28. MEDNARODNA KONFERENCA O MATERIALIH IN TEHNOLOGIJAH

11.–13. oktober 2023, Portorož, Slovenija

28th INTERNATIONAL CONFERENCE ON MATERIALS AND TECHNOLOGY

11–13 October 2023, Portorož, Slovenia

PROGRAM IN KNJIGA POVZETKOV

PROGRAM AND BOOK OF ABSTRACTS

INŠTITUT ZA KOVINSKE MATERIALE IN TEHNOLOGIJE, LJUBLJANA

28. MEDNARODNA KONFERENCA O MATERIALIH IN TEHNOLOGIJAH /
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PROGRAM IN KNJIGA POVZETKOV / PROGRAM AND BOOK OF ABSTRACTS

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28th INTERNATIONAL CONFERENCE ON MATERIALS AND TECHNOLOGY, 11–13 OCTOBER, 2023

Wednesday, 11.10.2023

9:00	**OPENING CEREMONY – Chair of the Conference Matjaž Godec, ADRIA HALL**	
9:15	**PLENARY LECTURE - Beste**	
10:00	**EFC COO - Collet**	10:00-16:30 PHAROS HALL WORKSHOPS
10:25	ITR lab - Sponsored	
10:40	**Coffee Break**	
11:00	Zaefferer	
11:20	Godec	
11:40	Donik	
12:00	Jeromen	
12:20	Malej	
12:40	Potočnik	
13:00	**LUNCH**	
	ADRIA HALL – Young Researchers Session	
14:30	Simončič	
14:40	Prijatelj	
14:50	Gregori	
15:00	Tome	
15:10	Velikajne	
15:20	Nečas	
15:30	Tomić	
15:40	Vuga	
15:50	Ali	
16:00	**Coffee Break**	
16:20	Bajželj	
16:30	Zielinska	
16:40	Učakar	
16:50	Kouroutzidou	
17:00	Rudolf	
17:10	Wojtacha	
17:20	Kušter	
17:30	Hosova	
17:30 - 20:00	**POSTER SESSION IN MEDITERANEA HALL**	

Thursday 12.10.2023

	ADRIA HALL		
09:00	**PLENARY LECTURE - Orlov**		**9:00-13:20 PHAROS HALL WORKSHOPS**
09:45	**PLENARY LECTURE - Swieszkowski**		
10:30	Dobkowska		
10:50	**Coffee Break**		
11:20	Kevorkijan		
11:40	Žist		
12:00	Šarler		
12:30	**LUNCH**		
	ADRIA HALL		
14:00	Podlogar	**14:00 - 17:00 EMERALD HALL Slovenian industrial meeting**	
14:20	Bajt Leban		
14:40	Kubasek		
15:00	Stojanović		
15:20	Filipović		
15:40	Sotniczuk		
16:00	Dvorak		
16:20	Kruse		
17:00 - 22:00	**MAREZIGE - SOCIAL EVENT**		

Friday 13.10.2023

			ADRIA HALL
09:00 MEDITERANEA HALL 5IBS	**9:00-13:45 PHAROS HALL WORKSHOPS**	09:00	Burja
		09:20	Mede
		09:40	Hren
		10:00	Conradi
		10:20	Paulin
		10:40	Žužek
		11:00	**Coffee Break**
		11:30	Glodež
		11:50	Stopar
		12:10	Feizpour
		12:30	Hočevar
12:50	**Closing ceremony**		
13:00	**LUNCH**		

PROGRAM 28. MEDNARODNE KONFERENCE O MATERIALIH IN TEHNOLOGIJAH
28th INTERNATIONAL CONFERENCE ON MATERIALS AND TECHNOLOGY: PROGRAM

Wednesday 10.10.2023 ADRIA HALL	
	Predsedujoči – Chair: M. Godec, T. Kosec
	ADRIA HALL
9:00	**ODPRTJE – OPENING CEREMONY – Matjaž Godec**
Plenary 9:15	**Additive Manufacturing as the revolution of wear resistant metals** Dr Ulrik Beste Co-founder and Chief Technical Officer VBN Components AB
Invited 10:00	**The EFC, a federation for all corrosion specialists and experts in material sustainability** Pascal Collet COO of European Federation of Corrosion
10:25	ITR lab - Sponsored
10:40	**Coffee Break**
11:00	**Investigating the 3-dimensional microstructure of a 3D printed Ti 42 Nb alloy for bone implant applications** Stefan Zaefferer1 and Sravya Tekumalla2 1Max-Planck-Institute for Iron Research, Düsseldorf, Germany 2Victoria University, Victoria, Canada
Invited 11:20	**Advancing Surface Engineering in Additive Manufacturing of Metallic Materials** Matjaž Godec1, Danijela Skobir Balantič1, Črtomir Donik1, Aleksandra Kocijan1, Francisco Ruiz-Zepeda1,2, Bojan Podgornik1 1Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenia 2National Institute of Chemistry, Slovenia
Invited 11:40	**Presentation of the Horizon Europe Project "InShaPe" and the Role of IMT in the Consortium** Matjaž Godec, Črtomir Donik, Irena Paulin, Bojan Podgornik, Danijela Skobir Balantič, Katrin Wudy2 1Institute of Metals and Technology, Ljubljana, Slovenia 2Technical University of Munich, TUM School of Engineering and Design, Munich, Germany
12:00	**Annular Laser Beam Intensity Distribution as a Tool to Influence the Performance of Directed Energy Deposition of Metal Powder** Andrej Jeromen, Ana Vidergar, Edvard Govekar University of Ljubljana, Faculty of Mechanical Engineering, Aškerčeva 6, SI-1000 Ljubljana, Slovenia
12:20	**Comparison of Hybrid Additive Manufactured Parts Properties for Three Different Alloys** Simon Malej1,2, Črtomir Donik1, Matej Balazic2, Darja Feizpour1, Damjan Klobčar3, Matjaž Godec1 1Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenia 2Balmar d.o.o., Kidričeva ulica 24A, 3000 Celje, Slovenia 3Faculty for Mechanical Engineering, University of Ljubljana, Aškerčeva cesta 6, 1000 Ljubljana, Slovenia
12:40	**Genetic Algorithm-based Optimization of Laser Beam Path in Additive Manufacturing** Primož Potočnik, Andrej Jeromen, Edvard Govekar University of Ljubljana, Faculty of Mechanical Engineering, Aškerčeva 6, SI-1000 Ljubljana, Slovenia
13:10	**LUNCH**
	Predsedujoči – Chair: M. Čeh, B. Podgornik, D. Orlov, A. Dobkowska, B. Šetina Batič
	ADRIA HALL – Young Researchers Session

14:30	**Deposition Path Strategies in Directed Energy Deposition of Thin Wall 316L-In718 Functionally Graded Material** Jaka Simončič, Andrej Jeromen, Edvard Govekar University of Ljubljana – Faculty of mechanical engineering, Aškerčeva cesta 6, Ljubljana
14:40	**Examining corrosion currents of copper-steel coupling during early oxic phase with coupled multi-electrode array** Klara Prijatelj, Miha Hren, Tadeja Kosec, Andraž Legat Slovenian National Building and Civil Engineering Institute, Dimičeva 12, 1000 Ljubljana, Slovenia
14:50	**Industrial validation of microstructure evolution prediction tool RSProSim (Rolling Schedule Process Simulator)** 1N. Gregori, 1B. Bradaškja, 1J. Foder, 2T. Šuštar, 2P. Šuštaršič, 3D. Bombač, 3G. Kugler 1SIJ Acroni d.o.o., Cesta Borisa Kidriča 44, 4270 Jesenice 2C3M d.o.o., Tehnološki park 21, 1000 Ljubljana 3Naravoslovnotehniška fakulteta, Univerza v Ljubljani, Aškerčeva cesta 12, 1000 Ljubljana
15:00	**Effect of Tempering on Additively Manufactured AISI H13 Hot Work Tool Steel** Samo Tome, Irena Paulin, Matjaž Godec Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, SIovenia
15:10	**Influence of Preheating on SLM Processed EN AW 7075 Aluminium Alloy** Nejc Velikajne, Črtomir Donik, Matjaž Godec, Irena Paulin Institute of Metals and Technology, Ljubljana, Slovenia
15:20	**Zn–Mg–Sr Alloy Synthesized by Mechanical Alloying and Spark Plasma Sintering for Bioapplications** David Nečas1, Jiří Kubásek1, Jan Pinc1, Ivo Marek1, Črtomir Donik2, Irena Paulin2, Dalibor Vojtěch1 1Department of Metals and Corrosion Engineering, Faculty of Chemical Technology, University of Chemistry and Technology, Prague Technická 5, 166 28, Praha 6–Dejvice, Czech Republic 2Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Lepi pot 11, Slovenia
15:30	**Antioxidative Resveratrol Particles as a Bioactive Component for Material Design** Nina Tomić1, Nenad Filipović1, Dragana Mitić Ćulafić2, Magdalena M. Stevanović1 1Group for Biomedical Engineering and Nanobiotechnology, Institute of Technical Sciences of SASA, Belgrade, Serbia, Knez Mihailova 35/IV 11000 Belgrade, Serbia 2University of Belgrade, Faculty of Biology, Studentski trg 16, Belgrade, Serbia
15:40	**Modelling of a thermo-mechanical response of hot-rolled steel bars on a cooling bed with a meshless numerical approach** Gašper Vuga1, Boštjan Mavrič1,2, Umut Hanoglu1,2, Božidar Šarler1,2 1Faculty of Mechanical Engineering, University of Ljubljana, Slovenia 2Institute of Metals and Technology, Ljubljana, Slovenia
15:50	**Phase-field modelling of crack propagation with a meshless numerical approach** Izaz Ali1, Gašper Vuga1, Umut Hanoglu1,2, Božidar Šarler1,2 1Faculty of Mechanical Engineering, University of Ljubljana, Slovenia 2Institute of Metals and Technology, Ljubljana, Slovenia
16:00	**Coffee Break**
16:20	**Influence of surface-active elements on nucleation of non-metallic inclusions** Anže Bajželj1,2, Jaka Burja1,2 1Institute of Metals and Technology, Ljubljana, Slovenia. 2University of Ljubljana, Faculty of Natural Sciences and Engineering, Department of Materials and Metallurgy, Ljubljana, Slovenia
16:30	**Mg-Li-Ca alloys produced by laser powder bed fusion** A. Zielińska1*, A. Dobkowska1, I. Paulin2, Č. Donik2, M. Godec2, W. Święszkowski1 1Warsaw University of Technology, Faculty of Materials Science and Engineering, Warsaw, Poland, 2Institute of Metals and Technology, Ljubljana, Slovenia

16:40	**Phase evolution of Strontium hexaferrite Sintered by Pressureless Spark Plasma Sintering (PSPS)** A. Učakar1,2,3, A. Kocjan1, B. Belec4, J. Košir5, T. Kallio5, B. Šetina Batič6, and P. Jenuš1 1Department for Nanostructured materials, Jožef Stefan Institute, Ljubljana, Slovenia 2Jožef Stefan International Postgraduate School, Ljubljana, Slovenia 3Center for Microscopy and Microanalysis, Jožef Stefan Institute, Ljubljana, Slovenia 4Materials Research Laboratory, University of Nova Gorica, Nova Gorica, Slovenia 5Department of Chemistry and Materials Science, Aalto University, Espoo, Finland 6Institute of Metals and Technology, Ljubljana, Slovenia
16:50	**Effect Of 3D-Printed Fibers on Concrete** Parthena Koltsou 1,2, Maria Stefanidou1, Leon Chernin2, Chrysoula Kouroutzidou1 1Aristotle University of Thessaloniki, Laboratory of Building Materials 2University of Dundee
17:00	**Efficiency of Product Development Process as a Factor Determining Effectiveness of Implementation of Subsequent Project Phases Acc APQP** Ł. Rudolf1, M. Roszak2 1School of Doctors, Silesian University of Technology, Faculty of Mechanical Engineering, Department of Engineering Materials and Biomaterials, Stanisława Konarskiego 18A, 44-100 Gliwice 2Silesian University of Technology, Faculty of Mechanical Engineering, Department of Engineering Materials and Biomaterials, Stanisława Konarskiego 18A, 44-100 Gliwice
17:10	**Influence of Material State on Austenitic Transformation in HSLA-type Steel** Anna Wojtacha1, Mateusz Morawiec2, Marek Opiela1 1Silesian University of Technology, Faculty of Mechanical Engineering, Department of Engineering Materials and Biomaterials, Konarskiego 18a St., Gliwice 44-100, Poland 2Silesian University of Technology, Faculty of Mechanical Engineering, Materials Research Laboratory, Konarskiego 18a St., Gliwice 44-100, Poland
17:20	**Composite material based on polymer matrix reinforced with Al-based Quasicrystal powder** Monika Kušter1,2, Miroslav Huskić3, Marko Bek4, Zoran Samardžija1, Jean-Marie Dubois1,1, Sašo Šturm1,2 1Jožef Stefan Institute, Department for Nanostructured Materials, Jamova cesta 39, 1000 Ljubljana, Slovenia, 2International Postgraduate School Jožef Stefan, Jamova cesta 39, 1000 Ljubljana, Slovenia, 3Faculty of Polymer Technology, University of Slovenj Gradec, Ozare 19, 2380 Slovenj Gradec, Slovenia, 4Faculty of Mechanical Engineering, University of Ljubljana, 1000 Ljubljana
17:30	**3D Printed Ti-Ni Alloys Prepared by Selective Laser Melting for Solid-State Cooling Technologies** Marketa Strakova1,2, Jan Pilch1, Kevin O'Toole1, Dermot Brabazon3, Dalibor Vojtech2, Jiri Kubasek2 1Exergyn Ltd., Dublin, Ireland, 2University of Chemistry and Technology Prague, Faculty of Chemical Technology, Department of Metals and Corrosion Engineering, Prague, Czech Republic, 3Dublin City University, School of Mechanical & Manufacturing Engineering, Faculty of Engineering & Computing, Glasnevin, Dublin 9, Ireland
17:30-20:00	**Poster Session in MEDITERANEA HALL**

Thursday 12.10.2023	
	Predsedujoči – Chair: M. Bajt Leban, M. Conradi
	ADRIA HALL
Plenary 9:00	**Microstructure, Performance and Characterisation Challenges in rare-earth free biodegradable Mg alloys** Dmytro Orlov Division of Mechanics, Materials and Component Design, Department of Mechanical Engineering Sciences, LTH, Lund University, Ole Römers väg 1, 223 63, Lund, Sweden
Plenary 9:45	**Synthesis and Characterization of Biomaterias** Wojciech Święszkowski Biomaterials Group, Materials Design Division, Faculty of Materials Science and Engineering, Warsaw University of Technology, Poland
Invited 10:30	**Microstructure dependent corrosion of newly developed Mg-Zn-Y-Al alloys containing LPSO phases** Anna Dobkowska, Diana Martinez, Aleksandra Zielińska, Wojciech Święszkowski Faculty of Materials Science and Engineering, Warsaw University of Technology, Woloska 141, 02-507 Warsaw, Poland
10:50	**Coffee Break**
11:20	**Development of the Low-Carbon Wrought Aluminium Alloys based on Post-Consumed Scrap** Varužan Kevorkijan Impol R in R d.o.o. Partizanska 38, 2310 Slovenska Bistrica, Slovenia
11:40	**Effect of Vanadium on the structure and properties of AA 6086** Sandi Žist1, Varužan Kevorkijan1, Franc Zupanič2, Tonica Bončina2 1Impol d.o.o., Partizanska 38, 2310 Slovenska Bistrica, Slovenia 2Fakulteta za strojništvo, Smetanova ulica 17, 2000 Maribor
12:00	**Multiphysics and Multiscale Simulations of Direct-Chill Casting** Božidar Šarler1,2, Tadej Dobravec1, Viktor Govže1, Boštjan Mavrič1,2, Katarina Mramor1, Robert Vertnik3, Gašper Vuga1, Peter Cvahte4, Marina Jelen4, Marko Petrovič4, Aleksandra Robič4 1Laboratory for Fluid Dynamics and Thermodynamics, Faculty of Mechanical Engineering, University of Ljubljana, Aškerčeva 6, 1000 Ljubljana, 2Laboratory for Simulation of Materials and Processes, Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, 3Štore Steel d.o.o., Železarska 3, 3220 Štore, 4Impol d.o.o., Partizanska 38, 2310 Slovenska Bistrica
12:30	**LUNCH**
	Predsedujoči – Chair: A. Dobkowska, D. Orlov
	ADRIA HALL
Invited 14:00	**Degradation of synthetic textile microplastic fibers by fungi and photocatalysis** Matejka Podlogar1, Tina Radošević1, Anja Černoša2, Lara Einfalt1, Nik Gračanin1, Martina Kocijan3, Damjan Vengust1, Manca Kovač Viršek4, Cene Gostinčar2, Nina Gunde Cimerman2 1Jožef Stefan Institute, Ljubljana, Slovenia, 2University of Ljubljana, Ljubljana, Slovenia 3University of Zagreb, Zagreb, Croatia, 4Institue for Water of the Republic of Slovenia, Ljubljana, Slovenia
14:20	**Influence of microstructure on corrosion and biocompatible properties of Ti6Al4V alloy** Mirjam Bajt Leban1, Tadeja Kosec1, and Matjaž Finšgar2 1Slovenian National Building and Civil Engineering Institute, Dimičeva 12, 1000 Ljubljana, Slovenia 2University of Maribor, Faculty of Chemistry and Chemical Engineering, 2000 Maribor, Slovenia

Invited 14:40	**Bioabsorbable zinc alloys – the effect of materials processing on microstructure, mechanical and corrosion properties** Jiří Kubásek1, David Nečas1, Irena Paulin2, Črtomir Donik2, Jaroslav Čapek1, Jan Pinc1, Vojtěch Hybášek1, Dalibor Vojtěch1, Matjaž Godec2 1University of Chemistry and Technology, Prague, Faculty of Chemical Technology, Department of Metals and Corrosion Engineering, Technická 5, 16628 Prague 2Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana
15:00	**Fine – Tuning and Performance Testing of Pre – Trained Large Language Models for Applications in Domain of Biomedical Materials Synthesis** Zoran Stojanović, Maja Kuzmanović, Magdalena Stevanović Group for Biomedical Engineering and Nanobiotechnology, Institute of Technical Science of SASA, Knez Mihailo Street 35, Belgrade, Republic of Serbia
15:20	**Selenium nanoparticles: Effects of particle properties on biological activity** Nenad Filipović, Nina Tomić, Maja Kuzmanović, Zoran Stojanović and Magdalena Stevanović Institute of Technical Sciences of SASA, Group for biomedical engineering and nanobiotechnology
15:40	**Surface Behaviour of the Ultrafine Grained Biomedical Titanium** A. Sotniczuk* and H. Garbacz (Warsaw University of Technology)
16:00	**Non-destructive Testing of CIPP Defects Using Machine Learning Approach** Richard Dvořák, Luboš Pazdera, Libor Topolář, Luboš Jakubka, Jan Puchýř, Richard Dvořák Brno University of Technology, Veveří 331/95, 60200 Brno, CZ
16:20	**Advanced Cooling Approach Combined with AI-Supported Material Simulation** Michael Kruse, Doris Wehage FRIEDRICH KOCKS GMBH & CO KG, Neustraße 69, 40721 Hilden GMT Gesellschaft für Metallurgische Technologie- und Softwareentwicklung mbH
17:00 – 22:00	**MAREZIGE – SOCIAL EVENT**

Friday 13.10.2023	
	Predsedujoči – Chair: J. Burja, J. Kubasek
	ADRIA HALL
09:00	**Microbiologically Induced Corrosion of Stainless Steel in a Hydroelectric Power Plant** Jaka Burja, Borut Žužek, Barbara Šetina Batič 1Institute of Metals and Technology, Lepi pot 11, Ljubljana, Slovenia
09:20	**A Coupled CFD-DEM Approach to Modelling Powder Stream in Direct Energy Deposition** Tijan Mede, Matjaž Godec Institute of Metals and Technology, Lepi pot 11, Ljubljana, Slovenia
09:40	**Evaluation of Steel Corrosion Propagation in Blended Cements Using Multiple Corrosion Characterization Techniques** Miha Hren, Tadeja Kosec, Andraž Legat Slovenian National Building and Civil Engineering Institute, Dimičeva 12, 1000 Ljubljana, Slovenia
10:00	**Tribological evaluation of vegetable oil/MoS2 nanotubes-based lubrication of laser-textured stainless steel** Marjetka Conradi1*, Bojan Podgornik1, Maja Remškar2, Damjan Klobčar3 and Aleksandra Kocijan1 1Institute of metals and technology, Lepi pot 11, 1000 Ljubljana, Slovenia, 2Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia, 3Faculty of Mechanical Engineering, University of Ljubljana, Aškerčeva 6, 1000 Ljubljana, Slovenia
Invited 10:20	**Additively manufactured high-strength aluminium alloys** Irena Paulin, Nejc Velikajne, Črtomir Donik Institute of metals and technology, Ljubljana, Slovenia
10:40	**Degradation Mechanism of Steel in Boilers Due to SRF co-incineration** B. Žužek, J. Burja, B. Šetina Batič Institute of Metals and Technologies, Lepi pot 11, Ljubljana, Slovenia
11:00	**Coffee Break**
	Predsedujoči – Chair: J. Burja, D. Feizpour
	ADRIA HALL
11:30	**Fatigue behaviour of brazed joints for heat exchangers** Jernej Kralj1, Blaž Hanželič1, Branko Nečemer1, Janez Kramberger1, Roman Satošek2, Srečko Glodež2* 1University of Maribor, Faculty of Mechanical Engineering, Smetanova 17, SI-2000 Maribor, Slovenia 2Danfoss Trata d.o.o, Korenova 5, SI-1241 Kamnik, Slovenia
11:50	**Preventing cracking of OCR8W ledeburitic tool steel during hot deformation** G. Stopar1,2, M. Terčelj1, G. Kugler1 and D. Bombač1 1Faculty of Natural Sciences and Engineering, University of Ljubljana, Aškerčeva cesta 12, 1000 Ljubljana, SI – Slovenia, 2SIJ Metal Ravne d.o.o., Koroška cesta 14, 2390 Ravne na Koroškem, SI – Slovenia
12:10	**Magnetic Properties and Microstructural Analyses of Cu-Added Rare-Earth-Free MnAl Permanent Magnets** Mahdi Feizpour1, Hadi Barzegar Bafrooei1, Gholamreza Ghane Ezzabadi1, Matjaž Godec2, Darja Feizpour2 1Department of Materials Science and Engineering, School of Engineering, Meybod University, 89616-99557, Yazd, Iran 2Department of Physics and Chemistry of Materials, Laboratory of Surface Engineering and Applied Surface Science, Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenia

Invited 12:30	**Enhancing Biocompatibility of Stainless Steel Surfaces Through Laser Functionalization in an Argon Atmosphere** Matej Hočevar[1], Barbara Šetina Batič[1], Damjana Drobne[2], Peter Gregorčič[3] [1]Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana [2]Biotechnical Faculty, University of Ljubljana, Jamnikarjeva ulica 101, 1000 Ljubljana, Slovenia [3]University of Ljubljana, Faculty of Mechanical Engineering, Aškerčeva 6, 1000 Ljubljana, Slovenia
12:50	**Closing Ceremony, LUNCH**
13:00	**LUNCH**

POSTER SESSION
Wednesday 11. 10. 2023 (17:30 – 20:00)

YR1	**Scanning Electron Microscope for Biological Samples** Victor Ganin, Barbara Šetina Batič, Damjana Drobne Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenia
YR2	**ZnO nanorod arrays for photocatalytic degradation** Klara Laura Konda, Tina Radošević, Matejka Podlogar Jožef Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia
YR3	**Photocatalytic degradation of synthetic textile microplastic fibers with TiO2 as photocatalysts** Tina Radošević1, Lara Einfalt1, Nik Gračanin1, Martina Kocijan2, Janja Vidmar1, Damjan Vengust1, Matejka Podlogar1 1Jožef Stefan Institute, Jamova cesta 39, Ljubljana, Slovenia 2Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, Zagreb, Croatia
YR4	**Low-Power Microwave Dehydration Of Alkali-Activated Materials** Anže Tesovnik, Barbara Horvat, Vilma Ducman Slovenian National Building and Civil Engineering Institute, Dimičeva ulica 12, 1000 Ljubljana, Slovenia
YR5	**The Effect of Hot-Rolled Quarto Plate Thickness and Thermomechanical Conditions on the Prior Austenite Grain Size and Distribution** Matic Bernik1, Noel Gregori1, Jan Foder1, Boštjan Bradaškja1, Primož Šuštarič2, Tomaž Šuštar2, Dejan Zgonc1 1SIJ Acroni d.o.o., Cesta Borisa Kidriča 44, 4270 Jesenice, Slovenia 2C3M d.o.o., Tehnološki Park 21, 1000 Ljubljana, Slovenia
YR6	**Corrosion resistance of 316L oxide dispersion strengthened (ODS) steel** A. Zielińska1*, A. Dobkowska1, J. Kubasek2, M.K. Kruszewski1, B. Adamczyk-Cieślak1, J. Mizera1 1Warsaw University of Technology, Faculty of Materials Science and Engineering, 141 Wołoska St, 02-507 Warsaw, Poland 2University of Chemistry and Technology, Prague, Technicka 5, Praha 6, 166 28
1	**Structural Factors of High-temperature Brittleness of High-manganese steel** Gabriela Fojt-Dymara1, Marek Opiela2 1Automation and Integrated Manufacturing Systems, Konarskiego 18a St., Gliwice 44-100, Poland 2Silesian University of Technology, Faculty of Mechanical Engineering, Department of Engineering Materials and Biomaterials, Konarskiego 18a St., Gliwice 44-100, Poland
2	**Microstructure Evolution of 4Mn Steel Subjected to Quenchning and Partitioning Heat Treatment** Aleksandra Kozłowska, Barbara Grzegorczyk Silesian University of Technology, Faculty of Mechanical Engineering, Department of Engineering Materials and Biomaterials, Konarskiego 18a Street, Gliwice, 44-100, Poland
3	**Recycling of Nickel Swarf into Wire Form using CONFORM SPD Technology** David Hradil, Martina Šípová COMTES FHT a.s., Průmyslová 995, 334 41 Dobřany, Czechia
4	**The research of structures for organic-inorganic hybrid solar cells** P. Jarka1*, A. Drygała, b. Hajduk2*, T. Tański1 1Department of Engineering Materials and Biomaterials, Silesian University of Technology, Konarskiego 18a str., 44-100 Gliwice, Poland 2Centre of Polymer and Carbon Materials, Polish Academy of Sciences, 34 Marie Curie-Skłodowska str., 41-819 Zabrze, Poland

5	**Conductometry Analysis – Beneficial Method for Determining the Chemical Composition of Alkaline Silicate Solutions** Lukáš Kalina, Vlastimil Bílek, Michaela Flídrová, Josef Fládr, Libor Topolář Brno University of Technology, Faculty of Chemistry, Brno, Purkyňova 118, 612 00
6	**The influence of the position of the SLM printed TiAlV part on microstructure, porosity and corrosion** Mirjam Bajt Leban1, Miha Hren1, Tadeja Kosec1, Andrej Jeromen2 and Edvard Govekar2 1Slovenian National Building and Civil Engineering Institute, Dimičeva 12, 1000 Ljubljana, Slovenia, 2University of Ljubljana, Faculty for Mechanical Engineering, Aškerčeva cesta 6, 1000 Ljubljana, Slovenia,
7	**Copper Effect on Toughness in High-Strength Steel for Spring** Jakub Kotous, Pavel Salvetr, Zbyšek Nový COMTES FHT a.s., Průmyslová 995, 334 41, Dobřany, Czech Republic
8	**Anfis System for Cutting Tool Loads Modeling fn Helical-End Milling of Layered Functionally Graded Metal Materials** Uroš Županl1, Miha Kovačič2 1University of Maribor, Faculty of mechanical engineering, Smetanova 17, 2000 Maribor, Slovenia 2University of Ljubljana, Faculty of mechanical engineering, Aškerčeva cesta 6, 1000 Ljubljana, Štore steel, Železarska cesta 3, 3220 Štore, Slovenija
9	**Characterization of Primary Austenite Grains and Retained Austenite in Steel Alloy: A Comparative Analysis of Metallography, EBSD, and XRD Techniques** Nataša Lipovšek, Borut Žužek, Barbara Šetina Batič Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana
10	**Numerical Analysis Of High-Strength Structural Steel S960 Tensile Test** Přemysl Pařenica, Martin Krejsa, Petr Lehner Department of Structural Mechanics, Faculty of Civil Engineering, VSB-Technical University of Ostrava, Ludvíka Podéště 1875/17, 708 33 Ostrava-Poruba, Czech Republic
11	**Characteristics of AlCrSiN Coating Deposited by Planar Cathode with Arc Technology** Krzysztof Lukaszkowicz, Justyna Galeja Silesian University of Technology, Faculty of Mechanical Engineering, Konarskiego 18A, 44-100 Gliwice, Poland,
12	**Cement mortars with the addition of PCM as an innovative construction material for maintaining a pleasant living environment in households** P. Štukovnik1, M. Marinšek2 V. Bokan Bosiljkov1, Tina Skalar2 1University of Ljubljana, Faculty of Civil and Geodetic Engineering, 2University of Ljubljana, Faculty of Chemistry and Chemical Technology
13	**Comparison of Electrochemical and Tribocorrosion Properties of Conventional and Quasicrystalline Aluminium Alloys** Petra Močnik1, Mirjam Bajt Leban1, Tadeja Kosec1, Pia Popovič2, Tim Drevenšek2, Blaž Leskovar2 1Slovenian National Building and Civil Engineering Institute, Dimičeva 12, 1000 Ljubljana, Slovenia 2University of Ljubljana, Faculty of Natural Sciences and Engineering, Department of Matrials and Metallurgy, Aškerčeva cesta 12, 1000 Ljubljana, Slovenia
14	**Stabilisation of Annular Laser Beam Directed Energy Deposition of Metal Wire** Jaka Peternel, Jaka Simončič, Andrej Jeromen, Edvard Govekar University of Ljubljana, Faculty of Mechanical Engineering, Aškerčeva 6, SI-1000 Ljubljana, Slovenia

15	**Pre-Feasibility Study Results Of Usability of Sawing Sludge as Potential Material For Glass Production – A Case Study of Circular Economic Aspects from the Silicate Dimensional Stone Production** Željko Pogačnik1, Tilen Sever2, Mateja Golež3 1Georudeko, d.o.o., Anhovo 1, 5210 Deskle, Slovenia, zeljko.pogacnik@georudeko.si 2Steklarna Hrastnik, d.o.o., Cesta 1. Maja 14, 1430 Hrastnik, tilen.sever@hrastnik1860.com 3Slovenian National Building and Civi Engineerig Institute, Dimičeva ulica 12, 1000 Ljubljana, Slovenia,
16	**Abrasive wear resistance of hardened tool steel – Influence of matrix hardness, carbide fraction, size and type of carbides** Božo Skela1, Marko Sedlaček2, Fevzi Kafexhiu3, Črtomir Donik2, Bojan Podgornik2 1Impol R in R, d. o. o.Partizanska ulica,Slovenska Bistrica, Slovenia 2Institute of Metals and Technology, Lepi pot 11, Ljubljana, Slovenia 3V-Research GmbH, Stadtstraße 33, 6850 Dornbirn, Austria
17	**Mechanical fracture quantification of role of hemp fibres on self-healing processes in selected composites** Stanislav Seitl1,2, Petr Miarka1,2, Lucie Malíková1,2, Ildiko Merta3, Bojan Poletanovič3, Vlastimil Bílek4 1Institute of Physics of Materials, Czech Academy of Sciences, Žižkova 22, 616 00 Brno, Czech Republic, 2Faculty of Civil Engineering, Brno University of Technology, Veveří 331/90, 602 00 Brno, Czech Republic, 3Faculty of Civil Engineering, TU Wien, Karlsplatz 13/E207-1, 1040 Vienna, Austria, 4Faculty of Civil Engineering, VŠB Technical University of Ostrava, Ludvíka Podéště 1875/17, 708 33 Ostrava-Poruba, Czech Republic
18	**How to Tailor Magnetic Properties of High-Silicon Soft Magnetic Fe-Si Alloys with Additive Manufacturing?** Tina Sever1, Ermin Rahmanović2, Črtomir Donik1, Darja Steiner Petrovič1, Irena Paulin1, Martin Petrun2 1Institute of Metals and Technology, Lepi pot 11, Ljubljana, Slovenia, 2University of Maribor, Faculty of Electrical Engineering and Computer Science, Koroška cesta 46, Maribor, Slovenia
19	**Surface Hardening of Additive Manufactured Inconel 625 by Plasma Nitriding** Danijela A. Skobir Balantič, Črtomir Donik, Bojan Podgornik, Aleksandra Kocijan, Matjaž Godec Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenia
20	**The Effects of Gamma Irradiation on PET and Formation of Microplastic Particles Down to 1 µm** Lara Mikac1, Attila Csáki2, Benedek Zentai2, Ana Tolić1, Ekaterina Šprajc3, Marinko Pleština3, Sandy Lovković3, Marijan Sudić3, Mile Ivanda1, Miklós Veres2 1Ruđer Bošković Institute, Bijenička 54, Zagreb, Croatia, 2Institute for Solid State Physics and Optics, Wigner Research Centre for Physics, Budapest, Hungary, 3Jamnica plus d.o.o., Getaldićeva 3, Zagreb, Croatia
21	**Synthesis and Characterization of 1-D Nanostructures Hydroxyapatite Prepared from Galatea Paradoxa for Energy Applications** Yao Mawuena Tsekpo1, Paweł Jarka1, Benjamin Agyei-Tuffor2 and Tomasz Tański1 1Faculty of Mechanical Engineering, Silesian University of Technology, Poland 2Department of Material Science and Engineering, University of Ghana, Ghana
22	**The effect of annealing temperature on the microstructural evolution and mechanical properties of the superaustenitic stainless steel UHB 904L** F. Tehovnik, B. Arh, F. Vode, F. Tehovnik Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenia

23	**Phase Formation Kinetics in TiAl-based Coating Prepared by Self-propagating High-temperature Synthesis** Anna Teichmanová1, Alena Michalcová1, Lukáš Koláčný2 Veronika Balejová1 1Department of Metals and Corrosion Engineering, University of Chemistry and Technology, Prague, Technická 5, 160 00 Prague 6-Dejvice, Czech Republic, 2Department of Organic Technology, University of Chemistry and Technology, Prague, Technická 5, 160 00 Prague 6-Dejvice, Czech Republic
24	**Thermal fatigue testing** Franci Vode, Bojan Podgornik Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenia
25	**Hydrogen embrittlement of additively manufactured metallic materials** Dalibor Vojtěch, Zdeněk Kačenka, Angelina Strakosova University of Chemistry and Technology, Prague, Technická 5, 166 28 Prague 6, Czech Republic
26	**Ageing Effect on Microstructure and Mechanical Properties of Creep Resistant Steels** B. Žužek, G. Puš, A. Guštin, G. Velikajne Institute of Metals and Technologies, Lepi pot 11, Ljubljana, Slovenia
27	**Imaging of HiPIMS Plasma by High-speed Camera** Matjaž Panjan Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia

Additive Manufacturing as the revolution of wear resistant metals

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Most metal Additively Manufactured materials are relatively soft, such as Ti and Al alloys for aerospace, Ni and Co base alloys for high-temperature applications, and stainless steels such as 316L. Low-carbon martensitic steels are printed industrially, and printing of tool steels such as H13 is increasing, but even H13 only reaches a hardness of 55 Rockwell C (HRC). Carbide-containing materials possess high hardness but printing these was for long considered impossible, as they tend to crack due to the rapid cooling present in AM processes.

However, as VBN Components demonstrated several years ago, it is possible to print high-carbon materials using Electron Beam Melting. The vacuum environment ensures stable and improved material chemistry, and it is possible to maintain the part at elevated temperature during printing, thereby preventing cracking.

Since then, VBN Components has developed and commercially released five different hard AM materials with extreme wear and heat resistance under the brand name Vibenite®. Their hardness ranges from 55-72 HRC to suit different types of industrial applications and they all contain fine, uniformly distributed carbides in a fine-grained matrix.

The Vibenite® range of high-speed steels (tool steels) contain 7-25 vol% carbides and have hardnesses of 55-72 HRC, with Vibenite® 290 being the world's hardest, commercially available steel. These materials have fatigue properties better than comparable PM-HSS and excellent wear resistance. Vibenite® 350 is a stainless martensitic steel with 20 vol% carbides, a hardness of 60 HRC, good corrosion resistance, and 6-7 times better wear resistance than 316L [1].

Vibenite® 480, the world's first commercially available 3D printed cemented carbide, has 65 vol% carbides, a hardness of 67-70 HRC and excellent thermal stability. Combining the hot hardness of hardmetals with the toughness of HSS, Vibenite® 480 out-performs high Cr white iron in wet wear.

Successful application examples of hard and wear-resistant AM materials from different fields, such as the energy, tooling, and food industry, will be presented. The presentation will also contain some history of VBN and outlook of AM for the future. In addition, a materials surprise will be presented.

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The EFC, a federation for all corrosion specialists and experts in material sustainability

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The EFC is a federation of organisations with interests in corrosion, active in Europe and beyond. Its aim is to advance the science of corrosion and protection of materials by promoting cooperation in Europe and collaboration internationally through the management of working parties, publications and the organization of the well-recognised EUROCORR scientific congress.

The federation also supports events, courses and webinars to disseminate knowledge, encourage networking and help develop the next generation of corrosion professionals.

Microstructure, Performance and Characterisation Challenges in rare-earth free biodegradable Mg alloys

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Sustainable development goals along with the criticality of available minerals and recent geopolitical developments demand new material solutions. One of the most abundant in Earth crust, yet second-most critical material for the EU, magnesium (Mg) has excellent potential for addressing most of these demands due to lowest density of all structural metals and friendliness to the environment including biocompatibility.

Relatively modest performance characteristics of pure Mg can be dramatically enhanced and tailored for specific applications through alloying and thermo-mechanical processing. Top-performing modern Mg alloys containing rare-earth (RE) elements supersede strongest aluminium alloys and are on parity with titanium alloys by structural efficiency. Mg-RE alloys might be an excellent solution for light-weight mobility, but highest criticality for the EU and high cost of REs make such alloys less attractive in real-life. Moreover, their application in biomedical sector is questionable due to poorly understood while often toxic effect of REs on human body.

We have been working on the development of magnesium – zinc (Zn) based alloys for biodegradable implant applications. To address the specific challenges of a balance between sufficient strength and controllable degradation upon implantation, minor additions of other elements, all of which are biocompatible and essential for human body, and thermomechanical processing are necessary. The challenges in alloy design are further amplified by those in material performance characterisation due complexity of surface interaction phenomena and correlation between *in vitro* and *in vivo* testing.

In this talk, we overview recent trends in the design of biodegradable magnesium alloys and their achievements in real-life biomedical applications. Special attention is also paid to recent progress in laboratory and large-scale facility based *in situ* characterisation techniques and our contributions to the development of respective experimental methods.

Synthesis and Characterization of Biomaterials

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Since materials for clinical applications interact with biological systems for therapeutic purposes, scientists and engineers must investigate novel biomaterials. By interacting with the host biological system, we must design and develop these materials having in mind both, technical properties and potential to replace a diseased or defective tissue's native function. However, during biomaterials' design we must consider not only numerous medical concerns, but also biology, chemistry, tissue engineering, and materials engineering. They can be derived from nature or synthesized through a variety of processes involving polymers, ceramics, composites, and biodegradable metals.

For orthopaedic applications, absorbable biomaterials such as natural and synthetic polymers or metals (zinc, iron, and magnesium) have emerged as a temporary support alternative. Synthetic polymers can be manufactured in a variety of sizes and shapes, and their degradation can be controlled by altering their composition or processing techniques. However, the incorporation of stabilisers, plasticizers, and antioxidizes during polymer synthesis can result in an adverse host tissue responses due to the leaching of harmful products. In addition, the release of acidic degradation products causes non-infectious inflammatory responses, an increase in foreign body reactions, pathological bone resorption, and an accelerated rate of polymer implant degradation.

In recent years, magnesium (Mg) and its alloys have acquired popularity as absorbable metallic implant materials. Mg and its alloys, as biodegradable metals for orthopaedic applications, have shown mechanical properties similar to bone, including elastic modulus and density. Concerns have been expressed about Mg-based devices due to their rapid and unpredictable degradation rate and loss of mechanical stability prior to fracture repair. To overcome these limitations, alloying, coatings and surface treatments have been used. Extensive *in vitro* and *in vivo* research has identified optimal biological properties that qualify Mg-based devices for orthopaedic clinical applications, including osteoinductive and osteoconductive properties, angiogenesis, and enhanced osseointegration.

The presentation will summarize the achievements in the development of advanced biomaterials for healing and engineering of cartilage, bone, tendon, nerve, and microvascular tissues, utilizing a variety of biocompatible polymeric and Mg-based materials as well as different fabrication techniques.

BioMaterials Group

Analysis of non-metallic inclusions released during solidification of laboratory cast steels with Automatic inclusion analysis and Mahalanobis distance

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Non-metallic inclusions in steel are detrimental to the properties of steel products, such as strength, toughness, fatigue and surface quality. During steel casting, solid inclusions can also be gradually deposited on the wall and on the submerged inlet nozzle and eventually cause its clogging. Therefore, one of the important tasks in steel production is control over the formation of inclusions during steel production and continuous casting. Exogenous inclusions - mainly originate from the wearing of refractory materials and slag entrapment. Most endogenous inclusions are formed by deoxidation of steel during secondary metallurgy. One of the purposes of secondary metallurgy is to reduce the amount of non-metallic inclusions, to control the composition, size and uniform distribution of inclusions during solidification to achieve better steel quality. Inclusions are compounds of metals with oxygen, sulfur and nitrogen in steel. Analysis of inclusions on steel samples was done on an electron microscope with automatic analysis of inclusions and Mahanalobis distance. Mahalanobis distance is a measure of dissimilarity between a point and a distribution in multidimensional space. It takes into account the covariance structure of the variables, making it particularly useful in multivariate statistical analysis.

Phase-field modelling of crack propagation with a meshless numerical approach

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Due to the simple nature and ease of application, the phase-field modelling of cracks has gained significant attention recently as a promising method for simulating crack behaviour in various metallic materials during metallurgical thermomechanical processing. In this study, for the first time, the combined governing equations for phase-field and mechanical modelling are solved in a strong form using the meshless local radial basis function collocation method (LRBFCM) [1] to simulate crack propagation subjected to tensile loading conditions.

The cracks in the phase-field approach are defined as diffuse interfaces within the material, describing the crack by a continuous scalar field smoothly transitioning between the broken and intact material. Phase-field can capture the crack evolution without explicitly tracking the crack surface.

To validate the proposed solution procedure, we solved a benchmark test of a square geometry with a pre-defined crack in an elastic material subjected to tensile loading increments. The effects of different formulation parameters, such as length scale parameter, number of local support nodes, node density, and order of augmentation of the polyharmonic splines used for the shape functions, are analysed in this study. Our results fit the previously published data in the literature.

Since our results fit the previously published data, we demonstrate that LRBFCM combined with the phase-field approach can accurately capture the crack behaviour under tensile loading conditions. Furthermore, the meshless approach offers an advantage in efficient and straightforward coping with complex crack geometries without changing the domain discretisation during the crack growth.

The application of LRBFCM to the phase-field modelling of cracks contributes to computational fracture mechanics based on strong-form meshless methods. It complements our previous studies, using this method in various metallurgical processing.

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Influence of microstructure on corrosion and biocompatible properties of Ti6Al4V alloy

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Ti6Al4V alloy is widely used in different industries because of its beneficial mechanical and corrosion properties. In terms of biocompatibility, Ti6Al4V has demonstrated favorable characteristics for biomedical applications.

Ti6Al4V typically consists of the primary α-phase and the secondary β-phase. The microstructure of Ti6Al4V can be influenced by various factors, including alloy composition, heat treatment parameters, cooling rates, and processing methods. Since the chemical composition of α- and β-phase could differ significantly, this is critical for oxide film formation and its corrosion resistance.

The present research was focused on the investigation of corrosion resistance of Ti6Al4V alloy consisting of α- and β-phase, produced by three different technologies: by selective laser melting and additional heat treatment, by investment casting, and by forging. Electrochemical methods in artificial saliva were conducted in order to study the differences in their corrosion properties. Surface characterization methods, such as SEM/EDS and ToF-SIMS, were applied in addition to metallographic observation to study the correlation between the microstructure and spatial distribution of different species in the formed oxide film.

It was found that corrosion resistance depends on various microstructural factors: quantity, size, location, and shape of β-phase relative to α-phase.

Influence of surface-active elements on nucleation of non-metallic inclusions

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The composition and temperature of steel melts play vital roles in determining the size, type, and chemistry of non-metallic inclusions. During the production of steel melts, significant changes in composition and temperature occur, leading to evolving melt purity. Steel purity, characterized by low concentrations of non-metallic inclusions, plays a pivotal role in determining the mechanical properties and overall quality of steel and iron-based alloys, including corrosion resistance, fatigue resistance, formability, and weldability. Thermodynamic calculations for the formation of non-metallic inclusions are complex and require assumptions and simplifications, primarily considering the activity of elements in relation to composition and temperature. These calculations often overlook surface energy, which is crucial for calculating the critical radius of non-metallic inclusions.

The present research investigates the influence of surface-active elements, specifically sulfur, on non-metallic inclusion nucleation in the Fe-C alloy system. The study aims to illuminate how these elements alter the surface tension of the melt and subsequently affect the formation of non-metallic inclusions. In the realm of basic research, experimental equipment for determining surface tension values using the sessile drop method has been developed. We will explore potential applications in the steelmaking and foundry industries.

The outcomes of the research are anticipated to have a significant impact on steelmaking practices. Understanding the interplay between surface-active elements, surface tension, and non-metallic inclusion formation is crucial for improving material quality, enhancing industrial processes, and reducing technological disruptions, such as nozzle clogging during continuous casting.

Microbiologically Induced Corrosion of Stainless Steel in a Hydroelectric Power Plant

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Upon investigation of turbine blades at a hydroelectric power plant, evidence of corrosion damage in the form of pitting corrosion was identified. On-site examination of the martensitic stainless steel blades unveiled a substantial biofilm coating. Subsequent removal of the biofilm exposed numerous corrosion pits, some reaching depths of up to 3 mm. Notably, the distribution of these pits was uneven, exhibiting a cavernous morphology. Chemical analysis of the deposits within the corrosion pits highlighted a significant concentration of manganese (Mn). Remarkably, the stainless steel material exhibited no inherent metallurgical flaws. Replica samples were obtained and subjected to thorough analysis, confirming the presence of pitting corrosion. These findings collectively point to the involvement of manganese-oxidizing microorganisms as instigators of this corrosion phenomenon also called "microbiologically induced corrosion". An explanation of this phenomenon's mechanics is provided.

Tribological evaluation of vegetable oil/MoS2 nanotubes-based lubrication of laser-textured stainless steel

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In the present work, functionalization of AISI 316L surfaces by nanosecond Nd:YAG laser texturing in order to modify the surface morphology with crosshatch and dimple patterns is presented. Tribological analysis under lubrication with sunflower and jojoba oil with and without addition of solid lubricant, MoS2 nanotubes, was performed. In connection to friction/wear response la-ser-textured surface wettability, oil spreadability and oil retention capacity were analysed. It was shown, that the crosshatch pattern generally exhibited lower friction than the dimples pattern, with the addition of MoS2 nanotubes not having any significant effect on the coefficient of friction under the investigated contact conditions. This was additionally with better oil spreadability and oil retention capacity results of crosshatch textured surface. Furthermore, texturing reduced wear of the stainless-steel surfaces but led to approximately one order of magnitude larger wear rate of the steel counter-body, primarily due to the presence of hard bulges around the textured patterns. Overall, the crosshatch pattern showed better oil retention capacity and lower friction in com-bination with different vegetable oils, thus making it a promising choice for improving tribo-logical performance in various environmentally friendly applications.

Microstructure dependent corrosion of newly developed Mg-Zn-Y-Al alloys containing LPSO phases

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Magnesium alloys, because of their low density and high specific strength, are attractive structural materials. Nevertheless, their wide use in the industry is restricted due to insufficient corrosion resistance. Therefore, the Mg-based alloys containing long period stacking ordered (LPSO) structures have been recently developed [1–3]. The role of the LPSO phases in the micro-galvanic corrosion of Mg-Zn-Y-Al alloys was investigated, and their cathodic nature has been already proven [3]. Considering this matter, new solutions to reduce the microgalvanic effects are investigated. One of them is annealing as a result of which the homogenization of the microstructure can be achieved.
In this study, we have investigated the microstructural features which may significantly affect corrosion resistance of Mg-Zn-Y-Al alloys containing LPSO phases. To approach this, rapidly solidified and extruded Mg-Zn-Y-Al was investigated. Additionally, annealing under various conditions was performed. As a reference, conventionally extruded rod was taken.
The microstructural characterization was composed of electron back scattered diffraction, high resolution microstructure observations, as well as phase composition was analyzed. The corrosion resistance was analyzed based on the electrochemical measurements in 0.01 M NaCl at room temperature. This included open circuit potential evolution, electrochemical impedance spectroscopy and potentiodynamic polarization tests. Corrosion rate based on the hydrogen release was also measured. Corrosion damage was observed using field emission scanning electron microscopy, and surface development was tested using optical profilometry.
Our research clearly show that the corrosion resistance of the Mg-Zn-Y-Al alloys containing LPSO structures is microstructure dependent. The corrosion performance is not solely related to the ratio of anodic Mg matrix to cathodic LPSO phases, but also grain size and their crystallographic orientation play a significant role in the corrosion behavior of the investigated alloys.

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Presentation of the Horizon Europe Project "InShaPe" and the Role of IMT in the Consortium

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The project "Green Additive Manufacturing through Innovative Beam Shaping and Process Monitoring" with the acronym "InShaPe" is a Horizon Europe project, part of Pillar II: Global Challenges & European Industrial Competitiveness and belongs to clusters: Digital, Industry & Space.

The demand for lightweight, strong and durable metallic components is surging in various industrial sectors like automotive, aerospace and energy. Applications like advanced gas turbines require stable yet lightweight heat shields. A crucial technology for this demand is the Powder-Bed-Based Additive Manufacturing of Metals (PBF-LB/M). While promising, PBF-LB/M is not always cost-competitive compared to conventional manufacturing. Enter the InShaPe project, backed by a substantial €6.8 million EU grant, aiming to drive the technology forward. Under the coordination of the Technical University of Munich (TUM), eleven partners from eight countries collaborate on this venture.

The InShaPe project targets the flexible adaptation of laser-beam shapes, tailoring the beam to the material and the geometry of the 3D-printed parts. The benefits include a quicker process, lower costs, and less energy being consumed. Compared to current methods, the project aims to achieve remarkable benefits: a sevenfold production rate increase, over 50 % cost reduction, 60 % lower energy consumption, and 30 % less waste. However, the new conditions associated with the PBF-LB/M process and the laser-beam shapes are creating new microstructures within the printed parts, leading to unexpected mechanical properties. The Institute of Metals and Technology (IMT) has recently joined the consortium with the aim of identifying the extent of the possibilities for tailoring the microstructure in relation to beam shape and controlling the mechanical properties. The main task of IMT will be characterising the printed parts of different alloys and supporting analyses of the printed industrial samples.

Non-destructive Testing of CIPP Defects Using Machine Learning Approach

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In the field of civil engineering, retrofitting actions involving repairs to pipes inside buildings and in extravehicular locations present complex and challenging tasks. Traditional repair procedures typically involve disassembling the surrounding structure, leading to technological pauses and potential disruptions to the working environment. An alternative approach to these procedures is the use of "cured-in-place pipes" (CIPP) technology for repairs. Unlike standard repairs, CIPP repairs do not require disassembly of the surrounding structures; only the access points at the beginning and end of the pipe need to be accessible. However, this method introduces the possibility of different types of defects [1].

The objective of this research is to observe a defects between the host pipe and the newly cured pipe inside it. However, the presence of holes, cracks, or obstacles prevents the attainment of this desired close fit state, ultimately reducing the life expectancy of the retrofitting action. This paper focuses on the non-destructive observation of these defects using the NDT Impact-Echo (IE) method. The study specifically applies this method to CIPP composite pipe segments inside concrete host pipes, forming a testing polygon. Previous results have indicated that the mechanical behavior of cured CIPP composite pipes can vary in stiffness depending on factors such as the curing procedure and environmental conditions [2]. The change of stiffness can be described by the change of acoustic parameters such as resonance frequency, attenuation and other features of typical IE signals.

This paper presents a comparison of different sensors used for IE proposed testing, namely piezoceramic and microphone sensors, and evaluates their ability to distinguish between different defects present in the body of the CIPP via machine learning approach using random tree classifiers.

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Magnetic Properties and Microstructural Analyses of Cu-Added Rare-Earth-Free MnAl Permanent Magnets

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The MnAl ferromagnetic phase has great potential for industrial applications as one of a family of non-rare-earth permanent magnets due to its large magnetocrystalline anisotropy, high magnetization, high Curie temperature, low cost, and relatively easy processing. This research exploited an induction casting furnace protected by an Ar atmosphere to prepare the τ-MnAl magnetic phase. Considering the appropriate compositions, pure ($Mn_{54}Al_{46}$, known as MnAl), 2 wt. % ($MnAl_{98}$–Cu_2), and 5 wt. % ($MnAl_{95}$–Cu_5) Cu-added MnAl samples were alloyed. The microhardness and bulk density of the melted ingots increased from pure to 2 wt. % Cu alloys accompanied by a slight decrease in 5 wt. % Cu-added sample. XRD and SEM confirmed the formation of the τ, γ, and β phases in all three sets of initially melted ingots. At the same time, it was revealed that the addition of Cu could facilitate the formation of the ferromagnetic τ-MnAl phase in both doped samples.

The research results showed that adding copper stabilizes the τ phase directly and affects the magnetic properties of the MnAl samples, resulting in an increase in the coercivity and remanence. The H_C of the $Mn_{54}Al_{46}$ and the five percent-copper-added samples changed from 250 to 500 Oe, respectively. While the saturation magnetization remained nearly unchanged, the remanence showed an uptrend and increased remarkably from 5.40 emu/g (pure) to 11.62 emu/g (for 5 wt. % Cu). The results of this study show that adding Cu could be beneficial in promoting the magnetic properties of pure MnAl. However, more systematic studies are needed to adjust the proper amount of Cu, especially for final heat-treated samples.

Keywords: MnAl, rare-earth-free magnets, magnetic characterization, copper

Selenium nanoparticles: Effects of particle properties on biological activity

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Nanotechnology, as a most promising approach in material science, has resulted in numerous enhancements and breakthroughs in diverse scientific fields. One of the examples is selenium nanoparticles (SeNPs) which emerged as a new form with some improved properties compared to other Se forms. Among these properties, anticancer, antimicrobial, antioxidative, and reduced toxicity are the most interesting from the aspect of biomedical applications. Due to simplicity, short duration, scalability, and reproducibility, chemical reduction is a synthesis technique very often applied in SeNPs production. The choice of reducing agents, their molar ratio with a precursor, and the choice of stabilizing agents are recognized as determining parameters for the application efficiency of designed SeNPs.

This presentation includes an overview of the results of SeNPs obtained by the reduction of sodium selenite and stabilized with different agents. Furthermore, the effects of synthesis parameters on the properties of obtained particles (size, morphology, crystallinity, stability, surface chemistry) and biological activities such as antimicrobial, antioxidative, and cytotoxicity will be elaborate. In addition, some potential applications of SeNPs will be discussed, with particular reference to the results of *in vivo* experiments.

Structural Factors of High-temperature Brittleness of High-manganese steel

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The paper presents the results of structural tests of high-manganese steel with the content of 0.04% C, 27.5% Mn, 4.2% Si, 2.0% Al, 0.033% Nb, 0.009% Ti and 0.0028% N. The first part of the tests samples were solution heat-treated at different temperatures in a range from 900°C to 1200°C. In order to determine the effect of temperature and hot plastic deformation on the steel structure, plastometric tests were carried out using the Gleeble 3800 thermomechanical simulator. Another part of samples was subjected to deformation in the temperature range from 1050°C to 1200°C. The microstructure was characterized by light microscopy and scanning electron microscopy.

The main reason for the formation of hot cracks is the decrease in the hot ductility of steel in the range of high-temperature brittleness. Intermetallic phases precipitate on the boundaries of austenite grains, and non-metallic inclusions are visible in the steel structure. The research carried out was aimed at explaining the structural causes of cracking at high temperature. Fractographic studies allowed to determine the mechanisms of hot cracking.

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Scanning Electron Microscope For Biological Samples

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Scanning electron microscopy (SEM) has been widely used as a tool for providing a better understanding of micro and nanoscale topographical characteristics with high-resolution. However, some scientists believe that biological sample preparation may alter the structure and integrity of the specimen potentially leading to diminished image quality.

The main aim of this work is to show how different imaging parameters influence the image quality, with a particular focus on assessing the influence of electron beam voltages. Different groups of specimens which differed in size, shape, and topography were selected for this purpose, and coated with a thin layer of Au/Pd to ensure conductivity. All samples were observed using JEOL JSM 6500-F field emission scanning electron microscope.

The research has shown that there was no observable damage for the investigated samples but further optimization process needs to be performed to obtain the highest quality images.

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Advancing Surface Engineering in Additive Manufacturing of Metallic Materials

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In recent years, additive manufacturing processes have emerged as powerful techniques for synthesising various metallic materials, with methods like powder bed fusion and direct energy deposition leading the way. These cutting-edge processes have ushered in a new era of material production characterised by unique microstructures resulting from rapid solidification. These microstructures include dislocation substructures, distinct grain shapes, varying degrees of porosity, nano oxide particles, micro or nano segregations, and the accumulation of internal stresses.

In order to improve the corrosion resistance and wear properties of metallic materials, surface-hardening techniques like plasma nitriding have become increasingly popular. Among these techniques, plasma nitriding has proven to be highly effective in enhancing these important characteristics. However, when it comes to additive manufacturing, the relationship between the complex microstructures involved and the formation of surface compounds and diffusion layers during processes like plasma nitriding requires careful consideration.

Our presentation will show the results of plasma nitriding, specifically on stainless steel AISI 316L, maraging steel M300, and the nickel super alloy Inconel 625. We aim to reveal the differences in microstructure between the resulting compound and diffusion layers and compare them to materials produced through conventional methods. Additionally, we will investigate how different heat treatments affect the formation of nitride layers and provide detailed information through measurements of corrosion and wear. The cutting-edge additive manufacturing processes of laser powder bed fusion with advanced surface-hardening techniques present a promising path for optimising the properties of metallic materials.

Microstructure Evolution of 4Mn Steel Subjected to Quenchning and Partitioning Heat Treatment

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The growing demands concerning the increase of fuel efficiency and passenger safety accelerate the development of Advanced High Strength Steels (AHSS). Currently, the research is focused mainly on the third generation of AHSS, especially medium-Mn steels containing from 3 to 12% of Mn. These steels show the superior combination of high strength and ductility due to the phase transformation of retained austenite into martensite during plastic deformation, which is called strain-induced martensitic transformation (SIMT). Quenching and Partitioning (Q&P) processing is the promising strategy of increasing the strength-ductility product of medium-Mn steels. The Q&P heat treatment consists of austenitization followed by quenching to the temperature between Ms and Mf to produce some fraction of martensite and then a heating step to a higher temperature is applied for C partitioning from the supersaturated martensitic laths into the austenite. Therefore, the Ms temperature of the C-enriched austenite is lower and some fraction of this phase can be stabilized to the room temperature constituting the retained austenite (RA).

The aim of this study was to determine the effect of time-temperature parameters of quenching and partitioning heat treatment on the microstructure evolution of 0.17C-4.2Mn-1Al-0.9Si-0.05Nb steel. The heat treatment cycles were performed by means of dilatometry. The obtained microstructures were characterized by scanning electron microscopy (SEM) and electron backscattered diffraction (EBSD) techniques. The quantitative analysis of the fraction of retained austenite after the heat treatment was carried out via X-ray diffraction (XRD). The obtained microstructures are composed of primary martensite formed during quenching, lath-type retained austenite and some fraction of secondary martensite formed during the final cooling.

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Industrial validation of microstructure evolution prediction tool RSProSim (Rolling Schedule Process Simulator)

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The aim of the study was the industrial validation of a tool to predict microstructure evolution during hot rolling. The simulations of the microstructure development were carried out with the developed software RSProSim. The input parameters for predicting the microstructure during hot rolling (strain, strain rate, temperature) resulted from finite element modelling (FEM) using industrial rolling parameters. The evaluation was carried out for the stainless steel grade 1.4404 (AISI 316L) using two industrially rolled plates with thicknesses of 12 mm and 50 mm. The microstructure was predicted for five different positions in the plate cross-section (S1, Q1, M, Q2, S2) and compared with the microstructure of industrially rolled plates. The grain size distribution was compared between the predicted results and samples from hot rolled plates. The influence of thermomechanical parameters on the simulated and measured grain size distribution was evaluated.

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Enhancing Biocompatibility of Stainless Steel Surfaces Through Laser Functionalization in an Argon Atmosphere

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Metallic biomaterials such as stainless steel, are widely used in biomedical applications because of their excellent mechanical properties and low-cost. At the same time, they enable different surface functionalization processes that modify surface morphology, surface chemistry and surface wettability. These physiochemical properties of the surface regulate biological interaction at the material-cell interface. Therefore, the modification and functionalization of the surface, which comes into direct contact with biological systems, play an important role in biomaterial design.

Within this context, laser surface engineering can be used for controlled surface transformation on micro- and nanoscale, thereby significantly change its properties and transform its functionality without affecting the properties of the bulk material. These modifications, occurring in a thin surface layer, depend on laser parameters (orientation of light, pulse fluence, pulse duration, polarization and wavelength) and processing environment.

The processing environment has a significant influence on the surface morphology and chemistry of the material. When laser surface processing of stainless steel is carried out in an argon environment, it effectively reduces the formation of toxic chromium oxides, thereby enhancing biocompatibility in terms of adhesion behaviour, cellular viability, cell shape, and cell morphology as compared to samples processed in ambient conditions. These findings underscore the potential of laser surface functionalization in optimizing cellular responses and improving biocompatibility properties of metallic biomaterials.

Keywords: laser processing, surface functionalization, stainless steel, biocompatibility

Magnesium Alloys With High Ignition Temperature

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High demands for weight reduction and improved fuel efficiency has led to a growing interest in magnesium alloys. With their low density and high strength-to-weight ratio, magnesium alloys have the potential to significantly reduce the weight of vehicles, resulting in lower fuel consumption and reduced emissions, aligning with the need for environmentally-friendly transportation solutions. Nevertheless, magnesium alloys come with their own set of challenges. They exhibit high reactivity with oxygen, poor corrosion resistance, and a notable flammability risk. These drawbacks were so significant that the use of magnesium alloys in aircraft cabins was banned for safety reasons until 2015. The lifting of this ban by the Federal Aviation Administration (FAA) has sparked increased interest in the application of magnesium alloys in the aviation industry.

In this study, we focused on Mg-Y based alloys containing further alloying elements such as Ca and Zn. The addition of these elements resulted in improved mechanical properties and ignition resistance of prepared alloys. Specifically, the alloying elements contributed to the formation of resistant oxide layers, leading to higher ignition temperatures (Y and Ca), enhanced strength (Y and Zn), and reduced materials costs (Ca and Zn). The alloys were prepared by melting the constituents in an induction furnace and casting them into brass mold. The microstructures of the prepared samples revealed a solid solution of alloying elements in magnesium, supporting increased resistance to ignition. Furthermore, the equilibrium phases corresponding to the specific chemical composition of each alloy, which are responsible for the strengthening of the materials, were analyzed. This project was supported by GACR No. 22-22248S and by specific university research – project No. A1_FCHT_2023_009.

Recycling of Nickel Swarf into Wire Form using CONFORM SPD Technology

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The recycling of nickel swarf generated from metalworking processes offers an opportunity for sustainable resource utilization and the recovery of valuable nickel content. This abstract explores the feasibility of recycling nickel swarf by applying CONFORM SPD (Severe Plastic Deformation) technology to transform it into wire form. The study employs characterization techniques, including optical microscopy and hardness measurement, to evaluate the microstructural changes and mechanical performance of the recycled nickel wire.

The potential applications of recycled nickel wire in industries such as electrical and electronic components, automotive, and aerospace are expected, as these sectors extensively utilize nickel wire. The findings of this study demonstrate the viability of recycling nickel swarf into nearly fully dense wire form using CONFORM SPD technology. The subsequent diameter reduction is accomplished through the rotary swaging process. The input swarf is conglomerated into pellets prior to the ECAP (Equal Channel Angular Pressing) processing. The research provides valuable insights into the structural and mechanical properties of recycled nickel wire, thereby enabling the sustainable utilization of nickel resources in wire manufacturing.

Overall, this research demonstrates the feasibility and potential of recycling nickel swarf through CONFORM SPD technology to produce high-quality nickel wire. The findings contribute to advancing sustainable metal recycling techniques and underscore the importance of responsible resource management. The study encourages the adoption of circular economy principles, fostering resource conservation and the responsible utilization of materials.

Evaluation of Steel Corrosion Propagation in Blended Cements Using Multiple Corrosion Characterization Techniques

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Mineral admixtures can refine the pores and change the pore solution composition in cementitious materials. Pore refinement is a well-known beneficial effect that can slow down chloride penetration and the carbonation progression. Both mentioned parameters can postpone corrosion initiation times, reduce corrosion rates of embedded steel, and influence the type of corrosion attack. Long term impact of these effects on steel corrosion is not yet well understood.

In this study, mortar specimens with embedded steel rebars were made from multiple cements blended with natural pozzolana, fly ash and blast furnace slag. Half of the specimens were carbonated naturally, while the other half were exposed to accelerated carbonation. The specimens were additionally exposed to cyclic wetting with 3.5% sodium chloride solution to initiate the corrosion processes. Cement, mortar and pore solution properties were examined using the following techniques: XRD, XRF, Hg porosimetry, phenolphthalein test and ion chromatography. Throughout the 1-year chloride exposure period, corrosion processes were monitored using embedded ER sensors and the galvanostatic pulse technique. After the exposure, the corrosion damage of embedded steel was examined with optical microscopy and the microCT technique.

Using multiple complementary characterisation techniques, and doing statistical evaluation from 6 identical specimens per mortar, allowed us to get a more accurate long-term evaluation of corrosion behavior in various types of mortars[1]. The results showed that both porosity and carbonation had a significant impact on corrosion behavior, with carbonated mortars showing shallower damage over a larger surface area. This effect was more pronounced for blended cements that exhibited greater susceptibility to carbonation, while OPC was prone to localised corrosion damage, regardless of carbonation[2]. Eventual impact of these parameters to the service life of reinforced concrete structure was also addressed.

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The research of structures for organic-inorganic hybrid solar cells

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In this work, Authors team have presented the investigation of the structure, optical and electrical properties of 3rd generation solar cells based on hybrid structure containing inorganic semiconducting mesoporous layer, photosensitive, organometallic dye and polymer solid state active transport layer (HTL) – spiro-OMeTAD. The mesoporous layer has been created by blends containing nanoparticles/nanowires (3d/1d) of ceramic semiconductors.. The architecture of hybrid solar cells was manufactured using a combination of modern technologies allowing for fast and economical consumption of starting materials and energy. The 3d/1d structure has been deposited with use screen printed method, spiro-OMeTAD was deposited by spin-coating method, and the Ag layer has been used by sputtering method. The structure and topography of individual cell layers was examined using an atomic force microscope (AFM) and a scanning electron microscope (SEM). The optical and electrical properties of created semiconductor mesoporous layers as well as spiro-OMeTAD/ and Ag layers were tested using UV-Vis spectrometry (based on the analysis of the light absorbtion results will determine Eg – the band gap widht, k – the extinction coefficient ,the n - refractive index, the real and imaginary part of the dielectric constant).The influence of the physical properties of the single layers on the solar cells performance have been determine by current - voltage (I-V) characteristics alalysis under stanard test conditions (AM 1.5, 1000 W/m2).The characteristics mealures allowed for determination and analysisbasic parameters of the manufactured hybrid photovoltaic devices: Isc- short circuit current, Voc -open circuit voltage, IM – current at maximum power , UM – voltage at maximum power, PM – maximum power of a solar cell, FF – filling factor, Eff- efficiency.

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Annular Laser Beam Intensity Distribution as a Tool to Influence the Performance of Directed Energy Deposition of Metal Powder

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Directed energy deposition (DED) of metal powder using a laser beam is one of the established additive manufacturing (AM) processes for metals. The metal powder is deposited by delivering it in a melt pool created by the laser beam on the surface of the workpiece. The characteristics of the process and the deposited clad depend not only on the process parameters, but also on the laser beam intensity distribution (LBID) and its interaction with the powder. The recently introduced annular laser beam (ALB) DED head with axial powder feed enables shaping of laser beam intensity distribution (LBID), which has been proven to be an influential process parameter[1]. In this contribution, the influence of LBID on the DED process and the resulting clad is investigated by considering three different LBIDs: Ring, Top-Hat and Gaussian-like LBID. Based on the experimental results, including high-speed camera images of the melt pool, measured powder-catchment efficiency, and clad properties, it was shown that the LBID has the greatest impact on process performance at a lower surface energy density, where the LBID-dependent distribution of delivered energy between the powder stream and the workpiece is most pronounced. Namely, due to the intensity peak in the center of the Gaussian-like LBID, most of the ALB energy is delivered to the powder stream, resulting in the highest powder-catchment efficiency (90%) and the smallest but unevenly distributed dilution cross-sectional area. On the other hand, due to the intensity peak at the edge of the ring LBID, most of the ALB energy is delivered to the workpiece, resulting in a lower powder-catchment efficiency (77%), but a larger and more evenly distributed dilution cross-sectional area. For the same reason, the ring LBID also outperformed the Gaussian-like and top-hat LBIDs by providing higher stability of the melt pool, lower porosity of the interface between the workpiece and clad, and higher quality of the metallurgical bond.

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Conductometry Analysis – Beneficial Method for Determining the Chemical Composition of Alkaline Silicate Solutions

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The study deals with the methodology for determining the chemical composition of alkaline silicate solutions. Nowadays, the most widely used method in the industry is the acid-base titration. This technique is very accurate for the determination of alkali content (e.g. Na_2O, K_2O, Li_2O). However, the problem arises in the titration of SiO_2, since the color change of the methyl red indicator is very slow and therefore the equivalence point is unclear. The main aim of this work is to present the benefits of conductometric titration, where the equivalence point is indicated by a sudden change of conductivity. The applicability of the method has been verified with other analytical techniques, such as ICP-OES and gravimetric analysis. The results mutually confirmed similar values of the obtained silicate module (molar ratio of SiO_2 and alkaline oxide) both in the case of sodium, potassium and lithium water glasses. Contrary, the previous acid-base titration recorded deviations of a few percent. Based on the obtained results, one can say that the conductometry is a very promising method providing an accurate, fast, and instrumentally undemanding chemical characterization of alkaline silicate solutions.

Development of the Low-Carbon Wrought Aluminium Alloys based on Post-Consumed Scrap

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The recycling of wrought aluminium alloys from end-of-life products is only carried out to a limited extent. The obstacles are the lack of: (i) appropriate chemical composition of the recycled melt and (ii) sufficient reliable sources. Both can be eliminated through the consistent traceability of alloys in end-of-life products at all stages of circular aluminium management. This paper describes the process of ensuring the universal traceability of aluminium alloys by type of alloy, by manufacturer, and by location in the end-of-life product. Tracking begins with the disassembly of end-of-life products into their components or components made from wrought aluminium alloys. We have built an innovative basic concept of ensuring the traceability of aluminium alloys using barcodes, well-adaptable for further upgrading. The solution enables the consistent separation and extraction of the highest-quality scrap from end-of-life products, comparable to the quality of the return material. This is, as an option, usually returned to the alloy manufacturer, and can be melted directly into wrought alloys. The solution enables a significant decarbonization of production and an increase in the added value of the products.

The innovation enables the production of selected types of wrought aluminium alloys for the automotive and aviation industries, with a carbon footprint and sustainability index chosen and defined by the customer. With this aim in mind, we designed alloys with a large proportion (>70%) of scrap based on end-of-life products and an appropriate production technology that allowed us to maintain the standard quality of the produced alloys. The production of wrought aluminium alloys with a large proportion of scrap from end-of-life products is a significant innovative step toward the decarbonization of the aluminum industry.

Effect Of 3D-Printed Fibers On Concrete

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Nowadays one of the most important parameters in construction is the sustainability due to different economic and energy efficient problems [1]. It is widely known that concrete has a very high compressive strength. However, resisting tensile loads is one of its weakest aspects. The addition of fibers as reinforcement, has proven to be very efficient throughout time [2]. Therefore, this research is trying to combine these two factors, sustainable materials to reinforce concrete through a viable approach. Specifically, the research considers the effect of 3d-printed fibers using recycled polymeric material on the mechanical properties of concrete. The selected polymers are Polylactic Acid (PLA) and Acrylonitrile Styrene Acrylate (ASA). Two different shapes of fibers designed and printed for this purpose intending to achieve a good adhesion in the mixture. The one is a cyclic fiber 2cm diameter, and the other one is a straight 3cm long as they depicted in figure 1. Five different concretes were laboratory produced and cylindrical specimens were formed. The influence of fibers was examined through tensile and compressive strength of the specimens at 7 and 28 days based on BS EN 12390-6:2009. The results shown that polymer fibers addition in concrete contributed positively to enhancing the mechanical properties of the material, especially the ASA and PLA cyclic fibers. They were found to be more effective than straight fibers in the concrete samples, so the shape of the fiber played an important role in the behavior of the specimen. Considering the polymer material, ASA seems to be more effective than PLA in both shapes of fibers.

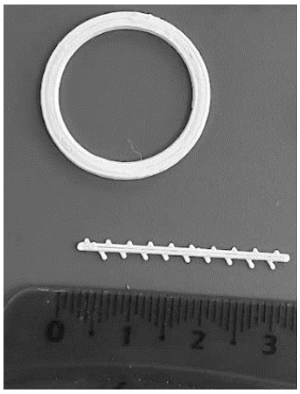

Figure 1: Fibers

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ZnO nanorod arrays for photocatalytic degradation

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The presence of organic pollutants in the environment and their alarming negative effects on the environment and human health have been described in numerous studies [1]. Various methods have been developed to reduce and degrade organic pollutants with varying effectiveness [1]. Synthetic, heterogeneous, semiconducting, and multidimensional ZnO is utilized in various fields [1,2]. ZnO can act as a photocatalyst in the oxidation of organic pollutants, both in powder and thin film form [3]. The main advantages of ZnO thin films are easier and more efficient reusability and the possibility of using them in continuous processes [3]. Several methods are known for the synthesis of ZnO, among which hydrothermal synthesis is widely used due to its advantages such as low process temperature, low cost, and environmental friendliness [2]. It enables the deposition of ZnO on the substrate and offers the possibility to control and optimize the size and morphology of the resulting ZnO crystals.

In this study, the ZnO nanorod arrays were synthesized in two parts. First, a solution of zinc acetate dihydrate (0.50 and 0.25 M) was spin-coated onto glass substrates and annealed at 360 °C for 5 hours. In the second part, the hydrothermal growth method was performed at 90 °C for 3 and 6 hours. The morphology and size of the synthesized particles were characterized by SEM. The photocatalytic activity of the ZnO nanorod arrays was evaluated by studying the degradation of a 5 ppm caffeine solution under simulated solar irradiation using UV-Vis spectrophotometry. The results show that ZnO films are photocatalytically active and that their catalytic performance is affected by the synthesis conditions. The ZnO films can be reused since their photocatalytic efficiency does not change significantly during the cycle. Since the stability of the catalysts is important from both an environmental and economic point of view and the results obtained are promising, it would be useful to further improve the ZnO films (e.g., by doping) and to test the photocatalytic degradation of other pollutants.

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The influence of the position of the SLM printed TiAlV part on microstructure, porosity and corrosion

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Selective laser melting (SLM) is the most widely used process in additive manufacturing (AM) of complex 3D metal parts. However, the consistency of the properties of the printed parts, which depends on the position of the part on the baseplate, among many other process parameters remains a challenge. Namely, SLM process conditions are strongly influenced by the flow of inert gas and associated by-products, which flow with the inert gas and can affect the microstructure and mechanical properties of the parts placed at different locations on the baseplate[1].

The consistency of printed TiAl6V parts is particularly important as they are mostly used as medical implants or lightweight components in aerospace industry. TiAl6V is an alloy, in which two microstructural phases (α and β) can be present, depending on the conditions of the SLM process. The microstructure and mechanical properties of the printed parts as well as the porosity are therefore also influenced by the location dependent SLM process conditions.

The aim of this study is therefore to characterize and compare the properties of TiAl6V metal parts produced by SLM process at different locations on the baseplate. For this purpose, SLM samples of Ti-6Al-4V (Grade 23, Heraeus) powder were fabricated at nine different positions on the baseplate. Surface roughness, porosity, microstructure, hardness and corrosion properties were investigated, compared and evaluated. A 3-D porosity of samples, which showed a strong dependence on the position of the sample, was determined using a novel 3D micro-computed tomography method.

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Copper Effect on Toughness in High-Strength Steel for Spring

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The alloying by copper is commonly used in ferritic or in maraging steels. In the first case, the copper is used for effectively solid solution strengthening. In the second, it is used precipitation strengthening. In the section of middle carbon steel is copper generally considered a harmful element. This communication was aimed to mapping influence of copper in various conditions of quenching and tempering in spring steel grade 54SiCr6 with and without 1,5 w.% Cu. The results of conventional quenching and tempering showed that copper precipitates improved strengths at the expense of elongation and area reduction at tempering above 400 °C. On the other hand the effect in solid solution at tempering below 300 °C caused no strengthening but increase of plastic properties. The ultimate strength was slightly decreased.

The optimized heat treatment was developed for high-strength application by fast induction heating. The yield and ultimate strengths was improved about 150 MPa in comparison with conventional hardening at tempering 350 °C. The elongation and reduction of area were at the same in steel without copper but on the contrary they were improved in 54SiCr6Cu at higher values.

The ultra high-strengths could be achieved by strain assisted tempering (SAT). The strength levels over 2700 MPa could be reach at the cost of loss of elongation. The difference of behavior is negligible between 54SiCr6 with and without Cu. The mechanical properties are almost the same.

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Anfis System for Cutting Tool Loads Modeling fn Helical-End Milling of Layered Functionally Graded Metal Materials

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Layered functionally graded metal materials are increasingly being used in the automotive industry to produce the metal forming tools. The economical manufacturing processes of such advanced materials is laser engineered net shaping (LENS), which uses a laser to melt metal powder into thin layers. By stacking layers, the shape of the forming tool is created layer by layer based on the CAD model. The machining of such layered materials is extremely demanding, especially from the point of view of the durability of the cutting tool. Impact loads on the cutting edge of the tool have the greatest effect on reducing the tool life of tools. Minimizing the loads on the cutting edges is decisive for the appropriate planning of machining technology and ensuring the machining quality. The purpose of the research is to replace the long-term analytical determination of maximum tool loads with the autonomous generation of predictive models based on machine learning and as few machine experiments as possible. Therefore, a system of three ANFIS (adaptive neuro-fuzzy inference system) was created to simulate the maximum loads of the cutting tool in helical-end milling of 4-layer functionally graded material 16MnCr5/316. The simulator considers the different machinability of individual material layer. Modeling data was obtained based on machining experiments on a machining center Heller. A 9 mm diameter carbide helical end mill with two flutes is used. A piezoelectric dynamometer was used to measure the maximum loads on the cutting edges of the tool. A comparison of the simulator with a linear regression model and experimental data showed that the system accurately predicts the maximum loads of the cutting tool when milling 4-layer functionally graded metal material for a wide combination of specific cutting parameters. The simulated values of the cutting tool loads are in good agreement with the measured values. The maximum error of the simulated load values is 4.79% for all the comparison tests performed. The obtained accuracy of the ANFIS system is 97.9%.

Fatigue behaviour of brazed joints for heat exchangers

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The plate heat exchanger (PHE) is a component that provides heat to be transferred from hot water to domestic cold water without mixing them with high efficiency. Over the lifetime of the PHE, cyclic pressures act on the brazing points and the plates, and this may lead to fatigue failure. The fatigue behaviours of the PHEs, which are designed by using copper-brazed 316L (also known as 1.4404) stainless steel, were investigated in this study by performing fatigue tests to obtain the S-N curve of the analyzed brazed joint. The fatigue tests have been performed on the Vibrophore 100 testing machine under the load ratio R = 0.1 for different values of calculated amplitude stress. Based on the obtained experimental results, an appropriate material model of the analyzed braized joint has been created, which was validated with numerical calculation in a program code Ansys. A validated material model can then be used for the subsequent numerical analysis of PHE.

Advanced Cooling Approach Combined with AI-Supported Material Simulation

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The article illustrates advances in water box design. Especially in contrast to existing ones, this new design offers increased flexibility as well as high-precision cooling in combination with a new automation and control concept.

Furthermore this contribution will show how the use of advanced cooling nozzles results in cooling to a required temperature by optimally controlling the temperature. Hereby, extremely homogeneous technological material properties can be guaranteed especially for thicker dimensions of the rolled product.

Realistic material simulation is becoming increasingly important in the mapping of rolling and cooling processes. The more accurate the material data and models are, the better the match between the simulation and the results of the production process will be. The paper demonstrates the use of AI in the form of neural networks for the simulation of phase transformation processes in steels during cooling from the forming heat.

Examples show the influence on the development of microstructures in long products.

Bioabsorbable zinc alloys – the effect of materials processing on microstructure, mechanical and corrosion properties

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Zinc-based materials are intensively studied in relation to the possible application like bioabsorbable medical devices including stents or various fixation devices like screws, and plates. Zinc is favourable due to its excellent biocompatibility and rather low corrosion rate with the absence of concomitant hydrogen release making him an interesting alternative to Mg-based bioabsorbable implants. To comply with the high requirements on mechanical and degradation properties, zinc has to be appropriately alloyed and thermomechanically processed enabling significant improvement in strength and also elongation. One of the remnant shortcomings is related to the pour mechanical strength at increased temperate (even body temperature at 37 °C) and low creep resistance, both these factors are related to the low recrystallization temperature of pure zinc. In the last years, powder metallurgy techniques have been suggested to overcome the issues of low strength and poor creep behaviour, further with the tendency to support a more homogeneous corrosion process preceding the onset of localized corrosion. In this work we try to insight into the behaviour of several materials consisting of key suggested alloying elements for zinc (Mg, Ag, Sr) and processed by various techniques including conventional casting and extrusion but also powder metallurgy methods including mechanical alloying (MA) and spark plasma sintering (SPS). Our results indicated a strong positive effect of thermomechanical processing (hot extrusion) on materials microstructure with a reduced grain size of up to 2 µm and increased mechanical properties (strength, elongation). However, these results were even overcome by the application of powder metallurgy methods resulting in grain and intermetallic particle size below 1 µm and slightly improved strength over conventionally processed materials attacking 400 MPa. Furthermore, a higher tendency for uniform corrosion has been observed. In sum, powder metallurgy products are suggested as highly competitive to conventionally processed alloys. The study has been funded by the Czech Science Foundation, project 21-11439K.

Composite material based on polymer matrix reinforced with Al-based Quasicrystal powder

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Composite materials are innovative materials synergistically combined to create a material with enhanced properties and exclusive applications. In this work, we have studied possibilities for a unique combination of the best properties of a technical polymer and a quasicrystalline material for enhanced mechanical properties of such a composite. Quasicrystals (QCs) can offer an excellent compromise between high hardness and low adhesion energy for non-stick applications [1]. We anticipated that these new quasicrystal-based composites will maintain functionality and resist fatigue failure and wear, even under long-term use in normal or extreme conditions.

Scanning electron microscopy (SEM) was used to specify the microstructure of the composite materials with different fillings of $Al_{59}Cu_{25}Fe_{13}B_3$ (at.%) QC into the Polyphtalamide polymer matrix (Fig. 1). Mechanical tests showed that the material breaks differently when we add QC into the polymer. Measurements of the Vickers hardness (load of 200g) of the composite materials indicated that 5 vol.% of QCs added into the polymer matrix does not have a significant influence on the overall Vickers hardness (~ 15 HV) but becomes significant at additions of 30-35 vol.% (~ 24 HV). The surface energy for the composites is between 37 – 39 mJ/m^2, which is comparable to the surface energy of both the naked polymer Polyphtalamide (39 mJ/m^2) and QC equipped with his native oxide layer (average around 37 mJ/m^2) in the air. Conventional metallic fillers like aluminium alloys or stainless steel would make this figure much higher.

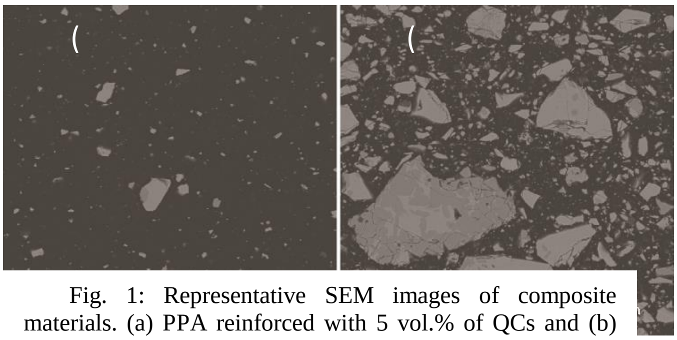

Fig. 1: Representative SEM images of composite materials. (a) PPA reinforced with 5 vol.% of QCs and (b) PPA reinforced with 35 vol.% of QCs.

Acknowledgement

This work was performed within the frame of the International Research Project (IRP) PACS2. The research was financially supported by Slovenian Research Agency (P2-0084), CNRS and Université de Lorraine, France, and the European Union Horizon 2020 research and innovation programme under grant agreement No. 823717 – ESTEEM3.

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Characterization of Primary Austenite Grains and Retained Austenite in Steel Alloy: A Comparative Analysis of Metallography, EBSD, and XRD Techniques

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The accurate characterization of primary austenite grains and the quantification of retained austenite in steel alloys are critical aspects of materials science and metallurgy, with implications for the mechanical properties and performance of these materials. This study presents a comprehensive investigation into two distinct methods for determining primary austenite grains: metallographic techniques involving etching and Electron Backscatter Diffraction (EBSD) combined with parent grain reconstruction. Additionally, we compare the measurements of retained austenite using metallographic techniques, EBSD, and X-ray Diffraction (XRD) techniques.

Metallographic techniques have long been employed for primary austenite grain analysis. In this study, we utilize traditional metallography with selective etching to reveal the primary austenite grains within the microstructure of steel alloys. The etching process highlights grain boundaries and facilitates the identification and measurement of primary austenite grains, providing valuable information about their size, distribution, and orientation. Complementing the metallographic approach, EBSD is employed to determine primary austenite grains through crystallographic orientation mapping. EBSD data is processed to reconstruct parent grains. This method offers high spatial resolution and provides insights into the crystallographic characteristics of the primary austenite phase. In our case, two different specimens were used in comparing metalographic techniques and EBSD austenite parent grain reconstruction.

The retained austenite content in the two specimens was also investigated using multiple techniques. Metallography allows for direct observation of retained austenite regions within the microstructure, and different etchants or etchant concemtrations can give significantly different results. On the other hand, EBSD provides crystallographic information, aiding in the identification and quantification of retained austenite; but it is time consuming and the investigated area can be too small to see the overall picture. XRD does not rely on image data, but the interpretation through Rietveld simulation and refinement can be challenging in case of additional phases.

Numerical Analysis Of High-Strength Structural Steel S960 Tensile Test

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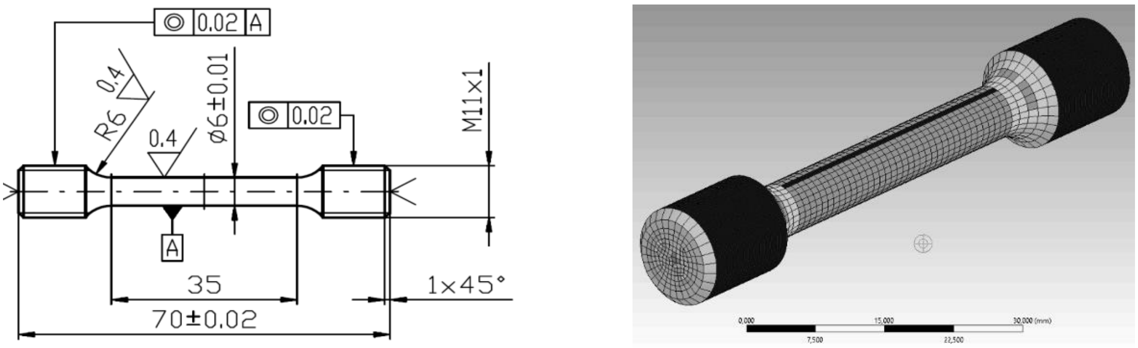
This contribution presents the results of the comparison between the experiment and the numerical model of such a test of high-strength structural steel (HSS) of S960 grade. The finite element numerical model (FEM), which accurately simulates the experiments, was prepared based on the available information from tensile tests of high-strength steels. With this analysis, it is possible to determine other HSS parameters by inverse analysis. A standard tensile test was performed on a circular specimen 70 mm long and 11 mm in diameter at the edges, and 6 mm in the middle (see Fig.1(a)). The specimens were successively loaded under tensile stress. The test was carried out on a Zwick-Roell apparatus according to EN ISO 6892-1 [2]. Five test specimens were prepared to account for statistical inaccuracies, and a model accurately simulating the tensile test was created in the commercial software ANSYS [1]. The finite element mesh has a size of 1.5 mm (see Fig. 1 (b)). This model was used to estimate the material parameters of the analyzed S960 grade steel.



(a) (b)

FIG. 1. (a) Drawing of the test sample for the experiment and model. (b) Numerical model prepared in Ansys Workbench.

This contribution has been developed as a part of the research project GACR 21-14886S "Influence of material properties of high strength steels on durability of engineering structures and bridges" supported by the Czech Science Foundation.

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Characteristics of AlCrSiN Coating Deposited by Planar Cathode with Arc Technology

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Coatings produced by physical vapour deposition are recognised as one of the very interesting premium technologies for protecting and modifying products' surfaces due to the real possibility of synthesising materials with unique physical and chemical properties [1]. One of the most effective coatings of this type is the AlCrSiN hard coating. Furthermore, due to their outstanding mechanical properties and oxidation resistance, AlCrSiN coating has been developed for high-temperature wear applications, such as cutting tools, extrusion dies or die-casting moulds [2].

The AlCrSiN coating was deposited in the arc PVD unit PLATIT π1511. Tests using the HRTEM confirmed a nanocrystalline structure of the investigated coating. Furthermore, XPS evaluated the chemical bonding of particular elements in the tested coating. In sliding dry friction conditions, the investigated coating reveals high wear resistance. In addition, the coating demonstrated a dense cross-sectional morphology and good adhesion to the substrate.

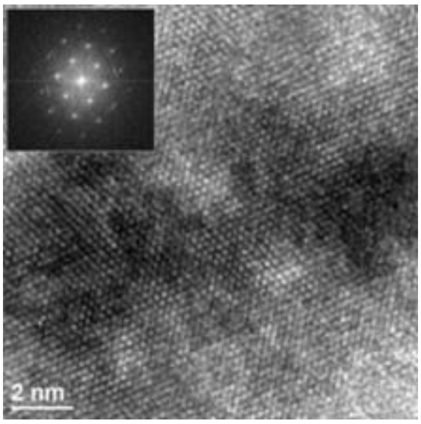

Figure 1. Structure of AlCrSiN coating, HRTEM image and the corresponding Fourier transform (FFT) pattern.

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Comparison of Hybrid Additive Manufactured Parts Properties for Three Different Alloys

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It is often desirable to produce a component with different technologies to achieve unique properties or a combination of good mechanical properties and productivity. Recently, hybrid additive manufacturing has gained attention, where multiple technologies can be combined or linked in a process chain. The primary motivation is to exploit the benefits of various technologies in one product. Hybrid additive manufactured parts were produced from Inconel 718, 625 and titanium alloy Ti6Al4V in the scope of this study employing powder bed fusion and direct energy deposition in a process chain. The focus of the study was the metallurgical and mechanical characterisation of the hybrid parts compared to individual technologies. The hybrid sub-parts were built first by powder bed fusion and then finished by DED. Samples were made with longer axes in vertical and horizontal x orientation. X-ray computed tomography, microstructural examinations, and tensile testing coupled with digital image correlation were employed to assess the parts. Results showed that the mechanical properties of hybrid additive manufactured parts relate to DED materials' properties. In addition, local changes in the temperature proved to cause problems with porosity generation at the interface and below standard mechanical properties with parts having small cross-sections.

Cement mortars with the addition of PCM as an innovative construction material for maintaining a pleasant living environment in households

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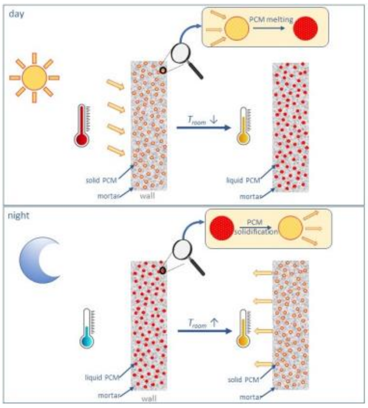
One of the big goals of the EU, in accordance with the European Green Deal, is to make our society carbon neutral by 2050. In Europe, slightly more than 20% of all energy produced is consumed in households largely for the purpose of conditioning the living spaces. Simple reflection suggests that the above facts represent a significant economic cost for individual households and, last but not least, adversely affect the environment due to the way energy is produced. One of the possibilities of more efficient use of energy to achieve favorable living conditions in buildings is the greater use of so-called smart materials in construction, which also includes materials with a mineral binder (mortars, plasters and concretes) with the addition of phase-changing materials (PCMs). PCMs used in construction are materials that show a phase change in the temperature window of favorable living temperatures. Their characteristic is that, in the case of phase change, i.e. transition from the liquid phase to the solid and vice versa, accept or release a large amount of heat. The addition of PCM to mortars or plasters therefore changes the specific heat capacity of the material [1][2].

The aim of this work is to examine the possibility of using PCM in cement plasters and their influence on material's functional properties i.e., mechanical strength, thermal properties and microstructure evolution. Cement plaster was prepared using pure Portland cement clinker CEM I 42.5 N as a hydraulic binder and dolomite as an aggregate. The PCM addition was set to 5 vol.% or 10 vol.%. The results of mechanical tests revealed that no significant loss in compressive or flexural strength is observed if the PCM addition does not exceed 5 vol.%. Additionally, PCM microcapsules were homogeneously distributed throughout the plasters and remained undamaged after plaster preparation and subsequent hardening. The heat effects of PCM phase transformations can be clearly measured repeatedly in 10 cycles without losing the potential of latent heat absorption or latent heat release in solid-liquid or liquid-solid phase transformation during heating or cooling, respectively.



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A Coupled CFD-DEM Approach to Modelling Powder Stream in Direct Energy Deposition

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Metal-based additive manufacturing (AM) is revolutionizing the production process and introducing unprecedented capabilities, which are quickly becoming indispensable across a wide range of industries [1]. Direct Energy Deposition (DED) in particular is exhibiting a high potential for space applications due to no imposed limitation on the size of manufactured objects and the ability to operate in micro-gravity conditions [2]. DED however remains hindered by poor deposition quality and reproducibility, which appear to originate in the powder stream condition [3]. Increased accuracy of the blown powder dynamics hence represents a crucial ingredient of next-generation DED models [4]. Powder stream is usually modelled with the use of computational fluid dynamics (CFD) as a two-phase flow problem involving a dispersed second phase [5]. Powder particle collisions and their interaction with the melt-pool cannot be accounted for by these models and are regularly disregarded on the account of these particles occupying a small volume fraction in the carrier gas flow [5]. This assumption was put to the test using a Discrete Element Method (DEM) model of the particle stream of a discrete coaxial nozzle. While neglecting the interaction between carrier gas and powder particles, the results showed that non-negligible portions of powder grains are involved in grain collisions with substantial rebound angles, which underlined the need to account for inter-particle interaction in DED stream models. This sparked the development of a fully coupled CFD-DEM model of powder stream in DED, the results of which will be presented at the conference.

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Comparison of Electrochemical and Tribocorrosion Properties of Conventional and Quasicrystalline Aluminium Alloys

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In this research, corrosion and tribocorrosion properties of two types of aluminium alloys, used in automotive application, are studied: conventional DIN 226 and newly developed aluminium alloy, reinforced with quasicrystalline phase. Electrochemical and tribocorrosion tests were performed at room temperature in phosphate buffer solution with pH = 7. In electrochemical tests, 1 mM chloride was added to the test solution to demonstrate the effect of de-icing agent during the winter season. The difference between different alloys will be sought.

The differences between materials will be also determined by measuring the friction force and material wear during tribocorrosion experiments. Corrosion products and wear tracks will be analysed with SEM/EDS and optical microscope. Basic electrochemical characterization in terms of open circuit potential, linear polarization, electrochemical impedance spectroscopy and cyclic potentiodynamic polarization will be performed to compare corrosion resistance of both aluminium alloys. The contributions of electrochemical, chemical and mechanical wear will be evaluated and compared.

The effect of quasicrystalline phase in an aluminium alloy on corrosion and tribocorrosion properties will be elaborated.

Zn–Mg–Sr Alloy Synthesized by Mechanical Alloying and Spark Plasma Sintering for Bioapplications

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Zinc is recognized as a promising material for biodegradable applications, primarily due to its remarkable biocompatibility and reasonable corrosion rate, which avoids the formation of toxic byproducts and hydrogen release. However, its mechanical properties are often inadequate for many medical applications.

This study focuses on addressing the mechanical limitations of zinc by refining its microstructure, particularly by reducing grain size. To achieve this, we employ a combination of two powder metallurgy techniques: mechanical alloying (MA) and spark plasma sintering (SPS). By utilizing these methods, we prepare a nanograin material with a composition of Zn–1Mg–0.5Sr. Both selected alloying elements to improve the mechanical properties and biocompatibility of zinc alloys.

The compacted material exhibits a microstructure comprising zinc grains and intermetallic phases of Mg_2Zn_{11} and $SrZn_{13}$, ranging in size from 100 nm to 500 nm. This refined microstructure leads to exceptional mechanical properties, including high hardness (86 HV1) and compressive strength (327 MPa). Notably, the proposed combination of techniques offers an innovative approach to achieving extremely fine microstructures while minimizing significant grain coarsening during powder compaction at elevated temperatures.

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Imaging of HiPIMS Plasma by High-speed Camera

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Magnetron sputtering is a widely used method that utilizes plasma for the deposition of high-quality thin films. A commonly accepted belief has been that magnetron discharges are azimuthally homogenous; namely, such homogeneity can be observed with the naked eye or by images recorded with a standard camera. Using high-speed cameras researchers have discovered that magnetron plasma is not homogeneous instead, it is concentrated in dense regions called spokes. These structures have triangular shape, form quasi-periodic patterns, and rotate with velocities in the 1-15 km/s range. Spokes have been observed in continuous DC magnetron sputtering [1], pulsed high-power impulse magnetron sputtering (HiPIMS) [2] and oscillatory RF magnetron sputtering [3].

In this work, we performed a detailed imaging study of individual pulses of HiPIMS plasma by a high-speed camera. The plasma was investigated for a range of pressures (0.25-2 Pa) and peak currents (10-400 A). Experiments show that plasma in the initial stages forms spoke patterns similar to the ones observed in DCMS. During this period, spokes rotate in the direction opposite to drifting electrons. As discharge current increases above a certain threshold, typically around 20-30 A, a chaotic re-organization of plasma occurs. After this period, stable spoke patterns begin to form that exhibit triangular shape. In this stage, spokes rotate in the same direction as drifting electrons.

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Additively manufactured high-strength aluminium alloys

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Laser powder bed fusion (LPBF) is one of the most often used additive manufacturing (AM) technique, also known as a 3D printing. It uses technology that allows adding material during the simultaneous creation of a final object. It utilizes data from computer-aided-design software or 3D object scanners to govern the hardware and deposit material layer by layer in order to create geometric shapes. It is being widely used by industries where the manufacturing of customized, high-added-value and geometrically complex metal components is a primary task. LPBF is a process where metal parts are built by selectively melting and fusing metallic powder. However, only a limited number of metallic-based alloys can be currently additively processed due to the peculiarities of the solidification process. In particular, high-strength, unweldable alloys such as high-strength aluminium and nickel super alloys demonstrate low selective laser melting processability due to their high solidification-cracking susceptibility during the process.

Conventionally processed, high-strength aluminium alloys are widely used for automotive and aerospace applications. With the emergence of LPBF technology, they are confronted with a number of difficulties due to the phenomenon of solidification-cracking susceptibility. This solidification cracking is related to the alloy’s characteristics, such as a large solidification range, the solidification shrinkage, and poor fluidity of the molten phase. It occurs during the melt-pool solidification when the thin liquid film cannot accommodate the solidification shrinkage. An additional challenging issue is the evaporation of the volatile alloying elements (Zn, Mg, Mn, Li) during the process. This causes a modification of the composition, which could lead to an increase in the cracking susceptibility as well as changing the microstructure and the properties.

A parameter assessment has been carried out on the 3D printing process to obtain crack free printing of these alloys. We envisage a number of parameters to check, namely the temperature of the base plate, the laser power, speed and density. The aim of the study is to better understand (and subsequently control) the process and to obtain crack-free material.

Stabilisation of Annular Laser Beam Directed Energy Deposition of Metal Wire

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In the laser-directed energy deposition (L-DED) process of metal wire, a stable melt bridge between the wire-end and the workpiece surface must be established and maintained during process initialization and the stationary phase of the process. For this purpose, the process parameters that define the energy input into the process (laser beam power, wire and workpiece feed rates) must be well synchronized[1]. If the energy input is too low or too high instability of the process occurs, leading to wire-end stubbing or dripping phenomena[2,3]. To avoid these undesirable phenomena during the process of annular laser beam (ALB) DED of a metal wire, a process stabilisation system (PSS) was developed. The system consists of an integrated control unit and two sensors: a sensor of wire feed force, which was designed and printed by an SLM machine, and a sensor of electrical resistance between the wire-end and the workpiece. The signal from the force sensor is used to detect and prevent stubbing phenomena by controlling the wire feed and laser beam power. The signal from the resistance sensor is used to detect and prevent dripping phenomena by controlling the laser beam power. When an appropriate laser beam power is selected, the control system maintains laser beam power and process stability. However, if an inappropriate laser beam power is initially selected, the PSS iteratively sets either the lowest minimum or the highest maximum value of laser beam power that ensures a stable process, depending on the initial value selected. Thus, the proposed -PSS provides a robust, self-adjustable stabilisation of the process of ALB-DED of a metal wire by avoiding dripping and stubbing phenomena during the initialization and stationary phases of the process. The PSS also ensures successful termination of the process. As such, the system is essential for the stability of the L-DED metal wire process.

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Degradation of synthetic textile microplastic fibers by fungi and photocatalysis

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Numerous studies expose the catastrophic impact of plastic pollution on a daily basis. The research conducted to assess its impact on global ecology and human health suggests an immediate need for action. In particular, aquatic systems are full off toxic chemicals and small man-made organic debris that irreversibly break down into even smaller fragments through biotic or abiotic processes. Among these are microfibers from synthetic textiles.

Within the work, we explored the degradation of polyethylene terephthalate (PET), polypropylene (PP), and polyamide (PA) fibers for the purpose of remediation of wastewater from washing machines. By mimicking natural processes, we investigate the benefits of photodegradation enhanced by the use of a photocatalyst and biodegradation by fungi. In the study, photocatalysis was conducted for 48 hours in a covered quartz beaker. The beaker contained fibers, Milli-Q water, and photocatalyst; we tested TiO_2 and ZnO. Reactor systems were irradiated while stirring using a UV-vis simulated sun spectrum (Ultra Vitalux, 300 W, Osram). Biodegradation was performed by two selected species of fungi, *Pleurostoma richardsiae* and *Coniochaeta hoffmannii.* Sterilized plastic fibers were transferred to tubes with sterile M9 liquid medium. A cell suspension of each selected strain was added to the tube and incubated at 24°C for 2 and 6 months.

Microscopy analysis after the photocatalysis showed that the surface of individual fibers became rough with clear signs of partial degradation, which could not be observed on pristine fibers. We also observed a successful growth of fungi, indicating that their main food source came from fibers. Cross-sectional FIB-SEM analysis revealed details of the damage, and Raman analysis showed structural changes in the plastic material. The kinetics of both degradation processes are relatively slow; however, repetition and proper reactor design could potentially increase the dynamics of microplastics degradation.

Pre-Feasibility Study Results Of Usability of Sawing Sludge as Potential Material For Glass Production – A Case Study of Circular Economic Aspects from the Silicate Dimensional Stone Production

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In the framework of the transition of the mining sector to green, we cannot avoid the process of circular economy, which dictates, as a matter of course, the final use of all substances created in a unique technological process. Granodioritic micronized silt is formed in the technical processing and sawing of large constructional stone blocks (from the deposit located on the southern slope of Pohorje). The concessionaire deposits it in a suitably created landfill as part of mining operations. Regarding environmental and waste legislation, this quarry material is characterized as production residue or by-product, which, in case of inappropriate handling – storage, can even represent a potentially dangerous source of contamination with mineral dust.

Granodiorite results from an intrusion, forming a lenticular body – laccolith in the last crystallization stage during the regional deformations. Continuing the laccolith, the intrusions of aplite and pegmatite veins represent magmatic variations of the original tonalite-granodiorite magma, which are secondarily intersected.

After the material mineralogical analysis, it was established that such material could represent the input raw material for the production of packaging glass. Based on the preliminary simulations and compositional analysis, 5-10 wt% of the material can be mixed in the soda-lime glass batch to produce green or amber glass. Furthermore, by using sodium-rich alternative materials, significant reductions in GHG emissions can be realized in the carbon-intensive glass production industry.

In the case of the analyzed material sludge, it was found that the material fulfills the basic 3R processes (Reuse – Recycling – Remanufacturing), which, based on i) estimation of operating mining costs, directly affect the energy consumption of raw material extraction for glass production; ii) based on the analysis of quantity and costs benefits, it has a positive effect on the production processes of glass as the purpose of using the newly created product.

Genetic Algorithm-based Optimization of Laser Beam Path in Additive Manufacturing

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This study presents a methodology of genetic algorithm-based optimization of laser beam path for improving laser-based additive manufacturing (AM). The study focuses on AM with direct laser deposition (DLD) process. A simple thermal model is developed to simulate the effects of laser-induced heat input on the temperature distribution within the substrate during the process of deposition of one layer. The optimization approach aims to find solutions with more homogeneous temperature properties that minimize the thermal gradient on the substrate during the laser deposition process. This presumably results in lower residual stress and deformations of the substrate and more accurate 3D metal printing. The tool-path planning is formulated as the search for the optimal sequence of cell depositions that minimize the fitness function, which is composed of two primary components, i.e. thermal fitness, and process fitness. Thermal fitness is expressed as the average thermal gradient, and process fitness regulates the suitability of the proposed tool path for the AM process implementation. Various tool path generators are proposed to initialize the initial population of tool-path solutions. Generators are designed to implement standardized tool-path generators (such as raster, spiral, etc.), and a specialized stochastic-based path generator. Genetic algorithm-based tool-path optimization is proposed, where custom initialization, crossover and mutation operators are developed for application in laser-based AM. Simulation studies demonstrate the effectiveness of the genetic algorithm-based optimization in finding solutions that minimize the fitness function and therefore provide both thermally and for the AM process implementation more suitable laser beam path solutions. Compared to the traditional trial-and-error tool path formulations, the proposed approach offers an improved and automated solution for an efficient laser beam path in laser-based AM.

Examining corrosion currents of copper-steel coupling during early oxic phase with coupled multi-electrode array

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In several countries, a favoured design concept for nuclear waste disposal programs is a two part container consisting of iron-based inner structure with outer copper coating. Copper is being considered as a primary material for ensuring the effective containment of radionuclides. During the deposition process, a possibility of damage to the copper coating is identified. If such damage occurs, galvanic corrosion between copper and steel can happen. This present work focuses on examining corrosion current of steel when is galvanically coupled to copper in oxic environment with coupled multi-electrode array (CMEAs). Study will be performed in a simulated saline groundwater and in bentonite slurry at room temperature and under open circuit potential. The attention will be given to evolution of corrosion currents of 25 coupled electrodes, where only one is made of steel and others are made of copper. In early oxic phase when the copper coating in damaged, high corrosion currents are expected to be detected. In order to compare the evolution of corrosion currents without simulated container damage, we will also conduct CMEAs measurements on a sample where all 25 electrodes are made of copper. After CMEAs measurements, different microscopic and microCT scans will be conducted on electrodes to verify the type and extent of the corroded damage.

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Photocatalytic degradation of synthetic textile microplastic fibers with TiO_2 as photocatalysts

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Plastic, which was not so long ago considered the material of the future, is today one of the biggest environmental problems. The most common type of primary microplastics that enters the aquatic environment in large numbers are fibers released during the washing of synthetic textiles. Due to their small size, they do not enter the ecosystem only through wastewater, but also through sewage treatment plants.

In the present work, we tested a method for the degradation of microplastics from the wastewater of a washing machine, which is based on photocatalysis. In our study, the photocatalytic degradation of polyethylene terephthalate (PET) and polyamide (PA) fibers was carried out for 48 hours in a coved quartz beaker. The beaker contained fibers, 5 mg of TiO_2 as a photocatalyst, 5 mL of Milli-Q water and a stirrer. In a photocatalytic reactor, quartz beakers were placed on a magnetic stirrer and irradiated with simulated sunlight (lamp: ULTRA-VITALUX, 230 V, 300 W, Osram).

After photocatalysis, plastic samples were taken from the suspension and air-dried in a dust-free chamber. SEM analysis after photocatalytic degradation showed that the surface of the fibers became rough with clear signs of degradation, which could not be observed in the original ones. Cross-sectional FIB-SEM analysis revealed details of the damage. Changes in the chemical structure was analyzed by Raman spectroscopy, and ICP-MS analysis was used to analyze the amount of finer microplastic fiber fragments released into the suspension. In the future work, the presented degradation process will also be tested on real samples, which consist of different types of microplastic (PET, PA) and cotton fibers.

Efficiency Of Product Development Process As A Factor Determining Effectiveness Of Implementation Of Subsequent Project Phases Acc APQP

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Currently, with high market requirements for the final product, which is a car, most companies in the automotive industry are under great pressure related to minimizing the time for product development and high expectations regarding its reliability. In many cases, even a properly implemented APQP (Advanced Product Quality Planning) process must be supported by additional tools intended to increase the efficiency of implementing subsequent APQP phases; this is especially important for innovative products [1].

As part of the conducted research, a structured process of developing a new product or introducing changes to an already produced one was developed. The developed new tool is based on the assumptions of the P-D-C-A cycle (Plan-Do-Check-Act) and Design for Six Sigma. The main assumption when developing the new tool was to ensure the universality and simplicity of its use, regardless of the type of component being developed and the APQP phase in which the project is. The tool divides the product development process into 5 phases (Identity, Define, Design, Optimize, and Validate); the transition to the next phase requires the completion of certain activities in the previous phase [2].

Using the new tool is especially important when the client changes the design requirements, or the validation results are not acceptable; this requires introducing changes to the product without affecting project timing. The proposed solution aims to eliminate the possibility of omitting significant activities, which could negatively affect the further implementation of the project [3].

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Abrasive wear resistance of hardened tool steel – Influence of matrix hardness, carbide fraction, size and type of carbides

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Material strength (hardness) and toughness are the main properties that have been observed to increase wear resistance of the material. On the other hand presence of different carbides in terms of fraction, type and size (morphology) in martensitic matrix has different effects on wear, especially if matrix hardness changes.

The aim of this study was to correlate carbides fraction and morphology of V and Cr-rich carbides in tool steel with microstructure and fracture toughness and overall influence on abrasive wear resistance. For this reason, commercially available tool steels (Mat. No. 1. 2379 and Mat. No. 1.2367 modified hot work tool steel) having very different microstructures especially in terms of carbides fraction and morphology were used. In order to allow direct comparison, both steels were heat treated in such a manner that three different hardness levels were achieved, i.e.~ 45 +/-1 HRC, 49 +/-1 HRC and 54 +/-1 HRC. For correlation of wear resistance and wear behaviour with microstructure, i.e. especially hard carbides, different contact conditions were used. Furthermore, effect of wear particles removal from the contact was studied. When microstructure represents martensitic matrix with the presence of larger amount of carbides, especially coarse eutectic M_7C_3, wear behaviour is greatly influenced, if matrix hardness is too low. Matrix hardness is important to prevent carbide removal from the matrix. Plastic deformation of the tempered martensite matrix as well as carbide cracking and removing from the matrix is happening, being involved in wear process intensifying wear.

Mechanical fracture quantification of role of hemp fibres on self-healing processes in selected composites

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The proposed contribution deals with the role of distributed hemp fibres on self-healing processes in selected fine-grained composites based on a brittle matrix. The main goal of the contribution is the quantification of the role of hemp fibres during controlled damage of the studied materials by means of numerical analyses and advanced assessment of experimental data from fatigue and mechanical fracture tests.

Figure 1. Specimen dimension were 40×40×160 mm applied for fatigue performance.

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How to Tailor Magnetic Properties of High-Silicon Soft Magnetic Fe-Si Alloys with Additive Manufacturing?

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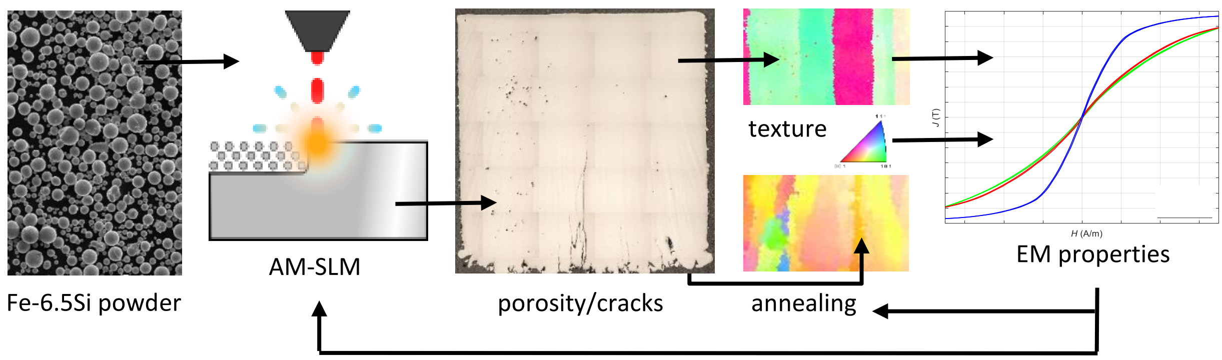
With the so-called green transition of contemporary society, the need for efficient, lightweight, and durable electrical machines and devices is more crucial than ever. High-silicon Fe-alloys and steels are regarded as the most suitable materials for their production as they possess the following properties:

- high permeability and induction;
- low power losses;
- low magnetostriction.

However, as the Si content in these alloys exceeds 5 wt.%, the material becomes brittle and the conventional metallurgical cold processing into thin sheets is not possible anymore.

Our project is focusing on optimizing process parameters of additive manufacturing - selective laser melting (AM-SLM), and the selection of the post-processing steps aimed to enhance not only the electromagnetic and mechanical properties of the material, but also the printability into desired geometries. Optimization takes place by iterating adjusted processing parameters of AM-SLM (and subsequent annealing) to control the texture, analyzing the resulting metallographic and electromagnetic (EM) properties, while also adapting and optimizing the evaluation steps.



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Deposition Path Strategies in Directed Energy Deposition of Thin Wall 316L-In718 Functionally Graded Material

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Directed energy deposition (DED) of metal powder is an additive manufacturing process capable of creating metallic structures of significant complexity. When feeding a time-dependent chemical composition of powder, functionally graded materials (FGMs) can be produced. One of the desirable material combinations is 316L stainless steel and Inconel 718 due to potential use in turbomachinery, combustion engines, and oil refining [1]. However, metallurgical defects occurring during deposition process severely compromise its mechanical properties. Although defect mitigation by optimizing DED process parameters has been researched, little attention has been paid to deposition strategy optimization. In this study the effect of deposition path strategy on metallurgical defect occurrence in thin-wall 316L-In718 FGMs is investigated. For this purpose, unidirectional (UD), bidirectional (BD) and segmented bidirectional (SBD) [2] deposition was performed. Same process parameters, linear composition gradient and layer deposition time were used in all three cases. Microscopy of sample cross-sections revealed significant differences in cracking: widespread cracks in the UD sample, less cracks in the SBD sample, and only one crack in the BD sample. Cracks in BD and SBD samples were short and oriented differently compared to UD sample. In all samples, the cracks were aligned with columnar dendrite orientation that depended on the strategy used. Energy dispersive spectroscopy was used to analyze chemical composition of the BD sample and revealed no sharp transitions between the layers, indicating good bonding. Presented results confirm that the choice of deposition path deposition strategy significantly affects metallurgical defect occurrence in thin wall 316L-In718 FGMs produced by DED.

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Surface Hardening of Additive Manufactured Inconel 625 by Plasma Nitriding

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Surface-hardening techniques, such as plasma nitriding, are commonly used procedures for improving the surface properties of conventional produced Ni-based alloys. During plasma nitriding, the diffusion of nitrogen hardens the surface layer of the alloy, leading to better wear resistance, higher coefficient of friction and higher surface hardness.

The present study investigates the possibility and the effects of plasma nitriding performed on additive manufactured (AM) Inconel 625 (IN625) in comparison to the conventional manufactured material nitrided under the same conditions. The growth kinetics of the nitride layer is influenced by the prior heat treatment; therefore, the plasma nitriding was performed on AM samples in different conditions: as-built, stress-relief annealed at 870 °C and solution treated at 1050 °C. The plasma nitridings were carried out at 430 °C and 500 °C for 15 h.

After nitriding, the XRD and SEM analyses confirmed the presence of nitrided surface layer and the diffusion layer beneath. Plasma nitriding at the lower temperature caused the formation of expanded austenite or a combination of expanded austenite and CrN, while the higher nitriding temperature led to the decomposition of the expanded austenite and precipitation of Cr-nitrides.

The precipitation of Cr-nitrides at the higher nitriding temperatures slightly decreases the corrosion resistance, while the wear resistance is significantly improved.

Surface Behaviour of the Ultrafine Grained Biomedical Titanium

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Commercially pure titanium (CP-Ti) offers vulnerable combination of the biocompatibility, corrosion resistance in the body fluids and relatively low stiffness, which justified the wide use of this material in the implantology. However, mechanical strength of the standard CP-Ti is not sufficient for its application in the highly-loaded implants. Large plastic deformation techniques provide the solution to this problem by offering the possibility to strengthen CP-Ti by refining its grains to the submicron range. Submicron structure in CP-Ti substrates could be developed e.g. by techniques based on extrusion (hydrostatic extrusion: HE) and multiple-pass cold rolling. HE technique allows to produce ultra-fine grained products in the form of rods, which can be subsequently exploited to fabricate narrow dental implants that transferring higher loads compared to the implants with standard dimensions. In order to fabricate ultra-fine grained CP-Ti products in the form of plates, techniques based on rolling procedures such as multiple-pass cold rolling or accumulative roll bonding (ARB) could be used. Changes introduced during large plastic techniques such as refining grains to the submicron range as well as development of particular crystallographic textures, could affect the properties of the protective oxide layers that are spontaneously formed on CP-Ti surface due to its contact with air. This study offers the analysis of how particular microstructural features affect corrosion resistance of CP-Ti in the simulated body fluid. Improvement of CP-Ti corrosion resistance, obtained by tailoring its microstructure, was compared with the enhancement possible to gain by the electrodeposition of the chitosan-based coatings.

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Fine – Tuning and Performance Testing of Pre – Trained Large Language Models for Applications in Domain of Biomedical Materials Synthesis

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Large language models (LLMs) like Generative pre-trained transformers (GPTs) emerged in past couple of years with increase of computational power. These models are used for various tasks in field of natural language processing, such as text classification, question answering and language translation. In this talk, research methodology, practical aspects and performance testing of fine – tuned LLMs, both commercial and open source in domain of materials synthesis, will be covered. So far, LLMs seems to have promising future in education, research and production only integrated with other chemistry tools, thus further development of integrated AI systems as well as LLMs is necessary to enhance performances and meet future demands.

Preventing cracking of OCR8W ledeburitic tool steel during hot deformation

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Hot rolling can achieve much higher productivity compared to hot forging and therefore hot rolling of tool steels is also considered the preferred hot bulk forming process. However, special attention should be paid to the occurrence of cracks in this hot forming process, which can be a limitation for industrial use. In this paper, an approach to prevent the occurrence of internal and surface cracks during the hot forming of OCR8W ledeburitic tool steel from ingot to hot rolled profile was developed. The first step to improve hot workability during deformation is to avoid cracks in the centre of the ingot during radial hot forging of the ingot, which was achieved by establishing suitable casting and forging conditions. The second step was to improve the intrinsic hot workability of the tool steel used, which was achieved by determining a suitable soaking temperature for as-cast and semi-wrouht states. For this purpose, a specially developed hot compression test procedure on the Gleeble 1500D thermomechanical simulator was used to determine the optimum soaking conditions. This extended the temperature range for safe hot working, i.e. at both the lower (850°C) and upper (1150°C) limits of the temperature range, and improved the intrinsic hot workability of the tool steel under investigation. This was confirmed by additional hot compression tests carried out in the temperature range of 850 – 1150°C and in the strain rate range of 0.001-10s^{-1}, obtaining flow curves that were mathematically described by an appropriate model. These results were used in the FEM simulation of hot rolling, which was the third step in preventing cracking. This step referred to increasing the compressive stress state in the workpiece during hot rolling, which resulted in complete elimination of billet cracks. Thus, FEM was used to determine the optimal shape of the calibres, which made it possible to achieve sufficiently high compressive stresses at critical points of the rolled workpiece, resulting in the elimination of surface cracks.

Multiphysics and Multiscale Simulations of Direct-Chill Casting

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This paper presents the simulation system for the direct-chill casting of round aluminium billets, developed through the sequence of the applied and fundamental ARRS projects with the MARTIN project at last. According to the scales, the system is divided into related macroscopic, mesoscopic and microscopic solidification models and includes the possible influence of electromagnetic fields. Macroscopic models are divided into fluid mechanics models, used to calculate the temperature, velocity, concentration and phase fields, and solid mechanics models, which are used to calculate the stresses and deformation fields. Mesoscopic models are intended for grain size calculation, while microscopic models are devoted to microsegregation and detailed grain shape calculations. The simulation system can predict defects such as macrosegregation and hot tearing. Verification and validation of models and examples of simulations are presented. Ultimately, we give further directions for the system upgrades for slabs and refinement of the existing models.

The Effects of Gamma Irradiation on PET and Formation of Microplastic Particles Down to 1 µm

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Microplastics (MP) are plastic particles less than 5 mm in size that are mainly produced by the degradation of large plastics by ultraviolet radiation, mechanical abrasion, and biological decay. They are of great concern because of their harmful effects on ecosystems and human health. Gamma irradiation is a widely used method for sterilizing medical devices, food, and other materials. Although it is widely used, there is evidence that it can adversely affect sterilized products and significantly alter the structural properties of irradiated products, especially if they are made of or packaged in polymers. In this study, the degradation of plastics upon γ-irradiation in water and the formation of microplastic particles were investigated by irradiating pristine and recycled polyethylene terephthalate (PET) with doses of 10, 50, and 100 kGy. The effects of γ-irradiation on the PET samples in water were studied by UV-Vis spectroscopy, Raman and dynamic light scattering (DLS). It was found that the absorbance of the water solution in which the corresponding plastic samples were γ-irradiated increased with increasing γ-irradiation dose. The formation of microplastics was investigated by Raman spectroscopy. The results showed the presence of micrometer-sized plastic particles upon γ-irradiation. The results also showed that significantly more microplastic particles were formed in the recycled PET after γ-irradiation than in the new material. At higher doses, a larger number of unidentified polymer particles with distinct Raman spectra were observed.

Synthesis and Characterization of 1-D Nanostructures Hydroxyapatite Prepared from Galatea Paradoxa for Energy Applications

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A novel hydroxyapatite [HAp: Ca10(PO4)6(OH)2] 1-D nanostructured material for energy applications was prepared from Galatea paradoxa (GP) clam shells using a combined sol-gel and electrospinning method. X-ray diffractometry and atomic absorption spectrometry were used to study the carbonate substitution as a function of stirring conditions. Stirring its effect on crystallite size and trace element concentrations was carried out. In addition, Infrared spectra, Raman spectra, and X-ray fluorescence spectra profiles confirmed the functional groups. The optical property analysis was performed on the basis of absorbance spectra recorded over UV–Vis spectral range. The complex refractive index n and complex dielectric permeability ε of obtained tin oxide nanowires were determined as a function of the radiation energy. The morphology and topography were investigated using a scanning electron microscope and atomic force microscope respectively. The results demonstrated herein the possibility of using locally prepared GP shells for energy applications.

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The effect of annealing temperature on the microstructural evolution and mechanical properties of the superaustenitic stainless steel UHB 904L

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The present study aims to investigate the effect of annealing temperature on microstructural evolution and mechanical properties of the superaustenitic stainless steel UHB 904L. Evolution of phases in selected samples were identified by optical and scanning electron microscopy. Mechanical properties of selected samples were determined by the tensile test.

Investigation has shown that the average grain size increased with incresed annealing temperature, with consequent decrease of yield strength, tensile strength and increased elongation.

Phase Formation Kinetics in TiAl-based Coating Prepared by Self-propagating High-temperature Synthesis

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Intermetallic coatings, particularly those based on titanium aluminides (TiAl), have demonstrated exceptional mechanical and high-temperature properties, making them attractive for various industrial applications such as automotive or aerospace industry. The phase formation within such coatings is crucial in determining their performance. To achieve the best high-temperature and mechanical properties, this study investigates the formation kinetics of intermetallic phases γ-TiAl, $TiAl_3$ and Ti_3Al in intermetallic coatings prepared using Self-propagating High-temperature Synthesis (SHS).

The SHS technique offers a rapid and efficient means of synthesizing intermetallic coatings by initiating a controlled exothermic reaction between compacted titanium alloy and aluminum powder. The resulting coatings were subsequently annealed at 800 °C for various durations to examine the phase formation kinetics. The evolution of intermetallic phases was studied using Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDS) and using Focused Ion Beam technique (FIB), a thin lamella was obtained from each sample for Transmission Electron Microscopy (TEM) analysis.

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Low-Power Microwave Dehydration Of Alkali-Activated Materials

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Modern industry and society follows the concept of linear economy, resulting in overproduction that consumes large amounts of natural resources and accumulates large amounts of waste. The alternative approach of the circular economy is a technique based on the principle of recycling and reuse of materials. This idea promotes the reduction of the consumption of natural resources and the minimization of the amount of waste, making an important contribution to a more sustainable and responsible way of life for a better future.

New sustainable materials such as alkali-activated materials (AAMs), which could replace conventional cements, ceramics, etc., are on the rise in the construction industry. AAMs are formed from precursors with sufficient Al and Si in amorphous content, such as ashes and slags, which are alkali-activated with alkali silicates or hydroxides. After the initial curing process of slurry, the hardened AAM still contains a significant amount of water, which might allow undesirable reactions (such as efflorescence). To hinder this process, microwaves can be used to influence dehydration by volumetric heating for short times. The process is more uniform throughout the volume than heating in a convection oven, which allows faster dehydration and prevention of undesirable reactions.

Therefore, in our study, secondary raw materials slag, fly ash, glass wool, rock wool, and non-waste material metakaolin were used in different ratios as precursors for alkali activation with Na-silicate solution. The material was cured at 40 °C for 6 days. On the 7th day, half of the samples were additionally treated in an inverter microwave oven at 100 W until complete dehydration[1]. Mechanical strengths were measured for all specimens, dehydrated in microwave and non-dehydrated, after 7 days. The effects of microwave irradiation on the specimens in the post-early curing phase were additionally investigated using SEM-EDXS, MIP, FTIR and XRD.

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Effect of Tempering on Additively Manufactured AISI H13 Hot Work Tool Steel

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Additive manufacturing (AM) is a new and exciting process in any metallurgist's arsenal, especially Laser Powder Bed Fusion (LPBF). While it has been a boon to many high-tech applications, like the aerospace and medical sectors, its die-making potential has been somewhat overlooked. AM offers the ability to manufacture complex geometries, which would be unobtainable with regular means of production, like machining. Furthermore, it produces very little waste, as upon completion of a print, the leftover steel powder is fed back into the machine, reusing the unspent powder.

We manufactured our samples, 10x10x10 mm cubes, using an Aconity 3D mini (Aconity Gmbh, Herzogenrath, Germany), which utilizes the LPBF process. First, we created a 3D model of the parts using modelling software. Next, the model was sliced into thin 30 µm layers, and a scanning path for each layer was assigned. The sliced models were uploaded to the printer, and the first step of the LPBF process began: A brush deposited a thin layer of powder onto the work surface. The powder layer thickness depends on the size of the powder particles. In our case, the mean particle size was 30 µm. With the powder bed applied to the work surface, a laser scanned the geometry of a single slice, selectively melting the powder, to produce the desired shape. The last step was lowering the work surface and applying another layer of powder. These steps were repeated by the machine until the full model was built. We used a laser spot size of 60 µm, so the melt pools it created were relatively small resulting in very rapid solidification.

However, for all its benefits, there are also some drawbacks associated with the LPBF process. One problem is the somewhat poor mechanical performance of the as-built parts. Due to the high solidification rate, most of the carbide-forming elements remain in the solid solution. Because H13 derives a significant amount of its strength from small carbides located at grain boundaries, this leaves the as-built parts lacking in key properties such as hardness [1,2].

In this work, we studied the effect of tempering at 4 different temperatures (450 °C, 500 °C, 550 °C, 600 °C) on the hardness of LPBF-produced parts, manufactured on a preheated baseplate (200 °C, 350 °C) as well as without preheating. The microstructure of all the samples was analysed, and our results were compared to conventionally manufactured H13 tool steel.

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Antioxidative Resveratrol Particles as a Bioactive Component for Material Design

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There is a growing need for multifunctional components in material design, especially in tissue engineering. Among many natural compounds, polyphenols are gaining interest as biologically active additives of novel materials. Stilbenoid polyphenol resveratrol is one of the most known, mainly because of its antioxidative, antibacterial, anticancer, neuroprotective and other beneficial effects. To allow most efficient use of resveratrol, several nanoformulations have shown promise, but most of them also involve other, toxic or expensive compounds, beside resveratrol. During our research, we synthetized particles of pure resveratrol, in an elongated, nanobelt-like form. The shape of the particles, as well as absence of any polymer or other carriers makes these particles easy to handle for further implementation. For preliminary assessment of the functionality of these particles, several assays were employed. DPPH, TBA and FRAP assay proved antioxidative potential of obtained particles by several mechanisms in the concentration range from 1 µg/mL to 10 µg/mL. *Artemia salina in vivo* bioassay was used to show high bioactivity and also biocompatibility of the particle suspension. All of the results indicated that there is a high potential for use of these resveratrol particles as bioactive agent or as component in various composite biomaterial formulations.

Phase evolution of Strontium hexaferrite Sintered by Pressureless Spark Plasma Sintering (PSPS)

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Permanent magnets (PM) play an important role in enabling technologies and modern devices of today [1]. Ba- and Sr-ferrites are most-produced permanent magnetic materials in the world [2]. Although ferrite magnets are inferior in performance to rare-earth magnets, the harmful environmental impact of production, uneven distribution, and increasingly questionable supply chain force us to look for alternatives. One of the possible candidates comes from the group of hexagonal ferrites [3]. M-type ferrite magnets generally do not contain critical raw materials [4].

In our study we tested pressurless spark plasma sintering (PSPS) on strontium hexaferrite using graphite die in spark plasma sintering (SPS) device, that enabled to isolate radiation as a sintering mechanism. Although ceramic magnets and radiation assisted sintering process have been known for some time, this is a less commonly used approach to sintering this widely used magnetic material. This research focuses mostly on analysis of phase evolution during PSPS sintering of Sr-ferrite where we tried to determine newly formed phases in the sample. The samples were extensively analysed on a scanning electron microscope (SEM) where, with the help of energy dispersive spectroscopy (EDS) and electron backscatter diffraction (EBSD) techniques, we were able to determine the segregation of the base material and the new arrangement of grains. In addition, we analysed the diffractions with the help of transmission electron microscopy (TEM) and thus tried to determine the crystal phases of the newly formed phases. Additionally, we confirmed our results with X-ray diffraction analysis (XRD) and thermogravimetry differential thermal analysis (TG/DTA) analysis. We found that ferrite reduction occurs in the sample due to a slightly reducing atmosphere, which is caused by a combination of vacuum and carbon sputtering. This causes the appearance of strontium depleted and enriched phases.

Key words: Strontium hexaferrite, magnets, graphite die, sintering, PSPS

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Influence of Preheating on SLM Processed EN AW 7075 Aluminium Alloy

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In this study, we aimed to investigate the influence of preheating temperatures on EN AW 7075 aluminium alloy processed by selective laser melting (SLM). SLM is a widely used additive manufacturing technique for the production of complex metal parts. However, the use of mentioned alloy in SLM processes often leads to crack formation, posing challenges to the structural integrity of the printed components.

To explore this phenomenon, we conducted a comprehensive analysis of the microstructure of SLM-produced samples under different preheating conditions. Specifically, we examined the samples without preheating and at preheating temperatures of 100, 200, and 400 °C. The microstructure of the non-preheated samples revealed a high density of cracks throughout the printed structure. These cracks are believed to be a consequence of the rapid solidification and resulting thermal stresses during the cooling phase of the SLM process. However, as we initiated preheating at temperatures of 100 and 200 °C, we observed a slight reduction in the number of cracks present in the microstructure. This suggests that the preheating process facilitated a more gradual temperature transition during solidification, thereby minimizing the thermal stresses and subsequent crack formation.

Interestingly, at the highest preheating temperature of 400 °C, we observed a distinct phenomenon within the microstructure. Instead of individual cracks, the microstructure exhibited pillar-like formations where cracks seemed to coalesce. This intriguing observation suggests that the higher preheating temperature induced alterations in the solidification behavior, leading to the formation of localized pillars as opposed to scattered cracks.

These findings shed light on the role of preheating temperatures in the SLM processing of AA EN 7075 aluminium alloy. Preheating was found to significantly impact the microstructural characteristics, with temperature variations resulting in varying crack densities and the formation of unique pillar structures. This understanding provides valuable insights for optimizing the preheating parameters in SLM processes to enhance the structural integrity and quality of printed components.

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Thermal fatigue testing

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Predominant failure mode of die casting tools is heat-checking – a network of surface cracks. This failure mode stems in cyclic loading: higher pressures and temperatures followed by atmospheric pressures and reduced tool's surface temperatures. Currently there are no standards covering heat checking resistance neither in terms of experimental setups nor in terms of surface cracks network characterization.

Experimental setup consists of cyclic induction heating of outer surface of cylindrical specimen (outer geometry is hexagonal) and persistent inner cooling of specimen, altogether controlled by PLC. Specimen's surface temperature is measured by spot-welded thermocouple on one among six outer surfaces. The experimental setup is therefore more or less in line with the other research in this field.

Image processing of surface crack network consists of (1) prefiltering, (2) determination of cracked surfaces by image thresholding (binearization) and (3) quantification of obtained cracks. The most challenging tasks appears to be suitable image thresholding (2) in wide range of thermal degradations. Among seven established thresholding methods, only local Bradley thresholding method seems to yield acceptable results. Additional custom developed thresholding technique based on manual selection of non-cracked area and Mahalanobis distance seems to yield comparable results.

Hydrogen embrittlement of additively manufactured metallic materials

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Generally, hydrogen embrittlement is caused by the absorption of hydrogen in susceptible metals leading to a reduction of metal ductility and load-bearing capability. When a hydrogen-embrittled material is loaded, cracking or even sudden catastrophic brittle failure can occur even far below its yield stress. Titanium alloys and high-strength steels are very susceptible to this kind of damage.

One of the most widely used processes of additive manufacturing is Selective Laser Melting (SLM) of metallic powders. It uses a laser beam to melt the metallic powder within a powder-bed layer and to consolidate it into a solid layer of the final product. The final product is accomplished by the successive deposition of new powder layers and their subsequent sequential melting by laser beam controlled by the selected scanning strategy. Due to the laser melting of small volumes of powder and rapid heat transfer to surrounding cold powder, very high cooling rates are reached during SLM. It results in the occurrence of very fine microstructures, high internal thermal stresses, large amount of grain boundaries, defects, interfaces and internal porosity in the SLM-fabricated materials.

The presented work is focused on two types of materials manufactured by SLM, Ti-6Al-4V alloy and X3NiCoMoTi 18-9-5 maraging steel. The materials were exposed to hydrogen-containing environment under controlled conditions, followed by detailed studies of their microstructures and mechanical properties. Conventionally wrought alloys were used as reference materials.

It is demonstrated that the additively manufactured alloys show a strongly enhanced susceptibility to hydrogen trapping and embrittlement in comparison with the conventionally prepared wrought materials. Such susceptibility should be taken into account when using additive manufacturing for production of components exposed to hydrogen-containing environments, for example in power, chemical, petrochemical industries, or even in medical implants (chemical, electrochemical surface treatments, electrochemical corrosion).

Modelling of a thermo-mechanical response of hot-rolled steel bars on a cooling bed with a meshless numerical approach

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Following the continuous hot-rolling process, steel bars are transported to the cooling bed for cooling. Due to high temperatures, the yield strength is low and can be due to cooling exceeded, resulting in residual stress accumulation and bending formation. The study investigates how the spacing between bars and the distance to the heat shield above the cooling bed affect the radiative heat fluxes and, consequently, the thermo-mechanical response. The governing equations are solved in a strong form with a modified version of a local radial basis function collocation method – LRBFCM [1]. The initial bars cross-section geometry is obtained from the existing hot rolling simulation system developed in our research group [2]. The problem is solved in a decoupled way, where the temperature solution represents the driving force for the mechanical model. Temperature solution is obtained with explicit time propagation, where view factors, computed with a Monte-Carlo method, determine the radiative heat fluxes. The mechanical model assumes a generalized plane strain state and accounts for bar bending. Small strain elasto-plasticity with isotropic von Mises temperature-dependent hardening is considered. The global system of nonlinear equations arising from the mechanical model is solved with the Newton-Rhapson method. The return mapping algorithm is used to solve constitutive relations. The cooling process results indicate that the positioning of the heat shield has a minimal impact on temperature and stress distribution. Conversely, the spacing between bars has a more significant influence, which diminishes as the distance between them increases. The modified version of LRBFCM is proven capable of resolving such a complex thermo-mechanical industrial problem.

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Influence of Material State on Austenitic Transformation in HSLA-type Steel

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The paper presents the results of research on the influence of the material state on the course of austenitic transformation in HSLA-type steel. The as-cast steel with the following chemical composition was tested: 0.18% C, 1.94% Mn, 1.12% Si, 0.014% P, 0.019% S, 0.028% Cr and 0.2% Mo. In order to reveal the actual phases occurring in the steel during the individual stages of austenitic transformation, dilatometric tests were carried out. The samples were tested using a Bähr 805 A/D dilatometer with induction heating and a vacuum chamber. In order to determine the influence of hot plastic deformation on the course of the austenitic transformation, plastometric tests were carried out using the Gleeble 3800 thermomechanical simulator. The axisymmetric test sample was continuously compressed to a strain of 0.7. In the next step, microscopic examinations were carried out using the Observer.Z1m optical microscope by Zeiss and the Supra 25 scanning electron microscope by Zeiss. for detailed microstructure analysis.

The conducted tests showed significant differences in the course of austenitic transformation for steel in two different states. Especially for newly developed steels, the knowledge of phase transformations of supercooled austenite is extremely important [1, 2]. Therefore, the aim of this work is to try to explain the unusual course of austenitic transformation for HSLA steel in the as-cast state, which goes far beyond the classical values of critical temperatures, so far encountered in the literature.

M. Morawiec, A. Wojtacha, M. Opiela, *Materials*, **2021**, *vol 14*, 1–12.
A. Wojtacha, M. Opiela, *Advances in Science and Technology Research Journal*, **2022**, *vol 16*, 64–73.

Investigating the 3-dimensional microstructure of a 3D printed Ti 42 Nb alloy for bone implant applications

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[2]Victoria University, Victoria, Canada

The beta Ti alloy Ti 42 Nb is highly promising for permanent bone implant applications because of its extremely low elastic modulus, which approaches that of human bones, and its chemical inertness in body fluids. Additive manufacturing by Laser powder-bed fusion (L-PBF) appears as a very valuable technique to produce implants of tailored shapes, and mechanical properties and optimum integration into the bone. Ti 42 Nb is actually well L-PBF printable but it leads to microstructures that are very different from those known from other commonly printed materials like 316L stainless steel. For example, the TiNb material does not show the typical dislocation cell structures observed in 316L and other materials.

We produced 2 Ti 42 Nb samples with different L-PBF printing strategies which showed very different crystallographic textures and mechanical properties. In order to understand the texture formation of these samples we applied our newly developed EBSD (electron backscatter diffraction)-based large volume microstructure characterization system (ELAVO 3D) to study the 3-dimensional microstructures. We found that the shapes and crystal orientations of the grains are very different in both samples. We present a first interpretation on the relationship of printing properties and texture evolution. Furthermore, by means of EBSD-based measurement of elastic stresses, we could show that the low elastic modulus of the material is responsible for the lack of dislocations in the printed material. This may be beneficial for the fatigue behaviour of the material.

Effect of Vanadium on the structure and properties of AA 6086

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The research studied effect of a small vanadium addition to the alloy AA6086, due to the several recognized positive impacts of use as a alloying element. The base alloy presents high strength Al-Mg-Si alloy 6086 which could be used for the demanding application in automotive industry. In comparison with the standard 6xxx alloys e.g. AA6082, it contain the small addition of Zr, which enhance the strenghening effect by formation of the Al_3Zr dispersoids and higher content of Cu which result in formation of Q'-AlCuMgSi hardening precipitates.[1, 2] One of the key vanadium contributions is improvement of mechanical properties and grain refining.[3-5] The researched alloys were prepared by direct casting and heattreated under various cycles of time and temperature. Samples were examined by optical microscopy, XRD analysis and Vickers hardness measurements. The maximum hardness was achieved by alloy with vanadium (123,2 HV) after homogenization (450°C/30min) and isothermal aging at 170°/8h. Grain size analysis disproved the refining influence of vanadium to the alloy, which is confirmed in as-cast and homogenized condition. Alloy 6086 reach in average a mean grain diameter 213,9µm, what represent a 34% smaller grains in comparison with 6086 – 0,5V.

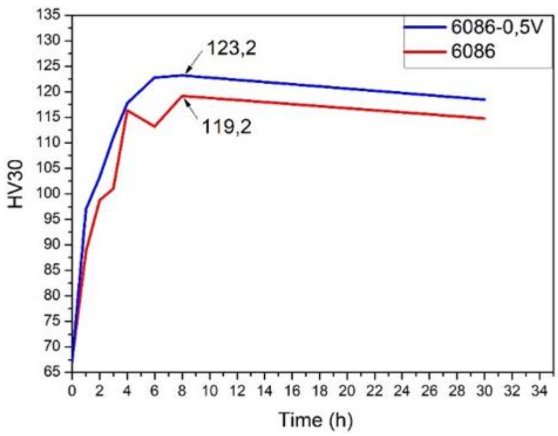

Figure 2: Development of peak hardness during isothermal heattreatment

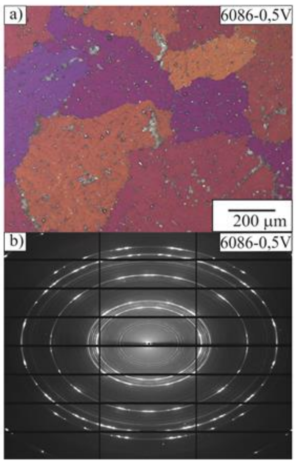

Figure 2: Grain analysis with use of light microscopy (a) and XRD (b) on homogenized sample with mean grain diameter (367,8µm).

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The Effect of Hot-Rolled Quarto Plate Thickness and Thermomechanical Conditions on the Prior Austenite Grain Size and Distribution

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Prior austenite grain size (PAGS) of hot rolled quarto plates has major influence on final mechanical and workshop properties of structural steels, either in as-rolled or in off-line quenched and tempered condition.[1,2] Thus, it is of great importance to obtain fine and evenly distributed PAGS after the rolling, which is related to the plate thickness. To evaluate the effect of plate thickness on through-thickness PAGS distribution of industrial hot-rolled structural quarto plates, PAGS distribution was determined in thickness range from 10 to 85 mm. PAGS in as-rolled condition was evaluated using manual method on micrographs obtained on scanning electron microscope, considering at least 400 grains in longitudinal direction in 5 positions across the thickness profile. The results confirm that the plate thickness majorly affects the through-thickness distribution, as also the average and maximum PAGS. Coarser grains and wider distribution can be linked to the limited total reduction ratio for thicker plates which is related to the partial static recrystallization during the passes, which is further related to the through-thickness thermo-mechanical conditions.[3] Thus, a fully implicit finite element thermo-mechanical model was used to calculate the through-thickness temperature, strain, and strain rate[4,5]. The results of the thermo-mechanical model show temperature heterogeneity and limited through-thickness strains and strain rates, which can result in anisotropic and sluggish softening kinetics, producing coarser grains and wider PAGS distribution.

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Mg-Li-Ca alloys produced by laser powder bed fusion

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Magnesium (Mg) alloys are used as biomaterials because of their biocompatibility and stiffness which is similar to that of human bone tissue. This reduces the stress shielding complications associated with bone resorption. Mg is one of the fundamental divalent ions that have an effect on bone-forming cells and also plays an important role in bone metabolism. This is supported by the results of *in vivo* studies, which indicate that Mg degradation does not damage surrounding tissue and promotes bone remodelling [ref]. One of the main drawbacks limiting the wide use of Mg alloys in biomedicine is their low corrosion resistance, and associated high hydrogen release in the surrounding environment which causes pain in the area of implant placement [1–3]. Additive manufacturing is an attractive alternative to conventional manufacturing of Mg alloys, and researchers have so far studied the properties of the following Mg-based alloys: Mg-Al-Zn, Mg-Zn-Zr, and REE- containing alloys [4].

In this research, we propose to develop possibilities of fabrication of Mg-based alloys enriched with Li and Ca which will decrease the density of the alloys and simultaneously improve mechanical properties of the alloys. It is expected to create ultra-refined microstructure which should lead to the lowering of the intensity of the occurring corrosion mechanisms. We decided to work on the Mg-4Li-0.5Ca and Mg-8Li-0.5Ca compositions. As a reference cast materials with the same composition were used. The microstructure of alloys was analyzed through electron back scattered diffraction and phase composition was analyzed using X-ray. Corrosion resistance of both alloys were performed using various electrochemical techniques in phosphate-buffered saline solution (PBS). The materials corrosion rate was investigated by hydrogen evolution tests, and corroded specimens were characterized by SEM and optical profilometer observations. Our results show that ultrafine grained microstructure was formed in Mg-4Li-Ca and Mg-8Li-Ca. It should be the main reason of the corrosion resistance improvement.

Keywords: Mg alloys, LPBF, SEM

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Corrosion resistance of 316L oxide dispersion strengthened (ODS) steel

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High-temperature and harsh conditions require the use of advanced and resistant materials. Nuclear reactors are a very good example of an environment with such conditions, and 316L Oxide Dispersion Strengthened (ODS) steel is suitable to build them. This is a material with desirable properties such as good workability, ductility, and mechanical integrity at high temperatures.

In this study, to improve the corrosion properties of 316 L steel, it was decided to add yttrium to the matrix. Materials for research are manufactured through powder metallurgy technique – Spark Plasma Sintering (SPS) and subsequently compared with reference materials (316L commonly available rods). The powders used for the SPS consolidation of the materials have been characterized. The effectiveness of the yttrium addition in increasing corrosion resistance was investigated. Moreover, electrochemical tests and corrosion rate measurements were carried out to determine the corrosive properties. The next stage of the research was the characterization of the corroded surface. The methods used to describe surface changes in the studied materials were scanning electron microscopy (SEM) and optical profilometry.

Keywords: ODS steel, corrosion properties, SEM

Acknowledgment: This research is realized under the project no. 2021/43/I/ST8/01018 "New ODS steel structure for extreme environments using the ultrasonic dispersion of nano-oxides in combination with SLM and PPS" financed by the National Science Centre in Poland.

Degradation Mechanism of Steel in Boilers Due to SRF co-incineration

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Co-incineration of waste in thermal power plants is a viable method waste disposal. Unfortunately, beside already known problems with corrosion of boiler materials when burning with coal, SRF (Solid Recovered Fuel) co-incineration introduces chlorine (Cl) into the boiler. Chlorine is extremely dangerous due to the fact that it forms low melting salts with potassium. KCl reacts with chromium oxide and forms a low melting eutectic and thereby eliminating the passive protection layer.

Furthermore, chlorine is not used up or easily eliminated in the system by burning, but can accumulate in the system. A so-called ˝chlorine cycle˝ can be created, which can be very dangerous for the corrosion of boiler materials, because the concentration of chlorine can increase with inadequate treatment and cause uncontrolled corrosion of steel in the boiler.

Ageing Effect on Microstructure and Mechanical Properties of Creep Resistant Steels

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Exposure of steel to elevated temperature causes changes in the microstructure which are responsible to the degradation of mechanical properties. Five different creep resistant steels were aged at three different temperatures 630 °C, 650 °C in 700°C, for 1 year and 2 years.

Analyzes of microstructure and mechanical properties before and after aging were performed.

With the difference in properties before and after aging, we obtained information on how the mechanical properties and microstructure of different steels will change during their operation in power plants and what behavior of steels can be expected in the future.

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5th INTERNATIONAL SYMPOSIUM ON BIOMATERIALS

PROGRAM

	Friday	**October 13, 2023**
9:00	OPENING	DRAGO DOLINAR chair
	Chairs: Drago Dolinar, Monika Jenko	
Invited 9:15	Veronika Kralj-Iglič, Zala Jan, Damjana Drobne, Aleš Iglič, Boštjan Kocjančič, Drago Dolinar, Monika Jenko	*IN VITRO* EFFECT OF DEBRIS FROM ENDOPROTHESIS PROCESSING ON HUVEC
Invited 9:30	Niharika Rawat, Ita Junkar, Metka Benčina, Ekaterina Gongadze, Veronika Kralj-Iglič, Aleš Iglič	HYDROTHERMALLY SYNTHESIZED TIO_2 NANOSTRUCTURE SURFACES FOR BIOMEDICAL APPLICATIONS
Plenary 9:45	Andrej Trampuž	LOCAL STRATEGIES TO PREVENT AND TREAT BONE AND IMPLANT-ASSOCIATED INFECTIONS
Plenary 10:15	Drago Dolinar, Monika Jenko	STUDY OF SURFACE AND BIO INTERFACE PHENOMENA OF IMPLANT MATERIALS AND BIOSYSTEMS
Invited 10:45	Klemen Avsec, Monika Jenko, Boštjan Kocjančič, Drago Dolinar	STUDY OF THE SURFACE PHENOMENA AND OSSEOINTEGRATION OF ZWEYMULLER HIP ENDOPROSTHESES
11:00 11:30	**COFFE BREAK**	
	Chairs: Veronika Kralj Iglič, Aleš Iglič	
Invited 11:30	Andrej Coer, Katja Šuster	SMART HYDROGEL WITH BACTERIOPHAGES AND HYDROXYAPATITE FOR IMPROVED OSSEOINTEGRATION AND PREVENTION OF EARLY PROSTHETIC JOINT INFECTION
Invited 11:45	Rok Podlipec, Janez Štrancar, Ariana Barlič, Drago Dolinar, Monika Jenko	NEW HIGH-RESOLUTION MICROSCOPY APPROACHES FOR UNDERSTANDING BIOCOMPATIBILITY OF HIP IMPLANTS
Invited 12:00	Barbara Šetina Batič, Matej Hočevar, Monika Jenko	SCANNING ELECTRON MICROSCOPY AND FOCUSED ION BEAM STUDIES OF CELLS AND THEIR INTERACTIONS WITH THE SURFACES
Invited 12:15	Aljaž Merčun, Monika Jenko, Boštjan Kocjančič	TRABECULAR TOTAL HIP ARTHROPLASTY – GLIMPSE OF PAST
Invited 12:30	Ema Kocjančič, Boštjan Kocjančič	OXIDIZED ZIRCONIUM IN HIP PROSTHESIS - CASE REPORT
Invited 12:45	Marta Hojker, Boštjan Kocjančič	METALLOSIS AND IMPLANT FAILURE IN PATIENTS WITH METAL-ON-METAL HIP ENDOPROSTHESIS
13:00	Oskar Zupanc, Timon Zupanc , Uroš Meglič	ISOLATED ANTERIOR ELBOW IMPINGEMENT: DIAGNOSIS WITH CT MEASUREMENT TECHNIQUE
13:15	Matej Valič[1,2], Danijel Erdani[1,2], Rok Markežič[3], Gašper Cafuta[3], Jaka Koren[3], Erika Cvetko[2], Ingrid Milošev[1,4], Rihard Trebše[1]	NEW ADVANCED TECHNICS FOR DIAGNOSTICS OF TKA FAILURES
	13:30 14:30 LUNCH	
	Chairs: Andrej Cör, Boštjan Kocjančič	
Invited 14:30	Borut Kovačič, Tanja Slokar, Drago Dolinar, Monika Jenko	RESORBABLE IMPLANTS IN EPIPHYSIODESIS PROCEDURES
14:45	M. Benčina, K. Lakota, P. Žigon, V. Kralj Iglič, N. Rawat, A. Iglič, I. Junkar	MULTIFUNCTIONAL NANOSTRUCTURED SURFACES FOR VASCULAR STENTS
15:00	Matic Kolar, Matija Veber, Lenart Girandon, Matej Drobnič	BIOMIMETIC OSTEOCHONDRAL SCAFFOLD AUGMENTED WITH MESENCHYMAL STEM/STROMAL

15:15	Gašper Smogavec	EXPLORING SCREW MATERIALS FOR ACL RECONSTRUCTION
Invited 15:45	Mojca Amon, Irma Virant Klun	BIOMATERIALS: CAN BIOMATERIALS BE TOXIC?
16:00	Neža Trebše, Marko Pokorn	SYSTEMATIC REVIEW AND META-ANALYSIS OF METAGENOMIC NEXT GENERATION SEQUENCING AS A DIAGNOSTIC TOOL FOR PATHOGEN DETECTION IN PROSTHETIC JOINT INFECTIONS
Invited 16:15	Miha Vodičar	WHAT IS THE OPTIMAL BIOMATERIAL FOR SPINAL FUSION?
16:30 16:45	**COFFE BREAK**	
	DENTAL MEDICINE	
	Chairs Boris Gašpirc, Rok Schara	
Invited 17:00	Boris Gašpirc	RECENT ADVANCES IN LASER TECHNOLOGY IN PERIODONTICS
Invited 17:15	Tom Kobe, Sonja Žarkovič Gjurin, Pia Horvat, Rok Gašperšič, Čedomir Oblak	TWO PIECE ZIRCONIA IMPLANTS WITH TWO DIFFERENT PLATFORMS – RCT PRELIMINARY RESULTS
Invited zoom 17:30	Miha Pirc	INTRAORAL SKENNER-REALITY OR FUTURE
Invited 17:45	Luka Hočevar, Alenka Pavlič	CONTEMPORARY MANAGEMENT OF INCISORS WITH MOLAR INCISOR HYPOMINERALISATION USING RESIN INFILTRATION
Invited 18:00	Nina Vovk Igor Frangež, Helena Ban Frangež, Ksenija Cankar, Lidija Nemeth	THE TECHNOLOGY OF PHOTOBIOMODULATION
Invited 18:15	Bojana Krneta Đokić	THREE-DIMENSIONAL ASSESSMENT OF JAWS AND FACE MOPRPHOLOGY IN CHILDREN IN YEARS OF GROWTH AND DEVELOPMENT.
Invited 18:30	Rok Schara	MAGNETIC RESONANCE IMAGING TECHNIQUE
19:00	**CLOSING**	
	POSTER SESSION	
	Chairs: Boštjan Kocjančič, Klemen Avsec	
P1	Anna Romolo , Matej Hočevar , Maxence Berry , Matevž Arko , Boštjan Korenjak , Zala Jan , Andrej Sečnik , Maja Brložnik, Roman Štukelj , Peter Kruljc, Vladimira Erjavec , Alenka Svete Nemec , Jernej Jakše, Aleš Iglič, Veronika Kralj-Iglič	INTERFEROMETRIC LIGHT MICROSCOPY ASSESSMENT OF SIZE AND NUMBER DENSITY AND SCANNING ELECTRON MICROSCOPY IMAGING OF EXTRACELLULAR PARTICLES IN DIFFERENT NATURAL MATERIALS
P2	Mojca Amon, Tina Kek, Dominika Celar Sturm, Irma Virant-Klu	PLASTICS AND HUMAN HEALTH
P3	Mojca Amon, Friderika Kresal	REHABILITATION: BIOMECHANICAL AND METABOLIC IMPACT OF OBESITY ON ORTHOPEDIC PATIENTS
P4	Tjaša Okleščen, Sonja Žarković Gjurin Čedomir Oblak	3D SCANNING – VOLUME CHANGES
P5	Anja Sedej, Nika Svetina, Aljaž Golež, Igor Frangež, Helena Ban Frangež, Lidija Nemeth, Maja Ovsenik, Ksenija Cankar	EFFECT OF PHOTOBIOMODULATION ON TOOTH MOVEMENT IN PATIENTS UNDERGOING ORTHODONTIC TREATMENT
P6	Rok Ovsenik, Miha Pirc, Jasmina Primožič, Rok Schara,Maja Ovsenik, Lea Kolenc,Janez Kovač , Monika Jenko, Boris Gašpirc	SURFACE CHEMISTRY OF FIXED ORTHODONTIC APPLIANCE AFTER ANTIMICROBIAL PHOTODYNAMIC THERAPY EXPOSURE
P7	Lea Kolenc, Maja Ovsenik, Maks Bitenc, Mojca Keržan, Monika Jenko, Barbara Šetina Batič	BIOCOMPATIBILITY AND ALLERGIC REACTIONS TO DENTAL MATERIALS

P8	Ingo Oblak, Čedomir Oblak, Tjaša Simončič, Nataša Ihan Hren	IS IT TIME FOR ALL-CERAMIC RESIN-BONDED PROSTHESES IN POSTERIOR TEETH? NEW APPLICATIONS OF ZIRCONIA OXIDE CERAMICS
P9	Urška Škof, Rok Schara	RECENT ADVANCES IN BIOMATERIALS FOR PERIODONTAL TISSUE REGENERATION
P10	Zala Herman, Alja Ravnik, Maja Ovsenik, Maja Hočevar	MYOFUNCTIONAL THERAPY: A CONTEMPORARYCONSTRUCTION OF THE VESTIBULAR PLATE

5th INTERNATIONAL SYMPOSIUM ON BIOMATERIALS

ABSTRACTS

In Vitro Effect of Debris from Endoprothesis Processing on HUVEC

Veronika Kralj-Iglič[1], Zala Jan[1], Damjana Drobne[2], Aleš Iglič[3,4], Boštjan Kocjančič[5,6], Drago Dolinar[5,6] and Monika Jenko[7]

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Blasting of endoprostheses leaves behind debris which when implanted, interacts with adjacent tissue. Previous work indicates that this debris may impact the tissue and increase the probability of early prosthesis failure. To test this hypothesis, the effect of debris on human umbilical vein endothelial cell (HUVEC) culture was studied. We treated the cells for 24 h with milled particles of corundum (Al_2O_3), corundum retrieved from removed prostheses (u. Al_2O_3), and zirconia/silica composite (ZrO_2/SiO_2). We examined for possible morphological changes by scanning electron microscopy (SEM). We assessed the inflammation markers - Interleukins IL-6 and IL-1β and Tumor Necrosis Factor α (TNF-α) by enzyme-linked immunosorbent assay (ELISA). The activity of Cholinesterase (ChE) and Glutathione S-transferase (GST) was measured spectrophotometrically. Reactive oxygen species (ROS), lipid droplets (LD), and apoptosis were measured by flow cytometry (FCM). We found no differences in the morphology of treated and untreated cells. We found an increased concentration of IL-1β and of IL-6 after the treatment with all particle types and increased ChE activity after the treatment with u. Al_2O_3 and ZrO_2/SiO_2. We found increased GST activity after the treatment with ZrO_2/SiO_2. We found an increased amount of LDs after the treatment with u. Al_2O_3. There was no toxicity found. The tested materials in concentrations added to *in vitro* cell lines of HUVEC were found non-toxic but bioactive.

Hydrothermally synthesized TiO_2 nanostructured surfaces for biomedical applications

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Various surface modification techniques, for instance, electrochemical anodization [1], hydrothermal treatment [2], etc. Have been proposed to enhance the biocompatibility of metallic materials used as implants. It has been shown that the alteration of surface physicochemical properties, e.g., morphology, surface chemistry, and wettability, influence the biological response [3,4]. In the present contribution, we describe the synthesis of different nanostructures by using the hydrothermal method [5,6] on the surface of titanium (ti)-based substrates. The morphology, surface chemistry, and wettability of as-prepared surfaces were analyzed by scanning electron microscopy combined with energy dispersive x-ray spectroscopy (sem-edx), x-ray photoemission spectroscopy (xps) and water contact angle analysis (wca). The efficacy of the hydrothermal treatment of ti-based substrates has been established through biological studies [5,6]. The theoretical analysis of experimental results is also presented.

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Local strategies to prevent and treat bone and implant-associated infections

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Study of surface and interface phenomena of implant materials and biosystems

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The past decades and current research and development of biomaterials and medical implants show some general trends such as an increased degree of functionalization of the material surface, better to meet the requirements of the biological host system. While the biomaterials of the past and those in current use are essentially bulk materials (metals, ceramics, polymers) or special compounds, possibly with some additional coating (hydroxyapatite), the current research on surface modifications points toward much more complex and multifunctional surfaces for the future. The surface modifications can be divided into three classes, one aiming toward an optimized three-dimensional physical microarchitecture of the surface (pore size distributions, roughness, etc.), the second one focuses on the (bio) chemical properties of surface coatings and impregnations (ion release, multi-layer coatings, coatings with biomolecules, controlled drug release, etc.), and the third one deals with the viscoelastic properties (or more generally the micromechanical properties) of material surfaces. The surface is recognized by the biological system through the surface properties and cell response.

The main concern regarding THA's failure has been the cells' biological response to particulate debris. The debris is generated by mechanical impact on elements of the prosthesis leading to osteolysis and aseptic loosening of the prosthesis. As prostheses are processed with corundum to obtain the desired roughness of the surface and better osteointegration, the corundum particles remain on the surface of prostheses inserted into patients. The hard corundum wear particles are embedded into a softer matrix of Ti6Al7Nb alloy during the sandblasting process. In addition to aseptic loosening, the corundum particles can cause also periprosthetic infection. The aim of our study was to find out the effect of titanium Ti6Al7Nb implant surface grit blasted with corundum on cell survival. We have retrieved the stem that underwent loosening, sterilized it, acquired material from the surface, processed it with corundum, and exposed it to cells in culture. The same procedure was applied to a material from a new polished stem for control. Also, corundum disks and corundum micro-particles were exposed and tested for cytotoxicity. Our results indicate that Al_2O_3 corundum does not cause the death of adjacent cells, however, it causes cracks in the matrix of prosthesis material Ti6Al7Nb alloy and increases the risk for adhesion of bacteria. This supports our hypothesis that Al_2O_3 blasting may be the cause of infection and loosening of hip endoprosthesis. As these results were obtained after 7 days of direct testing, it would be of interest to consider longer times, as well as the effects of Al_2O_3 on osteointegration and the use of alternative methods for surface modification of cementless prosthesis stems.

Study of the surface phenomena and osseointegration of Zweymuller Hip endoprostheses

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In our study, we have explored newly manufactured and retrieved cementless hip endoprostheses that experienced premature failure, attributed to aseptic loosening, infection, and latent infection. Our primary objective was to gain deeper insights into the physicochemical phenomena occurring on the surfaces and sub-surfaces of Ti6Al7Nb alloy implants. The outcomes of our research endeavor are expected to facilitate the differentiation of premature failure causes, enhance surface modifications, achieve optimal osseointegration, and extend the functional lifespan of these implants.

Surface properties of Ti6Al7Nb alloy hip-stem endoprostheses (comprising two new and thirty retrieved specimens) were meticulously assessed through contact-angle measurements and average surface roughness analysis. To delve into the surface chemistry and microstructure, we employed a battery of analytical techniques, including scanning electron microscopy (morphology assessment), energy-dispersive spectrometry (chemical characterization), electron back-scatter diffraction (phase analysis), Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (surface chemistry investigation), and electrochemical measurements (corrosion assessment).

Our research highlighted the improved wettability of the grit-blasted Ti6Al7Nb stems post-autoclaving and the remarkable super wettability following oxygen-plasma sterilization. Notably, secondary-electron imaging revealed analogous morphology and microstructure in both new and retrieved stems, irrespective of the failure cause, while EDS analysis unveiled corundum contamination in the grit-blasted surface.

Notably, our investigation unveiled corundum-contaminated surfaces and subsurfaces in both new and retrieved Ti6Al7Nb implants. These corundum residues present a potential concern, serving as potential sources of third-body wear particles and likely contributors to osteolysis and aseptic loosening.

In addition, the study also examined the concerns related to debris generation and accumulation in titanium joint arthroplasty (TJA) components, particularly those subjected to grit-blasting with Al2O3 (corundum) particles during manufacturing. This debris, including polymeric, metallic, and corundum particles, has been associated with osteolysis and implant loosening. We evaluated wettability, surface morphology, chemistry, phase analysis, surface chemistry, and of new and retrieved Al2O3 grit-blasted titanium alloy components.

Furthermore, biocompatibility and cytotoxicity assessments were conducted by exposing blasted new and retrieved stems to human mesenchymal stromal stem cells (BMSCs). We identified Al2O3 particles in peri-prosthetic soft tissue and found that Ti6Al7Nb with residual Al2O3 particles and Al2O3 microparticles displayed low cytotoxic effects. Importantly, neither polished titanium nor ceramic disks exhibited cytotoxicity. While titanium and corundum debris penetrated deep into the tissue, no significant toxicity was associated with these materials.

This comprehensive study sheds light on critical aspects of hip endoprosthesis performance, ranging from surface properties and debris-related concerns to biocompatibility, ultimately aiming to improve the longevity and safety of these vital medical implants.

Smart hydrogel with bacteriophages and hydroxyapatite for improved osseointegration and prevention of early prosthetic joint infection

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Joint replacements with a total joint prosthesis (TJPs) is a safe procedure with high patient satisfaction, however, approximately 10% of TPJ need to be replaced within ten years. The most common reasons for revision surgery are aseptic and septic loosening. Researchers and clinicians are constantly trying to discover new ways to prevent these complications and increase the survivorship of TJP.

A joint prosthesis requires proper osseointegration for increased survival. The surface of the implants can be modified to promote osteointegration. Changes in the surface roughness or the application of coatings such as hydroxyapatite (HA) coatings are frequently applied to ensure mechanical stability and increase and accelerate bone formation after implantation.

Prosthetic joint infections (PJI) are not the most common cause of joint prosthesis replacement, but they are certainly one of the most serious complications of arthroplasty. Revision surgery and antibiotics have been the standard treatment for PJI, however, in recent years, there has been growing interest in using bacteriophages (phages) as an alternative or complementary approach. Lytic phages are viruses that specifically attack and destroy bacteria but are harmless to human cells.

New biomaterials or functional coatings are investigated either for their ability to resist bacterial adhesion and biofilm formation or for the ability to support tissue cell adhesion and osteointegration. The concept of using the "smart materials" that release the incorporated factors for stimulation osteointegration and prevention early joint infections is an intriguing area of orthopedic research. An innovative delivery system based on phage-loaded alginate-nanohydroxyapatite was developed as a multifunctional approach for local tissue regeneration and infection prevention. This concept offers several advantages: 1. phages specifically target and eliminate bacteria; 2. alginate serves as a matrix for the phages and helps protect them during storage and application; 3. nanohydroxyapatite promotes bone regeneration and provide structural support and aid in the localized release of phages.

While this concept sounds promising, the implementation of such material would require extensive scientific research, testing and validation. However, ongoing materials science and biomedical engineering advancements offer hope for future TJP innovations.

Scanning electron microscopy and focused ion beam studies of cells and their interactions with the surfaces

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Understanding the intricate interplay between cells and surfaces is of paramount importance in various scientific and biomedical fields. Scanning Electron Microscopy (SEM) and Focused Ion Beam (FIB) imaging have emerged as powerful tools for visualizing and analyzing cellular interactions with surfaces at the micro and nanoscale. This study presents a comprehensive investigation into these interactions, shedding light on the structural and functional aspects that govern cell adhesion, morphology, and behavior in response to diverse surfaces.

The first part of the study will focus on the SEM imaging of cells on differently structured surfaces. High-resolution SEM allows us to capture detailed morphological changes in cells, such as membrane ruffling, filopodia formation, and vesiculation, as they respond to surface properties.

In the second part of the study, FIB-SEM tomography is employed to investigate three-dimensional cellular architectures and their interactions with surfaces. By utilizing focused ion beams to selectively mill and reveal internal structures of cells adhering to surfaces, we gain a holistic perspective on the subcellular organization and spatial dynamics involved in cell-surface interactions.

The study results show the importance of imaging techniques such as SEM and FIB in studies of cells and their interactions with surfaces, as these two techniques help us understand the complete morphological properties of the cells and their spatial relationship to the surfaces.

Trabecular total hip arthroplasty – glimpse of past

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Total hip arthroplasty (THA) is a commonly performed surgical procedure aimed at relieving pain in the hip joint and improving function. In the early years, the main problem with the prosthesis was permanent anchorage. The Slovenian orthopedic surgeon Franz Copf, who worked in Stuttgart, developed the so-called bionic or trabecular total hip endoprosthesis to improve the previously poor prosthesis integration and bone ingrowth. It was first implanted in 1981 and was intended for difficult cases and revisions. THA uses trabecular metal, a porous, three-dimensional metal material, to create a spongy and porous structure in the joint that promotes tissue ingrowth and osseointegration. Trabecular THA is designed to mimic the natural trabecular bone structure and provide a greater surface area for bone-implant contact, which can contribute to increased stability and better osseointegration between bone and implant.

Objectives The aim of this study is to analyze properties of explanted trabecular THA and to present a case report of a patient with several previous surgeries to the left hip.

We present a case of 85 F with several surgeries to the left hip joint who experienced aseptic loosening of the previously implanted revisional femoral stem and "head" acetabular component with diffuse loss of bone stock and muscle atrophy. Explanation of the fully integrated acetabular component was difficult, and the patient required reconstruction with an acetabular reinforcement cage and a double mobility liner cemented into the cage.

A newly proposed bionic endoprosthesis was invented by a Slovenian surgeon and implanted in the early 1980s. A breakthrough at the time with firm, albeit late, integration. The case report showed aseptic loosening and one of the rare patients with the "Copf" endoprosthesis still implanted.

Oxidized zirconium in hip prosthesis - case report

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Orthopaedic patients, such as those experiencing pain when engaging in daily activities, possibly because of arthritis damage or sudden injury, may seek several types of treatment. If such treatments are not effective, patients may seek a surgical relief of pain, total hip arthroplasty (THA). During this procedure, the surgeon removes the diseased or necrotic tissue from the hip joint, including bone and cartilage. The head of the femur and acetabulum are replaced with artificial materials. Prosthetic components may be made from several different materials, such as metal alloys and different ceramics. As an increasing number of younger and more active patients are receiving total hip and knee arthroplasties, there is an increasing necessity to fabricate materials with an increased life span. Lately, the development of prostheses has been targeted towards the reduction of friction between the femoral head and the acetabular interface, thus reducing the wear of articulating surfaces. Ceramic materials for THA began being used in the previous decades. They proved successful, showing reduced osteolysis, as well as lower revision rates. Oxidized zirconium (Oxonium, OxZr)At the end of the previous century, a new material alternative for hip prosthesis was introduced. It consists of a metallic zirconium alloy and a smooth articulating surface of oxidized zirconium (Oxinium, OxZr). Its idea was to present the toughness of metal with the benefits of a ceramic surface. In Oxinium prosthesis, ceramic is not a coating on metal, but rather a 4-5 μm thick transitional surface zone of ceramic-to-metal. It is fabricated with thermal treatment of metallic head by oxygen at 500°C which transforms zirconia into a durable low-friction oxide on top of metal head. The product is therefore a metallic head with an Oxinium ceramic surface. Oxinium heads offered the potential to reduce wear and consequently increase the lifespan of implants. Problems with Oxinium use in hip prostheses There have been several case reports regarding severe wear and damage of Oxinium implants. Some studies reported patients experiencing pain, shattering glass sounds or squeaking sound when walking, as well as limited and difficult movement. This started up to 4 months prior to revision surgery, which found ceramic acetabular liners to be broken and the Oxinium head severely deformed. The metal femoral stem was stable, but there was dark stained metallosis present in tissues surrounding the prosthesis. Other studies reported similar patient symptoms before revision surgery, with eccentric positioning and deformation of Oxinium femoral head. Polyethylene liner was found to be dissociated with wear. Particle debris from wear was present. Additionally, some reports demonstrated a 50-fold increase wear rate in damaged compared to undamaged Oxinium femoral heads. Such damage could be consequent to contact between the metallic acetabular shell and femoral head during dislocation or similar maneuvers. Therefore, in patients where dislocation is likely to occur, Oxinium femoral heads can be problematic.

The cases mentioned above demonstrate against Oxinium's supposed improved wear, prolonged lifespan, and consequent better patient quality of life, and rather towards accelerated wear and particle debris formation upon damage to Oxinium femoral head.

Metallosis and Implant Failure in Patients with Metal-on-Metal Hip Endoprosthesis

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Background: Metal-on-metal (MoM) endoprosthesis is a type of total hip replacement where both articular surfaces are made of metal. With the development of metal materials arose an opportunity to reduce the wear of the endoprosthesis surface and on the other hand, increase joint stability by enlarging the head of the femoral component. Due to high expenses, MoM was used mostly in younger patients. However, after extended use, numerous reports of complications appeared with 2 to 3 times higher rate of implant failure. Complications are mostly the consequence of contact between two metal surfaces that cause accumulation of metal particles. Metal ions enter in the bloodstream, bone, and soft tissue generating a chronic inflammatory response with necrosis of tissues and thus instability of endoprosthesis. In multiple cases metallises progresses in fluid-filled or solid extra-capsular soft-tissue lesion called pseudotumor. Now due to the high rate of complications general use of MoM is unrecommended by orthopaedic societies. Even so the field of MoM is lately gaining interest on account of ceramic-on-ceramic construction of endoprosthesis.

Clinical case: A 43-year-old female patient has operated on abroad due to severe right hip arthrosis. The surgeon decided to implement MoM. There were no reported perioperative and recovery complications. Nevertheless, after one year the patient started to experience dull pain in the right gluteal region that was progressing through time. Diagnostics revealed an expansive destructive lesion of the right pubic bone and an unstable acetabular component of the endoprosthesis. Because of severe progressive pain 12 years after the first operation a revision of endoprosthesis was made by removing pseudotumor in the acetabulum and changing both components of the prosthesis.

New Advanced Technics for Diagnostics of TKA Failures

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Increased wear of the tibial polyethylene inserts (PEI) after total knee arthroplasty (TKA) and consequent induced osteolysis and aseptic loosening is the result of a multifactorial problem that involves factors from the implant, the surgeon, and the patient (1). Suboptimal reconstruction of frontal-plane knee kinematics (referring to varus and valgus rotational movement) during TKA can lead either to mediolateral instability or excessive tension in the knee joint (2). Both causes alone contribute to early TKA failure and are relatively difficult to diagnose. In many patients with failed TKA, the exact cause for failure remains unknown. To improve the diagnostic process in these complex cases, two new diagnostic methods are being assessed in the following studies.

In the first, implant retrieval study, polyethylene wear is being evaluated after failed cruciate retaining (CR) type TKA. Every selected retrieved PEI has been scanned with an optical scanner, digitalized, and compared with its reference CAD (computer-aided design) model. Articular surface wear (linear end volumetric) rates have been measured and compared with respect to various causes for revision surgery, implant size, and surgical and patient factors. Moreover, we aim to identify a potentially characteristic linear wear distribution pattern of the articular surface in the most common causes of TKA failure.

In the second, cadaveric study, we aim to determine the effect of kinematically aligned CR type TKA on frontal-plane knee kinematics at different angles of knee flexion, compared to a native knee joint. A custom-made testing device, which provides precise, electronically guided measurement of frontal-plane kinematics (range of varus/valgus motion) with concomitant forces, has been constructed for this purpose. Furthermore, two types of cadaveric specimens, fresh-frozen (thawed) and fresh (without intermediate freezing) are being used, which will enable us to assess the influence of cadaveric specimens' variability on study results.

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Bioabsorbable implants in guided growth procedures

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Guided growth or epiphysiodesis is an orthopedic surgical procedure on growth plates often used to correct deformities and limb length discrepancies. The purpose of this paper is to review the literature describing the use of bioabsorbable implants in guided growth procedures.

In orthopedic surgery, bioabsorbable implants are commonly used: bioresorbable polymers, bioceramics, and bioabsorbable metals. The bioresorbable metals, particularly magnesium alloy screws, have been shown to be safe and effective for selected orthopedic procedures in patients with immature skeletons. Two animal model studies have revised the use of polymer screws and their effect on growth plates.

Many more basic science studies are needed to evaluate the effect of different types of bioresorbable implants on growth plates before clinical indications can be proposed.

Multifunctional nanostructured surfaces for vascular stents

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Desired biological response (improved cell adhesion of one cell type over the other, pre-vention of bacterial adhesion and biofilm formation, protein adhesion etc.) presents the cru-cial factor influencing on the lifespan of all implantable medical devices. Surface finishing procedures are one of the important aspects in this filed, as biological response of all biomaterials is closely linked with its surface features (micro and nanostructured topography, surface chemistry, wettability). Highly reactive gaseous plasma treatment presents an intriguing approach, as it enables surface modification without altering the bulk attributes of the material. On the other hand, it may be combined with other surface treatment techniques which enable formation of well-defined surface nanotopography. In case of vascular implants, it is of primary importance to achieve good proliferation of endothelial cells, while preventing proliferation of smooth muscle cells and reduce platelet adhesion and activation. The aim of our work was to fabricate different nanotopographies and optimize its surface properties.
By electrochemical anodization TiO_2 nanotubes with different diameters were fabricated, while by hydrothermal method TiO_2 nanocubes were fabricated. Further treatment with highly reactive oxygen and or hydrogen radiofrequency (RF) plasma was conducted to appropriately condition the surface. The surface properties were studied by scanning electron microscopy (SEM), atomic force microscopy (AFM), X-ray photoelectron spectroscopy (XPS). The *in vitro* biological response of nanostructured and plasma modified surfaces were studied with human coronary artery endothelial cells (HCAEC), human coronary artery smooth muscle cells (HCASMC) and whole blood. Our study showed that *in vitro* biological response is significantly influenced by the surface treatment techniques.

Biomimetic Osteochondral Scaffold Augmented with Mesenchymal Stem/Stromal Cells for the Knee Osteo-Chondral Treatment.

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Background: Multilayered osteochondral scaffolds, either stand-alone or augmented with active regenerative cells, are becoming increasingly utilized for the repair of knee joint surface lesions (KJSLs). The results of the only two scaffolds that are currently clinical available (MaioRegen®, by Finceramica, Italy; and Agili-C®, by Cartiheal, Israel) are generally promising. However, the literature is rather limited to around 700 documented cases.

Purpose: A) To evaluate clinical outcomes and safety of a combined single-step approach with a biomimetic collagen-hydroxyapatite scaffold (CHAS) (MaioRegen®, by Finceramica, Italy) and filtered Bone Marrow Aspirate (fBMA) in the treatment of KJSLs. B) To report the results of the largest single-center cohort in the literature so far.

Methods: All the patients operated on due to KJSLs (size ≥ 1.5 cm^2, ICRS grades III-IV) by the combination above were selected from the hospital registry database (100 pts, years 14 -59, and minimally 2-year follow-up). Treatment outcomes were followed clinically (KOOS, EQ-5D, Tegner activity scale - TAS) and by pursuing serious adverse events (SAE) and graft failures (GF). Paired Student t-test was applied to compare pre-and postoperative PROMs values and determine postoperative improvements.

Results: At the mean follow-up time of 54.2 (19.4) months, 78 (87%) patients returned their PROM questionnaires. Postoperative improvements of all PROMs were statistically significant (Table 2.). The mean improvement of primary outcome measure KOOS Pain met both: the Clinically Important Difference (CID) set at 8.3; and the Patient Acceptable Symptomatic State (PASS) defined at postoperative score of 72.2. CID for KOOS Pain was achieved in 52 (67%), and PASS in 58 (74%) patients. Only 4 GF in the whole cohort (4%) were noted during the observed timeframe.

Conclusions: CHAS augmented with fBMA proved as an adequate and safe approach for KJSLs treatment up to mid-term follow-up. Further research and developments are desirable in the promising fields of tissue engineering and regenerative medicine to broaden the indications and enable native joint preservation.

Exploring screw materials for ACL reconstruction

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Titanium screws: The first ACL graft fixation using interference screws was achieved using a metallic device, in 1983. At present, titanium is the most common material used for this class of devices. Titanium alloy Ti6Al4V is the most common titanium alloy used in orthopaedics. Ti6Al4V has a biphasic alpha–beta microstructure, The Al and V alloying elements stabilize the alpha-beta microstructure, and improve the mechanical properties, in relation to CP Ti (Commercial pure titanium) such as tensile and yield strengths. These properties can be modulated by heat treatment and mechanical working. Despite Ti and Ti alloys combining a range of excellent properties, i.e. mechanical properties, corrosion resistance, fatigue–corrosion resistance, low density, and relatively low modulus, their processing is not easy.

Titanium screws provide high initial fixation strength and promote early integration into the bone, but, in the case of revision surgery, hardware removal may be technically Challenging, and the advantages of absorbable screws consist of reduced MRI artifacts and no need to remove the implant, justifying the widespread use of bioabsorbable screws.

PEEK screws: Polyetheretherketone (PEEK) pronounced (poly-ether-ether-ketone) is an exceptionally strong thermoplastic polymer. Implantable-grade PEEK is an advanced thermoplastic material that is extremely well-suited for both short- and long-term implantation. In orthopaedic devices, a mismatch of mechanical properties between the host bone and the orthopedic implant material is a concern. If an implant material is much stronger or has a higher modulus than the host bone, stress shielding can occur resulting in bone loss. This bone loss leads to implant loosening and subsequent biological failure of the implant. If an implant material is too weak or has a substantially lower modulus, the implant itself may fail mechanically [2] The tensile yield strength and shear strength of PEEK are superior matches to cortical bone, especially when compared to titanium materials. PEEK also has a low coefficient of friction, making it a "slick" material easing insertion into host bone. Neither repeated gamma sterilization or oxidation causes a significant deterioration of mechanical properties. In general, oxidation has no or little effect on PEEK. PEEK is extremely resistant to hydrolysis even at elevated temperatures. [2] Nonmechanical advantages in favor of PEEK are biocompatibility (defined as the suitability of a material for exposure to the body or body fluids) and biostability (defined as the ability of a material to maintain its physical and chemical integrity after implantation into living tissue). At early testing, there was no evidence of cytotoxicity, systemic toxicity, irritation, or macroscopic reaction, when testing biocompatibility. Mild fibrosis or light fibrous capsules were noted and no muscle degeneration, necrosis or other significant changes were observed in explanted

tissues, when testing biostability [1].

The third, nonmechanical advantage to PEEK is its ability to be imaged using MRI or X-ray. There is no metal present and therefore no metallic scatter is seen on MRI scan and the material is radiolucent.

Biocomposite screws: Absorbable composite interference screws for graft fixation in ACL and PCL reconstruction procedures have recently been discovered combining the inherent degradation characteristics of a biocompatible polymer with the bioactivity of a ceramic. Biodegradable polymeric materials such as polylactide (PLA) and polyglycolide (PGA) have been used in orthopaedic applications since the 1970s. Both materials are easily degraded within the body - PLA into lactic acid and PGA into glycolic acid. PLA is a crystalline material with a slow resorption rate, while PGA is amorphous and resorbs much faster. PLA and PGA materials can be combined in different ratios to produce poly(lactide-co-glycolide) (PLGA) polymers with variable degradation rates. PLA exists in two isomeric forms, L-lactide and D-lactide (PLLA or PLDA). Combining these PLA isomers can alter degradation time and mechanical strength. Ceramics such as hydroxyapatite (HA) and Beta-tricalcium phosphate (ß-TCP) have excellent bone biocompatibility and similarity in mineral content to natural bone. Their main problem is resorbability.

Biomaterials: can biomaterials be toxic?

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Biomaterial (BM) is defined as any matter, surface, or construct that interacts with biological systems. Therefore, BMs have a range of appplications from 1) medical implants as an artifical joints, dental implants, ligaments; 2) human tissues healing including sutures and staples for wound closure; 3) regenerated human tissues including bone regenerating hydrogel and a lab-grown human bladder; 4) molecular probes and nanoparticles that break through biological barriers; 5) biosensors as glucose monitoring devices and brain activity sensors and 6) drug-delivery systems as drug-coated vascular stents and implatable chemotherapy wafers (NIBIB, 2017). Specifically, polymeric BMs are used in the biomedical field because of the fabrication, flexibility, and biocompatibility, as well as mechanical, chemical, and thermal specifics (Shirvan et al., 2021). Polymeric BM have been widely used in many implantable prostheses due to their biological inertness and mechanical and structural compatibility. Recently, the paradigm shift toward bioactive polymers might lead to the development of new materials that not only are biocompatible but also can respond to molecular, cellular, and mechanical cues. Most of the studies conducted for the emerging materials so far have been limited to early synthetic approaches and *in vitro* evaluation (Dang et al., 2014; Basu, 2016; Kannan et al., 2022). We want to highlight that due to the fast growth of the field of tissues enginieering and regenerative medicine the selection of appropriate polymeric biomaterials can only be iteratively improved with information from postimplant monitoring of devices in existing clinical use. All new polymeric BMs intended for long-term applications should undergo a series of biocompatibility tests to assess any toxic/harmful effect to the host tissues and predictive testing such as evaluations in different models, accelerated aging, and statistical projections for safer clinical application. The conclusions and future perspectives of the polymeric materials used in medicine and a potential clinical study development will be brifly discussed.

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Systematic review and meta-analysis of metagenomic next-generation sequencing as a diagnostic tool for pathogen detection in prosthetic joint infections

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Metagenomic next-generation sequencing (mNGS) has shown to be a useful method for pathogen detection in prosthetic joint infections (PJI). The technique promises to minimize the PJIs without the known causative agent. Today we want to present how NGS has a potential to improve PJI diagnostics based on two studies.

In the first study, a meta-analysis was performed. PubMed and OVID Medline databases were used for article search. The studies using mNGS whole-genome sequencing method and the ones where PJI diagnosis was based on one of the currently recognized criteria were included. Univariate metanalysis using a random-effect model has been performed in R studio with a “meta” package. Pooled sensitivity, specificity, and DOR (diagnostic odds ratio) were calculated.

Nine studies with a total of 957 cases were included in the meta-analysis. Through meta-analysis, it was observed that mNGS technique is more sensitive than cultures with 89% (CI 81%- 94%) vs. 71% (63%-78%) respectively (p=0.0014). The specificity between methods was similar, for mNGS reaching 93% (CI 89%-96%) vs. culture 97% (CI 92%-99%) (p=0.14). In the PJI group, 159 new possible pathogens that were not isolated by microbiological culture were detected by the mNGS, most frequently anaerobes and CoNS in 30/159 (19%) Fourteen new organisms were detected in the control group and were mostly regarded as contaminants.

In the next study 16S NGS was compared to standard cultivation. Sonicate fluid samples from 27 patients undergoing revision arthroplasty using both routine culture techniques and metagenomic 16S amplicon sequencing (16S AS) were studied. Statistical comparison of both methods included stringent separation of contaminants from highly reliable true-positives.

Limited concordance between cultivation and 16S AS was found, with several bacterial genera, including Anaerococcus and Citrobacter, identified exclusively by 16S AS. Importantly, using culture-based methods, multiple PJI samples that were negative for bacterial pathogens were shown to harbor multiple bacterial taxa using 16S AS.

Conclusions: Metagenomic sequencing has shown to be more sensitive than microbiological cultures in pathogen detection and thus has a great potential to improve the diagnosis and treatment of PJI. More studies on different prosthetic joints and comparing different diagnostic criteria for PJI would be needed better to understand the true diagnostic power of this method.

What is the optimal biomaterial for spinal fusion?

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While historically spinal fusion consisted of autologous bone graft implantation and external fixation (casting), nowadays the development of biomaterials and surgical techniques allows for numerous different surgical approaches and implants that promote fusion with the concurrent restoration of the anatomy. Most of the novel implants are anteriorly based and promote interbody fusion which increases the fusion surface. Despite all the development, we cannot achieve solid fusion in all cases, hence the question of which concept is favorable is still in place. In this abstract, we aim to overview the current concepts of spinal fusion implants and to discuss the pros and cons of individual implant types. We performed a literature search on spinal fusion implants. We reviewed the papers on biomaterials, biomechanics, biotechnologies, and research progress in spinal fusion implants. We extracted the different types of implants, their materials, and the benefits and pitfalls of their properties.

The current concepts of spinal fusion implants are the following:

- Titanium and its alloys – these promote bony ingrowth in and around the implant by forming a nonreactive surface layer of TiO_2. Introducing nanoscale roughness on the surface shows increased osteoblast maturation. The biggest drawback of titanium implants is the high modulus of elasticity, which promotes stress shielding and implant subsidence. It is radiopaque, which makes it hard to determine the extent of fusion on X-rays.
- Porous titanium alloy implants (Ti-6Al-4V) – the modulus of elasticity drops form 110GPa to 2,5GPa in porous titanium, which makes it closer to the cortical bone, resulting in a more physiological stress distribution, reducing subsidence, while increased surface roughness and porosity promote better ingrowth.
- Porous tantalum – modulus of elasticity like trabecular bone prevents subsidence, pores provide scaffold for bony ingrowth, facilitates osteoblast differentiation. Studies have shown similar subsidence rates to titanium.
- PEEK (poly-ether-ether-ketone) – modulus of elasticity equal to natural bone, no subsidence, poor ingrowth, and osteoblast differentiation abilities – high risk of pseudarthrosis. Novel techniques with nanoscale surface layers show better bone ingrowth promotion.
- Bioactive ceramics – high strength and Osseo integrative properties to promote fusion, decrease the need for a rigid cage. Clinically similarly effective as titanium, but highly increased cost. Ceramic materials, such as CaO-SiO_2-P_2O_5-B_2O_3, 45S5, Silicon nitride have been tested.
- Hybrid technologies and surface coating – different technologies have been introduced to combine the modulus of elasticity and radiolucency of PEEK and the Osseo integrative potential of titanium. These implants, however, may cause a substantial wear debris accumulating around its surface, which may cause an inflammatory reaction. Silver coating was used to prevent infection.
- Surface coating with hydroxyapatite – it has been shown to increase the Osseo integrative properties of both titanium and PEEK
- 3-D printing – a porous 3-D printed titanium may decrease the wear debris produced by titanium coated PEEK while keeping all the benefits.

A perfect bone fusion implant would have the following properties: osseointegration (Osseo inductive), modulus of elasticity comparable to natural bone, no stress shielding, no subsidence, bioprotective (antibiotic).

The use of biomaterials in periodontal regeneration

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The use of bone grafting materials in periodontology has become so widespread over the past two decades that new products are rapidly being brought to market year after year. For that reason, it is crucial that treating clinicians optimize their regenerative outcomes with a better understanding of the biological properties of each of these classes of biomaterials.

The most widespread classification of bone grafting materials involves autogenous bone coming from the same individual, allografts coming from human cadaver bone, xenografts coming from another animal source, and synthetically fabricated allopath. Typically, all collagen and growth factors are removed during the processing of xenografts, the development of a natural bone mineral containing atelocollagen type 1 has been proposed that utilizes atelopeptidation and lyophilization technologies. Extracted teeth are routinely discarded, yet, owing to the bone-inducing potential of these mineralized tissues, they have been recently utilized as bone grafting particles. Freshly extracted teeth are ground into bacteria-free particulate autogenous mineralized dentin for immediate grafting. The freshly extracted tooth, which is most like the structure of autogenous cortical bone, offers the type of graft that effectively promotes new bone formation in the first stages of wound healing and supports and maintains the site with excellent long-term mechanical properties during the remodelling process. Numerous synthetically fabricated allopaths are fragile, difficult to process into porous forms, and unable to regenerate bone at optimal levels. However, 3D printing has become a prominent area of research because of its ability to create customizable, shape-specific alloplasts of various sizes. Techniques for 3D printing include inkjet printing, laser-assisted printing, extrusion printing, and stereolithography printing. Materials utilized to fulfill these tasks include natural and synthetic polymers, bioceramics such as hydroxyapatite and tricalcium phosphates, metals, and hydrogels, which may further include cells and growth factors within their 3D scaffold.

More recently, significant evidence appears to indicate that certain combinations of regenerative materials may additionally improve the clinical outcomes in defects with complicated anatomy (eg, growth factors with bone grafting materials, growth factors with barrier membranes, bone grafting materials with barrier membranes). The following combination approaches have been histologically shown to promote periodontal regeneration in humans: bone grafting material with enamel matrix derivative (EMD), bone grafting material with platelet-derived growth factor (PDGF), bone grafting material with growth differentiation factor 5 (GDF-5), and bone grafting material with barrier membranes. Hyaluronic acid (HA) has been utilized for a variety of regenerative medical procedures. HA has been utilized at various concentrations in either a crosslinked or non-crosslinked manner for the treatment of periodontal and bone defects. While more publications have investigated its use in the field of periodontology, its recent use for bone regeneration, specifically when utilized in combination with other biomaterials or cells, has shown positive results.

In conclusion, there is a trend favoring the combined use of biologics, barrier membranes and bone grafting materials in periodontal regeneration according to defect morphology.

Comparison of two-piece ceramic implants with a tissue- and bone-level platform: preliminary results of a randomized controlled clinical trial

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Aim: An ongoing randomised clinical trial evaluated the clinical outcomes of two-piece zirconia implants with platform at soft tissue or bone level six months after placement of all-ceramic single-tooth restorations. *Materials and Methods***:** A 10-mm-long and 4-mm-wide ceramic implant with a platform at soft tissue level (Z5-TL, Z-systems, CH) (n = 5) or at bone level (Z5- BL, Z-systems, CH) (n = 5) was placed in healthy adults with missing maxillary premolars and sufficient alveolar ridge height and width for direct implant placement according to the type 4 protocol. After digital position planning (Blue Sky Plan 4.8), all implants were placed with a drill guide in a partially guided procedure. The Ostell device was used to measure the stability of the implants immediately after implant placement and again three to four months later when the prosthetic procedures were planned. The crowns were made of lithium disilicate ceramic and bonded to the ceramic abutments with dual cured composite cement. We compared the planned and actual positions in the digital environment. After six months, a clinical and radiographic check-up was performed to assess the condition of the soft tissue and marginal bone.*Results:* Initial ISQ values ranged from 73 to 79, and after 3 to 4 months, these values ranged from 76 to 84. In 3/5 cases of BL group, 1 mm of marginal bone was resorbed before loading. In one case (BL platform), marginal bone resorption was so severe before loading that the BL platform was exposed in the oral cavity, requiring the use of an abutment designed for the TL platform. In one case, the fixation screw broke during attachment of the abutment to a BL implant, and the fragment was removed with an ultrasonic device. In nine cases (including BL implants with marginal resorption before loading), the mucosa adjacent to the implants was in perfect condition 6 months after placement, whereas one TL implant showed gingival recession and bleeding on probing. At 6 months, marginal ridge resorption of more than 1 mm was observed in 4/5 of the BL implants, while only slight remodelling was observed in 3/5 of the TL implants. Six months after implant placement, ten out of ten implants were well integrated and functional.

Conclusion: All ceramic implants implanted according to the type 4 protocol in the maxillary premolar region integrated successfully and could be restored with all-ceramic crowns. Prior to loading of the BL implants, mild but clinically acceptable resorption of the marginal bone was frequently observed, while the neck of the TL implants frequently exhibited remodelling characteristics of the TL platform. Six months after loading, the soft tissue around both types of implants was stable.

Intraoral Scanners: Present Reality or Future Fantasy?

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Intraoral scanners have rapidly evolved and become a focal point of innovation within the field of dentistry, raising the question of whether they represent the present reality or a future fantasy. This abstract delves into the current state of intraoral scanning technology, its applications, and its potential for shaping the future of dental practice.

Intraoral scanners are a remarkable technological advancement that has already made significant inroads in contemporary dentistry. These handheld devices employ advanced optical technology to create precise, three-dimensional digital representations of the oral cavity. This transformation from traditional impression materials to digital scanning has not only improved patient experiences but has also brought about a paradigm shift in clinical workflows.

The current reality of intraoral scanners is one of proven efficacy and growing adoption. Their applications span various domains of dentistry, including restorative dentistry, orthodontics, implantology, and prosthodontics. The ability to capture high-resolution, real-time digital impressions has streamlined treatment planning, design, and production of dental prosthetics. Dentists and dental technicians can collaborate seamlessly, exchanging digital impressions and designs electronically, reducing errors and enhancing overall efficiency.

However, the question remains: Are intraoral scanners merely the present reality or a future fantasy? The answer lies in the technology's ongoing evolution. As intraoral scanners continue to improve in terms of speed, accuracy, and affordability, their potential expands. Emerging features such as augmented reality integration, artificial intelligence-assisted diagnostics, and chairside 3D printing hint at a future where intraoral scanners may be central to a wide range of dental procedures, further enhancing precision, reducing costs, and expanding the scope of treatment options.

In conclusion, intraoral scanners are not just a present reality but a harbinger of a fascinating future in dentistry. They have already transformed many aspects of the field, and as technology continues to advance, their role is poised to expand, making dental care more accessible, efficient, and patient-centered. The journey from fantasy to reality is well underway, and intraoral scanners are at its forefront, shaping the future of dentistry.

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Contemporary management of incisors with Molar Incisor Hypomineralisation using resin infiltration

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Molar Incisor Hypomineralisation (MIH) is a prevalent developmental dental disorder characterized by enamel hypomineralisation affecting first permanent molars and incisors. This condition poses significant clinical challenges due to the susceptibility of affected teeth to caries and sensitivity, often leading to functional and aesthetic issues. This presentation highlights the contemporary management of incisors affected by MIH through resin infiltration, a minimally invasive and promising treatment approach.

Resin infiltration has emerged as a minimally invasive and effective treatment option for MIH-affected incisors. This technique involves the infiltration of low-viscosity resin into the porous enamel, sealing the microdefects and improving enamel strength and aesthetics. The procedure is less invasive than traditional restorative approaches such as composite fillings or crowns.

Research and clinical experience suggest that resin infiltration offers several advantages. It may effectively mask the discoloration associated with MIH, improving the aesthetic appearance of affected incisors. Additionally, it reduces hypersensitivity and provides a protective barrier against caries progression. We will discuss the selection of suitable cases for resin infiltration based on lesion severity and enamel porosity. Nevertheless, further research is warranted to expand our understanding of the long-term outcomes and clinical applications of resin infiltration in managing MIH-affected teeth, ensuring better oral health and improved quality of life for affected individuals.

The Technology of Photobiomodulation in Salivary Glands Dysfunction

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Photobiomodulation, also known as low-level light therapy, is a form of phototherapy that uses low-energy light to treat different tissues. The irradiation causes absorption of light in the chromophores of irradiated cells, ultimately boosting cellular metabolism and improving tissue immune response and regeneration. This method is increasingly applied as an aditional therapy for various medical conditions, including within the field of dentistry. Saliva, a bodily fluid produced by salivary glands, plays the main role in maintaining a healthy oral environment. Salivary gland disfunction, caused by different diseases, can cause qualitative or quantitative changes in saliva. Hyposalivation, characterized by reduced saliva secretion due to salivary gland dysfunction, increases the caries risk. Implementing a simple and non-invasive approach with stimulating salivary production through photobiomodulation, may prove successful to be important in caries prevention. With the increase of the salivary flow and its natural protective mechanisms, this therapy can improve oral health by reducing the susceptibility to dental caries.

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Three-dimensional assessment of jaws and face moprphology in children in years of growth and development

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Introduction The aim is to show the use of 3D imaging system in the clinical practice by characterizing facial and jaw morphology of children with Class III malocclusion and without malocclusion in primary and early mixed dentition.

Materials and methods. 3D surface facial scans of children with primary and early mixed dentition were obtained using two laser scanners (Figure1a). The 3D data were processed in Rapidform® 2006. The left and right scans of the face were registered and merged to produce a complete facial image (Figure 1b). The facial shells were superimposed on corresponding average templates using the best-fit method. Differences were quantified between respective facial regions (Figure 1c).

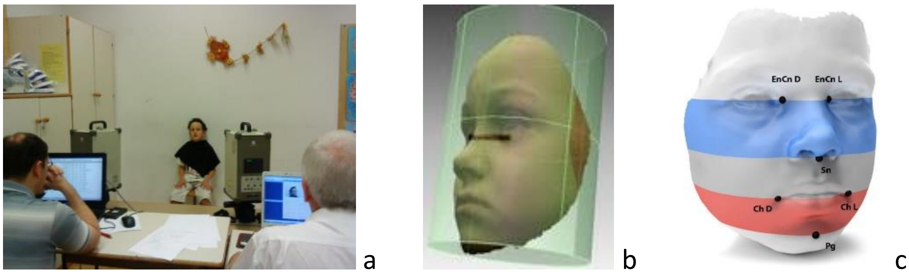

Figure 1 (a) Acquisition of 3D images of faces with high-resolution Minolta Vivid VI910 3D laser camera. (b) Showing face orientation in 3D space. (c) Parts of the face: Upper face (blue), mid-face (gray), lower face (red).

Results The results showed a significantly less prominent mid-face in the Class III group compared with the control group, in both primary and early mixed dentition, which agrees with other studies [1, 2]. Although the variables in the lower face, representing the mandible and lower lip, did not reach statistical significance, our results indicate a tendency of mandibular protrusion.

Discussion A non-invasive 3D laser surface scanning method and 3D analysis proved to be an effective tool in the early diagnosis of Class III malocclusion in primary and early mixed dentition.

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Magnetic resonance imaging technique in periodontology

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Magnetic resonance imaging (MRI) technique has become an accepted mode of examination in medicine. MRI can be used as a non-invasive method for the characterization of the inflammation and healing processes in periodontal tissues in contrast to occlusal radiography, panoramic radiography, CT, or CBCT with varying radiation exposure and health hazard. In dental medicine, it would be the most helpful in periodontology.

Periodontal disease is the most widespread chronic infection of mankind. Bacteria associated with dental plaque represent the primary etiologic factor in periodontal inflammation. It is characterized by the loss of the supporting tissues of the teeth as well as humoral and cellular immune response to bacterial antigens of the microbial dental plaque that accumulates at the dento-gingival junction. Periodontal inflammation represents the response of vascular gingival tissues to injury. Early diagnosis and therapy improve the prognosis of periodontal disease and so minimizes its influence on the systemic condition. Precise diagnosis is needed for good treatment planning that leads to a successful outcome of the periodontal therapy. The diagnosis and classification of periodontal diseases are usually based almost entirely on clinical and radiological analysis. Diagnostic imaging methods used in dentistry show mainly changes in hard dental and periodontal tissues. However, a diagnostic method that provides qualitative and quantitative data about soft inflamed periodontal tissues is lacking and it could be MRI technique.Magnetic resonance imaging allows image acquisition from the interior of the human body. It is capable of direct imaging in any plane, producing no harmful biologic effects in the diagnostic range currently utilized and has better soft tissue contrast than the best x-ray computer tomography. In addition to that, MRI offers a three-dimensional presentation of the tissues observed. Image slices at an arbitrary orientation can be acquired without recourse to ionizing radiation. MR imaging depends on several parameters, which can be selectively enhanced to obtain the greatest difference between normal and inflamed tissues. In dental medicine MRI is used mainly for the diagnosis of pathology of the temporomandibular joint, floor of the mouth, tongue, salivary glands, and paranasal sinuses. In orthodontics MRI is used in treatment planning in the detection of TMJ disorders and soft tissue malformations. MRI technique uses a powerful magnetic field to align the nuclear magnetization of (usually) hydrogen atoms in water in the body. Radio frequency (RF) fields are used to systematically alter the alignment of this magnetization. An image can be constructed because the protons in different tissues return to their equilibrium state at different rates, which is a difference that can be detected. By changing the parameters on the scanner, this effect is used to create contrast between different types of body tissue. On the MR images gingiva, periodontal ligament, dental pulp and the cancellous bone can be observed. The inflamed tissues can be well resolved from healthy tissues. That can be further enhanced with the use of contrast agents and the use of in vivo magnetic resonance spectroscopy (MRS) measuring T1 and T2 relaxation times. The in vitro T1 relaxation times measurements of gingival samples showed an increase in relaxation times with the increase of probing depth at the sites of tissue removal. The in vivo studies demonstrated that the reduction of inflammation and probing depth in gingival tissues after non-surgical periodontal therapy correlates with a decrease of magnetic resonance signal intensity (MRSI) in T1 weighted MR images. MRI is the ideal technique to display the soft-tissue abnormalities produced by inflammation. In general, these soft-tissue alterations are recorded by SI changes that reflect the increased water content of the soft tissues, induced by the inflammatory processes. In some cases, these changes are non-specific, but in others MRI can be quite helpful in detecting the presence and extent of the inflamed tissue, which helps to provide a better characterization than usually obtained by clinical parameters. It would also be interesting to supplement MRI data with CT scans as these could help to reveal inflammation processes in hard/soft-tissue interfaces.

POSTER PRESENTATIONS

Interferometric light microscopy assessment of size and number density and scanning electron microscopy imaging of extracellular particles in different natural materials

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Extracellular particles (EPs) have been acknowledged as important mediators in cell-to-cell communication on the microscopic as well as inter-organism, and inter-species interactions. Characterization of EPs is challenging due to their small size (in the nanometer to micrometer range) and transient identity. Therefore, techniques are sought to assess them with minimally invasive methods. Here we report on a recently developed interferometric light microscopy (ILM) to assess the average number density (n, per mL) and average hydrodynamic diameter (D_h, in nm) of extracellular particles in different natural samples. We detected (n=2060/mL, D_h=115±30nm) in isolate from spruce needle homogenate, (n=12.2/mL, D_h=207±68nm) in apoplastic fluid from hops leaves, (n=0.08/mL, D_h=469nm) in cultured media of microalgae *Chlorella vulgaris*, (n=0.31/mL, D_h=406±244nm) in cultured media of microalgae (*Phaeodactylum tricornutum*) in (n=85/mL, D_h=141±130nm) canine plasma, equine plasma (n=14/mL, D_h=202±75nm), human plasma (n=101/mL, D_h=186±86nm) and canine blood (n=104/mL, D_h=177±70nm). The samples and isolates were imaged with scanning electron microscopy indicating colloidal membrane-enclosed vesicles in isolate from spruce needle homogenate and in plasma. While other samples were abundant with EPs, the conditioned media of microalgae were poor with larger EPs. ILM proved convenient for assessment of number density and D_h of EPs in all samples, in blood preparations (e.g., plasma, diluted blood); therefore, its use in population and clinical studies is indicated.

Biomaterials: Plastics and Human Health

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The production, use and recycling of plastic products are not the only source of the environmental pollution, but they also may have health consequences. The health crisis caused by climate change from extreme weather events such as heat waves, droughts and floots, to related social unrest, and chemical pollutant exposure, results from ever-growing fossil fuel combustion and release of other gas emissions (Woodruuf et al., 2023). Environmental physiology rises the importance of environment and lifesyle habits that may also influence health, especially in more sensitive subpopulations as prenatal/postnatal period and reproductive-age males and females (Gore et al., 2015; Virant-Klun et al., 2022; Srnovršnik et al., 2023; Amon et al., 2023). Specifically, the environmental chemicals may influence on oxidative stress and endocrine system associated with reproduction complications; hormone-sensitive cancers and neuroendocrine disfunctions (Gore et al., 2015). Moreover, a large body of widely measured endocrine discrupting chemicals (EDCs) such as bisphenols (BPs), parabens (PBs), triclosan (TCS), phthalates are synthetic chemicals present in many consumer products and fluctuating concentrations in the body with suspected adverse health effects (Husøy et al., 2019; Runkel et al., 2022). The health community and decision makers must take responsibility for the potential impact of environmental factors on health in order to effectively address the global environmental threat.

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Rehabilitation: Biomechanical and metabolic impact of obesity on orthopedic patients

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Obesity is defined by calculating the Body Mass Index (BMI) of an individual. A BMI of >30 kg/m^2 is considered clinically obese. Physical inactivity and high caloric intake have been directly correlated with an increasing BMI. An increasing number of patients with obesity are presenting to orthopedic departments. Specifically, an elevated BMI can impact orthopedic issues through two broad mechanisms: biomechanically and metabolically. These two concepts cause issues to both the bone itself and/or the surrounding soft tissue and its structures. Obesity increases the risk of multiple co-morbidities, including but not limited to: hypertension, type 2 diabetes, coronary artery disease, stroke, sleep apnea, and osteoarthritis (Molina et al. 2023). Additionally, moderate dynamic mechanical loading is one of the most important mechanical factors for maintaining joint homeostasis. The integrity of articular cartilage is maintained under moderate loading conditions during routine daily activities. However, when receiving abnormal excessive mechanical loading, disruption of cartilage homeostasis and deformation of normal joint morphology occurs, further inducing and accelerating the progression of osteoarthritis (Chen et al., 2020). Recent studies highlighted the role of obesity and metabolic syndrome in the pathogenesis of knee osteoarthritis not simply through increased mechanical loading but the systemic effects of obesity-induced inflammation. The current concept of knee osteoarthritis is that of a 'whole joint disease', which highlights the involvement not only of articular cartilage but also the synovium, subchondral bone, ligaments and muscles (Shumnalieva et al:, 2023). These findings highlights that the adequate management of knee osteoarthritis needs to include an optimization of body weight, a beneficial mobility regimen and obesity-related inflammation treatment as a possible pharmacological therapy targeting specific molecules and a personalized approaches of physical therapy.

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Using digital technology to determine the removal of hard dental tissues associated with preparations for ceramic crowns

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Background: CAD/CAM technology first appeared in dentistry in the 70s of the last centuries. Since then, the development and use of digital technology in dentistry has grown exponentially. Digital techniques have replaced many classical techniques in clinical practice. The intraoral scanner captures data on the 3D appearance of the jaw, teeth, and soft tissues and converts them into digital data. It also enables visual analysis and measurement evaluation of changes in periodontal tissues, teeth, and prosthetic restorations. Today, modern ceramics are used in dentistry for all-ceramic restorations, which have increasingly better mechanical properties and are therefore used in the anterior as well as in the posterior area of the dental arch. Ceramics used in CAD/CAM technology are constantly changing and improving to meet aesthetic, biological, and sustainability requirements. *Objectives:* Today, more and more prosthetic constructions are made with the help of advanced digital technology, such as intraoral scanners, 3D printers, and CAD/CAM technology. Therefore, the aim of our study was to quantify and compare the amount of the removed tooth structure in the preparation for monolithic zirconium oxide ceramics crowns and in the preparation of metal-ceramic crowns using digital technology. *Materials and Methods*: On the Frasaco model of the upper jaw, the left molar (tooth 26) was prepared for a metal-ceramic crown and an all-ceramic crown. The sample size for each preparation was 15 teeth, and a total of 30 teeth were prepared. The prepared teeth were scanned with the Trios 3Shape intraoral scanner. The obtained STL files of the scanned teeth were then processed in the Geomagic program. With the help of the tool, we cut out a single prepared tooth from the scanned model and measured the volume of the crown part of the tooth. Each measurement was repeated 3 times, and the average value was calculated, which represented the final volume of the crown part of each prepared tooth. In the same way, we measured the volume of the crown part of the unprepared tooth, which served as a control. We used volumetric analysis to calculate the volume loss for each type of preparation. The results were statistically processed with a two-way analysis of variance (ANOVA).

Results: The loss of tooth substance in preparations for a metal-ceramic crown amounted to 49.6% $\pm$ 5.2 and in preparations for monolithic zirconium oxide ceramics crowns 30.6 % $\pm$ 4.1. The loss of hard dental tissues was statistically significantly lower in the preparation for the all-ceramic crown ($p < 0,001$). *Discussion and Conclusion:* The use of CAD/CAM technology enables a standardized process that is predictable, reliable, and more economical for both simple individual restorations and larger and more complex restorations. It also allows the use of more aesthetic materials such as aluminium oxide ceramics and zirconium oxide ceramics. All-ceramic crowns have a similar survival rate to metal-ceramic crowns, provide a more beautiful appearance, and less the preparation is less invasive, which is also confirmed by our research.

Effect of Photobiomodulation on Tooth Movement in Patients Undergoing Orthodontic Treatment

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*BACKGROUND***.** Photobiomodulation (PBM) is a form of treatment that uses low-power, red and near-infrared light to stimulate tissue repair and regeneration on the cellular level. It is supposed to accelerate tooth movement, thus shortening treatment time.

*METHODS***.** In the clinical cross-sectional study, 32 subjects were included (10 men and 22 women, aged 14.6 ± 2.0 years), who were treated with a fixed orthodontic appliance due to dental crowding. The subjects were divided into 2 groups, the experimental group, which received light therapy with PBM and the Placebo control group, which was irradiated with a non-therapeutic light according to the same protocol. Light therapy was performed twice a week, for 4 weeks in a row, each time for 10 minutes, with a minimum 2-day break in between. An intraoral scanner was used to capture the upper and lower dental arch, firstly before fixed orthodontic appliance (FOA) placement, then after 1 week and 4 weeks after placement. Analysis of 3D virtual study models was performed using MeshLab 2022.02 software. Scans after 1 and 4 weeks were compared with initial scan, respectively. 3D surface scan is made of a mesh of points forming triangles. Digital jaw models were registered using best-fit alignment method, that was enhanced by using pairs of points on the anatomical structures that are considered most stable during orthodontic tooth movements, i.e., on the molar cusps and on the lingual gingival plane of the teeth that were not included in FOA and additionally palatal rugae on the upper jaw models. We measured the length of the maximum amount of orthodontic tooth movement.

*RESULTS***.** In the PBM group, tooth movements were statistically significantly greater both after 1 week of placement and after 4 weeks compared to the status before FOA placement. After 1 week, the median body movement was 0.1 mm greater in the study group, after 4 weeks it was 0.5 mm.

*CONCLUSION***.** Photobiomodulation using LED light can accelerate tooth movements in initial stage of orthodontic therapy with fixed appliance. The PBM therapy could be useful as a supportive therapy during orthodontic teeth movements.

Surface chemistry of fixed orthodontic appliance archwire after antimicrobial photodynamic therapy exposure

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Gingival enlargement is a common complication of treatment with fixed orthodontic appliances, biocompatible stainless steel archwires (SS). Due to the retention areas, dental plaque accumulation is increased, which results in anaerobic conditions, favourable for periodontopathogenic bacteria. Therefore, it is reasonable to assume that periodontopathogenic bacteria can be found in patients with fixed orthodontic appliances. Organic deposits on the surface of archiweres were analyzed. 21 patients with fixed orthodontic appliances and gingival enlargement in the upper dental arch were included in the study. For determination of periodontopathogenic bacteria *Aggregatibacter actinomycetemcomitans*, *Porphyromonas gingivalis*, *Prevotella intermedia*, *Tannerella forsythia* and *Treponema denticola* the molecular microbiological method GenoType Test System was used. For surface analysis of new and in vivo exposed SS archwires X-ray Photoelectron Spectroscopy was used. The average probing depth at the baseline was 3.76 ± 0.85 mm. Three types of periodontopathogenic bacteria, *A. actinomycetemcomitans, T. forsythia and T. denticola*, were found to be present. The thickeness of the oxide film on new SS archwires was 12 nm consisting of a double oxide layer of the Fe-oxide grown on the Fe-/Cr-oxide layer. During in vivo exposure an organic film of plaque was grown on the SS archwires of thickness about 40 nm. Anaerobic periodontopathogenic bacteria can be found in patients with fixed orthodontic appliances. Therefore, special care is recommended during this kind of treatment.

Keywords: biocompatible SS archwires, periodontopathogenic bacteria; gingival enlargement; fixed orthodontic appliance, X-ray photoelectron spectroscopy (XPS)

Biocompatibility and allergic reactions to dental materials

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Materials for dental applications face one of the harshest biological environments the oral cavity. Different anatomical locations, even inside the same oral cavity, are subject to different *stimuli*, and the challenges faced increase exponentially as regards pathological conditions, individual morphologies, personal habits, body size, age, sex, ethnicity, etc.

Similar layers of protective oxides cover most biocompatible metals (titanium, cobalt alloys, and stainless steel), but polymers and even ceramics have, at their outermost surfaces, different properties and chemo-physical structures.

For the definition of *biomaterials*, a more phenomenologically accurate concept would be that of compatible bio-interfaces, where the surrounding biological environment and the chemically altered outermost surface layer of the biomedical device are studied while coupled.

All biomaterials used in dentistry must be evaluated for biocompatibility using screening assays to protect patient health and safety and for mechanical or structural compatibility. Allergic reactions are becoming prevalent in the general population and the materials used for dental filling, orthodontic instruments, etc must satisfy the biocompatibility specifications since they are indicated for a long time in the oral cavity.

The aim of our study is to investigate the effect of different dental materials on fixed orthodontic appliances. These materials are AISI 304 L stainless steel, CoCrMo, and weld.

For preliminary investigations, the XRD method for chemical analysis and scanning electron microscopy SEM Zeiss 550 for morphology and integrated EDS method for surface analysis were used. We found that the wire was not fixed by Ag solder, but laser welded to the basic part of the device made of AISI 304l stainless steel. The laser weld was porous and represented the possible place where bacteria from the oral cavity could adhere.

All-ceramic resin-bonded prostheses in posterior teeth, a case report

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BACKGROUND

Adhesive cementation techniques and advances in the development of dental ceramics enabled the advent of all-ceramic cantilever resin-bonded fixed dental prostheses – »Maryland bridges« (RBFDP) in the early 1990s. With the introduction of the cantilever (single retainer) design and the advent of zirconia, RBPs are now an excellent prosthetic alternative in the anterior teeth with high success and survival rates.

CLINICAL CONSIDERATIONS

This report describes a full rehabilitation of missing both lower first premolars with monolithic zirconia RBFDPs. A 21-year-old female patient was presented in July 2020 for treatment of missing both lower first premolars after orthodontic and subsequent orthognathic surgical treatment. Preparations were in enamel on occlusal and lingual surfaces of the lingual cusps of the second premolars. Trios (3Shape, Denmark) intraoral scanner was used for the digital impression. Restorations were milled out of Ivoclar monolithic zirconia (IPS e.max) oxide consisting of aesthetic 5Y-TZP and stabilizing (850 mPa) 3Y-TZP. The design requirements were set at min. 0.7mm for the retention wing thickness and min. 3x3mm for proximal connector cross area. Restorations were cemented with Panavia V5 (Kurraray Noritake, Japan), a phosphate monomer MDP bonding cement, and a rubber dam. The restorations were cemented in occlusion without latero- and propulsion contacts. After a 3-years observation period, both restorations are intact and in place with favorable aestetics.

CONCLUSION

Due to their minimal invasiveness, high aesthetics, low cost (compared to a conventional bridge or implant), and excellent experience in the anterior region, RBFDPs are a promising alternative for the replacement of single posterior teeth, especially in younger patients, where extensive preparation of healthy teeth unfavorable and postponed implant placement is desired, as well as in patients with higher wear. Nevertheless, further studies are needed for widespread use.

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Recent Advances in Biomaterials for Periodontal Tissue Regeneration

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In the last decade, a number of new biomaterials have been developed in the field of periodontal regenerative treatment. Significant progress has been made in the development of guided tissue regeneration (GTR) biomaterials and tissue engineering. Polymer composite GTR membranes have been fabricated to combine the advantages of different biomaterials. To improve tissue regeneration, multilayer GTR membranes with different functions in each layer have been made. In addition, GTR membranes have also been used as drug delivery systems (1,2). Scaffold materials are used as substrates for cell attachment, tissue ingrowth and initial structural support. For integrated periodontal regeneration multiphase scaffolds have been developed. Cells (PDLSc, BMMSc) seeded directly into such a scaffold are a viable option to further increase the success of regeneration (2,3). In recent years, periodontal regeneration therapy has also focused on promising cell sheet technology and gene therapy. Innovative engineering solutions and fabrication techniques have led to the production of hydrogels, complex 3D tissue constructs, smart materials with shape memory, and injectable immunomodulatory microspheres (4). Since periodontal tissue is composed of different tissue layers, delivery of multiple bioactive agents is desirable. There are several methods to achieve temporal control of multidrug releases (2). Even though composite multilayered biomaterials have successfully demonstrated the formation of all periodontal tissues in vitro and in animal models, their efficacy has yet to be further evaluated in human clinical trials. Despite the new technology, some issues of periodontal tissue regeneration are still unresolved.

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Myofunctional Therapy: A Contemporary Construction of the Vestibular Plate

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The vestibular plate is an interceptive orthodontic appliance and is used for treatment of orofacial disorders such as mouth breathing, incompetent lips, thumb sucking, tongue thrusting, lip biting and for mild anterior proclination in primary or early mixed dentition (1). The simplest form of the vestibular plate is a commercially manufactured thermoplastic appliance. The individually made vestibular plate ensures better fit but it demands more clinical and laboratory phases (2). The new digital imaging technology changed and improved dental and orthodontic practice. **Aim:** In this poster presentation we present a contemporary construction of vestibular plate with advanced clinical and laboratory digital workflow. **Methods:** The process commences by scanning both maxillary and mandibular arches, as well as the occlusion of the patient using an intraoral scanner (TRIOS®, 3Shape). The initial intraoral scans are first imported to a CAD software (ApplianceDesigner, 3Shape). First, processing of an intraoral scan to a digital model is made. Then, the vestibular plate is designed using different software options of this programme. Lastly, vestibular plate is printed out by 3D printer and finished by different polishing burs. **Conclusion:** The incorporation of a digital technology in dental practice highly enables time-efficient treatments with increased patient comfort and provides us with quality made orthodontic appliance. Nonetheless, digital workflows require an initial training period and may be associated with high acquisition costs.

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28TH International Conference on Materials and Technology

WORKSHOPS

WORKSHOP: LFIA-REC, Recycling of rapid antigen LFIA tests (COVID-19)

Programme Norway grant: Recycling of Rapid Antigen LFIA Tests (COVID-19), LFIE-REC

Pharos Hall Wednesday 11.10.2023

Invited lectures

10:00-10:10 **Recycling of Rapid Antigen LFIA Tests (COVID-19): extraction of nanogold**
Tilen Švarc, Peter Majerič, Timi Gomboc, Matej Zadravec, Rebeka Rudolf

10:10-10:20 **Mechanical recycling of SARS-CoV-2 rapid antigen test cassettes**
Janez Slapnik

10:20-10:30 **Refining of Au nanoparticles for reuse in USP synthesis**
Peter Majerič, Lidija Grobelšek, Roman Gajšek, Grega Palir, Rebeka Rudolf

10:30-10:40 **Separation of rapid antigen LFIA tests**
Slavko Dvoršak, Tina Frangež

10:40-10:50 **Characterization of Au nanoparticles recycled from rapid antigenic LFIA tests**
Aleksandra Kocijan, Darja Feizpour, Črtomir Donik, Matjaž Godec

10:50-11:00 **Transmission Electron Microscopy Study of Gold Nanoparticles' Markers from LFIA**
Darja Feizpour, Tilen Švarc, Peter Majerič, Žiga Jelen, Matej Zadravec, Timi Gomboc, Rebeka Rudolf

11:00-11:30 **Discussion**

Recycling of Rapid Antigen LFIA Tests (COVID-19): extraction of nanogold

Tilen Švarc, Peter Majerič, Timi Gomboc, Matej Zadravec, Rebeka Rudolf
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University of Maribor, Faculty of mechanical engineering has, as a part of the work done one the project Recycling of Rapid Antigen LFIA Tests (COVID-19), studied the extraction and recycling capabilities of nanogold from Covid-19 rapid antigen tests. During the Covid-19 pandemic millions of rapid antigens tests were used in Slovenia alone, these tests presented a significant increase in medical waste. With the European guidelines and the Paris Agreement encouraging sustainability the recycling process of rapid antigen tests is being studied. Since the full impact of nano-waste is not fully understood additional awareness must be raised[1]. In this presentation, the extraction of nanogold from lateral flow immunoassays (LFIA) was conducted with an aqua regia-based dissolution process, extracting gold nanoparticles from the conjugate pads of LFIAs. Subsequently, the resulting solution underwent further concentration via gold chloride salt ($HAuCl_4$), rendering it suitable for synthesizing new gold nanoparticles through ultrasonic spray pyrolysis (USP)[2]. Diverse characterization techniques, including scanning electron microscopy, ultraviolet-visible spectroscopy, and optical emission spectrometry coupled with inductively coupled plasma, were employed throughout this investigation. The findings demonstrate the feasibility of recovering gold nanoparticles from LFIAs and highlight the potential for integrating these newly synthesized nanoparticles into innovative products[3].

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Mechanical recycling of SARS-CoV-2 rapid antigen test cassettes

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The study aimed to evaluate the chemical composition and mechanical and thermal properties of polymeric materials originating from SARS-CoV-2 rapid antigen test cassettes present in Slovenian medical waste. Milled cassettes of rapid antigen tests collected at Maribor University Medical Centre were used in the study. The milled cassettes were processed by twin-screw extrusion to obtain granulate, which was subsequently processed into test specimens by injection moulding. The chemical composition of the prepared sample was determined by Fourier transform infrared spectroscopy (FT-IR). The mechanical and thermal properties were determined using tensile tests, Charpy impact tests, dynamic mechanical analysis (DMA), differential scanning calorimetry (DSC), and thermogravimetric analysis (TGA). The FT-IR spectral pattern matching revealed that investigated samples were composed of high-impact polystyrene (HIPS), indicated by the presence of characteristic absorption bands at 3025 cm^{-1} (aromatic C-H), 1601 cm^{-1} (aromatic ring), 964 cm^{-1} (aliphatic C-H, trans-1,4 configuration), 905 cm^{-1} (aliphatic C-H, vinyl-1,2 configuration), and 756 cm^{-1} and 696 cm^{-1} (monosubstituted aromatic). The tensile strength, modulus, strain at break, and Charpy impact strength of the measured sample were 1.6 GPa, 26.8 MPa, 20.1 %, and 4.7 kJ/m^2, respectively. DSC measurement sample exhibited a glass transition temperature of 91 °C as well as melting and crystallization peaks at 121 °C and 63 °C, respectively, which were attributed to the presence of unknown additives, such as processing aids. The sample exhibited a single decomposition step with a peak temperature of 429 °C, char content of 0.4 % and ash content of 2.2 %. The results of these studies indicate that SARS-CoV-2 rapid antigen test cassettes may be a valuable resource for the production of HIPS recyclates for the manufacturing of plastic products by injection moulding.

Refining of Au nanoparticles for reuse in USP synthesis

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In the second period of the LFIA-REC ATP 150 project, the installation and activation of the ammonia splitter was completed, which was delayed by the manufacturer of this equipment. During setting up of the nanogold refining process in the first period, a test production of Au nanoparticles was performed from commercially available gold chloride by USP ultrasonic spray pyrolysis and lyophilization, for determining the required process parameters. An experimental nanogold refining, USP synthesis and freeze-drying was then performed from membrane samples, obtained from the manual separation of LFIA tests.

For separating nanogold from the LFIA test membranes, aqua regia was used, which was then filtered and purified with distilled water. The excess acid volume was decreased by evaporation and was diluted to obtain a solution for the USP process. Analysis showed that some gold content is lost through evaporation, making it necessary to optimize this process for maximum yield. High acid volumes are also not favourable for the production of new nanoparticles with USP and freeze drying. The sizes, shapes and functional properties (absorption and scattering of light) of the resulting nanoparticles from refining were determined using appropriate analytical methods. The results show mostly irregular and spherical shapes of nanoparticles with sizes of 10 nm to 350 nm, with individual particles in the shape of triangles, pentagons and hexagons. The average size of spherical particles was 50 nm and around 150 nm for irregular particles. By using highly acidic gold solutions, larger quantities of irregularly shaped particles with sizes above 100 nm are produced by USP. The particle stability during freeze-drying is also decreased. For further work in the second phase of the activites, the amount of aqua regia acid in the refining will be lowered for the separation of nanogold from LFIA membranes. Thus, the conditions for further production and drying processes will be more favourable for the formation of more uniform shapes and sizes of Au nanoparticles.

Separation of rapid antigen LFIA tests

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The company Surovina has a key role in the LFIA-REC project, which the main goal is the collection and processing of rapid antigen LFIA tests. With many years of experience in the field of waste management, Surovina's role in the project is collection and preparation of rapid tests for further recycling processes. In the first months of the project, during the Covid-19 epidemic, the main source of collected tests was used rapid antigen LFIA tests collected in the premises of UKC Maribor. During the project, Surovina transported and received 247 kg of used tests from the project partner UKC Maribor. These tests were used to carry out numerous preliminary analyses, trial grindings and separations on the existing equipment of the project partners. Surovina, based on experiences and research, designed a separator consisting of three key components: a sterilizer that enables safe handling of the used rapid antigen tests; a separator that serves to successfully separate the tests into two separate fractions: plastic cases and test sticks containing nanogold; and a mill for grinding plastic to a sufficient particle size for further recycling.

Due to a changes in the coronavirus epidemic, that ended in the first half of 2023 in all countries, there was a large drop in the amount of used rapid antigen LFIA tests collected at the project partner UKC Maribor. During the summer months, Surovina received only 33 kg of used rapid antigen LFIA tests from UKC Maribor, which was not enough to provide material for all further research activities in the project. In the 2nd period, Surovina started to collect and disassemble unused rapid antigen LFIA tests, which are provided by distributors or companies due to the expiration date. In this way Surovina collected a larger amount of additional tests for the needs of the project, which enables further activities with the other project partners. The new source of input material requires the additional activity of manual disassembly and separation of different types of waste fractions, as the received new tests are packed in many different packaging material and contain additional components necessary for testing. With disassembling processes of the unused tests, large quantities of different types of plastic polymers, wooden packaging and cardboard packaging and paper are correctly separated. All these additional quantities of waste are being recycled according to the types of waste, which represents an added value to the project.

Characterization of Au nanoparticles recycled from rapid antigenic LFIA tests

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Within the framework of the LFIA-REC project, the Institute for Metal Materials and Technologies (IMT) participates in the WP T4 – Refining of Au nanoparticles, where we deal with the preparation of comparable refinements, the determination of appropriate chemicals and reagents, and advice on the implementation of experimental work on the dissolution of nano Au. For this purpose, a chemical analysis of the samples after refining Au nanoparticles was performed by ICP-OES. After the refining process, the content of the obtained Au was determined by the ICP-OES method, to ensure the purity for the further use of nano Au in the ultrasonic spray pyrolysis process. In some cases, the X-ray fluorescence spectroscopy (XRF) was used for identification purposes on solid samples. On the basis of expertise, the presence of Au in the delivered samples was proved and thereby confirmed the adequacy of the refining process.

In the WP T5 – Characterization of Au nanoparticles, IMT participates in the research of polymer samples, milled samples and emulsions. For this purpose, we used the following analytical techniques: ICP-OES, XRF, XRD, XPS, SEM, TEM and STEM/EDS. The chemical analysis of the delivered samples was carried out by using ICP-OES. The presence of Au nanoparticles as well as their nature were analyzed by XRD. XPS analysis was used to determine the composition and content of Au in the investigated materials. For TEM and TEM/EDS investigations and analyses, the corresponding areas where the sample was recorded were imaged at multiple sites, each site with multiple images of the same site at different magnifications and comparable identical magnifications at other sites for statistical comparison. Using TEM/EDS analysis, we determined the elemental composition of the samples with spot analyzes at several locations for statistical comparison. This enabled us to determine the state of nanogold/Au nanoparticles, in terms of size, quantity, agglomeration and activity. On the basis of the obtained results in different stages of recycling, the most suitable routes of nanogold recycling from rapid antigen tests are planned and optimized in terms of Au nanoparticles` synthesis using the USP method.

Transmission Electron Microscopy Study of Gold Nanoparticles' Markers from LFIA

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This study focused on repurposing wasted lateral flow immunoassays (LFIA), a simple diagnostic device for detecting specific analytes. The goal was to recover gold nanoparticles (AuNPs), used as markers in LFIA, by employing a dissolution process with aqua regia. This process released AuNPs from the LFIA conjugate pads. The resulting solution was concentrated using gold chloride salt (HAuCl4) for synthesizing new AuNPs through ultrasonic spray pyrolysis (USP). Various characterization methods were used to analyze the recovered AuNPs, one of them being Transmission Electron Microscopy (TEM) for imaging and high-resolution imaging with Selected Area Electron Diffraction (SAED) for crystalography and Energy Dispersive X-Ray Spectrometry (EDS) for elemental composition using JEM-2100HR (JEOL) microscope at an accelerating voltage of 200 kV.

A portion of the fibre sample containing AuNPs was extracted from the conjugate pad and transferred to a centrifuge filled with absolute ethanol. Using a dropper, we applied a mixture of ethanol and fibers to a TEM grid (carbon formvar B film, 200 mesh, Cu) and allowed the sample to air dry overnight. Following the drying process, we conducted TEM analysis for imaging and electron diffraction, as well as TEM/EDS for elemental composition assessment.

AuNPs were observed at various locations on the fibers of the conjugate pad. They were dispersed individually in some areas and formed agglomerates in others. The AuNPs displayed diverse morphologies, including rods, triangles, squares, and predominantly polygons, suggesting varied growth directions. Their sizes ranged from 10 nm to 50 nm. By employing SAED, we identified the 111 and 220 planes in regions where AuNPs were agglomerated. Additionally, elemental analysis via TEM/EDS confirmed the presence of AuNPs in the sample.

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

ARIS Project L2-4445: Development of advanced Ti6Al4V tank components for the aerospace industry with hybrid SLM/DED additive technology

Pharos Hall Wednesday 11.10.2023

Invited lectures

11:30-11:50 **Hybrid Additive Manufacturing Approach for Rapid Manufacturing of Larger Parts with Geometrically Complex Structures – Recent Trends in the Aerospace Engineering Industry**
Aleksandra Kocijan

11:50-12:10 **The Comparison of Conventional and Additive Manufacturing Technologies for Manufacturing of Ti6Al4V Structures in the Aerospace Industry**
Marjetka Conradi

12:10-12:30 **Optimization of SLM and DED Process Parameters for the Development of Hybrid Additive manufactured Ti6Al4V Structures**
Irena Paulin

12:30-12:50 **Optimization of Heat Treatment and Surface Post-processing in the Development of Hybrid Additive manufactured Ti6Al4V Structures**
Simon Malej

12:50-13:00 **Discussion**

Hybrid Additive Manufacturing Approach for Rapid Manufacturing of Larger Parts with Geometrically Complex Structures – Recent Trends in the Aerospace Engineering Industry

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Recent trends in the aerospace engineering industry are focusing on extending the range capability of aircrafts by implementing additional fuel tanks. Such optimization of an aircraft is in the first place expected to shorten travel time, which reduces total flight costs, maintenance costs and prolongs aircraft life expectancy. The longer-range capability has also beneficial influence on the environment. It leads to less fuel stops with less additional landing and take-off cycles where engines work at maximum power and therefore reduces exhaust emission.

The advantages of additional fuel tanks on the other hand bring challenges concerning aircraft performance and stability. Aircrafts are already optimized to their maximum. Therefore, special emphasis should be paid on location, size and shape optimization of extra fuel tanks in order not to interfere with the final flying capability. However, the complexity of the design of such products cannot be achieved by conventional manufacturing methods. Additive manufacturing (AM) of metal components has thus gained increasing interest in aerospace sector in the recent years due to the freedom of shape and design combined with high performance and low cost.

The main goal of the proposed project is the development of Ti6Al4V Hybrid AM advanced fuel system components by combining SLM and DED technology. 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 optimization of process parameters of both AM techniques. The influence of different process parameters, such as laser power, scan spacing, scan strategy, scan speed, powder flow rate and layer thickness, on the microstructure, corrosion and mechanical properties has to be evaluated in order to ensure optimal printing conditions. On the other hand, heat treatment of Ti6Al4V printed parts is considered as well. To improve the ductility, reduce thermal stresses and to achieve anticipated mechanical properties of Ti6Al4V AM manufactured products suitable heat treatments is assessed. Furthermore, surface plasma treatment is employed to additionally improve corrosion resistance trough surface oxide layer thickening.

The Comparison of Conventional and Additive Manufacturing Technologies for Manufacturing of Ti6Al4V Structures in the Aerospace Industry

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Ti6Al4V alloy is known as the most popular titanium alloy due to its high strength, low density, high fracture toughness and good corrosion resistance [1]. Ti6Al4V alloy with its excellent mechanical properties is used in aerospace industry since 1950s [2]. The main manufacturing challenge however represents its poor thermal conductivity, strain hardening and high oxygen affinity [3,4]. Conventional manufacturing technologies of Ti6Al4V parts, such as forging, casting, rolling and machining, involve large material waste, higher costs and less time efficiency [5].

To meet the increasing demands of the market and to overcome the challenges of Ti6Al4V alloy production, additive manufacturing (AM) has emerged as a promising manufacturing process for geometrically complex components [6–9]. Many different AM processing technologies for metallic materials are already known [10,11]. One of the most promising AM technologies is selective laser melting (SLM). The main advantages of SLM are high dimensional accuracy and excellent mechanical properties of finished parts, however, the duration of printing is time consuming. The second most commonly used AM technology is directed metal deposition (DED). DED enables faster printing times at the expense of lower resolution, which results in poorer dimensional accuracy of final printed parts. Compared to conventional technologies, AM is rapid manufacturing process that offers the freedom of shape and design combined with high performance, low cost and less material waste [12,13]. It enables recycling of unconsumed powders up to almost 100 %, which makes the technology more cost-effective and environmentally friendly [14]. Furthermore, the AM Ti6Al4V alloy with a buy-to-fly ratio of approximately 20:1 shows a significant improvement compared to conventional manufacturing of aircraft titanium parts [7].

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Optimization of SLM and DED Process Parameters for the Development of Hybrid Additive manufactured Ti6Al4V Structures

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To combine the advantages of the two AM technologies, SLM and DED, we propose completely new approach for the development of Hybrid Additive manufactured Ti6Al4V parts for aerospace applications. The combination of both technologies will enable us rapid manufacturing of larger parts and geometrically complex structures with reduced weight and optimized mechanical and corrosion properties. The great challenge also represents the optimization of the interface between the two joined parts due to the microstructure difference and encountered residual stresses.

To achieve good properties and bonding characteristics at the interface between both AM parts we have to consider appropriate powders for feedstock. Powder has to be analysed before SLM and DED processing. Size, shape, defects analysis and elemental analysis (Ti, V, Al, trace elements like H, O and N) have to be performed. These parameters are important since they can markedly influence SLM and DED processing as well as the mechanical properties of the finished samples (increased H, O and N contents can cause embrittlement while non spherical powder with defects can increase porosity level). Process parameters such as direction of the building (vertical or horizontal), layer thickness, scan spacing, scan strategy, laser power, powder flow rate (DED) and scan speed, for both AM technologies will be tailored. On one hand optimal microstructure has to be achieved (columnar or equiaxed grain structure → anisotropy in mechanical properties). On the other hand, residual stresses have to be reduced (warping of the part and occurrence of micro and macro fractures during processing). For hybrid specimens' geometry, laser power, scan strategy and scan speed have to be considered to minimize the size of heat affected zone (balance between heat introduction due to laser and heat dissipation via heat conduction, convection and radiation). In the case of longitudinal building pattern, the most optimal angle of inclinations has to be considered as well. Different angles of inclination can influence powder flow characteristic in the deposition zone which can lead to occurrence of defects like of lack of fusion sites.

Optimization of Heat Treatment and Surface Post-processing in the Development of Hybrid Additive manufactured Ti6Al4V Structures

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An upgraded Hybrid AM technology allows better customisation of products, internal structures that would be impossible to produce by conventional manufacturing methods, it also enables the building of hollow structures and therefore reduces weight of the parts, which is crucial in aerospace industry. To improve the ductility, reduce thermal stresses and to achieve anticipated mechanical properties of Ti6Al4V AM manufactured products suitable heat treatments will be assessed.

Heat treatment procedure will be optimized in order to eliminate residual stresses, undesired martensitic structures in both AM regions and to gain required mechanical and corrosion properties. The standard heat treatments for bulk alloys are not optimal for AM processed parts and have to be adapted to achieve desirable properties of as-built part. The different response of SLM, DED and SLM/DED parts on generally applied heat treatments will be studied and the influence of time, temperature and cooling rate will be evaluated. Sub β-transus annealing (800 to 950 °C for 1 h or more) with furnace cooling (to prevent martensite formation) will be employed. Temperature and time will be modified in order to eliminate martensite ($\alpha' \rightarrow \alpha + \beta$), improve elongation at fracture and prevent huge drop in yield and tensile strength.

Appropriate discharge and plasma parameters will be determined for modification of AM printed Ti6Al4V. Radiofrequency oxygen and hydrogen plasma will be used at different input powers ranging from 200 to 800 W. Variations in pressures and treatment times will also be studied. Pressure will range from 20 to 100 Pa and the optimal pressure will be determined. After the pressure and power adjustment, the treatment time will be optimized as well. As the surface in oxygen plasma will be modified by fluxes of high energy electrons, low energy ions, excited species and long-lived metastable species of oxygen we expect to obtain surface with higher oxygen content and with thicker oxide layer. Effects of different plasma treatment conditions will be evaluated by surface sensitive analysing techniques as well as corrosion resistance study. After optimizing plasma treatment conditions, the uniformity of treatment will also be studied on AM printed parts. The main goal in this part would be to allow for uniform modification of parts with complex geometries.

WORKSHOP: Circular Industry - The application of circular economy principles in industry processes (CIRCI - Norway Grant project)

Programme Norway grant, ATP55: Circular Industry - The application of circular economy principles in industry processes (CIRCI)

Pharos Hall Wednesday 11.10.2023

Invited lecture

14:30-15:15 **The application of circular economy principles in industry processes**
B. Podgornik, M. Sedlaček, A. Hlišč, S. Kneževič Vernon, S. Skagestad

15:15-16:30 **Round table Discussion - Circular Industry**

The application of circular economy principles in industry processes

B. Podgornik[1], M. Sedlaček[1], A. Hlišč[2], S. Kneževič Vernon[3], S. Skagestad[4]

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Slovenia has adopted several strategic documents and implemented numerous projects on the topic of circular economy and green transition. The main objective of the CIRCI project is to improve the eco-efficiency of the Slovenian and Norwegian (industrial) ecosystem and to increase the awareness about circular economy through innovation. The project aims to optimize the material and energy flow in the production process using sidestream materials for re-use purposes. The project's primary goal is to map these sidestream or secondary materials and establish a database that will be a source of information for interested parties. Sidestream materials can be an important material source for different production companies or industries. CIRCI will also consider the administrative implementation of waste legislation in Slovenia as there are some uncertainties about when the status of waste ends or how materials can circulate as sidestream materials, which is the basis of industrial symbiosis.

One of the main objectives of the project is to reduce greenhouse gas emissions through innovative approaches and the use of ICT to develop new circular business models and to promote industrial symbiosis. CIRCI will directly address the challenges of the transition to circular economy through practical application and raising awareness. The CIRCI project is fully in line with the national strategies for achieving the objectives of the program, as well as with the European objectives for a green and digital Europe. The consortium of the CIRCI partnership with Slovenian and Norwegian partners will also ensure knowledge transfer and increase bilateral cooperation. The key activity for achieving the goals of the project will be the establishment of a database of sidestream materials modelled on the Norwegian database. Based on the results obtained in three selected Slovenian industries (metal processing industry, processing of recyclable plastic resources, electrical industry) cooperation between industries, research institutions and interested organizations will be promoted through voucher scheme. The main achievement of the project foreseen is the introduction of innovative approaches, the implementation of demonstration / pilot projects and raising the awareness about the importance of sidestreams. The Slovenian-Norwegian partnership will encourage the transfer of best practices, joint research and development of new solutions in the field of the circular economy, and the transfer of knowledge and solutions to the wider European area.

WORKSHOP: Additively manufactured High-strength Aluminium Alloy – advantages and disadvantages

ARIS project L2-3164: A Novel High-strength Aluminium Alloy developed for Selective Laser Melting and Lightweight Applications

Pharos Hall Thursday 12.10.2023

Invited lectures

9:00-9:30 **Selective Laser Melting of AA7075**
Irena Paulin, Nejc Velikajne, Črtomir Donik, Matjaž Godec

9:30-9:50 **SEM EBSD characterization of SLM processed AA7075**
Črtomir Donik, Nejc Velikajne, Irena Paulin

9:50-10:10 **Thermodynamics of AA7075 rapid solidification**
Nejc Velikajne, Jožef Medved, Irena Paulin

10:10-11:00 **Discussion**

Selective Laser Melting of AA7075

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The ambitious goal of the proposed project involves the development of a new high-strength Al alloy suitable for the AM process, which will facilitate the production of crack-free components combined with improved mechanical and corrosion properties. To achieve this goal, we prepared samples from commercially available AA7075 aluminum powder on a laboratory LBPF device. We changed various process parameters and optimized the production of simple samples in the form of 10x10x10 mm^3 cubes, where we achieved the highest densities. Cracks were visible in all samples, which were different depending on the use of process parameters, but were always present. Then, we made the samples at different temperatures of the preheated base, where it turned out that higher temperatures do not have a favorable effect on the production of material without cracks. Lower preheating temperatures ensured better remelting in the material and thus less porosity in the material. In order to try to produce a material without cracks, in the next steps we started mixing AA7075 and AlSi12 powder, adding Si to the base material and thus reducing the difference in solidification temperature. Microstructural characterization showed that we successfully made a material without cracks. We used a mixture of aluminum powder and prepared samples on an overheated base with optimized process parameters. Mechanical testing and corrosion tests will follow. Due to the addition of Si, we anticipate that the mechanical properties will deteriorate somewhat, which we plan to improve with the addition of elements of transition metals, which could have a favorable effect on the mechanical properties of the material with nano and micro inclusions in the process of rapid solidification. After confirmation of a successfully produced material with a favorable combination of properties, we will study what is the necessary ratio of individual elements in the base material in order to be able to produce an alloy that can be atomized and made from it into the desired material/product without additional process steps.

SEM EBSD characterization of SLM processed AA7075

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Metallic powder of aluminum alloy AA7075 was selectively laser melted (SLM) with different process parameters and on different preheat substrates. Due to the interesting behavior of the samples, where cracking occurred mainly in the samples' built-up direction, we performed a systematic and detailed microstructural characterization. The samples were prepared according to a standard metallographic process by grinding and polishing in the samples' built-up direction. Characterization was done by light (LM) and scanning electron microscopy (SEM). For SEM analyses, it was necessary to additionally prepare the surface of the samples with a short OPS polishing. From the results of the SEM EBSD analyses, we could see that despite the preheated substrate, as the temperature increased, the stress in the material also increased, which led to cracking along the grain boundaries.

Thermodynamics of AA7075 rapid solidification

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As part of the project, simulations and analyzes of the influence of temperature and additional chemical elements on the solidification of a high-strength aluminum alloy were made. Alloy AA7075 was chosen for the starting chemical composition. For modeling, we used the ThermoCalc program with database 8.1. Since additive technologies involve rapid solidification, which has little in common with the usual equilibrium solidification that the program uses in its calculations, we used a simulation of rapid solidification, which we upgraded based on previous experience from the results of microstructural analyzes of previous materials with a similar chemical composition.

In the simulation, we added elements to lower the solidification temperature (e.g., silicon) and elements of transitional elements (e.g., iron, manganese), which cause nano and micro precipitation in the material during rapid solidification. That leads to an improvement in the mechanical properties of the material. The results of the analyzes and modeling will be used in the preparation of real alloys and the production of samples.

WORKSHOP: Nanoparticle-reinforced new Metal Matrix Composites Manufactured by Selective Laser Melting for the Tool Industry

ARIS project L2-2613: Nanoparticle-reinforced new metal matrix composites manufactured by selective laser melting for tooling industry

Pharos Hall Thursday 12.10.2023

Invited lectures

11:00-11:20 **Selective Laser Melting of AISI 316L mixed with TiB2 Nanoparticles**
Matjaž Godec, Danijela Skobir Balantič, Črtomir Donik, Irena Paulin

11:20-11:40 **Mixing TiB2 and TiC Nanoparticles to the Feedstock Stainless Steel 316L and Maraging Steel M300 and Tool Steel H13 Using Plasma Treatment**
Matjaž Godec, Miran Mozetič

11:40-12:00 **Plasma nitriding of SLM AISI 316L steel**
Danijela Skobir Balantič, Črtomir Donik, Irena Paulin, Aleksandra Kocijan, Bojan Podgornik, Matjaž Godec

12:00-12:20 **Plasma Nitriding of SLM Maraging Steel M300: A Comparative Analysis with Conventionally Produced Steel**
Črtomir Donik, Irena Paulin, Aleksandra Kocijan, Bojan Podgornik, Danijela Skobir Balantič, Francisco Ruiz-Zepeda, Matjaž Godec

12:20-12:40 **Heat Treatment and Plasma Nitriding of SLM Maraging Steel M300**
Irena Paulin, Črtomir Donik, Aleksandra Kocijan, Bojan Podgornik, Danijela Skobir Balantič, Matjaž Godec

12:40-13:00 **Selective Laser Melting of H13 Tool Steel**
Samo Tome, Irena Paulin, Danijela Skobir Balantič, Črtomir Donik, Aleksandra Kocijan, Bojan Podgornik, Matjaž Godec

13:00-13:20 **Improving the Surface Properties of Additive-manufactured Inconel 625**
Matjaž Godec, Črtomir Donik, Aleksandra Kocijan, Bojan Podgornik, Danijela Skobir Balantič

Selective Laser Melting of AISI 316L mixed with TiB_2 Nanoparticles

Matjaž Godec, Danijela Skobir Balantič, Črtomir Donik, Irena Paulin

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Advanced manufacturing technologies are gaining interest for industrial use, as they can often match or surpass the properties of traditionally manufactured metallic materials. In the tooling industry, using additive manufacturing (AM) such as selective laser melting (SLM) to create tool inserts or entire tool parts offers significant advantages in design, allowing for conformal cooling channels that follow the shape of the dies or moulds, resulting in more efficient cooling during operation. However, the mechanical properties of SLM tooling components do not yet match those of traditional ones. Currently, most tool parts are SLM manufactured from maraging steels, while high-carbon SLM tool steels are still being developed. There is a great need for improved mechanical properties of AM tool parts, making it important to establish proper industrial procedures for producing metal matrix nanocomposites (MMNCs) using AM. Our study looked into two different methods for mixing feedstock powder with TiB_2 nanoparticles. Direct mixing allows for the even distribution of nanoparticles around the matrix without altering their shape, resulting in good flowability of the final powder mixture. However, optimisation is needed to prevent nanoparticle clumping and to improve wettability. Ball milling involves repeatedly deforming, fracturing, and cold-welding powder particles, leading to uniform distribution and stable powder size. However, optimisation of shape and roughness is necessary to improve powder flowability. We conducted SEM analyses of mixed feedstock materials and studied the microstructure after the SLM process. We evaluated mechanical and corrosion properties and compared them to materials without nanoparticle reinforcement.

Mixing TiB_2 and TiC Nanoparticles to the Feedstock Stainless Steel 316L and Maraging Steel M300 and Tool Steel H13 Using Plasma Treatment

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Currently, no commercial feedstock of MMNC powder is available for SLM. The main goal was to achieve a proper mixing of the reinforcement and matrix powder while avoiding agglomeration and enabling the homogeneous dispersion of nanoparticles. The mixing utilised commercially available powders of stainless steel (316L), maraging steel (M300), and tool steel (H13) as a matrix. Two kinds of plasma treatments were applied; dusty plasma and oxygen plasma.
Dusty plasma treatment was performed using capacitive radio frequency (RF) plasma in a noble gas. Nanoparticles entered the gas phase, charged negatively upon the plasma conditions, and rather large negative bias of symmetrical discharge prevented the negatively charged nanoparticles from touching any wall or interaction between them. Commercial steel-based powders were dosed into the discharge. They also assumed a negative potential, but added floating potential, which was much smaller than the electrodes potential. Due to this effect the nanoparticles sticked to the surface of the commercial powders. The dosing was realised by dropping the powder through the plasma zone.
Oxygen plasma treatment enables thickening of oxide layer and therefore, increases the quantity of oxide nanoparticles in the matrix. We used inductively coupled RF reactor of height 1 m to drop commercial steel-based powders. Discharge power was about 10 kW and the pressure was about 1 mbar, so the plasma was sustained in pure H-mode. Such plasma enables extremely fast oxidation of the metals and simultaneous surface activation as well as removal of any organic impurities.

Plasma nitriding of SLM AISI 316L steel

Danijela Skobir Balantič, Črtomir Donik, Irena Paulin, Aleksandra Kocijan, Bojan Podgornik, Matjaž Godec

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Advanced manufacturing technologies are increasingly gaining attention for industrial use. In fact, they are capable of matching or even surpassing the properties of traditionally manufactured metallic materials. In the tooling industry, the benefits of using AM SLM to create tool inserts or whole tool parts are particularly noteworthy. This is because AM SLM allows for the creation of conformal cooling channels that follow the topography of dies/moulds. As a result, these channels provide more efficient cooling during operation, which is highly advantageous.
Due to the limited wear and corrosion properties of the austenitic stainless steel AISI 316L, some applications require the benefits of nitriding. The aim of this work was to investigate whether the same positive effect of nitriding could be obtained for 316L that was additive manufactured using the laser powder-bed fusion process and further solution treated at 1060 °C for 30 min, low-temperature plasma nitrided at 430 °C or both. This study was designed to understand better the additive-manufactured and solution-treated microstructures as well as the formation and development of a nitride and a diffusion layer. The comparison of the wear and corrosion resistance, the microhardness and the microstructure changes of the additive-manufactured steel in different post-treated conditions with commercial steel was carried out. It was found that the post-treated low-temperature plasma nitriding improves the wear and corrosion resistance of the additive-manufactured samples. The obtained values are similar to the values of conventionally fabricated and nitrided 316L. The solution treating itself (without further nitriding) did not have any significant impact on these properties. It was possible to explain the microstructure at the nano level as well as correlate the wear and corrosion properties.

Plasma Nitriding of SLM Maraging Steel M300: A Comparative Analysis with Conventionally Produced Steel

Črtomir Donik[1], Irena Paulin[1], Aleksandra Kocijan[1], Bojan Podgornik[1], Danijela Skobir Balantič[1], Francisco Ruiz-Zepeda[1,2], Matjaž Godec[1]

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We conducted an investigation on maraging steel grade 18Ni300 (M300) that was produced through the powder bed fusion (PBF) process and underwent plasma nitriding at three different temperatures. Our primary objective was to determine how the nitriding temperature affects microstructural changes and surface properties, including hardness, wear resistance, and corrosion resistance. A variety of analytical techniques were utilised to study the microstructural characteristics of the bulk material and nitrided layer, including electron-backscatter diffraction (EBSD), transmission electron microscopy (TEM), and X-ray diffraction (XRD) analysis.

The majority of the material's internal structure consisted of martensite, but there was also a small amount of retained austenite. At higher temperatures during the nitriding process, more austenite was present. Interestingly, the nitriding process also created precipitates which acted like an ageing treatment. A lamellar structure appeared on the surface during nitriding, mainly composed of the Fe_4N phase. Additionally, the retained austenite transformed into the nitride phase Fe_4N during nitriding.

It was discovered that higher nitriding temperatures can cause cracks in the nitride layer. This is due to nano and microsegregation during the laser powder bed fusion (LPBF) process, leading to the formation of austenite along grain boundaries that turns into Fe_4N during nitriding. When nitriding temperatures are increased, the nitride layer becomes thicker, resulting in better wear resistance, but does not significantly affect static mechanical properties. However, higher temperatures during nitriding can have a negative impact on corrosion resistance due to the formation of cracks.

Heat Treatment and Plasma Nitriding of SLM Maraging Steel M300

Irena Paulin, Črtomir Donik, Aleksandra Kocijan, Bojan Podgornik, Danijela Skobir Balantič, Matjaž Godec

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Maraging steel 18Ni300 (also known as M300 grade maraging steel) belongs to the low-carbon, nickel-rich martensitic steels that exhibit a unique combination of high strength and hardness together with good toughness, ductility and weldability. Due to their characteristics, they have gained a lot of attention in the field of additive manufacturing (AM) technologies, in particular directed energy deposition (DED) and powder bed fusion (PBF). Maraging steels are materials for severe environments; therefore, they are mostly applied as tool steels in the tool-and-die-making industry, where superior wear and corrosion resistance are required. Thermochemical treatments such as surface hardening by plasma nitriding can, therefore, represent a promising step forward for improving the surface properties of PBF-produced maraging steels.

M300 maraging steel manufactured by selective laser melting was plasma nitrided to improve its wear and corrosion resistance. The objectives of the work were to investigate the impact of different nitriding temperatures (440 °C, 480 °C and 520 °C) on the microstructural changes as well as on the surface properties such as hardness, wear and corrosion resistance. On the other hand, the effects of prior solution treatment, ageing and the combination of both on the microstructure and the properties before and after nitriding were investigated to provide a better understanding of the morphology and chemical composition of the nitrided layer in the additive-manufactured maraging steel.

Selective Laser Melting of H13 Tool Steel

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The use of Additive Manufacturing (AM) technologies has gained the interest of many industries, as it has the potential to match or exceed the properties of metallic materials manufactured using traditional methods. In the field of tooling, AM Selective Laser Melting (SLM) provides significant benefits. This is because it allows for the creation of tool inserts or complete components with conformal cooling channels that perfectly match the curves of dies and moulds. As a result, it leads to more efficient cooling during operation.
It's worth mentioning that tooling components produced through SLM often don't have as strong mechanical properties as those made through traditional methods. So far, maraging steels are the top choice for SLM-made tool parts, while high-carbon tool steels are still being developed.

One such material, H13 tool steel, has long been a cornerstone for crafting high-performance, hot-work tools and dies. Its remarkable attributes encompass outstanding wear resistance, toughness, and strength, particularly at elevated temperatures. Its exceptional wear resistance ensures a prolonged lifespan for these critical components, reducing downtime and maintenance costs. Paired with its cost-effectiveness, it is easy to see why H13 is a common choice for tool-making. With the advent of AM for tool making, new avenues for enhancing the properties of H13 even further opened up. One of these is reinforcing the steel with nanoparticles. The addition of these particles promises to enhance the already excellent strength and wear resistance of the steel. This combination of complex geometries reinforced by nanoparticles promises to greatly extend the lifecycle of hot-work tools, while simultaneously reducing material waste.

Improving the Surface Properties of Additive-manufactured Inconel 625

Matjaž Godec, Črtomir Donik, Aleksandra Kocijan, Bojan Podgornik, Danijela Skobir Balantič

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Plasma nitriding is a technique used to improve the properties of conventional Ni-based alloys by hardening the surface layer with nitrogen diffusion. This process leads to better wear resistance and a higher coefficient of friction, as well as increased surface hardness. This study examines the effect of plasma nitriding on additive-manufactured (AM) Inconel 625 (IN625) compared to its conventionally manufactured and nitrided counterparts. The laser powder-bed fusion (LPBF) process was used to produce the samples, which were then plasma nitrided in the as-built condition, stress-relief annealed at 870 ° C and solution treated at 1050 °C. The plasma nitridings were carried out at 430 °C and 500 °C for 15 hours. The nitride layer growth kinetics of the AM samples depend on prior heat treatments and are faster in the as-built state due to a specific cellular structure. XRD and SEM analyses confirm the presence of two layers: the surface layer and the diffusion layer beneath. The lower nitriding temperature causes the formation of expanded austenite or a combination of expanded austenite and CrN. The higher nitriding temperature leads to the decomposition of the expanded austenite and the formation/precipitation of CrN. The higher nitriding temperature slightly decreases corrosion resistance due to the increased number of precipitated Cr-nitrides, while wear resistance is significantly improved after plasma nitriding and is less influenced by nitriding temperature.

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

ARIS project N2-0276: New ODS steel structure for extreme environments using the ultrasonic dispersion of nano-oxides in combination with SLM and PPS

Pharos Hall Friday 13.10.2023

Invited lectures

9:00-9:20 **ODS stainless steel structure for extreme environments using the ultrasonic dispersion of nano-Y_2O_3**
Irena Paulin, Črtomir Donik, Anna Dobkowska, Jiří Kubásek, Matjaž Godec

9:20-9:40 **Feedstock Powder Preparation for SLM with Added TiB_2**
Matjaž Godec, Irena Paulin, Črtomir Donik, Anna Dobkowska, Danijela Anica Skobir Balantič, Jiří Kubásek

9:40-10:00 **Enhancing ODS Steel Performance for High-Temperature Applications**
Črtomir Donik, Anna Dobkowska, Irena Paulin, Aleksandra Zielinska, Matjaž Godec

10:00-10:20 **The synthesis of ODS steel by powder metallurgy using 316L stainless steel, Y and/or Y_2O_3 powder precursors**
Jiří Kubásek, Irena Paulin, Črtomir Donik, Anna Dobkowska, Matjaž Godec

10:20-11:30 **Discussion**

ODS stainless steel structure for extreme environments using the ultrasonic dispersion of nano-Y_2O_3

Irena Paulin[1], Črtomir Donik[1], Anna Dobkowska[2], Jiří Kubásek[3], Matjaž Godec[1]

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In this study, we prepared AISI 316 L powder mixed with varying amounts of nanopowder Y_2O_3 (ranging from 0.5 wt% to 3 wt%) using an ultrasonic mixer. We mixed the alcoholic suspension of both powders for about 30 minutes and then melted approximately 5 g of the mixture in a vacuum using a plasma melting gun at 300 A for 2 minutes in the AMAZEMET atomiser. After that, we cooled the meltdown with a water chiller on the copper holder inside the chamber.

For the production of the powders, we used two different melting procedures. The first option was just using a plasma melting gun, and the second option was to melt simultaneously with ultrasonic sonotrodes. The latter method was employed to reduce the grain size to mix the oxides into the alloy to change the microstructure, and subsequently, the alloys' properties.

Finally, we metallographically prepared the obtained alloys to evaluate the microstructure and oxide distribution in materials prepared with and without the sonotrode.

Feedstock Powder Preparation for SLM with Added TiB_2

Matjaž Godec[1] Irena Paulin[1], Črtomir Donik[1], Anna Dobkowska[2], Danijela Anica Skobir Balantič[1], Jiří Kubásek[3]

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ODS steels are recognized for their exceptional mechanical attributes at elevated temperatures and enhanced ability to withstand neutron irradiation embrittlement. These qualities make them ideal candidates for use as fuel cladding in next-generation nuclear systems and as blanket materials in fusion power systems.

In this study, we prepared AISI 316 L powder mixed with varying amounts of nanopowder TiB_2 (ranging from 0.5 wt% to 3 wt%) using an ultrasonic mixer. To produce the powders, we utilized two distinct melting techniques. The first approach involved using a plasma melting gun, while the second method involved melting simultaneously with ultrasonic sonotrodes. The latter method was implemented to diminish the grain size and mix the oxides into the alloy, which altered the microstructure and consequently, the properties of the alloys. Eventually, we prepared the alloys metallographically to assess the microstructure and oxide distribution in materials produced with and without the sonotrode. SEM and TEM were used to define particle distribution in the steel. Additionally, wear tests were performed to compare wear rates with and without TiB_2.

Enhancing ODS Steel Performance for High-Temperature Applications

Črtomir Donik[1], Anna Dobkowska[2], Irena Paulin[1], Aleksandra Zielinska[2], Matjaž Godec[1]

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ODS steels are known for their exceptional mechanical properties at high temperatures, making them ideal for future applications as fuel cladding for nuclear systems and blanket materials for fusion power systems. This project aimed to investigate whether ultrasonically gas-atomized precursor steel powder, combined with new consolidation techniques such as selective laser melting (SLM) and pulse plasma sintering (PPS), can enhance the performance of ODS steel under high-temperature conditions.

Austenitic 316L stainless steel was selected for its good ductility, workability, and mechanical integrity at high temperatures to demonstrate the concept. 316L was also selected due to its known SLM parameters in combination with mechanical properties using SLM and PPS. Y_2O_3 was chosen as the nanomaterial to be added to the matrix, as it has a higher ultimate tensile strength and improves oxidation resistance.

We needed to optimize the ball-to-powder ratio, milling speed, and nano-oxide concentration to successfully attach surface nano-oxide to 316L powder and to obtain the sphericity of stainless-steel powder. After selecting the powder mixture, it was prepared using SLM with optimized parameters and then characterized using SEM and LM.

The synthesis of ODS steel by powder metallurgy using 316L stainless steel, Y and/or Y2O3 powder precursors

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In the presented work, 316L stainless steel, Y and/or Y_2O_3 powder precursors were mixed in mill RETS Emax using mechanical alloying at different times. The resulting powder alloys were characterized using XRD, SEM and EDX and further compacted by spark plasma sintering (SPS). Results indicated that a longer time necessary to incorporate Y in the 316 affected the microstructure and phase composition by the formation of mechanically induced martensite. Simultaneously Y_2O_3 oxides were formed, however, the process was difficult to control and optimize due to the loss of powder on the walls of the milling vessel. On the contrary, the short milling of 316 stainless steel powder and Y_2O_3 oxides led to the formation of homogeneous material, which was successfully compacted by SPS. Results about microstructure and mechanical properties of compacted ample will be further presented and discussed.

WORKSHOP: New perspective in development of biodegradable Zn-based alloys by powder metallurgy methods

ARIS project N2-0182: Development of advanced bioabsorbable Zn-based materials using powder-metallurgy techniques

Pharos Hall Friday 13.10.2023

Invited lectures

11:30-11:50 **The Powder Metallurgy Processing Route for Zn-Mg Materials to Enhance Strength and Ductility for Medical Devices**
Jiří Kubásek, David Nečas, Črtomir Donik, Irena Paulin, Peter Gogola, Martin Kusý, Miroslav Čavojský, Matjaž Godec

11:50-12:10 **Development of Biodegradable Zn-based Alloys by Extrusion, SPS and SLM**
Irena Paulin, Črtomir Donik, Jiri Kubasek, Dalibor Wojtech, Matjaž Godec

12:10-12:30 **Development of biodegradable Zn-0.8Mg-0.12Sr alloys by SLM**
Matjaž Godec, Črtomir Donik, Dalibor Wojtech, Jiri Kubasek, Irena Paulin

12:30-12:50 **The role of powder metallurgy in grain size and corrosion behaviour of Zn-based alloys**
Jiri Kubasek, Dalibor Wojtech, Črtomir Donik, Irena Paulin, Matjaž Godec

12:50-13:45 **Discussion**

The Powder Metallurgy Processing Route for Zn-Mg Materials to Enhance Strength and Ductility for Medical Devices

Jiří Kubásek[1], David Nečas[1], Črtomir Donik[2], Irena Paulin[2], Miroslav Čavojský[3], Peter Gogola[4], Martin Kusý[4], Matjaž Godec[2]

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This study specifically examines zinc-magnesium alloys with 1 wt.% of magnesium and how they were produced using powder metallurgy techniques, including mechanical alloying (MA), spark plasma sintering (SPS), and extrusion.
The results show that MA led to a nano-grained microstructure, which allowed for magnesium solubility beyond thermodynamically stable conditions. However, it was found that zinc and magnesium oxide particles were still present in the microstructure, particularly at the grain boundaries, together with the Zn and Mg_2Zn_{11} phases.
This enabled the maintenance of the nano-grained microstructure even after compaction by SPS or extrusion at high temperatures. The consolidated materials had a zinc matrix with an average grain size of about 500 µm, as well as homogeneously distributed Mg_2Zn_{11} phases of similar size and zinc and magnesium oxides with a size of approximately 200 nm. In terms of mechanical performance, the SPS products had lower strength and plasticity due to the existence of oxide shells, while the extruded ones had superior mechanical properties for the studied alloying system. Specifically, the TYS, UTS, and elongation values meet the general mechanical requirements for bioabsorbable medical devices used in maxillofacial and dental surgery.

Development of Biodegradable Zn-based Alloys by Extrusion, SPS and SLM

Irena Paulin[1], Črtomir Donik[1], Jiri Kubasek[2], Dalibor Wojtech[2], Matjaž Godec[1]

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As part of the CEUS international project, we conducted a study on biodegradable zinc-based materials. Our aim was to gain a deeper understanding of Zn-Mg-X alloys through microstructure development studies using various powder metallurgy techniques such as extrusion, SPS, and SLM. In this study, we focused on the ternary alloy where the X component was Sr. Our main challenge was to achieve the desired mechanical properties without compromising the corrosion rate of the developed alloys. This is because Zn has an almost optimal corrosion rate for biodegradable alloys. Our results are crucial for developing improved Zn-based materials with superior and tailored properties.

During our study, we faced the challenge of finding suitable parameters for the SLM process because Zn has a very low evaporation pressure. However, we were able to achieve a density of over 95% in the SLM-prepared samples by adjusting only the power and scanning speed. To confirm the present phases, inclusions, and grains in the samples, we performed EBSD and TEM measurements.

Development of biodegradable Zn-0.8Mg-0.12Sr alloys by SLM

Matjaž Godec[1], Črtomir Donik[1], Dalibor Wojtech[2], Jiri Kubasek[2], Irena Paulin[1]

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In the past ten years, there has been increased interest in using orthopaedic and cardiovascular medical devices made of zinc-based materials. These materials need to have a mix of mechanical, corrosion, and biological properties that are associated with their microstructure. Despite attempts to enhance their performance, traditional methods like casting, extrusion, rolling, or drawing are still typically used. Powder metallurgy techniques, such as mechanical alloying (MA), spark plasma sintering (SPS), selective laser sintering (SLS), selective laser melting (SLM), and others, have been overlooked in the development of these materials to date. However, suitable processing through these techniques can lead to the formation of materials with highly different microstructure conditions and tailored mechanical, corrosion, and biological properties.
Additive manufacturing technologies have made significant progress, and selective laser melting (SLM) is now being used to prepare pure Zn, Zn-Mg alloys, and Zn-WE43 scaffolds. We utilised SLM to create samples of Zn-0.8 mg-0.12 Sr, and by adjusting the SLM process parameters, we were able to vary the porosity. These parameters also impacted the grain size and mechanical properties of the samples. Despite the main drawback of Zn's low vapour pressure during SLM processing, we found that adjusting the parameters led to a better microstructure with lower porosity.

The role of powder metallurgy in grain size and corrosion behaviour of Zn-based alloys

Jiri Kubasek[1], Dalibor Wojtech[1], Črtomir Donik[2], Irena Paulin[2], Matjaž Godec[2]

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In the presented work, Zn-Mg-based alloys were produced by powder metallurgy techniques including mechanical alloying, spark plasma sintering and/or extrusion, Obtained results indicate that materials contain a high portion of oxide particles of different sizes. These particles occupy predominantly grain boundaries. Furthermore, materials were characterized by very fine-grained microstructure containing grains with hundreds of nm in size and intermetallic particles of similar size. We observed that these intermetallic phases and oxide particles stabilize the microstructure even with extremely fine grains. At the same time, our results indicate the effect of oxides on corrosion behaviour and the tendency for localized attack in the vicinity of oxide particles. Based on these observations some modifications in materials synthesis and processing are suggested to improve the material's performance.