),  $\gamma'$ -phase and  $\sigma$ -phase (960 °C÷1050 °C most probably), MC (1050 °C up to 1235 °C). The DSC curves and values come to confirm these aspects.

# Increasing Microbiological Corrosion Resistance of Hydropower Turbine Blade Steel

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The 13-4 martensitic stainless steel is used for hydro power turbines. Its nickel content, along with low carbon ensures better weldability, ductility, impact resistance and fatigue resistance properties when compared to 13 Cr ferritic-martensitic grades. It has good corrosion resistance in fresh water and performs well under erosion-corrosion phenomena. It is specially designed for all applications requiring high mechanical properties combined with high toughness and may be used in medium corrosive conditions. The applications and production process (casting) mean that the steel has to have good weldability.

Due to changed conditions in Slovenian rivers (warmer water, stagnant stream) microbiologically induced corrosion (MIC) has occurred on turbine blades. MIC is a particularly unpredictable phenomenon that is primarily caused by bacteria. Low waterflow conditions enable the attachment of microorganisms to metal surfaces, the colonization enables the formation of a film (biofilm), followed by the attachment of diverse microorganisms, among them some have the ability to reduce/oxidise ions in water, which leads to corrosion. The phenomenon is closely connected to pitting and crevice corrosion. Pitting corrosion resistance can be swiftly evaluated by Pitting Resistance Equivalent Number (PREN). This particular study is aimed at increasing the PREN while maintaining the mechanical properties of the modified steel. Steel samples with modified chemical composition and increased PREN were made and tested for mechanical properties.

## **New safeguarding strategies for outdoor CH facing Climate Change**

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Outdoor Cultural Heritage (CH) is susceptible to degradation processes due to the interaction among physical, chemical and biological factors, especially in polluted environments. Furthermore, climate change is exerting an influence on these mechanisms of decay. The evolution in the utilisation of energy sources and in the management of environmental resources, guided by legislation and regulations, has a significant impact on the preservation of outdoor CH. These challenging issues are developing within a context of great interest and urgency, as suggested by the EU-CH Green Paper, entitled "Putting Europe's shared heritage at the heart of the European Green Deal".

It is evident that the global decline in SO<sub>2</sub> concentrations, the relative enrichment of NO<sub>x</sub>, O<sub>3</sub> and PM, and more generally, the local variations in terms of multi-pollutants, in conjunction with the effects of climate change, are engendering increasingly aggressive scenarios affecting the mechanisms of decay of CH materials, ranging from stones to metals. Despite the paucity of research in this area, it is evident that these aggressive scenarios have a detrimental effect on the life of bacteria communities, which play a fundamental role in the conservation of cultural heritage materials.

In light of the evolving environmental context, the preservation and maintenance of CH represent a significant challenge. In the domain of cultural heritage preservation, the development of sustainable and efficient protection strategies is imperative. Tailored formulations, based on advanced and eco-friendly treatments (coatings), are currently under investigation. These formulations require rigorous testing in a laboratory setting, where they can be subjected to conditions that more accurately replicate the complex outdoor system, characterised by the significant interplay of chemical, biological and physical parameters. The conception of an intelligent and sustainable protective strategy must encompass numerous factors in addition to efficacy, including toxicity and environmental impact (for instance, the LCA approach) and the alignment with the principles of the circular economy.

The presentation will focus on the latest advancements in the field.

# Effects of Laser Texturing and Sandblasting on Surface and Corrosion Properties of Magnesium

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Magnesium and its alloys, valued for their lightweight and durable characteristics, have garnered increasing attention for biomedical applications due to their exceptional biocompatibility and biodegradability. This work introduces a comparison of advanced and basic methods — laser texturing and sandblasting — on magnesium surfaces to enhance bioactivity for biomedical applications. Employing a comprehensive analysis spanning surface morphology, hardness, wettability, tribological performance, and corrosion behavior, this study elucidates the intricate relationship between varied surface treatments and magnesium's performance. Findings reveal that both laser texturing and sandblasting induce grain refinement. Notably, sandblasting, particularly with a duration of 2 seconds, demonstrates superior wear resistance and reduced corrosion rates compared to untreated magnesium, thereby emerging as a promising approach for enhancing magnesium bioactivity in biomedical contexts. This investigation contributes to a deeper understanding of the nuanced interactions between diverse surface treatments and their implications for magnesium implants in chloride-rich environments, offering valuable insights for prospective biomedical applications.

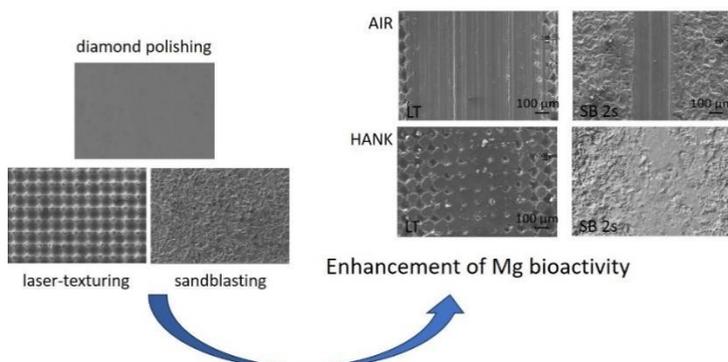


Figure 1: Diamond polished, laser textured and sandblasted Mg surface before and after the tribological evaluation in air and Hank's solution.

# **From design to functionality: Engineering biodegradable metals as durable implants through powder bed fusion – laser beam processing**

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Additive manufacturing through Powder Bed Fusion—Laser Beam (PBF-LB) allows tailored fabrication of biodegradable alloys for bone implants, but challenges remain in printability, microstructure control, and in achieving optimal material properties for clinical use. This study provides an overview of printability, microstructure, and material properties of degradable Mg and Zn alloys produced by PBF-LB. Magnesium and Zn are both essential nutrients in the human body, playing vital roles in bone and tissue regeneration, and in some instances, also boasting antibacterial properties. Nevertheless, despite clinical usage, full-scale implementation of degradable Mg alloys is hindered by an overall rapid degradation, particularly for alloys produced by AM. Zinc alloys, meanwhile, are yet to be clinically implemented, and suffer from unsuitable mechanical properties largely attributed to a low recrystallization temperature and a tendency for natural ageing. Material synthesis, PBF-LB process optimization and component design are used as attempts to tackle these issues. Microstructure characterization, along with mechanical and corrosion testing reveal alloy-specific differences, including distinct sub-grain structures, that heavily influence key material properties, while a clear dependence of component geometry is also demonstrated. Indeed, AM provides numerous opportunities for fabricating durable biodegradable implants, yet distinct challenges need to be overcome before full-scale clinical implementation.

## TiB<sub>2</sub>-modified 316L steel: correlation between reinforcement concentration, corrosion resistance, and mechanical properties

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Oxide Dispersion Strengthened (ODS) steels with TiB<sub>2</sub> addition combine the benefits of fine oxide particles and hard ceramic reinforcements to enhance mechanical and thermal performance. The dispersed TiB<sub>2</sub> particles contribute to improved hardness, wear resistance, and high-temperature strength due to their high melting point and excellent stability. Additionally, TiB<sub>2</sub> can act as a grain refiner and barrier to dislocation motion, further enhancing the creep resistance and structural integrity of the steel. This makes TiB<sub>2</sub>-reinforced ODS steels promising candidates for advanced structural applications in extreme environments such as nuclear reactors and aerospace systems.<sup>1</sup>

In this study, an attempt was made to characterize the properties of the manufactured materials (316L + TiB<sub>2</sub>). The design was aimed to obtain an ODS steel with an austenitic matrix, through the formation of *in situ* Ti-oxides. We produced composites with 316L as a matrix with the addition of 1,3 and 5 wt.% of TiB<sub>2</sub>. Powder precursors were mechanically alloyed for 5 h, and consolidated using pulse plasma sintering (PPS). The relationship between microstructure and corrosion as well as mechanical properties was evaluated. The results of this work clearly show that the higher the concentration of TiB<sub>2</sub>, the higher the strength of the composites, but the elongation decreases.

<sup>1</sup> McGuinness P., Paulin I., Donik C., Dobkowska A., Kubasek J., Pokorny J., and Godec M., *Recent Progress in Oxide-Dispersion-Strengthened (ODS) Alloys Produced By Additive Manufacturing*, „Materiali in Tehnologije”, 2025, vol.59, p. 3–10

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# Comparison of Microstructure and Properties of Austenitic ODS Steel Produced LPBF and Plasma Sintering

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This research systematically evaluates and compares mechanical and corrosion properties of Y<sub>2</sub>O<sub>3</sub>-strengthened steels fabricated via LPBF and Pulse Plasma Sintering (PPS), referencing results from Spark Plasma Sintering (SPS), using consolidating austenitic ODS steels. Preliminary experimental results have demonstrated significant variations in microstructure morphology between LPBF and traditional sintering techniques, with LPBF showing finer oxide dispersion and improved homogeneity.

Early-stage testing has already revealed promising enhancements in mechanical properties, notably increased tensile strength and hardness, in LPBF-manufactured samples relative to PPS and SPS counterparts. Corrosion tests indicate superior resistance in LPBF samples, attributed to refined grain structures and uniform distribution of nanoscale Y<sub>2</sub>O<sub>3</sub> particles. Current findings also suggest that process parameters such as laser energy density, scanning strategy, and powder layer thickness are critical in optimizing microstructural features and achieving targeted performance characteristics.

Further investigation focuses on refining LPBF processing parameters to enhance material performance in extreme operational environments systematically. The outcomes of this research not only provide essential insights into the formation and stabilisation of desired microstructural attributes but also support the practical application of LPBF-produced ODS steels in demanding industry sectors such as nuclear, aerospace, and energy production.

# TEM Characterization of Fe<sub>3</sub>O<sub>4</sub>–Au Hybrid Nanostructures Prepared by Coprecipitation and Ultrasonic Spray Pyrolysis

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Transmission electron microscopy (TEM) was a key tool for elucidating the morphology, crystallinity, and elemental distribution of Fe<sub>3</sub>O<sub>4</sub>–Au hybrid nanostructures synthesized by combining coprecipitation and ultrasonic spray pyrolysis (USP). The coprecipitation route yielded Fe<sub>3</sub>O<sub>4</sub> nanoparticles with sizes between 5 and 25 nm, exhibiting nanocrystalline cubic magnetite structure confirmed by Fast Fourier Transform (FFT) analysis. High-resolution TEM and selected-area diffraction patterns revealed concentric ring features, indicating polycrystalline character and random orientation of the grains.

After Au deposition via USP, the resulting hybrid nanostructures consisted of Fe<sub>3</sub>O<sub>4</sub> clusters decorated with spherical and irregular Au nanoparticles ranging from 10 to 200 nm. Scanning/TEM with energy-dispersive X-ray spectroscopy (EDS) mapping confirmed spatial overlap of Fe and O, corresponding to magnetite cores, while Au was distributed both on Fe<sub>3</sub>O<sub>4</sub> surfaces and as separate nanoparticles—evidence of bimodal Au formation during USP. High-resolution TEM images of isolated Au particles showed a lattice fringe spacing of 0.20 nm, matching the (200) planes of fcc Au, and corresponding spot FFTs confirmed their single-crystalline nature.

The TEM investigation demonstrated that coupling coprecipitation with USP effectively produces Fe<sub>3</sub>O<sub>4</sub>–Au hybrids with high crystallinity and well-defined phase separation. However, aggregation of Fe<sub>3</sub>O<sub>4</sub> cores limited coating uniformity and led to the presence of independent Au nanoparticles. These observations provide valuable insight into optimizing the USP process parameters for improved surface coverage and magnetic-plasmonic functionality of Fe<sub>3</sub>O<sub>4</sub>–Au nanostructures.

**Key words:** Transmission Electron Microscopy (TEM), Hybrid Nanostructures, Magnetite (Fe<sub>3</sub>O<sub>4</sub>) Nanoparticles, Gold Nanoparticles (AuNPs), Ultrasonic Spray Pyrolysis (USP)

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# Molecularly Imprinted Polymers Nanoparticles for Antibiotic Detection in Aqueous Systems

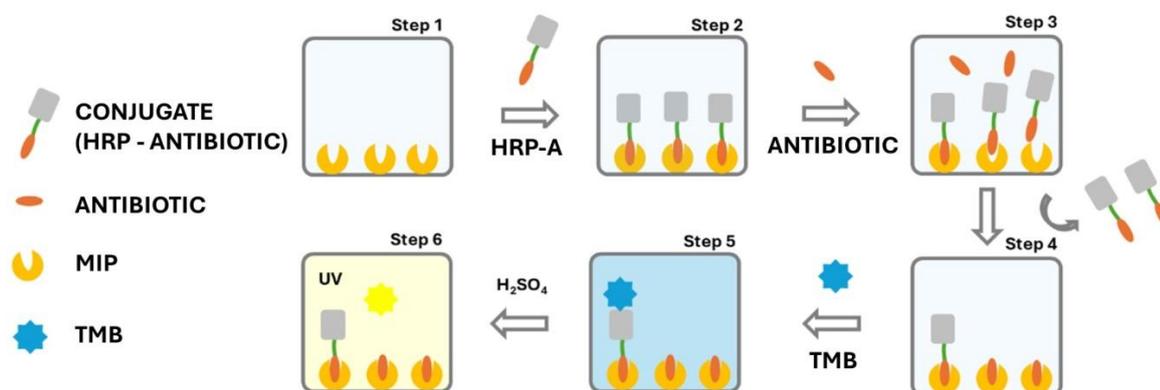
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Water is a vital resource for life on Earth. According to the *United Nations Sustainable Development Goals*, all countries must ensure the availability and sustainable management of water and sanitation by 2030 (1). Developing fast, effective, low-cost, accurate, and simple analytical technologies to detect contaminants in water bodies is essential to guarantee their safety for human use, recreation, and food production (2). This study investigates the development and application of molecularly imprinted polymer nanoparticles (nanoMIPs) as selective platforms for detecting tetracycline and gentamicin in aqueous systems. MIPs offer high selectivity toward target molecules, mimicking the recognition properties of natural receptors (3). We synthesized two types of nanoMIPs using a solid-phase approach: one using lymecycline, a target molecule structurally analogous to tetracycline (TC), to obtain MIP-TC, and another using gentamicin (GEN) to obtain MIP-GEN. In each case, the template molecule was used to generate specific artificial recognition sites. For the detection of antibiotics, we designed a *pseudo*-enzyme-linked immunosorbent assay (*pseudo*-ELISA) by substituting conventional monoclonal antibodies with nanoMIPs. Each assay was capable of identifying TC and GEN, respectively, at subnanomolar concentrations with high specificity. The assay exhibited a strong linear response and low limit of detection, highlighting its potential for environmental monitoring applications.



**Fig 1.** *Pseudo*-enzyme-linked immunosorbent assay by substituting conventional monoclonal antibodies with nanoMIPs for antibiotic detection.

**Acknowledgments:** The authors thank the National Research and Development Agency for funding, through the EXPLORACION Project 13220020.

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## Assessing and mitigating corrosion in historic concrete: the NUK case study

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The preservation of historic concrete buildings, such as the UNESCO-listed National and University Library (NUK) in Ljubljana, requires non-destructive diagnostic methods to evaluate material degradation with minimal intervention. Among the main causes of deterioration in such structures is the corrosion of embedded steel, initiated by environmental exposure. Unlike atmospheric corrosion, corrosion in reinforced concrete often results from carbonation-induced pH reduction, leading to the loss of steel passivity. This process remains hidden until advanced stages, presenting unique diagnostic challenges.

This study aims to assess the corrosion condition of selected historic concrete components of NUK—primarily architecturally complex windowsills and decorative roof tiles—using an individualized, non-destructive testing (NDT) approach. These elements are particularly exposed to weathering, and no reliable documentation exists regarding their internal structure. To avoid damaging the valuable heritage components, a combination of NDT techniques is being applied, including Ferroskan for locating and mapping reinforcement, half-cell potential measurements to identify corrosion-prone zones, and X-ray computed microtomography for high-resolution 3D visualization of internal structure, reinforcement, cracks, voids, and corrosion damage—also supporting digital archiving and replication.

In addition to diagnostics, the potential application of electrochemical realkalisation is being explored for elements in early stages of corrosion. This technique aims to restore the alkaline environment of carbonated concrete by introducing an external alkaline solution and applying electrical current to generate OH<sup>-</sup> ions near the reinforcement. It is minimally invasive and may slow the corrosion process, though its effectiveness depends on factors such as concrete composition and moisture content.

The study highlights the critical role of NDT in developing sustainable preservation practices for historic concrete and supporting informed conservation strategies, enabling either preservation in situ or accurate replication where necessary.

# High-Temperature Stability of PBF-LB/M Processed AISI 316L ODS Steel with Micrometre-Sized Y<sub>2</sub>O<sub>3</sub> Additions

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Oxide dispersion-strengthened (ODS) steels are a class of ferritic or austenitic alloys distinguished by a homogeneous distribution of thermally stable oxide particles—most commonly yttrium oxide (Y<sub>2</sub>O<sub>3</sub>)—within the metallic matrix. The presence of these finely dispersed oxides enhances structural stability and mechanical strength at elevated temperatures. The outstanding high-temperature performance of ODS steels primarily arises from two strengthening mechanisms: (i) Orowan strengthening, which limits dislocation motion through the interaction with non-deformable oxide particles, and (ii) Zener pinning, where the dispersed oxides hinder grain boundary migration by acting as stable anchoring sites.

In this work, commercially available AISI 316L stainless steel powder was blended with micrometre-scale Y<sub>2</sub>O<sub>3</sub> particles using a Turbula mixer and subsequently processed via laser powder bed fusion (PBF-LB/M) under optimised parameters. The selected processing conditions enabled partial dissolution of Y<sub>2</sub>O<sub>3</sub> particles and their uniform reprecipitation within the austenitic matrix, producing a thermally stable microstructure. This finding is supported by detailed microstructural examinations and further corroborated by mechanical, corrosion, and tribological tests, which collectively demonstrate the improved high-temperature stability and performance of the modified alloy.

# Study for corrosion behavior in vitro of in-cast Zn-1Mg and Zn-1Mg-1Ag (wt.%) under different simulated body fluid conditions and first insights of antibacterial activity

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Zinc (Zn) is a biodegradable metal with controlled degradation, unlike iron (Fe), which degrades slowly with long-term retention of its corrosion products, and unlike magnesium (Mg), which corrodes rapidly, producing harmful hydrogen gas. Zn is known as an essential nutrient for physiological functions in the human body, with intermediate potential vs SHE (-0.76 V) compared to Fe (-0.44 V) and Mg (-2.73 V). These factors make Zn a promising biocompatible material for biomedical applications that can extend to diverse domains such as in cardiovascular stents, orthopedic scaffolds, and wound closure devices<sup>1-2</sup>. Therefore, the main goal of this work was to analyze the corrosive behavior of cast Zn alloys: Zn-1Mg and Zn-1Mg-1Ag (wt. %) and describe the role of silver (Ag) addition on the degradation performance. To approach this, immersion tests were performed using various solutions simulating physiological conditions (HBSS+P/S, DMEM+P/S, and DMEM+FBS+P/S) during 7 days under cell culture conditions according to ASTM G1-03<sup>3</sup>. pH, osmolality, and corrosion rate were analyzed. Surface degradation was examined using scanning electron microscopy (SEM) and optical profilometry. For preliminary antibacterial activity observations, agar diffusion tests were conducted. As per the results of this work, both Zn-1Mg and Zn-1Mg-1Ag provided stable pH and osmolality values, and their corrosion rate and surface damage match the requirements of biomedical applications. As for the inhibition zone registered against *S. aureus*, the addition of Ag improved the antibacterial effect.

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# A Comparative Study of Conventional TEM and FIB Sample Preparation Techniques for High-Entropy Alloys

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High-entropy alloys (HEAs) have emerged as a transformative class of materials in the field of materials science and engineering. Unlike conventional alloys, which are typically based on one or two principal elements, HEAs are composed of multiple principal elements [1]. Since their introduction just over a decade ago, HEAs have attracted significant attention due to their exceptional mechanical strength, thermal stability, and corrosion resistance. The complexity of their microstructures offers unique challenges and opportunities for fundamental research and practical applications [2]. This study presents a comparative evaluation of conventional Transmission Electron Microscopy (TEM) sample preparation and Focused Ion Beam (FIB) sample preparation methods for HEAs, highlighting their respective advantages, limitations, and impact on microstructural interpretation [3].

In this study, a comprehensive approach to TEM sample preparation for HEAs is presented. A comparative analysis was conducted between conventional preparation techniques and FIB lamella preparation using a Helios 5UC. Conventional TEM samples were prepared using a Precision Diamond Wire Saw, Gatan Disc Grinder Model 623, Dimple Grinder Model 656, and subsequently thinned using a Precision Ion Polishing System (PIPS). An additional variant of the conventional method incorporated a final low-energy ion milling step using a Model 1040 NanoMill, aimed at improving surface quality and reducing damage layers. For comparison, FIB TEM lamella was prepared using a semi – automated process on the Helios 5UC system, followed by final thinning with the NanoMill to achieve electron transparency and minimize Ga<sup>+</sup> ion damage. To evaluate and compare four different preparation routes: conventional cross section, conventional cross section with NanoMill, FIB lamella, and FIB with NanoMill. Sample thickness and quality were assessed using the Scanning Transmission Electron Microscopy detector (STEM) on the Helios 5UC and imaged in a Jeol JEM - 2100 TEM. The primary objective of this work was to identify the most effective sample preparation method for accurate microstructural characterization of HEAs.

**Acknowledgement:** Infrastructure Center for Electronic Microscopy and Microanalysis, Jožef Stefan Institute, Ljubljana, Slovenia (PR-05722).

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# Corrosion, Electrocatalysis, Biofilms: The Role of Local Electrochemistry in Materials Science

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The development and engineering of materials rely on a detailed understanding of their intrinsic properties, which are commonly determined under vacuum or ambient conditions. However, when materials operate in liquid environments, such properties often fail to correlate directly with their behavior or performance, as assessed, for example, by bulk electrochemical methods, and may even be altered to some extent. To overcome this limitation, a range of advanced techniques now enables direct probing of local electrochemical performance. These methods provide high-resolution spatial mapping of regions with distinct properties, which is particularly valuable in fundamental studies of corrosion, electrocatalysis, and biofilms. An additional advantage is the ability to probe materials without external polarization, as well as materials that are non-conductive or electrochemically inactive.

With their current spatial resolution, scanning electrochemical techniques allow rapid screening of electrode surfaces, revealing the distribution of zones with varying electrochemical activity. Among these, scanning electrochemical microscopy, electrochemical atomic force microscopy, and scanning electrochemical cell microscopy have proven especially effective in studying corrosion and protection mechanisms, including systems with conductive and insulating films. In electrocatalysis, localized methods provide insight into reaction intermediates, mechanisms across different electrode regions, and processes at three-phase boundaries such as gas bubble nucleation, growth, and detachment. These techniques have also been successfully applied to investigate the formation and stability of solid electrolyte interphases in batteries and side reactions at supercapacitor electrodes, offering perspectives beyond routine characterization and revealing key processes responsible for performance degradation.

# Comprehensive Material Characterization and Reliable Biocompatibility Testing as Steps Toward the Standardized Evaluation of Metallic Biomaterial Surfaces

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Despite progress in surface engineering of metallic biomaterial, a major challenge remains the lack of standardized procedures for surface characterization and biocompatibility testing. The wide variation in protocols and biocompatibility evaluation methods among research groups makes it difficult to compare results and draw reliable conclusions.

It is therefore crucial to establish consistent techniques and protocols for all steps of biocompatibility testing from material preparation to final biocompatibility evaluation.

Surface cleaning and storage can significantly influence surface material properties, for example oxidation and hydrophobicity changes.

Our investigation of laser-modified metallic surfaces and their biocompatibility aims to address these issues.

We started with controlled surface preparation (consistent polishing and cleaning), followed by laser surface processing and consistent sample storage in controlled environment.

Based on intended biomaterial function we selected appropriate cell lines and biocompatibility tests (overall biocompatibility, cell viability, cytotoxicity, selective compatibility, and different cell–substrate contact times).

The results are expected to provide guidelines for sample preparation, selection of test and reference materials, and appropriate testing conditions.

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## Microstructural Engineering Ni-Based Alloy Surfaces for Enhanced OER Performance

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Efficient and affordable electrocatalysts are essential for advancing alkaline water electrolysis as a foundation of green hydrogen production. Nickel-based electrocatalysts represent the state-of-the-art, offering a promising platform due to their tunable surface properties and industrial scalability [1].

We demonstrate that sequential nitridation and anodic oxidation of Inconel 625, a commercial Ni-based alloy, induces the formation of NiFe-rich, Cr-depleted regions at grain boundaries and microcracks that enhance the electrochemical surface area and boost OER performance. The resulting nanostructured surface, with an optimized Ni/Fe ratio (~8:1), outperforms both the untreated alloy and benchmark IrO<sub>2</sub> electrodes. Morphological and compositional changes were tracked using advanced electrochemical techniques, namely identical-location SEM/EDS [2], EBSD, and also supported by XPS and ToF-SIMS. Cr segregation and  $\delta$ -phase precipitation were found to drive intergranular corrosion during activation, while fine-grained regions exhibited greater porosity and catalytic activity.

These findings highlight the potential of commercial nickel-based alloys as scalable, cost-effective electrocatalysts for alkaline water electrolysis. This work demonstrates how targeted microstructural engineering and electrochemical treatments can repurpose industrial alloys for sustainable hydrogen technologies.

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# Sustainable Alkali-activated Composites from Industrial Byproducts and Waste Keratin Fibres

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The building sector is a major contributor to anthropogenic CO<sub>2</sub> emissions, primarily due to its extensive use of cement. Cement is made from primary raw materials at temperatures exceeding 1000 °C, both representing a challenge for sustainability. Therefore, alternative inorganic materials are being researched to replace conventional cement. One of the options is alkali-activated materials (AAMs), which offer a low-carbon alternative because they can be made from solely secondary raw materials, such as fly ash (FA), at temperatures below 100 °C. However, secondary resources can contain materials which cause challenges in the final product, like non-combusted cellulose in FA from coal-fired thermal power plants.

This study investigates the use of FA from Thermal Power Plant Šoštanj (TEŠ) as a precursor for alkali-activated binder synthesis. FA was mechanically milled and sieved below 125 µm to increase its reactivity by enlarging the specific surface area and to thermally degrade residual cellulose. Due to the predominantly spherical morphology of FA particles, which offer no inner flexural resistance, fibrous reinforcement has to be introduced to improve the bending strength of AAM. To avoid increasing the carbon footprint through the use of synthetic fibres, waste keratin-based hollow fibres from selected dog breeds with water-work functional coats were used in different FA-to-fibre ratios. The fibre-reinforced AAMs were subjected to low-power microwave irradiation and compared to their non-irradiated counterparts. Results show that all fibre types improved compressive strength, with Chesapeake Bay Retriever fibres achieving over 65 MPa. Microwave treatment significantly enhanced strength in other fibre variants as well.

The findings demonstrate a promising circular solution for valorising complex waste streams into high-performance, fibre-reinforced AAMs, offering potential for future sustainable cement alternatives.

## Corrosion data acquisition in the wake of artificial intelligence

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In recent years, great progress has been made in popularizing the use of artificial intelligence (AI) among the general population. Image recognition, text generation and speech transcription are just some of the more well-known examples where deep learning is being used to identify and predict objects in different types of data. Regardless of the application, there was a common requirement that made these breakthroughs possible: large data sets with accurate data were needed to train the AI models.

In the field of corrosion, machine learning is often used to predict the corrosion behavior of materials based on their underlying microstructural properties, electrochemical properties, geometry and environmental conditions. Coelho et al.<sup>1</sup> recently reviewed the use of machine learning for corrosion prediction in many areas, such as atmospheric corrosion, marine corrosion, pipeline corrosion, inhibitors and reinforcement corrosion. They concluded that expanding the types of input variables is likely to improve the performance of the models and that accurate and reliable modelling requires large amounts of training data (especially for deep learning), which is currently not available in most corrosion areas.

To overcome these problems and make corrosion research a more promising field for machine learning, the philosophy of how to collect corrosion data must change. Experimental setups need to become more modular, scalable, cost-effective and consistent, and they need to take into account multiple properties that are monitored simultaneously. The aim of this presentation is to introduce an alternative method of corrosion data acquisition that provides larger amounts of reasonably accurate and consistent data for machine learning applications. A potential solution will be presented that incorporates low-cost, off-the-shelf components with multiple sensors to monitor different corrosion parameters simultaneously.

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# The Effect of Material Strength and Internal Defects on Fatigue Performance of LPBF Metals

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Additive manufacturing (AM), particularly Laser Powder Bed Fusion (LPBF), is increasingly utilized for producing complex metallic components tailored for applications in aerospace, energy, and biomedical fields. Despite the extensive advantages of AM in achieving intricate designs and reduced material waste, the fatigue performance of LPBF-manufactured components remains a critical challenge due to inherent material characteristics such as internal defects, surface irregularities, and residual stresses.

This research investigates the fatigue performance of LPBF-produced AISI 316L, Inconel 718, H13, and Maraging Steel (MS1). Fatigue tests were conducted under both bending and axial loading conditions on samples in as-built and electropolished states, using varied LPBF process parameters. Selected results from an extensive collaborative research project between LUT University, University of Oulu, and Finnish industry are presented to illustrate the relationships among material strength, defect structures, and fatigue behavior.

Findings indicate a direct correlation between alloy strength and achievable fatigue strength, although this relationship diminishes as material hardness increases. Particularly, fatigue strength optimization via process parameter refinement proved most effective in the softer alloy AISI 316L, which achieved an optimal fatigue-to-tensile strength ratio approaching 50%. Conversely, the presence of internal defects, surface roughness, and residual stresses was found to significantly deteriorate fatigue performance, especially in high-cycle fatigue regimes.

These results underscore the necessity of comprehensive process optimization and post-processing treatments, such as electropolishing, when designing LPBF components subjected to fatigue-critical conditions. A holistic approach integrating material selection, process optimization, and post-processing techniques is strongly recommended to enhance fatigue resistance in LPBF-produced components.

# Influence of HIP on the properties of the LPBF manufactured austenitic ODS steels

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The materials used in nuclear reactors must withstand challenging conditions, such as high temperature and neutron irradiation. Oxide dispersion-strengthened (ODS) steels are promising candidates in that regard, as they exhibit excellent properties in such environment. The most common manufacturing route for ODS steels is powder metallurgy followed by sintering. However, in recent years there has been an increase in interest of producing ODS steels via additive manufacturing.<sup>1</sup>

In this work, 316L steel with addition of 1 wt. % Y<sub>2</sub>O<sub>3</sub> with the size of 1-2 μm, was manufactured by laser powder bed fusion (LPBF, AconityMini) and later post-processed by hot isostatic pressing (HIP). To determine the influence of HIP post-process treatment on the properties of the produced materials, the mechanical and corrosion tests were performed. The electrochemical tests were composed of open circuit and potentiodynamic measurements, while mechanical studies included Brinell hardness measurements and tensile tests, alongside small punch creep test. The obtained results were juxtaposed to characterize the properties of 316L ODS steels, before and after HIP, and thus determine the influence of HIP post-treatment on the printed materials.

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## 30 Years of Industrial Research and Development in Light Metals and Composites

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This contribution provides an overview of the key milestones from more than 30 years of research on light metals and composites, carried out across both academia and industry. The initial focus was on fundamental research into aluminium alloy composites reinforced with ceramic particles, conducted in collaboration with the Institute of Metals and Technology and the Jožef Stefan Institute. Later, the research continued at the Impol Group, with an emphasis on applied and industrial development. Among various projects, two major “greenfield” initiatives stood out: the establishment of an aluminium alloy forging facility and a continuous strip casting plant. The forging facility marked a significant step toward the production of high value-added products, while the strip casting project culminated in a patented technology for producing blister foil from continuously cast strips—an achievement regarded as a significant competitive advantage. A recurring theme in many other applied projects was the recycling of wrought aluminium alloys. The main challenge involved achieving the desired chemical composition in melts primarily based on post-consumer scrap. This led to the development of advanced techniques for collecting and sorting scrap, as well as industrial methods for determining alloy composition. In parallel, we also developed several non-standard alloys with broader tolerance ranges for certain alloying and trace elements. Although the concept—explored in more depth with the aid of artificial intelligence—ultimately had limited market viability, it provided valuable insights. Metrology, the cornerstone of all production processes and quality assurance, also played a critical role in our research and development. Through a series of innovative solutions successfully implemented in industrial environments, we contributed to improved process stability and enhanced product quality. Many of our research outcomes have been published, fostering opportunities for pre-competitive collaboration with other research groups. This brief overview concludes with a forward-looking perspective, highlighting areas and topics I consider most promising for future development in the field of light metals and composites.

# **Microstructure, Corrosion Resistance and Mechanical Properties of Additively Manufactured Ti-6Al-4V alloy: A Comparative Study of Powder Bed Fusion, Directed Energy Deposition and Hybrid Techniques**

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This study focuses on the development of Ti6Al4V hybrid additive manufacturing (HAM) advanced fuel system components for aerospace applications by combining powder-bed fusion (PBF) and directed energy deposition (DED) techniques. Ti6Al4V alloy is the most dominant titanium alloy in aerospace engineering industry due to its high strength, low density, high fracture toughness and superior corrosion properties. We focus on the optimization of process parameters of both, PBF and DED techniques. The microstructure, corrosion resistance and mechanical properties of Ti6Al4V components fabricated using PBF, DED and HAM for aerospace applications were studied. To prevent  $\alpha'$  martensite formation, the samples were subjected to heat treatment. The microstructure was characterized by using optical microscopy (OM), scanning electron microscopy (SEM), and electron backscatter diffraction (EBSD). Corrosion resistance was evaluated through potentiodynamic polarization tests, and mechanical properties were assessed using Vickers hardness measurements. The PBF sample exhibited a fine, homogeneous microstructure with crystal grains and  $\alpha$ -laths, while the DED sample showed visible deposition layers, a larger crystal grain structure and  $\alpha$ -lamella. The increased hardness of the DED sample was attributed to higher nitrogen content, which acts as a solid solution strengthening agent. The DED sample displayed superior corrosion resistance compared to both PBF and HAM samples, probably due to a higher nitrogen content and a more stable microstructure with fewer lattice defects.

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# Surface Evolution and Hydrophobicity of Sulphide Patinas on Bronze: Linking Chemistry, Morphology, and Corrosion Behavior

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Over time, changes in the hydrophobicity of sulphide patinas on bronze, produced by the torch application of potassium sulphide to achieve a brown color, have been observed. This study aims to explore the relationship between corrosion protection, surface wettability, and the morphology of corrosion products.

Natural patinas formed through long-term atmospheric exposure are typically porous and hydrophilic, particularly when they contain basic copper sulfates or chlorides. In contrast, artificial patinas produced under controlled conditions can be tailored in composition and structure, resulting in variable contact angles and surface properties.

Two bronze alloys of different compositions were examined. Potassium sulphide was applied using the same process to ensure consistency. Patina properties were monitored over a six-month period. Corrosion potential and polarization resistance were measured monthly, along with contact angle assessments. During most significant changes, field-emission scanning electron microscopy with identical location spectroscopy was conducted to observe surface evolution.

X-Ray diffraction Pattern analysis and Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) were employed to provide additional insights into the formed surface's properties. Surface changes were examined during patina formation and after one week of exposure to a controlled laboratory environment, to investigate whether carbonate species contribute to increased hydrophobicity in aged patinas.

The work presents a detailed analysis of the interrelations between surface roughness, environmental conditions, patina morphology, electrochemical behavior, and the chemical composition of the topmost layer on the bronze sulfide patina.

# Melt Refining of Wrought Aluminium Alloy Al-Mg-Si with Increased Fraction of External Scrap

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In the recent study, the effectiveness of melt refining and cleaning processing using RFI technology were investigated in relation of different charge's compositions and different recycling contents. Serial batches of aluminium wrought alloys series Al-Mg-Si modified with Zr, were study on several recycle rate recipes of dedicated alloy were treated with flux mixture by rotary flux injection (RFI) technology. Efficiency of inclusions, alkali metals removal, by various charge content, using different proportions of secondary raw materials and primary aluminium were observed and also correlation to the final mechanical properties of final product were introduced.

Input charges were consisting with more than 50% of recycling content (RC) and 80% total secondary composition and remain of primary aluminium ingots. RFI injection process parameters were applied with constant parameters to achieved repeatability; uniform flux feeding distribution and same contact reaction time by optimal set-up of flux injection parameters. Samples for the quantitative and qualitative determination of melt cleanliness were taken using the PODFA method. Investigations and content of non-metallic inclusions were determined using light, scanning electron microscopy and optical emission spectroscopy.

## Enhancing mechanical properties of CoCrFeNiMn high-entropy alloy with carbon waste materials

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The CoCrFeNiMn alloy is known for excellent ductility and strain-hardening capacity; it suffers from the drawback of comparatively low yield strength. Efforts to enhance yield strength have been pursued either through thermo-mechanical processing or by introducing reinforcing particles. Conventional casting methods are generally used to achieve these improvements, although powder metallurgy offers an alternative approach. Beneficially, powder metallurgy – particularly mechanical milling – promotes the homogeneous distribution of reinforcement particles and significantly refines the microstructure of the material.

In this study, carbon nanomaterial waste was used to synthesize the carbide particles via mechanical alloying, which were subsequently incorporated into the CoCrFeNiMn alloy. Using the carbon waste derived from the microwave plasma gasification, the proposed method complies with the principles of a circular economy.

The synthesis of carbide particles was optimized according to the results of XRD and XRF analysis, with a focus on minimizing the contamination during the alloying process. The resulting carbides were uniformly distributed throughout the CoCrFeNiMn alloy, ultimately improving the mechanical properties such as hardness and compressive yield strength.

The authors want to acknowledge the Czech Science Foundation (project No. 24-10767S, Advanced high-entropy alloys reinforced by in-situ grown carbides formed from various types of nanostructured carbon precursors) for its financial support.

# Machine Learning versus Threshold Techniques for Phase Segmentation Analysis

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The increasing use and development of artificial intelligence (AI) also found its place in metallography. Complexity of micrographs, especially the ones obtained through the means of scanning electron microscopy and transmission electron microscopy, showed the need for novel approach of phase classification and microscopy analysis. This study introduces a novel AI-based segmentation model using deep learning techniques with commercially available Zeiss Arivis Cloud software and random forest technique included in Ilastik image segmenter. Laves phase in laser powder bed fused Inconel 718 was quantified using different segmentation methods. Such phase in Inconel 718 is formed during solidification and impacts mechanical properties during loading. Quantifying the amount of Laves phase in material is therefore crucial to assess the properties in as-printed state. Scope of research was to determine if trained AI-based models present concise results and provide less data scattering than other methods. Deep learning instance model was trained and compared to three different thresholding techniques, which include greyscale thresholding, Niblack and Sauvola method. Models were trained and compared on 45 images taken at 5000× and 42 images taken at 8000× magnification, acquired in ECCI mode. Results for both magnifications show less scattering of data for deep learning and random forest segmentation compared to other methods. Evaluated amount of Laves phase also aligns with fraction reported in literature as Chen et al. reported Laves phase fraction of  $2.24 \pm 0.25$  %, while Ghaemifar et al. set the amount at  $4.78 \pm 0.12$  %.

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## Powder Metallurgy of Zinc Alloys for High Strength and Retained Ductility

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Zinc and its alloys have recently attracted increasing attention as candidates for biodegradable medical devices due to their moderate corrosion rates and good biocompatibility. In particular, alloying zinc with magnesium enhances mechanical strength and refines microstructure, while also promoting osteogenic activity and favorable degradation behavior. These properties make Zn-Mg-based systems promising for temporary load-bearing implants, especially orthopaedic fixation devices.

In this study, we explored the synthesis and characterization of Zn-Mg-Ag materials processed via high-energy mechanical alloying followed by extrusion. By adopting the powder metallurgy route, we achieved ultrafine-grained microstructures with an average grain size below 700 nm stabilized by the presence of intermetallic phases like  $Mg_2Zn_{11}$  and dispersoids (MgO, ZnO). These structural features enabled the development of alloys with ultimate tensile strengths exceeding 400 MPa and fracture elongation near 12 %, surpassing most conventionally processed Zn-based materials. Detailed microscopy, including EBSD, TEM, and APT, revealed the refined grain structure and distribution of second-phase particles, correlating these with the observed mechanical and corrosion properties. Corrosion studies confirmed slow, uniform degradation and formation of stable surface layers. Furthermore, the addition of silver contributed to the antibacterial effect showing strong efficacy against *S. epidermidis in vitro*. The results demonstrate that combining mechanical alloying and extrusion may lead to the production of zinc-based materials with an excellent balance of strength, ductility, and biocompatibility.

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## **Corrosion Sensing Beyond Electrochemistry**

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Classical electrochemistry postulated by Wagner and Traud is the basis for the evaluation of general corrosion properties of metals and alloys in various environments. Different electrochemical techniques like linear polarization, potentiodynamic tests, electrochemical impedance spectroscopy, etc. based on this theory can provide main electrochemical parameters, including depassivation potential and general corrosion rate. It should be noted, however, that three basic conditions for the reliable determination of these parameters are required: the existence of the mixed potential, stationarity of a process, and uniformity of a process. Actually, in a large part of corrosion processes one or more of these conditions are not fulfilled. A few typical cases including pitting corrosion, atmospheric corrosion, corrosion in concrete and stress-corrosion cracking will be presented and discussed. In this sense, specific results of various measuring techniques and their combinations, as electrochemical noise, coupling multi-electrode array (CMEA), acoustic emission (AE), and electrical resistance sensors (ER), will be presented and interpreted. An attempt to evaluate benefits and limitations of these techniques in comparison to the conventional ones will be made. In this sense also the critical parameters of highly non-stationary and non-uniform corrosion processes will be highlighted.

# SEM and EDS characterization of 316L Stainless Steel exposed to *P. fluorescens* and *S. aureus* in a rich growth media

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Microbiologically Influenced Corrosion (MIC) is the degradation of metals and other materials driven by microbial metabolic activity. Bacteria, fungi, and algae attach to surfaces, form biofilms, and produce by-products such as acids, sulfides, and ammonia that accelerate corrosion. MIC is a major concern in sectors such as oil and gas, water treatment, and marine engineering [1].

Samples of 316L stainless steel were polished to 1200 grit or further finished with 1 µm diamond paste and placed in Petri dishes containing nutrient-rich media inoculated with *P. fluorescens*, *S. aureus*, or mixed bacterial cultures from a corroded metal key. Samples were incubated at 37 °C for one, three, or six months, with media replaced weekly. After incubation, samples were ultrasonically cleaned in distilled water (5 s) to remove loosely attached bacteria and analyzed by Scanning Electron Microscopy (SEM) coupled with Energy Dispersive X-ray Spectroscopy (EDS).

No visible corrosion was observed after one or three months, confirming the high resistance of 316L stainless steel to MIC. After six months, corrosion products were detected on the metal surface, though no pitting occurred.

Consistent with biofilm development adherent bacteria and organic deposits were identified on the surface. Achieving higher corrosion rates for the study of mechanisms of pitting corrosion may require the use of modified media, selected microbial strains, or defined bacterial cocultures.

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## **Project SMARTChain: Steps towards digital integration in the NGO electrical steel value chain**

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In line with the Clean Steel Partnership (CSP) Strategic Research and Innovation Agenda (SRIA)<sup>1</sup>, digitalisation plays a strong role in enabling the carbon-neutral transition. Therefore, the optimal deployment of digitalisation, through an integrated approach across the steel value chain, is required. Within this framework, SMARTChain aims to advance digitalisation in the steel industry, taking process control and optimisation a step further. It supports horizontal integration in the steel value chain through secure data sharing and promotes interoperability of systems and tools. This enables higher quality of final and intermediate products, optimises energy consumption, and consequently reduces CO<sub>2</sub> emissions, contributing to the achievement of the EU climate neutrality goal<sup>2</sup>.

In Use Case 2: NGO Electrical Steel Digital Passport, the steel value chain between SIJ Acroni, a steel producer, and Hidria, a steel user, is examined in terms of mechanical and electrical properties to enhance the quality of automotive components. Hidria uses NGO electrical steels from SIJ Acroni to manufacture stators and rotors for EV/HEV drivetrain applications in the automotive industry, employing the rapid stamping process. The software environment for the digital integration of the steel value chain, enabling data sharing both within and outside the steel plant, will be presented in detail. A robust software environment architecture has been designed, enabling regulated and secure data sharing through technologies such as IDS, DMP/DPP, and blockchain. The environments include the SMARTChain Platform for steelmakers and the SMARTChain platform for end users, as well as AI-based modules for holistic optimisation of the value chain, including LCA estimation.

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[CSP-SRIA-Oct2021-clean.pdf](#)

[SEAMLESS DIGITAL INTEGRATION IN STEEL VALUE CHAIN FOR HIGH QUALITY FINAL PRODUCTS | SMARTChain | Project | Fact Sheet | HORIZON | CORDIS | European Commission](#)

# Surface Finishing of 17-4PH Steel Produced via Binder Jetting: a Comparison Between Mass Finishing and Electron Beam Techniques

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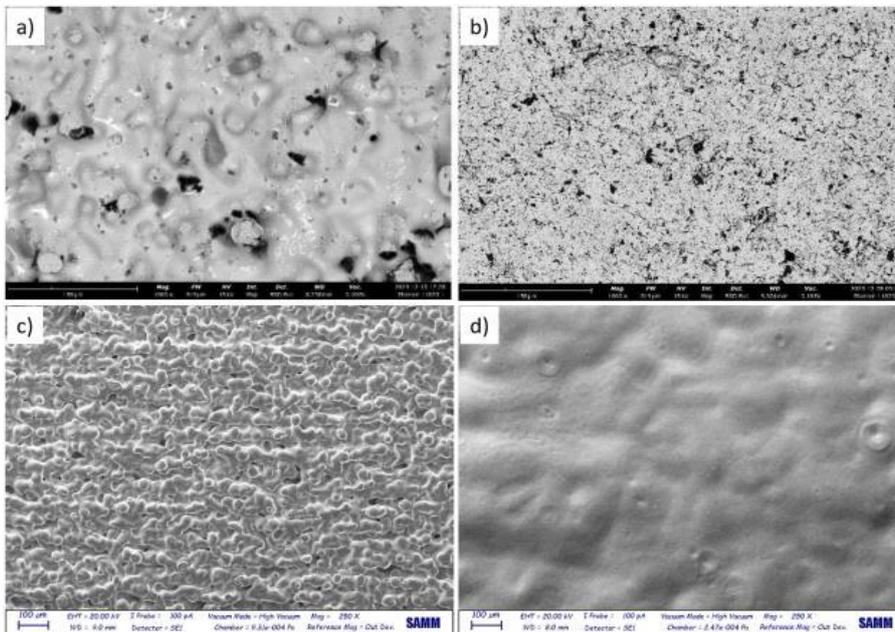
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Binder Jetting (BJT) is an additive manufacturing technique characterized by the consolidation of 3D printed parts through sintering, rather than by the use of collimated energy beams, as is typical in other AM technologies. This study investigates the feasibility of applying the BJ process for the production of surgical instruments for orthopedic applications, as an alternative to conventional CNC machining. The project focuses on printing topology, mechanical properties of the manufactured components, and the effectiveness of various surface finishing techniques. Parts produced via BJT typically exhibit surface roughness on the order of tens of micrometers, which is unsuitable for surgical applications. A set of samples was BJT produced using a Desktop Metal Shop System 3D printer (Aidro S.r.l.) with 17-4PH stainless steel powder (D90 = 50  $\mu\text{m}$ , layer thickness = 75  $\mu\text{m}$ ). This work presents the results of surface finishing treatments carried out using:

- a) Centrifugal High-Energy Disk Machine (FKS 02, Rösler Italiana S.r.l.);
- b) Low-Energy High-Current Electron Beam (RITM, Microsplayv OOO).

MF acts simultaneously on multiple parts with processing times on the order of several hours, while LEHCEB operates in vacuum, treating parts in a matter of minutes. Moreover, LEHCEB provides the added benefits of removing contamination and compacting the top surface layer.



**Figure 1.** SEM surface morphology of a sample printed with horizontal orientation (a,b) processed by mass finishing and with vertical orientation (c, d) processed by electron beam.

# Optimization and Wear Properties of Titanium Metal Matrix Composite Built by Direct Energy Deposition

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Ti-alloys, widely used in the automotive, aviation, space, and military industries for their high specific strength, excellent chemical resistance, and biocompatibility, are not without limitations. The Young's modulus, wear resistance, and heat resistance of Ti-alloys are somewhat limited. These shortcomings highlight the need to explore alternatives, such as Ti-MMCs, which have significant potential in addressing these issues. While Ti-MMCs are less common than Al-MMCs, mainly due to high-cost input materials and complex manufacturing methods, their potential to overcome these limitations remains substantial. Additive manufacturing (AM) technologies can make the processing and integration of Ti-MMCs more cost-effective and straightforward. AM is a promising technology for processing MMCs because it allows for local adjustments to composition and process parameters, enabling property tailoring of the material both on macro and micro levels. In this work, we present the results of optimising the Direct Energy Deposition (DED) process of Ti-MMCs with added TiC particles in the Ti6Al4V powder. During the study, wear resistance through sliding wear was used to characterise and compare the produced samples to other materials. The dense bulk parts were fabricated after optimising the DED process for metal matrix composites, with Ti6Al4V as the matrix and TiC as the reinforcement. Some cracking and porosity persisted, and not all TiC particles melted during the DED process. The wear resistance of the produced parts was comparable to that of Ti6Al4V alloy produced via conventional and powder bed fusion techniques.

## Crosslinked Monolayers for Enhanced Corrosion Protection of Bronze and Its Patina

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Bronze artifacts often develop natural or artificially applied patinas that serve both decorative and protective functions. However, these layers remain vulnerable to degradation in polluted environments, leading to surface damage and aesthetic loss. Conventional protective coatings often fail to provide a balance between environmental compatibility and long-term performance. This study explores an alternative corrosion protection strategy based on self-assembled monolayers (SAMs) of behenic acid and their transformation into polymer nanocoatings (PNCs) via gamma-induced crosslinking<sup>1</sup>. The coatings were applied to bronze and chemically prepared patinas based on formulations used for regional bronze sculptures.

A multidisciplinary characterization approach was employed, combining spectroscopy (FTIR-ATR, Raman), microscopy (SEM-EDS, metallography), electrochemical testing (EIS, Tafel analysis), contact angle measurements, and visual assessment (colorimetry). The patinas were structurally distinct, dominated by Cu<sub>7</sub>S<sub>4</sub> or mixed copper chlorides (atacamite/paratacamite). Electrochemical studies were conducted on freshly prepared and UV-aged samples. SAM coatings initially reduced corrosion rates across all sample types but lost effectiveness over time due to molecular desorption. In contrast, crosslinked PNCs exhibited long-term protective performance with minimal electrochemical degradation. The same coatings were also applied to ancient Roman coins, with surface behavior confirmed by colorimetry and contact angle measurements.

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## Powder Particle Velocity at the Nozzle Outlet in Directed Energy Deposition

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Metal-based additive manufacturing (AM) is challenging the conventional manufacturing approaches by enabling the production of complex structures with extremely favourable strength-to-weight ratio. Nowhere is this more crucial than in aerospace technology, where powder bed-based AM is already quickly being adopted. It is however the Directed Energy Deposition (DED) that is considered the truly disruptive variation of AM for the space industry. With no fundamental limitation on the size of the manufactured products and the ability to operate in microgravity conditions it could enable in-orbital manufacturing and repairs. However, before the latter can be employed, the quality of the manufactured products as well as predictability of the process needs to be significantly improved. Both ends could be achieved through high-fidelity numerical models.

Many of the shortcomings of DED originate in poor understanding and control of the powder delivery. We have developed a state-of-the-art model of powder stream where the powder phase and gas phase are modelled by using a fully coupled combination of Discrete Element method (DEM) and Computational Fluid Dynamics (CFD). This approach however necessitates an accurate boundary condition for the powder at the nozzle outlet. An original approach was developed where powder particle velocity distributions are measured at the nozzle outlet using a pair of high-speed cameras. Using this novel experimental technique, we were able to show that the powder velocities depend heavily on the particle size. Moreover, contrary to widespread assumptions, smaller powder particles were found to move through the nozzle faster than the average carrier gas speed by concentrating the center area of the nozzle.

# Extraction of Kinetic Corrosion Parameters of Passivating Metals Using Electrochemical Impedance Spectroscopy With an Upgraded Point Defect Model Framework

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Impedance spectroscopy has long been used in corrosion science, catalysis and battery research to discover and verify the electrochemical processes occurring at liquid – solid interfaces. By writing possible physical model schemes and then fitting these models to the experimental impedance data, one can verify which set of chemical equations is correct for the system under study. These physical models often have many parameters, as even the simplest models can contain 15 or more parameters. Since these systems are overparametrized, most of the time a conclusion can be made about the validity of the model, but the set of parameters that can fit the experimental data contains infinitely many combinations, so exact determination of the correct set has been difficult. Our study has made an attempt at overcoming the over-parametrization problem, using a point defect model equivalent circuit transformation. We have also derived the exact equivalent circuit that represents the point defect model framework, providing a fast diagnostic criterion.

# Evaluation of Protective Layers on Weathering Steel in Diverse Environmental Conditions

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Weathering steel is widely used in architecture, infrastructure, and art due to its characteristic ability to form a stable, protective oxide layer under suitable atmospheric conditions. However, the performance of this natural patina can be compromised in environments with high humidity, air pollutants, or insufficient drying cycles. This study investigates the effectiveness of different protective layers on weathering steel to improve its corrosion resistance.

Samples of weathering steel grade S355 J0WP were prepared with different surface treatments: natural patina development in an urban environment, simulated patina formation under aggressive conditions (chloride and SO<sub>2</sub> exposure), and an ideally preformed patina. One group of samples was additionally treated with a special top coat to stabilize the patina and prolong its protective function. The samples will be exposed to outdoor conditions in Ljubljana (Slovenia) and Zagreb (Croatia). Corrosion behaviour, patina development, and coating stability will be monitored using visual inspections, mass loss measurements, and surface analysis techniques, including Raman spectroscopy, electrochemical impedance spectroscopy (EIS), SEM/EDX, and XRD.

The aim of this study is to gain comparative insights into the performance of protective layers and the influence of local environmental factors on the durability of weathering steel.

## **Fabrication of austenitic ODS steels with TiB<sub>2</sub> addition: effect mechanical alloying time on microstructure and mechanical properties**

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Oxide Dispersion Strengthened (ODS) steels are advanced materials known for their exceptional high-temperature strength, good corrosion resistance, and excellent stability under irradiation. These properties make them ideal candidates for use in harsh environments, such as nuclear reactors or aerospace applications. ODS steels achieve these enhanced properties through the dispersion of fine, stable oxide particles, which act as barriers to dislocation movement, thereby improving the material's mechanical performance. Besides the most common Y<sub>2</sub>O<sub>3</sub>, which provides dispersion strengthening and improves high-temperature creep resistance, other elements such as Ti and Ti-based compounds can form stable Ti–Y–O, further refining the oxide particle distribution and enhancing thermal stability. TiB<sub>2</sub> has been suggested as a potential strengthening phase due to its high thermal stability and mechanical properties.

The study aimed to analyze the influence of TiB<sub>2</sub> on the microstructure and mechanical properties of the austenitic ODS steel. 316L stainless steel and 1 wt.% TiB<sub>2</sub> powders were subjected to mechanical alloying for varying durations (5, 10 and 50 hours) and consolidated using pulse plasma sintering. The resulting microstructure was examined based on light and scanning electron microscopy, while mechanical properties were assessed through tensile testing and hardness measurements. The experiments revealed that the milling time of the powders significantly affected grain size development.

The conducted studies clearly demonstrated the impact of the ceramic addition on the mechanical properties of the obtained materials, as evidenced by both the strength tests and microhardness measurements. The longer the mechanical alloying time, the coarser powder particles were obtained. This, in turn, promoted formation of bimodal microstructure during sintering. TiB<sub>2</sub> was incorporated between smaller and greater grains. We did not observe formation of nano compounds. Depending on the fraction of small and large grains in the bimodal microstructure, the mechanical properties vary.

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# Application of Spark Image Analysis and Artificial Intelligence for Predicting Carbon Content in Steels

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Determining the carbon content of steels is a crucial factor for predicting their mechanical and technological properties. Traditional laboratory methods, while accurate, are often time-consuming and expensive. This study proposes an alternative approach that integrates spark image analysis with deep learning methods to provide a faster and more cost-effective solution. In the experimental setup, 102 steel samples of different compositions were ground under controlled conditions, and images of the generated sparks were captured using a machine vision system. After preprocessing, the images were used directly to train convolutional neural networks (CNNs). Three different CNN architectures were used: GoogLeNet, SqueezeNet and DarkNet-53. The performance of the models was evaluated using Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE). Among the tested architectures, DarkNet-53 achieved the best results, with RMSE of 0.0416 and MAPE of 9.58 %, demonstrating both high accuracy and computational efficiency. The results confirm that CNN-based spark image analysis enables reliable prediction of carbon content. This approach has strong potential for application in metallurgical industries, where it can optimize production processes, reduce testing costs and enhance quality control in real time.

Keywords: spark image analysis, convolutional neural networks (CNNs), machine vision, carbon prediction, steel

## In-Situ Formation of $Y_2O_3$ Particles in 316L ODS Steel Using $YH_2$

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The growing global demand for energy, combined with the need for environmentally friendly and efficient solutions, has highlighted Generation IV nuclear reactors as a promising path forward. These reactors require advanced structural materials capable of withstanding high temperatures and intense neutron irradiation. Oxide dispersion strengthened (ODS) steels are among the leading candidates due to their excellent thermal and radiation resistance [1-3].

This work investigates the preparation and characterisation of austenitic 316L stainless steel reinforced with yttria ( $Y_2O_3$ ) particles formed in-situ using  $YH_2$  as a precursor. The study examines how mechanical alloying time affects powder properties and the resulting microstructure after consolidation. The results show that alloying duration and precursor choice significantly impact phase composition and yttrium distribution. A 4-hour milling time was identified as optimal for achieving homogeneous dispersion while minimising powder loss. The findings confirm  $YH_2$  as a suitable precursor for ODS steel, contributing to the development of materials for next-generation nuclear applications.

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# High-Entropy Oxide Catalyst for Durable Anion Exchange Membrane Seawater Electrolysis

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Seawater electrolysis is the ideal sustainable pathway for large-scale hydrogen production, offering an abundant, inexhaustible feedstock that does not compete with scarce freshwater resources. Among the available technologies, anion exchange membrane water electrolysis (AEMWE) combines the merits of alkaline and proton exchange membrane electrolysis, including non-precious metal catalysts, alkaline operation, and low-cost components, making it particularly suitable for direct seawater splitting. However, chloride-induced corrosion, biofouling, catalyst degradation, and membrane instability remain major barriers to practical deployment. In AEMWE-based seawater electrolysis, the oxygen evolution reaction (OER) at the anode is the rate-limiting step due to sluggish kinetics and the competing adsorption of chloride and hydroxide ions, which accelerates corrosion and reduces performance. While noble metal catalysts such as IrO<sub>2</sub> and RuO<sub>2</sub> exhibit high OER activity, their scarcity, cost, and limited durability in saline environments restrict large-scale use. To overcome these challenges, robust, earth-abundant catalysts with high activity, strong OER selectivity, and superior corrosion resistance are urgently needed. Here, we report a high-entropy oxide (HEO) as an efficient and durable OER catalyst for seawater electrolysis in AEMWE. The synergistic interactions among multiple redox-active metals tailor the electronic structure, enhancing both catalytic activity and halide tolerance. The HEO catalyst delivers a low overpotential of 325 mV at 100 mA cm<sup>-2</sup> and excellent durability in alkaline seawater. Integrated into an AEMWE system, it achieves 1 A cm<sup>-2</sup> at 1.88 V and stable operation for 300 h at 500 mA cm<sup>-2</sup>. With its earth-abundant composition, outstanding seawater-splitting activity, long-term durability, and scalable synthesis, this catalyst offers strong potential for cost-effective, large-scale hydrogen production via seawater electrolysis.

# Versatile Applications of Scanning Electrochemical Microscopy: From Localized Corrosion Analysis to Electrocatalysis in Metals and Alloys

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Scanning Electrochemical Microscopy (SECM) has established itself as a fundamental and versatile technique in surface electrochemistry, with extensive applications in corrosion science and electrocatalysis. Its capacity for spatially and chemically resolved measurements enables precise investigation of localized electrochemical phenomena, such as redox reactions, inhibitor efficacy, and ion transport within protective coatings [1-5].

When combined with structural characterization methods such as Electron Backscatter Diffraction (EBSD) and Energy Dispersive X-ray Spectroscopy (EDX), SECM yields comprehensive mechanistic insights into the influence of microstructural features on material degradation. In electrocatalysis, SECM facilitates the evaluation of hydrogen evolution (HER) [6], oxygen evolution (OER) [7], and oxygen reduction reactions (ORR) [8] at the level of individual grains, specific crystallographic facets, or even single nanoparticles. It also complements techniques such as Scanning Electrochemical Cell Microscopy (SECCM) by offering broader spatial coverage and enabling performance mapping across complex surfaces. With its comprehensive capabilities, SECM serves as an indispensable tool for elucidating surface reactivity and guiding the rational design of robust, high-efficiency materials.

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## Mining the Technosphere

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Over the last five decades, the global extraction of virgin materials has more than tripled, from 26.7 billion tonnes in 1970, to more than 106.1 billion tonnes in 2021. At the end-of-life, only 6.9% was redirected into a new life cycle by recycling. On top of that Europe also suffers from a lack of critical and non-critical raw materials (1, 2). Economy of the EU is already in a phase of transition from linear to circular, where the materials are maintained in the economy as long as possible, and waste generation is reduced.

Disposed waste, created as a result of human activities (called the technosphere), has been already recognized as deposits of secondary and critical raw materials (3). Mining the technosphere to valorise and exploit these resources is carried out by similar mining practices as in the processes of conventional mining the ore deposits in the lithosphere, including (i) exploration, (ii) exploitation, (iii) extraction, (iv) development of low-carbon construction products, (v) life-cycle and techno-economic analysis, and (vi) environmental risk analysis related to mitigation of potential negative impacts in all phases.

For the first time in Slovenia a comprehensive research on this topic is currently going on, based on field and laboratory activities, in the case of two landfills, i.e. the metallurgical landfill Vrhe (steel and foundry slags, foundry sand and metallurgical dusts) and the municipal landfill Gajke (residual plastic and organic/mineral part). The aim is to develop and validate feasible solutions for landfill mining practices and to prove that the mining processes can be performed safely and efficiently, with significantly lower environmental footprint compared to conventional lithosphere mining.

Such solutions are also intended to rehabilitate waste disposal sites and thus improve the state of the environment as well as provide a versatile source of materials for application in construction sector (aggregates for asphalt, concrete and materials for earthworks). The preliminary research results will be presented in the paper.

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## Atomic-Scale Mechanisms of Mg Oxidation

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Magnesium (Mg) is the lightest structural metal with medium strength and remarkable friendliness to the environment including biocompatibility. Despite abundancy, Mg is one of the most critical materials for the EU, which contributes to many sustainable development goals. Its reactivity and susceptibility to degradation is well known for many years, and the bulk body of studies can be found in the literature. Nevertheless, fundamentals of physical processes around the interface of Mg alloys with gaseous and aqueous environments and oxide film formation at early stages is surprisingly scarcely studied. Main reasons for this stem from objective difficulties associated with high magnesium reactivity in normal atmospheric conditions.

In this talk, we focus on fundamental mechanisms of Mg oxidation at early stages. In the experimental part, high-resolution X-ray photoelectron spectroscopy (HR-XPS) in ultra-high vacuum conditions was used. It is a synchrotron-based surface sensitive technique, which reveals local chemical environments of near-surface atoms in a sample. Based on the analysis of energy shifts in the core-level electrons, it allows revealing surface states and the kinetics of oxide formation from the very first interaction of O<sub>2</sub> molecules with Mg surface. Nevertheless, HR-XPS cannot provide information on the geometric characteristics of Mg-O units.

Therefore, the experimental HR-XPS studies need to be complemented with theoretical density-functional theory (DFT) based simulations which we did using Quantum Espresso code. The DFT simulations enable unrevealing local structures of MgO units and their evolution into oxide layer. The theoretically feasible atomic configurations in the oxide units are then used for calculating energy shifts in the core-level electrons of respective surface atoms. These energy shifts are eventually compared to experimentally found values, and coherent mechanisms of Mg oxidation depending on the crystallographic orientation of surface are reconstructed.

As main results, we demonstrate that Mg reactivity and kinetics of oxidation strongly depend on the crystallographic orientation of surface, while some surfaces even reconstruct prior to oxidation.

# Electrochemical and Spectroscopic Characterization of Patinated Bronze Sculptures

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Bronze sculptures are usually covered by a layer of artificial patina, which is an important part of its visual identity. When continuously exposed to outdoor environment, i.e. rain, moisture condensation, salt and particle deposition and UV light, patina layer can dissolve or chemically transform, which is commonly noticed on statues exposed in urban areas. In some cases this process can lead to overall improvement of the patina and bronze stability, as the reactive patina components are dissolved or converted to more stable compounds. In other cases patina dissolution leads to increased porosity and enhances the dissolution of bronze substrate. In practice it is difficult to determine which of the above ascribed processes is taking place.

Electrochemical methods are important for determination of corrosion stability of metallic surfaces. For this reason, they are applied in this work to examine the corrosion properties of several bronze statues placed in polluted urban areas. Studied statues are covered by a black or green artificial patina layers and date from mid 20<sup>th</sup> century to beginning of 21<sup>st</sup> century. Electrochemical measurements were conducted within a three-year period by using a non-destructive method, electrochemical impedance spectroscopy (EIS). Analysis of the obtained impedance spectra showed that for some of the sculptures, patina did not change much that period, while on others an improvement or deterioration of patina stability occurred. Besides the EIS measurements, patina was examined by FTIR spectroscopy. However, EIS proved to be more sensitive to patina modification detection compared to FTIR spectroscopy.

# Electrochemical Realism in Single-Atom Catalysis

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Single-atom catalysts (SACs) represent a powerful and adaptable class of materials that hold great promise across a broad spectrum of catalytic applications, particularly in electrochemistry. By virtue of their atomically dispersed active sites, SACs offer a unique platform for maximizing metal efficiency and precisely tuning catalytic behavior. Furthermore, the structural simplicity of these active sites makes them highly amenable to theoretical modeling.

Yet, one of the fundamental challenges in this field lies in the dynamic nature of the active site under real electrochemical operating conditions. Variations in parameters such as pH and electrode potential can significantly alter the structure and reactivity of these sites, effects that are too often overlooked in theoretical treatments.

In this lecture, we introduce a conceptual and computational framework designed to bridge this gap. By extending the concept of surface Pourbaix diagrams to the realm of SACs, we provide a strategy for assessing their electrochemical stability and predicting their active configurations under working conditions. This approach facilitates a deeper understanding of catalytic function and supports the rational design of SACs with enhanced durability and performance.

While the methodology is broadly applicable to various SAC systems, including those based on metal oxides, carbon materials, or ceramic supports, we will focus on illustrative examples involving two-dimensional materials. Ultimately, incorporating electrochemical stability into the design paradigm offers a crucial step forward in the development of next-generation SACs for energy conversion and other technologically relevant processes.

## Production of ODS steels via additive manufacturing for demanding environments

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Oxide dispersion-strengthened (ODS) steels are recognised for their excellent mechanical performance at elevated temperatures and their improved resistance to embrittlement caused by neutron irradiation. These characteristics make them strong candidates for future applications such as fuel cladding in next-generation nuclear reactors and blanket materials in fusion power systems.

This work investigates whether using an ultrasonically gas-atomised precursor steel powder enriched with oxide nanoparticles, or alternatively, a steel powder modified through smart surface oxidation, in combination with advanced consolidation techniques like laser powder bed fusion (LPBF), can improve the high-temperature performance of ODS steels in extreme environments.

As a proof of concept, austenitic 316L stainless steel was selected due to its good ductility, workability, and mechanical stability at elevated temperatures. Yttrium oxide ( $Y_2O_3$ ) was chosen as the primary nano powder additive for its superior ultimate tensile strength compared to other oxide powders. As the project advances and the strengthening mechanisms of the nano-oxide dispersion are better understood, titanium diboride ( $TiB_2$ ) nanoparticles—with their higher melting point—will also be incorporated.

The production of ODS steels involves mechanical mixing using a Turbola mixer, followed by ball milling and LPBF processing. The materials are then subjected to detailed microstructural characterisation, high-temperature mechanical testing, corrosion resistance evaluation, tribological analysis, and Vickers hardness measurements. Scanning electron microscopy (SEM), equipped with energy-dispersive X-ray spectroscopy (EDS) and electron backscatter diffraction (EBSD), is employed to analyse the morphology and phase composition of the powders and LPBF-fabricated samples.

# Corrosion Resistance of AISI 316L ODS Steel Strengthened by In-Situ Formed $Y_2O_3$ Particles

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Austenitic stainless steels, such as AISI 316L, are widely used in corrosion-prone environments due to their excellent corrosion resistance, which primarily arises from the formation of a protective  $Cr_2O_3$  passive layer.<sup>1</sup> However, localized corrosion mechanisms such as pitting and intergranular corrosion (IGC) can still occur, particularly in the presence of chloride ions or after thermal exposure leading to sensitization.<sup>2, 3</sup> The present study investigates the corrosion resistance of oxide dispersion strengthened (ODS) AISI 316L steel, in which nanoscale  $Y_2O_3$  particles are formed in-situ from  $YH_2$  precursors during mechanical alloying and subsequent spark plasma sintering (SPS). The aim is to understand how the incorporation of thermally stable oxide dispersoids affects the microstructure and corrosion behavior under aggressive conditions.

Microstructural changes were characterized by scanning electron microscopy (SEM) and X-ray diffraction (XRD). The degree of sensitization (DOS) to IGC was evaluated by electrochemical method, specifically electrochemical potentiokinetic reactivation (EPR), alongside potentiodynamic cyclic polarization (PCP) to assess pitting corrosion resistance. The findings suggest that the in-situ formation of oxide particles not only enhances the mechanical properties of ODS steels but may also contribute to improved corrosion resistance by promoting passive layer stability and mitigating pitting susceptibility. These improvements make ODS AISI 316L a promising candidate for demanding applications in chloride-containing or high-temperature environments.

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## Performance of AM Stainless Steels in Hydrogen Rich Environments

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Properties of common metals are detrimentally affected by exposure to hydrogen, which may lead to hydrogen embrittlement (HE). Deterioration depends on the specific environment, mechanical loading and internal stresses, but mainly on the type of material and its microstructure. Microstructure of metals deviate significantly when using different processing routes. The characteristics of laser-based additive manufacturing (AM) processes are high temperature gradients, residual stresses, anisotropy and complex microstructures with high dislocation density. These specifics can have critical impact on susceptibility to HE.

In terms of reducing pollution related to energy production, AM provides light-weight high-strength design with reduced energy needs, while green hydrogen represents viable alternative to fossil fuels. However, the main challenge in combining these two technologies is susceptibility of AM materials used in production, storage, transport and use of hydrogen to HE.

The main aim of our research was to investigate differences in properties of conventionally and AM produced stainless steels and how they are affected by exposure to hydrogen. Investigation was focused on two types of stainless steel, martensitic AISI 420 and austenitic AISI 304. AM was performed by AconityMIDI machine using LPBF process and powders of 50  $\mu\text{m}$ . Conventionally and AM produced steels were subjected to electro-chemical charging in 0.1 M NaOH for 48 h at 65°C and 20 mA/cm<sup>2</sup>. Performance was evaluated in terms of Slow Strain Rate testing, toughness, tensile strength, as well as fatigue and wear resistance. Results indicate that in general AM materials show higher strength and wear resistance but reduced toughness. Both materials show drop in performance when exposed to hydrogen, however reduction in properties depends on type of microstructure and production route. For AISI 304, AM material shows reduced HE susceptibility as compared to conventional one, while for AM420 few fold increases and critical drop in properties was observed.

## Monitoring galvanic corrosion between copper and steel

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Galvanic corrosion is an electrochemical process in which two dissimilar metals are connected and exposed to a corrosive electrolytic environment. The driving force behind galvanic corrosion is the potential difference between the two dissimilar metals. A galvanic cell is formed, which consists of a cathode and an anode that corrode. The ratio of the surface areas of the anode and cathode is also important. The larger the surface area of the cathode than the anode, the greater the galvanic anodic current and the faster the metal corrodes.<sup>1,2</sup> There are not many techniques for measuring galvanic corrosion and there is no easy way to observe and monitor it. One of the techniques for monitoring galvanic corrosion is a sensor consisting of a coupled multi-electrode array (CMEA) connected to a zero-resistance ammeter (ZRA) which allows monitoring of anodic and cathodic currents at zero applied potential. As such, CMEA is a technique that enables continuous monitoring of corrosion currents in space and time. In this study, the evolution of the corrosion current of 25 electrodes is analyzed, with three electrodes made of carbon steel (CS) and the others of copper (Cu). This represents a galvanic coupling between copper and steel with a ratio of Cu:CS=22:3. The measurement was carried out under bentonite, saturated with simulated saline groundwater at room temperature for approx. 4 months. Following the CMEA measurements, various microscopic and spectroscopic investigations were carried out to determine morphology and chemical analysis of corrosion products on steel and copper electrodes. In addition, the corrosion damage is assessed using X-CT and compared with the measured corrosion activity using CMEA.

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# Enhanced NiTi-TiC Composites for Ballistic Protection: Effect of Reinforcement Origin and Milling Strategy

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Recent advances in ballistic protection emphasize the need for weight reduction and efficient energy dissipation. Replacing conventional polymer layers with metal matrices reinforced with ceramic particles offers a promising alternative<sup>1,2</sup>. This study investigates NiTi-based composites reinforced with TiC particles, using both commercially available TiC powders and TiC produced via mechanical alloying of Ti with graphene or through plasma-catalytic pyrolysis. NiTi was selected for its excellent mechanical properties, including high strength and toughness and lower density<sup>3</sup>. Initially, hand-mixed composites with varying TiC contents were assessed; however, compositions exceeding 12.5 wt.% exhibited poor cohesion after sintering. To enhance the microstructure, mechanical milling at 800 rpm was employed. Milling for 0.5 h significantly modified the phase composition, resulting in the formation of TiNi<sub>3</sub> and Ni<sub>4</sub>Ti<sub>3</sub> phases. After 2 h of milling, the Ni<sub>4</sub>Ti<sub>3</sub> phase disappeared, with improved TiC dispersion and increased wear resistance. However, the overall presence of hexagonal phases negatively affected the mechanical properties, prompting the application of thermal treatment to improve ductility. These findings underscore the advantages of mechanical alloying in achieving uniform particle dispersion and favorable phase transformations in NiTi-TiC composites, advancing their potential for high-performance ballistic applications.

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# Impact of Surface Preparation on the UCI Hardness Measurements

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Hardness measurement in the field using the Ultrasonic Contact Impedance (UCI) method offers great convenience and portability, but ensuring full compliance with standard requirements—especially surface preparation—is often difficult or impossible. This study investigates how surface preparation influences UCI hardness measurements, where Vickers hardness measurements according to ISO 6507-1:2023 was used as a reference measurements on metallographically prepared specimens.

Specifically, we review the UCI standard requirements (DIN 50159-1:2022 and ASTM A1038-19) regarding maximum surface roughness. While these standards typically define allowable roughness as the 2D line-based average roughness **R<sub>a</sub>**, in this study we used the 3D areal surface parameter **S<sub>a</sub>** instead. The reason is that **S<sub>a</sub>** provides a more representative and robust description of real surface conditions. This approach also reduces measurement bias that can occur when **R<sub>a</sub>** is measured along a single profile that may not capture localized surface features.

In our experimental work, we used two tubes made of creep-resistant steels, T24 (7CrMoVTiB10-10) and VM12 SHC (X20CrMoV11-1). We performed hardness measurements using both the UCI method and a stationary Vickers tester at two different loads: HV1 and HV10. One set of samples was metallographically prepared in the lab to fully satisfy the ISO 6507-1:2023 specimen preparation requirements, while the comparative UCI measurements were made in field-like conditions where some of the standard surface preparation requirements were not fully met. The results show the magnitude and direction of measurement deviations introduced by non-ideal surface preparation, correlated with roughness levels (expressed as **S<sub>a</sub>**) and test force.

The findings quantify under what conditions UCI measurements deviate beyond acceptable limits compared to Vickers reference values, and thus provide guidance for practitioners.

# **Advances in 3D Characterization Using Focused Ion Beam (FIB) Technology**

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Thermo Fisher Scientific

Three-dimensional (3-D) characterization has become an indispensable tool for understanding the complex structure–property relationships in advanced materials. To this end, focused ion beam (FIB) technology, when coupled with scanning electron microscopy and complementary analytical methods, enables access to subsurface features with nanometer precision. The aim is to show recent advances in 3-D workflows that integrate serial sectioning with high-resolution imaging and correlate them with different microanalysis techniques.

Emphasis will be placed on strategies to optimize resolution, minimize artifacts, and combine chemical and structural information in a single dataset. Together, these capabilities establish FIB technology as a powerful technique for high-resolution 3-D characterization and microanalysis across a wide range of scientific and industrial applications.

# Influence of hydrogen charging on fatigue life of additive manufactured austenitic stainless steel AISI 304 and martensitic stainless steel AISI420

Marko Sedlaček<sup>1</sup>, Barbara Šetina Batič<sup>1</sup>, Bojan Zajec<sup>2</sup>, Andraž Legat<sup>2</sup>, Irena Paulin<sup>1</sup>, Frantz Martin Franz<sup>3</sup>,  
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In the framework of the green transition, hydrogen is emerging as a key alternative energy carrier for applications such as heating, chemical manufacturing, and refining. Its adoption, however, raises material-related challenges due to hydrogen embrittlement (HE), caused by the diffusion of atomic hydrogen into metallic lattices. While HE mechanisms are relatively well-established in conventionally manufactured steels, the advent of additive manufacturing (AM) introduces distinct microstructural features—such as residual stresses, anisotropy, and porosity—that may alter susceptibility to hydrogen-assisted damage.

This study examines hydrogen embrittlement in both conventionally produced and additively manufactured (laser powder bed fusion) austenitic stainless steels AISI 304 and AISI 420. Specimens were hydrogen pre-charged using a cathodic method at a current density of 20 mA/cm<sup>2</sup>, followed by tensile, Charpy impact toughness, and Brinell hardness tests. Fatigue performance was assessed under varying stress amplitudes, and fracture surfaces were analyzed via Scanning Electron Microscopy (SEM) to characterize crack initiation and propagation mechanisms.

Results show that AM steels possess enhanced strength and hardness compared to conventional steels, yet their fatigue life is significantly reduced after hydrogen charging. Hydrogen exposure decreases elongation and ultimate tensile strength, while impact toughness remains largely unaffected. SEM analyses confirmed hydrogen-assisted crack propagation features.

These findings highlight the dual effect of additive manufacturing: while it improves baseline mechanical performance, it also amplifies the sensitivity of stainless steels to hydrogen embrittlement. This emphasizes the need for tailored processing and mitigation strategies for AM components in hydrogen applications.

# Microstructural Evolution of Plasma-Nitrided Additively Manufactured AISI 316L, 18Ni300, and IN625

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Additive manufacturing (AM) enables the production of complex metallic components with tailored microstructures, but the as-built surfaces and porosity often limit their performance in demanding applications. Thermochemical surface engineering, particularly plasma nitriding, offers a promising post-processing route to enhance their surface performance such as wear and corrosion resistance. In this study, plasma nitriding treatments were applied to three representative AM alloys: austenitic stainless steel AISI 316L, maraging steel 18Ni300, and Ni-based superalloy IN625. The influence of process parameters on phase formation, microstructural evolution, hardness profiles, and surface integrity was investigated. For AISI 316L, nitrogen supersaturation produced an expanded austenite (S-phase) layer with significantly increased surface hardness while retaining corrosion resistance. In 18Ni300, the nitriding temperature governed the balance between retained/reverted austenite and the formation of  $\text{Fe}_2\text{Mo}$  and  $\text{Ni}_3(\text{Ti},\text{Mo})$  precipitates. Higher nitriding temperatures promoted greater austenite content, and produced thicker compound layers. Within the plasma-nitrided compound layer, retained austenite transformed mainly into  $\text{Fe}_4\text{N}$  with minor  $\text{TiN}$ , accompanied by Ni diffusion to phase boundaries and nitrogen enrichment of martensite. The resulting surface layer exhibited a lamellar structure dominated by  $\text{Fe}_4\text{N}$  with segregated N and Co. In IN625, strong affinity of nitrogen with alloying elements such as Cr and Mo lead to nitride precipitation and modified diffusion pathways. Lower nitriding temperatures produced expanded austenite or austenite with minor CrN, while higher temperatures caused decomposition of expanded austenite and extensive CrN precipitation. The resulting bilayer microstructure consisted of a thicker surface layer and a thinner diffusion zone, with lattice relaxation at elevated temperatures. Across all alloys, the nitrided layers exhibited improved wear resistance compared to the untreated AM counterparts, with microstructural variations strongly dependent on alloy composition. These results confirm nitriding as an effective and versatile post-treatment for extending the performance envelope of additively manufactured alloys.

# Anti-Corrosive Protection of Aircrafts unsustainable Coatings Based on Biomass Waste: Local Lignin Valorization for high Technology

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The aerospace industry faces major challenges related to the corrosion of metallic alloys, particularly aluminum Al2024, widely used in aircraft structures for its low weight and high mechanical strength.<sup>1</sup> However, its high corrosion susceptibility compromises long-term structural integrity. Traditional protective coatings often use chromate-based compounds, now heavily restricted due to their toxicity and regulations like REACH. This scenario drives the search for sustainable, efficient surface protection technologies aligned with industrial requirement.<sup>2</sup>



Fig. 1: SiO<sub>2</sub>@Lignine Core-shell nanoparticles

In this context, lignin—an aromatic biopolymer derived from paper industry waste—has emerged as a promising raw material for anticorrosive formulations. This work presents the development of lignin-based core-shell nanoparticles (as shown in Figure 1), consisting of a silica (SiO<sub>2</sub>) core and a lignin shell, synthesized *via* nanoprecipitation. These nanoparticles were deposited onto Al2024 aluminum substrates using dip coating through the evaporation-induced self-assembly (EISA) technique, forming a uniform and functional coating.<sup>3</sup> The applied coating is supposed to have both some mechanical specificities (provided by the silica) and a certain hydrophobicity (provided by the lignin). Scanning electron microscopy (SEM) revealed a continuous and nanorough film, while X-ray photoelectron spectroscopy (XPS) confirmed the successful deposition and chemical integration. Atomic force microscopy (AFM) measurements quantified nanoscale roughness induced by the coating. These preliminary results demonstrate the potential of lignin-based hybrid nanoparticles as active agents in eco-friendly coatings, supporting the transition to greener corrosion protection technologies in the aerospace sector.

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# Accurate Measurement of Coating Thickness on Fully-Finished Non-Oriented Electrical Steels Using FIB-SEM

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In the characterization of coated layers on fully-finished non-oriented electrical steels (NOES), precise determination of their thickness is crucial for understanding the material properties of the product and ensuring quality control. One of the common challenges in these measurements arises when the sample is not perfectly aligned during measurement—that is, when it is slightly tilted relative to the reference plane of the measurement system. Due to the inclination, the effective measurement path becomes longer, resulting in an apparently greater layer thickness than the actual one. This phenomenon is especially pronounced in very thin layers, where errors can be comparable to the actual thickness. If the tilt is not detected or properly corrected, it can lead to misinterpretation of data, inaccurate results, and consequently, incorrect conclusions in research or technological processes.

In this study, we investigated the potential of using the FIB-SEM microscopy technique to measure the thickness of coated layers on fully-finished conventional NOES.

When using FIB-SEM with gallium ions ( $\text{Ga}^+$ ) to prepare cross-sections of layers with a thickness of a few micrometers ( $\mu\text{m}$ ), precise ablation of material with good spatial resolution is essential.  $\text{Ga}^+$  generated at an acceleration voltage of 30 kV enable effective localized removal of material. The sample is protected with a thin layer of platinum (Pt) deposited by  $\text{Ga}^+$  to prevent damage to the top layer during the initial ablation process and to achieve a smoother final cut. The result of this procedure is a clean and sharp cross-section suitable for high-resolution SEM imaging.

The presented microscopic method for measuring the thickness of coatings on conventional fully-finished NOES samples using FIB-SEM has proven to be repeatable, robust, specific, and has an appropriate detection limit for the thickness range of typical coated layers in NOES.

# Carbon Capture and Storage of Glowing Flaming Plant Induced by Photosynthetic Efficiency for Vein-absorbed Graphene Quantum Dot

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A recent study has demonstrated that graphene stimulates plant root growth and enhances the activity of antioxidant enzymes, resulting in elevated mitochondrial respiration functions. These enhanced functions are compensated by an increase in root length. The utilization of graphene was augmented the total size, surface area, average diameter, and the number of roots in lettuce roots. Additionally, it effectively alleviated the negative effects of heavy on root growth. Moreover, the application also enhanced the quality of lettuce, resulting in reduced heavy accumulation in both leaves and roots and increasing in the levels of soluble sugar, protein, and vitamin C content. In this study, we investigated the response of plant growth by implanted different concentration of glowing graphene quantum dots in veins of 8 varieties of Flaming plant. Quantum yield and efficiency of chlorophyll fluorescence and were used to demonstrate photosynthesis function. Furthermore, CO<sub>2</sub> exchange rate is determined to qualify the increasing carbon sink in plants. We found efficiency of donation electron to PSI ( $F_v/F_o$ ), maximum quantum yield of PSII ( $F_v/F_m$ ), performance index on absorption basis (PIABS) energy fluxes absorbed (ABS/RC) and trapped (TRo/RC) per reaction center (RC), primary photochemistry ( $\psi_o$ ), electron transport rate (ETo/RC) and non-photochemical quenching for energy dissipation (Dlo/RC) of Flaming plant are enhanced after graphene is implanted in vein.

# Electrocatalyst Discovery through Advanced Synthesis, Characterization, and Data Integration

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The development of efficient and scalable electrocatalysts for energy applications increasingly demands not only innovation in synthesis but also a systematic approach to data generation and interpretation. In this talk, I will present a comprehensive overview of our strategies for preparing electrocatalysts based on metals, alloys, and high-entropy materials, emphasizing a modular and data-centric workflow.

We employ diverse synthesis methods including electrodeposition, nitridation, anodic oxidation, and laser surface structuring to tailor catalytic properties and engineer finely tuned surface chemistries. Particular attention will be given to our use of laser-based methods which enable rapid surface modification suitable for both research and industrial contexts. To understand the evolution of structure and composition at each stage, we integrate advanced characterization techniques, such as identical location scanning electron microscopy (IL-SEM), XPS, XRD, and electrochemical testing. One such example of structural and compositional complexity can be found in our recent work,<sup>1</sup> which highlights the multi-level complexity of such systems — ranging from material structure to collaborative workflows—and underscores the need for new, systematic approaches capable of handling and leveraging this complexity.

A key focus of our work is the interplay between experiment and data science. We harness machine learning algorithms to process large datasets, reveal hidden correlations, and guide the synthesis. Data is structured and managed through the Qx application, enabling standardized, searchable, and interconnected records across synthesis, characterization, and performance evaluation.

By combining multiple synthesis methods, advanced characterization techniques, and structured data management and analysis, we create an integrated approach that accelerates the discovery of next-generation electrocatalysts. The talk will conclude with reflections on how integrating digital tools into experimental workflows enables more systematic exploration, knowledge extraction, and informed decision-making in electrocatalyst development.

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# Corrosion Behaviour of Reinforced Steel in LC3 and OPC Simulated Pore Solutions

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Carbonation, a process in which atmospheric CO<sub>2</sub> reacts with the alkaline components of concrete, reduces the pH of the pore solution from values above 12 to around 9. This reduction in pH can compromise the passive layer on the embedded steel surface and significantly increase the risk of corrosion, especially in combination with chlorides.<sup>1</sup> A promising alternative to ordinary Portland cement (OPC) is limestone calcined clay (LC3) cement, which significantly reduces environmental impact, primarily through lower CO<sub>2</sub> emissions. However, OPC and LC3 differ in cement composition, microstructure and pore solution chemistry, which affects their carbonation behavior. LC3-based systems tend to carbonate more readily, potentially resulting in lower pH values. Simulated concrete pore solutions provide a controlled environment to study the corrosion characteristics of steel under conditions relevant to both OPC and LC3 systems before and after carbonation.<sup>2</sup>

In this study, we investigated the corrosion behavior of carbon steel immersed in simulated non-carbonated and carbonated OPC and LC3 pore solutions. The corrosion behavior was evaluated using classical electrochemical techniques, including open-circuit potential (OCP), linear polarization (LPR), Tafel extrapolation, and potentiodynamic polarization. These results were complemented by measurements of temporal and spatial corrosion current distributions obtained using coupled multi-electrode arrays (CMEA), which provide additional insight into corrosion activity. All electrochemical measurements were performed in triplicate to ensure reproducibility and allow for statistical comparison. After electrochemical testing, the exposed steel surfaces were examined using optical microscopy to assess the extent and morphology of corrosion damage.

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# Tensile Behaviour of Laminated Wood and Aluminium-Reinforced Composites: An Experimental and ARAMIS-Based Analysis

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The increasing demand for sustainable engineering solutions, particularly in automotive and construction sectors, emphasizes the importance of developing environmentally friendly structural materials. Laminated wood composites represent a viable alternative to conventional polymer composites due to their biodegradability, favourable mechanical properties, and low carbon footprint. Reinforcing laminated structures with metallic layers offers the potential to further improve load-bearing performance.

In this study, the tensile strength of six laminated wood composites was investigated: two layer and three-layer beech and oak laminates, and two-layer beech and oak laminates reinforced with a 1 mm aluminium sheet. A total of 48 specimens were prepared and tested according to HRN EN 408:2012 using a universal testing machine. Mechanical properties including tensile strength, Young's modulus, and total elongation were determined. The highest tensile strength was achieved by two-layer beech specimens (69.51 MPa), with the lowest standard deviation, indicating uniform mechanical behaviour. In contrast, aluminium-reinforced samples demonstrated higher elongation but significant scatter of results, attributed to the anisotropy of wood and non-uniform adhesive bonding between wood and aluminium layers.

To gain a more detailed insight into the deformation behaviour, additional static tensile tests were performed using the ARAMIS 2D optical measuring system. This system enabled full-field strain and displacement analysis, allowing the evaluation of local deformations across individual layers of the composite. The ARAMIS results revealed distinct strain distribution patterns, with reinforced specimens exhibiting localized stress concentrations and early delamination effects at the wood–aluminium interface. In contrast, two-layer beech laminates showed uniform displacement progression across lamellas, correlating with their superior mechanical consistency. The combination of force–displacement curves with ARAMIS measurements provided a comprehensive understanding of load transfer mechanisms within laminated and hybrid composites.

The results highlight the potential of laminated beech composites as reliable load-bearing elements under tensile stress, while aluminium-reinforced variants require further optimization of the adhesive bonding process to reduce variability and improve stress distribution. The integration of optical measurement techniques such as ARAMIS proved highly valuable for capturing layer-specific deformation, thereby offering new possibilities for design and development of advanced sustainable composites.

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## Low-carbon decorative concrete floor tile strengthened by carbonation curing

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The floor made of cement tiles, which adorns many buildings from the end of the 19<sup>th</sup> century, represented a revolutionary approach to pattern, color, and shape in interior design. Master craftsmen of the time succeeded in producing multicolored tiles, offering an affordable and accessible alternative to intricate mosaic flooring [1]. However nowadays in Slovenia, there are no manufacturers of concrete tiles for the renovation of cultural heritage buildings or new constructions, as the technology is no longer known. This contribution presents preliminary results from an ongoing study focused on developing sustainable and replicable production processes for concrete tiles. The approach utilizes carbonation curing, limestone calcined clay cement (LC<sup>3</sup>), and natural pigments derived from the Sitarjevec mine.

Cementitious mixtures were formulated by replacing 50 wt.% of cement clinker with a combination of metakaolin and limestone, creating a low-carbon binder system. To achieve the desired aesthetic diversity, thermally treated mine sludge was used as a pigment source, producing multicolored cement mixtures. These mixes were cast and subjected to carbonation curing in a controlled CO<sub>2</sub> chamber. The research focused on understanding the reaction mechanisms, optimizing curing parameters, and evaluating the mechanical, microstructural, and durability properties of the resulting materials. A particular emphasis was placed on the carbonation curing process as a sustainable hardening technique, contributing to carbon capture and improved durability.

This work demonstrates how innovative, sustainable material approaches combining industrial waste valorization, carbon sequestration through CO<sub>2</sub> curing, and low-carbon binders can contribute to circular economy principles and support the conservation and restoration of cultural heritage buildings.

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# Effect of a $\text{La}_{0.07}\text{Ba}_{0.93}\text{SnO}_3$ Interlayer on Epitaxial $\text{Li}_4\text{Ti}_5\text{O}_{12}$ Anodes for All-Solid-State Batteries

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Our study investigates the use of a La-doped  $\text{BaSnO}_3$  (LBSO) interlayer to improve the epitaxial growth of spinel lithium titanate ( $\text{Li}_4\text{Ti}_5\text{O}_{12}$ , LTO) thin-film anodes on  $\text{Nb}:\text{SrTiO}_3$  (Nb:STO) substrates. LTO is a promising "zero-strain" anode for all-solid-state thin-film batteries, but its synthesis via pulsed laser deposition (PLD) often leads to undesirable secondary phases. We demonstrate that a ~50 nm thick, epitaxial LBSO interlayer, deposited by PLD on (100), (110), and (111)-oriented Nb:STO substrates, effectively suppresses the formation of these secondary phases, as confirmed by high-resolution X-ray diffraction. Atomic force microscopy showed that the LBSO interlayer preserved the characteristic orientation-dependent surface morphologies of the LTO films while reducing facet sizes. Reciprocity space mapping and rocking curves indicated improved structural quality, notably for the (100) orientation. Electrochemical testing in liquid electrolyte cells revealed that the (111)-oriented LTO films performed poorly. In contrast, the (100) and (110) LTO films grown on LBSO interlayers exhibited superior performance, delivering stable discharge capacities near 140 mAh  $\text{g}^{-1}$  at a 3C rate. The LTO+LBSO (110) configuration demonstrated excellent long-term cycling stability, retaining approximately 93% of its capacity after 200 cycles. Post-cycling scanning transmission electron microscopy confirmed a well-preserved interface with no detectable degradation layer. This work establishes LBSO interlayers as a highly effective strategy for enhancing the phase purity and structural quality of epitaxial LTO anodes, advancing their application in advanced thin-film batteries.

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## Nitrides and carbides in 2101 lean duplex stainless steels

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The 2101 lean duplex stainless steel (LDX) was designed mainly for lightweight constructions and as a more economical substitute for the dominating stainless-steel grades. Compared with other duplex stainless steels, the corrosion resistance and costs of processing the 2101 duplex stainless steel are usually worse, as the Ni and Mo contents are lower; it is compensated by higher N and Mn contents to stabilize the austenite. At lower test temperatures the precipitation of different phases was observed, so different annealing experiments were conducted to further investigate the occurrence of precipitation. As the composition of lean duplex stainless steel differs from that of conventional duplex stainless steels, a different aging behaviour is expected. The embrittlement of 2101 lean duplex stainless steel occurs at approximately 700 °C to 750 °C, because of the precipitation of the deleterious Cr<sub>2</sub>N and M<sub>23</sub>C<sub>6</sub> at the  $\delta/\gamma$  and  $\delta/\delta$  interfaces, which begins after a few minutes of aging. These temperatures of the nitride precipitations are crucial to the cracking during the end of hot-working operations, which should stop at higher temperatures. The purpose of the research was to qualitatively analyse the phases in lean duplex stainless steel after thermal aging. Optical microscopy (OM), scanning electron microscopy (SEM) and electron-backscatter diffraction (EBSD) were used to investigate the structural stability and the chemical compositions of the phases.

# Microstructure and Mechanical Properties of Co-28Cr-6Mo for Medical Applications: Casting vs. Additive Manufacturing

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Cobalt-based alloys were initially developed for their excellent mechanical properties, making them suitable for applications in the aerospace industry. Later, their outstanding corrosion resistance and biocompatibility led to their widespread use in the medical field. Among these materials, Co-28Cr-6Mo has become the most widely used cobalt alloy for orthopedic implants such as knee joint replacements, due to its combination of strength and biocompatibility.

Traditionally, components made from Co-28Cr-6Mo have been manufactured using precision casting techniques. In recent years, additive manufacturing technologies have emerged as a promising alternative, enabling the production of patient-specific implants with intricate geometries and offering the potential for creating porous structures. Among these technologies, Selective Laser Melting (SLM) is the most commonly used.

This study presents a comparative analysis of Co-28Cr-6Mo alloy produced by precision casting and by SLM, focusing on differences in microstructure and mechanical properties. The SLM-produced samples demonstrated a significantly finer microstructure and, as a result, exhibited enhanced mechanical properties. Tensile testing revealed an increase of approximately 50 % in the yield strength of the SLM material compared to the cast alloy. A smaller difference was observed in hardness, with the cast sample reaching 330 HV 1 and the SLM sample 380 HV 1.

To comprehensively evaluate both fabrication methods, mechanical testing was supplemented with detailed analyses of the microstructure and phase composition. The results suggest that SLM is a viable and potentially superior alternative to casting for the fabrication of orthopedic implants, provided that the processing parameters are carefully controlled and optimized.

This work was financially supported by the Specific university research funding (A1\_FCHT\_2025\_011).

# Enhancing the Hydrogen Evolution Reaction in Anion Exchange Membrane Water Electrolyzer Using De-alloyed and Platinum Decorated Catalyst

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In this study, Pt-decorated NiCoZn alloy was designed and synthesized as a high-performance hydrogen evolution reaction (HER) electrocatalyst in alkaline media. The NiCoZn alloy was obtained via a microwave-assisted solvothermal method, followed a dealloying process. Various materials characterizations, including SEM, TEM, XRD, ICP, EA, and XPS, have been performed. Electrochemical tests show that the HER electrocatalyst, with only 10 wt% Pt, exhibits outstanding activity, achieving a low overpotential of 32.9 mV at 10 mA cm<sup>-2</sup> and a Tafel slope of only 58 mV dec<sup>-1</sup>. Moreover, the catalyst achieves nearly 100% Faradaic efficiency and maintains long-term operational stability for over 1000 hours in an anion exchange membrane water electrolyzer. Overall, the result highlights that the combination of dealloying and Pt decoration effectively tailors the surface and electronic structure to give remarkable activity and durability, thus offering a promising strategy for developing efficient alkaline HER electrocatalysts with low noble metal contents.

## Identical Location SEM on a Case Example of Copper Degradation During Electrochemical CO<sub>2</sub> Reduction

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Identical location scanning electron microscopy (IL-SEM) enables direct visualization of material evolution by imaging the same surface region before and after various treatments.<sup>1</sup> In this lecture, a step-by-step approach to implementing IL-SEM, including surface marking, image alignment, and sample handling protocols, will be presented. The methodology will be demonstrated on a case study of copper catalysts undergoing degradation during electrochemical CO<sub>2</sub> reduction.<sup>2</sup> The observed dissolution and redeposition processes provide clear evidence of dynamic morphology restructuring, emphasizing the catalytic property changes.

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# **AISI H13 Hot Work Tool Steel Produced by Laser Powder Bed Fusion**

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By now, additive manufacturing (AM) is more commonplace in the field of materials research, as many authors explore possibilities of given materials and expand our knowledge on the application of AM. However, despite these great strides we made, a lot of research remains to be done, as each answered question tends to bring up several new ones.

AM has three main benefits: the ability to produce complex geometries, that you would not be able to manufacture with other means, the specific microstructure that is innate to the process and the ability to produce very low amounts of waste material. The two main drawbacks of the technology are high upfront costs and low production volumes. This is why AM is already quite popular in advanced technology sectors like aerospace and medicine, where it fills strictly defined niches for individual tailored parts, while other sectors have been slower in adopting AM as a method of production. One sector that could greatly benefit from AM is the tooling sector. As it currently stands, most tools are made with reductive processes, where their shape is achieved by removing material. This is somewhat limiting, as it creates large amounts of material waste in the form of shavings, and the design is limited to mostly straight channels. As the AM process builds the tool from the ground up, the cooling channels can be made to conform to the shape of the tool, optimizing the heat control and ensuring a longer service life of the tool. The shape of the tool itself can also be as complex or as simple as the job requires and the steel powder used in manufacturing the tool can be almost entirely recuperated, only needing a sieve, to take out any agglomerated particles.

AISI H13 hot work tool steel is already a common pick for tools, as it has excellent hardness and wear resistance at room and elevated temperature, paired with good softening resistance and an economical price, make it a shoo-in for many tool makers. While it has impressive mechanical properties given the relatively low amount of alloying, it tends to be difficult to weld, due to the fact that the steel hardens very quickly which causes it to be at risk of cracking. The same principles apply to manufacturing parts with laser powder bed fusion (LPBF) which is one of the main methods of AM. The high cooling and solidification rate inherent to the LPBF process induce a lot of residual stress in the produced parts, which make them brittle. This can be somewhat alleviated with the use of base plate preheating, which reduces the amount of residual stress build up in the parts.

In this work we aim to present a summary of all the stages of the LPBF production of H13 parts from the impact of the powder, to the printing parameters and the post treatment of samples. To facilitate this, we produced a variety of samples ranging in geometry, printing parameters and heat treatments. We analyzed the microstructure of these samples, and performed a variety of tests to measure their mechanical, physical and corrosive properties.

# Large area SEM analysis of Sintered Strontium Hexaferrite in different atmospheres

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Permanent magnets play an important role in modern devices and enabling technologies as they allow storing, delivering and converting energy. [1] By volume, Strontium and Barium Ferrites are one of the world's most-used permanent magnetic materials [2]. Although rare-earth magnets exhibit overwhelming superiority in performance, the harmful environmental impact of their production, uneven distribution of raw materials, and increasingly questionable supply chain force us to look for alternatives. One of the solutions can be found in the group of hexagonal ferrites [3], which do not contain critical raw materials.

Aim of this study was to investigate the influence of the atmosphere during sintering on macrostructural changes of the Sr-hexaferrite using Large Area electron microscopy techniques. The investigated material was sintered in different atmospheres (air, Ar, N<sub>2</sub>, Ar+5%H<sub>2</sub> and vacuum). This created a difference in partial pressure of oxygen in the immediate surrounding of the sample and has caused material segregation to Sr-rich and Sr-depleted phases. Samples prepared in that manner were analysed using Large Area SEM and Large Area SEM-EDS techniques, which enables monitoring the macroscopic changes through the microstructure of the samples sintered in various different atmospheres. Samples sintered in air did not experience any segregation, while emphasized segregation of the material in samples sintered in vacuum and in Ar+5%H<sub>2</sub> was observed.

Key words: large area SEM, Sr-hexaferrite, magnets, sintering, atmosphere effect

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## Effects of the addition of silicon to EN AW 7075 aluminum alloy on solidification behaviour

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The high-strength aluminum alloy EN AW 7075 presents significant challenges for additive manufacturing due to its wide solidification range and strong susceptibility to hot cracking. These limitations hinder its broader use in advanced laser powder bed fusion (LPBF) processes. In this study, we investigate the effect of silicon addition on the microstructural development of EN AW 7075 alloy to enhance its LPBF processability.

To address the alloy's poor weldability/processability, the chemical composition was modified by adding 5 wt% silicon, accompanied by slight adjustments of magnesium and zinc. The modified alloy powder was produced by ultrasonic atomization and subsequently processed by LPBF without preheating. Detailed microstructural characterization was performed using scanning electron microscopy (SEM), transmission electron microscopy (TEM), energy-dispersive spectroscopy (EDS), and selected area electron diffraction (SAED).

The results show that the silicon-modified alloy exhibits a refined cellular-dendritic microstructure with improved uniformity and a significantly reduced incidence of solidification cracking. The addition of silicon promoted more stable solid–liquid interface dynamics, which enhanced the alloy's printability and microstructural integrity.

# Additive Manufacturing of Architected Inconel 718 Structures: Exploring the Strength and Failure of Lattice Structures

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Additive manufacturing (AM) enables the fabrication of complex geometries, including lattice structures, which offer potential for lightweight yet mechanically efficient components in aerospace, energy, and medical sectors. This study investigates the mechanical performance of Inconel 718 lattice structures fabricated via Laser Powder Bed Fusion (L-PBF). Five distinct unit cell types were evaluated: three triply periodic minimal surface (TPMS) geometries—Schoen Gyroid (SG), Schwarz Diamond (SD), and Schwarz Primitive (SP)—and two beam-based structures—body-centred cubic (BCC) and beam diamond (BD). Lattice specimens with similar volume fractions (~18–20%) were produced using EOS M290 and post-processed according to EOS-recommended heat treatment.

Compressive and tensile tests were conducted to compare peak strength and failure modes. Results indicate TPMS structures outperform beam lattices in both tensile and compressive strength, with the SP structure showing the highest compressive stress (~1752 MPa) and SD achieving the greatest tensile strength (~817 MPa). Failure analysis revealed brittle fracture characteristics across all lattices, with beam structures failing predominantly at beam-node intersections and TPMS samples showing localised shearing near the load interfaces.

These findings highlight the mechanical advantage of TPMS geometries over conventional beam lattices in static load-bearing applications, and support the use of AM Inconel 718 lattices for components requiring high strength-to-weight ratios.

# Role of Cryogenic Cycle Design in Tailoring Mechanical Performance of D2 Tool Steel

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Achieving a balance between hardness and fracture toughness in D2 tool steel continues to be a significant challenge, as improvements in hardness and wear can often lead to a decrease in toughness and fatigue resistance. This study clarifies the effects of deep cryogenic treatment (DCT) and cyclic deep cryogenic treatment (CDCT) protocols on this trade-off, with a particular focus on the significance of cycle design and reheating strategies. All samples were hardened at 1000°C for 30 minutes, then double tempered at 350°C. They were then subjected to conventional heat treatment (CHT), DCT, or CDCT with different cycle counts and durations: 2×2 hours, 4×1 hour, 8×30 minutes, 2×30 minutes, and 2×3 hours, with room temperature as the reheating strategy. Additional variants included reheating to –50°C as well as to 100°C. Hardness measurements were carried out using Rockwell and Vickers scales, while fracture toughness was assessed using circumferentially notched and fatigue pre-cracked tensile bar specimens. DCT and all CDCT variants increased hardness by 1-2 HRC compared to CHT, but toughness decreased by 11-54%. The CDCT-2×2 h variant reached 59.3 HRC with a toughness of 19.2 MPa·m<sup>1/2</sup>, maintaining the hardness level of DCT while recovering about 3.3% of the toughness. Other CDCT methods achieved similar hardness levels but exhibited lower toughness than both DCT and CDCT 2×2 h. These results demonstrate that careful management of cryogenic cycling can reduce the hardness–toughness trade off, with CDCT 2×2 h offering a viable route for applications demanding both high wear resistance and improved fracture tolerance.

## Impact of hydrogen charging parameters on the hydrogen embrittlement of conventional and 3D printed (AM) austenitic stainless steel

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The hydrogen economy is a cornerstone of the transition to a climate-neutral future, but it also presents significant challenges for structural materials. Alloys used in hydrogen production, storage, and transport must tolerate high mechanical loads and resist hydrogen embrittlement (HE), a phenomenon that can cause unexpected and catastrophic failures. This is especially critical for additively manufactured (AM) austenitic stainless steels, which feature fine columnar grain structures, high dislocation densities, microsegregation, and anisotropy that may affect their susceptibility to HE.

Austenitic stainless steels have a very low hydrogen diffusion coefficient and a higher hydrogen solubility compared to martensitic or ferritic stainless steels. As a result, hydrogen charging of AISI 304 austenitic stainless steel is slow and is typically performed using high-pressure gaseous charging at elevated temperatures (200–300 °C), where Sievert's law governs the hydrogen concentration at a given pressure and temperature. In this study, tensile specimens were electrochemically charged with hydrogen in 0.1 M NaOH solution. The charging was performed at several current densities, two temperatures, and different charging durations. The cylindrical tensile specimens were fabricated from AISI 304 stainless steel using both conventional method and AM (laser powder bed fusion). The degree of hydrogen embrittlement was evaluated by slow strain rate tensile (SSRT) testing performed immediately after charging, and the actual hydrogen content was measured using the melt extraction method. The interplay between hydrogen diffusion depth and fracture morphology is clearly evident in the SEM images of the fracture surfaces. Detailed post-exposure and post-fracture microstructural examination was conducted to identify differences in HE behaviour between conventionally manufactured and AM material.

## **SIQUAL 6368 – Development of a High-Strength, Nickel-Enhanced Steel for Pressure Vessel Applications**

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This work presents the rapid development and industrial production of SIQUAL 6368, a high-strength steel grade (15NiCuMoNb5-6-4), designed for demanding pressure vessel applications requiring superior mechanical properties at elevated temperatures and pressures.

The steel exhibits enhanced tensile strength, creep resistance up to 600°C, and improved toughness, achieved through a high nickel content combined with an optimized chemical composition and heat treatment. The chemical composition was carefully balanced to meet strict mechanical requirements which also enable reduction of plate thickness, leading to material savings and lower component weight, while maintaining all safety standards in energy and chemical industries.

A key challenge was fulfilling an urgent order for nearly 300 tons of steel heavy quarto plates within a two-month timeframe. The interdisciplinary team optimized chemical composition, rolling schedules, and heat treatment parameters using Thermo-Calc simulations and extensive laboratory testing. The chemical composition was controlled well below EN 10028-2 standard limits, minimizing raw material usage and energy consumption without compromising mechanical performance.

# Corrosion and cytotoxicity properties of ultralight Mg-8Li-0.5Ca alloys produced by laser powder bed fusion

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Biodegradable magnesium (Mg) alloys are meant to support healing processes and to be a replacement of human tissue over a period of time after fulfilling their function in terms of mechanical stability in the infected bone. The effect of Mg ions on bone-forming cells and their effect on osteogenic ability is beneficial. Achievement of the desired mechanical properties of Mg alloys is possible, but their widespread application is limited by the high and unpredictable corrosion rate. For orthopaedic implants, a uniform degradation rate of <0.5 mm/year in simulated fluids at 37°C is considered to ensure proper support of the implant [1-2].

This study focuses on producing a Mg-based alloys using laser powder bed fusion (LPBF) to investigate how the manufacturing method influences corrosion performance comparing to their cast counterpart. The powders for LPBF were produced using induction ultrasonic atomisation. The corrosion properties of both cast and LPBF Mg-8Li-0.5Ca alloys were tested using electrochemical and immersion methods. The corrosion rate of the materials was also investigated using hydrogen evolution and ion-release measurements. The cytotoxicity of the materials under investigation was assessed using the L929 murine fibroblast cell line. The samples were incubated at 37 °C in a 5% CO<sub>2</sub> atmosphere for 1, 3, 5 and 7 days. To evaluate the effect of released corrosion products on cell viability, an MTS assay was performed. Cytotoxicity testing revealed that LPBF produced material exhibited better biocompatibility than its cast counterpart. The obtained results provide a first insight into the corrosion and cytotoxicity properties of Mg-based alloys with the selected alloying elements produced by LPBF.

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# Stabilization Strategies for Prussian Blue Electrodes in Polyamine Sensing Applications

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Polyamines (PAs) spermine and spermidine, play vital roles in cellular functions and are tightly regulated by homeostasis. Their abnormal concentration is closely linked to various health conditions, including neurodegenerative diseases and cancer. Therefore, accurate PA monitoring in biological fluids such as saliva and urine is essential for both diagnostic and therapeutic purposes. In recent years, electrochemical biosensors have emerged as a promising alternative for real-time PA monitoring, offering rapid analysis, miniaturization potential, and compatibility with portable devices.

PAs cannot be directly detected due to electrochemical inactivity, most existing PA sensors integrate Prussian blue (PB) with polyamine oxidases. These enzymes catalyse the oxidation of PAs, generating hydrogen peroxide ( $H_2O_2$ ), which is then detected electrochemically via the PB layer. Known for its exceptional electrocatalytic activity and selectivity for  $H_2O_2$  reduction, PB functions as an artificial peroxidase, enabling  $H_2O_2$  detection at low applied potentials around 0 V vs. Ag/AgCl.

However, the stability of the PB layer in biological fluids at neutral pH is limited, reducing its activity and shortening the sensor's operational lifespan. To address this challenge, various approaches have been explored to enhance the stability of the redox mediator layer, including optimization of the synthesis method and the incorporation of nanomaterials and polymers.

The present study investigates different synthesis approaches for fabricating PB-modified carbon screen-printed electrodes, focusing on how these methods affect the stability of the PB layer during  $H_2O_2$  sensing in phosphate-buffered saline (PBS). Additionally, it evaluates the binding performance of several polymers, including polyaniline, polyvinylpyrrolidone, polydiallyldimethylammonium chloride, and chitosan. Our results demonstrate that incorporating a conductive polymer effectively minimizes material loss while maintaining the sensor's sensitivity to  $H_2O_2$ .

## Failure Analysis of leakage in NEK Reactor Cooling System

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Operators at Nuklearna Elektrarna Krško (NEK) identified a leak in the Reactor Coolant System (RCS) on October 4th, 2023. Two days later, on October 6th, the decision was made to shut down the plant in order to determine the source of the leakage. The investigation revealed the leakage on the SI-53 Safety Injection line to the reactor vessel. As a result, both SI-53 and its sister line, SI-52, along with the associated reducers and elbows, were removed and replaced.

The failure analysis process involved close collaboration between Westinghouse Electric Company (WEC), NEK, and Institute of Metals and Technology (IMT). A section of the SI-53 piping was subjected to detailed destructive examination at Westinghouse Churchill Site (WEC) to investigate the Direct Cause Analysis (DCA) for the crack initiation and its propagation. The crack was identified as circumferential crack, which initiated in the heat-affected zone (HAZ) on the Inner Diameter (ID), very close to the fusion line with further transgranular propagation through the weldment. Two different crack propagation mechanisms were identified on the fractured surface. Chemical analysis, tensile tests and hardness measurements were also performed on the investigated sections of the pipe, all of which did not reveal any irregularities.

The findings of the investigation were the basis for the Root Cause Analysis (RCA).

## WORKSHOP: PERMANET - PERmanent MAGnet Network for the European Transition

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<https://www.permanetproject.eu/>

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*Mediterranea Hall, Wednesday 15<sup>th</sup> October 2025*

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- 10:00–10:10 **Opening and PERMANET Horizon Europe Overview**
- Dr Pierre Padilla, Moderator, Founder at N-ABLE
  - Kristiina Jokelainen, Operational Coordinator at PERMANET, Iberian Sustainable Mining Cluster (ISMC)
- 10:10- 10:55 **PERMANET approach - 3 connected Tech Hubs covering the REE PM supply chain**
- Hub 1 – Sustainable REE Supply - Peter Flemming, Project Manager, Technology Development Department, Critical Raw Materials Unit, TÉCNICAS REUNIDAS S.A.
  - Hub 2 - Circular REE Magnets by Dr Lama ITANI, Business Development Manager, Rare Earths Special Chem Global Business Unit, Solvay
  - Hub 3 – Sustainable PM Manufacturing by Professor Tullio TOLIO, Manufacturing and Production Systems, Politecnico di Milano
- 10:55–11:50 **Strategic Panel on Investment, Scale-Up, and EU-Wide Industrial Deployment Challenges**
- Dr Laura Quijano, Technical and Operational Coordinator, Iberian Sustainable Mining Cluster
  - Raúl Fernández Abad, Owner and Managing Director, Leonore Development
  - Dr Lama ITANI, Business Development Manager, Rare Earths Special Chem Global Business Unit, Solvay
  - Boris Saje, Applications Engineer, Kolektor Mobility d.o.o.
  - Piia Moilanen, REMHub Horizon Europe, Development Manager, CLIC Innovation Oy
- 11:50–12:00 **Q&A and Wrap-Up**
- Dr Pierre Padilla, Moderator, Founder at N-ABLE

## **PERMANET, Making the EU supply of REE PM Resilient and Sustainable**

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The purpose of the session is to demonstrate the importance of collaboration between academia and industry to accelerate the development of technologies in Rare earth elements, which is aligned with ICM&T's mission to foster dialogue between research and industry, promoting effective knowledge transfer and innovation.

PERMANET is a Sustainable REE Innovation and Supply Network covering the full Rare Earth Elements (REE) Permanent Magnet (PM) value chain. It is structured upon 5 layers: 1) Three Sustainable, Connected Tech 'Hubs' segmented along the full REE PM value chain and organizing thematic collaborative R&D and supply ecosystems 2) fully Scalable Innovations to reach TRL7 and expand in scale and deployment range along the entire value chain 3) A structural layer of R&D infrastructure, equipment and services to fuel Pilot and Demonstration activities 4) Five Enabling "Engines" addressing the key conditions for sustainable and competitive REE supply 5) A single PERMANET Network Infrastructure. The Network accelerates leading-edge innovations, from REE extraction from mining tailings and hydrometallurgical processes to oxide reduction and innovative production processes, all the way to the production of innovative PM and their testing by end-users in industrial environments across three key areas: 1/ E-Mobility, 2/ Energy, and 3/ Industrial Equipment. PERMANET also secures key sources of REE, including leading mining projects from the EU and Partner Countries, as well as end-of-life (EoL) sectors (WEEE, EV, etc.). The project relies on enabling activities, ranging from strategic venturing to investment support, to build suboptimal EU REE PM Segments. The project unlocks viable reserves of REE, including unconventional sources, and will demonstrate novel, cost-effective, and environmentally sound REE extraction, processing, and separation routes. Additionally, it will establish the first EU hub for PM boosting circular PM technologies, enabling their deployment at market scale.

## **PERMANET, Making the EU supply of REE PM Resilient and Sustainable – Sustainable supply of Rare Earth Elements (REE)**

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PERMANET is a Sustainable REE Innovation and Supply Network covering the full Rare Earth Elements (REE) Permanent Magnet (PM) value chain. It is structured upon 5 layers and three Sustainable, Connected Tech 'Hubs' segmented along the full REE PM value chain and organizing thematic collaborative R&D and supply ecosystems. HUB1 is structured around organizing a Sustainable supply of Rare Earth Elements. We aim to Create a fully-fledged Tech Hub to secure reliable REE streams from deposits and sources in the EU S3P 'Mining Regions' Partnership Regions. Within this HUB we will:

- 1) Build a sustainable Hub of REE Deposits and circular mining sources for REE supply
- 2) Anchor of sustainable capacity for the production and refinement of REE from standard (incl. Matamulas/Longonjo) and non-conventional (incl. IHO/Aridos) deposits
- 3) Demonstrate innovative and sustainable processing and refining methods for 1/ the production of REE from monazite concentrates and 2/ the production of REE concentrate from iron ore
- 4) Demonstrate two fully scalable hydrometallurgical processes for the efficient and green production REE's carbonate and REE's oxides from concentrates miscellaneous mining sources
- 5) Build the ground for reduction to metallic Nd and Pr suitable to PM manufacturing.

We are employing two types of concentrates (inputs): REE's carbonate-oxides / concentrates from mines (task 3.1) or REE's oxide (Nd<sub>203</sub>-Pr<sub>203</sub>) / concentrate from iron mining (see T3.2).

In this HUB we will address securing a sustainable supply of REE for the EU PM industry and other strategic value chain, we will also try to provide a sustainable production and refinement of REE concentrates from standard REE sources, and create an ecosystem of innovative sustainable refinement and concentration production of REE concentrate from iron ore model deposits, and work towards sustainable refinement and production of REE's monazite concentrates from miscellaneous mining tailings. Last activity in this hub will be considering innovative cost efficient and green production of REE's carbonate and REE's oxides from concentrates miscellaneous mining sources.

## **PERMANET, Making the EU supply of Rare Earth Permanent Magnet Resilient and Sustainable – Demonstrating long- and short- loop circular supply**

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PERMANET is a Sustainable Rare Earth Elements (REE) Innovation and Supply Network covering the full REE Permanent Magnet (PM) value chain. It is structured upon 5 layers: 1) Three Sustainable, Connected Technical 'Hubs' segmented along the full REE PM value chain and organizing thematic collaborative R&D and supply ecosystems. The HUB2 is focused on demonstrating European capabilities to valorize and explore its critical metals urban mines and to recycle RE PM from different type of wastes. To achieve this target, a complementary approach between short loop recycling and long loop recycling will be demonstrated. The workstreams in this HUB could be split in two main streams:

1/ Mechanical stream including the collect, dismantling, extraction and sorting of End of Life (EoL) magnets from different waste streams (mainly Wastes from Electrical and Electronic Equipment (WEEE) and e-motors).

Within this mechanical stream, HUB2 will aim to:

- Create an innovative central marketplace for the convergence and consolidation of currently scattered REE-containing waste streams to reach critical mass
- Map, qualify and classify REE-containing EoL streams
- Pilot and demonstrate at scale leading-edge technologies and solutions for the dismantling, extraction and sorting of EoL magnets

2/ Chemical stream including sustainable and scalable hydrogen decrepitation, hydrometallurgical and solvent extraction processes.

Within this chemical stream, HUB2 will aim to:

- Innovative recovery technologies will provide a sustainable supply of REE (i.e., Nd-Fe-B, but not limited to) from recycled End of Life (EoL) products, converting them into precursors suitable for producing new PM. Under this hub, the demonstrated pilots will aim to:
- Deploy a scalable short-loop recycling demonstrator for the production of new high-grade sintered magnets and magnetic powders for bonded magnets
- Deploy scalable hydrometallurgical and solvent extraction process for the long loop recycling to complement the short loop recycling in the treatment of low-grade EoL magnet and the production of customised RE raw materials for the production of high-grade NdFeB sintered magnets.

## **Making the EU supply of REE PM Resilient and Sustainable – Innovative, efficient, and sustainable PM manufacturing**

Simona Knežević Vernon<sup>1</sup>, Alen Draganović<sup>1</sup>, Tulio Tolio<sup>2</sup>

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PERMANET is a Sustainable REE Innovation and Supply Network covering the full Rare Earth Elements (REE) Permanent Magnet (PM) value chain. It is structured upon 5 layers, which include three Sustainable, Connected Tech 'Hubs' segmented along the full REE PM value chain and organizing thematic collaborative R&D and supply ecosystems. HUB3 will provide for fully scalable and replicable production lines in demonstration cases. The aim is to demonstrate the production of PMs in a cost-efficient way and at a commercial scale, while also meeting all standards.

We will aim to achieve the following goals:

- Ensure the full alignment of the REE PM production chain with OEM requirements and specifications for PM (performance, size, shape, cost efficiency, reduced use of critical raw materials...).
- Pilot and Demonstrate innovative oxide reduction and metallization technologies
- Demonstrate innovative PM manufacturing technologies across 3 leading technological families – Sintering, Bonding, Fused Filament Fabrication.
- Test and validate the functionality of PERMANET PM in 3 key application areas (EV, Energy, Industrial Equipment), through iterative feedback loops implemented at TRL6-7.
- Successfully close the demonstration of the full integration of the 3 REE supply routes from EoL and Mining sources to the very end-user integration (before closing the circular loop).

In this HUB we will aim to understand and structure user quality and criteria as per OEM requirements, pilot and demonstrate innovative oxide reduction tech, innovate and replicate modular pilots for the recovery and recycled raw materials, demonstrate and check the production testing lines, and test end of quality life, end user quality testing and validation.

## **WORKSHOP: HyBReED - Development of resilient chemical energy storage using hydrogen and batteries**

**Acknowledgement:** The project is financed by the European Union – NextGenerationEU in the frame of “Načrta za okrevanje in odpornost” with co-financing by Slovenia’s Agency for Research and Innovation (ARIS) and Ministry of Higher Education, Science and Innovation of the Republic of Slovenia (MVZI).

<https://www.ki.si/odseki/d13-odsek-za-katalizo-in-reakcijsko-inzenirstvo/hybrid/>

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*Mediterranea Hall, Wednesday 15<sup>th</sup> October 2025*

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### Invited Lectures

- 14:30-14:50 **Performance of Different Stainless Steels in Hydrogen-Rich Atmosphere**  
*B. Podgornik, M. Sedlaček, Č. Donik, M. Godec, T. Večko Pirtovšek, P. Kirbiš*
- 14:50-15:10 **Hydrogen Embrittlement Resistance of Conventionally and Additively Manufactured Stainless Steels**  
*I. Paulin, M. Sedlaček, B. Podgornik, M. Godec, B. Zajec, M. Bajt Leban*
- 15:10-15:30 **Effect of Electrochemical Hydrogen Charging on Dislocation Migration in Austenitic Stainless Steel 304L: Insights from ECCI and TEM**  
*M. Godec, B. Podgornik, I. Paulin, N. Hodnik, B. Tomc, Č. Donik*
- 15:30-16:00 **Influence of Electrochemical Hydrogen Charge Diffusion on the Mechanical Behaviour of Austenitic 304L Stainless Steel**  
*Č. Donik, B. Podgornik, I. Paulin, N. Hodnik, B. Tomc, M. Godec*
- 16:0-16:15 **Discussion**

## Performance of Different Stainless Steels in Hydrogen-Rich Atmosphere

B. Podgornik<sup>1</sup>, M. Sedlaček<sup>1</sup>, Č. Donik<sup>1</sup>, M. Godec<sup>1</sup>, T. Večko Pirtovšek<sup>2</sup>, P. Kirbiš<sup>2</sup>

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Stainless steels play a key role in the transition toward a green hydrogen economy, where hydrogen production, storage, and transport require materials with high strength, corrosion resistance, and reliable resistance to hydrogen embrittlement. Their performance can be effectively tailored through alloy design and appropriate heat treatment, enabling optimisation of microstructure and mechanical properties for demanding hydrogen environments.

In this study, four stainless steels with distinct microstructural characteristics were investigated: two commercially available austenitic grades (AISI 316L and AISI 316Ti) one martensitic grade (17-4PH) and a new series of stainless steel aimed for nuclear powerplants with superior corrosion resistance and outstanding mechanical properties (SINOXX E790). The austenitic steels were tested in solution-treated condition, while the martensitic steels were evaluated both in solution-treated and annealed states. To assess the effect of hydrogen exposure, specimens were electrochemically hydrogen charged at 65 °C for 48 h under varying current densities, followed by mechanical testing in terms of tensile strength, impact toughness, and fatigue resistance.

The obtained results were compared with uncharged counterparts to evaluate hydrogen-induced degradation of mechanical performance. Fractographic analyses of fractured surfaces complemented the mechanical tests, providing insight into the mechanisms of hydrogen-assisted damage and failure. The findings contribute to understanding the behaviour of different stainless steel types in hydrogen-rich environments and support material selection and design for future hydrogen infrastructure applications.

# Hydrogen Embrittlement Resistance of Conventionally and Additively Manufactured Stainless Steels

I. Paulin<sup>1</sup>, M. Sedlaček<sup>1</sup>, B. Podgornik<sup>1</sup>, M. Godec<sup>1</sup>, B. Zajec<sup>2</sup>, M. Bajt Leban<sup>2</sup>

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Additive manufacturing (AM) has emerged as a transformative technology in the production of complex metallic components, enabling design flexibility, reduced material waste, and improved sustainability — key aspects for the green transition and hydrogen-based energy systems. However, the unique microstructures formed during layer-by-layer solidification, characterised by high dislocation density, residual stresses, and micro segregation, may alter the material's susceptibility to hydrogen embrittlement compared to conventionally processed steels.

The present study aims to compare the resistance to hydrogen embrittlement between conventionally manufactured (cast and hot-rolled) and additively manufactured (laser powder bed fusion) stainless steels. Two representative types of stainless steels are considered: austenitic and martensitic. Specimens were electrochemically hydrogen-charged under controlled conditions, followed by mechanical testing to assess tensile strength, impact toughness, fatigue, and wear resistance.

The results will provide insight into how the transition from conventional to additive manufacturing affects the hydrogen-assisted degradation mechanisms and overall performance of stainless steels. Understanding these differences is essential for the safe and reliable use of additively manufactured components in hydrogen-rich environments and for the design of future green hydrogen infrastructure.

# Effect of Electrochemical Hydrogen Charging on Dislocation Migration in Austenitic Stainless Steel 304L: Insights from ECCI and TEM

Matjaž Godec<sup>1</sup>, Bojan Podgornik<sup>1</sup>, Irena Paulin<sup>1</sup>, Nejc Hodnik<sup>2</sup>, Blaž Tomc<sup>2</sup>, Črtomir Donik<sup>1</sup>

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The presented study investigates the effect of electrochemical hydrogen charging on dislocation migration and microstructural evolution in austenitic stainless steel 304L. Hydrogen was introduced via controlled electrochemical charging in an acidic medium, promoting uniform hydrogen ingress across the material. To elucidate the interaction between hydrogen and dislocation dynamics, electron channelling contrast imaging (ECCI) and transmission electron microscopy (TEM) were employed for high-resolution microstructural analysis. Post-charging observations revealed increased dislocation density and pronounced planar slip, indicating hydrogen-enhanced localised plasticity (HELP). ECCI imaging demonstrated intensified dislocation pile-ups near grain boundaries and slip bands. At the same time, TEM analysis confirmed the presence of refined dislocation structures and stacking fault intersections associated with hydrogen trapping. The results suggest that hydrogen charging facilitates dislocation mobility at low applied stresses, resulting in localised strain accumulation and potential microcrack initiation. These findings offer new insights into the role of hydrogen-dislocation interactions in austenitic stainless steels, highlighting the importance of microstructural characterisation in understanding the mechanisms of hydrogen embrittlement in 304L under service conditions.

# **Influence of Electrochemical Hydrogen Charge Diffusion on the Mechanical Behaviour of Austenitic 304L Stainless Steel**

Črtomir Donik<sup>1</sup>, Bojan Podgornik<sup>1</sup>, Irena Paulin<sup>1</sup>, Nejc Hodnik<sup>2</sup>, Blaž Tomc<sup>2</sup>, Matjaž Godec<sup>1</sup>

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This study examines the impact of electrochemically induced hydrogen charge diffusion on the mechanical response of austenitic stainless steel 304L under various testing conditions. Hydrogen was introduced through a controlled electrochemical charging process in an acidic solution, ensuring uniform hydrogen diffusion throughout the specimen. After charging, tensile, slow strain rate (SSRT), bending and microhardness tests were performed to assess hydrogen-induced degradation. Results showed a significant reduction in ductility (up to 30%) and a decrease in ultimate tensile strength, especially during SSRT, indicating high sensitivity to hydrogen-assisted cracking. Fractographic analysis revealed a shift from ductile microvoid coalescence to quasi-cleavage and intergranular fracture morphologies, confirming the role of hydrogen-enhanced localised plasticity. Microhardness measurements further indicated localised surface hardening, consistent with hydrogen diffusion profiles. These findings emphasise the critical influence of hydrogen charge diffusion on the mechanical integrity of 304L stainless steel, underlining the importance of controlling diffusion and implementing mitigation strategies in hydrogen-exposed service environments.

## **WORKSHOP: Hybrid PBF/DED Additive Manufacturing of Ti6Al4V Advanced Fuel System Components for Aerospace Industry**

**Acknowledgement:** The project is financed by Slovenia's Agency for Research and Innovation (ARIS) L2-4445

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*Mediterranea Hall, Thursday 16<sup>th</sup> October 2025*

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### Invited Lectures

- 14:30-14:50 **Advanced Fuel System Components for Aerospace Industry via Hybrid PBF/DED Additive Manufacturing of Ti6Al4V**  
*A. Kocijan*
- 14:50-15:10 **Unlocking the Future of Aerospace: Meeting Market Demand for Limitless Additive Manufacturing Solutions with Speed and Cost Efficiency**  
*M. Balažic, A. Kocijan*
- 15:10-15:30 **Advantages of Additive Manufacturing: Enabling Design Flexibility, Material Efficiency and Rapid Production of Complex Geometries**  
*M. Godec, A. Kocijan*
- 15:30-16:00 **The influence of Heat Treatment on the Mechanical properties of Hybrid Additively Manufactured Ti6Al4V Structures**  
*S. Malej, A. Kocijan*
- 16:00-16:15 **Discussion**

## **Advanced Fuel System Components for Aerospace Industry via Hybrid PBF/DED Additive Manufacturing of Ti6Al4V**

Aleksandra Kocijan

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The ARIS project L2-4445, “Hybrid SLM/DED Additive Manufacturing of Ti6Al4V Advanced Fuel System Components for the Aerospace Industry,” successfully explores a novel Hybrid Additive Manufacturing (AM) approach by combining Powder Bed Fusion (PBF) and Directed Energy Deposition (DED) to produce advanced Ti6Al4V fuel system components. Ti6Al4V remains the titanium alloy of choice in aerospace applications due to its high strength-to-weight ratio, excellent corrosion resistance, and superior fracture toughness.

The project focuses on optimizing process parameters for both AM technologies—such as laser power, scan strategy, scan speed, powder flow rate, and layer thickness—to achieve the desired microstructure, mechanical performance, and corrosion resistance. Additionally, post-processing through heat treatment is crucial to enhance ductility, relieve residual stresses, and ensure the required mechanical properties. Surface plasma treatment is also applied to improve corrosion resistance by increasing the thickness of the protective oxide layer.

This Hybrid AM approach presents a significant advancement in aerospace component design and manufacturing. It enables the creation of complex internal geometries, lightweight hollow structures, and customized parts that are otherwise unattainable with conventional methods. The technology not only reduces manufacturing time and cost but also aligns with sustainability goals by minimizing material waste and enabling powder reuse. Furthermore, by facilitating the integration of additional fuel capacity into aircraft, the project supports reduced refuelling stops and lower emissions—contributing directly to the goals of the EU Green Deal – Sustainable Mobility initiative. Overall, this project demonstrates the strong potential of Hybrid AM to revolutionize aerospace manufacturing, combining technical innovation with environmental responsibility.

# Unlocking the Future of Aerospace: Meeting Market Demand for Limitless Additive Manufacturing Solutions with Speed and Cost Efficiency

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The aerospace industry is undergoing a transformative shift driven by the need for advanced manufacturing technologies that can meet increasingly complex design requirements while reducing cost and lead times. Additive manufacturing (AM) has emerged as a critical solution, offering unprecedented freedom in geometry, lightweight structures, and the ability to consolidate parts. There is a strong and growing market demand for AM systems capable of producing large-scale, high-performance components at faster build rates and lower costs. This trend is fuelled by the need for greater efficiency in aircraft production, rapid prototyping, on-demand part replacement, and the drive toward sustainable manufacturing practices. As the sector moves toward more adaptive and digitalized production models, innovations in AM are poised to redefine the possibilities in aerospace design, fabrication, and supply chain management.

To address the growing market demands and challenges associated with the production of Ti6Al4V alloy components, additive manufacturing (AM) has emerged as a promising solution for fabricating geometrically complex parts. In this study, we propose a novel approach by integrating two advanced AM technologies—Powder Bed Fusion (PBF) and Directed Energy Deposition (DED)—to develop hybrid-manufactured Ti6Al4V components for aerospace applications. This combination leverages the strengths of both processes, enabling the rapid production of large, lightweight structures with complex geometries and enhanced mechanical and corrosion properties. A key challenge lies in optimizing the interface between the joined parts, as differences in microstructure and residual stresses must be carefully managed to ensure structural integrity.

# Advantages of Additive Manufacturing: Enabling Design Flexibility, Material Efficiency and Rapid Production of Complex Geometries

Matjaž Godec, Aleksandra Kocijan

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AM offers several advantages over conventional methods, including design flexibility, material efficiency, and the ability to manufacture complex geometries with reduced lead times. Various AM techniques are available for metallic materials, with powder-bed fusion (PBF) and directed energy deposition (DED) being the most commonly used for Ti6Al4V. PBF technology enables the fabrication of high-precision parts with fine microstructural control, but it is relatively time consuming. DED, on the other hand, allows faster deposition rates and larger build volumes, although at the expense of dimensional accuracy and surface finish. Despite all benefits, AM also introduces specific challenges, including residual stresses, porosity, and surface roughness, all of which can influence the mechanical performance and corrosion behaviour of the final components.

One of the key challenges in the AM of Ti6Al4V is the microstructural evolution due to the unique thermal conditions of the process. Rapid melting resolidification and processing conditions like atmosphere during AM processing result in the formation of a non-equilibrium microstructure (like  $\alpha'$  martensite), which is different to the  $\alpha+\beta$  microstructure found in conventionally processed Ti6Al4V. While  $\alpha'$  martensite enhances strength, it compromises ductility and toughness, necessitating post-processing treatments such as heat treatment to refine the microstructure and optimize the mechanical properties. Studies have shown that a heat treatment above 700 °C can lead to complete decomposition of the  $\alpha'$  martensite into a more stable  $\alpha+\beta$  phase, improving the material's ductility and toughness. Optimizing these treatments is crucial for achieving the desired mechanical properties in AM-fabricated Ti6Al4V components, particularly for demanding aerospace applications.

# **The influence of Heat Treatment on the Mechanical properties of Hybrid Additively Manufactured Ti6Al4V Structures**

Simon Malej, Aleksandra Kocijan

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This study represents a hybrid manufacturing approach, combining powder-bed fusion (PBF) and directed energy deposition (DED) for the production of Ti6Al4V components for aerospace applications to fully exploit the advantages of AM. This hybrid approach aims to leverage the precision and fine microstructural control of PBF, while benefiting from the high deposition rates of DED. However, integrating these two technologies introduces challenges related to the interface between the joined sections, where differences in microstructure, residual stresses, and thermal properties must be carefully managed. Process-parameter optimization, post-processing heat treatments, and surface finishing therefore play a crucial role in ensuring that the final component meets the rigorous mechanical and corrosion-resistance requirements of aerospace applications. A comprehensive understanding of these factors is essential for selecting optimal materials and manufacturing methods for various environments, ultimately improving the durability and reliability of metallic components.

## **WORKSHOP: SLO-CEA – Understanding H-embrittlement mechanisms in additive manufactured stainless steels**

**SLO-CEA bilateral project (NC-24004)**

**Acknowledgement:** The project is financed by the European Union – NextGenerationEU in the frame of “Načrta za okrevanje in odpornost” with co-financing by Slovenia’s Agency for Research and Innovation (ARIS) and Ministry of Higher Education, Science and Innovation of the Republic of Slovenia (MVZI).

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*Mediterranea Hall, Thursday 16<sup>th</sup> October 2025*

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### Invited Lectures

- 16:30-16:50 **Understanding H-embrittlement mechanisms in additive-manufactured stainless steels**  
*B. Podgornik, M. Sedlaček, I. Paulin, B. Šetina Batič, M. Bajt Leban, B. Zajec, F. Martin*
- 16:50-17:10 **Effect of Hydrogen Embrittlement on Microstructural Evolution during Slow Strain Rate Testing of Conventional and Additively Manufactured Austenitic Stainless Steel**  
*M. Bajt Leban, B. Šetina Batič, B. Zajec, I. Paulin, B. Podgornik*
- 17:10-17:30 **Comparative Study on the Effect of Hydrogen Charging on Mechanical and Fatigue Properties of Additively Manufactured AISI 304 and AISI 420 Stainless Steels**  
*M. Sedlaček, B. Šetina Batič, B. Zajec, A. Legat, I. Paulin, F. Martin, B. Podgornik*
- 17:30-18:00 **LPBF sample preparation for H-embrittlement mechanisms investigation**  
*I. Paulin, M. Bajt Leban, M. Sedlaček, B. Šetina Batič, B. Zajec, F. Martin, B. Podgornik*
- 18:00-18:15 **Discussion**

## Understanding H-embrittlement mechanisms in additive-manufactured stainless steels

Bojan Podgornik<sup>1</sup>, Marko Sedlaček<sup>1</sup>, Irena Paulin<sup>1</sup>, Barbara Šetina Batič<sup>1</sup>, Mirjam Bajt Leban<sup>2</sup>, Bojan Zajec<sup>2</sup>,  
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Properties of common alloys are detrimentally affected by exposure to hydrogen, which lead to hydrogen induced ductile to brittle transition known as hydrogen embrittlement (HE). The magnitude of the deterioration depends on the material and its microstructure, the specific environment, mechanical loading and internal stresses developed during manufacturing. Microstructure of steels, despite having identical chemical composition, deviate significantly when using different processing technologies. The characteristics of laser-based AM processes are high temperature gradients, residual stresses, anisotropy, highly complex and hierarchical microstructures with high dislocation density and chemical inhomogeneity. These specifics can have a critical impact on HE susceptibility. HE can occur through a variety of mechanisms, however, when it comes to AM materials exact underlying mechanisms are still a subject of intensive research and discussion.

The main challenges related to production, storage, transport and use of green hydrogen as a future energy carrier is hydrogen embrittlement of commonly used material - stainless steel, and how HE differs depending on its type, microstructure and production. To address these questions workshop organized as a part of bilateral SLO-CEA project (NC-24004) is focused on understanding the effect of hydrogen exposure on properties of additively manufactured stainless steels and how the mechanisms of hydrogen embrittlement (HE) differ as compared to conventional stainless steels.

# Effect of Hydrogen Embrittlement on Microstructural Evolution during Slow Strain Rate Testing of Conventional and Additively Manufactured Austenitic Stainless Steel

Mirjam Bajt Leban<sup>1</sup>, Barbara Šetina Batič<sup>2</sup>, Bojan Zajec<sup>1</sup>, Irena Paulin<sup>2</sup>, Bojan Podgornik<sup>2</sup>

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Alloys used in hydrogen production, storage, and transport must withstand high mechanical loads and resist hydrogen embrittlement (HE). Austenitic stainless steels have a low hydrogen diffusion coefficient and higher hydrogen solubility, as well as better resistance to HE compared to martensitic or ferritic stainless steels. However, there is significant concern regarding how additive manufacturing (AM) may alter their behaviour compared to conventional production/manufacturing methods. In this study, tensile specimens made from AISI 304L austenitic stainless steel were electrochemically charged with hydrogen in a 0.1 M NaOH solution at 65°C for 48h. Immediately after hydrogen pre-charging, slow strain rate tests (SSRT) were conducted. Subsequently, the fractured surfaces and cross-sections near the fracture were examined using scanning electron microscopy (SEM) and electron backscatter diffraction (EBSD).

The relationship between hydrogen diffusion depth and fracture morphology is clearly evident in the SEM analysis of the fracture surfaces. Clear differences in microstructural evolution were also observed between conventionally produced and additively manufactured AISI 304 steels, in both uncharged and hydrogen-charged conditions. In the uncharged conventional sample, extensive strain-induced transformation from austenite to deformation martensite ( $\alpha'$ ) occurred near the fracture zone, with the microstructure almost completely converted to martensite due to high plastic deformation (fracture strain around 80%). In contrast, the uncharged AM specimen showed much less martensitic transformation, as fracture occurred at a lower strain (approximately 40%), resulting in a predominantly austenitic structure with only localised  $\alpha'$  formation along slip lines. After hydrogen charging, the conventional steel exhibited suppressed austenite-to-martensite transformation, with most regions between and near cracks remaining fully austenitic. Cracks initiated early during loading and propagated along slip lines and sometimes along grain boundaries. In AM samples, the hydrogen-charged condition also retained a mostly austenitic microstructure, with less than 1% martensite detected near the fracture. Cracks were fewer and shallower compared to the conventional material and similarly propagated through slip bands, suggesting that hydrogen diffusion influenced crack paths, but that the AM microstructure—characterised by finer grains and inherent defects—responded differently.

# Comparative Study on the Effect of Hydrogen Charging on Mechanical and Fatigue Properties of Additively Manufactured AISI 304 and AISI 420 Stainless Steels

Marko Sedlaček<sup>1</sup>, Barbara Šetina Batič<sup>1</sup>, Bojan Zajec<sup>2</sup>, Andraž Legat<sup>2</sup>, Irena Paulin<sup>1</sup>, Frantz Martin<sup>3</sup>,  
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In the context of the green transition, hydrogen is gaining prominence as a sustainable energy carrier for applications such as heating, chemical processing, and refining. However, its widespread use introduces challenges associated with hydrogen embrittlement (HE), a phenomenon driven by the diffusion of atomic hydrogen into metallic lattices, leading to a degradation of mechanical integrity. While HE in conventionally manufactured steels is well understood, the unique microstructural characteristics of additively manufactured (AM) materials—such as residual stresses, anisotropy, and porosity—may significantly alter their resistance to hydrogen-assisted damage.

This study presents a comparative investigation of the effects of hydrogen charging on the mechanical and fatigue behaviour of both conventionally produced and additively manufactured (laser powder bed fusion) austenitic stainless steel AISI 304 and martensitic stainless steel AISI 420. Specimens were pre-charged with hydrogen using a cathodic charging method at a current density of 20 mA/cm<sup>2</sup>, followed by tensile, Charpy impact toughness, and Brinell hardness tests. Fatigue performance was evaluated under different stress amplitudes, and fracture surfaces were analysed using Scanning Electron Microscopy (SEM) to identify hydrogen-induced damage mechanisms.

The results reveal that AM variants exhibit higher strength and hardness compared to their conventionally produced counterparts but experience a more pronounced reduction in fatigue life after hydrogen charging. Hydrogen exposure decreases ductility and ultimate tensile strength, while impact toughness remains relatively unaffected. SEM observations confirmed characteristic features of hydrogen-assisted crack initiation and propagation.

Overall, this comparative analysis demonstrates that additive manufacturing enhances baseline mechanical performance but concurrently increases the susceptibility of stainless steels to hydrogen embrittlement. These findings underline the importance of optimising AM processing parameters and post-treatment strategies to ensure material reliability in hydrogen-based environments.

## LPBF sample preparation for H-embrittlement mechanisms investigation

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Samples intended for the study of hydrogen embrittlement were fabricated using the Laser Powder Bed Fusion (LPBF) process, a type of Additive Manufacturing (AM) technology. For this purpose, two different stainless steel alloy powders were utilised: AISI 304 powder was used to produce samples for investigating the effects of hydrogen on austenitic steels, while AISI 420 powder was employed to prepare samples for studying hydrogen embrittlement behaviour in martensitic steels.

Due to the significant differences in the metallurgical and mechanical properties of the two alloys, it was necessary to optimise the process parameters for each material to achieve parts with the highest possible density. Both alloy powders had particle size distributions ranging from 15 to 45 microns, with an average particle diameter of approximately 30 microns. The powders were spherical in shape, free of satellites or irregularities that might hinder uniform spreading across the build platform during the printing process.

For AISI 304 stainless steel, the LPBF process was carried out using the following parameters: laser power (P) of 300 W, scan speed (v) of 1400 mm/s, layer thickness (b) of 30 µm, hatch spacing (h) of 80 µm, and laser beam diameter (d) of 60 µm. The fabrication process was relatively stable, with no significant variations observed across samples of different geometries or sizes.

In contrast, printing AISI 420 martensitic stainless steel presented more challenges. To obtain dense samples, significantly lower scan speeds were required. The printing parameters were: laser power (P) of 400 W, scan speed (v) of 400 mm/s, layer thickness (b) of 30 µm, hatch spacing (h) of 70 µm, and laser beam diameter (d) of 70 µm. Due to the slower scan speed, the overall build time for these samples was substantially longer.

All fabricated samples were subsequently characterised using a range of analytical techniques. Porosity was measured via the Archimedes method, while optical microscopy was performed on polished and etched cross-sections to evaluate microstructural features. Scanning Electron Microscopy (SEM) was used to assess the grain size, shape, orientation, and distribution within the printed material.

## **WORKSHOP: New ODS steel structure for extreme environments using the ultrasonic dispersion of nano-oxides in combination with SLM and PPS**

**Acknowledgement:** The project is financed by Poland's National Science Center (NCN) under grant number 2021/43/I/ST8/01018, by the Czech Republic's Grant Agency (GACR) under grant number 22-04227L, and by Slovenia's Agency for Research and Innovation (ARIS) under grant number N2-0276: New ODS steel structure for extreme environments using the ultrasonic dispersion of nano-oxides in combination with SLM and PPS

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*Pharos Hall, Friday 17<sup>th</sup> October 2025*

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### Invited Lectures

- 15:35-15:55 **Influence of 3 wt. % Y<sub>2</sub>O<sub>3</sub> Powder Addition on the Properties of 316L Stainless Steel**  
*A. Zielińska, A. Dobkowska, I. Paulin, Č. Donik, J. Kubasek, M. Godec, J. Mizera*
- 15:55-16:15 **Comparative study of ODS steels produced by PPS and SPS**  
*M. González, K. Das, J. Pokorny, D. Nečas, A. Dobkowska, J. M. Kruszewski, J. Kubasek, J. Mizera*
- 16:15-16:35 **In-situ formation of oxides and borides in 316-L stainless steel**  
*J. Kubasek, D. Nečas, A. Dobkowska, Č. Donik, I. Paulin, M. Godec, J. Mizera*
- 16:35-17:00 **Development of Oxide Dispersion-Strengthened (ODS) Steels via LPBF for High-Temperature Applications**  
*I. Paulin, S. Tome, N. Velikajne, Č. Donik, J. Kubasek, A. Dobkowska, M. Godec*
- 17:00-17:30 **Results and work plan presentation**  
*I. Paulin, M. Godec, A. Dobkowska, J. Kubasek*

## **Influence of 3 wt. % $Y_2O_3$ Powder Addition on the Properties of 316L Stainless Steel**

Aleksandra Zielińska<sup>1</sup>, Anna Dobkowska<sup>1</sup>, Irena Paulin<sup>2</sup>, Črtomir Donik<sup>2</sup>, Jiří Kubásek<sup>3</sup>, Matjaž Godec<sup>2</sup>, Jarosław Mizera<sup>1</sup>

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This study investigates the development of materials that can withstand the extreme conditions typically found in nuclear reactors. Oxide dispersion strengthened (ODS) 316L stainless steel emerges as a promising candidate, exhibiting excellent mechanical and thermal stability under such demanding environments. Its enhanced stability results from the fine, stable oxide particles uniformly distributed throughout the steel matrix, allowing it to retain mechanical integrity at temperatures exceeding 1000°C. In addition to its excellent high-temperature strength, the material exhibits superior corrosion resistance. These characteristics make it a suitable candidate for long-term operation in high-temperature, and corrosive environments.

The aim of the research was to enhance the corrosion resistance and mechanical properties of 316L steel by incorporating 3 wt.% in nano and micro sizes yttrium oxide ( $Y_2O_3$ ) into its matrix. To achieve this, materials were produced using the pulse plasma sintering (PPS) method from powders pre-prepared by mechanical alloying (MA). Three types of powders were produced, differing in their milling time: 5, 10, or 50 hours. The corrosion resistance of the 316L+ $Y_2O_3$  using electrochemical techniques in various solutions (0.5M NaCl, 0.5M  $H_2SO_4$ , 0.5M  $H_2SO_4$  + 0.5M NaCl) were performed. The electrochemical results revealed that adding 3 wt. % of  $Y_2O_3$  in micrometric form reduces the corrosion rate of 316L steel compared to adding  $Y_2O_3$  in nanometric form. Uniaxial tensile testing was performed. The mechanical behavior exhibited consistent trends across samples prepared under the same parameters. Specimens that were milled for the shortest time (1 hour) had the highest ultimate tensile strength (UTS) and the lowest elongation. In contrast, samples milled for the longest duration (50 hours) exhibited the greatest and the lowest UTS of all the tested variants. The present study confirmed that the parameters of powder preparation for PPS affect the mechanical and corrosion properties of austenitic 316L steel with  $Y_2O_3$  addition.

## Comparative study of ODS steels produced by PPS and SPS

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Austenitic stainless steels are crucial structural materials for fusion nuclear reactors and power plant applications. However, the stress corrosion resistance and ultimate tensile properties are inferior at high temperatures<sup>1</sup>. Adding high-temperature resistant oxide nanoparticles, i.e., Y<sub>2</sub>O<sub>3</sub>, can improve their properties, as in oxide-dispersed-strengthened (ODS) steels, which enhance the high-temperature mechanical strength and radiation resistance<sup>2</sup>. ODS steels are mostly produced through powder metallurgy (PM) involving mechanical alloying (MA) in a high-energy ball mill<sup>3</sup> followed by sintering methods as spark plasma sintering (SPS) or pulse plasma sintering (PPS). Both methods are similar. However, they work in various voltage parameters, which may change the properties of steels. Therefore, the aim of this study was to compare the austenitic 316L stainless steel with the addition of 1 wt. % Y<sub>2</sub>O<sub>3</sub> nano-sized particles ( 20 – 50 nm) produced using PPS and SPS. The materials were prepared as follows: for the PPS method, samples with a ball powder ratio of 1:5 were mechanically alloyed from prepared powders in an argon atmosphere for 5 h at 250 RPM with a 15+15 min break interval and rotation. For the SPS process, powders in a ratio of ball powder 1:15 were prepared in under Ar atmosphere with 0.04 g of stearic acid as the process control agent (PCA), at 800 RPM for 1 h. Test specimens were subject to XRD, EBSD, and SEM/EDS analysis. Afterwards, the mechanical properties were investigated and examined using tensile and Brinell hardness tests. Additionally, the corrosion behavior was analyzed using electrochemical tests. The obtained results showed that among the studied samples, the strength of the PPS samples is lower than that of the SPS ones. However, in terms of corrosion, SPS performed better than PPS.

1. Xu Y, Zhou Z, Li M, He P, *Journal of Nuclear Materials*, **2011**, Vol. 417, 283-285.
2. Deng L, Luo Jin-ru, Tu J, et al., *Materials Science & Engineering A*, **2023**, Vol. 872, 145008.
3. Raman L, Gothandapani K, Murty BS, *Defence Science Journal*, **2016**, Vol. 66(4), 316-322.

## **In-situ formation of oxides and borides in 316-L stainless steel**

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The in-situ formation of oxides and borides in 316L stainless steel offers a promising route to enhance its mechanical and functional properties. In this study, 316L stainless steel powder was blended with selected reactive additions, including YH<sub>2</sub> and Ti, as well as boric acid, using mechanical alloying. These additions promote the in-situ generation of fine Y<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub>, and complex borides during subsequent consolidation by spark plasma sintering (SPS). The approach enables uniform dispersion of thermally stable reinforcing phases within the steel matrix, refining microstructure and improving hardness, strength, and high-temperature stability. The work demonstrates that mechanical alloying coupled with SPS provides a flexible processing route for designing oxide- and boride-reinforced 316L composites with tailored performance for structural and functional applications.

## Development of Oxide Dispersion-Strengthened (ODS) Steels via LPBF for High-Temperature Applications

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Oxide dispersion-strengthened (ODS) steels are widely recognised for their outstanding mechanical strength at elevated temperatures and their superior resistance to embrittlement caused by neutron irradiation. These unique properties make them strong candidates for structural applications in next-generation nuclear reactors, particularly as fuel cladding materials, as well as in blanket modules for fusion energy systems.

As a proof of concept, austenitic 316L stainless steel was selected as the base matrix due to its excellent ductility, thermal stability, and mechanical robustness at high temperatures. Yttrium oxide ( $Y_2O_3$ ) nano and micro particles were chosen as the reinforcement phase owing to their demonstrated ability to enhance tensile strength more effectively than other oxides. During LPBF processing, the combination of a surface oxygen layer and  $Y_2O_3$  nanoparticles facilitates the in-situ formation and homogeneous distribution of nano-oxides within the steel matrix.

Comprehensive microstructural characterisation was conducted using SEM, EDS, EBSD, and ECCI techniques, confirming the uniform dispersion of nanoparticles and their influence on grain refinement and matrix strengthening. Mechanical testing at both room and elevated temperatures revealed substantial improvements in tensile strength and overall mechanical performance, validating the effectiveness of the proposed material design and processing strategy.

This research underlines the feasibility of producing next-generation ODS steels through tailored powder engineering and additive manufacturing, offering a scalable route toward components capable of operating in demanding nuclear and fusion energy environments.