SURFACES, INTERFACES AND COATINGS TECHNOLOGIES

SICT 2025

PLASMA PROCESSING AND TECHNOLOGY

PLASMA TECH 2025

TRIBOLOGY INTERNATIONAL CONFERENCE

Tribology 2025

SICT 2025 / PLASMA TECH 2025 / TRIBOLOGY 2025 JOINT CONFERENCES

23 - 25 April 2025 | Albufeira, Portugal

Book of Abstracts

Organizer

SETCOR Conferences & Exhibitions

SICT 2025 / PlasmaTech 2025 / Tribology 2025 Joint Conferences Program

23– 25 April 2025 | Albufeira, Portugal

23 April 2025		
08:00 - 12:00	**Participants registration**	
09:30 - 10:30	**Welcoming Coffee**	
SICT 2025 / Plasma Tech 2025 / Tribology 2025 Joint Plenary Session		
Conference Room Balaia		
Session's Chairs: **Prof. Holger Kersten, University Kiel, Germany** **Prof. Maude Jimenez, Univ. Lille, France**		
10:00 - 10:30	Advancing plasma technologies: innovations and insights from the N-PRiME group **L.L. Alves**	**Prof. Luis Alves**, IPFN-Univ. Lisbon, **Portugal**
10:30 - 11:00	Production of thermally sprayed HEBM High-Entropy Alloy coatings **S. Dosta,** G. Clavé, L. Betancor, K. Rozema, F. Touwen, G. Bolelli, L. Bortolotti, E. Forlin, E. Rossi5, G. Gigante, M. Sebastiani and C. Barreneche	**Prof. Sergi Dosta**, University de Barcelona, **Spain**
11:00 - 11:30	Exploring multi-modality and adaptivity of low-temperature plasmas for biomedical applications **M. Keidar**	**Prof. Michael Keidar**, The George Washington University, **USA**
11:30 - 12:00	The role of energetic species during the growth of thin films **D. Depla**	**Prof. Diederik Depla**, Ghent University, **Belgium**
12:00 - 12:15	Multidimensional Elemental and Molecular Analysis for Surface & Interface studies **P. Chapon** and A. Stankova	**Mr. Patrick Chapon**, HORIBA France, **France**
12:00 - 14:00	**Lunch Break – Restaurant**	
SICT 2025 - BEYOND PFAS Workshop		
Session's Chairs: **Mrs. Mireille Poelman, Materia Nova, Belgium** **Dr. Fabiola Brusciotti, TECNALIA, Spain**		
13:45 - 14:05	Waterborne PFAS-free coatings for packaging and textile sectors **R. Rodriguez**, O. Echeverria, B. Perez and H. Villaverde	**Dr. Raquel Rodriguez**, TECNALIA, Basque Research and Technology Alliance, **Spain**
14:05 - 14:25	PFAS-free non-stick coatings for kitchenware applications (TORNADO) **F. Brusciotti**, A. Suárez-Vega, L. Arce and G. Adversi	**Dr. Fabiola Brusciotti,** TECNALIA, Basque Research and Technology Alliance, **Spain**
14:25 - 14:45	PFAS-free sol-gel hybrid coatings with hydrophobic and non-stick properties for low-maintenance glass and food-packaging machines (PROPLANET) **F. Brusciotti**, A. Suárez-Vega, K. Nalyvayko, L. Arce and N. Casanova	**Dr. Fabiola Brusciotti,** TECNALIA, Basque Research and Technology Alliance, **Spain**
14:45 - 15:05	Biopolymer-based hydrophobic textile coatings: development within the PROPLANET project **A. Verbic**, U. Novak, B. Likozar and B. Stres	**Dr. Anja Verbic**, National Institute of Chemistry, **Slovenia**
15:05 - 15:25	Synthesis of safe and sustainable PFAS-free omniphobic coatings **T. Piock**, S. Nique, F. Somorowsky, C. Stauch and D. Lau	**Mrs. Tamara Piock**, Fraunhofer Institute for Silicate Research (ISC), **Germany**
15:25 - 15:45	Formulation and application of PFAS-free water and oil repellent coatings for textile applications **R. Garcia**, P. Aragón, C. Gómez, D. Lau, T. Piock and S. Nique	**Mrs. Ruth Garcia**, Leitat Technological Center, **Spain**
15:45 - 16:05	Safe and Sustainable by Design PFAS-free Hybrid Coating for Cosmetic Glass Packaging Application within BIO-SUSHY Project	**Mrs. Mireille Poelman**, Materia Nova, **Belgium**

	M. Poelman, E. Khousakoun, A.-L. Dechief, B. Belloncle, A. Mezy, A. Ballesteros Riaza, J. Alcodori, P. Camilleri Lledo, A. Rashid and A. Nelson	
16:00 - 16:30	**Coffee Break / Posters Session**	
SICT 2025 Session I. A: Surface treatments and coatings deposition and functionalization / Characterization / Properties Multifunctional composite and hybrid coatings		
Session's Chairs: Prof. Sergi Dosta, University de Barcelona, Spain Prof. Diederik Depla, Ghent University, Belgium		
16:30 - 16:45	Dealkalization of the internal surfaces of pharmaceutical glass vials: comparison between gaseous and liquid Sulfur-based treatments **G. Legrottaglie**, G. Trevisi, D. Costa, R. Martini, M. Poncini and D. Faverzani	**Dr. Giuseppe Legrottaglie**, University of Parma, **Italy**
16;45 - 17:00	Ion Implantation for Sustainable Surface Modification: A Case Study in Electrical Connector Industry for Enhanced Corrosion Resistance **A. Nasiri**	**Dr. Aida Nasiri**, IONICS Surface Technologies, **Belgium**
17:00 - 17:15	Manufacture of the Invar Fine Metal Mask Using an Electroforming Technique I.G. Kim, J.H. Lee, S.E. Shin and **Y.B. Park**	**Prof. Yong Bum Park**, Suncheon National University, **Rep. of Korea**
17:15 - 17:30	Stability of Expanded Austenite During Annealing in Vacuum **D. Manova**, H. Oh, D. Hristov and S. Mändl	**Dr. Darina Manova**, Leibniz Institute of Surface Engineering (IOM), **Germany**
17:30 -17:45	Characterization of electroplated zinc-iron coatings : Influence of organic additives and pulsed current **O. Solh**, J. Grosseau-Poussard, J. Creus and C. Savall	**Mr. Omar Solh**, La Rochelle University, **France**
17:45 - 18:00	Boosting Additively Produced Magnesium via Cerand´s ULTRACERAMIC® **A. Sharma**, J. Zerrer, A. Abel, M. Müller,J. Hermsdorf, S. Kaierle and A. Buling	**Mr. Anutsek Sharma** ELB - Eloxalwerk Ludwigsburg Helmut Zerrer GmbH, **Germany**
18:00 - 18:15	Transfer Matrix Method Approach for ex and in situ LASER Interferometry Analyses of Growing Thin Films – Applied on Initiated Chemical Vapor Deposition Grown Thin Films **G. Ehlers**, L. Storcks, T. Pogoda, S. Schröder and T. Ameri	**Mr. Gunnar Ehlers**, Kiel University, **Germany**
18:15 - 18:30	Self-healing and recyclable intumescent flame retardant coatings **F. Samyn** , K. Apaydin and Maude Jimenez	**Dr Fabienne Samyn**, Univ. Lille, **France**
18:30 - 18:45	Novel Photoprotective Solution for Rosé Wine: TiOx-AZO Coatings on Glass Bottles **E. Almandoz**, J. Moriones, B. Navarcorena, B. Garín, P. Amézqueta, J.F. Palacio, J. Osés, J. Fernández De Ara and G.G. Fuentes	**Dr. Eluxka Almandoz**, AIN - Industry Association of Navarra, **Spain**
18:45 - 19:00	Enhanced Conductivity Paraffin PCM Microcapsules for Textile Coating **A.Sankauskaite**, V. Skurkytė-Papievienė, V. Rubežienė, J. Baltušnikaitė-Guzaitienė and S. Varnaitė-Žuravliova	**Dr. Audrone Sankauskaite**, State research institute Center for Physical Sciences and Technolo-gy, **Lithuania**

23 April 2025		
Plasma Tech Session I. B: **Plasma fundamentals / Modelling / Atomic and Molecular Processes**		
Conference Room Santa Eulalia		
Session's Chairs: **Prof. Tiberiu Minea, Paris-Saclay University, France** **Dr. Pavel Baroch, University of West Bohemia, Czech. Rep**		
14:00 - 14:30	Non-Conventional diagnostics for the investigation of atmospheric pressure discharges **H. Kersten**, L. Hansen, H. von Wichert, T. Hahn, D. Solodov, M. Gaal and M. Klette	**Prof. Holger Kersten**, University Kiel, **Germany**
14:30 - 15:00	From VLEO to Space: Selected EP systems analyzed by modeling and experiment **J. Schein**	**Prof. Jochen Schein,** University of Federal Armed Forces Munich, **Germany**
15:00 - 15:30	Overview of Electric Propulsion Thruster and Diagnostic Developments at TU Dresden E. Berka, G. Hentsch, J. Hertel, R. Nerger, O. Neunzig, L. Peiffer, C. Peter, F. Prochnow, T. Reichelt, J.-Ph. Wulfkühler and **M. Tajmar**	**Prof. Martin Tajmar**, Dresden University of Technology, **Germany**
15:30 - 16:00	Conventional and non-conventional diagnostics on micro discharges **L. Hansen** , G. Bilgin, N. Kohlmann , F. Köhler , U. Schürmann , L. Kienle, H. Kersten and J. Benedikt	**Dr. Luka Hansen**, Kiel University, **Germany**
16:00 - 16:30	**Coffee Break / Posters Session**	
Session's Chairs: **Prof. Jochen Schein, University of Federal Armed Forces Munich, Germany** **Prof. Martin Tajmar, Dresden University of Technology, Germany**		
16:30 - 16:45	Numerical Modeling of Approximate Plasma Evolution through Gaussian Functions for Magdrive Devices - An MPI-Parallelised Approach **M. J. Warrick**, C. K. Stavrou and M. Drolia	**Mr. Michael Warrick**, Magdrive, **UK**
16:45 - 17:00	Using remote plasma emission spectroscopy for monitoring and control of vacuum processes **L.Maroto**, J. Brindley, B. Daniel, V. Bellido-Gonzalez and D. Monaghan	**Ms. Lara Maroto**, Gencoa Limited, Liverpool, **UK**
17:00 - 17:15	Extended self-similarity in a 2D complex plasma with active Janus particles **V. Nosenko**	**Dr. Volodymyr Nosenko**, German Aerospace Center DLR, **Germany**
17:15 - 17:30	AI-Driven Modelling for Predictive Optimisation of Atmospheric Plasma Treatment in Microporous EVAs **C. Ruzafa-Silvestre**, V.M. Serrano-Martínez, J.M. Carot-Sierra , M.D. Romero-Sánchez and E. Orgilés-Calpena	**Mr. Carlos Ruzafa Silvestre**, INESCOP, **Spain**
17:30 - 17:45	Combined in-situ PM-IRRAS and XPS analysis of nitrogen plasma surface modification of polylactide thin films **S. Gołębiowska**, M. Voigt, T. de los Arcos and G. Grundmeier	**Ms. Sandra Gołębiowska**, Paderborn University, **Germany**

23 April 2025		
SICT 2025/ Tribology 2025 Joint Session I. C: Surface Engineering, Coatings and Tribology		
Conference Room Algarve		
Session's Chairs: **Prof. Robert L. Jackson, Auburn University, USA** **Prof. Auezhan Amanov, Tampere University, Finland** **Prof. Mihai Arghir, Univ. Poitiers, France**		
14:00 - 14:30	Post-processing treatments to enhance the interlayer strength of extrusion-based 3D printed polymer composites S. Bhandari and **R.A. Lopez-Anido**	**Prof. Roberto Lopez-Anido**, University of Maine, **USA**
14:30 - 14:45	Electroplated Metal-Graphene Coatings as Solid Lubrication **S. Zhao**, L. Fabbri, N. Savjani, E. Johansson, A. M. Andersson, E. Piciollo, G. Bartolini, F. Bertocchi, M. A. Bissett and I. A. Kinloch	**Dr. Su Zhao**, ABB AB Motion, **Sweden**
14:45 - 15:00	Multilayer Cu-graphene composite coating system for high-load solid lubrication – Exploring dynamic and quasi-static friction **E. Johansson**, S. Zhao, A.M. Andersson, L. Fabbri, E. Piciollo, G. Bartolini and F. Bertocchi	**Dr. Erik Johansson**, ABB AB, Motion, **Sweden.**
15:00 - 15:15	The Influence of Methods for Distributing the IF-WS2 Modifier into the Structure of Al2O3 Aluminum Oxide Coatings on Their Micromechanical Properties **J. Korzekwa**, A. Barylski, M. Niedźwiedź and M. Bara	**Dr. Joanna Korzekwa**, University of Silesia in Katowice, **Poland**
15:15 - 15:30	Low-Friction Coatings for the External Surface of Glass Vials: From Dipping to Spray Deposition for Industrial-Scale Applications **T. Pastore**, G. Trevisi, F. Casoli, L. Savio, M. Remešová, V. Bednaříková, L. Čelko, M. Doubrava, O. Sharifahmadian, M. Krbata, D. Costa, M. Poncini and D. Faverzani	**Ms. Tiziana Pastore**, University of Parma, **Italy**
15:30 - 15:45	The Microstructure and Properties of Carbon Coatings Produced by Low-Temperature RFPACVD Processes on Nanobainitic and Martensitic 35CrMnSi-5-5-4 steel K. Wunsch,, K. Kulikowski, A. Roguska , R. Chodun, E.Skołek and **J. R Sobiecki**	**Prof. Jerzy R. Sobiecki**, Warsaw University of Technology, **Poland**
15:45 - 16:00	Wear Behavior of Chromium and Chromium Nitride Coatings Subjected to Different Probe Geometry During Impact Fatigue Tests **J. Krupa** and S. Zimowski	**Ms. Jolanta Krupa**, AGH University of Krakow, **Poland**
16:00 - 16:30	**Coffee Break / Posters Session**	
Session's Chairs: **Prof. Robert L. Jackson, Auburn University, USA** **Prof. Auezhan Amanov, Tampere University, Finland**		
16:30 - 16:45	Influence of Ultrasonic Nanocrystal Surface Modification on the Surface Integrity and Microstructure of Inconel 718: A Finite Element and Experimental Investigation **I. Cetintav** and A. Amanov	**Dr. Isik Cetintav**, Trakya University,**Turkey**
16:45 - 17:00	Relationship between Acoustic Emission Signals and Surface Conditions in Rolling Contact Fatigue Tests **Y. Mukai** and A. Hase	**Mr. Yu Mukai**, Nippon Steel Technology Co., Ltd., **Japan**
17:00 - 17:15	The effect of milling-induced surface topography on the tribological behavior of chromium-molybdenum alloyed steel. **A. Dzierwa**, J. Sep and P. Pawlus	**Prof. Andrzej Dzierwa**, Rzeszow University of Technology, **Poland**
17:15 - 17:30	Analyzing area roughness parameters of ground and superfinished components: toward the description of surface performance **M. Gragnanini**, A. Fortini, A. Fantini and A. Blum	**Mr. Michele Gragnanini**, University of Ferrara, **Italy**
17:30 - 17:45	Development of electrically conductive adhesive technology for the automotive industry **F. Tajti**, K. Polyák, M. Berczeli and Z. Weltsch	**Mr. Ferenc Tajti**, John von Neumann University, **Hungary**
17:45 - 18:00	High speed and quasi-static tensile test of DP600 adhesive joints **P. Péczi-Kovács**, F. Klejch, E. Schmidová and M. Berczeli	**Mr. Péter Péczi-Kovács**, John von Neumann University, **Hungary**

18:00 - 18:15	Increasing the Machinability of 3D Printed IN718 by Indigenously Developed Bimodal Reactive Nitride Coatings **G. Kumar**, P. Sansanwal, S. Ghosh and P.V. Rao	**Mr. Gaurav Kumar**, Indian Institute of Technology Delhi, **India**

24 April 2025		
Conference Room Balaia		
SICT 2025 Session II. A: **Surface and coatings Characterization / Properties** **Multifunctional composite and hybrid coatings**		
Session's Chairs: **Prof. Juan F. Sánchez Royo, University of Valencia, Spain** **Prof. Luca Magagnin, Polytechnic Milan, Italy** **Prof Michael Morris, Trinity college Dublin, Ireland**		
08:30 - 09:00	Nanoporous/nanocomposite thin films by magnetron sputtering deposition in Helium: New materials and applications **A. Fernández**	**Prof. Asunción Fernández,** Materials Science Institute of Seville, **Spain**
09:00 - 09:15	Next generation Surface Treatments to Preserve Buildings **M.J. Mosquera**, R. Zarzuela, M. Luna, A.B. Mosquera, A. Peñalo-za and M.J. Ruíz-Bejarano	**Prof. María J. Mosquera**, University of Cádiz, **Spain**
09:15 - 09:30	A new route to produce smart coatings with switchable superhydrophobic-superhydrophobic surface in response to metal ions and pH **R. Zarzuela**, C. Porras-Ketterer and M. J. Mosquera	**Dr. Rafael Zarzuela**, University of Cadiz, **Spain**
09:30 - 09:45	g-C3N4-TiO2-SiO2 nanocomposites for producing multifunctional building with hydrophobic, self-cleaning and depolluting properties **M. Luna,** C.G. Silva, J.M. Gatica, M.J. Mosquera and J.L. Faria	**Mr. Manuel Luna**, University of Cádiz, **Spain**
09:45 - 10:00	Fluorine-free Superhydrophobic Treatment for Textiles **A.B. Mosquera**, R. Zarzuela and M.J. Mosquera	**Mr. Alfonso B. Mosquera**, University of Cadiz, **Spain**
10:00 - 10:15	Expanding Transparent Covalently Attached Liquid-like Surfaces for Icephobic Coatings with Broad Substrate Compatibility **A. Jalali Kandeloos**, T. Eder, D. Hetey, A. Bismarck, M. R. Reithofer, M. J. Cordill and JM. Chin	**Mr. Amirhossein Jalali Kandeloos**, University of Vienna, **Austria**
10:15 - 10:30	Development of nanocomposite coatings to enhance leather surface properties S.A.F. Neves, L. Lima, S. Pinho M.A. Lopes and **C. Fonseca**	**Prof Carlos Fonseca**, University of Porto, **Portugal**
10:30 - 11:00	**Coffee Break / Posters Session**	
Session's Chairs: **Prof. Asunción Fernández, Materials Science Institute of Seville, Spain** **Prof. Juan F. Sánchez Royo, University of Valencia, Spain** **Prof Carlos Fonseca, University of Porto, Portugal**		
11:00 - 11:30	Surface engineering of stainless steel for dairy fouling management **M. Jimenez**, S. Zouaghi, M. Grunlan, S. Bellayer, F. Samyn and G. Delaplace	**Prof. Maude Jimenez**, Univ. Lille, **France**
11:30 - 11:45	Study and evaluation at low temperature of base formulations of icephobic coatings for aeronautical applications. **F. Piscitelli**, G. Bruno, A. Diana, V. Ambrogi and G. Filippone	**Dr. Filomena Piscitelli**, Italian Aerospace Research Centre – CIRA, **Italy**
11:45 - 12:00	Multi-functional Fusion Bonded Epoxy Coatings: UV resistant and Anti-Corrosion performance in marine environment **A.Madhan Kumar**	**Dr. Madhan K. Arumugam**, King Fahd Univ. of Petroleum & Minerals, **Saudi Arabia**
12:00 - 12:15	New Approach for Evaluating Surface Heterogeneity in Nanostructured Coatings **R. Griffo**, M. Sirignano, M. Minale and C. Carotenuto	**Mrs. Raffaella Griffo**, University of Campania Luigi Vanvitelli, **Italy**
12:15 - 12:30	Carbon Nanoparticles at Liquid Interface: An investigation on different surface functionalization processes with Pendant Drop Tensiometry **R. Esposito**, R. Griffo, A. Caputo, M. Sirignano, M. Minale and C. Carotenuto	**Ms. Rosada Esposito**, University of Campania Luigi Vanvitelli, **Italy**
12:00 - 14:00	**Lunch Break – Restaurant**	
Group Photo at 13:45		

SICT 2025 - FreeMe project workshop on safe and sustainable coatings		
Session's Chairs: **Prof. Luca Magagnin, Polytechnic Milan, Italy**		
13:30 - 13:40	An introduction to the FreeMe Project **L. Magagnin**	**Prof. Luca Magagnin**, Polytechnic Milan**, Italy (FreeMe)**
13:40 - 14:00	Self-Activating Sprayable Resins for Toxic-Free Plating on Plastics R. Bernasconi and **L. Magagnin**	**Prof. Luca Magagnin**, Polytechnic Milan**, Italy (FreeMe)**
14:00 - 14:20	Synthesis of Bio-Based Thermosetting Resins for Advanced Composite Applications in Plating on Plastics (PoP) Processes **Z.L. Koutsogianni**, D. Bikiaris and K. Triantafyllidis	**Ms. Zoi-Lina Koutsogianni**, Aristotle University of Thessaloniki, **Greece (FreeMe)**
14:20 - 14:40	A process optimization tool for emerging Plating on Plastics Processes **K. A Pyrgakis**, D. Zoikis-Karathanassis, E. Poupaki, M. Kartsinis, A. Grigoropoulos and A-Z. Karathanassis	**Dr. Konstantinos A Pyrgakis**, EXELISIS IKE, **Greece (FreeMe)**
14:40 - 15:00	A Multiscale Model for the Etching Mechanism of a Piranha Solution on an ABS Substrate **F. D. García**, I. Bellanato and A. Martos	**Mr. Francisco Daniel García**, IDENER Research and Development, **Spain (FreeMe)**
15:00 -15:20	Boosting the Research and Development of Safe and Sustainable-by-Design Ni-Based Materials for Energy Applications **A. Nicolenco**, F. Alcaide, U. Huizi, E. García-Lecina, E. Pellicer, R. de Paz-Castany, K. Eiler, G. Brunin, D. Waroquiers, G.M. Rigagnese, B. van den Bossche, J. Steck, F. Petrakli and R. Chatzipanagiotou	**Dr. Aliona Nicolenco**, CIDETEC, **Spain (NICKEFFECT)**
15:20 - 15:40	Development of tuned SOEC electrode by spray coating **A. Glukharev**, H. Witters, Z. Chen, J. Song, M. Jacobs and V. Middelkoop	**Dr. Artem Glukharev,** Flemish Institute for Technological Research-VITO, **Belgium (NOUVEAU)**
15:40 - 16:00	Production of reinforced coatings obtained by CGS **S. Dosta**, G. Clavé, L. Betancor, and C. Barreneche	**Prof. Sergi Dosta**, University de Barcelona, **Spain (Co-BRAIN)**
16:00 - 16:10	**Q&A**	
16:00 - 16:30	**Coffee Break / Posters Session**	
SICT 2025 / Plasma Tech 2025 Joint session II. B: **Bio-interfaces, Biomedical / Bioactive surfaces and coatings** **Plasma applications for biology, medicine, and agriculture**		
Session's Chairs: **Prof Marta Miola, Polytechnic of Turin, Italy** **Prof. Maude Jimenez, Univ. Lille, France**		
16:30 - 17:00	Changes in morphology and physiology of carrot calli in relation to selected plasma treatment **N. Puac**, M. Milutinović, S. Živković, G. Malović and N. Škoro	**Dr. Nevena Puac**, Institute of Physics Belgrade, **Serbia**
17:00 - 17:15	Tannic acid-assisted green in situ reduction of antimicrobial silver nanoparticles on clinoptilolite surface **M. Miola**, F. Gattucci, M. Lallukka, N. Grifasi, M. Armandi and M. Piumetti	**Prof Marta Miola**, Polytechnic of Turin, **Italy**
17:15 - 17:30	Surface-designed biocidal TiO2-based nanohybrids for enhanced photocatalytic and antimicrobial activity **E.R. Silva**, A. Barreto, A. Carapeto, M. Pereira, L.C. Gomes, R. Teixeira-Santos and F.J.M. Mergulhão	**Dr. Elisabete R.Silva**, University of Lisbon, **Portugal**
17:30 - 17:45	Sputtered deposition and laser structuration of multimetallic thin films for antibacterial/antiviral applications **P. Birnal**, P. Brault, D. Boivin, N. Semmar, B. Aspe, L. Lounis, P. Andreazza, E. Bourhis, T. Vaubois, E. Menou, M. Cavarroc-Weimer, C. Andreazza and A.L. Thomann	**Mr. Pierre Birnal,** University of Orleans, **France**
17:45 - 18:00	A Fluidized Bed Approach to Nonthermal Plasma Inactivation of Foodborne Pathogens in Presence of Low Water Content	**Mr. Julian Espitia**, KU Leuven, **Belgium**

	J. Espitia, D. Verheyen, E. Dankwa, R. Serhan, S. Akkermans, D.S. Kozak and J.F.M. Van Impe	
18:00 - 18:15	Synergistic Antibacterial Effect of Photoactivated, Plasma-Synthesised Copper Oxide and Zinc Oxide Nanoparticles **B. Erol**, S. Akkermans, M. Pradhan, R. Ní Dhomhnaill, D. Kozak and J. F.M. Van Impe	**Mrs. Busra Erol**, KU Leuven, **Belgium**
18:15 - 18:30	Design and Development of a Non-Thermal Plasma based Handheld Device for Sterilisation of Surfaces in Spacecraft Applications **E. N. Skariah**, M. K. Kim, K. Olsson-Francis and B. P. Stephens	**Dr. Emil Ninan Skariah**, University of Southampton, **UK**
18:30 - 18:45	CAP-generated RONS disrupt leukemia cells' function by mitochondria-related damage **B. Stańczyk**, B. Szymczak, B. Maciejewski, M. Świdziński, K. Roszek and M. Wiśniewski	**Ms. Beata Stańczyk**, Nicolaus Copernicus University, **Poland**

Conference Dinner
Conference venue hotel, from 19:30

24 April 2025		
Conference Room Santa Eulalia		
SICT 2025 / Plasma Tech 2025 Joint Session II. C: **Plasma fundamentals / Modelling / Atomic and Molecular Processes** **Plasma Processing / Materials Interactions / Coatings**		
Session's Chairs: **Prof. Luis Alves, IPFN- Univ. Lisbon, Portugal** **Prof. Holger Kersten, University Kiel, Germany**		
09:00 - 09:30	Plasma devices for surface treatment – specific applications **T. Minea**	**Prof. Tiberiu Minea**, Paris-Saclay University, **France**
09:30 - 10:00	Advanced Spatio-Temporal Modulation Control of Induction Thermal Plasma Fields for High-Rate Production of Nanomaterials **Y; Tanaka**	**Prof. Yasunori Tanaka**, Kanazawa University, **Japan**
10:00 - 10:30	Bipolar HiPIMS Discharges: Principles, Diagnostics, and Thin Film Deposition Strategies **P. Baroch**, A.D. Pajdarová, T. Kozák, M. Farahani, T. Tölg and J. Čapek	**Dr. Pavel Baroch**, University of West Bohemia, **Czech. Rep**
10:30 - 11:00	**Coffee Break / Posters Session**	
11:00 - 11:30	HIPIMS Sputtering for Thin Film Deposition for Applications **A.P. Ehiasarian**	**Prof. Arutiun Ehiasarian**, Sheffield Hallam University, **UK**
11:30 - 12:00	Development of a diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS) flow cell for characterizing nonthermal plasma catalysis under conditions close to dielectric-barrier discharge (DBD) reactors J. Niu, Y. Chen, S. Chen, H. Chen, J. Huang and **X. Fan**	**Prof. Xiaolei Fan,** University of Manchester, **UK**
12:00 -12:15	Development of a bonding technology for painted and unpainted aluminium sheets by cold plasma surface treatment B. Körömi, P. Péczi-Kovács, F. Tajti, Z. Weltsch and **M. Berczeli**	**Dr. Miklós Berczeli**, John von Neumann University, **Hungary**
12:00 - 14:00	**Lunch Break – Restaurant**	
Group Photo at 13:45		
Session's Chairs: **Prof. Jochen Schein, University of Federal Armed Forces Munich, Germany** **Prof. Arutiun Ehiasarian, Sheffield Hallam University, UK**		
14:00 - 14:30	Interplay of plasma processes and diffusion during solid carbon active screen plasma nitrocarburizing of AISI 316L **S. Mandl**, D. Manova, A. Dalke and H. Biermann	**Dr. Stephan Mandl,** Leibniz Institute of Surface Engineering (IOM), **Germany**
14:30 - 14:45	Simulating the influence of nanopores and chemical structure on gas permeation through silicon-based PECVD coatings **J. Franke** and R. Dahlmann	**Mr. Jonas Franke**, RWTH Aachen, **Germany**
14:45 - 15:00	Technological approaches for plasma-assisted thermochemical diffusion treatments of steels **S. Jafarpour**, A. Dalke and H. Biermann	**Dr. Saeed M. Jafarpour**, TU Bergakademie Freiberg, **Germany**
15:00 - 15:15	Automatic Feature Extraction from Optical Emission Spectra of Reactive Ion Etching Using Dynamic Mode Decomposition **M.A. Sayyed**, S. Zieger, T. Seifert, T. Rothe, J. Langer, M. Haase and, H. Kuhn	**Mr. Mudassir Ali Sayyed**, TU Chemnitz, **Germany**
15:15 - 15:30	O2 plasma degradation of space-technology polymers **C.A.P. da Costa**, N. Laidani, G. Gottardi, L. Maines, M. Michielan, L. M. Martini, P. Tosi and D. Ascenzi	**Dr. Cíntia Aparecida Pires da Costa**, Univ. Trento, **Italy**
15:30 - 15:45	Synthesis of quantum dots in non-thermal plasma: tuning the energy-storage properties and surface reactivity via dominant faceting **F. Matejka**, P. Galar, J. Kopenec, R. Kral, P. Zemenova, M. Dopita, P. Hapala, D. König, P. Vrbka and K. Kusova	**Mr. Filip Matejka**, Institute of Physics of the CAS, **Czech Rep.**

15:45 - 16:00	Development of ceramic-based composite coatings by combining cold-spray deposition and plasma electrolytic oxidation **J. Martin**, A. Maizeray, G. Marcos, M.P. Planche, H. Liao, A. Cappella, S. Philippon, T. Czerwiec and G. Henrion	**Dr. Julien Martin**, Univ ; Lorraine, **France**
16:00 - 16:30	**Coffee Break / Posters Session**	
SICT 2025 / Plasma Tech 2025 Session II D: Plasma Processing / Materials Interactions / Coatings Plasma application in Energy and environment		
Session's Chairs: Dr. Pavel Baroch, University of West Bohemia, Czech. Rep Dr. Luka Hansen, Kiel University, Germany		
16:30 - 16:45	Deposition of copper-containing carbon-based nanocomposite thin films in laboratory environment and process transer into industrial-size PECVD reactor **R.Přibyl,** M.Karkuš, Š. Kelarová, R.Václavik, O.Jašek, E.Staňková, I.Sedláček and V. Buršíková	**Mr. Roman Pribyl**, MUNI-ISI Brno, **Czech Rep.**
16:45 - 17:00	Characterization of the surface forces on smooth hydrophobic plasma polymer films M. Góra, P. Navascués, D. Hegemann, M. Heuberger and **A. Southam**	**Dr. Astrid Southam**, Empa, Swiss Federal Lab. for Materials Science and Tech., **Switzerland**
17:00 - 17:15	Surface Characterization and Interaction Dynamics of Hydrophilic Plasma Polymer Films **M. Gora**, P. Navascués, U. Schütz, D. Hegemann and M. Heuberger	**Mr. Michal Gora**, Empa, Swiss Federal Laboratories for Materials Science and Technology, **Switzerland**
17:15 - 17:30	Properties of a-C:H:F produced with tetrafluorethane **B.B. Ramos**, F. A. Vicente, N. Andrioni, G. Hammes, J.D.B. de Mello and C. Binder	**Mr. Bruno Ramos**, Federal University of Santa Catarina, **Brazil**
17:30 - 17:45	Revealing Cooperative Role of Non-thermal Plasma and Copper-Zinc Catalysts in the Hydrogenation of CO2 to methanol **S. Xu**, X. Fan and. C. Hardacr	**Dr. Shanshan Xu**, University of Manchester, **UK**
17:45 - 18:00	Reaction engineering approach for a stable rotating glow to arc plasma – key principles of effective gas conversion processes **S. Kaufmann,** P. Rößner, V. Seithümmer, H. Chinnaraj and K. Peter Birke	**Mr. Samuel Kaufmann**, University of Stuttgart, **Germany**
18:00 - 18:15	NOx Formation in Atmospheric Microwave Plasma **M. Wnukowski**, N. Modliński and U. L. Amasi	**Dr. Mateusz Wnukowski,** University of Science and Technology, **Poland**
18:15 - 18:30	Scenario-based economic feasibility study of plasma torch concepts to decarbonize cement produciton **H. Basche**, N. Alavandar and C. Winnewisser	**Ms. Hanna Basche**, TRUMPF Hüttinger GmbH + Co, **Germany**
18:30 - 18:45	Comparative study of atrazine degradation in water using advanced plasma bubble reactors K. Papalexopoulou, A. Bastani and **C.A. Aggelopoulos**	**Dr. Christos Aggelopoulos**, Foundation for Research and Technology Hellas, **Greece**
18:45 - 19:00	Advancing Metal Powder Production and Recycling Through Ultrasonic Atomization **T. Choma**, Ł. Żrodowski, B. Kalicki, B. Morończyk and J. Ciftci	**Mr. Tomasz Choma**, Warsaw Univ.Tech/ AMAZEMET, **Poland**

Conference Dinner
Conference venue hotel, from 19:30

24 April 2025		
Tribology 2025 Session II. E: Coatings and Surfaces Corrosion / Tribological Properties / Physics or Chemistry of Tribo-Surfaces/ Nanotribology		
Conference Room Algarve		
Session's Chairs: Dr. Stefan J. Eder, AC2T research GmbH/ TU Wien, Austria Dr. James Knowles, Loughborough University, UK		
09:00 - 09:30	The Electro-Mechanical Tribology of Rough Lubricated Interfaces **R. L. Jackson**	**Prof. Robert L. Jackson**, Auburn University, **USA**
09:30 - 10:00	Tribology and Seizure Resistance of Journal Bearings under Lubrication Regime Transition **A. Amanov**	**Prof. Auezhan Amanov**, Tampere University, **Finland**
10:00 - 10:30	Modelling the formation of tribofilms across the scales **D. Dini**	**Prof. Daniele Dini,** Imperial College London**, UK**
10:30 - 11:00	**Coffee Break / Posters Session**	
Session's Chairs: Prof. Robert L. Jackson, Auburn University, USA Dr. James Knowles, Loughborough University, UK		
11:00 - 11:30	Computational Materials Tribology — Nanoscale Simulations to Address Engineering Challenges **S.J. Eder**	**Dr. Stefan J. Eder**, AC2T research GmbH/ TU Wien, **Austria**
11:30 - 11:45	Surface Study of Additively Manufactured Steel Processed through Vibration Assisted Ball Burnishing **A. Travieso-Disotuar**, R. Jerez-Mesa, J.A. Travieso-Rodríguez and M. Vilaseca	**Mr. Adrián Travieso**, Eurecat, **Spain**
11:45 - 12:00	Effect of Tribological Conditions on Organic Friction Modifiers tri-bofilm **M. Homayoonfard**, S.L M Schroeder, P. Dowding and A. Morina	**Mrs. Marjan Homayoonfard**, University of Leeds, **UK**
12:00 -12:15	Comparative Tribological Analysis of Conventional and Cyclic Deep Cryogenic Treatment on AISI D2 Tool Steel **V. Yarasu**, B. Podgornik, B. Batic, M. Sedlacek, Č. Donik and F. Zepeda	**Dr. Venu Yarasu**, Institute of Metals and Technology, **Slovenia**
12:00 - 14:00	**Lunch Break – Restaurant**	
Group Photo at 13:45		
Session's Chairs: Prof. Mihai Arghir, Univ. Poitiers, France Prof. Maria Clelia Righi, University of Bologna, Italy Prof. Karlis Gross, Technical University, Latvia		
14:00 - 14:15	Wear and fretting in corrosive atmospheres at ultra-high temperature using a specially developed SRV tribometer test rig **P. Beau**, Dr. N. Kind and G. Patzer	**Mr. Patrick Beau**, Beau Engineering Services, **Germany**
14:15 - 14:30	Nitrogen ion implantation of a refractory high entropy HfMoNbTaTiVWZr thin film metallic glass **K. Stępniak** and. M. Jarząbek	**Ms. Karolina Stępniak**, Institute of Fundamental Technological Research, **Poland**
14:30 - 14:45	Wear on Radial Shaft Seals- Wear Models and Influencing Parameters **J. Gerhard** and F. Bauer	**Ms. Jacqueline Gerhard**, University of Stuttgart, **Germany**
14:45 - 15:00	Determination of the contact temperature of rotary shaft seals without compromising the tribological system **C. Olbrich**, N. Piechulek; S. Feldmeth and F. Bauer	**Mr. Christoph Olbrich** University of Stuttgart, **Germany**
15:00 - 15:15	Optimization of Laser Engraved Pumping Structures on Lip Seals for Pressure Loaded Applications **M. Gohs** and F. Bauer	**Mr. Marco Gohs**, University of Stuttgart, **Germany**
15:15 - 15:30	Rolling Contact Fatigue Prediction of 42CrMo4 Steel Using Multiaxial Fatigue Parameters	**Dr. Ibai Ulacia**, Mondragon University, **Spain**

	I. Ulacia, I. Llavori, M. Maiztegui, A. Iñurritegui, A. Arana and J. Larrañaga	
15:30 - 15:45	Effect of Surface Roughness on Contact Area Measurements: Experimental and BEM Analysis **M. Maiztegui**, J. Larrañaga, A. Arana, A. Oyanguren, I. Ulacia and J. F. Molinari	**Mr. Mattin Maiztegui**, Mondragon University, **Spain**
15:45 - 16: 00	Micropitting resistance of bearing steels in hybrid contacts **V. Brizmer**, P. Andric, B. Minov, T. Nuijten, R. van der Zwaan, G.E. Morales-Espejel and C. Vieillard	**Dr. Victor Brizmer**, SKF Research & Technology Development, **The Netherlands**
16:00 - 16:30	**Coffee Break / Posters Session**	
Session's Chairs: Prof. Maria Clelia Righi, University of Bologna, Italy Prof Alan Hase, Saitama Institute of Technology, Japan		
16:30 - 16:45	Experimental study of the influence of the mechanical design of a tribometer on the friction response for a pin-on-disk configuration **P. Jolly**, N. Brunetière and L. Ravaud	**Dr Pascal Jolly**, Univ. of Poitiers, **France**
16:45 - 17:00	Estimating tyre friction from road surface roughness: is a PSD enough? T. Sanders, G. Mavros and **J. A. C. Knowles**	**Dr. James Knowles**, Loughborough University, **UK**
17:00 - 17:15	Measurement of ice friction at different length scales **K.A. Gross**, T. Lemmettylä, U. Hangen and V. Linnamo	**Prof. Karlis Gross**, Technical University, **Latvia**
17:15 - 17:30	Microstructural and tribological investigations of M2 high-speed steel alloy fabricated by directed energy deposition process **N.K. Sah**, G. Singh, P.M. Pandey and S. Ghosh	**Mr. Neetesh Kumar Sah**, Indian Institute of Technology Delhi, **India**
17:30 - 17:45	Tribological Performance of Microindented 100Cr6 Steel Surfaces in Dry and Lubricated Non-Conformal Contacts **F. Davoodi**, P. Guglielmi, G. Palumbo and G. Carbone	**Dr. Farideh Davoodi**, Polytechnic University of Bari, **Italy**
17:45 - 18:00	Studying the ligand chain length effect on wear resistance of nanostabilized greases **B. Soltannia**, A. Milani and D. Grecov	**Dr. Babak Soltannia**, The University of British Columbia, **Canada**
18:00 - 18:15	Friction of the PtSe2 layers with different grain sizes in ambient air and vacuum **A. Kozak**, M. Sojkova, J. Hrda, M. Hulman and M. Tapajna	**Dr. Andrii Kozak**, Institute of Electrical Engineering, **Slovakia**
18:15 - 18:30	Femtosecond laser texturing for improved journal-bearing performance **G. Schnell** and H. Seitz	**Dr. Georg Schnell**, University of Rostock, **Germany**

Conference Dinner
Conference venue hotel, from 19:30

25 April 2025		
SICT 2025 / Plasma Tech 2025 Session III. A: Coatings for Energy and Environmental Applications		
Conference Room Santa Eulalia		
Session's Chairs: Dr. Luka Hansen, Kiel University, Germany Prof. Arutiun Ehiasarian, Sheffield Hallam University, UK		
08:45 - 09:15	Fabrication and Characterizations of SnOx-based Flexible and Invisible Synaptic Memristor and Their Application **T-Y. Tseng**, P-X. Chen and D. Panda	**Prof. Tseung-Yuen Tseng**, National Yang Ming Chiao Tung University, **Taiwan**
09:15 - 09:45	Two-dimensional lead iodide perovskites for solar-cell applications: An study of Surface Stability Conditions M.E.-Changarath, M. Krecmarova, J. Rodríguez-Romero, I. Mora-Seró, J.P. Martínez-Pastor, M.C. Asensio and **J.F. Sánchez-Royo**	**Prof. Juan F. Sánchez Royo**, University of Valencia, **Spain**
09:45 - 10:00	Surface Magnetic Structures in Flexible Composite Glass Covered Microwires **A. Chizhik** and A. Zhukov	**Dr. Alexander Chizhik**, University of Basque Country, **Spain**
10:00 - 10:30	**Coffee Break**	
Session's Chairs: Dr. Stephan Mandl, Leibniz Institute of Surface Engineering (IOM), Germany Prof. Tseung-Yuen Tseng, National Yang Ming Chiao Tung University, Taiwan		
10:30 - 10:45	AlxTayOz thin films deposited by pulsed direct current reactive magnetron sputtering for dielectric applications **R. Drevet,** P. Souček, P. Mareš, P. Ondračka, M. Fekete, M. Dubau and P. Vašina	**Dr. Richard Drevet**, Masaryk University, **Czech Rep.**
10:45 - 11:00	Durable VO2@SiO2-based Thermochromic Coatings on Building Ex-terior Structures for Enhanced Energy Efficient and Thermal Comfort **X. Guo**, J. Vitse, J. Li, H. Hallez and V. Vandeginste	**Mrs. Xinyu Guo**, KU Lueven, **Belgium**
11:00 - 11:15	Adaptation of a paper surface functionalization driver for the manufacture of a lithium-ion battery negative electrode. J. Luneau, R. Passas and **C. Martin**	**Mrs. Celine Martin**, Univ. Grenoble Alpes , **France**
11:15 - 11:30	Thin-film coating development for enhanced conductivity and corrosion resistance of stainless steel bipolar plates in hydrogen applications **M. Steinhorst**, M. Giorgio, N. Fredebeul-Beverungen, T. Roch and C. Leyens	**Mr. Maximilian Steinhorst**, Fraunhofer Institute for Material and Beam Technology IWS, **Germany**
11:30 - 11:45	Oxidic barrier development and hydrogen gas phase permeation analysis **L. Gröner**, F. Burmeister and J. Swoboda	**Mr. Lukas Gröner**, Fraunhofer IWM, **Germany**
11:45 - 12:00	Self-stratifying and self-healing vitrimer coatings **J. Bratasanu**, K. Bui, F. Samyn, Maude Jimenez	**Mrs. Julie Bratasanu**, Univ. Lille, **France**
12:00 - 12:15	Migration of LiFePO4 particles inside a self-stratifying system epoxy vitrimer and PVDF **A. Kerrache**, F. Samyn, J-F. Gohy and M. Jimenez	**Mr. Alban Kerrache**, Univ. Lille, **France**
12:15 - 12:30	Thin ZnO films prepared by plasma-enhanced atomic layer deposition (PEALD) for future photocatalytic applications **A. Omerzu**, D. Jardas Babic, R. Peter, K. Salamon, T. Radosevic, D. Vengust and M. Podlogar	**Prof. Ales Omerzu**, University of Rijeka, **Slovenia**
Lunch		

25 April 2025		
Tribology 2025 Session III. B: Lubricants and hydrodynamic lubrication / Biotribology		
Conference Room Algarve		
Session's Chairs: Prof. Auezhan Amanov, Tampere University, Finland		
08:30 - 09:00	Unravelling the functionality of lubricants and exploring tribochemistry mechanisms by molecular dynamics based on machine learning **M. Clelia Righi**	**Prof. Maria Clelia Righi**, University of Bologna, **Italy**
09:00 - 09:30	Lubrication with liquid-air mixtures in industrial applications **M. Arghir**, A. Voitus and M-A. Hassini	**Prof. Mihai Arghir**, Univ. Poitiers, **France**
09:30 - 09:45	Control of lubricant film thickness by using electro-responsive biolubricants **M. García-Pérez**, S. D. Fernández-Silva, C. Roman, R. Glovnea, M. A. Delgado and M. García-Morales	**Ms. Maria Garcia Perez**, University of Huelva, **Spain**
09:45 - 10:00	Exploring Surface Microtexture Parameters with OpenFOAM **A. L. Nagy** and G. Laki	**Dr. Andras Nagy**, Szechenyi Istvan University, **Hungary**
10:00 - 10:30	**Coffee Break / Posters Session**	
10:30 - 10:45	Optimization of Artificial Oil Aging Process for E20-contaminated Oils Using Design of Experiment Methodology **D. Pinter** and A. L. Nagy	**Ms. Dominika Pinter**, Szechenyi Istvan University, **Hungary**
10:45 - 11:00	Design and experimentation of a tribometer for non-lubricating fluid studies in journal bearing applications **F.Cammelli**, G.Brignolo, G. Ferrarese and M. Dabalà	**Mr. Francesco Cammelli,** University of Padova, **Italy**
11:00 - 11:15	Multi-scale friction model for finite element analysis of automotive brake pad-disc components **J. Yun Won**, H. Seo, Y. Kim, H. Jeong, J. Kyeong and M-G. Lee	**Mr. Jung Yun Won**, Seoul National University, **Rep. of Korea**
11:15 - 11:30	Tribological Study on Friction and Wear Mechanisms of Neodymia, Yttria, and Tungstic Oxide Nanoparticles in a Partially Formulated Engine Oil **A.I. Szabo**	**Mr. Adam Istvan Szabo**, Széchenyi István University, **Hungary**
11:30 - 11:45	Anisotropic visco-pseudo-hyperelasticity constitutive model for creep behavior in brake friction materials **Y. Kim** and M-G. lee	**Mr. Youngjae Kim**, Hyundai Motor Company, **Rep. of Korea**
11:45 - 12:00	A Study on improving performance and energy efficiency using self-powered triboelectric sensor **H.S. Shin**, Y.K. Kim , J.M. Baik, G.H. Han and S.H. Lee	**Mr. Heesup Shin**, Hyundai Motor Group, **Rep. of Korea**
12:00 - 12:15	Revalorization of industrial plastic waste for lubricant application **M. Solà**, G. Macías and L. Batlle	**Ms. Mireia Solà**, Leitat Technological Center, **Spain**
Lunch		

Group tour around Algarve (Free of charge subject to confirm – 50 seats available)

Tour Program:

- **Pick-up in the Grande Real Santa Eulalia Resort & Hotel Spa at 13:30,**
- **You have around 1h30 in Lagos and then around 45min in Cape St Vincent.**
- **The guide will give you historical information about the places you see from the bus and on the places where the bus stops.**

SICT 2025 / PlasmaTech 2025 / Tribology 2025 Joint Conferences Posters

23 and 24 April 2025 Sessions (No Posters session on 25 April 2025)

N.	Poster Title	Author, Affiliation, Country
1.	Surface Engineering of Metallic Thin Films for SAW Sensor IDTs L.A. Almeida Santos, R.L. Gonçalves, M. Amorim Fraga and **M. Massi**	**Prof. Marcos Massi**, Mackenzie Presbyterian University, **Brazil**
2.	Influence of Plasma Cleaning on the Magnetron Sputtering Deposition of TiCN Thin Films on Ti6Al4V B.M. M. Silva, R.L.P. Gonçalves, **A.A. Couto** and M. Massi.	**Prof. Antonio A. Couto**, Mackenzie Presbyterian University, **Brazil**
3.	Modification of AAO coatings with copper using PVD and electrochemical methods **M. Bara**, J. Korzekwa, M. Niedźwiedź and S. Kaptacz	**Dr. Marek Bara**, University of Silesia in Katowice, **Poland**
4.	Hot dip metallic coatings on steel produced in a HDP Simulator **A. Montes**, J.M. Artímez, J.A. García, M. Panera and L. Suarez	**Ms. Alicia Montes**, IDONIAL Technology Center, **Spain**
5.	PTFE thin films deposited by Pulsed Electron Beam Deposition A. Niemczyk, S. Fryska, R. Jędrzejewski, D. Moszyński, P. Kochmański, D. Deacu and **J. Baranowska**	**Prof. Jolanta Baranowska**, West Pomeranian University of Technology in Szczecin, **Poland**
6.	Enhancement of Sol-Gel coatings for the preservation of quality in high-end products. **J. Moriones**, J. Osés, N. Jiménez-Moreno, I. Esparza, P. Amézqueta, J.F. Palacio, J. Fernández De Ara and E. Almandoz	**Ms. Jennifer Moriones**, AIN - Industry Association of Navarra, **Spain**
7.	Surface Characterization of SiO_2 Thin Film on NiTi Alloy Obtained via Atomic Layer Deposition **A. Taratuta**, J. Lisoń-Kubica, J. Kolasa, K. Goldsztajn, B. Rynkus, M. Antonowicz, A. Orłowska and M. Basiaga	**Dr. Anna Taratuta**, Silesian University of Technology, **Poland**
8.	Characterization of macro and microstructure, along with corrosion resistance, of super austenitic stainless steel cladding deposited on car-bon steel using GTAW **E.J. da.Cruz Junior**, F.M.F.A. Varasquim, F.O. Carvalho, L.F.F. Santiago, V.A. Ventrella, I. Calliari and A. Zambon	**Dr. Eli J.D.Cruz Junior**, São Paulo Federal Institute of Education, Science and Technology, **Brazil**
9.	The influence of unit pressure on the tribological properties of graphite-modified oxide coatings **M. Niedzwiedź**, M. Bara, J. Korzekwa and S. Kaptacz	**Dr. Mateusz Niedzwiedz**, University of Silesia in Katowice, **Poland**
10.	Stress and local structure evolution in the sol-gel thin-films during high temperature annealing **JB. Bringuier**, E. Burov, E.Barthel, A.Benedetto and J.Teisseire	**Mr. Jean-Baptiste Bringuier**, Saint-Gobain Recherche, **France**
11.	The interface of mating surfaces under extreme tribological conditions **J.L. Endrino** and S. Goel	**Mr. Jose L. Endrino**, Univ. Loyola Andalucía, **Spain**
12.	Surface modification of elastomers via laser structuring and DLC coating for high-performance tribological applications S. Vogel, M. Trenn, B. Schlüter, B. Blug, **M. Mee** , F. Kirsch and T. v. Roo	**Dr. Manuel Mee**, Fraunhofer Institute for Mechanics of Materials IWM, **Germany**
13.	Analysis of Vibration Characteristics by Lifetime of Roller Type Linear Motion Guide System **B.R. Cho**, D.W. Kim, H. J. Jung, J.Y. Park, Y.G. Kim, S.G. Choi and J-H. Kim	**Mr. Bo Ram Cho**, Korea Institute of Industrial Technology, Rep. of Korea
14.	Twin-Disc Testing for Wheel-Rail Interaction: A Versatile Approach to Wear and Friction Analysis **M. Panera**, J.M. Artímez, J.A. García and A. Montes	**Ms. María Panera**, IDONIAL Technology Center, **Spain**
15.	From current collection to plasma parameters: models **E. Seran** and M. Godefroy	**Dr. Elena Seran**, Sorbonne University, **France**
16.	Electrical Characterization of a Superimposed HiPIMS / RF Deposition Process on a Single Magnetron J. Müller, J. Swoboda, **F. Burmeister**, A. Fromm and M. Wirth	**Dr. Frank Burmeister**, Fraunhofer Institute (IWM), **Germany**
17.	Surface functionalization of titanium alloy with biodegradable polymer coatings for medical applications **K. Goldsztajn**, M. Godzierz, J. Jaworska, K. Jelonek, K. Nowińska, W. Kajzer and J. Szczenko	**Mrs. Karolina Goldsztajn**, Silesian University of Technology, **Poland**
18.	pH-Responsive Switchable Antifouling and Antibacterial Coatings for Prevention of Catheter Associated Urinary Tract Infections	**Ms. Xiaojin Liu**, University of Groningen, **The Netherlands**

	X. Liu and M. Kamperman	
19.	Biofouling Mitigation Through Biocidal Coatings: A Nanoscale Perspective Using AFM **A.P. Carapeto**, G.M. Afonso, M.S. Rodrigues and E.R. Silva	**Dr. Ana Carapeto**, University of Lisbon, **Portugal**
20.	The Antifungal Activity of Ag-DHLA Nanoclusters against Fungi Isolated from Indoor Environments **R. Mikkola**, S. Chandra, M. Makki and H. Salonen	**Dr. Raimo Mikkola**, Aalto University, **Finland**
21.	A Micropatterning Strategy for Assessing Endothelial Cell Morphology and Topography **D. Pedroni**, C. Gaucher and H. Alem-Marchand	**Mr. Daniele Pedroni**, Univ. Lorraine, **France**
22.	Improvement of TNZ alloy properties by large deformation and surface treatment **H.Garbacz**, A. Kowalczyk, A. Sotniczuk and J. Pura	**Prof. Halina Garbacz,** Warsaw University of Technology, **Poland**
23.	Enhancing Zein Biopolymer Performances: Insights from Low-Pressure Cold Plasma Treatment for Sustainable Food Packaging Solutions **M. Saleh**, M. Pedroni, E. Vassallo, R.Campardelli, G. Firpo and E.Drago	**Dr. Miriam Saleh**, ISTP-CNR- Milan, **Italy**
24.	Monosaccharide layers deposited by PLD and PED technique **A. Niemczyk**, A. Goszczyńska, D. Moszyński, P. Figiel, S. Fryska, D. Deacu and J. Baranowska	**Dr. Agata Niemczyk,** West Pomeranian University of Technology, **Poland**
25.	Pulsed Electron Beam Deposition of Glucose – the influence of process parameters **D. Deacu**, A. Niemczyk, A. Goszczyńska, T. Idzik, J.G. Sośnicki, S. Fryska and J. Baranowska	**Mr. Daniel Deacu**, West Pomeranian University of Technology, **Poland**
26.	SUPREME – Sustainable nanoparticles enabled antimicrobial surface coatings **E. Merli**, D. Spinelli, I. Canesi and N. Cei	**Mrs. Elena Merli**, Next Technology Tecnotessile, **Italy**
27.	Modeling free burning arc radiation with ANSYS Fluent **C. Gouze**, A. Truilhé, Y. Cressault, F. Valensi, M. Benmouffok, P. Puyuelo-Valdes, A. Varais and M. Darques	**Mrs. Camille Gouze**, Univ. Toulouse, **France**
28.	Thermal Plasma Modeling Using COMSOL: Study of the Radiative Losses in an Arc Between Two Cables in Aeronautical Configuration **A. Truilhé**, C. Gouze, Y. Cressault and F.Valensi	**Mr. Antoine Truilhé**, Paul Sabatier Univ , **France**
29.	Elucidation of H2O2 reaction pathways in plasma-driven biocatalysis **S. Klopsch**, T. Dirks, M. Krewing, F. Hollmann and J. E. Bandow	**Mrs. Sabrina Klopsch**, Ruhr University Bochum, **Germany**
30.	Catalytic Bio-hybrid Coating-based Degradation of Haloalkanes in the Gas-Phase A; Skopp, **M. Marosevic**, B. Rühmann and V. Sieber	**Mr. Matea Marosevic**, Technical University of Munich, **Germany**
31.	Smart materials with depolluting and self-cleaning activity by combining g-C3N4-with TiO2 photocatalysts decorated with Au NPs **H. Nezzal**, M..Luna and M.J. Mosquera	**Ms. Hala.Nezzal**, University of Biskra, **Algeria**
32.	Development of g-C3N4-TiO2 visible light active photocatalysts for NOx depollution applications. M. Luna, **D.A.Peñaloza**, C.G. Silva, J.L. Faria and M.J.Mosquera	**Mrs. Damaris A. Peñaloza**, University of Cadiz, **Spain**
33.	Bluefire- CO2-Loop Based on Carbon Capture and Novel Plasma Technology for Sustainable Synthetic Fuels or CO2 Neutral Cement Production **V. Seithümmer**, S. Kaufmann, H. Chinnaraj,P. Rößner and K. Peter Birke	**Mr. Valentin Seithümmer**, University of Stuttgart, **Germany**
34.	Low-pressure reduction of iron oxides in a hydrogen-containing inductively coupled rf plasma M. Mayer, **M. Pustylnik**, C. Altenbach, U. Manzoor, I.R. Souza Filho, H.M. Thomas, D. Raabe and D. Zander	**Dr. Mikhail Pustylnik**, DLR Institute of Materials Physics in Space, **Germany**
35.	High performance IWO thin films with a new hybrid technology for the deposition of thin films for solar cells application **Z. En-Naji**, A. Bes, P. Carroy and A. Lacoste	**Mr. Zakariae En-Naji**, Univ. Grenoble Alpes, **France**
36.	Computationally supported SSbD design of Solid Oxide Electrolyzer Cell anodes: Integrating Quantum Mechanical calculations with Machine Learning methods **D. Falkowski**, A. Mikolajczyk, P. Skurski, J. Brzeski and T. Puzyn	**Mr. Dawid Falkowski**, QSAR Lab Ltd, **Poland**

SICT 2025 / Plasma Tech 2025 / Tribology 2025 Joint Plenary Session

Advancing plasma technologies: innovations and insights from the N-PRiME group

L.L. Alves[1]

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Abstract:

The group N-Plasmas Reactive: Modeling and Engineering (N-PRiME) [1] is part of of Institute for Plasmas and Nuclear Fusion in Lisbon (Portugal). N-PRiME investigates the potential of **N**onequilibrium low-temperature plasmas (LTPs) to tailor energy and matter at the **N**anoscale and to reach **N**ew Horizons in Space exploration. We intertwine experimental, theoretical and model-based predictive capabilities, studying LTPs and applying them in novel plasma technologies. The group is organized in three activity axes: the Plasma Engineering Laboratory (PEL), Modelling & Simulation activities (M&S) and the Plasmas Hypersonic Laboratory (HPL).

The R&D work of PEL is in the cutting-edge area of Plasma Nanoscience. We have developed a prototype plasma machine (see Figure 1) [2] for the controllable selective synthesis of multiple graphene derivatives with prescribed structural qualities. Using the same machine with different protocols it is possible to fabricate pure graphene sheets, N-graphene sheets and N-graphene-Metal Oxides/Metal Sulfides nanocomposites at a gram scale, ensuring single-layer high-selectivity (~50 %), high yield (~30 mg/min) and repeatability, while using cheap starting materials (e.g. ethanol, methane, acetonitrile, etc).

M&S activities focus on the study of non-equilibrium reactive plasmas (interacting in volume and with surfaces), for a large variety of systems and conditions. M&S's team develops state-of-the-art kinetic schemes, adopting multi-dimensional transport of species and radiation, also under hydrodynamic flow regimes, which are implemented on new computational platforms. We are responsible for the development of the LisbOn KInetics (LoKI) simulation tools [3,4], in articulation with the open-access website LXCat [5], which has been used to study several complex systems, relevant for sustainable chemistries: O_2, N_2-O_2, N_2-H_2, CO_2, CO_2-N_2, CO_2-CH_4.

HPL hosts the European Shock-Tube for High Enthalpy Research (ESTHER) [6], the sole Portuguese Space facility for the planning of planetary exploration missions. ESTHER is a piston-free combustion-driven shock-tube capable of reaching shock speeds in excess of 10km/s. ESTHER is funded by the European Space Agency and is part of the Portuguese Roadmap of Research Infrastructures with Strategic Interest. Recently, this facility achieved a deflagration pressure of 750bar for $8He:2H_2:1.2O_2$ 42bar filling pressure in the driver chamber.

Figure 1: Plasma machine for the systhesis of multiple 2D-materials.

Keywords: low-temperature plasmas, plasma nanoscience, non-equilibrium, reentry plasmas, LoKI, ESTHER

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Acknowledgments

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Production of thermally sprayed HEBM High-Entropy Alloy coatings

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Abstract:
The goal of Cobrain project is to replace conventional coating solutions based on the use of critical materials, which means hazardous materials and/or large demand materials such as Co based alloys or hardmetals, or carcinogenic hexavalent chromium used in the production of electroplated hard chrome. For those reasons, the development of new material combinations combining some elements in near-equimolar proportions, will allow to produce new High-Entropy Alloys (HEAs), reaching improved properties. The presentation will provide an overview on the optimization and microstructural characterization of different HEBM HEA powders and coatings developed in the project though HEBM process. Novel formulations for wear- and corrosion-resistant coatings based on HEAs have been developed and coatings have been obtained by different thermal spray techniques.

Keywords:
HEBM; High Entropy Alloys; Coatings; Cold Gas Spray

Exploring multi-modality and adaptivity of low-temperature plasmas for biomedical applications

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Abstract:
The uniqueness of low-temperature plasma is in its ability to change composition in situ. Plasma self-organization could lead to formation of coherent plasma structures. These coherent structures tend to modulate plasma chemistry and composition, including reactive species, the electric field and charged particles. Formation of coherent plasma structures allows the plasma to adapt to external boundary conditions, such as different cell types and their contextual tissues [1]. In this talk we will explore possibilities and opportunities that the adaptive plasma therapeutic system might offer. We shall define such an adaptive system as a plasma device that is able to adjust the plasma composition to obtain optimal desirable outcomes through its interaction with cells and tissues.

Various approaches for plasma therapy based on plasma adaptation to target conditions will be reviewed. These approaches are based on the ability of measuring the cellular response to plasma immediately after treatment and modifying the composition and power of plasma via a feedback mechanism. Plasma self-adaptation might be feasible due to self-organization and pattern formation when plasma interacts with targets. In this talk we present an optimal feedback control scheme to adjust treatment conditions responsive to the biological response as well as approaches based of artificial neural network [2,3]. In addition, we will discuss various modalities associated with cold atmospheric plasmas.

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The role of energetic species during the growth of thin films

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Abstract:
Magnetron sputtering is a physical vapor deposition technique used at both laboratory and industrial scale. Besides the film constituent atoms other species are at the growing thin film. Characteristic for magnetron sputtering is that these species can have a high energy and momentum and can strongly influence the growth of thin films. In this talk, a few interesting examples.

Many thin film applications are based on oxides. The optimization of the oxide properties is an on-going process and requires a deep understanding of the deposition process. A typical feature of reactive (magnetron) sputter deposition is the presence of negative oxygen ions. The presence of negative ions in gas discharges was already postulated in the very first paper on sputtering by Grove.In a magnetron oxygen containing discharge, two groups of ions can be identified based on their energy. Low energy ions are generated in the bulk of the discharge. The high energy ions are emitted from the oxide or oxidized target surface. As these ions are generated at the cathode, they are accelerated by the electrical field towards the growing film. Depending on the discharge voltage and the powering method, their energy is typically several tenths to hundreds electron volt. As such the ions can have a strong impact on the film properties. Nevertheless, despite the many illustrative studies on the impact of negative oxygen ions, quantification is often lacking as the negative ion yield is only known for a few oxides. A compilation of several literature sources permits not only the prediction of the negative ion yield, but also a comparison amongst different oxides.

As a second example, a series of experiments demonstrating the significance of energetic reflected neutrals. The first series of experiments focuses on the phase composition of tungsten (W) films, which can consist of a mixture of α-W and β-W crystals. Various mechanisms have been proposed to explain phase selection, including substrate heating due to plasma exposure and residual gas pressure. However, a broad parameter scan rules out these trends and shows that the phase composition can be quantitatively correlated with the flux of reflected neutrals with energies exceeding the displacement energy threshold. To establish this correlation, the phase composition is quantitatively determined using X-ray diffraction (XRD) analysis and combined with test particle Monte Carlo simulations to evaluate the energy of the reflected neutrals. The energy of these neutrals is defined by binary collisions between argon (Ar) and tungsten (W) atoms and the initial energy of the argon ions, which is set by the discharge voltage. Increasing the target thickness results in a lower magnetic field strength and, consequently, a higher discharge voltage. This effect allows the phase composition to be tuned by just adjusting the target thickness. Using the same approach as for tungsten, a series of experiments will be presented showing the role of energetic argon on the percolation film thickness during the growth of silver (Ag) thin films. In-situ four-point probe resistance measurements are used to investigate the initial nucleation of these films. A power-law correlation between the percolation thickness and the deposition flux is observed, with the correlation exponent adjustable through variations in target thickness.

The two examples demonstrate that reporting only the discharge power during experiments omits essential information critical for other researchers.

Depla, D.. “The Measurement and Impact of Negative Oxygen Ions during Reactive Sputter Deposition.” Critical reviews in solid state and materials sciences, vol. 49, no. 4, 2024, pp. 718–53

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Multidimensional Elemental and Molecular Analysis for Surface & Interface studies

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Abstract:
Surface and Interface studies require the use of complementary analytical techniques as each instrumentation provides partial results only, also based on the interaction of the investigated material with a probing medium [1].

For multiple materials & coatings, obtaining elemental and molecular information for different probing size and depth is especially crucial. HORIBA offers a Platform with multiple instruments that could be coupled permitting to tackle complex analytical challenges.

Glow Discharge Optical Emission (GD) relies on a plasma to sputter a representative area of a material and provides fast elemental depth profile with nanometer resolution [2]. GD has already been used to prepare samples for SEM and has been coupled with XPS and HAXPES.

Coupling GD and Raman Microscopy is very interesting to simultaneously obtain both the elemental profiles and molecular information at various depths with high lateral resolution [3,4].

Similarly mapping a surface with both µ XRF and µ Raman will offer spatially resolved elemental and molecular information of a material and could be used also for example to provide full identification of particles deposited on a substrate.

Coupling an ICP instrument to an electrochemical cell (AESEC technique) transforms a technique dedicated to the compositional analysis of liquids (ICP) into a tool for corrosion studies of metals and alloys offering deep insight into dissolution mechanisms and surfaces reactivity [5].

An other coupling - ICP with ETV – Electrothermal Vaporisation offers direct measurement of solids by ICP - for example to study battery Carbon purity [6].

We will illustrate the benefit of this Platform for Elemental and Molecular Analysis by showing selected results on metallic parts for high temperature fuel cells, catalysts coated PEM membranes, fuel facing materials in Na fast reactors, perovskite solar cells, hydratation of anodic films, batteries and DLC coatings on bipolar plates.

Keywords: Surface & Interface studies, GDOES, Raman, AESEC, Elemental & Molecular analysis

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SICT 2025 - BEYOND PFAS
Workshop

Biopolymer-based hydrophobic textile coatings: development within the PROPLANET project

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Abstract:
Per- and polyfluoroalkyl substances (PFAS) are synthetic chemical compounds, highly valued in various industries, including textile, where they are used to enhance fabric performance by imparting hydrophobic and oleophobic properties. They are known for their strong carbon-fluorine bonds, which provide exceptional thermal, chemical and mechanical stability to the coating [1]. Textile industry is one of the biggest PFAS consumers, which utilizes these compounds to create durable outdoor apparel or technical textiles, which repel water, oil and stains. However, their chemical structure makes them difficult to degrade, causing environmental persistence, bioaccumulation and adverse environmental and human health effects. This is especially concerning in the textile industry, where the coated textiles can be in a direct contact with human skin. The repeated exposure can lead to accumulation of PFAS in the body, causing harmful health effects, such as hormonal, developmental problems, weakened immune system, higher cholesterol levels and cancer [2]. As a result of these health implications and ongoing regulative efforts to ban PFAS use, the scientific and industrial community is forced to find safer alternatives.

This problem is being addressed by the PROPLANET project, which develops novel coating solutions for textile, food-packaging machines and glass applications in alignment with the Safe and sustainable by Design (SsbD) principles to ensure the use of safer and more sustainable materials. The development of hydrophobic textile coatings is being tackled by using biomaterials, which can be either chemically modified to achieve hydrophobic properties if they are inherently hydrophilic, or by combining multiple biomaterials to achieve synergistic effects. Various combinations of polysaccharides, waxes, and other compounds have been thoroughly examined, leading to a substantial dataset that was previously non-existent. The experiments involved testing multiple polysaccharides, adjusting their concentrations, exploring different ratios between them, and experimenting with various combinations and chemical modifications. Additionally, various application processes have been utilized (e.g. rod-coating, spray-coating and dip-coating) including the influence of the number of coating layers, to optimize performance and functionality. The initial indicator of success was the visual appearance of the coatings and their applicability on textile substrates. Following this, the hydrophobicity of the coated samples was determined to assess their effectiveness. This systematic approach enabled to identify which formulations were suitable for further development and modifications, paving the way for innovative and sustainable coating solutions that align with the project's goals. With the application of developed biopolymer coatings, cotton and polyester fabric were hydrophobized, achieving water contact angles > 90°.

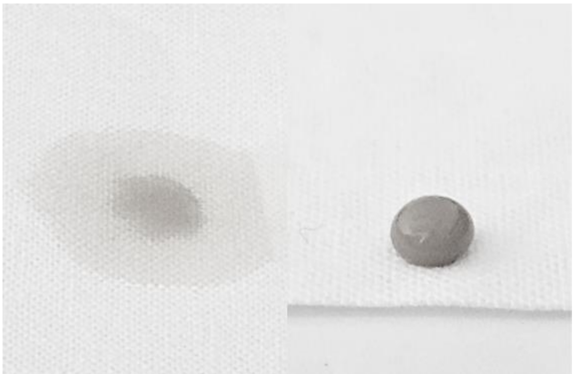

Figure 1: Demonstration of wettability of control (left) and coated (right) textile sample.

Keywords: water-repellence, hydrophobicity, biopolymers, biomaterials, coatings, textile

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Waterborne PFAS-free coatings for packaging and textile sectors

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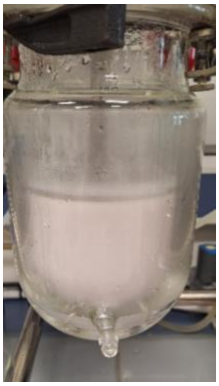
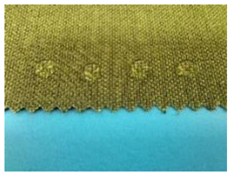
Abstract:
Due to a variety of unique properties, including excellent water and oil repellency, high thermal stability, remarkable oxygen affinity, as well as excellent surfactant properties, the substances class of Per- and polyfluoroalkyl substances (PFAS) are found in a broad portfolio of products. This class of substances have been produced since the 1940´s and used in a broad range of consumer products and industrial applications. In 2020, the EU published the Regulation (EU 2020/784) that amends current EU legislation and restrict the use of persistent organic contaminants. The new regulation specifically limits the sue of PFOA (perfluooctanoate), its salts, and PFOA-PFOA and any of its salts, and a maximum concentration of 1mg/kg manufactured substances that meet the definition of PFAS and that are produced and are part of consumer products [1]. Base on concerns regarding the high persistence of PFAS and the lack of knowledge on properties, uses, and toxicological profiles of many PFAS currently in use, it has been argued that the production and use of PFAS should be limited (Figure 1).
Therefore, chemicals having a chronic effect for human health and environment must be substituted, particularly, in consumer products. Based on this, new toxicity-free coating with the same functionalities than coatings based on PFAS and minimizing the environmental footprint of the new coatings in particular on climate change, resource use ecosystems and biodiversity from a life cycle perspective represent a challenge.
The objective of this work has been to develop new biobased coating for textile and packaging sectors with similar performance that the actual coatings based on PFAS. The new coatings have been designed to present water and oil repellency and moreover are based on biomass resources. An environmentally friendly polymerization process were carried out to obtain new polymers with the required properties and the influence of process parameters on final product properties were characterized for textile and packaging sectors.

Keywords: waterborne coatings, PFAS-free, hydrophobic, packaging, textiles.

Waterborne acrylic biobased system



Textile sector



Packaging sector

Figure 1: Water repellency on textile and packaging sector based on waterborne acrylic biobased systems.

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PFAS-free sol-gel hybrid coatings with hydrophobic and non-stick properties for low-maintenance glass and food-packaging machines (PROPLANET)

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Abstract:
Per- and poly-fluoroalkyl substances (PFAS) are commonly used in several applications and products. This includes coatings for textiles (water and oil repellency), for food packaging and related equipment (non-stick), for glass (anti-soiling and anti-reflection, e.g. car windows, solar panels), but also cosmetics and construction materials, among many others. Despite their valuable properties, they pose a serious risk to human health, as these chemicals do not break down under normal conditions and this leads to their accumulation in the environment and eventually in any organism in contact with contaminated water and food.
PROPLANET project addresses novel coating materials solutions, tackling the problem from a sustainable-business perspective, to overcome the barrier for environmental protection, safety, chemical improvements, and circular value chains.
The sol-gel technique is a promising approach, offering a vast range of possibilities for coating design. Its ability to synergistically combine inorganic and organic moieties leads to the formation of hybrid materials with covalently bonded parts: the inorganic moiety confers very good adhesion to the substrate as well as chemical and mechanical resistance and hardness, while the organic part confers elasticity and density. In addition, the organic functional moiety provides the hydrophobic and non-stick properties required for these applications.
Two lines of coatings have been developed to fulfil the requirements of two different sectors:
o Sol-gel based hybrid coatings, with hydrophobic and anti-soiling properties for low-maintenance glass applications. The resulting coatings are transparent and homogeneus and should retain their hydrophobic properties over time and exposure to typical usage conditions, as seen in applications like car window shields and shower doors.
o Sol-gel based hybrid coatings functionalized with PFAS-free compounds to provide non-stick and anti-wear properties for application in food-packaging machines. The resulting coatings show hydro- and oleo-phobic properties, besides mechanical properties and resistance to high temperature, as needed during machine operation.
Different types of chemistries, as well as functional groups, have been screened during the development and the resulting coating omniphobic properties have been evaluated by means of SFE (Surface Free Energy), calculated through the measurements of the water and hexadecane contact angles, besides assessment of the other required properties and their durability in specific conditions.

Keywords: sol-gel hybrid coatings, PFAS-free coatings, hydrophobic surfaces, oleophobic surfaces, low-maintenance glasses, metal surfaces.

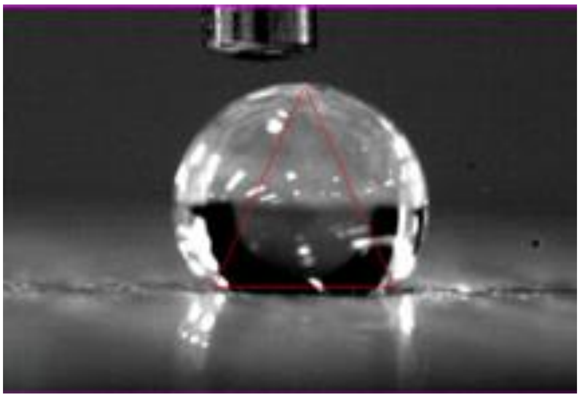

Figure 1: Water drop on a hydrophobic coating developed at TECNALIA.

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PFAS-free non-stick coatings for kitchenware applications (TORNADO)

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Abstract:
Specific surface properties are requested to allow consumers to cook in a safe and healthy way, limiting food adhesion without adding fats. Kitchenware materials need to be "non-stick" and "non-wetting", durable, mechanically strong, elastic, resistant to high temperatures and should not change the organoleptic properties of food. To obtain the required properties and make cleaning easier, kitchenware surfaces are normally coated. Polytetrafluoroethylene (PTFE), better known by its brand name Teflon®, has been the most used coating in this field. PTFE prevents the occurrence of attached burnt deposits because of the high bonding energy of the C-F bond, which results in an inert surface with low surface free energy. However, environmental concerns have been raised nowadays, due to the release of fluorine, which is considered toxic and carcinogenic. Thus, research is now focusing on the development of new coatings, replacing PFAS products while keeping the required properties.
A PFAS-free ceramic coatings, synthetized through sol-gel chemistry, is being developed for this application within the framework of TORNADO project. The sol-gel method is based on the hydrolysis and condensation reactions of metal alkoxides, and it is suitable for preparing homogeneous films of high purity oxides as well as hybrid (organic-inorganic) networks. The non-stick properties of the resultant ceramic coatings arise from the hydrophobic, low surface energy siloxane network with the organic functional group. Although non-stick properties are crucial for cookware applications, other properties are equally important: non-stick ceramic coatings must be scratch, impact, and abrasion-resistant, corrosion resistant, and these properties must be durable on time. In addition, the coatings should comply with the aesthetic requirements and must whithstand the high temperatures reached during cooking (around 300 ºC).
A combination of the right precursors and proper adjustment of their chemical ratios results in the optimized coating formulation to obtain the desired surface properties. The inclusion in the sol-gel matrix of biobased compounds, coming from vegetable oils and properly funcitionalized, has been also tested. The final coating system consists of a base-coat plus top-coat layers, which have been applied by spraying on pans and characterized in the laboratory as per standard methods used in industry. The results show a homogeneous coating, hydro- and oleo-phobic, with good mechanical properties and resistant to high temperature

Keywords: sol-gel hybrid coatings, PFAS-free coatings, hydrophobic surfaces, oleophobic surfaces, cookware, non-stick properties.

Figure 1: Two different hybrid sol-gel coating systems developed at TECNALIA and applied on Alluflon pans made with aluminium alloy AA3104.

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Synthesis of safe and sustainable PFAS-free omniphobic coatings

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Abstract:
Omniphobic coatings, i.e. coatings that can repel water and also low surface tension liquids, are often based on the use of per- and polyfluoroalkyl substances (PFAS), owing to their extremely low surface energy[1]. Furthermore, PFAS materials show a high chemical stability directly linked to the accumulation and persistence of PFAS in the environment and living organisms[2]. PFAS are associated to harmful health impacts[3], their use and release should be limited, leading to the need for innovative alternative materials. Since it is estimated, that textiles are one of the biggest sources for PFAS pollution in the EU[4], the demand for safe and sustainable PFAS-free omniphobic coatings for textile applications is enormously high.
The herein investigated alternative PFAS-free liquid repellent coatings are based on ORMOCER®, an organic-inorganic hybrid material class developed by Fraunhofer ISC. This material platform, prepared by a sol-gel process, can be tailored by adopting the inorganic and organic components to yield a range of different material properties[5]. To obtain the desired omniphobicity, different strategies based on chemical modifications, the addition of performance additives and surface structuration effects have been studied. Excellent results concerning hydrophobicity have been achieved and the promising results concerning oil repellency are being further improved. The developed coating formulations and obtained coatings have been characterized thoroughly, by a range of different bulk and surface analysis techniques.
The planned application field of these innovative coatings can be found in the textile industry, being investigated as part of the ZeroF project funded by the EU and SERI. Within the framework of this project, the developed coatings are evaluated concerning their safety and sustainability.

Keywords: omniphobicity, liquid repellent, sol-gel process, PFAS-free, hybrid coating, textile application

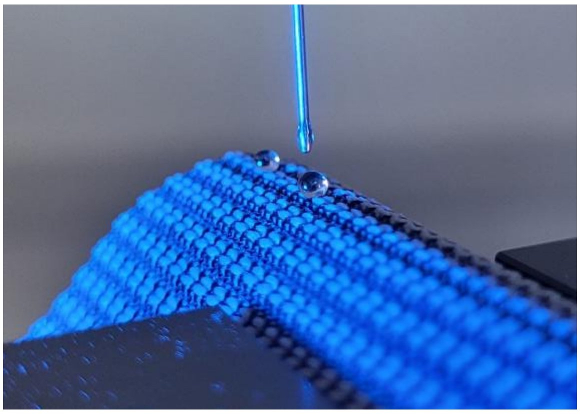

Figure 1: Textile with a safe and sustainable PFAS-free ORMOCER®-based coating exhibiting a repellence against paraffin oil droplets.

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Safe and Sustainable by Design PFAS-free Hybrid Coating for Cosmetic Glass Packaging Application within BIO-SUSHY Project

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Abstract:
Comprising more than 4 700 chemicals, per and polyfluorinated alkyl substances (PFAS) are a group of widely used, man-made chemicals that accumulate over time in humans and in the environment. PFAS are widely used to provide water and oil repellence for various applications, such as non-sticking utensil pan surfaces, water repellent and anti-soiling treatment for textiles, food-contact anti-soiling coating on paper and/or cardboard packaging or specific paints.

BIO-SUSHY Horizon Europe aims at developing innovative coating solutions that will be designed to meet the policy ambition of the EU’s chemical strategy for sustainability toward a toxic-free environment. BIO-SUSHY particularly targets new biofriendly ways to obtain durable water and oil repellent coatings, without PFAS. To achieve these objectives the development is based on 3 pillars, R&I coating development, supported by computational modelling for performances, toxicity assessment and by Safe and Sustainable by Design (SSbD) methodology to ensure safety and environmental performances.

Glass packaging for cosmetic applications has been targeted as one of the BIO-SUSHY case studies. Hybrid organic/inorganic coatings based on sol gel technologies are developed for inner application of cosmetic glass containers to ensure quality and complete availability of the products and content are protected. The use of inner surface treatment on glass packaging is compliant with restriction on the use of toxic chemicals in the cosmetic products but indeed provides additional functionalities as product waste reduction (up to 20-25%), facilitates reuse of the container thanks to easy cleaning properties and allows keeping aesthetics (keep clean surface). Hybrid sol gel is the most convenient technology for that purpose. BIO-SUSHY coatings aim at minimizing waste through total content recovery and support container reuse strategies.

The implementation of SSbD framework along the coating development will ensure reducing toxicity through degradation and leaching, considering persistency of emitted chemical species.

Fig. 1 BIO-SUSHY concept and case studies

Keywords: SSbD, PFAS, coating, sol gel, glass packaging, biobased material.

Acknowledgment : The BIO-SUSHY project is funded by the European Union under the Grant Agreement Number 101091464. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Health and Digital Executive Agency (HaDEA). Neither the European Union nor the granting authority can be held responsible for them.

Formulation and application of PFAS-free water and oil repellent coatings for textile applications

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Abstract:
Per- and polyfluoroalkyl substances (PFAS) are widely used in textile coatings due to their thermal stability, stain-resistance and water and oil repellency [1]. However, the non-degradable and bioaccumulative nature of PFAS leads to persistent contamination in humans and the environment [2, 3]. Textiles are a significant contributor to PFAS pollution in the EU, releasing these substances throughout their lifecycle [1]. While existing PFAS alternatives provide good water repellency, achieving comparable oil repellency remains a key challenge [4].

The ZeroF project aims to overcome this by developing innovative, PFAS-free water and oil repellent coatings for upholstery textiles. Based on Fraunhofer ISC's ORMOCER® organic-inorganic hybrid materials, Leitat investigates the impact of performance agents, surface roughness, application methods, and application parameters on water and oil repellency, coating fixation and durability, while maintaining the intrinsic textile properties. Various upholstery textile substrates, including polyester, cotton, acrylics and their blends, are being tested, and plasma pre-treatments have been used to improve wettability and coating adhesion. Mid-project results indicate excellent water repellency, with current research focusing on optimizing formulations to enhance the promising results on oil repellency and coating fixation.

The ZeroF project is co-funded by the European Union and the Swiss State Secretariat for Education, Research and Innovation (SERI).

Keywords: PFAS, water and oil repellency, textiles, formulation, surface chemistry.

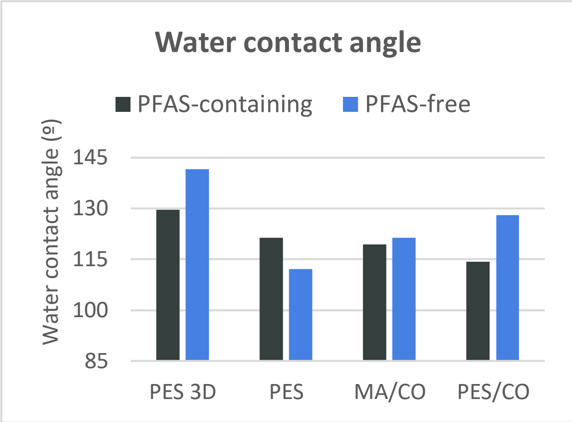

Figure 1: Figure demonstrating water repellency results on various textile substrates, comparing the performance of the ZeroF PFAS-free coating with a standard PFAS-containing reference.

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SICT 2025 Session I. A:
Surface treatments and coatings deposition and functionalization / Characterization / Properties Multifunctional composite and hybrid coatings

Dealkalization of the internal surfaces of pharmaceutical glass vials: comparison between gaseous and liquid Sulfur-based treatments

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Abstract:
One of the issues affecting pharmaceutical glass vials is the release of alkali and alkaline-earth metals into aqueous solutions. This phenomenon is known as "Specific Release". Among all pharmaceutical glass containers, soda-lime silicate glass (SLS), due to its composition, release highly mobile monovalent and divalent ions into solution[1].
Diverse types of treatments of the internal vial surface have been introduced to mitigate this leaching. Some methods involve the deposition of protective coatings inside the vials, which significantly raises production costs[2]. For decades, most pharmaceutical glass industries have opted for dealkalization of glass surfaces using Sulfur based gaseous treatment[3]. Despite its effectiveness, this treatment is not free from drawbacks as the involvement of a toxic gas that must be handled by qualified personnel with dedicated equipment. In addition, a detailed analysis of the conversion efficiency of sulfuric acid produced in micro-mist form is still lacking, leading to uncertainties in the process accuracy.
Given these issues, new types of treatments, based on non-toxic compounds, and different application processes relying on liquid solutions are highly desirable. These treatments are still under development, and further study is needed to understand their behavior and mechanism of action.
The evaluation of specific releases follows pharmacopoeia regulations that set detection limits but do not account for all elements released or structural changes in treated glass surfaces[1]. This study compares Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) and Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) to analyze elements leached from untreated SLS pharmaceutical vials, those treated with sulfur based gaseous treatment, and those treated with a developing Sulfur based liquid treatment. Additionally, Scanning electron microscope (SEM) and Secondary-ion mass spectrometry (SIMS) are used to examine the internal surfaces of the vials.
Untreated vials show concentrations of Si, Na, and Ca in the order of several ppm in solution, which are reduced by at least 90% for all the internal treatments. Morphologically, treated vials exhibit repeated pitting across the area of the vial that came into contact with the treatment. This morphology is not observed in untreated vials and is therefore characteristic of the type of treatment used (Figure 1). SIMS analyses are used to investigate the depth of treatment, in particular we observe a glass composition that is Na, K and Ca depleted at the surface and that recovers to the bulk value only after few tens of nm.
In conclusion, initial tests of a developing liquid treatment show promising results in terms of leaching reduction and process effectiveness. This opens the way to further studies necessary to fully characterize the new treatment effects on SLS pharmaceutical vials in view of its implementation in the industrial environment.

Keywords: dealkalization, glass surface, pharmaceutical glass packaging, leachables.

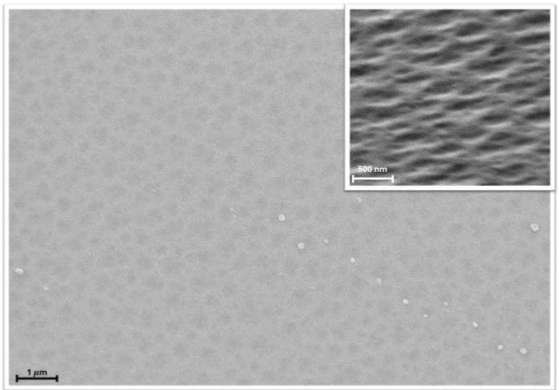

Figure 1: Plan-view SEM micrograph of the internal surface of a SLS glass vial subjected to sulfur-based gaseous treatment; the inset shows an image of the same surface acquired at larger magnification in tilted condition

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Ion Implantation for Sustainable Surface Modification: A Case Study in Electrical Connector Industry for Enhanced Corrosion Resistance

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Abstract:
This study investigates the impact of ion implantation on gold-plated electrical connectors, focusing on its ability to enhance corrosion resistance, improve mechanical properties, and significantly reduce precious metal consumption. Ion implantation is a surface modification technology, first developed in the mid-20th century, which involves bombarding surfaces with accelerated ions to create a modified layer that improves material properties. However, despite its scientific potential, it remained largely inaccessible to industry for decades due to the substantial size, cost, and energy requirements of traditional implantation facilities.

Since 2017, Ionics has overcome these limitations by developing a new-generation micro-particle accelerator, which is compact and lightweight (only 10 kg) while still providing the same high-precision treatment as traditional systems. This advancement reduces the physical and energy footprint of ion implantation by a factor of 10, making the technology scalable and commercially viable for widespread industrial applications. Furthermore, ion implantation is conducted at low temperatures, which eliminates the risk of thermal deformation and reduces energy consumption, offering an environmentally friendly and highly precise solution for surface modification.

The study explores how various ion implantation parameters, such as ion species, dose, and energy, affect the surface properties of gold-plated connectors. Electrochemical analysis demonstrates that ion implantation enhances corrosion resistance by a factor of four compared to untreated connectors. This significant improvement is attributed to the densification of the surface and the closure of micro-pores, which effectively block the penetration of corrosive agents, as evidenced by scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy (XPS).

Moreover, the results highlight that the optimal implantation parameters vary depending on the thickness of the gold layer. Tailoring the ion implantation process to the specific characteristics of each connector ensures that the most effective results are achieved for corrosion resistance and durability.

Mechanical evaluations, including nanoindentation and wear resistance tests, confirm that ion implantation enhances surface hardness and wear resistance. These improvements are due to ion-induced grain refinement and the introduction of compressive stresses, which increase the material's resistance to deformation under mechanical stress. This is particularly beneficial for connectors used in high-traffic environments, such as in automotive and aerospace applications, where frequent engagement and disconnection are required.

The study further highlights the economic and environmental benefits of ion implantation. Experimental findings show that the thickness of the gold layer can be reduced by up to four times, while maintaining superior corrosion resistance and mechanical performance. This reduction in precious metal usage leads to significant material cost savings and supports sustainability goals. Accelerated aging tests, conducted according to the automotive standards, validate the long-term reliability of ion-implanted connectors, establishing the technology’s industrial relevance.

Keywords: Ion implantation, corrosion resistance, mechanical enhancement, Sustainability in materials engineering, Electrical connectors.

Manufacture of the Invar Fine Metal Mask Using an Electroforming Technique

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Abstract:
In the manufacturing processes of red-green-blue (RGB)-type organic light emitting diode (OLED) displays, Invar (Fe-36 wt.% Ni alloy) is used as a material for the fine metal mask (FMM), which guides the evaporated diode materials through its small holes onto the correct positions of the substrate glass. Because the hole size of the FMM should not change during the evaporation process, Invar, whose thermal expansivity approaches zero[1], must be used for the FMM material. For high-quality color images in the display, the thickness of the FMM needs to be thinner [2]. Contrary to the conventional top-down method of producing Invar, a bottom-up approach of electroforming is a promising technology for producing very thin FMMs. The present authors have recently presented that the electroformed Invar via sophisticated heat treatment exhibits the coefficient of thermal expansion (CTE) lower than that of the conventional Invar [3]. The current work has been aimed at investigating the effect of the microstructure evolution on the CTE during heat treatment in electroformed Invar. Finally, we propose optimal process conditions to manufacture the Invar FMM applied for an ultra high definition (UHD) grade of the OLED display.

Keywords: CTE, Electroforming. Invar, OLED display, Thermal expansivity

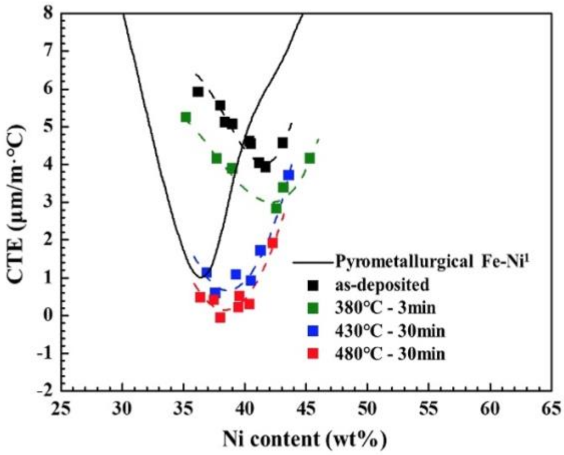

Figure 1: The coefficients of thermal expansion as a function of the alloy composition in the electroformed Fe-Ni alloys, compared with those of metallurgically produced Fe-Ni alloys.

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Stability of Expanded Austenite During Annealing in Vacuum

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Abstract:
Nitriding of austenitic stainless steels is a well-established method for increasing the surface hardness and wear resistance while maintaining their excellent corrosion resistance. However, a strict time-temperature regime has to be used during the process as the expanded austenite is metastable: for temperatures of 450 °C and higher, the decay into CrN precipitates and an Fe-Ni rich matrix occurs already after one hour. This compromises the corrosion resistance as no longer mobile chromium for oxide formation on the surface is available.
As there is a continuous nitrogen supply during nitriding, the formation starts near the surface. This leads to a two-layer formation with CrN near the surface and expanded austenite close to the substrate material. For longer times, a complete transformation of the expanded austenite is observed as the growth of this layer is faster than the growth of the expanded austenite layer.
Using in-situ XRD during nitriding for investigating the evolution of the expanded austenite phase as well as during sputter etching for the analysis of the actual layer structure allows us to deduce processes occurring inside the material. Time-of-flight secondary ion mass spectroscopy (ToF-SIMS) enables the identification of trapping and precipitation without reverting to TEM.
In this presentation, the stability of expanded austenite formed after nitriding is investigated during annealing in vacuum. The difference to nitriding experiments is that no additional nitrogen is supplied, thus these annealing experiments always show the competition of CrN formation and nitrogen diffusion. Thus, the surface concentration will decrease with time, slightly complicating the data analysis.
For the austenitic stainless steel 316Ti, a temperature series of annealing at different temperatures between 370 and 550 °C reveal an activation energy for the decay of expanded austenite of around 1.0 eV. However, the decay starts simultaneously throughout the whole layer and does not start at the surface – contrary to the observations during nitriding. At the same time, the lattice expansion of expanded austenite is a straightforward proxy for the amount of free nitrogen not converted into CrN precipitates.
In contrast, superaustenitic stainless steel 904L shows a different behaviour. While the temperature threshold seems similar to 316Ti, even at 500 °C no complete transformation of the expanded austenite into CrN and Fe-Ni is observed.
Finally, the duplex stainless steel 318LN exhibits a transition from austenite+ferrite to expanded austenite to CrN. However, here the Fe-Ni phase manifests itself as a martensitic phase – in contrast to an austenitic phase for 316Ti.

Keywords: stainless steel, nitriding, expanded austenite, CrN precipitates, SIMS.

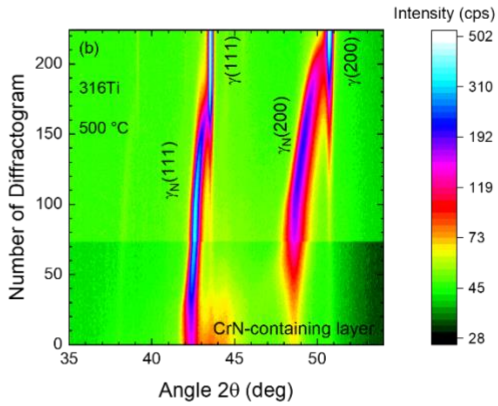

Figure 1: 2D contour plot of measured X-ray diffractograms during sputter etching of steel 316Ti nitrided at 500 °C. The layered structure is clearly visible.

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Characterization of electroplated zinc-iron coatings : Influence of organic additives and pulsed current

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Abstract:
Historically, electrodeposited cadmium coatings were widely used for protection against corrosion. However, their use was drastically restricted for many applications due to their toxicity. Zinc coatings are used for corrosion protection but the dissolution kinetics are very high in saline solutions. Addition of an alloying element from the iron group (Fe, Ni, Co) reduces the coating's galvanic coupling with steel. During the last decades, ZnNi coatings were proposed for the replacement of Cd coatings in many applications [1]. But these coatings require the use of Ni salts which are classified as CMR. Electrodeposited ZnFe alloys are under investigation because they are an environmentally friendly alternative, as both iron and zinc salts are non-toxic.

In a previous study, ZnFe coatings were deposited through electrodeposition in highly alkaline bath with zinc oxide and ferrous gluconate [2]. The coatings contain 14wt% Fe but their pyramidal morphology leads to an important surface roughness that requires optimization. The use of organic additives and pulsed currents has significant effects on the microstructure. Pulsed currents reduce the pitting on the deposit surface due to hydrogen evolution reaction. Vanillin is investigated as an eco-friendly additive in the electroplating process of Zn based coatings [3]. Our approach consists on conducting electrochemical measurements to determine the optimal vanillin concentration and its effect on the throwing power, morphology and thickness for a large range of cathodic current densities. The influence of deposition parameters (additive, current density, pulse parameters) on the morphology, the microstructure and the composition of the coatings is studied by using different experimental techniques. Mirror-like coatings can be obtained at high current densities when vanillin is present in the bath. The results also show that the additive induces a finer grain structure and strongly modify the crystalline orientation of the deposits. The impact of the microstructure and the morphology of the coatings on their functional properties (microhardness and corrosion behavior in saline solution) is then evaluated.

Keywords: electrodeposition, anticorrosion, additives, pulsed current, microstructure.

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Boosting Additively Produced Magnesium via Ceranod´s ULTRACERAMIC®

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Abstract:
Magnesium (Mg) and its alloys are one of the most promising metals in the field of lightweight applications. Due to their high strength to density ratio their application results in significant weight reduction accompanied by increased efficiency. However, with these unique properties, Mg is also highly susceptible to corrosion, and this, in turn, limits its application possibilities. Hence, deploying Mg parts in harsh environments is extremely challenging and innovative surface solutions should be considered.
Further optimization in terms of lightweight and material saving can be achieved by additive manufaturing techniques. In this work, laser-based powder bed fusion of metals (PBF-LB/M) is utilized for producing 99,9 % dense 3D printed Mg components. To bring such structures in use, the corrosive behavior must be brought under control which could be achieved by developing ULTRACERAMIC® PEO (Plasma-Electrolytical Oxidation) surfaces on additively produced Mg components. PEO is an environmentally friendly process, which is applicable to additively produced Mg substrates; providing not only corrosion protection but also increased wear resistance. The unique properties of PEO surfaces combined with additively produced Magnesium components are thoroughly examined in this work.
The work is focused on exploring the properties of the 3D printed Mg samples, enriched with PEO surfaces. Extensive tribological investigations are performed on the PEO protected and unprotected surfaces with the help of Pin-on-Disc tribometer followed by hardness testing to examine and compare the difference in mechanical properties. Initial tribological investigations have revealed very promising outcomes with up to 1000x decrement in wear volume of PEO protected samples compared to unprotected surfaces. Electrochemical corrosion tests are performed in order to examine the corrosive behavior and the protective performance of the PEO surfaces. To understand the mechanisms behind the wear and corrosion protection, the tested surfaces are examined with the help of SEM (Scanning Electron Microscope) and EDS (Energy- Dispersive X-ray Spectroscopy).
Based on the findings, optimized PEO surfaces are presented within this talk, which are adopted to complex 3D manufactured geometries, thus, extending the possibilities of applications in lightweight industry.
Authors would like to thank funding provided under KK5311902FF1 by Federal Ministry of Economic Affairs and Climate Actions.

Transfer Matrix Method Approach for *ex* and *in situ* LASER Interferometry Analyses of Growing Thin Films – Applied on Initiated Chemical Vapor Deposition Grown Thin Films

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Abstract:
Interferometry, in our setup, describes that a LASER is directed onto a film during growth, generating an oscillating interference signal from the increasing path length in the layer with time. This enables *in situ* and non-destructive measurement of thickness and refractive index, critical for real-time deposition monitoring and process control.
State-of-the-art approaches rely on analytical solutions for single or multiple reflections using geometric series. However, they are inadequate for efficiently modelling many base layers, unsuited for conveying complex ray propagation between the layers and, often, lack physical foundation.
Therefore, we introduce a novel approach based on the transfer matrix method (TMM), following R. Rumpf's improved formulation[1] and grounded on Maxwell's equations. Genetic algorithm fitting is used for *ex* and Bayesian inference for *in situ* analysis. In principle, a TMM model is constructed by a stack of layers (with one layer growing over time) connected infinite reflection and transmission half-spaces. Each layer can be understood as a four-terminal device receiving and emitting intensity at each side, and is represented by a layer scattering matrix (SM). Combining these layer SMs to a device SM, allows for determining the light propagation through the device.
Exemplary data for an *ex situ* fit of a poly(ethylene glycol dimethacrylate) (p(EGDMA)) deposition on a silicon wafer substrate via initiated chemical vapor deposition (iCVD), a process well-suited for interferometry due to conformal growth[2], is shown in Fig. 1.
The TMM model achieved R^2 = 96.7% with respect to the measurement after 50 generations with a population of 200 simulations per generation. The remaining variance can be explained by falsely assuming constant growth rate. Nevertheless, the final thickness of the growth layer (747.9 nm) plus a p(EGDMA) base layer, from a later measurement onset than deposition start, result in a simulated total thickness of 772.1 nm, deviating by 1.7 nm from ellipsometry analysis (Cauchy layer model for p(EGDMA), uncertainty ± 0.9 nm). These pre-measurement deposited 24.2 nm p(EGDMA) reveal themselves as a phase shift in the interferogram. The TMM simulation further aligns with ellipsometry given that $n_{p(EGDMA)} \approx 1.52$ was fitted, matching 1.51 from ellipsometry. Furthermore, refractive indices of SiO_2 and silicon are in agreement with those from literature.
In conclusion, a novel TMM approach for analyzing interferometry data purely based on Maxwell's equations was developed and validated for depositions via iCVD.

Keywords: transfer matrix method, interferometry, reflectometry, thin films, iCVD, thickness measurement, refractive index measurement, reflectance.

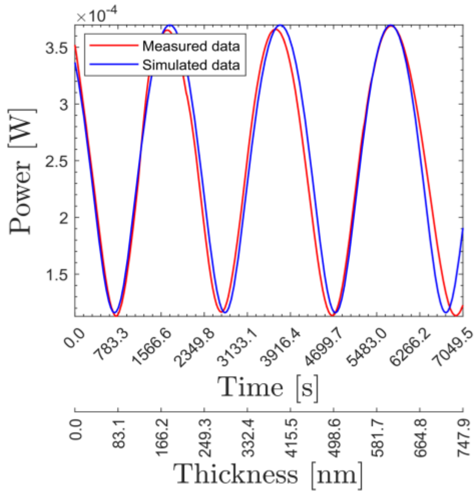

Figure 1: Figure displaying the recorded LASER interferometry data (red) alongside the TMM *ex situ* fit (blue).

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Self-healing and recyclable intumescent flame retardant coatings

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Abstract:
Intumescent epoxy paints are coatings which, when exposed to a source of heat, swell developping a thermally insulating expanded multicellular carbon structure. These paints are used to provide effective fire protection for various substrates used in buildings (steel, wood), or even in transportation (plastics [1], composites [2]). The use of thermoset binders in them present two main drawbacks: their difficult maintenance following damage (impacts, scratches...) and their end-of-life management limited by the lack of solution for separating the paint from the substrate. The use of stimuli responsive binders could enable to tackle this issue. In particular, vitrimers resins are covalent adaptative networks that can change topology by thermal activation of associative bond exchanges reactions imparting them intrinsical recycling and healing abilities [3]. One challenge in preparing intumescent virtimer coatings is the high additifs loading used in such coatings (30 to 50 wt.%). In the literature the impact of fillers in vitrimer resins has bearly been reported.

In this context of the study, we evaluate the potential of using epoxy vitrimer binders to replace the thermoset one for an easy removal of the intumescent paint. The main scientific challenge lies in the formulation of the intumescent vitrimer paint, which must (1) strike a balance between fire performance and properties of use (mechanical and processability), (2) retain the mobility of the polymer chains to allow bond exchange reactions and (3) have exchange kinetics that allow rapid disassembly under thermal stimulus. The influence the structure of the monomerhardeners and epoxy on the properties have been evaluated. The expansion of the fireproofed sample was tested in a oven at 500°C. The curing of the resins was evaluated using DSC and IR spectroscopie. The coating films were cut and heated above the temperature at which the bond exchanges are activated to confirm the vitrimer behavior. Finally the fire performances were evaluated.Promising results were obtained even if the presence of the flame retardant seems to impact the dynamic kinetics of the vitrimers.

Keywords: vitrimers, epoxy, intumescent coating, fireprotection

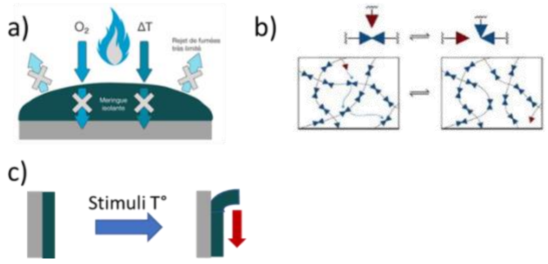

Figure 1: figure illustrating a) the mechanism of protection of a substrate using an intumescent paint, b) the principale of bond exchange reactions in vitrimer resin, c) the aim of replacing the thermoset epoxy by a vitrimer epoxy in order to be able to remove the paint from the susbtrate

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Novel Photoprotective Solution for Rosé Wine: TiOx-AZO Coatings on Glass Bottles

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Abstract:
PVD coatings of titanium dioxide (TiO_2) (1) and aluminum-doped zinc oxide (AZO) (2) are primarily used for their optical and photocatalytic properties, making them useful for filtering the ultraviolet spectrum. The preservation of rosé wine quality during storage remains a significant challenge in the wine industry, and the application of coatings such as AZO and TiO_2 on flint bottles emerges as a viable solution, since the use of colored bottles presents limitations due to consumer preferences (3). In this work, the potential of TiOx-AZO coatings applied through PVD is investigated as a photoprotective solution for wine, without adding any color properties to the bottles (**Figure 1**).
TiOx-AZO coatings were deposited on flat glass samples at varying temperatures (75 °C, 200 °C, 325 °C and 400 °C) with the aim of optimizing coatings properties. For this purpose, magnetron sputtering technology was employed using pulsed DC sources in a PVT xPro4C equipment. These coatings underwent chemical, optical, and mechanical characterization to assess their properties and effectiveness.
Based on the mentionated analyses, the coating that exhibited the most promising characteristics was selected for scaling up to full-size wine bottles. The photoprotective effect of this optimized TiOx-AZO coating was then evaluated bottling rosé wine inside and subjecting these wines to accelerated degradation tests (4). Our findings demonstrate that PVD-applied TiOx-AZO coatings offer a viable and innovative solution for protecting rosé wine from light induced degradation while maintaining the aesthetic appeal of clear glass bottles. This research contributes to the development of advanced packaging solutions in the wine industry, potentially revolutionizing the way rosé wines are stored and presented to consumers.

Keywords: PVD, pulsed DC, TiOX-AZO coatings, rosé wine, bottle.

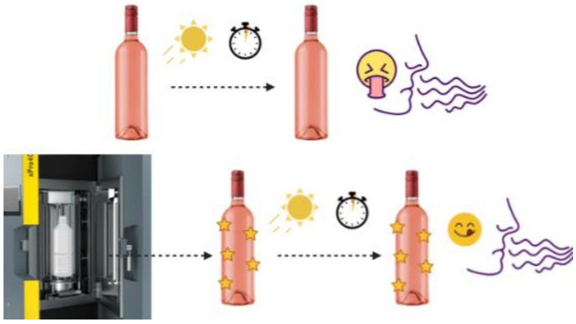

Figure 1: Figure illustrating the fundamental question that we are tempting to solve experimentally: development of PVD TiOx-AZO coatings to apply on bottles for photoprotection of rosé wines.

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Enhanced Conductivity Paraffin PCM Microcapsules for Textile Coating

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Abstract:
The growing demand for textile garments which respond to the changes of ambient temperature, are able to adapt to new conditions and meet physiological needs depending on the physical activity has stimulated the development of active smart textile products. These trends are reflected in the increased focus on phase-changing materials (PCMs) known as “smart materials” which can improve thermal insulation and thermal comfort of textiles, through the thermo-regulating effect of the PCMs.

Paraffinic hydrocarbons in the solid-liquid phase in the organic materials group are the most preferred and practical material for the production of microencapsulated PCMs (MPCMs) [1]. However, the problem of paraffin is its low thermal conductivity (0.22 W/(m·K)) [2].

This study is aimed to improve the thermal performance of paraffin PCM microcapsules for textile application by modifying their outer shell. For this purpose, the melamine-formaldehyde (MF) resin shell paraffinic microcapsules with a transition temperature of 32.02 ℃ were modified with conductive fillers – multiwall carbon nanotubes (MWCNTs) or poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS) using *Layer-by-Layer* self-assembly method. A multilayer thin coating was formed by electrostatic interaction between the cationically charged MF resin shell and the anionically charged conductive additives. The presence of them on the outer shell of modified MPCMs was observed by a scanning electron microscope (SEM) (**Figure 1**). A 3D warp-knitted spacer fabric from PET was dip-coated with shell-modified paraffinic MPCM that demonstrated optimal thermal characteristics, and its thermal performance—heat storage and release capacity, thermal conductivity, and dynamic thermal behavior—was evaluated.

The determined excellent thermal sensitivity of microcapsules with conductive fillers provided an efficient way to regulate thermal radiance, depending on the ambient temperature. So these microcapsules could be used as heat sinks responsible for reducing the temperature and therefore the thermal signature of human target. Coating textile materials with such modified microcapsules is a promising technology to be used to camouflage the thermal signature of the soldier system. Further development of this technology is part of the research conducted under the project ACROSS "Adaptive Camuoflage for soldiers and vehicles”, founded by the European Union.

Keywords: paraffin PCM — melamine-formaldehyde microcapsules; outer shell; MWCNTs and PEDOT: PSS; DSC, dip coating; thermal conductivity; heat storage and release capacity; dynamic thermal behaviour.

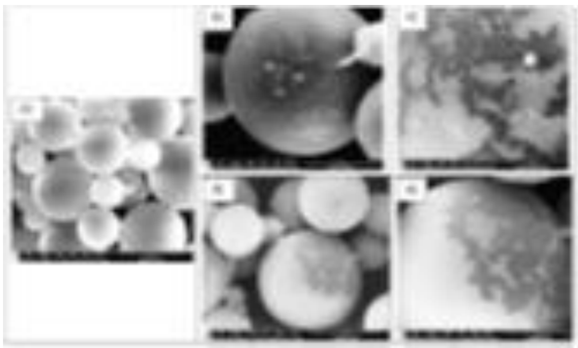

Figure 1: SEM images of paraffin PCM microcapsules: (a) unmodified, magnification 5000x; (b, c) with 5 wt.% MWCNTs shell-modified, magnification 5000x and 10000x; (d,e) with 5 wt.% PEDOT: PSS shell-modified, magnification 5000x and 10000x.

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Plasma Tech Session I. B:
Plasma fundamentals / Modelling / Atomic and Molecular Processes

Non-Conventional diagnostics For the investigation of atmospheric pressure discharges

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Abstract:
For an optimization of plasma-based processes as surface modification or thin film deposition, suitable diagnostics are required. In addition to well-established plasma diagnostic methods we perform examples of “non-conventional” low-cost diagnostics, which are applicable in technological plasma processes – in particular, also for atmospheric pressure discharges. Examples are the determination of energy fluxes by calorimetric probes (CP), the use of micro-sized test particles for the determination of charging processes and electric fields, and the measurement of sound pressure by acoustic sensors and force probes, respectively.

The integral energy influx from plasma to substrate is determined by means of calorimetric sensors. One method uses a passive thermal probe (PTP) based on the determination of the temporal slope of the substrate surface temperature (heating, cooling) in the course of the plasma process [1,2]. By knowing the calibrated heat capacity of the sensor, the difference of the time derivatives yields the integral energy influx to the surface. By comparison with model assumptions on the involved plasma- surface mechanisms the different energetic contributions to the total energy flux in dependence on the experimental conditions can be separated [3]. Due to gas heating and the motion of charged species small changes in the gas pressure are generated, which can be observed by the method of momentum transfer to a sensitive force probe [4] as well as by detection of acoustic waves [5]. Finally, observation and analysis of the behavior of small probe particles in the plasma layer of a surface barrier discharge by a high-speed camera can reveal fundamental properties of the plasma characteristics.

The diagnostic methods will be demonstrated for operation of diffuse coplanar surface barrier discharge (DCSBD) as well as for atmospheric pressure plasma jet (APPJ).

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From VLEO to Space: Selected EP systems analyzed by modeling and experiment

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Abstract:
Electric propulsion has shown to provide significant advantages over chemical propulsion during long duration missions. Due to improved launch opportunities industry forecasts suggest that by 2030, the total number of satellites could reach between 20,000 and 27,000. For instance, a report by Quilty Space anticipates around 20,000 new satellite launches by the end of the decade. Similarly, McKinsey projections indicate that the number of active satellites may exceed 27,000 by 2030 [1]. The orbits those satellites will operate in can vary from VLEO to GEO. A large number of those spececraft will carry EP systems. The lifetime of these propulsion devices will determine how long the satellites can operate.
Ground based lifetime testing procedures require a lot of time and - in many cases – can not fully simulate the conditions in space. Hence model based performance prediction is playing a significant role. In this paper approaches for gridded ion thruster and ABEP systems will be presented. For space based propulsion in most cases the reasons for lifetime occurring events are fully based on the system itself, e.g. neutral elements of the propellant are interacting with accelerated particles, thus limiting the amount of variables to be considered in the simulation. For ABEP systems, however, the use of high atmosphere gas particles acting as propellant with the contents of which not even being constant in combination and density adds a significant amount of complexity to the problem [2]. Hence while space based systems can be evaluated with a combination of PIC and DSMC for ABEP systems chemistry plays a large role and also calls for the application of a CLL model, which in addition requires a chemical kinetics model.
This paper will describe the current SOA of the work done at Bundeswehr University Munich in this area.

Keywords: electric propulsion, ABEP, ion thruster, lifetime prediction, surface interaction.

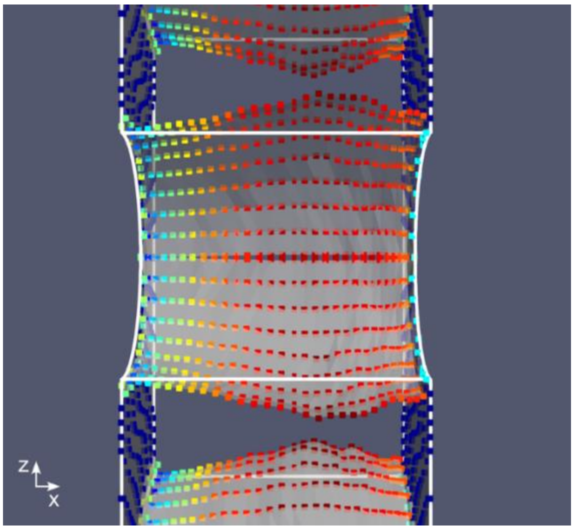

Figure 1: Predicted erosion pattern in gridded ion thruster ion optics.

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Overview of Electric Propulsion Thruster and Diagnostic Developments at TU Dresden

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Abstract:
Electric Propulsion is a key spacecraft technology saving fuel through higher efficiencies and enabling missiong by providing thrusts with high accuracy over a large range from sub-Newtons down to micro-Newtons. Here we will present an overview of our activities covering both plasma sources as thrusters, electron emitters and special diagnostics. Our thrusters focus on Hall-effect thrusters with integrated thrust vector control, field-emission thrusters with magnetized liquid metal as fuel or RF sources for high efficiency thrusters that can utilize the ambient air as propellant for very-low-Earth orbit applications. Our electron emitters focus on hollow cathodes using C12A7 which enable heaterless ignition as well as propellantless cold emitters using CNTs or diamond coatings up to the tens of milli-Ampere range for electrodynamic tether applications. Apart from classical plasma diagnostic tools like Langmuir probes and Faraday cups, we specialize in the development of very precise and compact thrust balances that can be used as a diagnostic tool as well.

Keywords: electric propulsion, plasma thrusters, thrust balances, electron sources, plasma diagnostics.

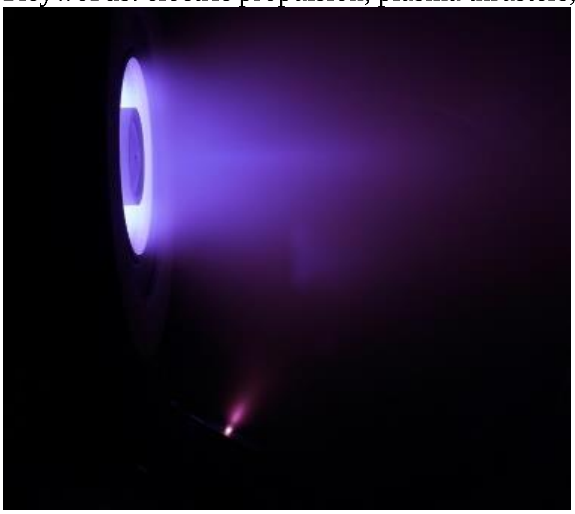

Figure 1: Example of TUD Low-Power Hall Thruster and Cathode

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Conventional and non-conventional diagnostics on micro discharges

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Abstract:
Micro discharges, or microplasmas, are weakly-ionized, nonequilibrium plasmas spatially confined to a cavity having a characteristic dimension between nominally 1 µm and 1 mm [1]. Due to their small dimensions they are operated at elevated pressures, typically atmospheric pressure, and offer high energy densities in the range of 10^4 W cm^{-3} to 10^6 W cm^{-3} [1]. Applications are manifold reaching from surface treatments and deposition processes to the efficient production of vacuum ultraviolet (VUV) photons and even biomedical applications [2].

Plasma diagnostics are aggrevated by the small dimensions and high operating pressures which limits conventional diagnostics mainly to electrical and optical methods. Current-voltage characteristics offer insight into, e.g., the discharge mode, electrical input powers and power densities. Optical diagnostics, like optical emission spectroscopy, allow to evaluate, e.g., gas compositions and (electron) temperatures.
So-called non-conventional diagnostics like the passive thermal probe (PTP) [3] and VUV spectroscopy extend the pool of available diagnostics and help to understand observed phenomena. PTPs are calorimetric probes to measure the power transfer from the plasma to a surface. They can be used, e.g., as electrodes for micro discharges to measure the energy flux to the electrode surface [4].

A parallel plate DC micro discharge was developed with the ultimate goal of being integrated into a transmission electron microscope (TEM) to study the plasma-surface interaction *in situ* and in real time. As preparation for the *in situ* studies the micro discharge was studied by conventional and non-conventional diagnostics proving its stable operation in the normal glow mode and high energy fluxes which should result in *in situ* observable surface modifications [4]. *Ex situ* studies confirmed and visualized surface modifications of thin gold films [5]. Differences in the surface modifications could be seen based on the working gas being Argon or Helium. The origin of these differences could be found in different energy transfer mechanisms of the respective ions by combining the energy flux and electrical measurements.

Next to ions also highly energtic photons are influencing the plasma-surface interaction. For micro discharges VUV photons originating from excimer emission are of special interest due to their high energies in the 10 to 20 eV range. Measurement of these photons is challenging as they have to be transferred into a vacuum environment to avoid absorption and typical window materials have a cut-off wavelength in the 115 nm region (~11 eV). A new approach based on a 20 nm thin Si_3N_4 membrane as vacuum window will be introduced, which allows to measure the VUV emission of atmospheric pressure plasmas without disturbing the plasma or introducing systematic errors into the spectrum due to absorption effects.

The talk will shortly introduce the addressed non-conventional diagnostics and showcase their potential also in combination with conventional diagnostics.

Keywords: micro discharge, microplasma, atmospheric pressure plasma, plasma-surface interaction, plasma diagnostic.

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Numerical Modeling of Approximate Plasma Evolution through Gaussian Functions for Magdrive Devices - An MPI-Parallelised Approach

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Abstract:
Magdrive's spacecraft propulsion system leverages an advanced electric plasma propulsion mechanism, requiring precise parameter optimization for peak performance. Given the impracticality of exhaustive experimental exploration and the need for deeper insights into plasma behavior, we developed REWIND, an in-house numerical simulation suite tailored for Magdrive’s unique thruster design.
This study focuses on AGE, a core component of REWIND designed to simulate plasma evolution post-thermalization. AGE employs a high-fidelity computational framework to model plasma transport and interaction dynamics, enabling accurate predictions of key performance characteristics. Leveraging parallel computing and an adaptive numerical approach, the system efficiently captures complex plasma behaviors while maintaining computational scalability.
Our findings demonstrate the capability of numerical simulations to enhance the understanding of plasma dynamics and inform the optimization of electric propulsion systems, contributing to the advancement of next-generation space propulsion technologies.

Keywords: spacecraft propulsion, post-thermalization plasma evolution, gaussian functions, parallel computing, high-performance simulation, numerical modeling, aerospace engineering.

Using remote plasma emission spectroscopy for monitoring and control of vacuum processes

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Abstract:
Some form of monitoring of the vacuum is essential for the efficient operation of any vacuum processes. Residual Gas Analysis allows for detection and identification of individual species within the vacuum. This can result higher process yields through faster troubleshooting, scrappage reduction through contamination detection, or a more controlled vacuum environment. Historically, residual gas analysis (RGA) was typically performed with quadrupole mass spectrometers. The limiting factor for Quadrupole RGAs is the pressure range over which they can operate. Above $1x10^{-4}$ mbar damage will occur to the sensor's filament.

Plasma emission monitoring (PEM) has been used for a number of years to either monitor the condition or actively control vacuum processes that rely on plasma generation (e.g. Physical Vapour Deposition). This approach to monitoring the process has many advantages – such as fast response time, sensitivity and the ability to control uniformity by monitoring different areas of the process. There are however some disadvantages – e.g. there is required a clear line of sight to the plasma that can be obscured by substrate movement, the PEM sensor can become coated by the deposited material, and of course, it can only be used when the process itself generates a plasma.

Remotely generated plasma is a convenient method to successfully control a number of process types – including non-plasma processes such as reactive E-Beam evaporation. Advances in miniature spectrometers have enabled these Penning PEM sensors to perform optical plasma spectroscopy. This has the potential to facilitate its use as a low-cost, multi-purpose vacuum sensor.

An alternative residual gas monitoring sensor that operates directly at pressures above $1x10^{-4}$ has been built around plasma emission monitoring. A small "remote" plasma can be generated inside a vacuum sensor. Consequently, species that are present within the vacuum will become excited in the sensor's plasma, emitting a spectrum of light, which can then be used to identify and monitor the emitting species, resulting in a robust, lower-cost, multi-purpose vacuum sensor.

Presented are examples and findings from using this method for monitoring of plasma treatment and deposition in a roll-to-roll system, leak detection in semi-conductor fabrication, contaminant detection in a tool coating system and comparisons with an equivalent differentially pumped RGA.

Extended self-similarity in a 2D complex plasma with active Janus particles

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Abstract:
Extended self-similarity (ESS) is a concept originally proposed by Benzi [1] for a fully developed turbulence. ESS refers to the power-law scaling of the structure functions of the velocity field expressed through the structure functions of different orders rather than distance. Extended self-similarity of the velocity fields in fluids is particularly important because it can help to identify otherwise obscured scaling regimes and can even provide a more accurate method of measuring the scaling exponents.

We experimentally studied a two-dimensional (2D) suspension of active Janus particles in a gas-discharge plasma. The Janus particles were micron-size plastic microspheres with a hemispherical metal coating, see Fig. 1. Plasma was produced by a capacitively coupled radio-frequency (rf) discharge in argon at 13.56 MHz in a modified Gaseous Electronics Conference (GEC) rf reference cell. The gas pressure was 0.66 Pa, the discharge rf power was 20 W.

When injected in plasma, the Janus particles formed a single-layer suspension in the plasma sheath of the lower rf electrode. The particles were levitated by the balance of the sheath electric field and gravity. The suspension consisted of around 780 particles and had a diameter of approximately 40 mm. Due to the Janus particles' self-propulsion, they acquired high speeds greatly exceeding the thermal speed, which prevented them from forming a regular lattice [2]. Their trajectories, however, remained in the horizontal plane due to the strong vertical confinement. The self-propulsion force was balanced by the neutral gas drag force.

To characterize how chaotic the Janus particles' motion is, we utilised a tool widely used in the field of turbulence – the longitudinal velocity structure functions defined as $S_p(r)=\langle|\Delta u(r)|^p\rangle$, where Δu is the longitudinal velocity increment over a separation distance r, p is the order of the structure function, and the brackets denote averaging over all particle pairs and instants of time. We showed that the velocity field of the system of active Janus particles features extended self-similarity, i.e. $S_p(r)\propto(S_3(r))^{\xi}$, where $\xi\approx p/3$, even though the underlying structure functions $S_p(r)$ lack respective power-law scaling.

Given the extended self-similarity of its velocity field, the chaotic intermittent flow in the 2D system of active Janus particles can be regarded as active turbulence.

Keywords: complex plasma, active matter, Janus particles, plasma coating.

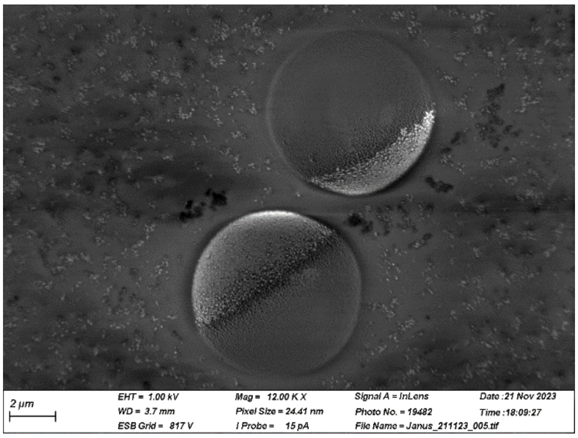

Figure 1: SEM image of Janus particles. Melamine-formaldehyde microspheres with a diameter of 9.27 µm were coated on one side with a 40-nm layer of gold using magnetron plasma sputtering.

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AI-Driven Modelling for Predictive Optimisation of Atmospheric Plasma Treatment in Microporous EVAs

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Abstract:
Atmospheric plasma technology is a versatile and efficient method for modifying the surface properties of polymeric materials, particularly microporous ethylene-vinyl acetate (EVA). However, optimizing process parameters to achieve the desired adhesion and surface characteristics often requires extensive experimental efforts. This work presents an AI-driven predictive modelling approach to streamline the optimization of atmospheric plasma treatments for microporous EVA. The model is based on machine learning algorithms trained on experimental data, incorporating key plasma parameters such as power, treatment distance, and application speed. Additionally, the study investigates different types of microporous EVAs with varying physical and chemical properties, providing a detailed understanding on how these properties influence plasma-induced modifications. By correlating plasma parameters with adhesion values, and the intrinsic material characteristics, the model predicts optimal treatment conditions tailored to specific performance targets. Results demonstrate the capability of AI-driven modelling to significantly reduce the need for experimental iterations, enabling precise control over surface modifications. This predictive approach ensures process efficiency while maintaining consistent performance. Moreover, the study highlights the potential for this technology to address challenges associated with industrial-scale plasma treatments, particularly in applications where uniformity and reproducibility are critical. This work represents a step forward in integrating artificial intelligence into plasma processing, offering a scalable and sustainable solution for enhancing the functionality of polymeric materials. Future research aims to expand the model's applicability to other polymer systems and explore its potential for real-time process control.

Keywords: plasma treatments, microporous EVA, predictive modelling, surface adhesion, AI optimization, plasma parameters, polymer surfaces, machine learning, material processing.

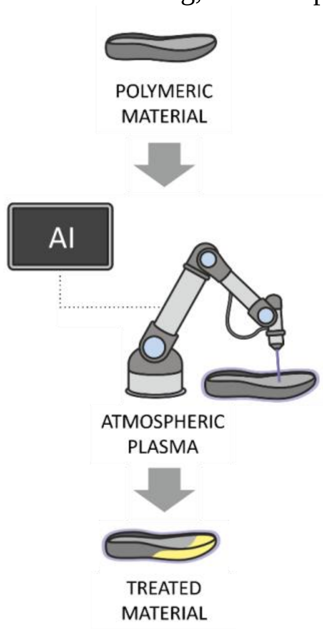

Figure 1: Figure illustrating the fundamental process being addressed: AI-driven optimization of atmospheric plasma treatments for microporous EVA.

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Combined in-situ PM-IRRAS and XPS analysis of nitrogen plasma surface modification of polylactide thin films

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Abstract:
Polylactide (PLA) is a versatile biodegradable polymer, currently under research for a wide range of applications, including medical implants and packaging. The surface chemistry requirements for PLA differ significantly depending on the specific application. Low temperature plasma modification is an established approach for the surface chemical functionalization of synthetic polymers such as PP or PET.[1–4] In contrast, the plasma-induced surface chemistry of biopolymers such as PLA has received comparatively less attention in research thus far.. The complex surface-level modifications caused by the treatment need to be characterized, as their understanding is crucial for the further optimization of PLA for specific applications.
In the present study, spin-coated thin PLA films subjected to nitrogen plasma were analyzed in-vacuo using X-ray photoelectron spectroscopy (XPS), revealing partial substitution of surface oxygen species by nitrogen. A parallel study conducted in a different plasma reactor was monitored using polarization modulated infrared reflection absorption spectroscopy (PM-IRRAS) indicated progressive etching of the PLA film due to the plasma exposure. PM-IRRAS analysis further confirmed that the plasma treatment did not modify the bulk composition of the film significantly. Subsequent ex-situ XPS analysis supported the initial findings, showing a consistent trend of surface oxygen species substitution by nitrogen.
Water contact angle studies confirmed the increased wettability of the PLA surface following plasma treatment. The combined results from wettability studies and the spectroscopic analyses suggest that the plasma-treated surfaces undergo a reorientation of macromolecular fragments in the surface-near region depending on the polarity of the surrounding environment.

Keywords: polylactide, plasma activation, in-vacuo XPS, in-situ FTIR

Acknowledgement:

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Figures:

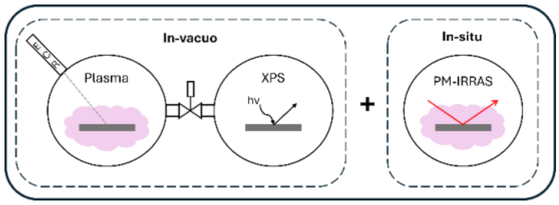

Figure 1: Schematic representation of used analytical setups, including in-vacuo XPS analysis and in-situ PM-IRRAS.

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SICT 2025/ Tribology 2025 Joint Session I. C:
Surface Engineering, Coatings and Tribology

Post-processing treatments to enhance the interlayer strength of extrusion-based 3D printed polymer composites

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Abstract:
A critical limitation of 3D-printed polymer composites lies in their weak interlayer strength, resulting from the layer-by-layer deposition process inherent to additive manufacturing. This process creates numerous interfaces per unit volume, which act as potential sites for mechanical failure. Enhancing the diffusion of polymer chains across these interfaces offers a promising solution to improve interlayer bonding and overall structural integrity. This work focuses on strategies to improve interlayer strength, with emphasis on two key aspects: the influence of polymer composite viscosity at melt and the role of post-processing treatments in promoting bonding. The post-processing treatments involve elevating the temperature at the interface to further the process of bonding at the interface, sometimes referred to as healing. Two techniques are considered: annealing (Bhandari et al. 2019), and induction heating (Bu et al. 2024). Annealing involves heating the material above its glass transition temperature, enabling chain mobility and improving strength. Induction heating provides localized, rapid heating, offering an efficient means to drive interfacial bonding. Rheological and thermal analyses, such as rheometry and differential scanning calorimetry (DSC), along with tensile testing, are used to understand the relationship between material properties and interlayer performance. The study underscores the importance of material composition for interlayer strength of additively manufactured polymer composites. Post-processing techniques present a potential to increase interlayer strength through enhanced diffusion. This discussion contributes to a broader understanding of how material properties, processing conditions, and thermal treatments interact to improve the performance of 3D-printed polymer composites, advancing their application in structural and functional components.

Keywords: material extrusion, thermal analysis, annealing, interlayer strength, 3D printing, additive manufacturing, bond formation, surface contact, interfacial molecular diffusion, polymer, thermoplastic

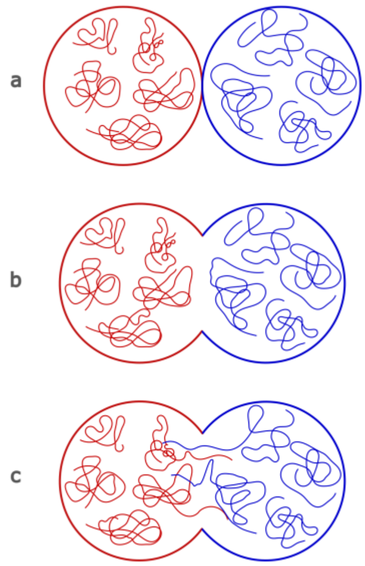

Figure 1: Stages in bond formation between 3D printed filaments: a) surface contact, b) neck growth, and c) molecular diffusion at interface and randomization described by Bellehumeur et al. (2004) and Bhandari et al. (2019).

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Electroplated Metal-Graphene Coatings as Solid Lubrication

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Abstract:
In mechanical actuators, metal-to-metal sliding contact surfaces are commonly included in the design to achieve physical movement. To enable the low friction and low wear movement of these parts, "liquid" lubricants like grease or oil are mostly used. These organic lubricants are often prone to aging and thermal issues. In the worst case, failure of lubrication can lead to complete blockage of the function of the actuator. Therefore, labor- and cost-intense regular maintenance and regreasing are often applied in these devices.

In this context, graphene has been gaining interest in recent years as a solid, thermally stable, self-lubricating, friction- and wear-reducing additive for these types of applications[1, 2].

Here, a new family of Metal-Graphene multilayer coatings, having graphene nanoplatelets incorporated within metal matrix during its electro-crystallization, was evaluated for the use as solid lubrication. Coatings with different multilayer structures were prepared by a novel electro-deposition process[3, 4]. Friction properties of the coatings under different loading conditions using standard Pin-on-Disc (PoD) tests were evaluated. Wear tracks from the friction tests were analyzed by optical microscope and white light interferometry. Tribofilm formation in the wear tracks were confirmed and the layer thicknesses were compared. From this, a hypothesis for the tribological mechanism of the system was proposed [5,6].

Experimental results will be presented and discussed in light of the potential use of this family of materials in mechanical actuators.

Keywords: tribology, friction, wear, solid lubrication, graphene composites, metal composites.

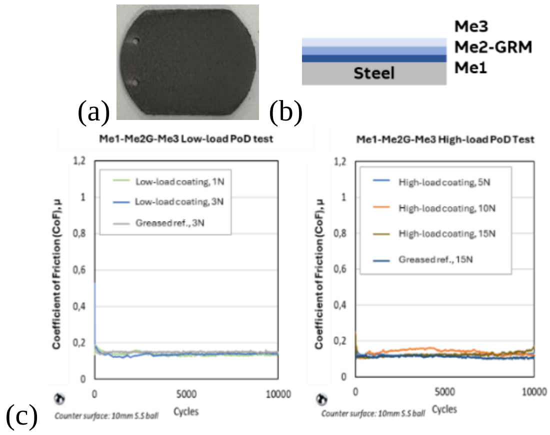

Figure 1: (a) The deposited coating, (b) the schematic of the multilayer coating structure, (c) example of PoD tribological assessment of the multilayer system at low load (1 and 3 N) and high load (5,10 and 15 N), showing that the hybrid multilayer/compositing approach promotes long-lasting, low friction lubrication.

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Multilayer Cu-graphene composite coating system for high-load solid lubrication – Exploring dynamic and quasi-static friction

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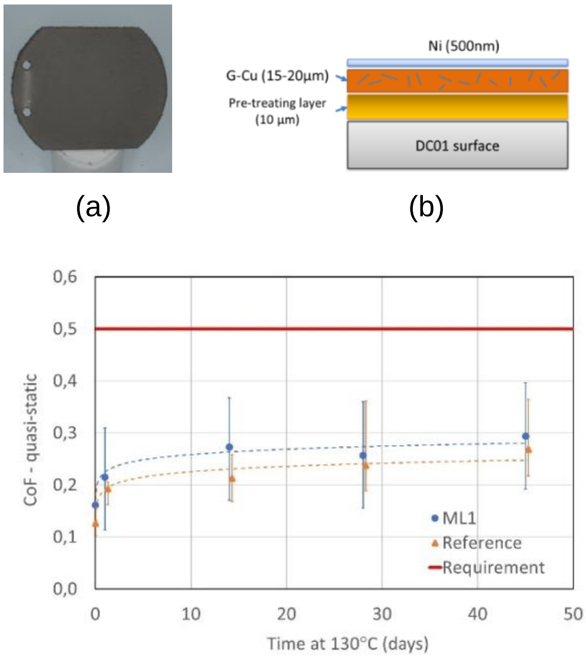
Abstract:
Copper coatings are widely utilized across various applications[1]. However, their high ductility and low shear strength, along with the tendency for adhesive material transfer to opposing surfaces, restrict their use in tribological applications. Enhancing copper coatings by implementation of copper-metal multilayer structures[2] or by incorporating graphene into the metal matrix[3] have shown potential in improving their physical and mechanical properties. Despite demonstrating good performance at low contact pressures, these methods fail to provide adequate lubrication at contact pressures exceeding 1 GPa.

This study investigates the tribological performance, with a focus on friction, of a novel hybrid copper coating that combines both multilayers and graphene reinforcement. The coatings were designed as a multilayer (ML) system, consisting of a metallic base layer, a Cu-GNP (graphene nanoplatelets) composite layer, and a Ni top-coat, applied to steel (DC01) substrates (Figure 1). Tribological evaluations, conducted using pin-on-disc tests, revealed very low friction under both dynamic and quasi-static conditions, comparable to the reference system of grease-lubricated steel. For the quasi-static conditions, the impact of varying holding times was examined, showing that holding time within the tested range had minimal effect on static friction. Additionally, accelerated aging in air at high temperatures, corresponding to the expected lifetime of mechanical drive systems, had negligible impact on lubricating performance.

The findings will be presented and discussed in the context of the potential application of this material family in lubricated mechanical actuator systems, where static friction is one of the main design criteria.

Keywords: copper coating, graphene, nickel, top-coat, quasi-static friction, , mechanical drive system.



(c)

Figure 1: (a) The deposited coating, (b) the schematic layout of the ML hybrid coating, and (c) quasi-static pin-on-disc tribological assessment of the multilayer system after different aging times, showing long-lasting, high-load lubrication when freshly produced and after accelerated aging at **130°C**.

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The Influence of Methods for Distributing the IF-WS_2 Modifier into the Structure of Al_2O_3 Aluminum Oxide Coatings on Their Micromechanical Properties

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Abstract:

High-strength aluminum alloys are extensively utilized across the machinery, automotive, and aerospace industries, primarily due to their outstanding mechanical properties relative to weight. However, without adequate surface treatment, aluminum and its alloys are highly susceptible to adhesive wear under frictional contact. In recent decades, significant research efforts have focused on developing various modifications to enhance the tribological performance of anodic coatings formed on aluminum alloys. The porosity of anodic oxide layers is recognized as a functional attribute, capable of acting as a lubricant reservoir. This characteristic enables the design of self-lubricating systems, effectively reducing friction and wear. The primary challenges often stemmed from the dimensions of the lubricant powder particles, which exceeded the pore sizes of the oxide coatings. Furthermore, a reduction in the thickness of the aluminum oxide layer was found to compromise the mechanical strength of the oxide surface [1, 2]. In recent years, nanoparticles as lubricant additives have increasingly garnered attention, similar like new methods of their surface application [3].

In our study, we addressed the challenge of nanoparticle agglomeration, which is inherently linked to the quality of nanopowders [4]. Consequently, it is imperative to investigate methods for disintegrating agglomerates of modifiers and achieving a homogeneous suspension, thereby enabling the effective incorporation of modifiers into nanoporous oxide layers.This study investigates the micromechanical properties of Al_2O_3 surfaces, focusing on an experimental approach to enhance the dispersion of IF-WS_2 nanopowder. The approach employs intensive ultrasonication under novel conditions to facilitate the introduction of the nanopowder into the nanopores of Al_2O_3 coatings [Fig.1].

Keywords: AAO coating, IF-WS_2 nanolubricant, mechanical properties, ultrasonication.

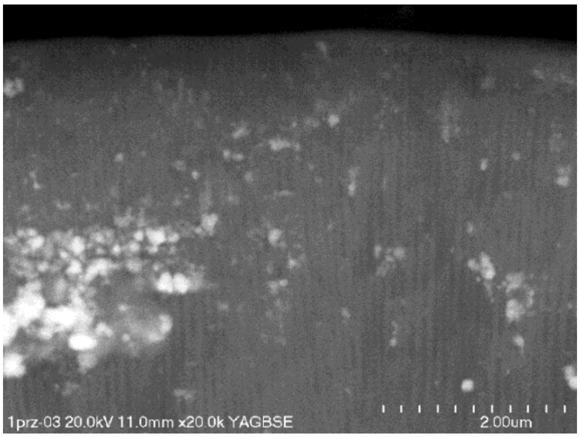

Figure 1 Fresh cross-section of the AAO coating with IF-WS_2 nanolubricant.

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Low-Friction Coatings for the External Surface of Glass Vials: From Dipping to Spray Deposition for Industrial-Scale Applications

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Abstract:
This work focuses on the development of low-friction and abrasion-resistant water-based coatings for industrial applications on pharmaceutical glass vials. Glass, the material of choice for pharmaceutical packaging[1], faces challenges such as surface damage and limited scratch resistance, which can compromise product integrity. Conventional coatings, based on toxic precursors and multi-step processes, pose environmental and industrial scalability issues. To address these issues, we conducted a study on silane-based coatings deposited on the external surface of soda-lime-silicate (SLS) glass vials using water-based organosilane[2] formulations (Fig. 1, a) in combination with a lubricant to improve mechanical performance while reducing environmental impact. The study evaluates the deposition techniques (Fig. 1, b1 – b2), starting from the study of the dipping method, to move to manual airbrush spraying and finally to an automated spraying system, optimizing them for large-scale industrial applications. Transparent SLS glass substrates were activated chemically or with plasma pretreatment to improve silanization efficiency, with subsequent characterization performed by contact angle measurements, AFM analysis, FTIR and X-ray photoelectron spectroscopy (XPS). Mechanical performance was evaluated by scratch resistance test and tribological analysis. Scratch resistance tests revealed improved resistance, with coated surfaces showing critical loads (Lc) higher than that of uncoated glass; such a delay in the onset of surface damage essentially indicates an improved protection of coated surfaces against mechanical stress. Tribological results demonstrated that the aminosilane primer, combined with the lubricant, significantly improved the surface friction behavior of the glass with a reduced coefficient of friction – COF (Fig. 1, c). The proposed one-step primer-lubricant application simplifies the application process, eliminating a dedicated primer-only deposition step. This approach reduces environmental impact and production costs while maintaining promising mechanical performance. These results highlight the potential of water-based organosilane coatings as a sustainable solution for pharmaceutical glass packaging, paving the way for green manufacturing practices and industrial scalability. Future work will focus on optimizing water-based formulations and validating the long-term performance of these coatings under industrial conditions.

Keywords: Low-friction coatings, Abrasion resistance, Water-based organosilane, Pharmaceutical glass packaging, Sustainable manufacturing.

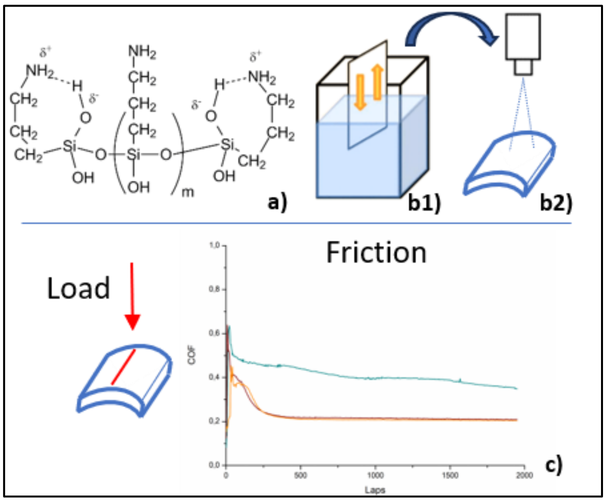

Figure 1: a) molecular structure of organosilane; schematic views of b1) dipping and b2) spray deposition methods; c) friction graph showing reduced COF for silane primer-based coatings (orange/red) versus lubricant-only (blue).

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The Microstructure and Properties of Carbon Coatings Produced by Low-Temperature RFPACVD Processes on Nanobainitic and Martensitic 35CrMnSi-5-5-4 steel

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Abstract:
Nanostructured steels obtained through bainitic transformation are characterized by remarkable mechanical properties, combining high hardness and tensile strength [1]. Nanobainitic structure can be achieved even in medium and low carbon steels [2]. However, such alloys may exhibit unsatisfactory wear resistance. This issue can be addressed by producing a suitable coating with low friction coefficient and high surface hardness. Due to the relatively low thermodynamic stability of nanobainite only low-temperature methods can potentially be used for their surface treatment. Carbon coatings such as Diamond-Like Carbon (DLC) and its derivatives can successfully improve the tribological properties of coated steel components [3]. These coatings allow for a reduction in friction coefficient, increase in surface hardness, resulting in reduced susceptibility to wear. Obtaining them is possible using low-temperature CVD methods, which enable processing temperatures to be lowered to 250°C and below, which also results in more favorable tribological properties. The primary limiting factor for the utility of DLC coatings is their relatively low adhesion to metal surfaces, especially if no interlayer is applied, or prior surface treatment such as nitriding and nitrocarburizing is conducted. The aim of this study is to investigate the possibility of producing carbon coatings on nanobainitic substrate in the RFCVD process while maintaining the substrate structure. It also aims to compare the adhesion of the coating to isothermally hardened (nanobainite) and martensitic substrates, as well as to study the effect of process temperature in the stability range of nanobainite (50-250°C) on the properties of the coating. Annealing of nanobainitic samples at 200°C did not reveal any observable changes in the structure. Similarly, in the case of martensitic samples, after annealing at this temperature for 30 minutes, only tempering was observed, indicating that under the assumed conditions of processing by RFCVD, no other undesirable significant processes adversely affecting the properties of the processed substrate have been observed. The carbon coatings obtained in the course of the research are characterized by an amorphous structure, in which the content of sp^3-type bonds ranges from about 25-27% to about 33-37%, as confirmed by Raman spectroscopy and XPS studies. In both measurements, an increase in the content of sp3-type bonds with increasing temperature was shown, which corresponds to a simultaneous increase in their nanohardness . Also, with the increase in processing temperature, a higher oxygen content in the obtained coating has been observed, which might also be the cause of an increase in sp^3 content. The observed increase in nanohardness with increasing processing temperature corresponds to a slight increase in the proportion of sp^3-type bonds, as expected. Unfortunately, this also increases the difference in properties between the substrate and the coating, which in turn negatively affects its adhesion, which in all tested cases was relatively low (below 10N). Scratch tests showed that with increasing temperature above 100°C, the adhesion of the coatings significantly decreases, until reaching a level where spontaneous delamination of the coating produced at a temperature of 250°C occurs. Also, the nature of the damage became increasingly unfavorable with the increase in the temperature of the RFCVD process. Coatings on martensitic substrates exhibited higher adhesion, likely due to their higher initial surface hardness.

Keywords: RFPACVD, DLC, adhesion, nanohardness, nanobainite

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Wear Behavior of Chromium and Chromium Nitride Coatings Subjected to Different Probe Geometry During Impact Fatigue Tests

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Abstract:

The study of micro-impacts allows the analysis of wear of materials subjected to repeated impacts in concentrated contact. The dynamic nature of the loading means that the tests can perfectly simulate the process of plastic processing or machining. Micro-impact surface fatigue tests of coatings (Figure 1) were carried out using the Impact Tester stand available at the Laboratory of Tribology and Surface Engineering of the AGH University of Krakow (Figure 2) [1].

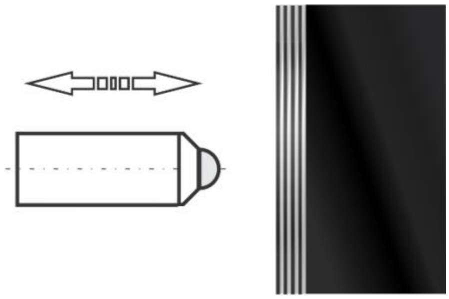

Figure 1: Scheme of the coating's impact fatigue

As part of the research work carried out, tests were performed on 1 μm-thick coatings deposited by the PVD method with single-layer and multilayer (2, 4 and 8 layers) systems. The tests were based on the analysis of wear mechanisms of coatings when subjected to repeated load cycles at different contact pressures. For this purpose, diamond indenters of Rockwell geometry with an indenter radius (R) of 100, 200 and 500 μm were used, and tests with the following number of cycles were applied: 1 000, 10 000 and 100 000.

The wear of the material was described using the SEM method and an optical profilometer, which allowed the geometry of the craters formed to be measured. Significant differences were observed in the depth and shape of the craters formed for tests using individual indenters, as shown for the 4-layer Cr-CrN coating at 100 000 cycles (Figure 3). Increasing the radius of the indenter significantly affects the post-contact area, which has a direct influence on the depth of penetration [2]. As indicated by graphs mapping the cross-section of the resulting craters (Figure 3), the depth for a crater obtained with an R=500 μm radius is minor size - 0.12 μm, compared to 1.43 and 1.22 μm for R=200 μm and R=500 μm indenters, respectively.

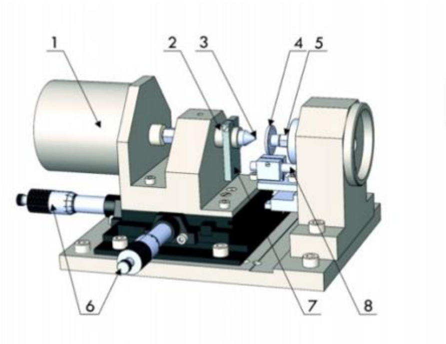

Figure 2: Impact Tester scheme: 1- inductor, 2- head of indenter, 3-indenter, 4- holder of sample, 5- force sensor, 6- micrometer screws, 7- mirror target, 8- displacement sensor

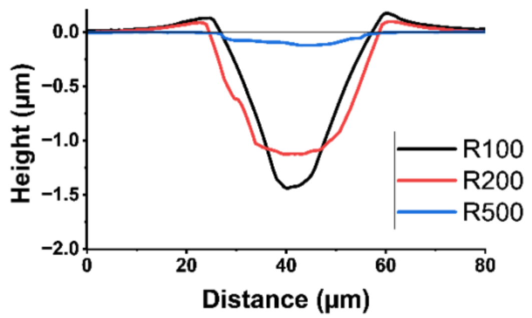

Figure 3: Crater depth in 4-layer Cr-CrN coating after 100 000 impacts with different indenter geometries

Keywords: micro impact, PVD coatings, coatings fatigue wear.

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Influence of Ultrasonic Nanocrystal Surface Modification on the Surface Integrity and Microstructure of Inconel 718: A Finite Element and Experimental Investigation

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Abstract:
This study investigates the effects of ultrasonic nanocrystal surface modification (UNSM) on the surface and microstructural properties of Inconel 718 alloy. UNSM, a high-frequency surface treatment technique, has emerged as a promising method to enhance surface hardness, residual stress distribution, and fatigue life. By integrating finite element simulations and experimental validations, this work aims to elucidate the underlying mechanisms of UNSM and its influence on surface integrity at both micro and macro scales.

The finite element analysis (FEA) was performed using Abaqus/Explicit to model the dynamic interaction between a hemispherical tool (2.38 mm, tungsten carbide) and the alloy's surface. A Johnson-Cook material model was implemented to capture the elastoplastic behavior of Inconel 718 under the high-frequency impacts of UNSM. The tool was subjected to sinusoidal displacement (amplitude: 30 µm, frequency: 20 kHz) along with a static preload force of 50 N. Key simulation outputs, including plastic strain, residual stress distributions, and surface deformation, were analyzed. Plastic strain data were utilized to estimate dislocation density using an empirical relationship, providing insights into grain refinement and its impact on surface hardening.

Experimentally, UNSM was performed under identical conditions, and surface integrity was assessed using a profilometer and micro-hardness tester. Scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS) characterized surface morphology and chemical composition before and after fretting tests. Nanocrystallization and grain refinement were evaluated using electron backscatter diffraction (EBSD) and X-ray diffraction (XRD). Mechanical properties, including yield strength, were determined from tensile tests using standard dog-bone-shaped specimens.

Preliminary findings suggest significant plastic deformation and compressive residual stresses induced by UNSM, promoting grain refinement and increased surface hardness. Surface roughness improvements and enhanced microstructural stability were observed, aligning with computational predictions. This integration of experimental and computational approaches offers a robust framework for optimizing UNSM parameters and advancing its applications in high-performance alloys for aerospace and energy industries.

This study provides a comprehensive understanding of the interplay between process parameters, microstructural evolution, and mechanical property enhancements in Inconel 718 subjected to UNSM. The integration of simulation and experimental approaches establishes a robust framework for optimizing surface engineering techniques for high-performance alloys. These findings contribute to advancing UNSM as a versatile surface treatment for improving material performance under extreme operating conditions.

Keywords: IN718 superalloy, grain size, hardness, ultrasonic nanocrystalline surface modification, residual stress, finite element method

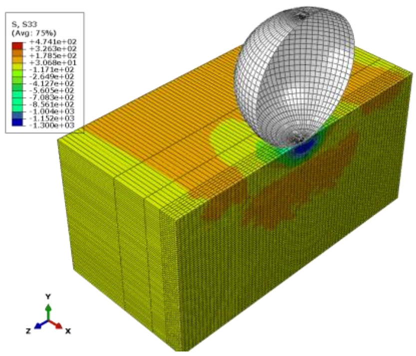

Figure 1: Stress distribution in the UNSM scanning direction(Z-direction)

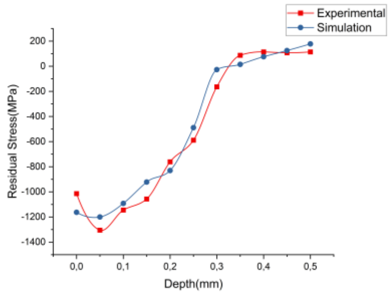

Figure 2: Comparison of residual stress distributions obtained by FEM and experimental observations.

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Relationship between Acoustic Emission Signals and Surface Conditions in Rolling Contact Fatigue Tests

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Abstract:
In the rolling contact fatigue conditions for steel materials, it is known that cracks form on contacting and sliding surfaces, eventually leading to pitting. Factors such as load and slip complexity affect rolling contact fatigue life and contribute to crack initiation and damage progression. However, due to the difficulty of direct observation during testing, this phenomenon has not been fully understood. This study focuses on the utilization of an acoustic emission (AE) technique, which enables in-situ measurement of surface damage in materials. AE signals generated during rolling-slip tests using a twin-cylinder friction and wear tester were measured and analyzed, with comparisons made with the observed surface conditions. As a result, the AE envelope signal showed large burst-type responses and an increase in amplitude towards the end of the test, which correlated with changes in the surface condition of the specimen (Figure 1). Furthermore, an analysis of the frequency spectrum of AE signal waveforms and the change in the peak magnitudes (Figure 2) showed that the peak at a frequency below 0.1 MHz was associated with surface roughness, while the appearance of the peak in the 0.2 to 0.4 MHz frequency range was associated with plastic deformation and surface cracking (Figure 3), under different friction modes. Analyzing the changes in frequency spectrum of the AE signal waveforms is effective for evaluating the surface conditions during rolling contact fatigue tests, as these changes were not captured by a vibration sensor.

Keywords: tribology, acoustic emission, rolling contact fatigue, friction mode, steel material, frequency analysis.

References:

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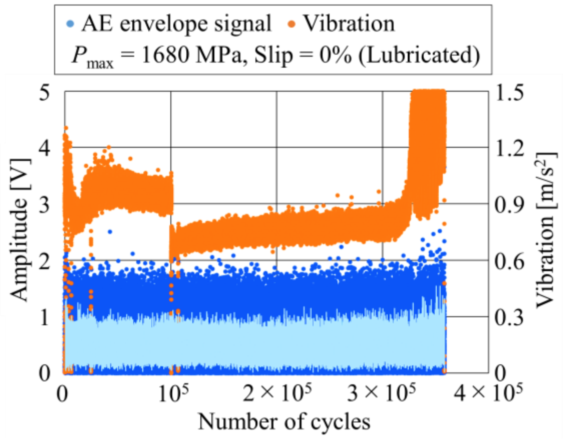

Figure 1: Comparison of the AE envelope signal and the vibration.

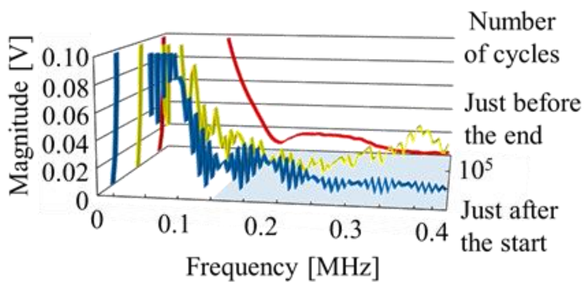

Figure 2: Change in the frequency spectrum of AE signal waveforms.

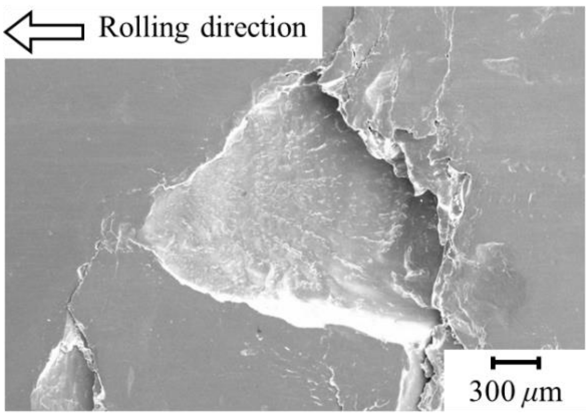

Figure 3: SEM observation of the specimen surface.

The effect of milling-induced surface topography on the tribological behavior of chromium-molybdenum alloyed steel.

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Abstract:

Surface topography plays a pivotal role in mechanical engineering, influencing the performance, reliability, and longevity of components across diverse applications [1]. Defined as the micro-geometry of a material's surface, surface topography encompasses parameters like roughness, waviness, and texture, which collectively determine how a surface interacts with its environment.

In engineering systems, the functional significance of surface topography is evident in areas such as tribology (friction, wear, and lubrication), fatigue resistance [2], and the ability of components to withstand corrosive or erosive environments. For instance, in tribological applications, surface roughness impacts friction coefficients and wear rates [3], while in fatigue-critical systems, the micro-topography can influence crack initiation and propagation. Surface texture also affects adhesion and contact mechanics, making it a critical factor in applications like seals and bearings.

Manufacturing processes such as milling, grinding, turning, and polishing are tailored to achieve specific surface characteristics suited to an application. Therefore, the main aim of this study was to analyze the effect of the disc surface topography after milling process on friction and wear resistance of steel surfaces in dry and lubricated conditions. Two types of tribological tests were carried out: in rotational and reciprocating motion. The discs were made of 42CrMo4 steel and its finishing treatment was milling process. Disc surfaces were characterized by different values of root mean square height of surface Sq from 0.35 to 5.95 µm. The frictional pairs also consisted of stationary balls made of tungsten carbide (WC) with a hardness of 72 ± 2 HRC.

Tribological tests in rotational movement were conducted using a tribological tester T-11 (Fig. 1) and in reciprocating motion using the Optimol SRV5 system (Fig. 2). Dry and lubricated sliding tests were carried out at room temperature (20–22 °C). Before and after tribological tests disc surfaces were measured by a white light interferometer Talysurf CCI Lite in order to determine the amount of wear. Friction coefficient of frictional couples was also calculated. It was found that the surface topography had a significant impact on tribological properties.

Keywords: wear, friction, milling process, surface topography.

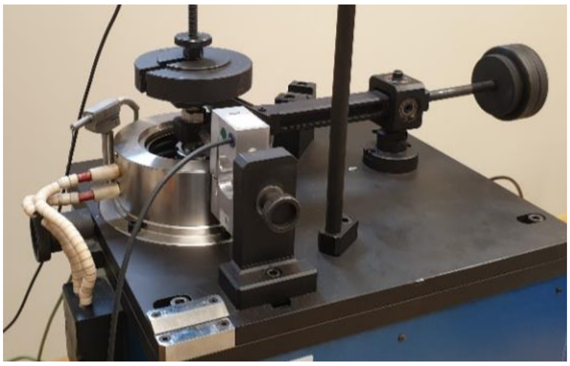

Figure 1: Tribological tester T-11.

Figure 2: Optimol SRV5 tester.

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Analyzing area roughness parameters of ground and superfinished components: toward the description of surface performance

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Abstract:
Surface roughness is crucial in automotive applications, affecting the efficiency, durability, and performance of components. The superfinishing process enables enhanced lubrication and reduced wear during operation, albeit the obtained surface quality cannot be properly represented using traditional linear roughness parameters. These conventional metrics provide a limited view of surface quality by failing to capture the complex texture characteristics, which are critical for tribological performance. The present study seeks to quantitatively describe the surface texture of ground and superfinished steel components through a multi-parametric approach. The analysis involved experimental trials and statistical studies investigating the influence of various process parameters on the resulting surface quality. Experimental evidence demonstrates that parameters derived from the Abbott-Firestone curve offer a comprehensive assessment of surface functionality and topographical features. The findings underscored that area roughness parameters provide a more functionally relevant representation of surface texture, effectively capturing the distinctive features created by grinding or superfinishing processes. Moreover, the proposed parameter combination has proven effective for assessing surface supply conditions and finishing quality, directly linked to associated process variables. This comprehensive characterization allows for a more accurate evaluation of the process quality and surface performance.

Keywords: machining processes, area roughness parameters, surface texture, material ratio curve

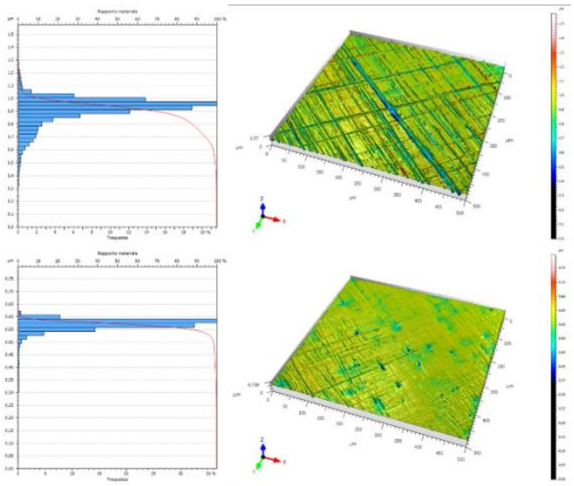

Figure 1: Comparison of 3D surface topography between the ground sample (top-right corner) and the superfinished sample (bottom-right corner), along with their respective material ratio curves.

References:

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Development of electrically conductive adhesive technology for the automotive industry

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Abstract:

Electrically conductive adhesives perform two important functions. They are special materials that are able to bond electrically conductive materials together with high strength while ensuring the conductivity of electric current. Technological advances in recent years have made these adhesives important in many industries, particularly in electronics and automotive, where weight reduction, miniaturization and cost efficiency of components have become a key concern, as well as simpler assembly processes and increased demands for environmental sustainability. To achieve this electrical conductivity, they contain electrically conductive metals and materials such as silver, copper, nickel or certain carbon-based materials such as graphite and carbon nanotubes. These metal particles are embedded in a binder matrix, mostly polymers, which are responsible for mechanical stability. The metal particles provide the electrical connection between the bonded surfaces, while the polymer matrix creates an adhesion bond between the surfaces, so that the material remains electrically conductive yet flexible and mechanically stable.

With the development of electric and hybrid vehicles, conductive adhesives offer new applications for the integration of battery connections and electrical systems. In the automotive industry, the use of lightweight and flexible connectors is an advantage, as they offer lower weight and easier application compared to conventional connectors.

In our research, we investigated a two-component epoxy adhesive containing silver flakes. A good electrically conductive adhesive bond requires that the metal particles are in good contact with the surfaces and each other. In addition, it should contain enough adhesive for strength. To optimize these conditions, the clamping force required to create the bond was investigated.

Keywords: electrically conductive adhesive, battery, adhesive bonding, clamping force, battery application.

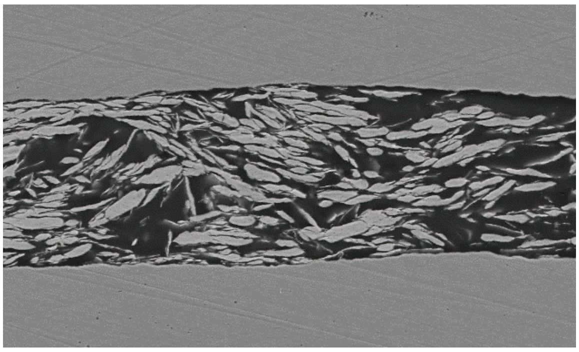

Figure 1: Scanning electron microscopy reveals the conductive particles and the adhesive material between them. The conductive grains barely touch each other under low clamping forces, so the conductivity of the bond remains low.

References:

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High speed and quasi-static tensile test of DP600 adhesive joints

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Abstract:
High-speed tests and experiments conducted at high strain rates have gained significant relevance in the technical domain over the past decades. The rate at which a material undergoes deformation directly influences its response to applied loads. Rapid deformation or a shorter time frame for the activation of natural deformation mechanisms often results in a material behavior that deviates significantly from that observed under static loading conditions. Consequently, the speed of deformation plays a critical role in determining both the material's response and its evolving properties, such as strain hardening. Dynamic compression and tensile testing frequently yield results across diverse testing machines and sample types. High-speed evaluations are also prevalent in applications such as stamping or advanced material characterization. Adhesive bonding has emerged as a popular alternative to traditional welding in recent years. This shift has sparked intensive research into the behavior of adhesive joints under impact conditions, with a particular focus on their performance in automotive applications. To compare the adhesive bonded DP600 steel, the focus was on understanding its fundamental mechanical properties under quasi-static loading conditions. The adhesively bonded steel plates were surface treated with a femtosecond laser, which produced LIPSS phenomena The results can offer insights into the material's performance in applications where gradual loading is predominant, such as structural components in automotive designs.

Keywords: surface treatment, surface wetting, high speed tensile test, quasi-static tensile test

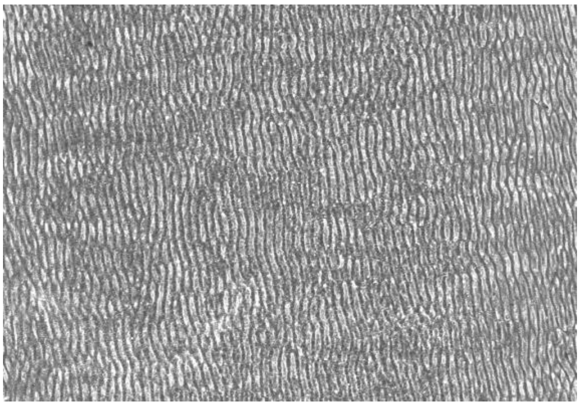

Figure 1: LIPSS on the DP600 steel surface of the bonded joints.

Increasing the Machinability of 3D Printed IN718 by Indigenously Developed Bimodal Reactive Nitride Coatings

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Abstract:
Inconel 718 (IN 718) is widely used in various aircraft industries due to its excellent mechanical properties. The machining of IN718 is difficult owing to its good mechanical properties and therefore comes under difficult to machine alloys. In the current research work, the end milling of IN718 fabricated by Laser Powdered Bed Fusion (LPBF) is done with two different types of multilayer coatings in a nanofluid assisted MQL environment. The cutting forces, surface roughness, tool wear, and cutting temperature were analyzed. The multilayer AlTiN/TiN/TiN coated cutting tool fabricated by combination of arc evaporation, pulsed direct current, and radio frequency sputtering showed promising results when compared with the AlTiN/TiN coating deposited by arc evaporation and radio frequency sputtering. There is a 19.44%, 31.92%, 44.73%, and 21.7% reduction in cutting forces, tool wear, surface roughness, and cutting temperature when AlTiN/TiN/TiN coated cutting tool is compared with the AlTiN/TiN coated cutting tool which shows the technology as a scope for future machining applications.

Keywords: Hybrid PVD coating, Laser Power Bed Fusion, Inconel 718.

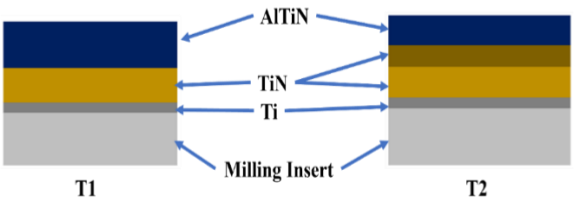

Figure 1: Deposition layer on cutting tool insert by hybrid PVD process

References:

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SICT 2025 Session II. A: Surface and coatings Characterization / Properties Multifunctional composite and hybrid coatings

Nanoporous/nanocomposite thin films by magnetron sputtering deposition in Helium: New materials and applications

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Abstract:
"Magnetron sputtering (MS)" is a widely used plasma assisted deposition technique for fabrication of thin films and coatings. A first objective of the work to be presented is the investigation of Helium introduction as process gas in MS. He ions irradiation (1-500 keV) and He plasma surface interaction have been widely investigated due to their technological interest related to damage in nuclear reactor materials. The formation of He filled high pressure nano-bubbles and porous fuzz structures have been widely reported as undesired damage effects. By using MS deposition in He atmospheres we aimed to transform the formation of defects (i.e. gas bubbles) in a solid matrix into an opportunity for the controlled fabrication of nanoporous/nanocomposite thin films. Results on the fabrication methodology and microstructure and composition characterization will be shown for the case of nanoporous Si, Co and Cu thin film coatings loaded with Helium. Applications arise from fundamental characteristics of these nanostructured films:

i) The high stability and the high amount of gases trapped in the matrix (e.g., up to 40 at% He for the amorphous silicon). Helium in a condensed state is trapped in pores dispersed over the entire thickness of the Si films. The films are being tested as ^{4}He and ^{3}He solid targets for nuclear reaction studies. These targets can overcome limitations of cryogenic or gas cell-based systems, which are bulky and difficult to handle [1].

ii) The nanocomposite character of the material which affects the properties as a whole. The reduction of the refractive index of the nanoporous vs. the dense films leads to tailored opticall properties and devices fabrication [2].

iii) The effect of the nanoporosity on the matrix itself. Typically for metals as Co and Cu, although the amount of trapped He is smaller, highly porous nanostructured films were obtained [3].

In summary the presented results will show an interdisciplinary and collaborative international research covering the synthesis, advanced characterization and application of functional thin film coatings prepared by magnetron sputtering deposition in Helium atmospheres.

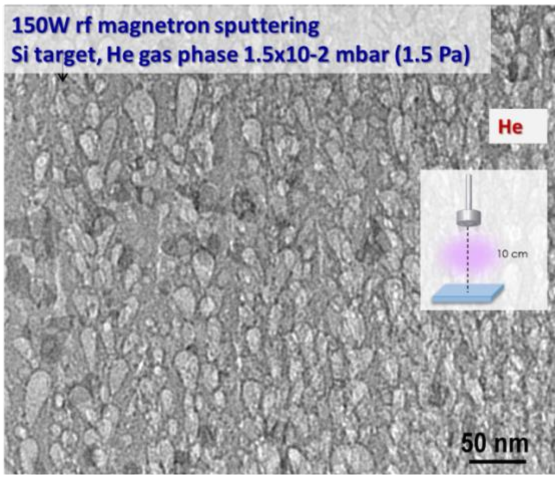

Figure 1: Transmission Electron Microscopy (TEM) image obtained for a Si film grown by MS in Helium. He-filled nanopores (nano-bubbles) are clearly indentified

Keywords: Magnetron sputtering of Si, Co and Cu in helium, He filled nanopores/nanobubbles, ^{4}He and ^{3}He charged thin films, microstructural characterization and IBA analysis, He solid targets for nuclear reactions studies, optical multilayer devices, nanoporous films.

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Next generation Surface Treatments to Preserve Buildings

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Abstract:

Alkoxysilanes are frequently employed for preserving building materials, such as concrete or stone. Their advantages are well-known: (i) they present a low viscosity that promotes their penetration in the porous structure of substrates and (ii) they polymerize spontaneously via sol-gel producing a material filling cracks, holes and pores of damaged substrates. A silica polymer with the capacity to bond with substrates' siliceous components is produced. Our research group has successfully developed innovative alkoxysilane-based solutions to preserve stone, concrete and other Cultural Heritage materials for 25 years[1]. Specifically, we developed an innovative inverse micelles mechanism route preventing gel cracking during drying[2], a well-known drawback of sol-gel processes[3]. Additional functionalities producing hydrophobicity, superhydrophobicity, antifouling or depolluting performance have been added to this strategy, giving rise to next generation surface treatments for buildings.

In the case of concrete, we achieved a significant breakthrough in terms of preservation because we successfully adapted our inverse micelles route to produce calcium silicate hydrates (C-S-H) gel, in situ, into the cracks of damaged concrete buildings. C-S-H gel is the main product of cement paste and responsible for the strength of cement-based materials, We demonstrated that C-S-H gel can be produced, instead of silica xerogel, by a simple reaction of alkoxysilane with Ca^{+2} ions existing in portlandite[4,5]. An additional functionality promoting superhydrophobicity on cementitious surfaces was also implemented. These two innovative synthesis routes are being currently up scaled at industrial level by the multinational SIKA, leader of building protection sector, as a previous stage for their worldwide commercialization.

Keywords: smart surfaces; self-cleaning; coatings; superhydrophobicity; concrete; C-S-H gel.

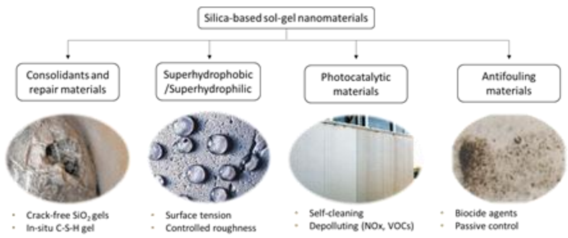

Figure: A summary of different performances of the next generation surface treatments.

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A new route to produce smart coatings with switchable superhydrophobic-superhydrophobic surface in response to metal ions and pH

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Abstract:
Surface modification with special wetting properties, such as superhydrophobicity and superhydrophilicity, is a common strategy to produce advanced materials with self-cleaning, antifouling, antifogging and oil-water separation performance, among others. Silane-based sol-gel coatings find widespread usage due to their ability to polymerize in situ and the facility of incorporating different functional groups. Superhydrophobic surfaces, however, are susceptible to non-polar contaminants and mechanical damage, which can lead to permanent loss of performance, while superhydrophilic ones resist organic fouling but do not protect from water-related decay. Smart surfaces with reversible wetting properties in response to external stimuli (e.g. Light, pH, magnetic and electrc fields) hav been proposed as a way to improve versatility and allow cleaning/recovery of the original properties.

We report a new sol-gel route to produce smart surfaces with reversible wetting properties in response to different stimuli, namely transition metal cations (Cu^{2+}, Ag^{+}, Zn^{2+}) and pH, by incorporating ethylenediamine functionalized nano-SiO_2 into an ormosil matrix. Metal chelation equilibria lead to a signifanctly faster transition to superhydrophilic compared to pH variations and occurs in milder conditions. Fabrics treated with the coating showed stain-resistant performance, underwater superoleophobicity and could be used as oil-water separation membranes, while the (superhydrophilic) metal-loaded surfaces showed excellent antimicrobial properties due to the low cell adhesion and biocide effect. The process is simple, scalable and can be applied at room temperature, and will serve as a starting point for the further development versatile multifunctional materials combining the advantages of superhydrophobic/philic surfaces while facilitating recovery of their properties after their contamination.

Keywords: Superhydrophobic, superhydrophilic, Smart surfaces, Coatings, Textile, Sol-gel, nanomaterials.

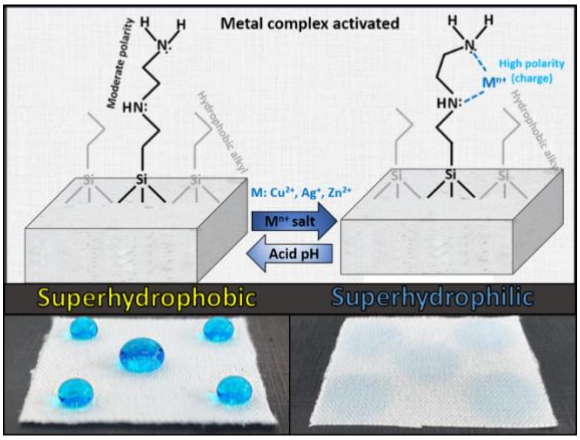

Figure: *(Top) proposed mechanism for the reversibility of superhydrophobic/superhydrophobic transition by response to metal ions and pH. (Bottom) Behavior of water doplets deposited on polyester fabric treated with the coating on its two different wetting states.*

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g-C_3N_4-TiO_2-SiO_2 nanocomposites for producing multifunctional building with hydrophobic, self-cleaning and depolluting properties

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[2]LSRE-LCM ALiCE, Faculdade de Engenharia, Universidade do Porto, Porto, Portugal
[3]Departamento de C. M., I. M. y Química Inorgánica, Universidad de Cádiz, Puerto Real, Spain

Abstract:
Research on nanotechnology has driven the development of innovative solutions for creating advanced functional building materials. A prime example is the incorporation of photocatalytic nanoparticles into building materials, enabling self-cleaning, depolluting, and self-sterilizing properties [1]. These properties preserve the aesthetic appeal of buildings and contribute to improved public health by purifying polluted air. Concurrently, significant effort is being invested in developing hydrophobic solutions to safeguard buildings from decay, as water-related processes are the primary cause of building deterioration [2]. Consequently, there is a strong focus on developing multifunctional construction materials that integrate multiple functionalities to create high-value, durable buildings.

This study focuses on the synthesis of a g-C_3N_4-TiO_2 hybrid photocatalyst to enhance visible-light activity and address the primary limitation of TiO_2 for outdoor applications: its exclusive UV-range absorption. The g-C_3N_4-TiO_2 photocatalyst was integrated into an alkoxysilane/alkylalkoxysilane sol, which was then applied by brush to cement mortar samples. The sol undergoes a spontaneous reaction, forming an organically modified silica (ormosil) xerogel that acts as a binder for the photocatalyst while simultaneously imparting hydrophobic properties to the substrate.

Characterization of the treated surfaces confirmed the formation of a well-adhered, homogeneous coating containing the photocatalyst with partial surface exposure. This resulted in a visible-light photoactive surface that demonstrated a 50% increase in methylene blue stain degradation compared to an equivalent TiO_2 coating (Figure 1a). The photoinduced superhydrophilicity effect of TiO_2 led to water contact angles below 10 degrees after UV-Vis irradiation, while the interior of substrate maintained hydrophobicity, reducing capillary water absorption by over 97%. This synergistic combination of wetting properties endows the material with excellent self-cleaning capabilities, enabling the removal of both polar and non-polar stains through simple water action. Furthermore, the photoactivity of the material also produces a depolluting effect, as demonstrated by NO photoelimination tests under UV-Vis irradiation.

These preliminary findings are highly promising, as the developed treatment can be easily applied in situ to buildings, enabling the creation of multifunctional surfaces with solar activity while providing protection against water damage.

Keywords: g-C_3N_4-TiO_2-SiO_2, functional surfaces, hydrophobic/superhydrophillic, self-cleaning, NO_x depolluting.

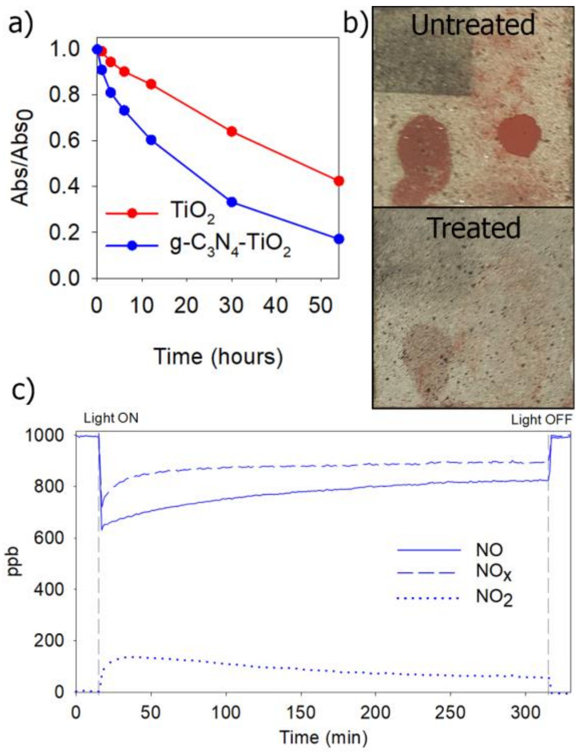

Figure 1: a) Methylene blue degradation, b) Self-cleaning effect and c) NO photoabatement.

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Fluorine-free Superhydrophobic Treatment for Textiles

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Abstract:

Superhydrophobic coatings are extensively utilized across various industries due to their remarkable ability to repel water and prevent its penetration. Fluorine-based compounds are a common choice for achieving this effect, as they effectively reduce surface tension. However, these compounds have notable drawbacks, including environmental pollution, bioaccumulation in the human body, and poor recyclability, driving the demand for alternative solutions. This study presents the development of a flexible, breathable, and superhydrophobic treatment synthesized through a simple, eco-friendly, low-cost, and highly efficient process. The treatment is designed for broad applications on textiles such as cotton, polyester, and nylon.

Our research group has developed a low viscosity sol incorporating two alkoxysilanes with complementary roles: propyltriethoxysilane, which enhances hydrophobicity, and (3-aminopropyl)triethoxysilane, which improves adhesion of modified nanoparticles on fabric surfaces. Additionally, silica-based nanoparticles functionalized with hydrophobic groups are included to achieve a Cassie-Baxter state by creating a hierarchical surface roughness.

The treatment, applied to fabrics via dip-coating, brushing, or spraying, creates a superhydrophobic surface with a water contact angle exceeding 150° and a hysteresis below 10°. The treated fabrics demonstrate durability, withstanding multiple washing and abrasion tests, making them suitable for various applications, including stain resistance, self-cleaning, water ingress prevention, and oil/water separation. Furthermore, has no adverse effect on the textiles physical properties of cotton, polyester and nylon fabric, such as the strength, air permeability, and flexibility.

Keywords: Superhydrophobic; Coatings; self-cleaning; smart surfaces; Textiles.

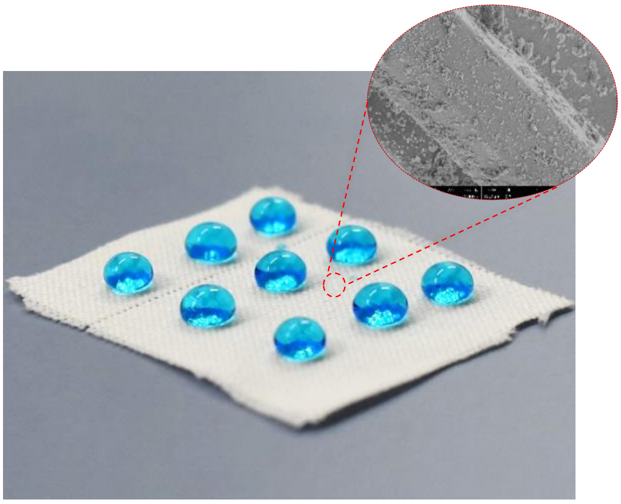

Figure: *Methylene blue water droplets on polyester specimen treated with the superhydrophobic treatment. The inset shows a treated polyester fiber.*

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Expanding Transparent Covalently Attached Liquid-like Surfaces for Icephobic Coatings with Broad Substrate Compatibility

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Abstract:
Ice accretion poses significant energy losses and safety issues across various sectors. Recent studies have shown that liquid-like surfaces (LLS) with ice-shedding properties can be generated through the covalent attachment of linear polymer chains onto smooth substrates bearing sufficiently high hydroxyl group densities. [1-3] To widen the substrate scope for LLS generation, a novel system utilizing non-halogenated organosilanes attached to a commercial epoxy-silicon (EpSi) coating is proposed and investigated. The EpSi coating acts as a smooth intermediate layer (R_a = 0.94 nm and R_q = 0.76 nm) and is modified with air plasma to increase hydroxyl group density. Immersion in non-halogenated organosilanes then forms a substrate with covalently attached polymer chains, generating an LLS. The resulting coating demonstrates low contact angle hysteresis (CAH < 10°), sliding angle (SA < 14°), and ice adhesion strength (τ_{ice} < 20 kPa). Scanning electron microscopy confirms the formation of smooth surfaces while dynamic CA, SA, and adhesion strength measurements verify LLS formation independent of the substrate type, coating thickness, and application method. The durable coating retains its slippery properties after exposure to harsh conditions of icing/deicing and heating cycles, organic solvents, and acid treatment. The coating is also highly transparent (Tave = 84.5%, t = 500 μm) with self-cleaning and anti-staining properties. The proposed methodology broadens the substrate scope of LLS, offering a sustainable route for ice accretion challenges.

Keywords: contact angle, low hysteresis, slippery behavior, anti-icing, self-cleaning, transparent coatings.

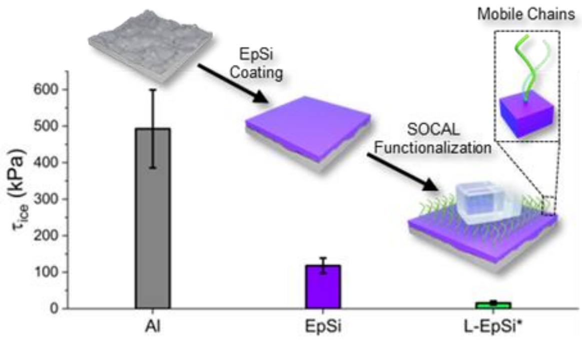

Figure 1: Figure illustrates the novel approach used in this study to create liquid-like slippery surfaces (LLS) on various substrates. The method involves the application of an epoxy-silicon (EpSi) coating on different substrates using various facile methods, followed by air plasma activation, and immersion in an organosilane solution, forming covalently attached siloxane chains. The resulting LLS demonstrates ultra-low ice adhesion strength while retaining high transparency, self-cleaning, and anti-staining properties.

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Development of nanocomposite coatings to enhance leather surface properties

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Abstract:

Leather is one of the oldest natural materials used by humans. After submitting the animal hide to chemical treatment, the so-called tanning, leather presents extraordinary durability, breathability, and flexibility, as well as an appreciated patina that develops when leather ages. These properties explain why natural leather is used in a broad range of applications, going from high-quality footwear and clothes to fashion accessories, car seats, or sofas.

However, the presence of hydroxyl, amine, and carboxylic groups from collagen makes the leather water permeable and vulnerable to staining, particularly with everyday products like coffee, juices, or tea.

The simplest way to solve the problem of water permeability and susceptibility to staining by water-based fluids is to coat the leather surface with a hydrophobic material. In this context, fluorocarbon-based chemicals impart the best hydrophobic and oleophobic properties to the surfaces. However, their production, application, and disposal raised serious health and environmental concerns, and these chemicals were removed from the market. To replace fluorocarbons, researchers started investigating safer and more environmentally friendly technologies.

In this work, we describe the development and testing of a hydrophobic and self-cleaning leather surface treatment. In the initial stage of the process, the leather is coated with nano-silica functionalized with a silane coupling agent. In the second stage, a long-chain alkyl compound is applied to reduce the surface energy. This combination provides hydrophobicity to the leather surface, as evidenced by water contact angles (WCAs) of approximately 120°, Figure 1. SEM/EDS and FTIR analysis proved the presence of the silane coatings. The application of several coating layers further increased the WCA, and the abrasion tests demonstrated that the hydrophobic properties are maintained even after 50 abrasion cycles. Stain repellency proved to be excellent for tea and coffee, even after a 10-minute contact with the fluids.

In conclusion, we developed a simple, two-step chemical treatment to impart hydrophobicity and stain resistance to leather. The leather coating doesn't change the leather's appearance, even with light colors, and it presents good resistance to abrasion.

Keywords: leather; water repellency; surface functionalization; coating; silica

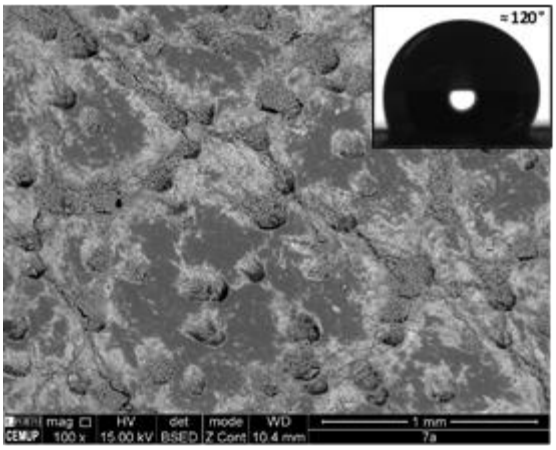

Figure 1: SEM image of the modified leather surface and the associated WCA.

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Surface engineering of stainless steel for dairy fouling management

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Abstract:
In food processing industries, products and especially dairy products undergo thermal treatments (pasteurization, sterilization) leading to fouling formation on heat exchangers' surfaces. These deposits can contaminate dairy products during pasteurization process and also impair heat transfer mechanism by creating a thermal resistance, thus leading to regular shut down of the processes. Therefore, periodic and drastic cleaning-in-place (CIP) procedures are implemented. These CIP involve the use of chemicals and high amount of water, thus increasing environmental burden. It has been estimated that 80% of production costs are owed to dairy fouling deposit.
To reduce dairy fouling, two pathways have been considered: (i) Process conditions optimization, mainly tested by food-processing industries and (ii) Stainless steel surface anti-fouling or fouling-release coating to either inhibit attachment of depositing species or to ease their removal during cleaning respectively.
In our team, we focus on this latter approach by developing biomimetic antifouling coatings, including slippery liquid infused surfaces, bi-layer atmospheric plasma coatings and amphiphilic coatings. These latter will be presented during this conference. The coating was formed by modifying an RTV silicone with a PEO-silane amphiphile comprised of a PEO segment and flexible siloxane tether ([(EtO)3Si-(CH2)2- oligodimethylsiloxane$_m$-block-(OCH2CH2)n-OCH3]). Contact angle analysis of the coating revealed that the PEO segments were able to migrate to the aqueous interface. The PEO-modified silicone coating applied to pretreated stainless steel was exceptionally resistant to fouling. After five cycles of pasteurization, these coated substrata showed no fouling. A heat exchanger plate was the coated and exposed to milk fouling, and outstanding anti-fouling results were obtained (Figure 1). PEO-modified silicone coatings also showed exceptional resistance to adhesion by foodborne pathogenic bacteria. A Life Cycle Analysis was carried out, showing a drastic decrease of environmental impact in presence of the coating. Finally, a new way to overcome a use of a CMR primer, i.e the design of self-stratified amphiphilic coatings will be presented. A complementary approach, consisting in developing self-stratified self-healing coatings, in which amphiphiles could be added to provide a multifunctional coating, will also be briefly presented.

Keywords: antifouling coating, dairy products, food processing, amphiphilic coatings, self-stratification, life cycle analysis

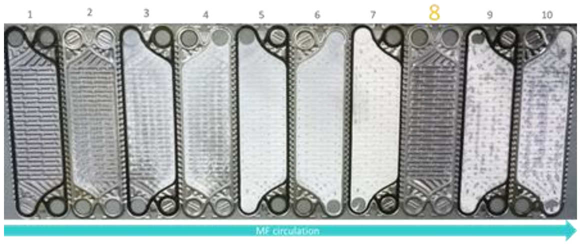

Figure 1: Figure illustrating the anti-fouling activity of the amphiphilic coating applied on the heat exchanger plate n°8, that is less fouled than its neighbours plate 7 and 9, showing the efficiency of the treatment.

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Study and evaluation at low temperature of base formulations of icephobic coatings for aeronautical applications.

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Abstract:

Aircraft icing has been widely recognized as a severe weather hazard to flight safety in cold climates, since the ice accretion on aircraft surfaces alters the flight aerodynamics, reducing lift and increasing weight and drag, thus leading to dangerous stall conditions with a temporary or permanent loss of control of the aircraft. Currently, active Ice Protection Systems (IPS) requiring energy are being employed, either to prevent icing (anti-icing) or to remove it (de-icing). These active IPS entail an increase in construction complexity and weight, in manufacturing and management costs together with an increase of the on-board power consumption, and then of the CO2 emissions. While active methods rely on energy input from an external system for the anti-/de-icing operations, passive methods take advantage of the physical properties of the airframe surfaces, such as the low wettability and surface free energy, to prevent, delay, or reduce the permanence of water and then of the ice accretion. Therefore, a combination of active IPS with passive superhydrophobic or icephobic coatings could be helpful in reducing the energy demand from active IPS.

In this contest the Italian Aerospace Research Centre (CIRA) in collaboration with the University of Naples Federico II has been studying polymeric base formulations to be used as matrices for icephobic coatings characterized by a low Surface Free Energy (SFE) and low roughness, in order to delay the ice formation and avoid the ice to be clung to the treated surface. These polymeric base formulations have been tested at low temperature using an experimental and innovative set-up designed and developed at CIRA, able to achieve temperature down to -20°C, so measuring the contact angle and freezing delay time at temperature and humidity controlled. Both silicon-epoxy hybrid, crosslinked with different functionalized hardeners, and cross-linkable fluoropolymers, have been investigated as polymeric base formulations. Preliminary results have demonstrated the effective capability of these formulations to delay the ice formation.

Future work will be focused on further developments of these formulations aiming to improve their durability and reduce the ice adhesion strength.

Keywords: icephobic coatings, anti-icing, surface free energy, low temperature, aeronautical applications, contact angle, freezing delay time.

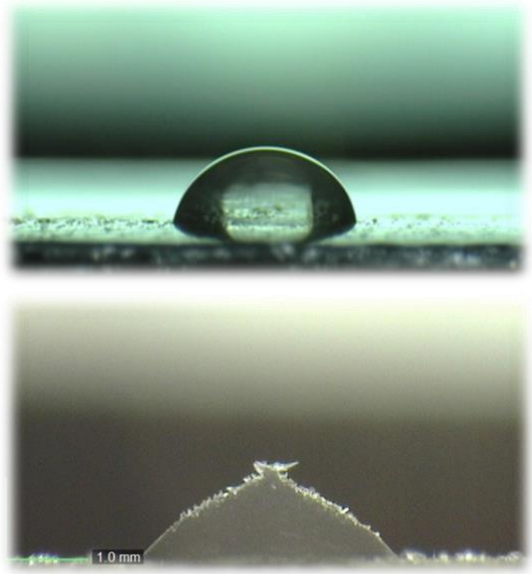

Figure 1: Pictures of unfrozen (up) and frozen (down) water droplet at -10°C.

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Multi-functional Fusion Bonded Epoxy Coatings: UV resistant and Anti-Corrosion performance in marine environment

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Abstract:
Fusion-bonded epoxy (FBE) coatings are widely used in industries like oil, gas, and infrastructure to protect steel components from corrosion, offering strong adhesion and durability through a fusion bonding process [1-3]. However, they can be susceptible to chipping under mechanical stress and UV degradation when exposed to sunlight. To enhance UV resistance, researchers reinforce FBE coatings with stabilizers like hindered amine light stabilizers (HALS), UV absorbers (UVA), and nanoparticles such as TiO_2 and ZnO. Inorganic UV absorbers are generally more stable and durable than organic ones, providing extended protection. TiO_2, in particular, offers high UV resistance, stability, and cost-effectiveness.The target of the current investigation is to develop the UV resistant fusion bonded epoxy (FBE) coatings by reinforcing the hybrid UV resistant nanocomposites based on the TiO_2 nanoparticles and hindered amine stabilizers (HALs) in different feed ratio. The developed FBE nanocomposite coatings will be thoroughly characterized using the different structural and surface analytical tools. Adhesion strength of the obtained FBE coatings will be checked to evaluate the influence of incorporated HALs/TiO_2 composite materials on the bonding ability of FBE coatings on steel specimens. Electrochemical corrosion tests will be performed using the electrochemical impedance spectroscopic (EIS) and potentiodynamic polarization measurements during the 30 days of immersion in NaCl medium. The effective execution of this possible plan will enable us to develop these materials locally as the only step left would be to apply them for the protection of steel structures in real exposure condition (of course, after passing all required testing to be used in real exposures to the marine environment).

Keywords: FBE Coatings; UV resistant; Corrosion; HALs; TiO_2

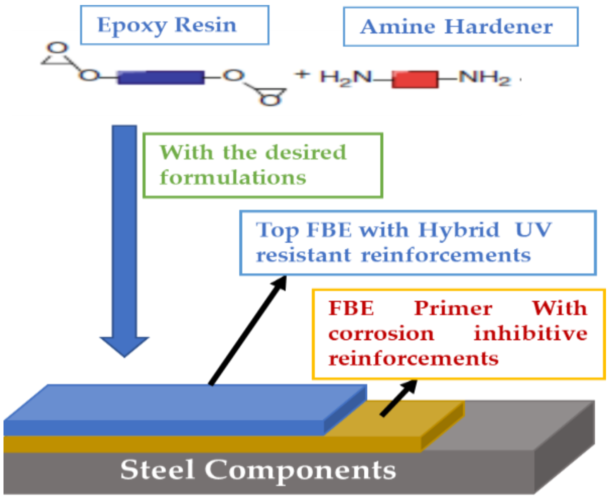

Figure 1: Figure illustrating the schematic representation of the current research work

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New Approach for Evaluating Surface Heterogeneity in Nanostructured Coatings

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Abstract:
Randomly nanostructured surfaces with micro- and nanoscale roughness exhibit remarkable wetting properties, achieving contact angles exceeding 150° and demonstrating pronounced superphobicity. These characteristics make them highly suitable for applications such as self-cleaning, anti-icing, and corrosion-resistant coatings [1]. However, the inherent heterogeneity of nanostructured surfaces complicates the achievement of uniform wettability, posing challenges for applications that require consistent and controlled surface performance.

To assess surface uniformity, this study presents an innovative and fast method based on contact angle measurements of a sessile liquid drop with progressively decreasing surface tension over time. In particular, aqueous mixtures of propylene glycol (PG) at 10% were used as liquid test. PG has a lower vapor pressure (0,07 mmHg) and a lower surface tension (36,1 mN/m) than water (23,8 mmHg, 72,8 mN/m). Consequently, as a sessile droplet of water/PG mixture evaporates over time on a superhydrophobic surface, it becomes enriched with the less volatile component, causing a gradual decrease in surface tension. Upon reaching a critical surface tension that enables the liquid to penetrate the surface nanostructure [2], a shift in contact angle occurs, leading to a transition in the wetting state from the superphobic Cassie-Baxter state to the philic Wenzel state (Figure 1).

To evaluate this method, a randomly nanostructured superhydrophobic carbon nanoparticles coating, produced via in-flame harvesting was used as coating test [3]. Different areas of these surfaces were tested to determine, for each zone, the critical surface tension at which the wetting transition occurs. In cases of surface heterogeneity, these tests revealed different values of critical surface tension across different regions, providing valuable insights into local nanostructure variations. Thus, wettability tests have the potential to serve as a standard method for the preliminary and rapid characterization of nanostructured superhydrophobic surface uniformity.

Keywords: Superhydrophobic Materials, Coating Characterization, Wettability Analysis, Wetting transition.

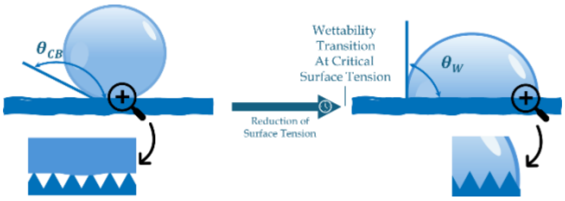

Figure 1: Illustration of wetting transition from superphobic Cassie-Baxter state to a philic Wenzel state occurs at a critical surface tension.

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Carbon Nanoparticles at Liquid Interface: An investigation on different surface functionalization processes with Pendant Drop Tensiometry

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Abstract:
Carbon nanoparticles (CNPs) are combustion by-products that, despite their environmental and health concerns, can be transformed into smart materials thanks to their unique structures, with applications in catalysis, energy storage, electrochemical sensing, advanced composites, and environmental remediation. Their suitability for these applications depends on their surface chemistry, which can be tailored through specific surface functionalization processes. The latter enhance interactions with other substances, allowing CNPs to modify the interfacial properties of liquids, which can be also useful for suspensions, emulsions, and foams stabilization. In this study, CNPs are produced by using a McKenna burner operating with a premixed ethylene/air flame, where flame conditions influence their morphology and size. High-rich flame conditions are selected to produce superhydrophobic fractal aggregates (~100 nm), which are subsequently functionalized with various chemical-physical treatments. To investigate how functionalized and non-functionalized CNPs modify interfacial properties, surface and interfacial tension of CNP-doped droplets are measured with a Pendant Drop Tensiometer, under both static and dynamic regimes. CNPs are initially homogenously suspended in a solvent and then they are directly placed at the liquid interface of a pendant drop using a syringe. In static experiments, surface tension is monitored over time to assess CNPs activity at the interface, while dynamic experiments, involving periodic droplet volume variations, are performed to investigate viscoelastic interfacial properties. This study provides insights into optimizing CNP surface functionalization for improved interfacial performances, broadening their applicability across various technological fields.

Keywords: Carbon Nanoparticles, Pendant drop, Interfacial Rheology, Surface functionalization, Particles at liquid interface.

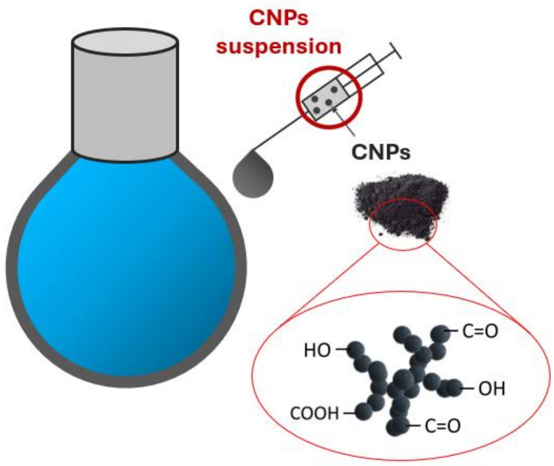

Figure 1: Cartoon representing the technique used to deposit a CNPs suspension at the droplet interface. A sketch of the fractal Carbon Nanoparticle is shown.

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SICT 2025 - FreeMe project workshop on safe and sustainable coatings

Self-Activating Sprayable Resins for Toxic-Free Plating on Plastics

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Abstract:
Plating on plastics (PoP) is a crucial process in current industrial practice. Indeed, PoP combines the advantages of polymers (low weight, reduced cost and flexibility) with those typical of metals (aesthetic appearance, wear resistance, high electrical or thermal conductivity and ferromagnetic behavior). As a consequence, PoP is used in a wealth of applicative fields: automotive, electronics, home goods production and fashion.

Current state-of-the-art PoP processes for ABS, the most widely used material, and other polymers are based on the use of toxic or scarcely available materials [1]. The etching step, required to enhance the adhesion between the polymer and the metal, relies on the use of highly toxic Cr(VI) species. The activation step, on the other side, makes use of Pd, which is a rare metal included in the EU list for critical raw materials.

In the perspective of safe and sustainable by design approaches, the FreeMe European project aims at eliminating both Cr(VI) and Pd from the PoP procedure, making it compliant to the REACH regulation. In the context of the FreeMe project, the present work describes the development of sprayable resins additivated with suitable metallic precursors. Such materials, due to the presence of the precursor itself, are characterized by a self-activating behavior, which avoids the use of etching and activation. Self-activating materials has been implemented in the electroless metallization of 3D printing structures [2]. The resins here described, however, can be directly sprayed on ABS substrates and the precursor can be reduced to the metallic state by immersion in a reducing agent. The metallic nuclei resulting from the reduction process activate the electroless deposition process of NiP, resulting in a uniform coating of metal (Figure 1). Alongside NiP, also Cu can be electroless plated in a similar way and this is demonstrated by selecting a suitable metal precursor added to the resin and a proper electroless plating bath (Figure 2). The resulting layer, made of either NiP or Cu, are characterized in order to evaluate their uniformity, morphology, phase composition and adhesion.

Keywords: plating on plastics, electroless metallization, sprayable resins, self-activating, toxic-free.

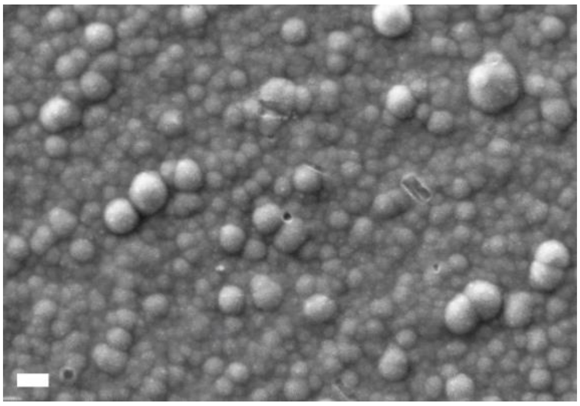

Figure 1: continuous layer of NiP deposited on the surface of a resin containing a nickel precursor (scale bar = 1 µm).

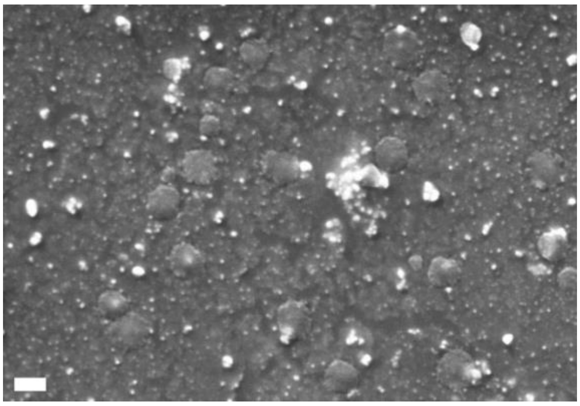

Figure 2: Cu nuclei formed after reduction on the surface of a resin loaded with a copper precursor (scale bar = 1 µm).

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Synthesis of Bio-Based Thermosetting Resins for Advanced Composite Applications in Plating on Plastics (PoP) Processes

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Abstract:
It is, nowadays, well known that research on bio-based and sustainable materials and processes can offer eco-friendly alternatives to petroleum-derived analogues. The polymer industry has also been moving in this direction over the last few decades. This work investigates the synthesis of biomass derived thermosetting resins and their application in Plating on Plastics (PoP) processes. The utilization of sugar derived monomers such as isosorbide and itaconic acid is being explored for the synthesis of epoxy and epoxy-acrylate resins. The produced resins were characterized using NMR and FTIR analysis techniques in order to identify the successful addition of epoxy groups and/or the modification of the latter to acrylate groups. The properties of crosslinked resins were evaluated by means of DSC, TGA, DMA and FTIR and were compared to the respective conventional BPA based epoxy resin, cured under same conditions. It was evident that the bio-based thermosetting resins demonstrate comparable performance to BPA-analogues. Moreover, the incorporation of nickel chloride into the resin revealed their potential in functional coatings and composite applications. Our results highlight the applicability of bio-based composite resins in Plating on Plastics industry overcoming environmental concerns of the conventional process related to the use of hexavalent chromium baths in the etching process and the use of Palladium in the activation step[1].

Keywords: biomass valorization, bio-based composites, bio-based coatings, epoxy resins, plating on plastics.

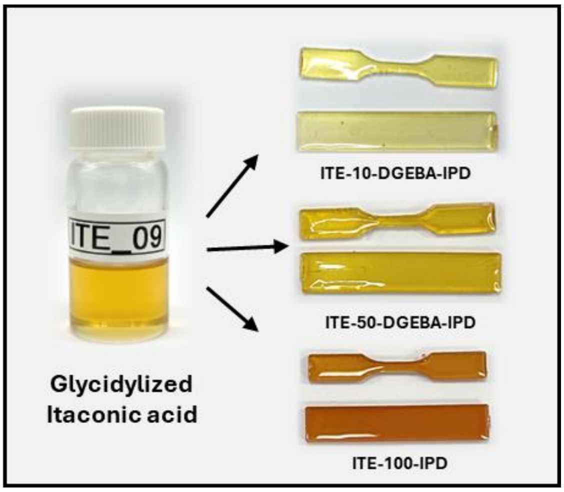

Figure 1: Product of glycidylation reaction of itaconic acid and cured epoxy polymers.

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A process optimization tool for emerging Plating on Plastics Processes

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Abstract:
This work includes the development of a Decision Support Tool (DST) for the design of a novel Plating on Plastics (PoP) technology. As an alternative to the toxic Cr^{6+} and rare Pd elements used in PoP industry, this work provides a modelling approach for the optimization and upscaling of a TRL5 technology, which uses REACH compliant materials. The new PoP technology effectively replaces Cr^{6+} with piranha (H_2O_2-H_2SO_4) for the etching and Pd with Ni salts for the activation of the plastic surface.
The 4-stage process includes: (1) Etching of the plastic substrate (ABS) with piranha solutions; (2) Activation of the etched surface with Ni^{2+} to create the preliminary ionic sites; (3) Reduction of the Ni^{2+} ions to metallic Ni^0 sites for downstream metallization; and (4) Ni-P electroless metallization of the pretreated surface. In this path, the design of etching and activation steps are critical to ensure necessary surface properties (specifications), like Adhesion of the metal coating on the plastic surface. Based on a big set of experimental data for all 4 processing stages, an analysis of the various phenomena taking place in the etching and activation stages has been performed to structure the conceptual framework of a new model that estimates plastic surface parameters after each stage.
The mathematical model involves kinetic-based and property estimation models and has been verified by the provided experimental data over a wide range of operating conditions, for piranha solution 1:4–1:10 (H2O2:H2SO4), Ni salts 1-10 gr/lt and operation times 5-240 minutes. The mathematical model of the PoP technology includes:

- The etching kinetics for the estimation of consumed H2O2 as a function of the piranha solution and the etching time.
- The Contact Angle (CA) property estimation model of the etched plastic as a function of the piranha concentration and the etching time.
- The surface concentration of hydroxyl groups after the etching procedure as a function of the measured CA.
- The CA of the activated surface as a function of the CA before activation and the Ni salts concentration (CA reflects the xydroxyls concentrations before/after activation).
- Data generated by the previous model revealed an additional relationship between the adsorbed Ni on surface and its concentration in the solution that was effectively (R^2>0.98) fitted by a Langmuir model.
- A relationship has been identified between the surface concentration of nickel sites and the adhesion after metallization spread around the sites.

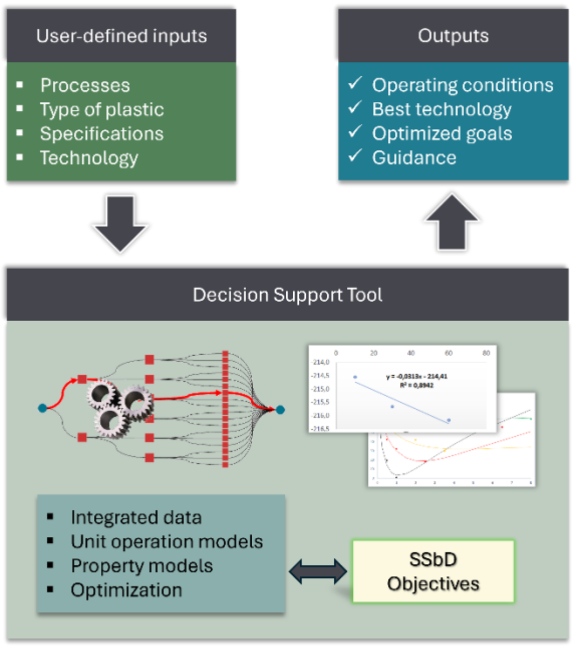

Figure 1: Representation of the input-outputs of FreeMe DST tool.

The above mathematical model has been stated under an objective function, which uses a linear approach including SSbD parameters and operation variables as follows:

$$SSbD_{obj} = w_1 \cdot (a_{econ} \cdot F_{materials}) + w_2 \cdot (b_{envi} \cdot G_{materials}) + w_3 \cdot (c_{safe} \cdot H_{materials})$$

where w_1, w_2, w_3 are the weights [0,1] for each criterion; a, b, c are parameters respectively reflecting the economic, environmental and safety criteria expressed as techno-economic or LCA indicators per unit (e.g. kg of used materials); and F, G, H are variables reflecting the materials flows used/consumed.

The inputs required for the use of the DST include the items' dimensions, the production capacity, and the baths' volumes (optional), as well as the specification of the coating as required by the end-user (e.g. Adhesion >2.5 MPa). The DST returns the best baths concentrations (piranha and Ni salts solutions), the etching processing time and, optionally, the optimal volumes for baths, when referring to new shops. The tool has been formulated as an optimization NLP model that optimizes the process design variables ensuring highest SSbD performance either in the form of individual or combined (weighted) criteria.

The DST tool is planned to be available online offering access to stakeholders for testing and getting introduced into its capabilities. The model identifies optimal operation regions guiding the plating shop at everyday planning of the design (qualification) of baths and production (number and type of items), and it be linked with monitoring systems, for real-time process analysis and baths management of the shop's everyday operations.

Keywords: Plating on Plastics, Process Design, ABS, Etching, Activation, Optimization, Modeling, Decision Support Tool

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A Multiscale Model for the Etching Mechanism of a Piranha Solution on an ABS Substrate

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Abstract:
Advanced simulations and in-silico modelling are pivotal in supporting experimental research for developing environmentally friendly metallisation processes for polymers.

The FREEME project is focused on two key processes: the adhesion between an epoxy resin and polymeric substrates and the etching process obtained through the interaction between a piranha solution and polymeric substrates. Several simulation approaches have covered both processes and, in particular, the etching of an ABS substrate was explored in depth through a multi-scale computational approach covering DFT, Molecular Dynamics and Monte Carlo simulations.
Specifically, DFT calculations were performed using NWChem [1] to uncover reaction mechanisms for the monomers of ABS—acrylonitrile, butadiene, and styrene—in the presence of the piranha solution. Each reaction step was simulated to identify transition states, calculate activation energies, and determine kinetic constants, allowing detailed reaction coordinate diagrams to be constructed. Additionally, Molecular Dynamics simulations were performed using the ReaxFF force field in LAMMPS [2][3][4], adopting the "molecular gun" method [5], in which the molecules of piranha solution interact with an ABS surface. This approach enabled the study of MSD, diffusion coefficient, penetration depth of the piranha solution, mass loss of ABS, and the evolution of chemical species throughout the simulation. Finally, Monte Carlo simulations [6] were used to model the oxidation evolution of the ABS surface during the etching process, enabling the analysis of surface energy changes post-oxidation. This comprehensive multi-scale approach offers valuable insight into the etching mechanisms described, which are crucial for developing Cr^{6+}- and Pd-free metallisation techniques for plastics.
The presented findings contribute to optimising environmentally sustainable metallisation processes by providing a deeper understanding of the underlying molecular interactions.

Keywords: Molecular Dynamics, etching, ABS, piranha solution, ReaxFF, Ab Initio calculations, DFT, Monte Carlo, metallisation of polymers.

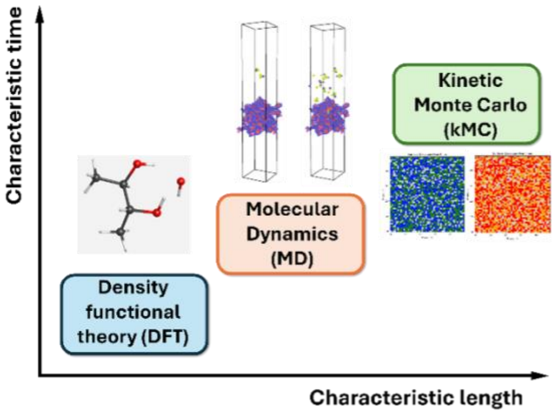

Figure 1: Multi-scale simulation framework employed in the research of the etching process.

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Boosting the Research and Development of Safe and Sustainable-by-Design Ni-Based Materials for Energy Applications

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Abstract:
Platinum-group metals (PGMs) are the benchmark for high-performance materials in energy applications due to their unique physico-chemical properties. However, their high cost, scarcity, and environmental impact drive the search for more sustainable alternatives. Nickel-based materials have emerged as promising candidates for replacing PGMs in key energy conversion and storage applications, such as hydrogen evolution reaction (HER) catalysts for water electro-lysis,[1] oxygen reduction reaction (ORR) catalysts for fuel cells, and advanced magnetic materials integrated in energy-efficient magnetic storage devices,[2] among others. In each case the application of sustainable-by-design (SSbD) approach can be employed from the early stages of materials development ensuring that environmental impact, resource efficiency, and end-of-life considerations are integrated into the fabrication process, leading to scalable and eco-friendly solutions.

The application of various SSbD tools for the fabrication of Ni-based catalysts for HER, one of the key use cases, will be demonstrated in more detail. The focus will will be put on the optimization of the electrodeposition process of high-performance catalysts while ensuring resource efficiency and minimal waste generation. From lab-scale synthesis to pilot-scale production, key fabrication parameters are refined to maintain catalytic activity and durability. To support and accelerate the development process, additional tools such as machine learning models based on active learning approach were implemented to guide experimental work towards optimal material compositions.[1] The electrodeposition process upscale has been successfully realized employing a computer aided engineering strategy that was used to design and configure plating tank components. The experimental results demonstrate that the HER activity of obtained Ni-based electrodes is comparable to that of conventional Pt-based catalysts. Finally, comprehensive assessments, including Life Cycle Assessment and Life Cycle Cost analysis, have been conducted to evaluate environmental and economic hotspots throughout the fabrication process. This work highlights the potential of Ni-based coatings to enable cost-effective and scalable energy solutions while reducing the reliance on PGMs and aligning with Sustainability Goals.

Keywords: SSbD, water electrolysis, catalyst for HER, nickel, nickel alloys.

Acknowledgements: Funded by the European Union under the GA number 101058076 - NICKEFFECT project. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Health and Digital Executive Agency (HaDEA). Neither the European Union nor HaDEA can be held responsible for them.

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Title: Production of thermally sprayed HEBM High-Entropy Alloy coatings

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Abstract:

The goal of Cobrain project is to replace conventional coating solutions based on the use of critical materials, which means hazardous materials and/or large demand materials such as Co based alloys or hardmetals, or carcinogenic hexavalent chromium used in the production of electroplated hard chrome. For those reasons, the development of new material combinations combining some elements in near-equimolar proportions, will allow to produce new High-Entropy Alloys (HEAs), reaching improved properties. The presentation will provide an overview on the optimization and microstructural characterization of different HEBM HEA powders and coatings developed in the project though HEBM process. Novel formulations for wear- and corrosion-resistant coatings based on HEAs have been developed and coatings have been obtained by different thermal spray techniques.

Keywords: HEBM; High Entropy Alloys; Coatings; Cold Gas Spray

SICT 2025 / Plasma Tech 2025 Joint session II. B:
Bio-interfaces, Biomedical / Bioactive surfaces and coatings Plasma applications for biology, medicine, and agriculture

Changes in morphology and physiology of carrot calli in relation to selected plasma treatment

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Abstract:

Non-equilibrium low temperature plasmas exhibit a rich reactive chemistry, enabling a diverse range of applications. However, with the growing necessity for developing non-equilibrium atmospheric pressure plasma (APP) sources, the effort to tailor plasma chemistry has reached new heights, presenting also its own set of challenges.

The next challenge is related to the composition and chemistry involved in targeted treatments, which are crucial for advancing new field of plasma applications such as Plasma Agriculture [1]. Reactive oxygen and nitrogen species (RONS) like excited oxygen (O_2), nitrogen (N_2), atomic oxygen (O), singlet oxygen ($^1O_2$), superoxide anion (O_2^-), ozone (O_3), H_2O^+, OH^-, OH• radicals, hydrogen peroxide (H_2O_2), atomic nitrogen (N), and nitric oxide (NO•) are particularly important. Moreover, the complexity increases when considering the treatment of liquids, as it necessitates understanding both the gas-phase plasma chemistry and the chemical kinetics at the gas-liquid interface and within liquid targets [2-4]. Currently, there exists a multitude of different APP sources, each proven effective in their respective applications, yet lacking a direct comparison framework. Here we will present the evaluation of APP treatment effects on plant calli, accounting for both plasma and biological sample aspects.

We have used two types of APP treatment of plant calli: treatments in gas phase and treatments of milli Q deonized water for production of Plasma Activated Water. During treatments in gas phase plant cells were in direct contact with plasma (i.e. influenced by short- and long-lived reactive oxygen and nitrogen species. And in case of application of PAW to plant calli only long-lived species interacted with cells.

Carrot (Daucus carota subsp. sativus) serves as a model system with well-characterized physiology and sequenced genome, widely used in the pharmaceutical industry. In the experiments we have used three varieties of *Daucus carota* and the metabolic status of APP-treated calli was determined at various cultivation time points. Antioxidant enzyme activities such as peroxidases (POX), catalases (CAT), and superoxide dismutases (SOD) were assessed, as well as, the total phenolic content (TPC) and total flavonoid content (TFC) of calli methanol extracts.

The primary objective was to analyze the morphological and physiological characteristics of plant calli subjected to varying APP treatments, specifically different gas-phase chemistries. Also, by using different varieties of *Daucus carota* species we have analysed investigated the influence of the variety on the treatment results.

Keywords: atmospheric pressure plasma, plasma activated water, plant calli, plasma agriculture, biotechnology.

Acknowledgments: This work was supported by the SF (7739780, APPer-TAin-BIOM) and by MSTDI, Republic of Serbia (Grants 451-03-66/2024-03/200024, 451-03-65/2024-03/ 200007).

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Tannic acid-assisted green in situ reduction of antimicrobial silver nanoparticles on clinoptilolite surface

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Abstract:
Natural zeolites are widely investigated and used for their remarkable adsorption capacity for toxic compounds, reducing airborne pathogens and ensuring clean air. Among them, clinoptilolite has gained attention in wastewater treatment and air purification [1]. Moreover, the functionalization of zeolites with antimicrobial nanoparticles can improve their pathogen removal capabilities.

In this work, clinoptilolite powders were functionalized with metallic silver nanoparticles (AgNPs) to impart an antimicrobial effect, using a green approach. The process involved the *in situ* reduction of AgNPs on the surface of the zeolites using tannic acid (TA) as an eco-friendly reducing agent. The multi-step functionalization process was characterized using Fourier transform infrared (FTIR), field emission scanning-transmission electron microscopy (FESEM, STEM, TEM) equipped with an energy dispersive X-ray spectroscopy (EDS), elemental mapping, and X-ray diffraction analysis (XRD); the absorption properties were also tested through BET analysis and the antibacterial effect was verified by the zone of inhibition and bioaerosol contamination tests.

The FTIR investigation confirms the effective functionalization of clinoptilolite powders with tannic acid; the morphological and compositional analyses demonstrate the presence of Ag-containing NPs on the surface of zeolite and XRD analyses verified the presence of metallic silver. The functionalized clinoptilolite shows antibacterial efficacy towards both Gram-positive and negative strains (Figure 1).

Thus, the eco-friendly process of functionalizing clinoptilolite with AgNPs presents a promising approach to develop natural zeolite able to adsorb toxic compounds and effectively prevent the growth of pathogens [2].

Keywords: clinoptilolite; surface functionalization; silver nanoparticles; green process; antimicrobial.

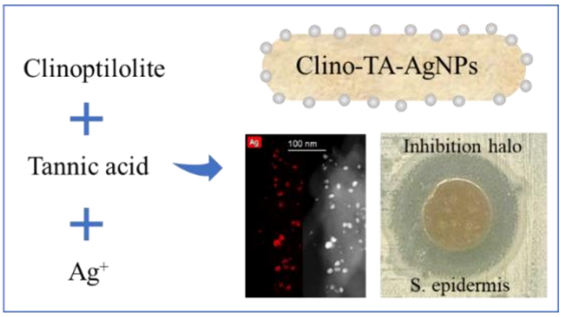

Figure 1: Figure shows the process of functionalization of clinoptilolite with tannic acid and silver to obtain nanoparticles with antimicrobial properties.

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Surface-designed biocidal TiO_2-based nanohybrids for enhanced photocatalytic and antimicrobial activity

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Abstract:
Biofouling on surfaces poses a significant global challenge, directly and indirectly impacting critical societal infrastructures across various sectors, including marine operations (e.g., shipping, fisheries, aquaculture, desalination units), onshore and offshore renewable energy systems, and the food and beverage industry. A common issue in these sectors is the spontaneous colonization of microorganisms on surfaces, which leads to biofilm formation. Biofilms are major contributors to premature material degradation, particularly Microbially Influenced Corrosion, responsible for up to 20% of corrosion in aqueous systems, incurring billions of dollars in rehabilitation costs, and the spread of waterborne diseases, threatening industrial sustainability and public health. Conventional decontamination strategies often rely on releasing toxic biocides into aquatic environments, raising ecological concerns under EU Regulation No. 528/2010 and limiting their long-term effectiveness. Addressing these challenges, this study [1] introduces a novel nanohybrid material, TiO_2-NCO/E, synthesized by grafting the Econea® biocide onto TiO_2 *anatase* nanoparticles. A comprehensive suite of methodologies was employed to characterize its physicochemical structure, composition, morphology, optical properties, and stability. Furthermore, the photocatalytic and antimicrobial properties of this nanohybrid material were evaluated. The new TiO_2-NCO/E (0.5 g/L) exhibited improved photocatalytic performance, with a notable 78% increase in a methylene blue degradation kinetic rate under visible (450 nm) light compared to pristine TiO_2, associated with its increased dye adsorption capacity. Additionally, it effectively inhibited the growth of Gram-positive and Gram-negative pathogens in both dark and UV-A light conditions, showcasing significant antimicrobial activity (Figure 1). Mechanistic studies revealed that the TiO_2-NCO/E targets bacterial cell membranes and induces metabolic changes and oxidative stress in bacteria. In addition, insights into the morphology and biophysical changes on inactivated methicillin-resistant *S. aureus* (MRSA) and *V. cholerae* bacteria following treatment with the TiO_2-NCO/E reveal synergistic antimicrobial effects from the biocide and TiO_2.
This study highlights the potential of tailored TiO2-based nanomaterials functionality, demonstrating their effectiveness in water decontamination, through enhanced pollutant degradation and antimicrobial activity while paving the way for further advancements in nanotechnology.

Keywords: Waterborne contaminants, grafted biocide, anatase, visible light photocatalysis, antibacterial mechanisms of action

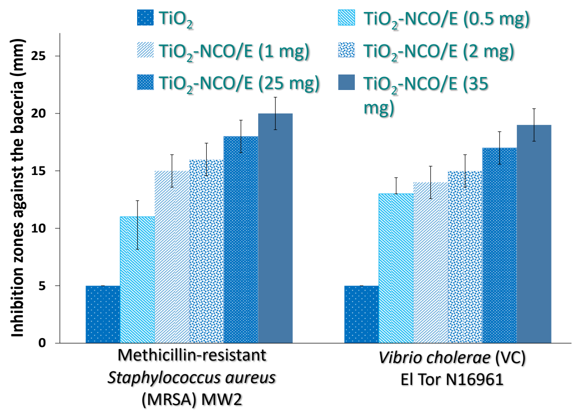

Figure 1: Antimicrobial susceptibility of TiO_2-based materials against two pathogenic bacteria (one Gram-positive and one Gram-negative) expressed by inhibition zones.

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Sputtered deposition and laser structuration of multimetallic thin films for antibacterial/antiviral applications

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Abstract:
Due to the recent pandemic situation, the development of biocidal surfaces was a main topic of scientific research during last years in a wide range of application fields (aerotonautics, medecine, environment etc.) [1]. To date, two ways are well-known to limit the microorganisms proliferation or induce their destruction [2] : the first one is the destruction by chemical means with the use of metallic elements such as silver, copper, zinc etc. (release killing). The second way is the mechanical damage caused to the membranes by the roughness of the surfaces (contact killing). This last process highly depends on the scale of the patterns formed at the surface as compared to the microorganism size [3].

In this study we aim at combining these two mechanisms in multimetallic thin films whose surfaces are structured by laser to enhanced the antibacterical and antivirus properties.

First step of this work was the elaboration of thin films by magnetron sputtering allowing the simultaneous deposition of five metallic elements whose proportions can be ajusted to optimize the biocidal activity along with other properties (chemical stability, mechanical resistance, abrasion resistance). The laser treatment was carried out using a Stsuma femtosecond laser (350fs) at 1030 nm with a frequency of 100 kHz.

The structure, the morphology and the composition of the films were studied by different techniques (SEM, AFM, XPS, RBS). A routine antibacterial test was used to perform a first screening of the samples before validation using standardized protocols. In an attempt to separate chemical from physical effect, mesurements of the metal ion release level were carried out using IC-OES (Iductively Coupled Optical Emission Spectroscopy).

First results showed that dense, amorphous and flat layers tend to hinder the antibacterial properties. We will compare the antibicrobial activity of the surfaces before and after laser treatment to conclude about the influence of the morphology on the destruction of pathogens.

Keywords: antimicrobial surfaces, sputtering deposition, multimetallic films, laser-matter interaction, Laser-Induced Periodic Surface Structure, biocide activity.

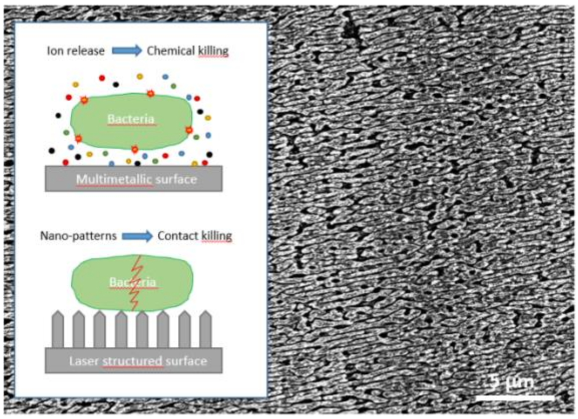

Figure 1: SEM image of a quinary multimetallic thin film surface after structuration by pulsed laser treatment in order to promote the killing of bacteria by physical interation; and schematics of the two well-known ways of pathogens destruction

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A Fluidized Bed Approach to Nonthermal Plasma Inactivation of Foodborne Pathogens in Presence of Low Water Content

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Abstract:

Nonthermal plasma (NTP) microbial inactivation has been investigated over the last decade, showing promising results and as an alternative technology to conventional heat treatments in food. Nevertheless, NTP technology can be considered a superficial treatment[1], which can limit its efficiency. This limitation can affect inactivation in food products with small sizes and low bulk weight such as powders, grains, seeds, etc. Therefore, to increase its effectiveness, a lab-scale NTP fluidized bed was developed, consisting of a glass cylinder (bed) with electrodes inside and outside (Figure 1). Food products with low water content are generally not subjected to any microbial inactivation process as they are considered microbiological safe. Nevertheless, food pathogens can survive and even increase their resistance under low water activity[2]. In this study, expanded Polystyrene (EPS) beads were used as a model system to mimic products with low water activity. *Listeria monocytogenes* and *Salmonella* Typhimurium inactivation, as well as DNA and cell membrane integrity, were investigated by fluidizing EPS beads with argon and air at 6 and 0.2 L/min for 30, 40 and 60 min below 50 ºC. Final reductions of 3.0 and 4.2 log CFU/cm^2 were found for *L. monocytogenes* and *S.* Typhimurium, respectively. Cell membrane was damaged for both microorganisms while DNA damage was observed only for *L. monocytogenes* from 30 minutes of treatment onward. This study demonstrates the potential of this novel technology for food decontamination at mild temperatures.

Keywords: nonthermal plasma, plasma inactivation, fluidized bed, novel technology, food pathogens, thermal resistance, food products, low water activity.

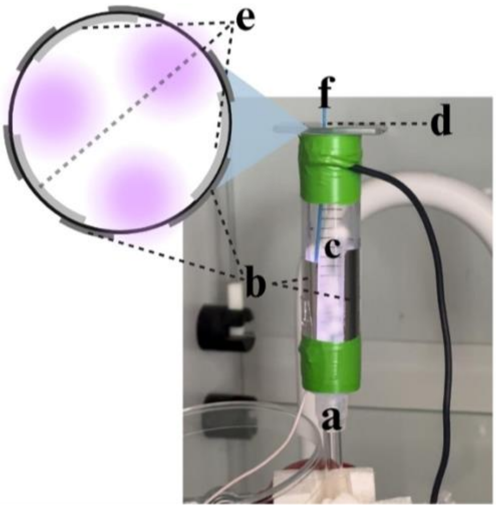

Figure 1: Figure illustrating the lab scale NTP fluidized bed (⌀: 3.0 cm, height: 12.0 cm) working at a frequency between 14.0 and 15.0 kHz and an input power ≤ 6.9 W. a) gas input, b) outside electrode, c) fluidized beads, d) temperature sensor, e) inside electrode, f) gas outflow through a filter.

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Synergistic Antibacterial Effect of Photoactivated, Plasma-Synthesised Copper Oxide and Zinc Oxide Nanoparticles

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Abstract:
Excessive antibiotic consumption causes the emergence of resistant pathogens, prompting the need for alternative antibacterial strategies. Recent studies highlight the potential of metal oxide nanoparticles, such as copper oxide (CuO) and zinc oxide (ZnO), which demonstrate enhanced antibacterial activity when photoactivated[1]. In this study, CuO and ZnO nanoparticles were synthesized using a non-equilibrium plasma process. The lab-scale synthesis system was adapted from Kozak et al. (2016). A custom set-up was developed to induce plasma for nanoparticle synthesis through reactive species like photons, electrons, radicals, and ions[2].This method yielded either pure metal oxide nanoparticles (CuO or ZnO) or nanoparticles consisting of a combination of CuO and ZnO. The goal of this study was to compare the antibacterial efficacy of the pure and combined nanoparticles. The photocatalytic performance of these nanoparticles was tested in the dark and under uniform white light exposure using a novel set-up based on the principle of an integrating sphere (Figure 1). The light intensity was measured to be ~3.7 klux. Four pathogenic bacterial strains were tested: *Escherichia coli* O157:H7, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Enterobacter cloacae*. The antibacterial effect of the nanoparticles against the four strains was compared by determining the Minimum Bactericidal Concentrations (MBC), i.e., the lowest tested concentration that causes 3-log bacterial inactivation within 24 h. Although CuO and ZnO had the same MBC for the most resistant pathogen (22.5 mg/L for *E. cloacae*), ZnO had 2-4 times lower MBC values than CuO for the more susceptible pathogens, making ZnO overall more antibacterial than CuO. Notably, combining CuO and ZnO had a synergistic effect against all pathogens with an MBC value that was 8 times lower for the most resistant pathogen compared to separate CuO or ZnO nanoparticles. This study underlines the antimicrobial efficacy of photoactivated, plasma-synthesised nanoparticles based on CuO and ZnO against bacterial pathogens. Specifically, this work revealed the strong synergistic antibacterial effect that arises when CuO and ZnO are combined in nanoparticles.

Keywords:
Metal nanoparticles, non-equilibrium plasma, photocatalytic activity, antibiotic resistant strains, minimum bactericidal concentration

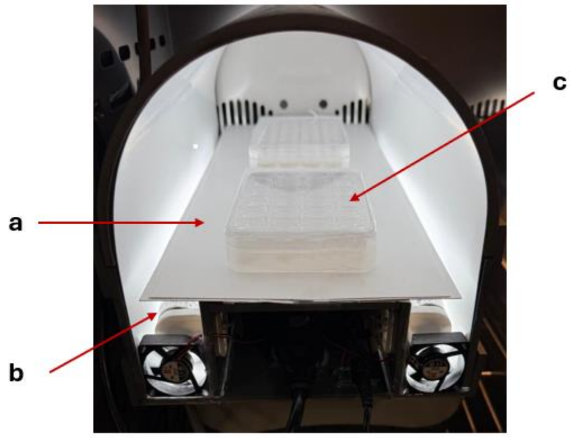

Figure 1. Light set-up: (a) interior surfaces with reflective McPET, (b) fluorescent D65 lamps and (c) 24-well plates with bacterial samples.

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Design and Development of a Non-Thermal Plasma based Handheld Device for Sterilisation of Surfaces in Spacecraft Applications

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Abstract:
Future space expedition missions demand efficient and safe sterilisation techniques necessitated by the planetary protection protocols for crewed and uncrewed mission flights. Non-Thermal Plasma (NTP) based technique offers excellent sterilisation capabilities and addresses the limitations of conventional chemical and/or heat based methods. The inactivation of microbial cells by NTP is owing to the synergistic action by its components viz, free radicals, ions, UV radiations etc., and are found to be effective for surface applications. This work is a UKSA funded project which explores the use of NTP for surface sterilisation in space applications, focusing on the design, development and testing of a handheld NTP sterilisation system. The proposed system consists of a Plasma Power Driver System (PPDS) and a Handheld Plasma Sterilisation Reactor (HPSR) which is intended for treating heat sensitive surfaces without producing any chemical byproducts. The PPDS is a variable high voltage high frequency power supply employing two-stage amplification and the necessary instrumentations for monitoring electrical operating parameters. The HPSR utilizes a surface dielectric barrier discharge configuration having an alumina sheet as the dielectric layer. A disk type circular copper electrode of 34 mm diameter and a 0.5 mm thick alumina disk are used as the high voltage electrode and dielectric layer respectively. A porous circular disk made of nickel is used as the ground electrode. The PPDS and HPSR are designed and fabricated to operate in a plug and play fashion and the plasma generation is tested at varying operating parameters. The homogenous plasma generation in the HPSR is verified visually as well as by monitoring the discharge current and charge-voltage Lissajous plots. The efficiency of this system in sterilizing microbially contaminated surfaces is experimentally analysed by exposing gram-positive and gram-negative bacterial cells and spores to the NTP. A sinusoidal applied voltage of 7.5 kVpp at 5 kHz frequency was used in the experiments while treating monolayer microbes. Experiments are conducted with HPSR kept at a fixed airgap of 2 mm from the glass slide contaminated with a diluted and known quantity of cultures of *Escherichia coli* and *Bacillus subtilis*. Various time periods of NTP treatment from 1 minute to 45 minutes were undertaken and the plasma treated samples were incubated for 24 hours. The viable cells in the plasma exposed spread plates are counted and compared with those in the control plates to calculate the log reduction obtained using NTP sterilisation method. A maximum log reduction of 2.23log and 3.2log and 1.10log were obtained for *E.coli* and *B.subtilis cells and B.Subtilis* spores treated for 45 minutes with NTP generated by the HPSR at the expense of a plasma discharge power of 5-6 W. A non-portable system used as the control HPSR could attain 4.20log reduction on *B.Subtilis* spores in 30 minutes. An optimised HPSR proves to be a viable option for sterilizing heat sensitive surfaces used in spacecrafts.

Keywords: non-thermal plasma, surface sterilisation, dielectric barrier discharge, gram-positive and gram-negative bacteria, log reduction.

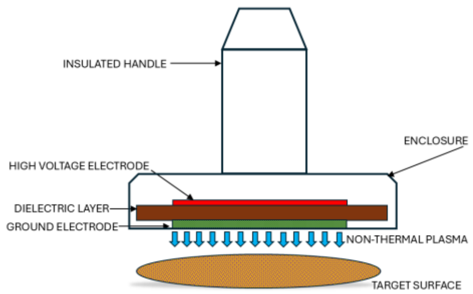

Figure 1: Figure illustrating the basic schematic of sterilization method using a surface DBD reactor

References:

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CAP-generated RONS disrupt leukemia cells' function by mitochondria-related damage

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Abstract:
Cold Atmospheric Plasma (CAP) offers a versatile approach to cancer therapy, with applications harnessing the controlled generation of reactive oxygen and nitrogen species (RONS) to target biological samples, such as cancer cells, selectively. Therefore, CAP can affect the molecular mechanisms and cellular pathways in malicious cells, leading to the development of potential anti-cancer therapy.
Our study investigates CAP's effects on human leukemia cells (K562) compared to the normal cell lines (HDF, HUVEC), focusing on the influence of exposure parameters on therapeutic efficacy. The viability of normal cell lines was unperturbed by CAP treatment, whereas the leukemia cells' viability and proliferation potential decreased spectacularly. It was probably caused by decreased catalase activity in K562. CAP-generated RONS accumulated in the malignant cells and disrupted mitochondrial function, leading to oxidative stress that culminates in apoptotic cell death. The findings highlight that direct CAP application results in more significant immediate cytotoxicity than indirect methods, although both modalities induce lasting anti-cancer effects. Observed CAP treatments propagated apoptotic pathways in leukemia cells, ultimately contributing to the deterioration of the cell nucleus and formation of apoptotic bodies.
This study underscores CAP's potential in selective targeting of cancer cells while sparing healthy tissue, presenting a promising strategy for future cancer therapies — these insights open pathways for optimising CAP parameters to enhance efficacy and safety in clinical applications.

Keywords: Cold Atmospheric Plasma, leukemia, oxidative stress, cancer therapy, mitochondrial damage, apoptosis.

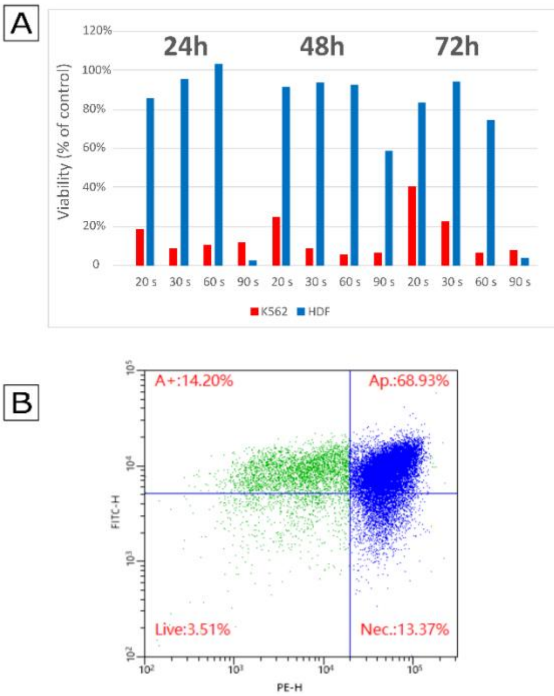

Figure 1: Effects of CAP treatment on leukemia cells.
A) The viability of K562 (red) decreases significantly in comparison to HDF viability (blue). **B)** Flow cytometry results for K562 cells displaying living cells/apoptosis/necrosis ratio.

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SICT 2025 / Plasma Tech 2025 Joint Session II. C:
Plasma fundamentals / Modelling / Atomic and Molecular Processes
Plasma Processing / Materials Interactions / Coatings

Plasma devices for surface treatment – specific applications

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Abstract:
A large panel of plasma devices has been designed over the years to address different fields of applications.
This communication focuses on novel devices for surface treatment, particularly for metal deposition, surface heating, improvement of surface reflectivity or conductivity, and optics cleaning. All these plasmas operate at low or very low pressure and *in situ*.

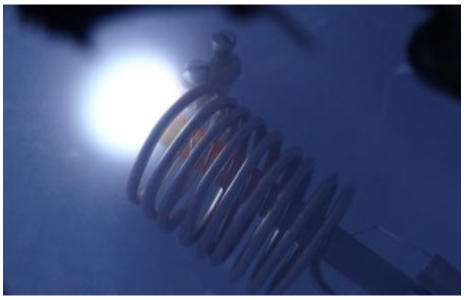

Figure 1: Operation view of the Solid Positive Thruster (SPoT) [1].

The device initially called SPoT (Solid Positive Thruster) was designed as a solid propellant ion thruster. As a (quasi-)fully ionized metal source, it is very effective for coatings under a high vacuum since it is gridless and electrostatically confined by forming a spherical virtual cathode (**Fig. 1**). SPoT operates in direct current (DC) at high voltage (~500 V) and high current (~1 A) but also in pulsed mode (>3 kV, >3 A).

The low-pressure surface heating of grounded metallic surfaces can be performed by a specifically designed linear Radio-Frequency (RF) Cylindrical Capacitive Coupled Discharge (CCCD), producing a linear and energetic plasma slab. It works in noble and molecular gases (argon and nitrogen) within a large pressure range (0.8 - 50 mbar) and RF power (100 – 3000 W). The fastest heating condition increases the surface temperature beyond 600°C within 1s exposure to plasma (**Fig. 2**) [2].

Powder surfaces sometimes have very specific properties compared to the bulk material. Metal powder can be highly reflective of light, while its electrical resistivity can increase by several orders of magnitude, even for metals. This is critical in powder-bed additive manufacturing for laser sintering of reflecting powders (Au, Ag, Cu, …) or electron-beam melting when the powder is superficially oxidized. Applying an ultra-thin film (< 50 nm) on the outermost surface can drastically change the powder properties. The light absorption can be increased from 1% to 40% using a sacrificial layer, and the conductivity can be increased using a conductive layer [3].

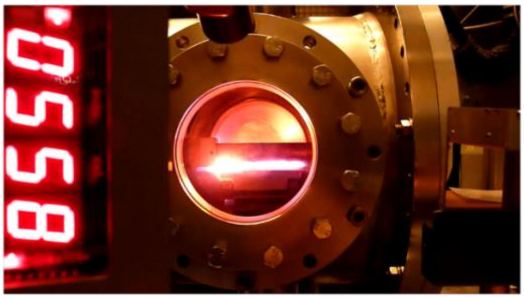

Figure 2: Operation view of plasma heating linear discharge with the indication of the surface temperature (left side) [2].

Finally, the last application is *in situ* window cleaning after metalization during an industrial process. A specific plasma device placed at atmospheric pressure (or under vacuum) can produce a low-pressure plasma that allows the window to recover 99% of its transmittance [4].

Keywords: plasma devices, low pressure, ion deposition, surface heating, enhanced electrical conductivity of surface, enhanced surface absorbance, surface cleaning.

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Advanced Spatio-Temporal Modulation Control of Induction Thermal Plasma Fields for High-Rate Production of Nanomaterials

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Abstract:

The significance of nanoparticles in a variety of technological applications, including electronics, biomedicine, energy storage, and environmental engineering, is attributable to their distinctive physicochemical properties. To address the escalating demand, there is an imperative to devise methods that facilitate high-throughput, scalable nanoparticle synthesis. Our research has led to the development of a highly efficient method, combining Tandem Modulated Induction Thermal Plasma (Tandem-MITP) with Time-Controlled Feeding of Feedstock (TCFF), achieving significant improvements in nanoparticle production rates and size control [1-4].

Tandem-MITP is distinguished by its incorporation of two independently controlled coils for a single plasma torch, a design that enhances the system's robustness against perturbations from high-load feedstock feeding while facilitating spatio-temporal modulation of the thermal plasma. Tandem-MITP maintains a stable thermal environment in the upper coil region while inducing rapid thermal modulation in the lower coil region, thereby optimizing feedstock vaporization and subsequent nucleation during the cooling phase. The integration of TCFF ensures synchronized, intermittent feedstock injection, thereby further refining nanoparticle growth dynamics. Experimental results have demonstrated that this approach enables the high-yield production of various nanomaterials, including Al^{3+}-doped TiO_2 (400 g/h), Fe^{3+}-doped TiO_2 (720 g/h), and Si nanoparticles (330 g/h). This approach achieves superior throughput compared to conventional techniques.

Further advancements were realized through the investigation of modulation waveforms for the coil currents (rectangular, triangular, saw-tooth, etc), where rectangular waveform modulation was found to yield smaller nanoparticles due to enhanced rapid cooling downstream of the plasma torch. Furtheremore, the introduction of strategically placed additional flanges in the reaction chamber has significantly enhanced entrainment gas flow, leading to increased nucleation rates and further boosting production efficiency. Numerical simulations corroborate experimental findings, revealing that modulated thermal fields combined with optimized entrainment flows drastically influence nanoparticle formation dynamics.

Machine learning techniques have been employed to determine optimal plasma operation conditions, facilitating precise control over thermofluid flow patterns [5,6]. Leveraging predictive modeling, we have successfully identified configurations that maximize production rates while maintaining narrow particle size distributions. These advancements provide a pathway toward large-scale, customizable nanoparticle synthesis with unprecedented efficiency.

This study introduces an advanced approach to nanoparticle synthesis using modulated induction thermal plasma technology, incorporating spatio-temporal plasma control, waveform-dependent modulation, and adaptive entrainment strategies. These findings contribute to the ongoing development of scalable nanomaterial production and open new possibilities for further innovations in plasma-driven material synthesis, with promising potential for industrial-scale applications.

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Bipolar HiPIMS Discharges: Principles, Diagnostics, and Thin Film Deposition Strategies

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Abstract:
The properties of thin films depend on their microstructure, crystal structure, and residual stress, which are influenced by the mobility of adatoms during the growth. In magnetron sputtering, deposition conditions can be adjusted to modify film properties, often by applying a bias voltage to induce ion bombardment that enhances adatom mobility and film densification. High-power impulse magnetron sputtering (HiPIMS) offers greater control by delivering high-power density pulses, producing a high fraction of ionized species and enhanced ion bombardment, even without a substrate bias. However, a bias voltage may still be needed to control low-energy ions. Recently, bipolar HiPIMS, where a positive voltage pulse follows the main negative voltage pulse, has been suggested to be used instead of a substrate bias voltage. The idea is based on "plasma biasing", where instead of decreasing the substrate potential, the plasma potential is increased to create the plasma-substrate potential difference necessary for ion acceleration towards the substrate.

This presentation summarizes our research on bipolar HiPIMS. Plasma analyses using the Langmuir probe and mass spectroscopy revealed that plasma parameters evolve similarly regardless of positive pulse parameters or distance from the target, though their values differ. During the initial phase of the positive pulse, a large potential difference (up to 200 V), high electron temperature (up to 150 eV), and a significant drop in electron density were observed. After this part, the difference between the potentials and the electron temperature is low. The time-averaged spectra of ions exhibit a prominent high-energy peak. It is shown that the position of the peak can be varied by the positive pulse amplitude, its magnitude scales with the pulse length and its width can be slightly influenced by the length of the delay interval.

Considering the results of the plasma analyses, we propose utilization of chopped bipolar HiPIMS to enhance energy flux to insulating surfaces. These conditions feature several short positive pulses replacing a single long positive pulse. The total energy fluxes are subsequently measured using a passive thermal probe. Moreover, the effect of the probe's capacitance with respect to the ground is systematically investigated by connecting an external capacitor. Results show that for an insulated surface with low capacitance, bipolar pulse configurations do not significantly increase energy flux to the surface due to its rapid charging by plasma ions. Conversely, high surface capacitance facilitates an increase in energy flux, as a large potential difference between the plasma and the surface remains even for a long positive pulse. For medium surface capacitance (tens of nF), chopping the positive pulse in bipolar HiPIMS effectively increases the energy delivered to the film by discharging the surface in the off-times.

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HIPIMS Sputtering for Thin Film Deposition for Applications

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Abstract:
High Power Impulse Magnetron Sputtering (HIPIMS) is being implemented in applications ranging from hard and decorative coatings to semiconductor devices. The dynamic high-power density plasma environment of the HIPIMS discharge gives rise to a high degree of freedom and associated free energy in the system and creates particles in several metal ionisation states and reactive gas atomic and molecular states. As adatoms, the particles determine the grain size, crystallographic orientation and overall density of the growing films, imparting performance enhancements in several applications. Recently, the constant current HIPIMS discharge has been used to deposit TiN films with excellent plasmonic properties. The pulse duration was used to tailor the plasma environment from gas-rich to metal-rich state, with increases in strain, grain size and toughness and clear (111) preferred orientation, whilst maintaining a strong metallic behaviour [1] at long wavelengths with high negative dielectric permittivity and presence of high-energy electrons.

Utilising reverse pulse approaches with HIPIMS, has allowed highly insulating SiO_2 films to be deposited in a controlled process [2]. The reverse voltage applied immediately after the pulse was most efficient in reducing arc damage and enabling Si ion dominated flux to the substrates, low microscopic roughness, high transparency, and high hardness to be achieved.

Nanoscale multilayer coatings of CrN/NbN have been synthesised to resist high-temperature oxidation in superheated steam environments. The density of the coating provided an effective barrier to oxygen diffusion and brought enhancements in fatigue behaviour of the P92 substrates under low-cycle testing [3].

CrAlYN/CrN nanoscale multilayer coatings deposited on nitrided H13 tool steel forge dies provided effective thermal insulation and protection against thermomechanical fatigue, cracking and pick-up when forging Inconel at a temperature of 1000 °C. In accelerated tests, limited damage was observed on the coated dies after 260 billets compared to extensive loss for uncoated nitrided dies.[4]

The HIPIMS discharge has been used to enhance plasma nitriding at low pressure. By avoiding particle collisions within the sheath, the approach has enabled a flux of highly energetic molecular nitrogen (N_2^+), atomic nitrogen (N^+), and N_2H^+ radicals to reach the substrate. Decoupling the plasma generation from biasing the substrate as in conventional nitriding allows a factor of 4 enhancement in nitriding speed of medial grade orthopaedic implant CoCrMo alloys, whilst improving the toughness and corrosion resistance.[5]

Keywords: high power impulse magnetron sputtering, plasma, thin film growth.

Figure 1: Low-pressure plasma nitriding HIPIMS (top) and conventional plasma nitriding.

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Development of a diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS) flow cell for characterizing nonthermal plasma catalysis under conditions close to dielectric-barrier discharge (DBD) reactors

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Abstract:
Nonthermal plasma (NTP) is the unique means for process intensification of catalytic chemical conversions at the molecular level, being the promising electrified technology for producing chemicals/fuels sustainably using the renewable energy. The hybrid NTP catalytic systems are very complex, and hence fundamental understanding of them is necessary, and it can be partially achieved by in situ diagnosis and characterization. Diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS) is a powerful tool for study surface phenomena during catalytic conversions, and recent developments[1] have shown that it can be applied to NTP catalytic systems as well. However, the flow and discharge conditions of the DRIFTS cells are rather different from that in the dielectric-barrier discharge (DBD) NTP reactors, which are commonly employed for fundamental research of NTP catalysis. Here, we show the development of new DRIFTS cell for NTP catalysis (**Figure 1**). In detail, by embedding the high voltage electrode below the catalyst and using the dome as the ground electrode, the electric field is distributed evenly, preventing concentrated discharge, avoiding arcing or overheating, and minimizing catalyst damage. We performed careful comparison of the flow fields and discharge characteristics between the newly design cell and a DBD reactor, showing the similar properties (**Figure 2**). Accordingly the newly developed DRIFTS cell enabled more accurate study of surface phenomena during different NTP catalytic reactions, which is beneficial to the rational design of bespoke NTP catalysts and catalytic systems. In this talk, we will share the princinoles of the cell design, as well as its applications in NTP catalysis.

Keywords: nonthermal plasma, catalysis, in situ characterization, diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS), flow cell.

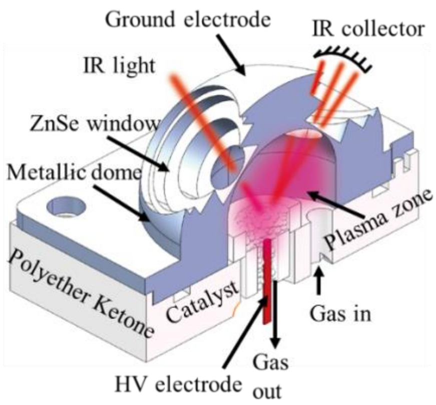

Figure 1: Figure illustrating the design of the DRIFTS cell for characterizing NTP catalysis.

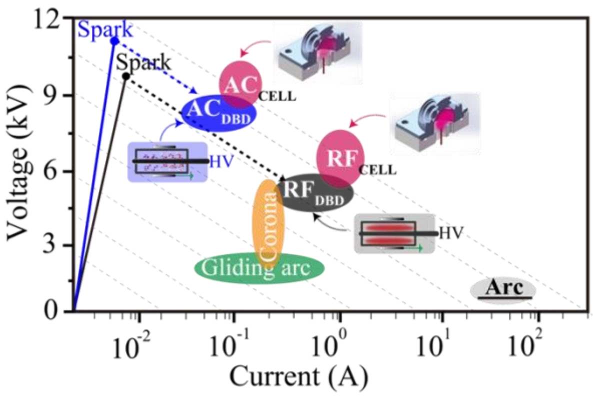

Figure 2: Figure illustrating the design of the DRIFTS cell for characterizing NTP catalysis.

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Development of a bonding technology for painted and unpainted aluminium sheets by cold plasma surface treatment

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Abstract:

This unique development project aims to renew and innovate the bonding technology of various aluminium and aluminium composite panels. The essence of the new technology, and thus of the technical improvement of the product created, is that, unlike other manufacturers, the present consortium does not change the adhesive but uses a specific innovative and fast process for the direct pre-treatment of the surfaces to be bonded. The project involves a surface treatment that alters the molecules at the interface of the materials to be bonded, activating them and thus increasing the surface adhesion force that can be developed and improving the quality of the bond. The development of better quality and higher strength bonds opens up the possibility of new technical and aesthetic solutions in the construction industry. The new production technology that will emerge at the end of the development project will lead to the production and use in construction processes of bonded aluminium and aluminium composite elements made with new techniques and in unprecedented sizes.

The panels play an important role in the cladding of large surfaces as a cost-effective, aesthetic and durable solution for the construction of large surface facades.

Preliminary research and literature analyses show that the bonding process is strongly influenced by the wettability of the surfaces to be bonded. The application of plasma surface treatment on metals is still an unknown and unexplored topic, whereas the process on polymers is already known. Literature suggests that plasma surface treatment can achieve improved bond strength and longer service life for polymers, but no examples of plasma surface treatment on metals in practice can be found.

Our aim is to analyse and investigate the effects of plasma jet surface activation, firstly in laboratory conditions, and then, through continuous development of the methodology, to implement a manufacturing and finishing process that can be adapted to real architectural workflows. In order to achieve these objectives, it will be necessary both to carry out research into adhesive technologies and to incorporate the new technologies thus developed into construction practice. Our aim is therefore to create a mobile plasma surface treatment technology for ionisation that can be used on site to treat the surface of the materials to be bonded immediately before the bonding operation, excluding the influencing factors of the on-site environment.

The development will involve bonding experiments with silicone and polyurethane adhesives following optimised plasma jet surface treatment. The adhesion and cohesive bonding between the surface treated aluminium and the silicone or polyurethane adhesive will be investigated. Our main goal is to optimize the elastic structural bonding and we consider the procedure appropriate if cohesive is the destructive one. This allows the slow and polluting application of primer to be dispensed with altogether.

Keywords: plasma surface treatment, aluminium, silicon adhesive, surface energy, wetting

Interplay of plasma processes and diffusion during solid carbon active screen plasma nitrocarburizing of AISI 316L

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Abstract:
Plasma nitrocarburizing based on active screen technology using a carbon-fiber reinforced carbon (CFC) active screen was applied in an industrial-scale unit for thermochemical surface treatment of austenitic stainless steel. This concept is based on the use of a solid-carbon-source for the generation of highly reactive process gases directly in the active screen plasma. In this work, plasma nitrocarburizing of AISI 316L stainless steel was performed with 50% H_2 and 50% N_2 at a pressure of 3 mbar without the use of any additional carbon bearing gas.

For these specific experiments, a plasma discharged CFC active screen, paired with a substrate holder at floating potential was used. Thus, no charged particles are in the vicinity of the sample surface. Only neutral atoms, molecules and radicals are arriving and contributing to the insertion of carbon and nitrogen into the stainless steel surface. For a temperature of 460 °C and duration of 300 minutes, a near-surface layer of 7 µm containing up to 25 at.% nitrogen and an underlying layer containing up to 10 at.% carbon were detected. This result is in agreement with conventional nitrocarburizing treatments indicating that ions are not required for the thermochemical modification of this steel.

At the same time, a rather homogeneous surface coverage with a carbon-containing phase was observed (Figure 1). A combination of scanning electron microscopy (SEM) and secondary ion mass spectroscopy (SIMS) results indicate that about 25 – 50 nm of carbon layer (possibly with some minor metal contamination) is formed on the surface of the nitrocarburized stainless steel. A more detailed investigation of the SIMS results shows that inside the original steel surface, a significant segregation of Cr near the steel surface within a depth interval of 50 nm is found, followed by a strong segregation of Mn (again about 50 nm thick).

When looking at the time evolution of this effect, starting with an effective nitriding time of 0 (only heating to 460 °C and cooling back to room temperature), 60 and 180 minutes, a progressive formation of the carbon-rich surface structure, followed by time-delayed segregation is observed. It is hypothesized that this surface segregation of specific alloying elements is supported by the agglomeration of the carbon-rich phase – which in turn increases the uptake of carbon and nitrogen from the gas phase – acting similarly to a catalyst.

Keywords: stainless steel, nitrocarburizing, active screen, GDOES, SIMS, SEM, segregation effects.

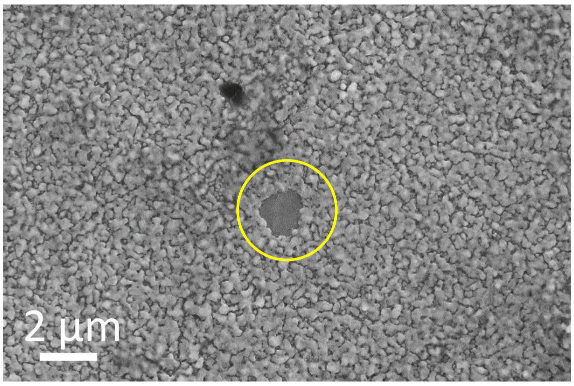

Figure 1: SEM viewgraph of surface after nitrocarburizing showing the carbon-rich coating as well as the underlying steel surface.

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Simulating the influence of nanopores and chemical structure on gas permeation through silicon-based PECVD coatings

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Abstract:
Silicon oxide thin film coatings can significantly enhance the permeation barrier properties of plastics. This approach has important applications in the food packaging sector, where high material throughput is essential. However, permeation measurements typically require hours or days to complete, creating a risk of substantial waste production if manufacturing defects occur. Consequently, understanding the correlation between coating processes and resulting barrier properties – with the goal of predicting permeation characteristics – remains an active area of research [1].

Various approaches have investigated the role of coating defects, particularly pores, which are considered the primary pathways for permeation. In our previous work, we employed positron annihilation spectroscopy to obtain depth-resolved data on nano-scale porosity in silicon oxide coatings, enabling the estimation of three-dimensional pore distribution patterns. This data allowed us to calculate gas diffusion coefficients of the pore-free bulk material [2]. Building on these findings, we have developed a model to simulate permeation processes through porous gas barrier coatings, providing deeper insight into how pores and bulk chemical composition affect barrier properties. Our analysis specifically compares silicon-organic and silicon-oxidic coatings to elucidate the transition between these chemical structures and understand how superior barrier properties emerge in more oxidic materials. Systematic variation of model parameters offers a foundation for targeted tuning of permeation properties. When combined with online process surveillance techniques, such as quartz crystal microbalance measurements, this approach enables potential real-time estimation of permeation properties.

Keywords: nanopores, gas barrier coating, permeation simulation, positron annihilation spectroscopy, silicon oxide thin films.

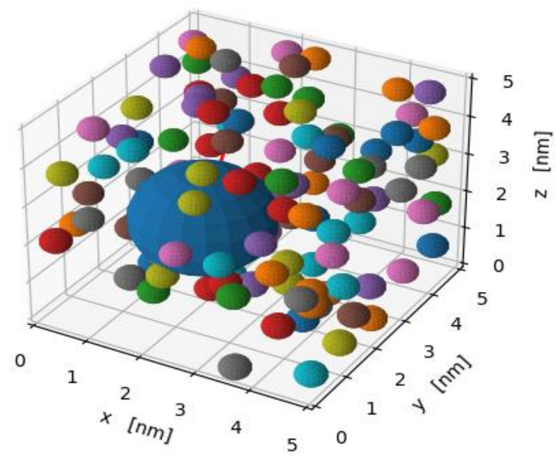

Figure 1: Example of a representative volume element from [2]. Based on positron annihilation spectroscopy data of a 5 nm SiO_x coating, pores of different sizes are situated in the element. In the surrounding bulk, diffusion is significantly slower than within the pores.

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Technological approaches for plasma-assisted thermochemical diffusion treatments of steels

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Abstract:
Plasma-assisted thermochemical diffusion treatment is industrially applied to increase the surface hardness, wear resistance and corrosion resistance of steels. The increasing demands on process efficiency, energy reduction and enhancing the service life of components require the adaptation and further modification of existing technologies.
The contribution covers the technological advancements in comparison to the state-ot-the-art conventional plasma treatments with gaseous carbon precursor by utilizing a plasma-activated solid carbon precursor inside the reactor for plasma nitrocarburizing. In parallel, by utilizing a laser-based absorption spectroscopy (LAS) during plasma-assisted treatments, type and concentrations of the generated gaseous species are in-situ monitored and in-line measured.
Therefore, standard cold- and hot-wall reactor configurations were modified by introducing a plasma-activated screen or electrode (**Figure 1**) in order to independently adjust the crucial treatment parameters. Accordingly, the technological benefits enable a control of the resulting plasma-generated gases measured by LAS and consequently tunable material response. On the example of austenitic stainless steel, it was shown that implementing a plasma-activated carbon electrode inside a hot-wall reactor coupled with LAS diagnostics offers a variety of technological possibilities for plasma-assisted nitrocarburizing including: (i) application of different surface activation methods, (ii) conducting treatments under afterglow and/or direct glow conditions at the treated steels and, (iii) adjustable concentrations of the plasma-generated treatment-relevant gaseous species. These unique possibilities open up potentials for flexible process design, reliable process control as well as a new concept for automatic process control.

Keywords: Thermochemical diffusion treatment, plasma nitrocarburizing, cold-wall and hot-wall reactors, plasma-activated electrode, laser absorption spectroscopy, austenitic stainless steel

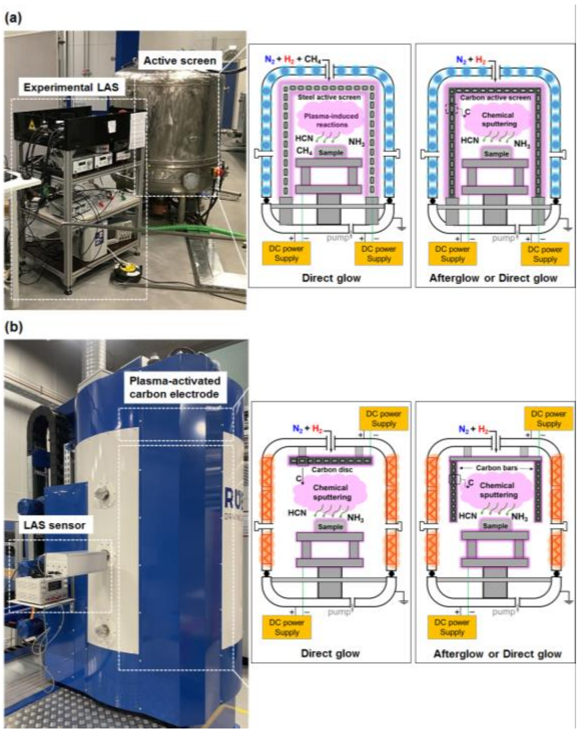

Figure 1: Figures illustrating the modified reactor configuration of a cold-wall reactor by utilizing an active screen made of carbon or steel combined with an experimental LAS setup (a) and a hot-wall reactor with different variants of modified configurations by implementing plasma-activated carbon electrodes combined with a LAS sensor (b). Both reactors were used for plasma nitrocarburizing of various steels.

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Automatic Feature Extraction from Optical Emission Spectra of Reactive Ion Etching Using Dynamic Mode Decomposition

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Abstract:
In this study, we present a novel application of Dynamic Mode Decomposition (DMD) for analyzing optical emission spectroscopy (OES) data from reactive ion etching (RIE) processes. DMD is a data-driven algorithm developed initially for fluid dynamics systems to decompose complicated, time-evolving data into separate spatial-temporal modes, with each mode capturing precise dynamic behavior. The DMD algorithm is adept at handling time series data and extracting linear dynamical behavior from a non-linear system. The eigendecomposition of this linear system gives us information on system modes. Here, we leverage DMD to extract modes representing key emission lines in the OES data (Figure 1), enabling the identification of wavelengths relevant to the etching process. The approach avoids the fundamental problem of low signal-to-noise ratios common in monitoring single emission lines, especially as exposed wafer areas decrease over time. Unlike manual observation methods, where the risk of human error can compromise wafer integrity, DMD provides a systematic, algorithmic approach for automatic feature extraction, enhancing process-monitoring sensitivity. By decomposing the OES data into modes, we isolate emission lines exhibiting temporally distinct behaviors from the collective spectral evolution, distinguishing process-critical features without reducing data scale. Our work is applicable where OES is used as a process-monitoring technique, especially for low-pressure plasma processing. Dynamic modes retain physical interpretability while offering efficient data reduction, making it a valuable tool for real-time plasma process monitoring in semiconductor manufacturing applications.

Keywords: dry etching process, reactive ion etching, optical emission spectra, spectral data compression, automatic feature extraction, dynamic mode decomposition

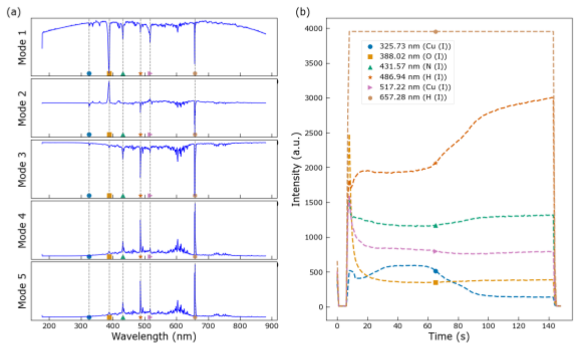

Figure 1: Dynamic mode decomposition on optical emission spectra of copper etching process: (a) top five dynamic modes with etching relevant wavelengths; (b) temporal behavior of the intensities of all etching relevant wavelengths for the copper etching process.

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O_2 plasma degradation of space-technology polymers

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Abstract:
Polymeric films and thermoplastic materials are widely used in aerospace applications due to their lightweight nature, excellent flexibility, and electrical and thermal insulation properties[1]. However, the specific conditions of Low Earth Orbit (LEO, up to 2000 km above Earth's surface[2]) - where most objects orbit, such as the International Space Station at 400 - 420 km and the Hubble Space Telescope at 515 km - cause polymer erosion, significantly degrading their performance. The long-term exposure of such materials in LEO leads to systematic degradation of their properties due to chemical erosion caused by atomic oxygen (O) and ionized oxygen (O^+), the main atmospheric components at such altitudes. Despite numerous ground-based exposure simulations and flight tests, a detailed understanding of the chemical erosion mechanisms remains elusive. This work aims to investigate the effects of non-thermal oxygen plasmas on spacecraft coating materials. Experiments exposing Kapton (polyimide) films to O_2 plasmas have been conducted as a function of exposure time, O_2 flux, and plasma power. Figure 1 shows scanning electron microscopy (SEM) images comparing a non-processed Kapton film to one processed by a 100 W O_2 plasma with an O_2 flow rate of 100 sccm for 8 hours. The unprocessed sample is very flat and smooth, the surface finish is due to the manufacturing process. In contrast, the processed sample clearly exhibits erosion caused by the plasma. Additionally, two distinct phenomena appear to occur: (i) a type of exfoliation where large pieces of material are detached (with some areas showing curled fragments), and (ii) the formation of rounded conglomerates of various sizes. Preliminary measurements of X-ray photoelectron spectroscopy (XPS) have also been performed.
The primary challenge in this ongoing research is implementing the residual gas analyzer (RGA) for efficient in situ mass spectrometry (QMS) measurements. QMS and X-ray photoelectron spectroscopy (XPS) are combined techniques employed in these experiments to assess desorbed materials and surface modifications resulting from plasma treatment. Additionally, these complementary techniques may provide precise information about the most fragile bonds in polyimide molecules. In other words, knowledge of the gas-phase products and identification of the modified chemical environment on the treated polymer surface can provide more precise insights into how the polymer is degraded. Furthermore, these experiments will be expanded to include polystyrene and graphite processing.

Keywords: O_2 plasma, polymers, Low Earth Orbit, coating of space instruments

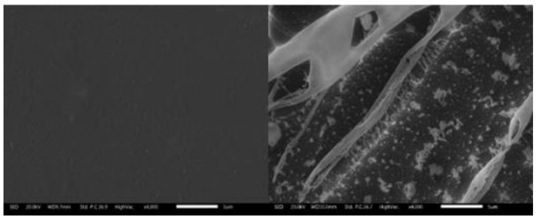

Figure 1: Secondary electron data (SED) from scanning electron microscopy of (Left) a non-processed Kapton film and (Right) one exposed to a 100 W O_2 plasma, with an O_2 flow rate of 100 sccm for 8 hours.

Acknowledgments

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Synthesis of quantum dots in non-thermal plasma: tuning the energy-storage properties and surface reactivity via dominant faceting

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Abstract:

Covalently bonded group-IV nanocrystals based on low-toxicity elements are an important material for prospective applications as luminescent materials or in energy storage. Synthesis in non-thermal plasma (NTP) is an ideal method for the fabrication these high-melting-point materials even in the crystalline form, since surface reactions in NTP are capable of delivering high amounts of energy to the forming nanoparticles without causing excessive heating. Here, we focus on silicon quantum dots (SiQDs) as a case-study material and demonstrate the range of tunability of energy-storage properties accessible via NTP synthesis.

The size and surface of QDs are the two main parameters influencing their properties. When it comes to surface reactivity, it can also be influenced by shape through differences in the type of exposed facets characterized by different rates of surface reactions. In contrast to this conventional approach, we show that NTP synthesis can be used to produce SiQDs highly differing in surface reactivity without apparent shape control. To explain this seeming contradiction, we introduce the term of dominant faceting, referring to the QDs attaining complicated highly polyhedral quasi-spherical shapes while keeping the spatial prevalence of a certain facet.The type of the dominant facet then determines surface reactivity.

The dominant faceting of NTP-synthsized SiQDs ranging from {111} through {001} to {110} can be connected to their increasing surface free energy (SFE), implying decreased thermal stability. A subsequent combined differential scanning calorimetry/thermogravimetric analysis/mass spectrometry measurements focused on the thermal dehydrogenation and oxidation processes revealed marked differences in the surface reactivities of NTP-synthesized SiQDs with different dominant faceting. In particular, we identified four distinctive stages of energy release with onset temperatures ranging between 140 − 250 °C, ~500 °C and 650−700 °C. Our comprehensive study thus demonstrates the potential of SFE-based engineering of energy storage in QDs enabled by the high versatility of structural surface properties of QDs attainable by NTP synthesis.

Keywords: silicon quantum dots (SiQDs), synthesis, surface free energy, plasma settings, energy storage, quantum dot stability, faceting, engineering, oxidation

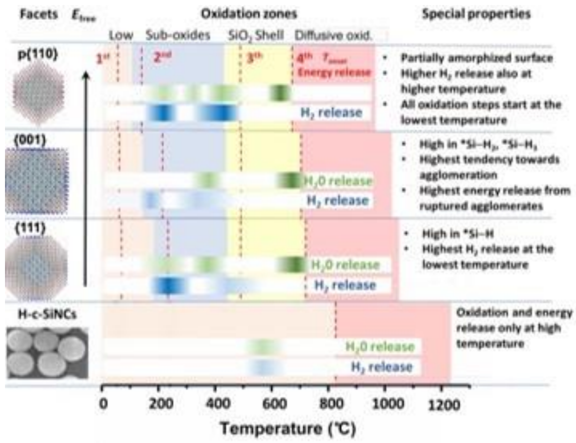

Figure 1: A schematic summary of the observed trends in SiQDs compared to commercial partially hydrogen terminated c-SiNCs, serving as a guide for tuning energy storage properties and its release.

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Development of ceramic-based composite coatings by combining cold-spray deposition and plasma electrolytic oxidation

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Abstract:
Plasma electrolytic oxidation (PEO) is strictly limited to valve metals such as Al, Mg, Ti or Zr and remains ineffective for widespread ferrous-based metals which may also suffering from wear and corrosion issues.
To broaden the use of the PEO process for any metals, the use of a duplex surface treatment combining cold spray deposition (CS) and PEO is proposed.
First, the present communication will focus on the feasibility of this duplex treatment that consisted, in its original setting, in cold spraying an aluminium coating on a metallic substrate, and then, oxidizing part of this sprayed layer through PEO. Particularly, it will be shown how this duplex treatment can enhance the PEO coating growth kinetic[1].
Second, using various spraying configurations (co-spraying, multilayer spraying), the development of new ceramic-based composite coatings will be presented[2,3]. In particular, the possibility to control the formation of advanced Al_2O_3-ZrO_2 composite ceramic coatings will be discussed (Figure 1).

Keywords: Duplex surface treatment, Cold spray, Plasma electrolytic oxidation, Ceramic composite coating, Alumina, Zirconia

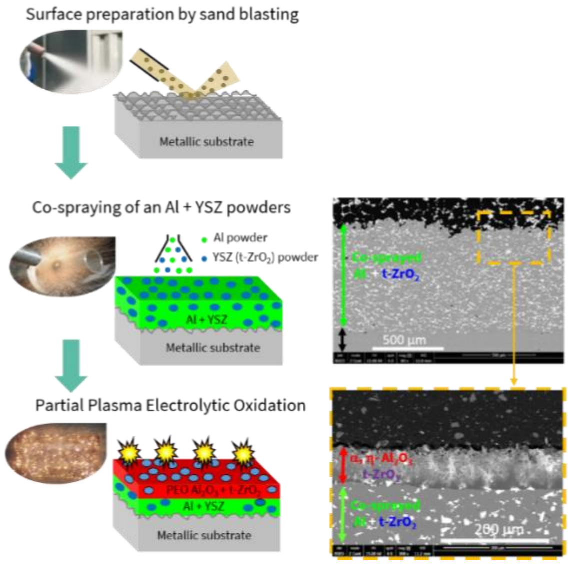

Figure 1: Preparation of a ZrO_2/Al_2O_3 ceramic composite coating by combining cold-spray deposition and plasma electrolytic oxidation.

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SICT 2025 / Plasma Tech 2025
Session II D:
Plasma Processing / Materials Interactions / Coatings
Plasma application in Energy and environment

Deposition of copper-containing carbon-based nanocomposite thin films in laboratory environment and process transer into industrial-size PECVD reactor

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Abstract:

The aim of the present work was to develop nanocomposite copper-doped thin films with antibacterial and antiviral properties. These films were deposited from a mixture of methane and a precursor containing fluorine and copper atoms: (hfac)copperVTMS (hfac = hexafluoroacetylacetonato, VTMS = vinyltrimethylsilane). The deposited thin films underwent comprehensive analysis using nanoindentation techniques, thermal testing, atomic force microscopy, X-ray photoelectron spectroscopy, Raman spectroscopy, and antibacterial testing using *E. coli* bacteria. The developed films demonstrated antibacterial properties while maintaining desirable characteristics, such as relatively high hardness and good adhesion to the substrate.

The next step was the development of an industrial-scale reactor for plasma-enhanced chemical vapor deposition (PECVD). We used the well-known GEC reactor geometry as a template. The reactor is powered by an RF power supply through a matching unit. Initial experiments demonstrated the successful transferability and reproducibility of diamond-like carbon (DLC) thin-film deposition processes from the laboratory-scale reactor.

Keywords: PECVD, thin films, copper doped DLC, DLC, antibacterial properties

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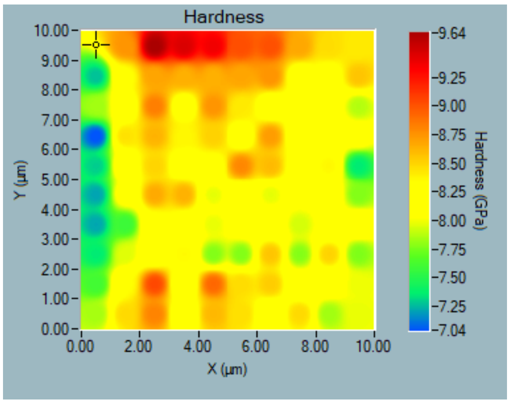

Figure 1: Example of results of mechanical property mapping using nanoindentation.

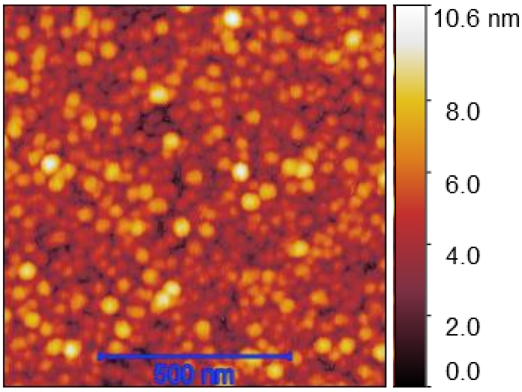

Figure 2: Typical surface morphology of deposited thin films.

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Characterization of the surface forces on smooth hydrophobic plasma polymer films

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Abstract:
Understanding surface wetting has historically been based on characterizing surface composition, topography and other physico-chemical material properties. Less systematic attention has been brought to free energy changes occurring in the fluid medium itself, measurable as a surface force in the first 100 nm from the surface. This has resulted in grey areas where surface properties are well characterized, but relevant aspects of wetting remain poorly understood.

A prominent example relates to the current move away from per- and polyfluoroalkyl substances (PFAS), organic fluorinated molecules heavily used in industry, but harmful to nature. Among many properties, they are hydrophobic and oleophobic (oil-repellent) and can coat or impregnate nearly any material [1-3]. Promising candidates for substitution are hexamethyldisiloxane (HMDSO) based hydrophobic plasma polymer films (PPF) [4, 5]. Plasma polymerization can produce PPFs with almost any elemental composition, but oleophobic PPFs have not yet been achieved without the use of fluorine. While hydrophobicity is well studied, no overarching theory encompassing surface forces has emerged, and oleophobicity remains uncharted territory. The C-F bond, while important, cannot alone explain oleophobicity; notably, changes of free energy in the oil phase have not been considered.

In this work, HMDSO-based PPFs are used as a model surface to systematically study the fundamental forces contributing to their hydrophobicity, and to understand the surface effects governing their lack of oleophobicity. The extended surface force apparatus (eSFA), the atomic force microscope (AFM) and the colloidal probe microscope (CPM) are used to study changes in the Gibbs free energy of liquid media in the first 100 nm from PPF surfaces, as well as molecular scale structural effects. Measurements are performed under controlled dry N_2 atmosphere and with degassed liquids (water, aqueous salt solutions and alkane- and siloxane-based oils), to minimize the effects of humidity and dissolved gases on surface forces and molecular structural effects.

Further surface force measurements were performed with a PPF coating containing carbon-fluorine bonds, which are known to be important to amphiphobicity (the presence of both water- and oil-repellency). This comparative study represents a systematic and fundamental study with PPF model coatings to quantify and deconvolute the effects contributing to water and oil repellency. These results are expected to be relevant to current understanding of PFAS and their by-products, and to understanding how PPFs can become fluorine-free substitutes.

Keywords: PFAS, hydrophobicity, oleophobicity, water-repellency, oil- repellency, surface forces, surface force apparatus, atomic force microscope, colloidal probe microscope, PFAS substitutes, plasma polymer films.

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Surface Characterization and Interaction Dynamics of Hydrophilic Plasma Polymer Films

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Abstract:
Thin polymeric layers showing hydrophilic properties are highly versatile for advanced applications, including their use as adhesion promoters [1], biocompatible coatings [2], and protective layers [3]. Among these thin polymeric layers are plasma polymers, which are synthesized from various organic compounds - for example HMDSO - through exposure to radio frequency electric field at low pressure. Plasma-enhanced chemical vapor deposition (PECVD) offers a method to fabricate highly interconnected plasma polymer films (PPFs) derived from HMDSO, resulting in hydrophobic and nano-porous PPFs [2]. The porous films form interconnected voids due to a Si-O ring network structure, allowing the diffusion of water molecules into the nano-porous structure at room temperature. The result is a nanometer thin polymer film that can be hydrated; despite many investigations on HMDSO-based coatings, there is still a lack of comprehensive understanding about the surface forces occurring on such nano-porous surfaces, especially in contact with aqueous liquids.
To detect how this polymer layer affects the vicinal liquid, we study the surface forces appearing on nano-porous SiOx plasma polymer surfaces using three different direct force measurement techniques, namely the atomic force microscope (AFM), the colloidal probe microscope (CPM) and the extended Surface Force Apparatus (eSFA). These methodologies allow us to explore physical phenomena across varying length- and timescales. To avoid dust contamination of the surface at nanoscale, we fabricate nano-porous plasma polymer films using direct plasma exposure and near-plasma chemistry, both resulting in surfaces with low surface roughness of less than two nanometers root mean square roughness. The intentional introduction of porosity confines fluid molecules within the nano-pores, leading to significant alterations in molecular arrangements and thermodynamic behaviors compared to the bulk state of the liquid. This study aims to advance the comprehensive understanding of surface forces in nanoporous SiOx plasma polymer films, enhancing their application potential in various scientific and industrial domains.

Keywords: thin films, surface forces, atomic force microscopy, colloidal probe microscopy, surface force apparatus, plasma polymerization, near-plasma chemistry

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Properties of a-C:H:F produced with tetrafluorethane

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Abstract:
Diamond-like carbon (DLC) films doped with fluorine (a-C:H:F) are produced primarily with perfluorocarbons-based precursors, such as tetrafluoromethane. Aiming to use a safer and less polluting fluorine-based precursor, this work examines the PECVD deposition of a-C:H:F films using tetrafluoroethane (TFE) as the fluorine precursor. Low temperature nitrided austenitic stainless steel with different surface roughness were coated with the DLC films. Methane was used as the carbon precursor and different levels of TFE were used to evaluate the changes on surface free energy (SFE) properties, tribological performance and corrosion resistance. By using TFE as fluor precursor it was possible to reach levels up to 20% of fluorine in the amorphous carbon films. Increasing fluorine levels led to 10 times greater deposition rates, when comparing it to the reference a-C:H films (Figure 1). The fluorine addition also led to lower hardness and elastic modulus, proportional to the fluorine levels. Fluorine doping didn't have significant effect on the SFE properties of the DLC films, which is primarily affected by the roughness of the surface. Regarding the tribological properties, fluorine doped films showed better performance than the standard films, despite being softer. The fluorinated films also showed a greater capacity of maintaining an insulating tribolayer on rougher finishings. In the corrosion tests, the studied films showed higher corrosion potential (E_{corr}) and lower corrosion current density (j_{corr}), signaling greater corrosion resistance. This is attributed to fewer film defects, such as cracks and detachments, and to the greater thickness. The results suggest that fluorine-doped DLC films, produced with tetrafluorethane, have potential for applications that require low SFE, corrosion resistance and controlled tribological properties.

Keywords: diamond-like carbon, PECVD , pulsed DC plasma, a-C:H:F, stainless steel, roughness

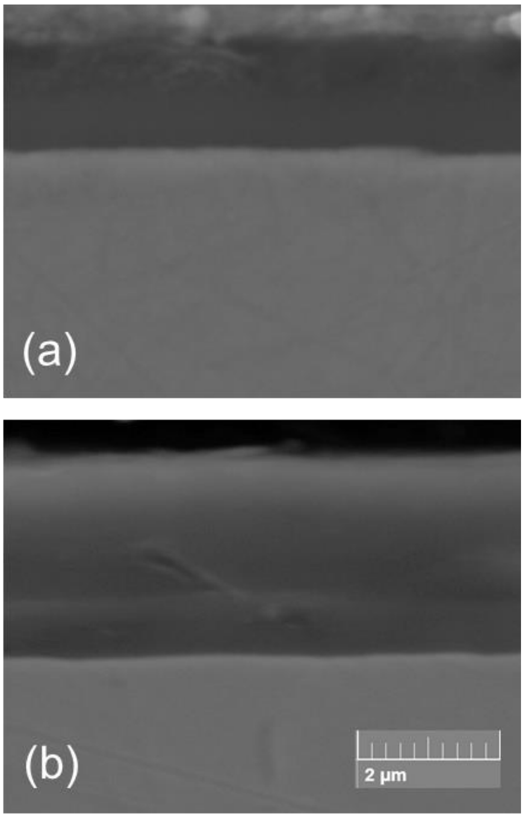

Figure 1: Thickness difference between (a) Non doped DLC and (b) fluorine doped film.

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Revealing Cooperative Role of Non-thermal Plasma and Copper-Zinc Catalysts in the Hydrogenation of CO_2 to methanol

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Abstract:
Conventional thermocatalytic processes for CO_2 hydrogenation to methanol are very energy intensive and are limited by both thermodynamics and kinetics, requiring high temperatures and particularly pressures (e.g., 220-300 °C and 50-100 bar of pressure) to reach reasonable conversion and selectivity [1]. In contract, non-thermal plasma can remove these limitations, activating CO_2 effectively and converting reactants over a catalyst to methanol under mild conditions (e.g., room temperature and atmospheric pressure) [2]. However, the synergistic effects between plasma and catalysts surface and the mechanistic understanding of CO_2 hydrogenation in plasma catalysis are still lacking. In this work, we focus on CO_2 hydrogenation into methanol at room temperature and atmospheric pressure by using plasma catalysis over ZSM5 zeolite supported Cu and CuZn catalysts. We have shown that comparing Cu catalyst, CuZn-based catalysts have a promoting effect on the methanol formation under plasma conditions. The surface reaction pathways for methanol formation and the interaction between plasma and catalyst were proposed based on the operando DRIFTS and X-ray absorption spectroscopy (XAS).
As shown in Figure 1, the NTP systems employing CZA catalyst was only selective to CO (>98%) and CH_4 (<2%) with a low CO_2 conversion of <4.4%. For 2Cu/ZSM5 catalyst, a CO_2 conversion of 13% with a 18.4% methanol selectivity was achieved. This demonstrated that NTP catalysis can form methanol at atmospheric pressure and room temperature. Comparatively, the NTP system using the packing of CuZn catalysts showed the higher CO_2 conversions and selectivity to methanol, indicating that Zn addition promoted CO_2 conversions to methanol. Interestingly, the ratio of Cu/Zn showed the considerable effect on their catalytic performance under NTP conditions. The 2Cu2Zn/ZSM5 catalyst showed the best activity with the highest CO_2 conversion of 15% and selectivity of methanol of 42% achieved. Zn addition improved the reductivity of Cu and affect the CO_2-Cu interactions, which may affect the catalytic performance for CO_2 hydrogenation. Additionally, in situ DRIFTS for plasma-catalytic CO_2 hydrogenation shows that co-existence of CO Hydro pathways parallel to the formate pathway over 2Cu2Zn/ZSM5 surface, and hence the CO Hydro pathways significantly contribute to the promoted methanol yield. Importantly, operando XAS characterisation of the NTP catalysis revealed the role of NTP in sustaining and regenerating the active state of Cu species for CO_2 hydrogenation and the cooperative role of zinc species in hindering the re-oxidation of Cu. This work provides a deep understanding of NTP catalytic CO_2 hydrogenation regarding the interplays between plasma, catalyst and surface reactions, serving as a guideline for developing mature NTP catalysis technology for potential practical adoptions.

Keywords: nonthermal plasma catalysis, CO_2 hydrogenation, synergistic effects, operando DRIFTS and XAS.

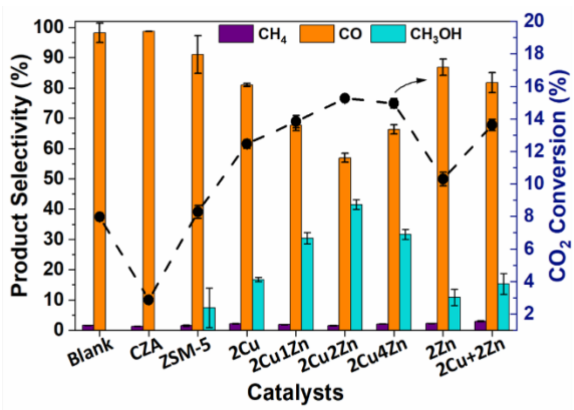

Figure 1: CO_2 conversion and product selectivity over 2Cu/ZSM-5, 2Cu1Zn/ZSM-5, 2CuZn/ZSM-5, 2Cu4Zn/ZSM-5 and 2Zn/ZSM-5 catalysts under plasma conditions.

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Reaction engineering approach for a stable rotating glow to arc plasma – key principles of effective gas conversion processes

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Abstract:
The development and industrial establishment of technologies that utilise renewable energies to electrify and connect sectors is becoming increasingly important. Sector coupling technologies, for example Power to X processes, are key for electrified chemical industry to reduce CO_2 emissions cross-sector [1].
Plasma-based systems play a critical role in Power-to-X research, offering electrified, sustainable pathways for industrial large volume processes in the production of chemicals and fuels.
Besides improvements in electrical circuit and chemical activity through the introduction of catalysts, engineering modifications in reactor development also show great potential for further development of plasma technologies. It is an important step necessary to optimize existing processes and take further steps towards industrial application. Aspects such as scaling effects, thermal management and flow control play important roles [2,3].
This work presents advancements in a rotating glow-to-arc plasma reactor, designed for stable gas conversion of robust molecules like CO_2, N_2 and CH_4.
We scaled the reactor's power from 200 W to 1.2 kW in a CO_2 plasma, which introduced instability due to uplift forces and arc behavior. The arc phenomena were defined and presented, like arc chattering, breakdowns, shortcuts and spiralizing. Most of the phenomena occur relatively stochastically and without significant frequency.
These were mitigated by integrating silicon carbide (SiC) ceramic foam as a mechanical restriction, significantly enhancing stability by reducing arc movement, confining convection, and balancing volumetric flow within the arc.
The stabilized rotating glow to arc plasma behavior was then analyzed in terms of arc rotation and chattering frequencies with various operating parameters including different magnetic flux densities, volume flows and voltages.
We identified dominant frequencies tied to the operational parameters, supporting potential in-operando monitoring and control using high-speed camera analysis and in-situ electronic frequency measurements. Arc rotation frequencies ranging from 5 to 50 Hz and higher frequencies (500 to 2700 Hz) related to arc chattering reveal the system's dynamic response to power and flow changes.
Higher rotation frequencies correlate directly with enhanced homogeneity and stability, while other phenomena like shortcuts and spiralizing introduce power fluctuations that can reduce efficiency. Observations further showed that the operational factors like magnetic flux density and gas flow rate impact the arc's rotational dynamics, resulting in a balanced force distribution that contributes to overall stability.
Moreover, the plasma residence time was evaluated for different operating parameters based on the experimentally determined frequency of the arc. The theoretical number of contacts per atom with the plasma arc was related to the specific energy input (SEI) and allows a more precise calculation of effective SEI by optimizing energy delivery to target molecules.
In summary, the combined use of SiC foam and controlled magnetic flux, along with careful management of rotation and chattering frequencies, supports improved plasma homogeneity, stability, and energy efficiency.
Therefore, our findings underscore the reactor's promise for scalable, efficient gas conversion in sustainable energy applications.

Keywords:

warm plasma; glow-to-arc-plasma; gas conversion; reaction engineering; frequency analysis; arc chattering; arc rotation; plasma catalysis

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NO_x Formation in Atmospheric Microwave Plasma

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Abstract:
NO_x production with the use of plasma reactors is gaining increasing attention [1]. This work reports on the performance of atmospheric microwave plasma in the production of nitric oxides. The research involves a set of varying parameters, i.e., O_2 concentration (10-60 vol%), volumetric gas flow rate (30-150 SLM), and input power (900-2400 W). The results show that up to 3 vol. % of NOx can be produced in the tested setup. Interestingly, the energy demand is barely influenced by the volumetric flow rate or the energy input, with the value varying around 4 MJ/mol. The most significant impact can be attributed to oxygen concentration – with its share of 40-50% the energy demand dropped by ca. 20%. Additionally, these concentrations of oxygen also increase the selectivity of NO_2.
The obtained experimental data are compared with a model that is based on CFD simulations (to provide temperatures and velocities profiles) and a 1D chemical kinetics model.

Keywords: microwave plasma, NO_x, warm plasma, nitric acid, nitrogen oxide

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Scenario-based economic feasibility study of plasma torch concepts to decarbonize cement producition

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Abstract:
The industrial sector plays a crucial role in global economic development but is also a significant contributor to greenhouse gas emissions. Especially high-temperature processes over 1000°C have limited technological options to decarbonize. One of these processes is cement production, being responsible for ~8% of global CO_2 emissions.

In the field of electrification solutions for the cement industry, plasma torches, particularly High-Power Plasma Torches (HP-PT), are gaining further attention -as electrical flames- replacing conventional fossil fuel burners. Capable of reaching the necessary high temperatures (~1450 °C) for clinker production without CO_2 emissions, HP-PTs offer adaptability, high energy density, and rapid start-up/shutdown capabilities. An additional benefit of plasma torches in the case of cement production is their ability to use CO_2 as process gas. This facilitates the capture of CO_2 emitted due to the chemical reaction of the calcination ($CaCO_3 \rightarrow CaO + CO_2$) and makes carbon capture and utilization (CCU) more attractive.

Although a feasibility is likely from a technological perspective and plasma torches are available on the market, costs are highly dependent on local electricity prices. Additionally, the cost of continuing the utilization of fossil fuels is impacted by CO_2 emission allowance and the EU ETS regulation.

The economic feasibility of electrification through high-power plasma torches (HP-PT) is discussed using a case study for the cement industry. Four future scenarios of 2030 have been developed using a PESTEL analysis to identify underlying key drivers. These scenarios are supported with quantitative data on economic parameters (e.g. electricity price, CO_2 regulations) and technological parameters (e.g. cost, efficiency).

In each of these scenarios, the economic feasibility between fossil fuels, DC-arc plasma torch, inductively-coupled plasma (ICP) torch, both with and without Monoethanolamine Carbon Capture and Storage (MEA CCS) integration, is compared.

Keywords: plasma torch, DC-arc, ICP, high-temperature decarbonization, scenarios

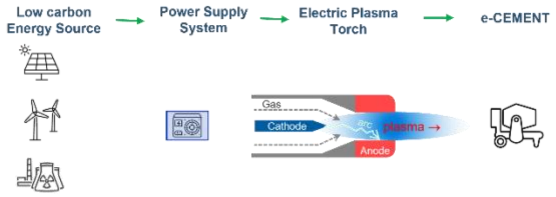

Figure 1: Schematic view of the energy supply for decarbonized, electrified cement production using a DC-arc plasma torch.

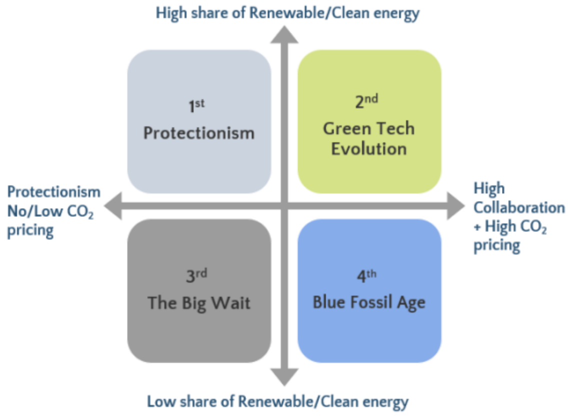

Figure 2: Schematic view of the four scenarios of 2030 developed by contrasting key drivers, acting as a baseline for economic comparison of available technologies in cement decarbonization.

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Comparative study of atrazine degradation in water using advanced plasma bubble reactors

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Abstract:
Water is an essential resource for life on Earth and one of the most vulnerable environmental compartments. As a result, water remediation presents significant challenges (1). The presence of emerging pollutants, a group of natural and synthetic chemicals, in aquatic environments is a major contributor to water pollution, with detrimental effects on both the environment and human health. The increasing prevalence of these organic contaminants in water underscores the urgent need for simple, cost-effective, and environmentally friendly remediation technologies (2).

Among the various methods for water remediation, cold atmospheric plasma (CAP) has emerged as a highly effective, rapid, and energy-efficient approach for the destruction of organic pollutants in water. CAP's effectiveness lies in its ability to generate highly oxidative and reductive reactive oxygen and nitrogen species (RONS), along with space charge and UV radiation, which collectively degrade organic contaminants (3). However, the performance of a plasma system is highly dependent on several factors, including plasma parameters (e.g. discharge source, applied voltage) and, most notably, reactor configuration.

In this study, atrazine-contaminated water was treated using two different underwater plasma bubble reactors: (i) dielectric barrier discharge (DBD) bubbles and (ii) corona bubbles. The influence of reactor configuration, plasma gas, water matrix composition, initial atrazine concentration, and the role of plasma-generated species were systematically evaluated. The physicochemical properties of plasma-activated water (PAW) were analyzed and correlated with reactor type, atrazine degradation efficiency, and energy requirements of the process. This study highlights the impact of plasma bubble reactor configurations on PAW composition and provides valuable insights into the efficient degradation of atrazine in water, contributing to the advancement of plasma-based water treatment technologies.

Keywords: cold atmospheric plasma, atrazine, underwater plasma bubbles, dielectric barrier discharge, reactive oxygen and nitrogen species, energy efficiency, wastewater.

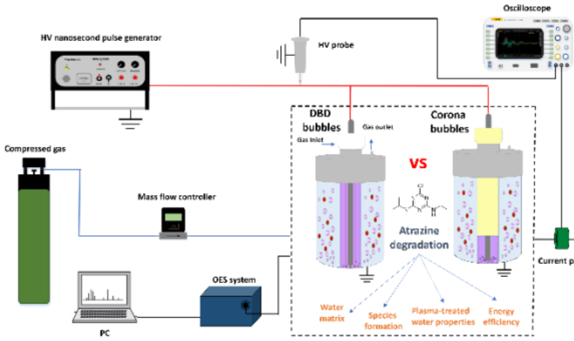

Figure 1: Schematic illustration of the experimental setup used to treat atrazine contaminated water by plasma bubbles.

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Acknowledgements:

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SCENARIOS

Tribology 2025 Session II. E: Coatings and Surfaces Corrosion / Tribological Properties / Physics or Chemistry of Tribo-Surfaces/ Nanotribology

The Electro-Mechanical Tribology of Rough Lubricated Interfaces

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Abstract:
Conduction between surfaces in contact or close proximity occurs either by design or in some cases due to leakage or stray currents. In either case, if the surfaces have sufficient metal contact, the electrical current often travels between the surfaces with little difficulty (See Fig. 1). However, if the contact area is too small, the isolated contacts can heat and melt or become damaged. Oxide can also form on metals surfaces at an accelerated rate at high temperatures. If there are vibrations within the system, small sliding motions between the surfaces can also induce fretting wear. One way to prevent surface fretting is with a lubricant.
In addition, in electric vehicles, wind turbines, spacecraft and other applications, the afor mentioned leakage currents will attempt to cross lubricated bearings and gears. When electrical current reaches an insulative lubricated contact, the electron charges will build up. If enough power accumulates, the electric current will discharge across the lubricating film. The discharge often occurs as a plasma arc. The electrons heat the lubricant until it ionizes and becomes plasma. These high temperatures degrade the lubricant and can ablate or melt the metal surfaces. Small pits or craters (i.e. frosting) are often left at the location of a discharge (see Fig. 1).
This work examines the influence of various conditions, such as lubricant composition, motion, and surface roughness, on the resulting discharges and surface damage. For instance, some lubricants containing conventional additives, or nanoparticles, can demonstrate less electrical surface damage[1, 2]. The motion and load, which also may influence film thickness and charge buildup, affect discharge damage[3]. This situation can also be theoretically rendered using coupled electro-mechanical tribological models[4]. The electrical fields can also influence the behavior of the solids and fluids, effectively changing their material properties. This results in a very complex situation over which the proposed models have only limited effectiveness.

Keywords: electrical contact, electrical wear, electrically induced bearing damage

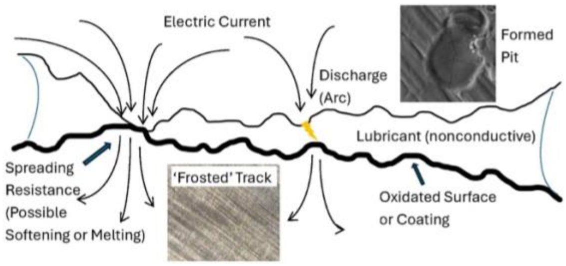

Figure 1: Illustration of the current flow across lubricated rough surfaces.

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Tribology and Seizure Resistance of Journal Bearings under Lubrication Regime Transition

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Abstract:
Journal bearings play a critical role in various engineering applications, where their performance is influenced by lubrication regimes and the transition between them [1]. For conditions involving full hydrodynamic lubrication, the understanding of the mechanisms involved in the tribology of dimpled surfaces is mainly derived from investigations of hydrodynamic seals or from the simulation of hydrodynamic bearings [2]. This study investigates the tribological behavior and seizure resistance of journal bearings under lubrication regime transitions, including hydrodynamic, mixed, and boundary lubrication. Experimental and numerical approaches are used to evaluate friction, wear, and seizure characteristics under different operating conditions. This study also examines the influence of surface texturing on the frictional behavior and seizure resistance of journal bearings during lubrication regime transitions. Fig. 1 shows the
pressure distribution along rotating (upper) and single stationary micro-dimple (lower) at rest. The results demonstrate that optimized surface dimples can enhance lubrication efficiency, reduce friction, and delay seizure by promoting lubricant retention and improving load-carrying capacity. Understanding these factors is essential for improving bearing reliability and extending service life in demanding applications. These findings provide valuable insights into the design of textured journal bearings for improved performance and durability in demanding applications.

Keywords: journal bearing, tribology, seizure resistance, lubrication regime transition, surface dimples, frictional behavior, wear mechanisms.

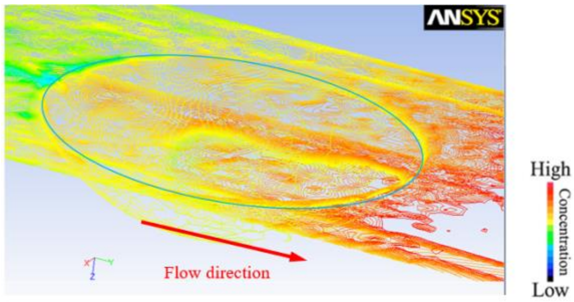

Figure 1: Pressure distribution along rotating (upper) and single stationary micro-dimple (lower) at rest.

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Computational Materials Tribology — Nanoscale Simulations to Address Engineering Challenges

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Abstract:
Developing materials that can withstand severe tribological conditions is critical for improving energy efficiency and extending the lifespan of components. While traditional materials selection tools, such as Ashby charts, provide broad design guidelines, they lack the tribology-specific data necessary for tailoring materials to friction and wear-intensive applications. Molecular dynamics (MD) simulations offer a powerful means of probing the nanoscale mechanisms governing friction, wear, and failure. By modeling materials under realistic tribological conditions, MD provides crucial insights into microstructural evolution, plastic deformation, and third-body dynamics. Our recent work [1–4] has demonstrated how MD can uncover key deformation mechanisms in high-performance alloys, revealing how factors like alloy composition, grain boundaries, and dislocation activity influence tribological behavior. However, the computational cost of MD, combined with the need for expert-driven analysis, limits the number of materials that can be systematically explored. Addressing this bottleneck is crucial for advancing tribological materials design. To overcome these limitations, we are exploring how machine learning (ML) can be integrated with MD simulations to accelerate materials discovery. In the near future, we plan to develop an initial ML framework capable of automating data extraction and analysis from MD simulations. As the models improve, our long-term goal is to generate tribology-specific Ashby charts populated with hundreds of optimized alloys, ultimately replacing much of the trial-and-error nature of tribological materials design.

Keywords: molecular dynamics simulations; microstructural evolution; alloy design; computational materials science; machine-learning-assisted materials discovery

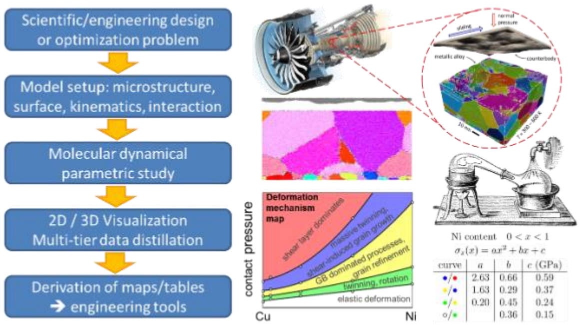

Figure 1: Schematic workflow of a conventional approach to map deformation mechanisms in tribological materials. The resource-heavy MD portion should, by and by, be replaced by powerful ML models.

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Surface Study of Additively Manufactured Steel Processed through Vibration Assisted Ball Burnishing

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Abstract:
This study investigates the application of Vibration Assisted Ball Burnishing (VABB) to improve the surface integrity of additively manufactured metal components. Its primary objective is to enhance surface roughness and surface hardness. The VABB process was applied to the steel specimens, and the resulting surface modifications were analyzed using optical profilometry and Scanning Electron Microscopy (SEM). Additionally, the coefficient of friction across different surface conditions was determined. Results demonstrate significant variations in key surface parameters, including Sa (arithmetic mean height), Ssk (skewness), Sku (kurtosis), among others. The VABB technique enhanced the surface roughness and other critical surface characteristics. Surface friction was observed to vary as the surface topography changed. The controlled deformation induced by the VABB process effectively eliminated surface irregularities and defects, compacting them through compressive forces. This not only improved surface parameters but also increased subsurface hardness. These findings suggest that VABB improves additively manufactured metal surfaces. This research contributes to the ongoing efforts to overcome the limitations of surface quality in additive manufacturing, leading the way for broader applications of this technology in high-performance engineering contexts.

Keywords: additive manufacture, surface integrity, finishing, burnishing, metal.

Effect of Tribological Conditions on Organic Friction Modifiers Tribofilm

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Abstract
The growing stringency of environmental and emissions regulations has increased the demand for lubricant additives with minimal or no phosphorus and sulfur content. Many organic friction modifiers (OFMs) meet these requirements and are increasingly incorporated into lubricant formulations. However, the precise mechanisms by which they reduce friction and protect surfaces in the boundary lubrication regime remain incompletely understood.

In this study, we conducted tribological investigations using steel surfaces and three glycerol oleate-based OFMs, both individually and in combination. Formulations of glycerol monooleate (GMO), glycerol dioleate, and glycerol trioleate in PAO4 base oil were tested at two different temperatures using a reciprocating TE77 tribometer. The thickness of the resulting tribofilms was measured, and their chemical composition was analysed using time-of-flight secondary ion mass spectrometry (ToF-SIMS).

Our findings indicate that the lowest boundary friction coefficients were achieved with a mixture of glycerol oleates at lower temperatures. The relationship between tribofilm formation, operating conditions, and tribological performance will be explored in detail.

Comparative Tribological Analysis of Conventional and Cyclic Deep Cryogenic Treatment on AISI D2 Tool Steel

V. Yarasu [1,*], B. Podgornik [1], B. Batic [1], M. Sedlacek [1], Č. Donik [1], F. Zepeda [2,1]
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Abstract:
The aim of this study was to explore the tribological properties of AISI D2 steel for cold-work applications through a modified heat treatment method involving cyclic deep cryogenic treatment (CDCT). This research compares conventional heat treatment (CHT), deep cryogenic treatment (DCT24), and CDCT with 2-cycle (CDCT2), 5-cycle (CDCT5), and 10-cycle (CDCT10) treatments, following double tempering at 570°C. The analysis included hardness, fracture toughness, and sliding-wear resistance measurement. While bulk hardness measurements indicated similar hardness across all treatments, the CDCT5 treatment exhibited a notable 6.8% increase in microhardness compared to CHT. Additionally, CDCT2 and CDCT5 treatments resulted in lower wear loss compared to CHT and other treatments. Fracture toughness was significantly improved by 13%, 68%, 5%, and 9% for DCT24, CDCT2, CDCT5, and CDCT10 treatments, respectively, compared to CHT. Advanced characterization techniques, including SEM-EDS, EBSD, STEM, and TEM, revealed enhanced count of small secondary carbides, nanoscale Cr precipitates, enhanced crystal defects (such as nanotwins and stacking faults), dislocations, and refined martensite, all of which contributed to the improvements in fracture toughness and wear resistance. This research suggests that CDCT achieves superior wear and fatigue performance in a shorter time, potentially reducing production costs for manufacturers in cold-work tooling applications.

Keywords: D2 tool steel, hardening, cryogenic treatment, cyclic cryogenic treatment, microstructure, friction, abrasive wear, cold-work tooling applications.

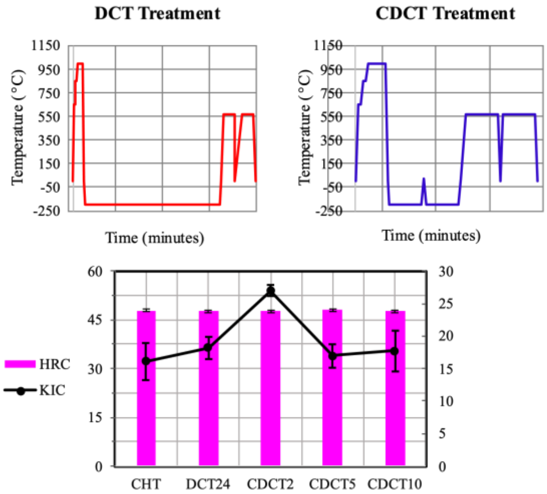

Figure 1: llustration of traditional deep cryogenic treatment and cyclic deep cryogenic treatment processes: A comparative analysis of time efficiency and potential property enhancements.

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Wear and fretting in corrosive atmospheres at ultra-high temperature using a specially developed SRV tribometer test rig

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[2] The German Aerospace Center (DLR-SG), Augsburg, Germany
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Abstract:
The urgent challenge of reducing CO_2 and climate-damaging emissions in the transport sector necessitates exploring alternatives, particularly in the Aerospace and utility vehicle domain. As a result of ever increasing aeroengine performance, leading to higher temperatures in the hot gas path, and in view of the use of alternative fuels (SAFs, H_2), a thorough understanding of the mechanisms behind wear and fretting in engine components at ultra-high temperature in diverse corrosive atmospheres is of utmost importance. The DLR Institute for Test and Simulation of Gas Turbines addresses this topic by making use of the latest developments in SRV tribometer and test rig prototypes. Employing Cobalt-based materials, Tribaloy T-400 and T-800, in an oscillating friction wear tribometer with a high-temperature test chamber, the research evaluates their tribological behavior in the temperature range of up to 1000 °C. The findings showcase improved tribological performance as a result of glaze layers forming at higher temperatures demonstrating wear-protective effects. The manufacturing process (cast vs. HFOV) as well as the initial heat treatment of both Tribaloys emerge as the key factors influencing the wear characteristics at a given temperature.
Besides the above mentioned factors the influence of corrosive atmospheres is of particular interest for aeroengines and gas turbines in general. A strong focus is placed on atmospheres containing high amounts of SO_2 and H_2O vapor. For this purpose, a test chamber was developed by Optimol Instruments Prüftechnik GmbH, which allows for testing at elevated pressure up to 20 bar with corrosive gas mixtures containing mainly N_2, O_2, CO_2, SO_2, CO, NO and H_2O vapor.
This study provides recommendations that are applicable across industry sectors, therefore also benefiting Aerospace applications.

Keywords: Cobalt-based alloys, fretting wear, corrosive atmosphere, glaze layer formation, high temperature tribology, SRV tribotesting, test rig development, Aerospace applications.

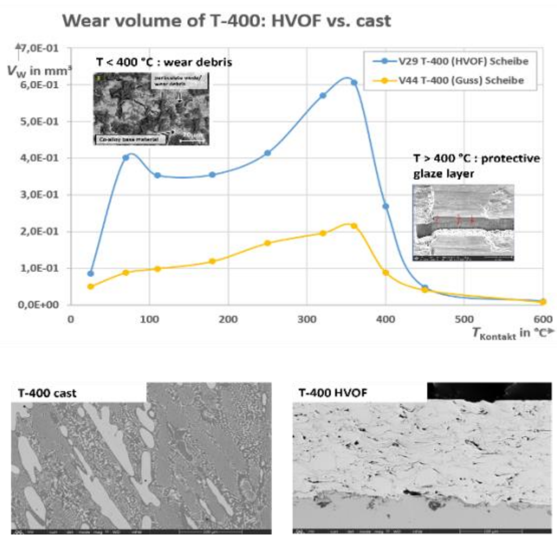

Figure 1: Figure illustrating the temperature dependency of wear behavior for T-400 (top) as well as the morphology and microstructure (bottom) and shows the key findings: 1.) Transition temperature between mild and severe wear is clearly identifiable; 2.) Formation of glaze layer for T > 400 °C, depending on microstructure and chemical composition (Cr-content); 3.) Reduced wear characteristics for cast alloys, as compared to alloys applied by high-velocity oxygen fuel (HVOF)

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Nitrogen ion implantation of a refractory high entropy HfMoNbTaTiVWZr thin film metallic glass

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[2] Warsaw University of Technology, Faculty of Mechatronics, Warsaw, Poland

Abstract:

Refractory high entropy alloys (RHEAs) resemble excellent mechanical properties, oxidation and corrosion resistance even in very high temperatures that is why in recent years so much importance has been attached to the study of these materials [1]. Ion implantation was used to improve tribological and mechanical properties of HfMoNbTaTiVWZr thin film metallic glass. Thin films of octonary HfMoNbTaTiVWZr were produced by magnetron sputtering and then implanted using very high ion doses: d_1 = 2e16 ions/cm^2, d_2 = 1e17 ions/cm^2 and d_3 = 1e18 ions/cm^2. This work was conducted to investigate the effect of nitrogen ion implantation on microstructure, chemical composition, mechanical and surface properties of TFMGs. Methods such as transmission and scanning electron microscopy (SEM and TEM), energy-dispersive x-ray spectroscopy (EDS), x-ray diffraction (XRD), atomic force microscopy (AFM), indentation were used. Experimental XRD diffractograms were compared with theoretical calculations. The authors also determined the depth of ion penetration into the material. Indentation measurements allowed to determine H/E and H^3/E^2 parameters which can be useful to predict wear [2]. This research shows that implantation has not changed the structure of the material from amorphous to crystalline. All samples exhibit homogenous microstructure, elements are evenly distributed both on the surface and cross sections. The study identified the most suitable ion dose (d_3 = 1e17 ions/cm^2) and the sample implanted with this dose showed the best mechanical as well as surface and tribological properties which can be observed as high hardness (figure 1a), lowest coefficient of friction and improved wear resistance (figure 1b). Implanting with higher ion doses introduces too many defects that significantly deteriorate the properties, while lower doses are insufficient to form an implanted layer.

Keywords: high entropy alloys, thin film metallic glass, implantation, microstructure, indentation, surface characteristics, wear

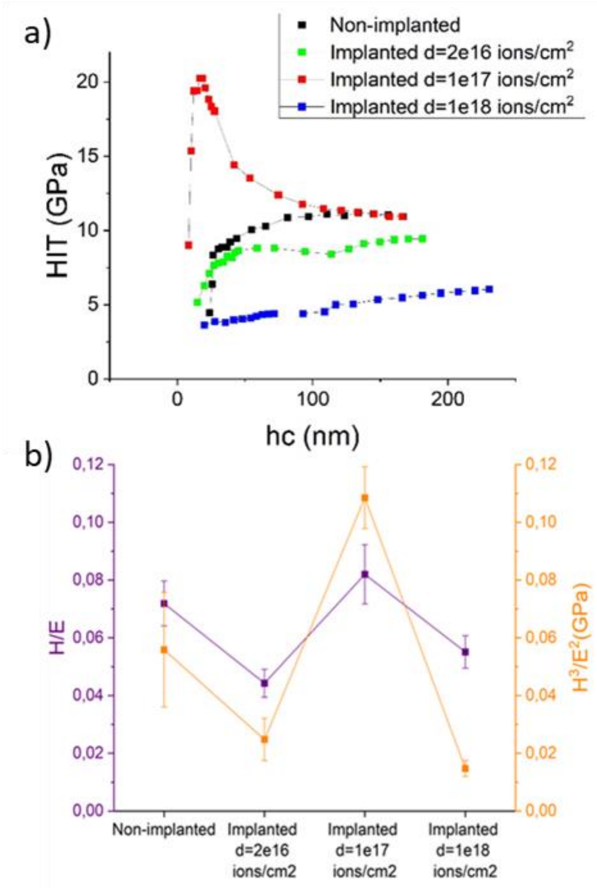

Figure 1: a) Measured hardness of implanted and non-implanted samples b) H/E and H^3/E^2 indexes obtained from indentation measurements; lines connecting the points are so called "guide for an eye"

References:

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Wear on Radial Shaft Seals
- Wear Models and Influencing Parameters

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Abstract:

Radial shaft seals prevent fluid exchange at shaft passages and have been used successfully for decades. The sealing edge of the cross-sectional geometry of a radial shaft seal and therefore the pressure distribution between the sealing edge and the rotating shaft is not symmetrical, **Figure 2**. This results in a back pumping mechanism which is crucial for leak tightness.

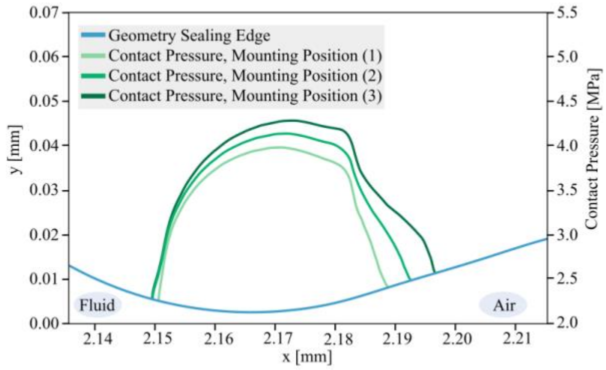

Figure 1: Outline of the two-dimensional geometry of the sealing edge and pressure distribution between the sealing edge and the shaft for different mounting conditions.

Wear on the sealing edge changes the geometry of the sealing ring and therefore the pressure distribution. The functionality of a radial shaft seal is therefore impaired by excessive wear during operation, which can lead to failure of the entire machine or system.

In order to determine and predict the wear of elastomer radial shaft seals, suitable wear models were researched. The finite element method was used to determine the contact pressure between the sealing edge and the shaft. Based on the contact pressure, different wear models taken from the literature were used to iteratively implement the material removal due to wear.

To achieve this, the nodes on the sealing edge, which are in contact with the rotating shaft, were moved inside the material by the calculated wear height. As the contact pressure changes due to the modified geometry, this process was repeated iteratively until a wear distance of 40,000 km was achieved. This resulted in the worn seal edge, with the wear dependent on several parameters eg. eccentricity or material properties.

The 2-dimensional geometries of the worn sealing edges, based on different wear models, are shown in **Figure 2**. The wear models, all taken from the literature, differ not only in the number of parameters but also in the material constants and variables included in the wear equation.

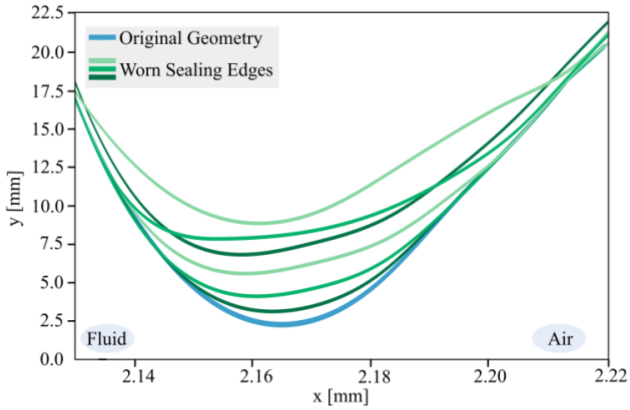

Figure 2: Outline of the worn sealing edges, determined by different wear models, compared to the geometry of the original sealing edge.

The wear models were used to evaluate which parameters are most relevant for the wear simulation of radial shaft seals. The influence of different material characteristics and the influence of the implemented wear model were analysed. The aim was not only to evaluate which wear model was most appropriate, but also to simplify this process of wear determination.

The ability to simulate wear allows various influencing factors such as lubrication condition or material parameters to be changed quickly and easily to assess the effect on the amount of wear. This information can be used to understand experimental test results and apply this knowledge in the design process to minimise wear and extend the life of radial shaft seals.

Keywords: Sealing Technology, Radial Shaft Seals, Wear, Elastomers, Material Parameter, Finite Element Methode, Finite Element Analysis

Optimization of Laser Engraved Pumping Structures on Lip Seals for Pressure Loaded Applications

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Abstract:

The Back-Structured Shaft Seal (B3S) is an optimized seal for rotating shafts in conditions where conventional seals cannot be used. It is designed to provide better dynamic tightness with high reliability and durability for the sealing of fluids.

The innovative laser-engraved structures on the back of the sleeve create a pumping mechanism in the sealing contact that actively prevents leakage. (Figure 1) This has already been successfully used to seal unpressurized fluids, but has not yet been adapted for pressurized applications.

The active pumping mechanism has now been investigated for pressurized seals. Simulations were used to analyze the functionality and to adapt the structures. Prototypes were then tested on various test rigs (Figure 2). The test results were employed to validate the simulation and to identify and exploit further optimization potential.

The results demonstrate that it is possible to seal pressure loaded applications with B3S if the structures are optimized for the changed conditions.

Keywords: rotary shaft seal, lip seal, pumping structures, PTFE, sealing technology, back-structured shaft seal, finite element methode, finite element analysis

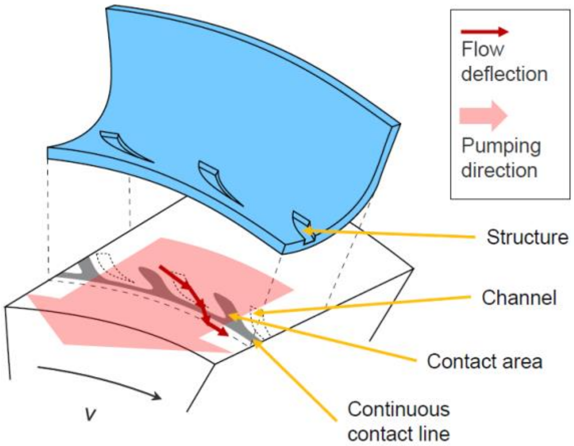

Figure 1: The figure illustrates the working principle of the Back-Structured Shaft Seal. The structures on the back-side create flat channels in the contact area. They have an angled orientation due to the special geometry. The drag flow of the fluid in the sealing gap then causes a pumping effect, improving the dynamic tightness.

Figure 2: The figure shows a laser engraved prototype tested on the test rig.

Rolling Contact Fatigue Prediction of 42CrMo4 Steel Using Multiaxial Fatigue Parameters

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Abstract:

Spur gears manufactured from 42CrMo4 steel are widely utilized in various engineering applications due to their excellent mechanical properties, including high strength and wear resistance. However, these gears are not immune to rolling contact fatigue (RCF), which often manifests as pitting or spalling on the gear surface. Over time, such damage can degrade transmission performance by increasing vibration and noise levels, ultimately compromising system reliability. Standardized gear sizing approaches, such as AGMA 2101 or ISO 6336, are tailored for demanding applications, often leading to oversized components that do not align with specific operational needs [1]. To address these inefficiencies, it is crucial to develop predictive methods for fatigue life estimation, allowing for optimal gear design and performance assessment.

The prediction of RCF in materials like 42CrMo4 is often reliant on multiaxial fatigue theories, yet their accuracy when based solely on uniaxial tensile test data remains an open question. While previous studies have explored multiaxial fatigue prediction methods, such as Fatemi-Socie (FS) and Smith-Watson-Topper (SWT) [2], their application to RCF in 42CrMo4 under practical operating conditions remains underdeveloped. This study seeks to bridge this gap by combining experimental testing with computational modeling to evaluate the RCF behavior of 42CrMo4 steel.

Laboratory-scale RCF tests were conducted using a three-disk tribometer, enabling controlled assessment of surface fatigue damage. These experimental findings were complemented by computational RCF life predictions using multiaxial fatigue methods informed solely by uniaxial tensile test data. Both FS and SWT methods were evaluated, with the FS method demonstrating superior accuracy in predicting fatigue life, as validated against experimental results (Figure 1).

The study provides valuable insights into the progression of surface fatigue damage in 42CrMo4 steel and its impact on vibration and noise in spur gear systems. By defining allowable pitting thresholds, this research offers a practical framework for optimizing gear design, reducing oversizing, and enhancing the reliability of transmission systems. Additionally, it emphasizes the importance of refining multiaxial fatigue prediction methods to better accommodate the complexities of rolling contact fatigue, ensuring more accurate and efficient gear sizing for diverse engineering applications.

Keywords: rolling contact fatigue, low-carbon steel, 3-disk tribometer, multiaxial fatigue.

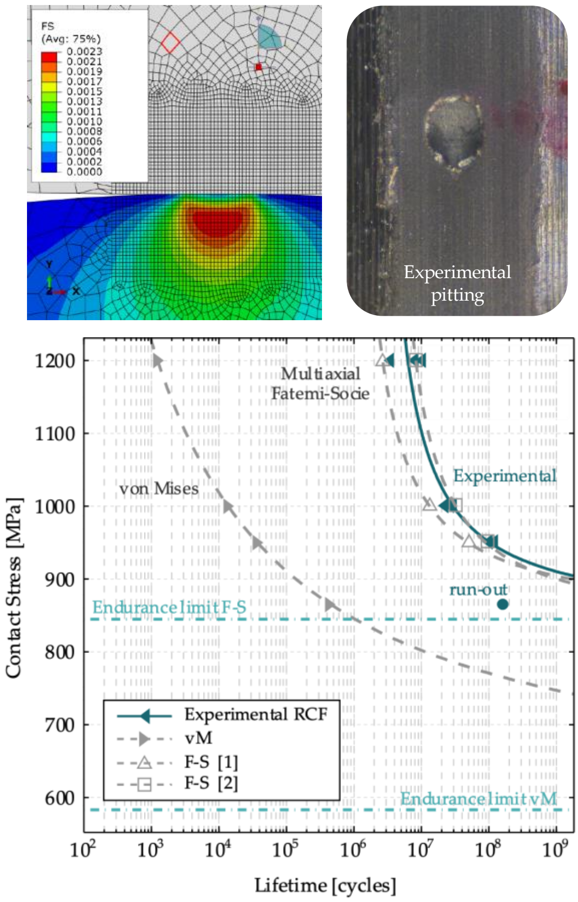

Figure 1:Experimental vs. predicted fatigue S-N curve using Fatemi-Socie method.

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Effect of Surface Roughness on Contact Area Measurements: Experimental and BEM Analysis

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Abstract:
Contact area measurement has been a topic of interest in the literature, where mainly smooth transparent materials have been used for experimental specimen construction [1]. The measured area has tipically been correlated with the applied load using Hertz's elastic contact theory. However, rolling machine elements for industrial applications cannot be tested using this technique, due to their construction using non-transparent materials with rough surfaces.
Recently, a non-destructive experimental technique for measuring spherical rolling element contact area was developed [2]. The technique involves chemically etched balls in contact with painted surfaces to measure the region of paint removal (see Figure 1). By assuming smooth surface conditions and modifying Hertz's theory for painted surfaces, analytical and experimental results were correlated with satisfactory accuracy. Still, this method cannot predict the experimentally observed rough contact area morphology shown in Figure 2 (a), which can generate measurement errors if the profile is too rough.
Therefore, the objective of the research is to assess the effect of surface roughness on the measured contact area by correlating experimental and numerical results. This approach seeks to explain the experimentally measured contact area morphology and determine the measurement error for different roughness profiles if the modified Hertz's theory is used.
To account for surface roughness, a BEM contact simulation software was used. This code enables rough-on-rough contact simulations with reduced computational cost compared to traditional FEM [3]. The method simplifies the contact problem by modelling a rigid rough indenter in contact with a equivalent smooth elastic flat semi-infinite body where only the flat surface is discretized. Surface roughness profiles, measured in a confocal profilometer, were used for the indenter.
Results for ball-to-flat contacts show a good correlation with experimental observations as shown in Figure 2 (b), where individual asperity contacts are shown spreading in a randomly distributed pattern. Simulation results also reveal contact spots outside the main contact region, which produce a negligible measurement error for the tested specimens. However, higher roughness surface profiles produce an inconsistent outer ring that produce inaccuracies when using the modified Hertz's theory, so BEM simulations must be used for this cases.
In conclusion, while Hertz's formulation is effective for the low-roughness contacts used for the experimental method, it cannot accurately predict real contact area morphology, so BEM simulation should be used for high roughness specimens where the measurement error is increased.

Keywords: Contact area, Rolling machine element, Rough contact, BEM.

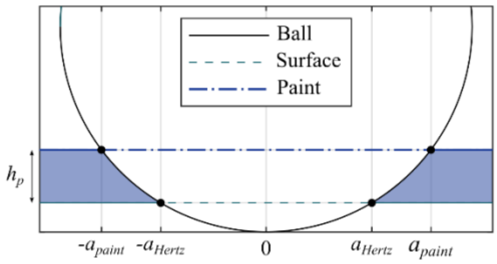

Figure 1: Painted ball to flat surface contact schematic.

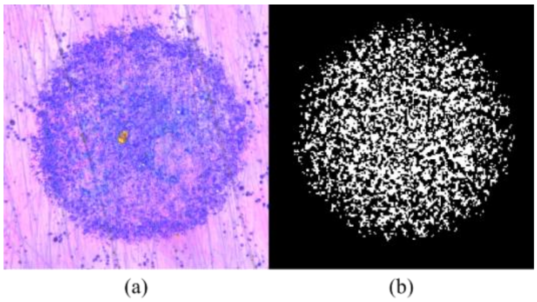

Figure 2: Ball to flat rough real contact area. (a) Experimental measurement on painted surface. (b) BEM simulation with ball surface profile.

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Micropitting resistance of bearing steels in hybrid contacts

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Abstract:
The ongoing demand for enhanced energy efficiency in lubricated rolling/sliding contacts, such as in rolling bearings, is typically met by increasing power density and using of low-viscosity (thin-film) lubricants. Under these conditions, a mixed lubrication regime often prevails, leading to significant interactions between the contacting surfaces at asperity level. This increases the risk of surface-initiated fatigue, e.g., in the form of micropitting.
In this study, the micropitting resistance of three bearing steels – 100Cr6, N360, and PM1 in a hybrid contact was experimentally investigated using the micropitting test rig (MPR) with ceramis (Si_3N_4) rings of different roughness. Based on the MPR results (see example in Figure 1), it was suggested that the steel microstructure and mechanical properties significantly affect the micropitting performance of the contact. It was also discovered that increased roughness of the Si_3N_4 surface could elevate the risk of micropitting on the steel countersurface. However, despite formation of some mild micropitting, the tested steels demonstrated at least acceptable performance.
Inspired by the experimental results, a theoretical framework was developed to predict the influence of steel mechanical properties on micropitting accumulation in a hybrid contact with varying roughness of the ceramic component. A new micropitting model was derived, based on the finding that the nucleation of a micropit is driven by local accumulation of the plastic strain in a mixed-lubricated rough contact, and by reduction of the total energy due to debonding of the plastically deformed zone. The model was shown to align with experiments across the range of test conditions (see simulation results in Figure 2). Finally, micropitting performance maps were obtained based on the steel's mechanical properties (yield strength, work hardening, and fracture toughness), the ceramics-to-steel roughness ratio, and the operating conditions.
The new theory can also be applied, with minor modifications, to predict micropitting resistance in all-steel contacts and adhesive wear resistance of various steels.

Keywords: Micropitting, surface distress, hybrid contact, plasticity, steel mechanical properties.

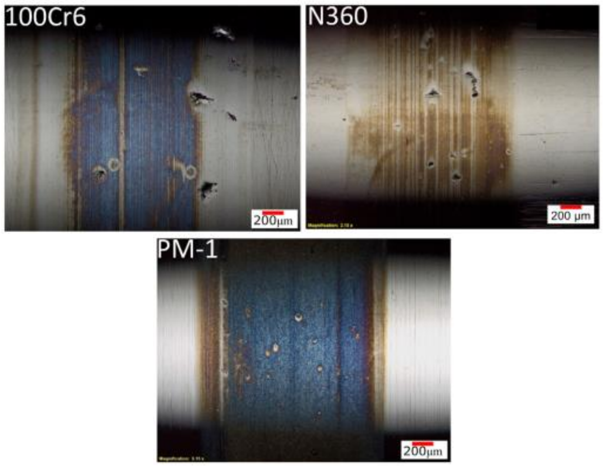

Figure 1: Micropitted surface of 3 bearing steels steel after $5 \cdot 10^6$ cycles at p_o=2.5 GPa [1].

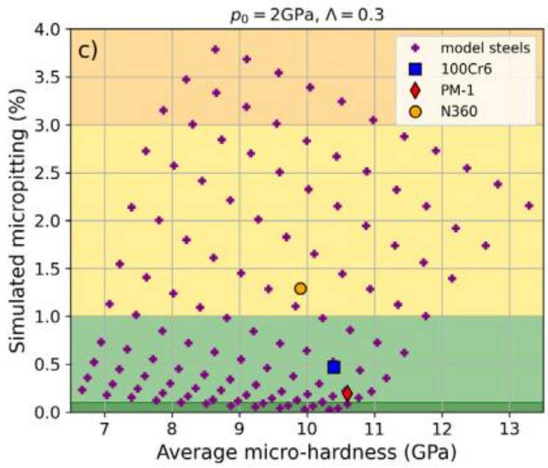

Figure 2: Predicted percentage of micropitted area for the 3 bearing steels, based on their mechanical properties [1].

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Experimental study of the influence of the mechanical design of a tribometer on the friction response for a pin-on-disk configuration

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Abstract:
A pin-on-disk tribometer is one of the most widely used instruments for characterizing the frictional behavior of a pair of materials in relative motion. This type of system consists of a rotating disk on which a pin, whose end may be flat, spherical or cylindrical, rests with a controlled normal force F (figure 1). The tangential force T generated by the movement of the disk is recorded and used to calculate the friction coefficient f = T/F of the pair of materials used for the pin and disk under different operating conditions.

It is now well known that system behavior and friction response depend on the properties of the tribometer, and in particular its elastic stiffness. Recently, theoretical work has shown that observations generally attributed to the “stick-slip” phenomenon (alternating sliding and sticking phases manifested in the form of strong oscillations or instabilities in the system) are in fact due to anisotropies in the tribometer's stiffness (1). Furthermore, recent approaches propose to use the tribometer's elastic properties to improve the accuracy of friction measurement in instability or oscillation phases (2).

The aim of this work is twofold:

1 - To verify experimentally whether differences in tribometer stiffness can indeed explain friction instabilities as proposed in (1). To this end, Strain gauges were installed on a tribometer with a flexible lever arm to measure tensile and bending forces (figure 1).

2 - Improve the method for analyzing results, in particular to take account of vibratory behavior in friction measurement, based on the work published in (2).

Keywords: tribometer, stick-slip, vibrations

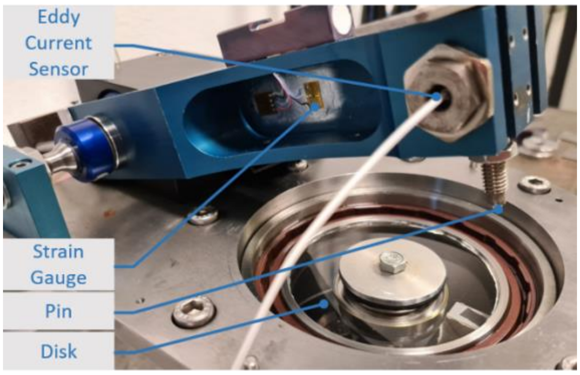

Figure 1: Pin-on-disk tribometer with flexible lever arm. The latter is instrumented with strain gauges to measure tensile and bending forces.

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Estimating tyre friction from road surface roughness: is a PSD enough?

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Abstract:
Tribological behaviour of rubber is of practical importance, especially in the tyre industry where rubber-road friction defines limits of tyre performance, wear and emissions. Persson's theory [1, 2] is the most complete to date and predicts the hysteretic component of rubber friction as a function of: road surface Power Spectral Density (PSD); rubber complex modulus; sliding speed; contact pressure. Practical application of the theory to real road surfaces remains a challenge [3], in part because the spatial distribution of roughness in real roads is not uniform. To date, approaches to tackle this lack of uniformity propose splitting the surface into 'top' and 'bottom' regions [4], but there are no methods to determine these regions a priori. With current work ongoing to define repeatable tests for Euro 7 non-exhaust emissions [5], overcoming these practical challenges is essential to be able to quantify the role of the road surface in tyre friction, and hence tyre wear and emissions.

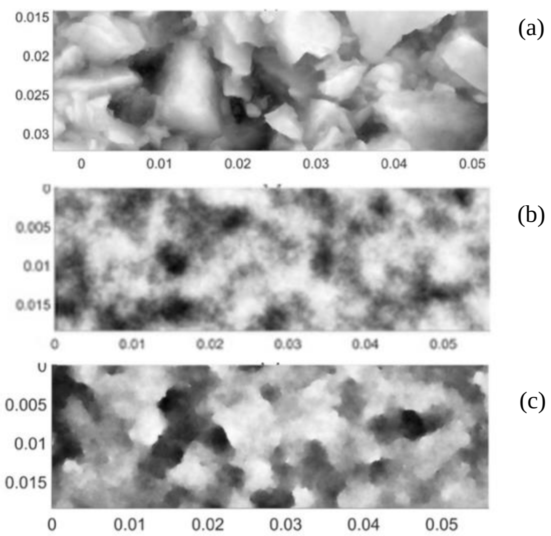

Figure 1: A comparison of road surface profile representations, with: (a) scanned surface; (b) existing state-of-the-art reconstruction approach (method from [6]); (c) our new reconstruction approach. In all cases, the PSDs are the same.

We present a new approach to determine the 'macro contact' regions between a sliding rubber block and real road surface, which uses known physical descriptors for the rubber (vertical load, sliding speed) to determine the regions of contact. We develop a method to expand the size of real road scans. This new method (output shown in figure 1c) distributes measured roughness in a manner that is more representative of real road roughness (figure 1a) than the previous state-of-the-art approaches [6] (figure 1b). Despite having identical PSDs, we postulate that such visual variability in surface topology would yield notably different friction values in reality. Hence, from our generated surfaces we capture hysteretic friction from the macro contact regions using the Boussinesq solution for an elastic halfspace, which defines (a priori) the parts of the road surface that are in the 'top' and 'bottom'.

This work has the potential to facilitate comparisons between tyres operating on different roads, which is an essential step that is currently missing within the development of upcoming Euro 7 tyre wear testing [5]. It may also help advance state-of-the-art predictive models for tyre wear [4], which rely on a PSD to capture the role of the surface in its entirety.

Keywords: rubber friction modelling, surface characterization, contact modelling, tyre friction, tyre wear, tyre emissions.

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Measurement of ice friction at different length scales

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Abstract:
Ice friction testing can show how different sliding surfaces and ice charactristics modify the co-efficient of friction, but this relies on an easy test method. Here we look at two new ice friction test methods – one at the submillimetre length scale and the other over a distance of a metre. At the submillimetre scale, the precise position and force measurement in the Hysitron TI 980 nanoindentation system (Bruker) measures friction in a cold cell along short 0.5 mm traverses. At the metre length scale, a custom built ice friction testing system with numerous signal collection over a distance of 1 metre (1). The aim of the investigation was to investigate the ability to measure the coefficient of friction (CoF) on ice along submillimetre and 1 m long sliding distances on pure ice. This study was repeated on ice with 3% salt and 3% organic salt.

A custom-made 10 mm diameter vessel contained water before freezing in the cold-cell in the Hysitron TI-980 nanoindentation system at Riga Technical University. In place of the traditional smaller sized probes, a 1 mm diameter stainless steel spherical probe was produced and fixed to the high load stage.

Ice friction tests over the 10 metre long ice track in an environmentally controlled chamber used a faster approach for testing ice-friction. Instead of slowly freezing the required depth of ice, the existing ice surface was machined flat, a row of 10 mm diameter water droplets added to the sliding path, and the 30 cm long metal slider traverses at 2 m/s under a 600 N load. Evenly spaced droplets provided a constant slider to ice contact area (Fig. 1).

The results related to submillimetre scale friction are being analyzed and will be presented at the Tribology 2025 conference.

The coefficient of friction on ice recorded every 2 mm over a 2 m distance showed repeatability on flat ice and on ice droplets with a CoF of 0.01.

Figure 1: A machined ice track with uniformly spaced frozen water droplets offers a faster approach for testing CoF of different composition water solutions.

Ice friction studies on ice droplets containing 3% salt indicated a 6% lower coefficient of friction. The CoF was lower for both inorganic salt and organic ice dissolved ice.

New fast friction tests are available at submillimetre and meter length scales. Further improvements to the test systems is extending the measurement in the nanoindentor platform from 0.5 mm to 2 mm and the linear tribometer from 2 m to 4 m for more extensive testing. The use of droplets and fast data collection will allow the friction to be measured under changing sliding conditions and ice compositions.

Keywords: ice friction, coefficient of friction, water droplets, salt

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Microstructural and tribological investigations of M2 high-speed steel alloy fabricated by directed energy deposition process

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Abstract:
M2 high-speed steel (M2 HSS) is widely utilized in the manufacturing of metal cutting tools, hot forging dies and extrusion tools due to its outstanding properties such as superior hardness, wear resistance and ability to withstand hardness at high temperatures. The M2 HSS alloys are traditionally fabricated using casting, forging or powder metallurgy processes. However, these processes are time-consuming and challenging to create complicated geometries. Directed energy deposition (DED) is a direct metal additive manufacturing technology capable for producing fully dense and intricate geometries of the M2 HSS component for a job-specific application. Thus, the primary objective of this study was to evaluate the wear resistance characteristics of the M2 HSS alloy fabricated using the DED process. The study primarily examined the phase composition, microstructure, microhardness and wear resistance properties. The findings revealed the presence of martensite, retained austenite and carbide phases that could be attributed to the rapid cooling during solidification and the presence of high carbon content as well as alloying elements such as W, Mo, V and Cr. The wear resistance behaviors of the fabricated samples were measured using a reciprocating wear test at different sliding speeds, and the coefficient of friction, mass loss and wear rates were evaluated. The wear mechanism was investigated through the examination of worn surfaces via scanning electron microscopy. The results indicated that the DED process is an effective technique for fabricating a metal sample with superior hardness and wear resistance performance.

Keywords: M2 high-speed steel; Directed energy deposition; Wear resistance; Microstructure; Microhardness.

Tribological Performance of Microindented 100Cr6 Steel Surfaces in Dry and Lubricated Non-Conformal Contacts

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Abstract:
The tribological behavior of micro-indented 100Cr6 steel surfaces under dry and lubricated conditions is experimentally investigated. Using a Vickers microhardness tester, spherical surfaces were textured with dimples of two scales: small (10 µm diagonal, 0.5 N load) and large (30 µm diagonal, 5 N load), resulting in void ratios (VRs) of 5% and 17%, respectively. Friction and wear performance were evaluated using a ball-on-disk tribometer. In dry conditions, microtextured surfaces demonstrated a significant reduction in the coefficient of friction (COF), with reductions of 45–65% compared to untextured samples, attributed to decreased contact area, debris trapping in dimples, and localized work hardening. However, large dimples caused bulges at the edges, which increased counter-surface wear and reduced wear resistance.
In lubricated conditions, small-scale dimples consistently reduced COF across the Stribeck curve, particularly at higher VRs, achieving up to 40% lower COF compared to untextured surfaces. This effect was linked to the dimples acting as secondary lubricant reservoirs. Conversely, large-scale dimples exhibited higher COF in mixed and hydrodynamic lubrication regimes due to bulge-induced wear and increased flow eddies. The COF results for some selected speeds under lubricated conditions are compared to those in dry conditions (Figure 1). These findings highlight the potential of micro-indentation texturing as an effective and adaptable method for enhancing tribological performance in both dry and lubricated systems, with promising industrial applications for locally improving friction and wear characteristics during component production and operation.

Keywords: Tribology, 100Cr6 steel, Microindentation, Dry and lubricated Friction, Wear, Void Ratio, Surface texturing, Nanohardness, Work-hardening

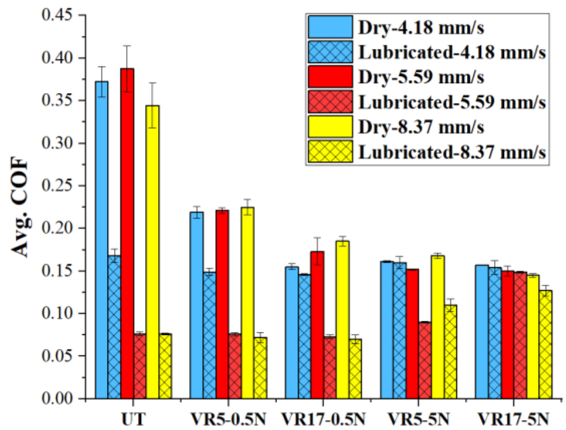

Figure 1: Comparison of COF for micro-indented 100Cr6 steel surfaces in dry and lubricated conditions

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Studying the ligand chain length effect on wear resistance of nanostabilized greases

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Abstract:
Advancements in lubrication technology play a crucial role in improving wear resistance, extending the lifespan of machinery, and enhancing energy efficiency across industries. Wear-induced failures remain a significant cause of economic loss and reduced operational efficiency in sectors relying on machinery, particularly in high-friction environments such as transportation and manufacturing. To address these challenges, nanotechnology has emerged as a transformative solution, leveraging the unique properties of nanoparticles to enhance lubricant performance.

This study investigates the effect of ligand chain length on the wear-resistance properties of nanostabilized greases. By tailoring the surface chemistry of nano-additives using fatty acids with varying chain lengths, the research aims to optimize interfacial interactions and develop more robust lubricant formulations. It is hypothesized that longer linear ligand chains enhance wear resistance by forming a stable protective layer under high-pressure contact, while branched or twisted chains may hinder performance due to irregular packing.

The research involves systematic synthesis and testing of greases formulated with nanoclay-based additives modified by fatty acids of different chain lengths. Tribological tests and 3D optic profilometry are performed to characterize the wear resistance and understand the mechanisms governing lubrication performance. Preliminary findings indicate that there is an optimum amount in increasing the ligand chain length of linear fatty acids to reduce the wear. The study explores the relationship between ligand chain length and final lubrication properties.

This work advances the understanding of nanoparticle-ligand interactions and their role in improving wear resistance. The findings contribute to developing high-performance, sustainable greases capable of reducing machinery failures, operational costs, and environmental impact, thus offering significant benefits to industries reliant on efficient and durable lubrication systems.

Keywords: 2D nanoparticles, Cloisite 20A, nanoparticle functionalization, organomodified nanoclays, fatty acid ligands, grease, tribology, wear resistance

Friction of the $PtSe_2$ layers with different grain sizes in ambient air and vacuum

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Abstract:
The two-dimensional (2D) van der Waals materials gain attention as a lubricants potentially used in MEMS, magnetic memory devices, or high-precision moving stages. Owing to their layered structure and low interlayer interaction, 2D materials demonstrate ultra-low shear strength that reduces the friction and wear of the sliding surfaces in relative motion [1]. Moreover, the solid nature of 2D materials is fundamental for effective lubrication in extreme conditions [2]. However, studies of the tribological properties of 2D materials are mostly focused on using these materials as additives to liquid lubrication systems, inappropriate for extreme conditions.

In this work, we investigated the macroscale coefficient of friction (COF) of ultrathin $PtSe_2$ layers for the first time. Large-area continues $PtSe_2$ layers (Figure 1) with different sizes of the polycrystalline grains (11, 63, and 105 nm) and horizontal orientation were prepared by one-zone selenization of the pre-deposited Pt layers on the *c*-plane sapphire substrates.

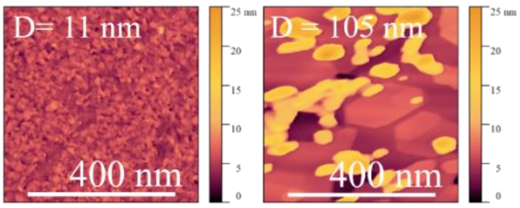

Figure 1: AFM images of the $PtSe_2$ samples with different flake sizes (11 and 105 nm).

The COF was measured with the SiN ball at the normal load of 0.25N in ambient air normal conditions and in vacuum (1×10^{-5} mBar). It was found that COF decreases with increasing the grain size in both ambient air and vacuum conditions. The COF reduction was more pronounced for large-grain samples when switching from ambient air to vacuum. COF decreased from 0.15 to 0.06 in ambient air and from 0.12 to 0.03 in vacuum as the grain sizes were reduced from 105 nm to 11 nm (Figure 2). Notable, previous investigation of the same samples on the nanoscale in ambient air demonstrated the same COF (equal to 0.15) independent of the size of the flakes [3].

The observed behaviour at macroscale is caused by the formation of tribofilm patches and transfer layers that increase in size with increasing grain size during ambient air and vacuum conditions sliding. At the same time, in the ambient air, the water vapour at the interface is supposed to increase the wear of the layer and friction. Obtained results extend the understanding of the tribological properties of dry 2D TMDC lubricants operating in different environments.

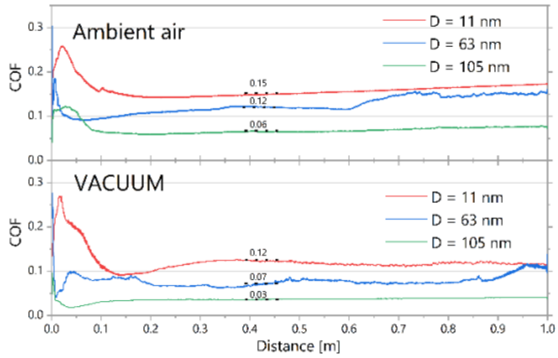

Figure 2: COF as a function of distance (1m, 250 cycles) of $PtSe_2$ samples with different flake size measured in vacuum and in air.

This work was funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V04-00709.

Keywords: 2D materials, friction in vacuum , ultrathin layers, $PtSe_2$

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Femtosecond laser texturing for improved journal-bearing performance

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Abstract
Journal bearings are the most commonly used load elements in rotating systems and have a long history in tribology research. However, the relatively new surface modification technique of femtosecond laser texturing has rarely been used to increase the efficiency of journal bearings. We used a 300-fs laser to create chevron-shaped microstructures in different circumferential texture locations on half-bearing shells to investigate the effect of partial texturing on the tribological performance of journal bearings. With a customized shaft-bearing shell setup, the coefficient of friction and lubrication film thickness were tracked in two load scenarios at varying rotational speeds. In fully film conditions, the findings demonstrate that textures in the high-load region of journal bearings provide the highest lubricant film thickness and lowest friction compared to textures in the pressure build-up, divergent zone, and unstructured reference. Moreover, surface textures in the high-load area also perform better in boundary and mixed lubrication. Experimental data have also shown that asymmetric texture designs have a detrimental effect on lubrication performance. In contrast to symmetric designs, the lubrication film build-up is hindered. The research results represent a step toward transferring laboratory findings on laser surface texturing for tribological optimization in real applications.

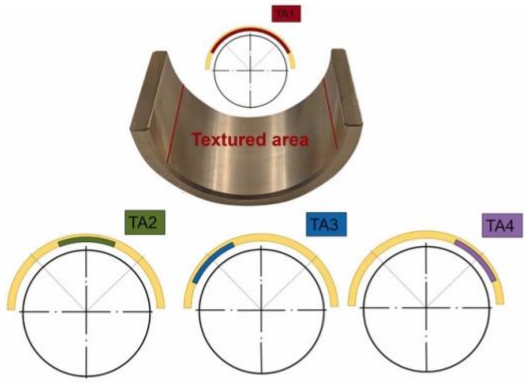

Figure 1: Laser surface texturing design for tribological optimization of hydrodynamic journal bearings

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SICT 2025 / Plasma Tech 2025
Session III. A:
Coatings for Energy and Environmental Applications

Fabrication and Characterizations of SnO_x-based Flexible and Invisible Synaptic Memristor and Their Application

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Abstract:
Nowadays, technology is rapidly evolving. Artificial intelligence(AI) is one of the fascinating technologies in the modern world. AI has made significant technological progress in face classification, speech recognition, strategic game, and decision-making. The processing of AI computing heavily depends on big data availability and requires a large amount of computation. Bio-inspired neuromorphic computing is expected to develop a more proficient computing architecture that mimics biological neural networks. Neurons and synapses are the two fundamental elements of neuromorphic architecture, where synapse plays an important role in learning and memory. Memristors can become a potential candidate to behave as synapse due to their chemical compositions and electrical properties. In the last few years, photonic memristors have attracted increasing attention for AI systems. Such memristive devices have excellent capabilities to reduce the von Neumann bottleneck issue. Additionally, integrated system consists of arrayed optical memristors to accept as building blocks of biospired vision system.
All oxide-based transparent flexible memristor is prioritized for the potential application in the artificially simulated biological optoelectronic synaptic devices. In our recent work, SnO_x memristor with HfO_x layer is found to enable a significant effect on synaptic properties. The memristor exhibits good reliability with long retention, 10^4 s, and high endurance, 10^4 cycles. The optimized 6 nm thick SnO_x-based memristor possesses the excellent synaptic properties of stable 350 epochs training, multi-level conductance (MLC) behavior, and the nonlinearity of 1.53 and 1.46 for long-term potentiation and depression, respectively, and faster image recognition accuracy of 100 % after 23 iterations. The memristor simulates synaptic behavior of spike-timing-dependent plasticity characteristic making it suitable for biological application. The flexibility of the device on the PEN substrate is confirmed by the acceptable change of nonlinearities up to 4 mm bending. Such a synaptic device is expected to be used in vision photo-receptor.

Keywords: all-oxide memristor, photonic synapse, transparent and flexible, photo-receptor

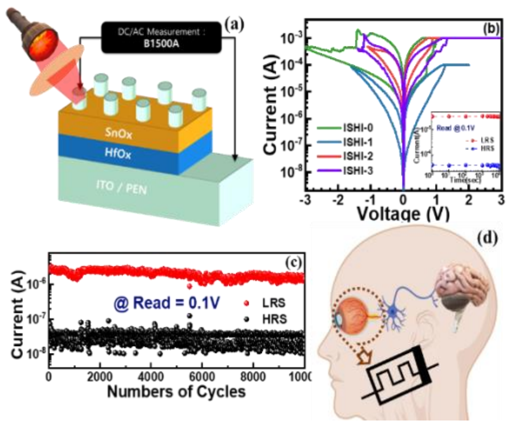

Figure 1: Figure illustrating (a) Schematic architecture of our all-oxide optoelectronic synapse and photo-recepting measurement set-up using LASER sources. (b) Bipolar I-V set/reset characteristic of different memristor synapses, inset showing the retention of optimized ISHI-1 device. (c) Endurance characteristics of the ISHI-1 and (d)Schematic of the human photo-receptor

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Two-dimensional lead iodide perovskites for solar-cell applications: An study of Surface Stability Conditions

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Abstract:
2D halide perovskites hold a great promise for electronics, optoelectronics, and solar cells applications due to the structural diversity, high absorption and photoluminescence, and tunable bandgap. Especially, they are one of the most promising studied material for photovoltaics. However critical issue is their low stability to ambient environment conditions. In this work, we have investigated degradation processes of 2D halide perovskites upon external factors such as oxygen, humidity, light, heat and photo-induced exposition. We have applied X-ray photoemission spectroscopy techniques, as well as optical techniques (micro-photoluminescence, micro-Raman spectroscopy), to demonstrate that 2D perovskites easy degrade upon heat and laser illumination in atmospheric conditions. Surprisingly, we have found a different aging chemical processes after crystal exposition to long periods (up to 1 year) in atmospheric conditions with and without the presence of external light. Crystals exposed to light aged into morphology with micro-holes and they are not photoluminescent active. On the other hand, crystals under dark conditions show wire-like morphology maintaining photoluminescence. The degradation processes finally results in removal of organic part from the crystal and formation of lead and iodine vacancies, which are probably related to side non-radiative recombination mechanisms responsible for the photoluminescence degradation. These vacancies are associated with crystal decomposition into PbI_2, metallic Pb, and Pb oxides (Figure 1).[1] This work is benefical for development of long-term stable perovskite devices with an enhanced optical performance.

Keywords: Solar Cells, Degradation, Perovskites, photoemission, photovoltaic applications

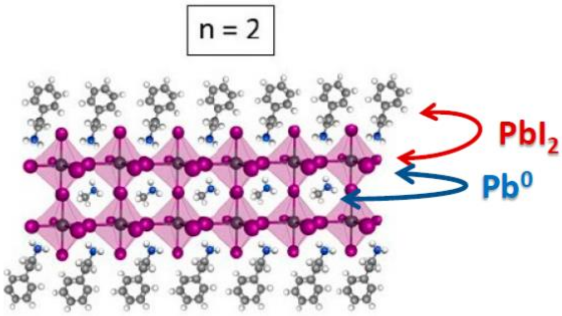

Figure 1: Figure illustrating the role that play the organic chains composing the n=2 halide perovskites in the degradation processes taking place.

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Surface Magnetic Structures in Flexible Composite Glass Covered Microwires

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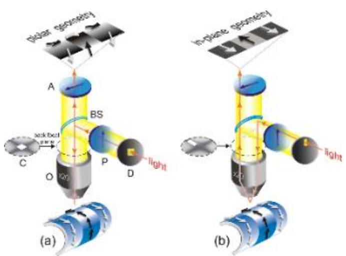
Abstract:
Advances in the technological application of magnetic glass-covered microwires have established a goal in studying the magnetic properties of these composite structures. We systematically study surface magnetic structures in microwires using magneto-optical Kerr effect (MOKE) and have achieved certain successes [1, 2]. In this work, we present the classification of surface magnetic domain structures that we have established as a result of our latest studies.
The magnetic domain structures in the microwire were investigated using a high-resolution, wide-field optical polarizing microscope, which was adapted for visualization of magnetic domains with all magnetization components in non-planar microwires (Fig. 1). For the polar geometry of the microscope, the magnetic areas with the out-of-plane component of magnetization in cylindrical microwires were observed, while in the longitudinal geometry we observed the in-plane components of the magnetization.
The magnetic structures of the studied microwires are affected by the magnetoelastic anisotropy and determined essentially by the sign of the magnetostricion. The magnetic structure consists of the inner core and the outer shell. The following surface magnetic structures were observed (Fig.1): circular, elliptic, spiral and longitudinal. Transitions between different structures can be induced by such external parameters as axial and circular and transversal mechanical stress, annealing temperature and thickness of the glass coating. Twisting and bending mechanical effects are key factors in fine-tuning surface domain structure for sensing application of composite microwires.

Keywords: magneto-optic Kerr effect, magnetic domains, flexible magnetic microwires,



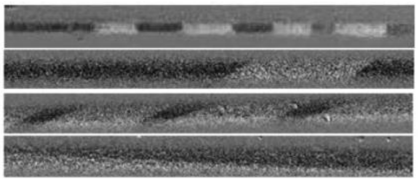


Figure 1: a) polar MOKE, b) longitudinal MOKE and examples of magnetic structures.

References:

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$Al_xTa_yO_z$ thin films deposited by pulsed direct current reactive magnetron sputtering for dielectric applications

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Abstract:
The dielectric behavior of oxide thin films is a major research topic due to many applications of microelectronic devices in our daily life and further efforts for their miniaturization [**1**]. The most recent research deals with ternary oxide thin films described for enhanced dielectric properties in comparison with binary oxides. This study aims to synthesize and characterize aluminum tantalum oxide thin films ($Al_xTa_yO_z$) deposited by reactive magnetron sputtering. They are compared to aluminum oxide (Al_xO_z) and tantalum oxide (Ta_yO_z) thin films deposited in the same experimental conditions.

$Al_xTa_yO_z$ thin films are deposited at low temperature by pulsed direct current reactive magnetron sputtering. Targets made of a mixture of aluminum and tantalum in various concentrations are sputtered in argon-oxygen atmosphere. The argon flow is kept at 60 sccm during deposition, and several oxygen flows are studied ranging from 5 sccm to 39.6 sccm.

The $Al_xTa_yO_z$ thin films are dense, uniform, and poorly crystalline regardless of the experimental conditions used in this study (**Figure 1**).

Their chemical composition is determined by the target composition and by the oxygen flow used during deposition. Tantalum promotes the deposition rate and amorphization of the $Al_xTa_yO_z$ thin films. Metallic tantalum clusters are identified in the thin films produced at low oxygen flow that are conductive. The highest dielectric strength is measured for the thin film containing a low amount of tantalum combined with a high amount of oxygen (**Figure 2**).

$Al_xTa_yO_z$ thin films were successfully deposited by pulsed direct current reactive magnetron sputtering. The concentrations of aluminum, tantalum, and oxygen in the thin films depend on the experimental conditions of the process. The deposition rate, chemical composition, and dielectric strength of the films were optimized by the experimental conditions of the process [**2**].

Keywords: reactive magnetron sputtering, ternary oxide, aluminum, tantalum, dielectric strength.

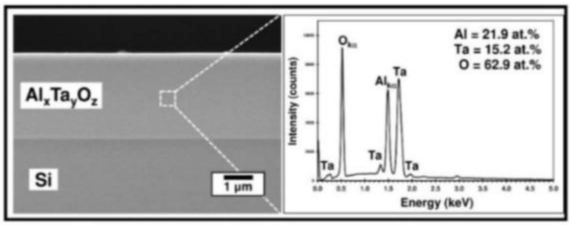

Figure 1: Cross-section SEM image and EDS spectrum of $Al_xTa_yO_z$ thin films deposited on silicon substrate by pulsed-DC reactive magnetron sputtering.

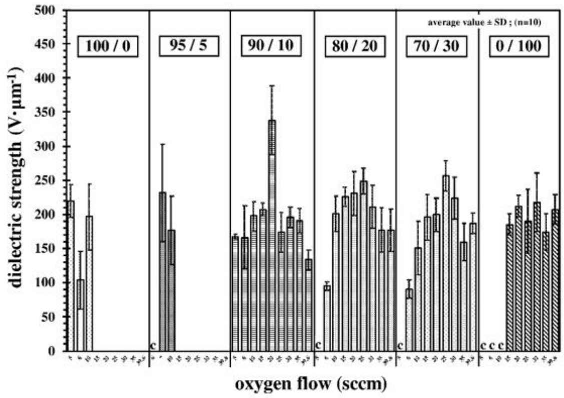

Figure 2: Dielectric strength of Al_xO_z, Ta_yO_z, and $Al_xTa_yO_z$ thin films deposited by pulsed-DC reactive magnetron sputtering at different oxygen flow from targets of different Al at.% / Ta at.% compositions. (c: conductive thin film)

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Durable $VO_2@SiO_2$-based Thermochromic Coatings on Building Exterior Structures for Enhanced Energy Efficient and Thermal Comfort

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Abstract:
Building energy accounts for 30-40% of the global energy consumption. Heating, ventilation and air conditioning (HVAC) systems, essential for maintaining thermal comfort, contribute to over 60% of total building energy consumption in EU countries[1]. Due to fossil fuel derived energy use, thermal comfort has played a role in climate change with consequences such as extreme weather events[2]. Improving the building envelope properties is a key solution to enhance thermal energy efficiency and maintain indoor thermal comfort. Thermochromic coatings, for example those based on VO_2, have great potential in this endeavor due to their ability to autonomously switch between absorptive and reflective states in response to cold or hot weather, respectively[3]. However, the poor durability of VO_2-based coatings in outdoor conditions presents a challenge for their application on large-scale building exterior structures. In this work, we successfully prepared tungsten-doped VO_2 particles with a phase change temperature of 29.4 ºC through a one-step hydrothermal synthesis method. Infrared-transparent protective SiO_2 shells were in-situ prepared on the surface of VO_2 particles to achieve improved oxidation resistance. Furthermore, a VO_2-based thermochromic coating that combined superhydrophobicity and strong adhesion properties was successfully fabricated by tuning the content of incorporated PDMS and epoxy in coating formulation, achieving a contact angle of 151.0º and an adhesion strength of more than 3.75 MPa. The coating showed excellent thermochromic properties which efficiently decreased indoor temperature fluctuations both in hot and cold building models verification experiments. This work successfully fabricated durable VO_2-based thermochromic coatings that adhere well to concrete substrates and have substantial energy-efficiency potential, providing a promising energy-saving solution to sustainable buildings.

Keywords: vanadium dioxide, smart coatings, thermal comfort, energy efficiency, interfacial engineering.

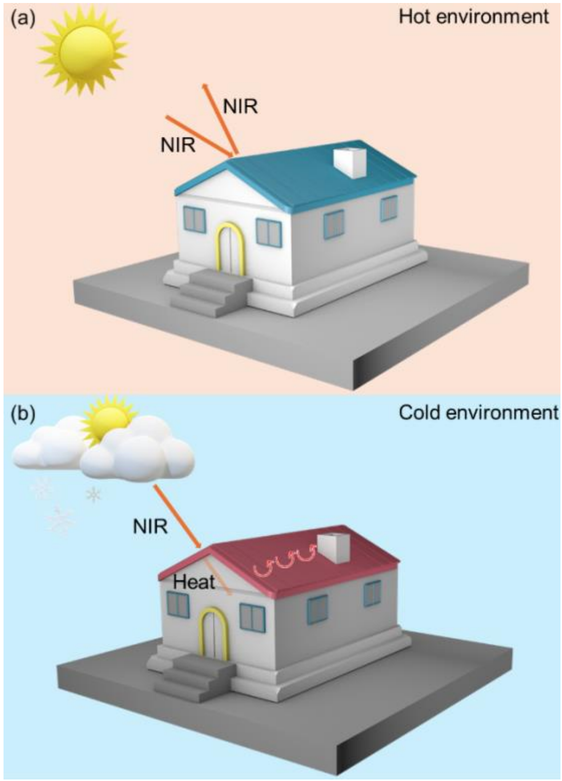

Figure 1: (a) VO_2-based thermochromic coating showed high reflection and low absorption performance in the hot environment, achieving a cool roof; (b) VO_2-based thermochromic coating showed low reflection and high absorption in cold environment, achieving a warm roof.

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Nanoparticle/PDMS Composite Films as Thermochromic, Anti-icing, and Self-Cleaning Coatings, *ACS Appl. Nano Mater.*, 5, 5599-5608

Adaptation of a paper surface functionalization driver for the manufacture of a lithium-ion battery negative electrode.

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Abstract:
Road transport accounts for 73% of greenhouse gas emissions from the transport sector[1]. In this context, the European Union has strengthened Regulation (EU) 2019/631, which prohibits the sale of new vehicles with direct CO_2 emissions starting in 2035. Lithium-ion batteries are one of the solutions to comply with these new European regulations. The negative and positive electrodes, along with the separator, are assembled in a multilayer structure and placed in pouches, which are then filled with electrolyte to form a battery cell.

In the paper industry, functionalization pilot lines are used to coat paper in order to improve specific functions (printability, durability…). Paper is a porous and hydrophilic material, and the coatings used are generally mineral-based, such as kaolin, or latex-based, such as styrene-butadiene rubber (SBR).

The negative electrode of lithium-ion batteries consists of a current collector (copper film) coated with an active layer (graphite) on both sides. The copper film is manufactured by an electrodeposition process, which results in different surface properties of the sides. The slurry, composed of graphite, carbon black, SBR, and carboxymethyl cellulose (CMC), is then coated onto the copper film using a slot-die coating technique. A hot air drying is then applied to remove the water before a calendaring stage.

The aim of this study is to assess the feasibility of using papermaking processes (Figure 1) for negative electrode production.

The copper film was characterized by measuring its surface energy using dynamic contact angle devices and its roughness via air flow technics. The rheological behavior of the slurry was also measured, along with its surface tension. These characterizations allow the definition of slot-die coating process parameters by determining the limits for swelling, air entrainment, and low flow rates. Available models[2] establish the pressure to be applied between the slot-die head and the substrate as a function of web speed (Figure 2).

Simulations of the slurry drying process were performed to estimate the drying time and the temperatures reached during the process, as excessive temperatures can degrade electrode performance. Excessively strong and rapid drying degrades the slurry's adhesion, making it brittle.

The two different sides of the copper film can lead to variations in coating quality and adhesion. For non-calendared electrodes, delamination always occurs on the smoother side. Calendaring appears to reduce these adhesion differences between them.

Based on the initial trials, it appears feasible to use papermaking processes for negative electrode production. However, several aspects require further investigation, including copper expansion, web tension adjustments, and calendaring conditions.

Keywords: lithium-ion battery, slot die coating, IR drying, hot air drying, negative electrode, manufacturing.

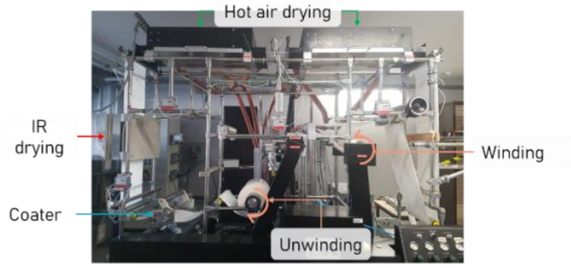

Figure 1: Paper functionalization facility.

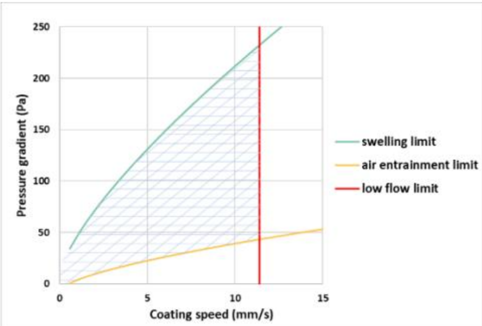

Figure 2 : Process window for slot-die coating.

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Thin-film coating development for enhanced conductivity and corrosion resistance of stainless steel bipolar plates in hydrogen applications

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Abstract:
The transition to a climate-neutral industry requires the strategic adoption of hydrogen, particularly within steel production, mobility, and energy industries. Polymer electrolyte membrane fuel cells (PEMFCs) and polymer electrolyte membrane water electrolyzers (PEMWEs) are central to this transition due to their high efficiency and operational benefits, such as long travel ranges and rapid refueling in the case of PEMFCs, and effective hydrogen production in PEMWEs. However, the adoption of these technologies is constrained by high production costs and limited operational lifetimes, primarily due to the instability of metallic bipolar plates (BPP) in acidic environments. Austenitic stainless steel (SS316L) is a promising candidate for BPPs, offering excellent mechanical properties, including formability and strength. While its native oxide layer offers relatively good corrosion resistance, it is inadequate for prolonged use and contributes to high electrical resistance, leading to performance losses. This research investigates different thin film coatings in order to enhance the bipolar-plate properties of the SS316L, crucial for both PEMFC and PEMWE applications (see figure 1). Our findings show that the developed carbon- and metal-based thin film variants significantly reduce the current density measured in the polarization tests. Moreover, the contact resistance of the stainless steel substrate is reduded by several orders of magnitude. These results indicate potential pathways for cost-effective and durable BPP solutions in both fuel cells and electrolyzers.

Keywords: thin film, corrosion, contact resistance, bipolar plate, fuel cell, electrolyzer

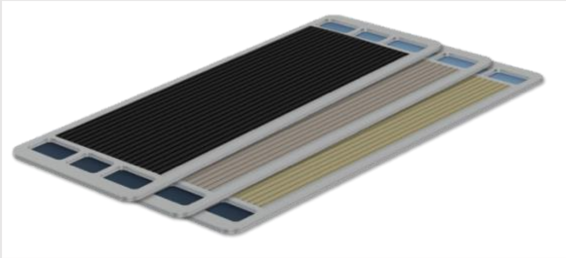

Figure 1: Figure illustrating the research topic of this study: thin-film coating development for stainless steel bipolar plates based on carbon and corrosion-resistant valve metals.

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Oxidic barrier development and hydrogen gas phase permeation analysis

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Abstract:
Hydrogen barriers are required in aerospace and automotive industries, as well as for energy generation and conversion processes where materials are exposed to hydrogen environments. These barriers are essential in preventing hydrogen incorporation into materials that can otherwise cause detrimental effects such as hydrogen embrittlement. This effect is due to hydrogen atoms occupying interstitials in the crystal lattice and thereby inducing increased brittleness and reduced fracture toughness [1]. Especially PVD processes offer the opportunity of tailoring the coatings composition and microstructure and are known for producing thin but dense and well-adhered coatings [2]. However, they suffer from substrate contaminations and growth defects like pinholes, limiting their performance as permeation barriers.

It is crucial to analyse the effectiveness of coatings through application-related tests. By utilizing custom-built, gas-phase hydrogen permeation test benches, we can directly assess how defects, deposition methods, microstructures, and other factors impact the barrier properties against hydrogen.

For depositing oxidic barrier layers on ferritic steel membranes, we employed reactive RF sputtering and HiPIMS. To overcome the disadvantages of the individual deposition methods, we have investigated a superposition of RF and HiPIMS on a single magnetron [3]. Scanning electron microscopy, X-ray diffraction analysis and light microscopy was used to identify and quantify the defect density. Nanoindentaion was performed for the analysis of mechanical properties.

Our results demonstrate that the defect density can be influenced by superimposing a HiPIMS pulse with an RF voltage. The influence of hydrogen permeation through defective coated membranes is shown in this work. However, further extensive investigations are needed to gain a deeper understanding of material-dependent defects and their impact on barrier performance.

Keywords: hydrogen barrier coating, oxidic coating, PVD, HiPIMS, hydrogen permeation analysis.

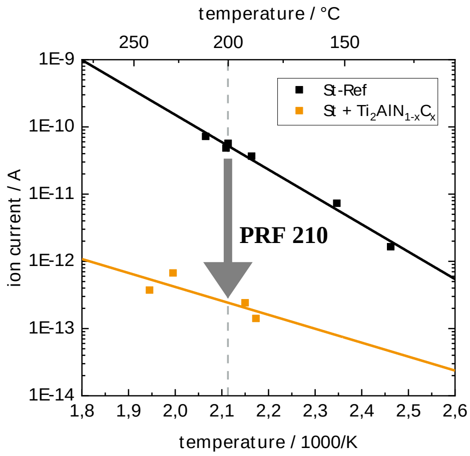

Figure 1: Arrhenius-diagram of an hydrogen permeation analysis to quantify the coatings barrier properties against hydrogen.

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Self-stratifying and self-healing vitrimer coatings

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Abstract:
Traditional multilayer coatings, while effective in providing adhesion, protection, and aesthetic properties on a variety of surfaces, require multiple successive application steps, increasing process complexity, costs, and solvent consumption. To overcome these limitations, self-stratifying coatings[1,2] represent a promising alternative: using a single formulation and application, this approach enables the spontaneous formation of distinct layers. This process not only reduces application complexity and significantly limits solvent use but also allows for greater control over the morphology and final properties of the film.

To address environmental concerns, our project focuses on developing self-stratifying and self-healing films based on vitrimers,[3] enabling the selective delamination and recycling of each constitutive layer independently. Various self-stratifying coating systems, including bio-based vitrimer epoxy/vitrimer silicon and vitrimer epoxy/vitrimer benzoxazine, will be discussed. The self-stratifying morphologies are observed by SEM/EDX, while vitrimer properties are investigated through linear rheology, particularly stress relaxation tests, to determine the optimal temperature conditions for activating covalent exchange reactions and enabling the selective dissociation of layers. Self-healing properties are assessed by optical microscopy, monitoring scratch healing after various thermal treatments. Finally, adhesion to the substrate is evaluated using standardized cross-hatch adhesion tests.

By combining vitrimeric properties with the benefits of self-stratifying coatings, this project paves the way for innovative, self-healing, and recyclable materials, contributing to the development of more sustainable coating technologies.

Keywords: self-stratifying, vitrimers, self-healing , recyclability

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Migration of $LiFePO_4$ particles inside a self-stratifying system epoxy vitrimer and PVDF

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Abstract:
In recent years, lithium metal batteries have emerged as the leading technology for electric transport. However, they continue to face significant challenges concerning safety and recyclability. Current research efforts are directed toward developing coatings for the cathode surface to reduce its erosion and degradation[1,2], as well as designing solid electrolytes to address safety concerns. Despite these advances, two critical challenges remain: enhancing ionic conductivity and ensuring the solid electrolytes' adhesion to the electrode. This study introduces an innovative solution to these issues by creating a recyclable and reusable self-stratifying coating based on vitrimer technology. Self-stratifying coatings enable the spontaneous formation of multi-layer structures in a single formulation, application, and drying step. This approach provides excellent adhesion to the cathode (via the base layer) and efficient ionic exchange (through the stratifying layer)[3,4]. Furthermore, incorporating vitrimer polymer networks, which combine thermoplastic properties with thermosets, imparts self-healing, recyclable, and reusable characteristics to the coatings.
The formulations employed an industrial disulfide epoxy resin, EPS35, crosslinked with a thiol (pentaerythritol tetrakis(3-mercaptopropionate)). The stratifying resin was a commercial fluoropolymer, Lumiflon LF200. SEM/EDX analyses confirmed type I self-stratifying patterns (the highest quality rating). Subsequently, nano- and micro-fillers, including carbon black and $LiFePO_4$, were integrated into the system. Depending on the formulation parameters, type I profiles were consistently observed. Adhesion tests using the cross-hatch cutter method yielded a type 0 rating, indicating excellent adhesion to aluminum and copper substrates according to the ISO 2409 (2020) standard.
Recycling tests demonstrated that the polymer coatings could be completely removed from substrates at varying temperatures (60°C to 140°C). Future work will involve conductivity testing for batteries, following the incorporation of lithium salts into the system. Additionally, efforts will focus on replacing the fluoropolymer with polyethylene oxide to achieve comparable ionic conductivity while eliminating PFAS.

Keywords: self-stratifying, vitrimers, lithium metal batteries, recyclability, solid-electrolyte

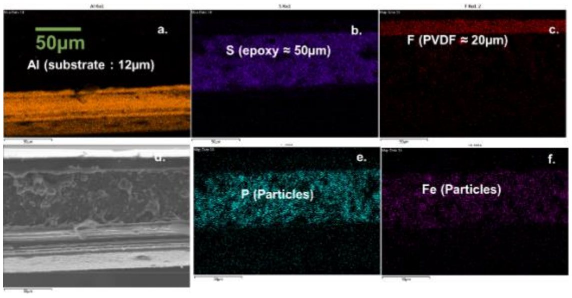

Figure 1: SEM-EDX view of a self-stratifying system. a.: Aluminium as susbtrate. b.: Epoxy layer with a mapping on sulfur from disulfide bond. c.: Fluorine mapping from PVDF layer. d.: SEM view of the bilayer coating. e.: Phosphorus mapping highlighting migration of $LiFePO_4$ particles only on base layer. f.: Iron mapping from $LiFePO_4$ particles

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Thin ZnO films prepared by plasma-enhanced atomic layer deposition (PEALD) for future photocatalytic applications

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Abstract:
Atomic layer deposition (ALD) is an advanced deposition technique that allows us to synthesize high-quality thin ZnO films. By varying the parameters for thin film synthesis, different structural and physical properties of the films can be obtained [1-3]. The most important synthesis parameter is the deposition temperature. In thermal ALD, the temperature range for the deposition of high-quality films is between 120 °C and 180 °C. An upgrade of conventional ALD is plasma-enhanced atomic layer deposition (PEALD), which enables deposition at lower temperatures without impairing the film quality and growth rate. The photocatalytic activity of the films deposited by the PEALD method shows a maximum value for films deposited at temperatures below 100 °C, and their efficiency is higher than that of the best thermal ALD films. In the present study, we compared the crystal structure, optical properties and photocatalytic activity of thin films deposited at 60°C, 80°C, 100°C and 200°C using the PEALD method. The HRTEM images show that the films synthesized at lower temperatures have smaller, roundish grains, while the films synthesized at higher temperatures consist of larger, elongated crystals that are perpendicular to the substrate. The smaller grain structure has a much higher concentration of localized surface states, resulting in better photocatalytic activity.

The final aim of the study is to develop an efficient technique for the photodegradation of microplastics. Since the PEALD technique can be applied at or near ambient temperature, we can use it for the deposition of a metal-oxide photocatalyst directly on the surface of the microplastic particles and thus singnificantly increase the degradation efficiency. The newly developed method is presented using the example of the photodegradation of PET microfibres.

Keywords: Thin films, zinc oxide, plasma enhanced atomic layer deposition, photocatalytic activity, photodegradation, microplastics.

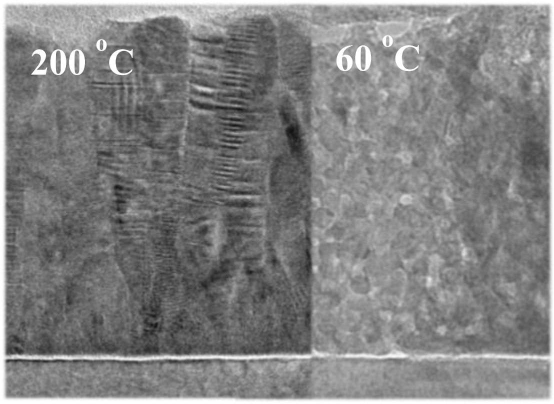

Figure 1: HRTEM images of the cross sections of PEALD ZnO thin films deposited at 200 °C and 60 °C show large differences in grain size, shape and orientation of the two pollycrystallyne films. The small grain structure leads to a significantly higher photocatalytic activity of the deposited thin film.

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Tribology 2025 Session III. B: Lubricants and hydrodynamic lubrication / Biotribolog

Lubrication with liquid-air mixtures in industrial applications

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Abstract:
Hydrodynamic and hydrostatic journal bearings used for guiding and supporting pump rotors in nuclear power generation units are often lubricated with water due to its abundance. There are however circumstances when air can be ingested into the bearing and even small volume fractions of air can modify the characteristics of the lubricant. The problem is first presented for hydrostatic bearings where air is ingested thru the feeding system [1]. The first question to answer is the homogeneous or non-homogeneous character of the flow. The problem is dealt with a CFD approach modeling. A non-homogeneous flow model showed that liquid and air phases can have different velocities at the transition zones between feeding orifices, pockets and the thin film lands. However, the impact on pressure variations is negligible compared to the homogeneous flow model. Therefore, it was considered that the mixture flow in the bearing is homogeneous and a thin film model based on averaged convective inertia forces was developed. This model was justified by the large reduced Reynolds number encountered in hydrostatic bearings which make the traditional Reynolds equation inappropriate. The results obtained with this model showed the impact of the ingested air on the rotordynamic coefficients of hydrostatic bearings (Fig. 1)
Hydrodynamic bearings can be also impacted by air ingestion [2]. This time the scenario is different because these bearings have a helicoidal groove design for creating an axial pumping effect that can also entrain air. The Reynolds numbers being lower than in hydrostatic bearings, Reynolds equation is used together with the assumption of a homogeneous thin film flow. The results showed how the ingested air modifies the cavitation area inside the bearing and how rotordynamic coefficients are impacted. The for heavy static loads the ingested air has a favorable impact that switches for lower loads.
The density and the viscosity of water-air mixture used in these models (convection dominated thin film model for hydrostatic bearings and Reynolds equation for hydrodynamic bearings) are based on formulas taken from the literature that employ either the volume or the mass fraction as interpolants between the characteristics of water and air. However, the results are quite contradictory especially for the viscosity of the water-air mixture. It is then emphasized the necessity of an experimental program that would clarify the dependence of the viscosity of the mixture on the ingested air fraction..

Keywords: hydrostatic and hydrodynamic journal bearings, water-air mixture flow, load capacity, dynamic coefficients.

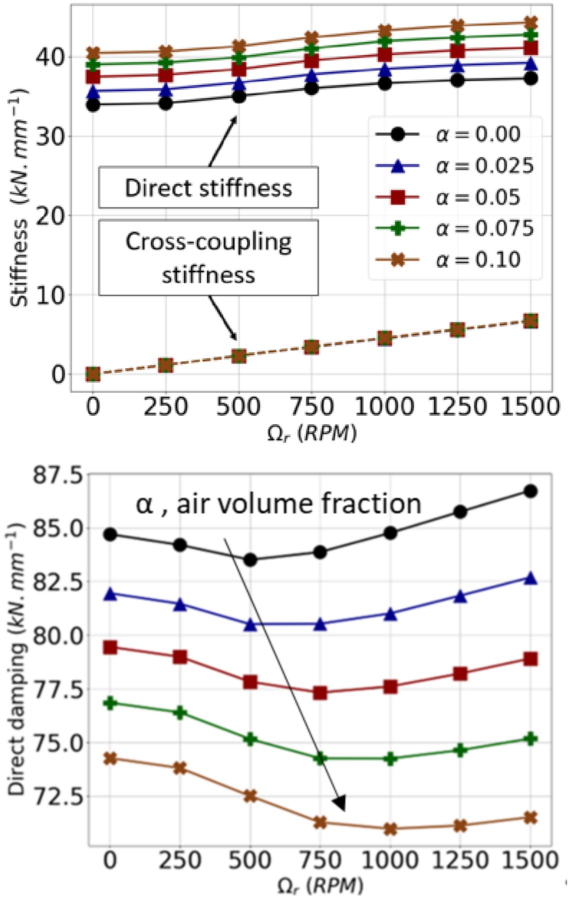

Figure 1: Variation of dynamic coefficients of a hydrostatic bearing fed with water-air mixture.

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Journal Bearing With Inclined Grooves, *J. Eng. Gas Turbines Power*, 147(4): 041013.

Control of lubricant film thickness by using electro-responsive biolubricants

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Abstract:

Electro-responsive fluids present great potential for smart lubrication. The reversible changes attained in such lubricants through the application of an external electric field allow them to adapt to specific operational conditions, which translates to an active control of the lubrication process. However, there are still numerous variables to be studied in the application of these fluids in lubrication, as it remains an emergent area of research. This experimental work focuses on the influence of the electric field on the lubricant film thickness in a non-conformal contact (ball-on-disc), using a simple and sustainable lubricant formulation. The biolubricants studied are composed of a vegetable base oil (castor oil) and a dispersed organo-modified nanoclay (Cloisite 15A) in concentrations between 1 and 6 wt.%. Through an optical interferometry experimental method, it was possible to determine film thickness across the entire contact area, over a range of entrainment speeds. The thickness variation applying 0 V and 30 V between the ball and the disc was observed. Hence, the effect of combined parameters (nanoparticle concentration, entrainment speed and electric potential difference) on film thickness is reported. This evaluation delves into film thickness along the entrainment direction, with special emphasis on central and minimum film thickness. The results confirm the capacity to electro-modulate film thickness, as it effectively thickened when an electric potential was applied, especially at lower speeds (Figure 1). This study underscores the relevance of this type of lubricants, which not only pose a minimum environmental impact but also may improve efficiency. Further research could be carried out to study the influence of electric field on friction in the same test conditions. The comprehension of both friction and film thickness behavior under electric field is fundamental for the design and development of potential applications.

Keywords: film thickness, electro-responsive lubricant, smart lubricant, biolubricant, optical interferometry, lubrication active control, EHL lubrication.

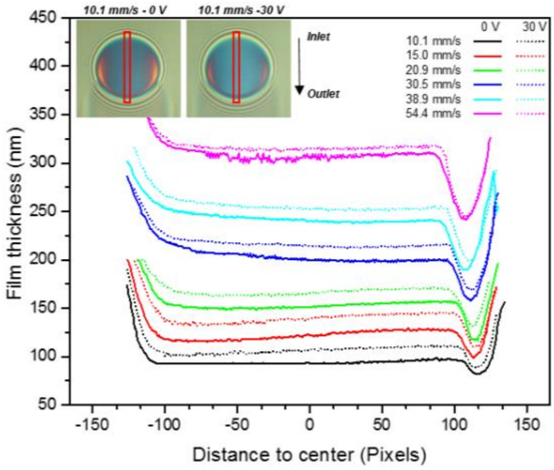

Figure 1: Film thickness profile along the entrainment direction for selected entrainment speeds (in pure rolling), at 0 V and 30 V, using a 6 wt.% Cloisite 15A dispersion in castor oil.

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Exploring Surface Microtexture Parameters with OpenFOAM

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Abstract:
Surface microtexturing has emerged as a promising method to reduce friction and enhance tribological performance in various engineering applications. However, the literature on this subject reveals a divide between experiment-first [1] and simulation-first [2] approaches. Simulation-first studies can be further categorized into those employing commercial computational fluid dynamics (CFD) software and those relying on custom implementations of the Reynolds equation, typically solved using finite difference (FDM) or finite element (FEM) methods. Altough a unique solution of the Reynolds equation provides a better description of the friction and lubrication regime, developing a solver or implementing the equation in commercial code and achieving a stable solution requires extreme effort. Hence, a simplified solution using CFD provides an achievable point of entry for most. Altough a CFD model will not be suitable for film thickness estimation, and a meaningful implementation of surface roughness is yet to be developed, other key phenomena – e.g., cavitation – can be considered [3] during solving the Navier-Stokes equation.
This work presents the development of a CFD model using OpenFOAM to investigate the influence of surface microtexture parameters on friction. OpenFOAM's flexibility enables the incorporation of a cavitation model. Cavitation, which involves the formation and collapse of vapor bubbles in the lubricating film, can significantly alter pressure distribution and film thickness, thereby impacting the overall tribological performance of textured surfaces. The study evaluates texture configurations across a range of parameter values, including depth-to-diameter ratios, cross-sectional shapes, and texture density. By varying these parameters in a controlled CFD environment, the model provides insights into optimal texture designs for minimizing friction under different operating conditions.

Keywords: surface microtexture, computational fluid dynamics, cavitation modelling,

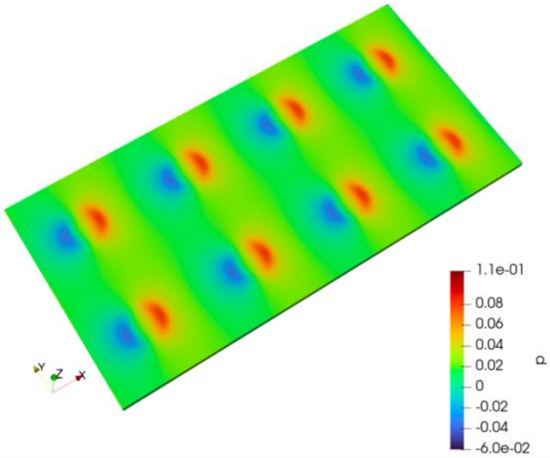

Figure 1: Pressure distribution over microdimpled sliding surface, highlighting the pressure increase on the leading edge and decrease on the trailing edge of the dimples.

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Optimization of Artificial Oil Aging Process for E20-contaminated Oils Using Design of Experiment Methodology

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Abstract:
The aim of this study was to establish an experimental methodology to produce artificially aged oils with properties closely approximating those of oil samples derived from engine dynamometer. The research focused on replicating the friction coefficient, average wear scar diameter, and anti-wear additive content of E20-contaminated used oil derived after 129 hours of operation, using an artificial oil aging process. A design of experiment (DoE) methodology was applied to explore the effects of various parameters on the system and to determine optimal settings. Based on the fractional factorial design used for preliminary screening, the aging temperature, heating period duration, and total aging time were modified (Figure 1). Friction and wear experiments were conducted using an Optimol SRV®5 tribometer in a ball-on-disc arrangement, while wear scars were analyzed with a Keyence VHX-1000 digital microscope. Oil analysis was performed using an Anton Paar 3001 viscometer and a Bruker Invenio-S Fourier-transform infrared spectrometer. The DoE methodology clarified that the heating period duration had a negligible effect on oil degradation. While the aging time mainly affected changes in the friction coefficient and average wear scar diameter, the aging temperature was found to be the key factor impacting the anti-wear additive content. Gaussian elimination was used to determine the optimal settings for artificial oil aging, based on the linear equations derived from the fractional factorial model and the used oil's (129h) friction coefficient, average wear scar diameter, and anti-wear additive content. To enable a comprehensive analysis of the results and establish further correlations, the test specimens were examined using a Zeiss Crossbeam 350 field-emission scanning electron microscope and a ThermoFisher NexsaG2 X-ray photoelectron spectrometer.

Keywords: design of experiment, artificial oil ageing, FT-IR, coefficient of friction, wear scar diameter, E20 fuel

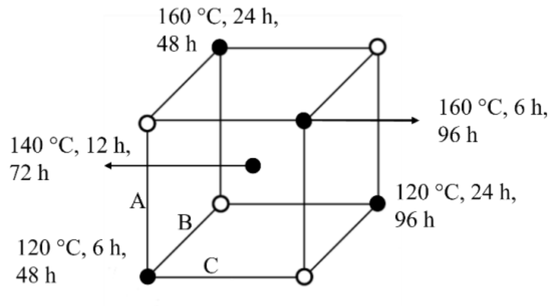

Figure 1: The figure illustrates the parameters selected and applied for artificial oil aging, determined based on the fractional factorial design of experiment methodology. During the artificial oil aging process, variables such as temperature (A), heating period duration (B), and total aging time were adjusted (C). This methodology enabled efficient system mapping and screening with a minimal number of experiments, highlighting the direction of further measurements and reducing the number of significant variables.

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Design and experimentation of a tribometer for non-lubricating fluid studies in journal bearing applications

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Abstract:
Friction and wear phenomena are considered nowadays a strategic research topic for European Union' sustainability goals: in fact, recent studies estimate a potential saving up to 24% of primary energy consumption derived through tribological improvements[1]. Within the vast field of tribology of shaft-journal bearing systems, mechanics in non-lubricating fluid environments still represents a partially unexplored scientific area. Many industrial sectors are affected by the need of transporting and storing non-lubricating fluids, adopting mechanical technologies that often turn out to be inadequate for this purpose. Wrong materials choice and unbalanced working conditions not only lead to short working life of many mechanical components, but also force users to adopt inefficient technologies to face industrial challenges. This scenario even worsen when non-lubricating fluids contain solid particles, which can result in abrasive agents towards materials.

The present study is based on an industrial problem to analyze this engineering issue. An innovative custom tribometer is proposed in order to simulate the behavior of different materials, treatments and coatings for shaft and journal bearing in non-lubricating environments. The instrument is designed to operate under high rotational speeds, heavy radial loads, and fixed operative temperature. A statistical approach is proposed to correlate torque and heat outputs with operating parameters, according to models proposed in previous literature.[2]

Keywords: journal bearing, non-lubricating fluid, tribometer design, statistical model

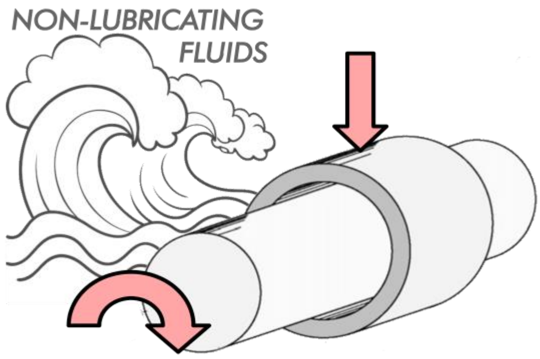

Figure 1: Figure illustrating the fundamental question that we are tempting to solve experimentally: how non-lubricating and abrasive fluids influence the tribological behaviour of journal bearings, depending on materials, coatings and treatments of sliding components?.

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Multi-scale friction model for finite element analysis of automotive brake pad-disc components

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Abstract:

Friction in automotive brake systems is a critical factor affecting safety, performance, and product durability, requiring a robust model associated with underlying mechanisms[1,2]. This study developed a novel multi-scale friction model for finite element (FE) simulation, integrating experimental results from brake dynamometer tests with advanced numerical modeling techniques. The dynamometer tests were performed under controlled pressure and temperature conditions to investigate the evolution of surface roughness and its influence on frictional behavior. The brake pad's surface topology was modeled using a double-Gaussian distribution, which accurately represented the effect of wear observed during iterative braking tests.

The proposed friction model comprises a contact model and a plowing model. The contact model predicts the real contact area by solving two governing equations: the energy balance equation, which formulates the equilibrium between external work and internal deformation energy, and the volume conservation equation, which ensures geometric consistency of asperity deformation. The plowing model, based on slip line analysis[3], estimates the friction coefficient by accounting for the interaction between hard disc asperities and softer brake pad surface. The effect of parameters such as pressure, temperature, and surface roughness on the contact area and friction coefficient was investigated.

To enhance computational efficiency, the friction model was coded externally and translated into a piece-wise linear function for implementation in the user subroutine of FE simulation. The FE simulations, performed using ABAQUS, successfully replicated experimental observations, demonstrating the model's capability to predict friction behavior under varying operating conditions. By linking surface topology, control variables, and macroscale friction coefficient, the multi-scale model provides a comprehensive framework for demonstrating tribological behaviors in automotive braking systems.

Keywords: Finite element analysis, multi-scale friction model, automotive brake system, constitutive modeling

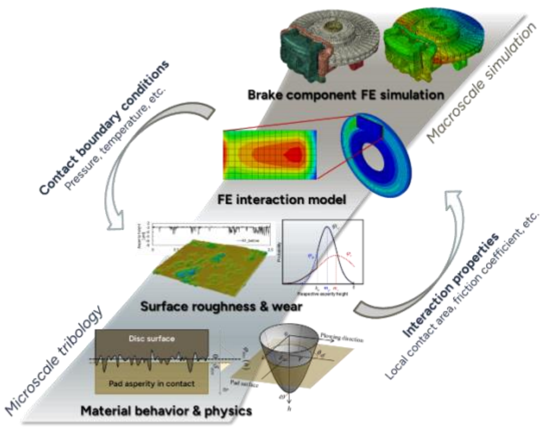

Figure 1: Multi-scale framework for the friction model, linking tribological mechanisms at the microscale to macroscale finite element (FE) analysis of brake systems

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Tribological Study on Friction and Wear Mechanisms of Neodymia, Yttria, and Tungstic Oxide Nanoparticles in a Partially Formulated Engine Oil

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Abstract:
This study explores the tribological effects of neodymia (Nd_2O_3), yttria (Y_2O_3), and tungstic oxide (WO_3) nanoparticles, which have not been previously investigated as lubricant additives from a tribological perspective. These materials represent a novel approach to enhancing lubrication performance. The nanoparticles were evaluated in a partially formulated engine oil containing viscosity modifiers, pour point depressants, detergents, and dispersants and in a Group III base oil to isolate their effects. Results revealed significant friction reduction (up to 20%) and wear reduction (up to 65%) in the tribological system. The nanoparticles integrate into the contact surfaces, reducing surface fatigue and forming a protective tribofilm with favorable tribological properties. Moreover, they exhibited strong synergistic effects with the formulating additives, enhancing overall lubrication efficiency. Tests were conducted using a ball-on-disc configuration under linear oscillating tribometer conditions, with high-resolution friction data collected to analyze performance at varying sliding speeds. Load-bearing capacity was assessed through wear scar diameter measurements, and wear volumes were quantified using confocal microscopy. Scanning electron microscopy and energy-dispersive X-ray spectroscopy characterized wear mechanisms and nanoparticle roles within the tribological interface. This research provides novel insights into the use of these oxide nanoparticles, demonstrating their potential to transform lubricant formulations with enhanced tribological performance.

Keywords: nanoparticle, tribology, friction, wear, yttria, neodymia, tungstic oxide, lubricant.

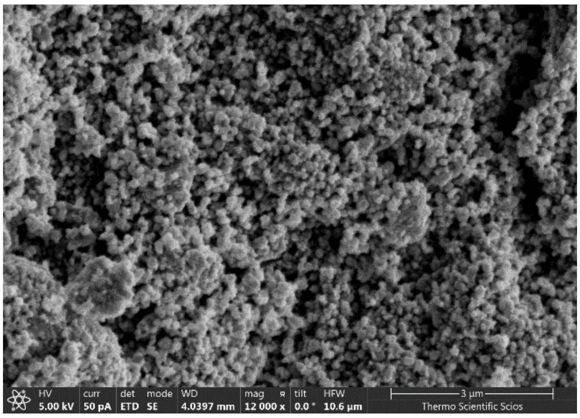

Figure 1: SEM micrograph of tungstic oxide (WO_3) nanoparticles at 12,000x magnification, showing individual nanoparticles and their agglomeration within the bulk powder.

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Anisotropic visco-pseudo-hyperelasticity constitutive model for creep behavior in brake friction materials

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Abstract:
The brake system is crucial for ensuring safe driving by decelerating or stopping the vehicle. Its fundamental principle involves transferring hydraulic or mechanical force generated by pressing the brake pedal to the brake pads, which apply pressure to the brake disc or drum. Rubber composites are extensively used in the automotive industry, particularly in brake system friction materials, which consist of over 20 raw materials. These composites ensure consistent braking performance over a wide temperature range. Due to the complex behavior of these materials, such as non-linear, anisotropic stress-strain relationships, creep, hysteresis, and permanent deformation, it is essential to develop constitutive equations that incorporate these characteristics for accurate prediction. This study aims to provide a comprehensive constitutive model integrating hyperelasticity, viscoelasticity, and pseudoelasticity within a unified framework. An advanced model based on the extended Saint Venant-Kirchhoff strain energy density function is proposed, including a Prony series-based linear viscoelastic model and introducing damage parameters into the energy density function to capture permanent deformation and the Mullins effect. The model is also validated through comparisons between numerical predictions and experimental results.

Keywords: Constitutive modeling; friction material; polymer composites; finite element simulation

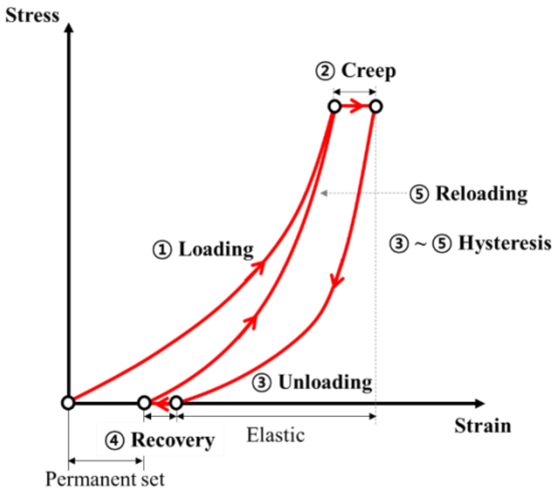

Figure 1: General stress-strain responses of the rubber-based composites friction material under various braking loading condition

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A Study on improving performance and energy efficiency using self-powered triboelectric sensor

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Abstract:
The ABS (Anti-lock Brake System) of a car is an essential device for stable braking, and its main purposes are to secure directional stability, controllability, and shorten the braking distance. Among the components, the wheel speed sensor plays an important role in measuring the wheel speed and determining whether the ABS is operating.

The conventional speed sensor measures speed through the Hall effect principle, which is a magnetic induction method using permanent magnets. When the brakes are applied, high temperature is formed in the surrounding environment. Then the magnets experience a decrease in output due to a decrease in magnetic force at high temperatures, which can interfere with stable signal analysis and cause the ABS system to malfunction.[1,2]

In this study, we developed a technology to utilize a self-powered wheel speed sensor that is stable and can improve performance and energy efficiency based on the triboelectric phenomenon. Triboelectric effect is a phenomenon in which electric charge transfer occurs between two objects when they contact or slide against each other. It is gaining attention as a technology that can self-power various sensors.[3,4] Since the wheel speed sensor is a component that must operates continuously for speed detection, we developed a new type of platform that is robust to wear and noise for evaluating a single electrode-based non-contact mode wheel speed sensor.

Since this technology uses a non-contact triboelectric phenomenon, it is important to select a material that has the maximum concentration of charge it can hold when an electric charge is artificially injected through corona discharge, etc.

The positively charged electrode was made using a composite of TPU as a polymer film and SiO_2 as ceramic particles that retain the injected positive charge for a long time. The negatively charged electrode was made using a composite of PDMS as a polymer film and PTFE as polymer microparticles that retain the injected negative charge for a long time.

The wheel speed sensor is a component exposed to the outside from the bottom of the vehicle, and since the operating environment conditions such as temperature and humidity are very poor, an amphiphobic surface was implemented through etching of the material surface to improve moisture resistance and fluorination to improve oil resistance so that it can maintain a high charge concentration even under harsh conditions. Through this process, it was confirmed that the optimized positively and negatively charged electrode pair generate output voltage up to a relative humidity range of 99% and shows an output level that can detect speed even when contaminated with various oil components.

Keywords: Non-contact mode triboelectric nanogenerators, harsh environment-tolerant, composites, amphiphobic surfaces, speed sensor.

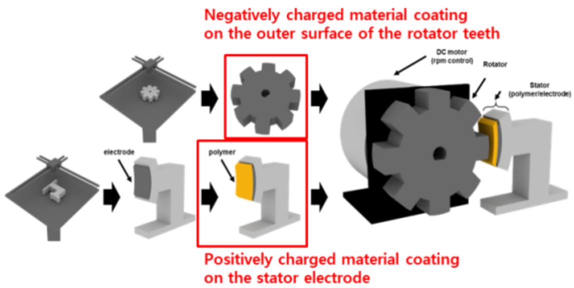

Figure 1: Example of manufacturing a platform for evaluating a single electrode-based non-contact mode wheel speed sensor. After coating the positively/negatively charged materials on the tone wheel and electrodes respectively, the charges are charged through corona discharge, and then the output voltage is measured and evaluated according to the various driving conditions of the vehicle (speed, external environment, etc.).

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Revalorization of industrial plastic waste for lubricant application

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Abstract:
Between 2005 and 2020, global plastic production increased by 60% [1], generating around 25.8 million tonnes of plastic waste annually in Europe, where less than 30% is recycled. In response to these environmental challenges, Europe has adopted a Strategy for Plastics in Circular Economy (2018) [2], which promotes research to convert plastic waste into valuable products such as lubricants.

The present study develops an efficient and innovative solution for the valorisation of industrial plastic waste in lubricant applications. With increasing regulations and public awareness, there is a general trend towards using vegetable or synthetic oils and reducing hazardous substances in lubricant formulations. Low MW poly-α-olefins (PAOs) are one of the most commonly used sustainable base fluids as an alternative to mineral bases. PAOs are produced by catalytic oligomerisation of α-olefins [3]. The aim of this research is to obtain α-olefins by thermal pyrolysis of plastic waste, followed by chemical modification via oligomerisation, to produce lubricating base oils with enhanced properties, potentially replacing conventional mineral oils.

The project evaluates physicochemical and tribological properties of lubricating base oils derived from significant quantities of industrial plastic waste, including mainly PE, PP, PUR, PVC (and some of the samples contain biomass). Results from thermal/oxidation stability, viscosity, and wear tests prove that the novel lubricants obtained exhibit similar properties compared to mineral oils (petroleum base). These findings suggest that industrial plastic waste with biomass content could be a feasible alternative feedstock when producing high-performance lubricants, contributing to more sustainable material reuse.

The technology developed within this project is expected to play a key role in reducing landfill plastic waste, mitigating environmental impact, and contributing to resource conservation.

Keywords: plastic waste, poly-α-olefins (PAOs), lubricants, tribology, thermal pyrolysis, environmental sustainability.

Figure 1: This image shows two samples of typical industrial plastic waste, that are used in the production of lubricating base oils. The sample on the left consists of 50% industrial plastic waste and 50% biomass, while the sample on the right is composed only with industrial plastic waste.

Acknowledgments:

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Posters Sessions Abstracts

Surface Engineering of Metallic Thin Films for SAW Sensor IDTs

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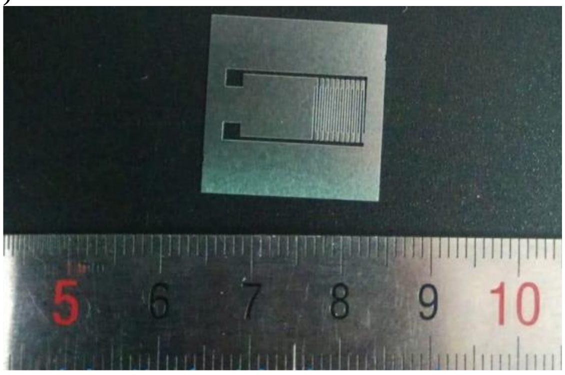
Abstract:

Surface engineering plays an important role in the development of Surface Acoustic Wave (SAW) sensors, as it directly impacts the device's performance, durability, and efficiency [1]. The choice of metallic thin films for Interdigital Transducers (IDTs) is particularly significant, influencing electrical conductivity, mechanical stability, and integration with piezoelectric materials [2]. Optimizing surface properties and material compatibility is essential to overcome challenges in fabrication and ensure reliable sensor operation. This study investigates the surface engineering of metallic thin films for the development of IDTs in SAW sensors. A zinc oxide (ZnO) thin film was deposited on a silicon substrate using the sputtering technique to explore its piezoelectric behavior. Subsequently, a metallic thin film was also deposited via magnetron sputtering, using a mechanical mask to define the metallic IDT structures for electrical contacts. Three samples with different metallic thin films (titanium, chromium and tungsten) were produced and analyzed. Based on the results, tungsten was identified as a potential alternative material, given its mechanical robustness and favorable properties for electrical contact applications. These findings provide preliminary insights into metallic material selection and fabrication strategies to improve SAW sensor performance.

Keywords: surface engineering, metallic thin films, SAW sensors, interdigital transducers (IDTs), piezoelectric materials.

a)



b)

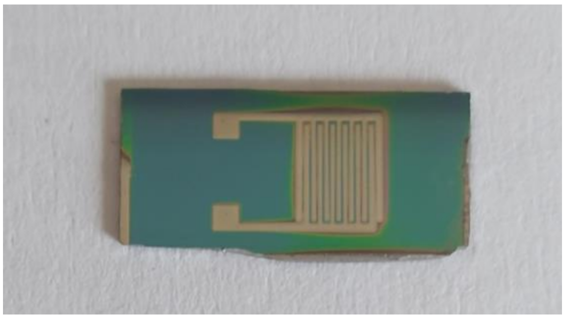


Figure 1: a) Mechanical mask, and b) IDT fabricated on ZnO film.

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Influence of Plasma Cleaning on the Magnetron Sputtering Deposition of TiCN Thin Films on Ti6Al4V

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Abstract:
TiCN is a coating widely used in industries such as aerospace, automotive, tools, and medical devices due to its excellent mechanical properties, wear resistance, and corrosion resistance. However, the deposition of this coating on the Ti6Al4V substrate presents challenges, particularly regarding adhesion. The formation of oxides on the substrate surface and the lack of proper pre-deposition treatment are factors that can compromise the adhesion of TiCN. Although several chemical methods can be used for substrate cleaning, plasma cleaning has proven to be one of the most effective approaches. This method is fast, controlled, non-contaminating, and applicable to a variety of materials, capable of removing contaminants and surface oxides, thus creating a more suitable interface for coating formation. In this study, argon gas was used with an RF source set to 100 W for 10 minutes. Plasma cleaning was investigated as a preparatory step for the deposition of TiCN thin films on Ti6Al4V substrates using the magnetron sputtering technique.The deposited films showed a hardness of 1455±200 HV, with crystallographic peaks characteristic of TiCN, corresponding to the (111), (200), (220), and (311) planes in the X-ray diffraction pattern. The average thickness of the films, determined by SEM and AFM, was 2.9 µm. The scratch test results showed a significant improvement in adhesion for the sample treated with plasma cleaning, with critical loads of Lc1 = 1.38 N, Lc2 = 11.03 N, and Lc3 = 27.45 N. In comparison, the untreated sample showed critical loads of Lc1 = 1.4 N, Lc2 = 1.9 N, and Lc3 = 2.37 N. These results demonstrate that plasma cleaning significantly improves the adhesion of TiCN thin films. By removing contaminants and oxides from the surface, plasma cleaning facilitates the formation of a rougher surface, which favors mechanical interlocking and results in better adhesion of PVD coatings. This study highlights the positive impact of plasma cleaning on the quality of TiCN thin films on Ti6Al4V substrates, making this coating more effective for high-performance applications.

Keywords: Plasma cleaning; TiCN thin films; Ti6Al4V substrate; Magnetron sputtering; Scratch test; Physical Vapor Deposition (PVD).

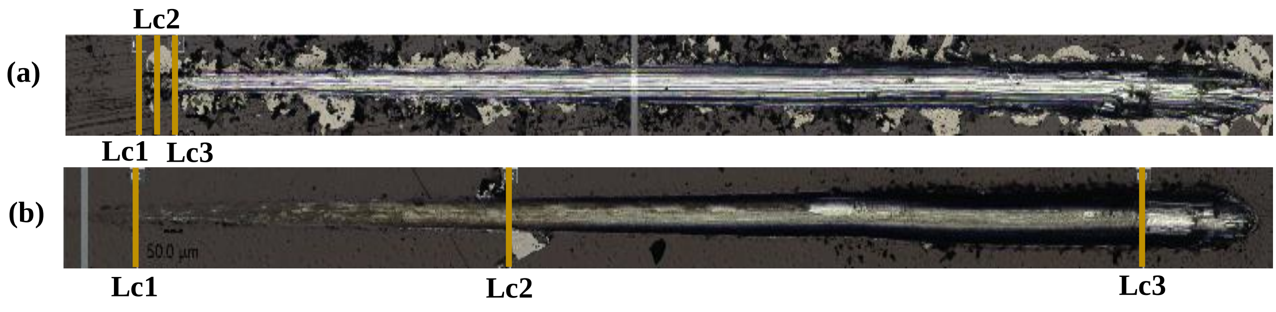

Figure 1. (a) Scratch test results for the sample without plasma cleaning prior to TiCN film deposition. **(b)** Scratch test results for the sample with plasma cleaning (RF) performed at 100 W for 10 minutes before TiCN film deposition.

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Modification of AAO coatings with copper using PVD and electrochemical methods

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Abstract:
Anodic oxidation of aluminum is one of the methods of producing oxide coatings (AAO) on its surface. AAO coatings produced in the anodic oxidation process belong to the group of dielectric materials. The essence of the anodizing process is the fact that the coating is formed at the expense of the substrate loss. Such positioning of the AAO coating explains its very good adhesion to the substrate [1]. The basic factor determining the properties of the AAO coating is its columnar structure and surface porosity (Figure 1). The size and shape of the pores depend on the structure of the substrate, the type of electrolyte and the conditions of the anodizing process [2]. Due to their characteristic porous surface, AAO coatings can be used as a matrix of the dispersion phase. In the case when the dispersion phase is a material with good lubricating properties (e.g. copper), it can be assumed that the coating will have appropriate tribological features for applications in combination with e.g. cast iron, in friction nodes with limited lubrication. Copper coatings are mainly produced on metal surfaces using electroless and electrochemical methods. However, on dielectric surfaces, these processes are significantly more difficult. The solution to this problem may be the use of physical vapor deposition (PVD) technology. In this study, a hypothesis was adopted about the feasibility of modifying the AAO coating by introducing copper into the structure and on its surface (Figure 2), which, due to its conductive properties, would allow the use of an electrochemical method to increase its thickness. The production of such a coating will improve tribological properties in friction nodes with continuous and limited (oil mist) lubrication. The presented results from the initial phase of the study show that the modification of the AAO coating with copper caused a reduction in the friction coefficient compared to the reference coating (AAO) by 56% (in the case of continuous lubrication) and by 32% (in the case of oil mist lubrication). The research provides new information on coatings produced on aluminium alloys for use in sliding contacts under friction conditions with limited lubrication, which is certainly a key issue in an era of continuous reduction in operating costs.

Keywords: AAO coating, Cu coating, tribological association, limited lubrication.

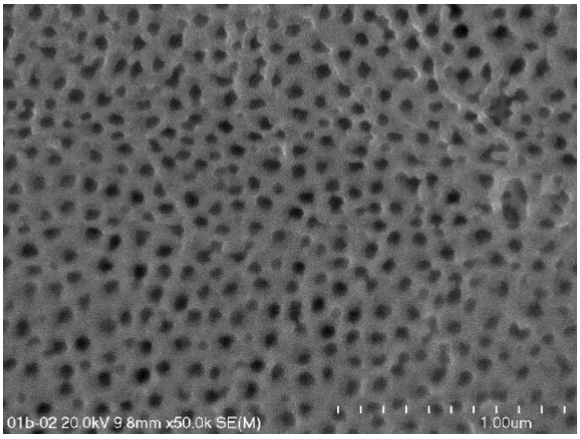

Figure 1: Surface morphology of the AAO coating.

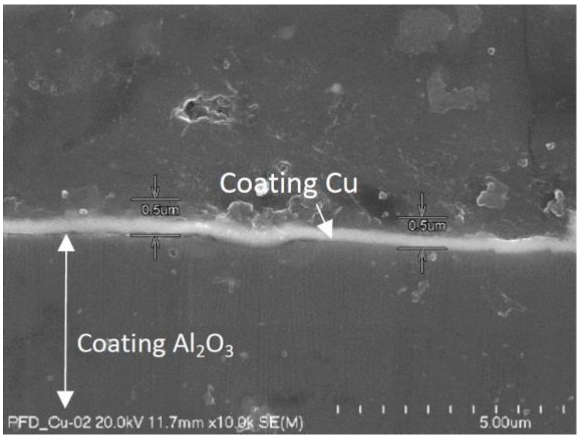

Figure 2 Microstructure of the AAO coating after modification in the PVD process.

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Hot dip metallic coatings on steel produced in a HDP Simulator

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Abstract:
Steel producers have increasingly advanced the technology of continuously annealed and coated sheet products to meet the challenges of automotive, construction, industrial and appliance manufacturers.

Steel product properties are influenced by multiple parameters in each process zone of Continuous Annealing (CA) and Continuous Galvanizing (CG) Production Lines, such that specifying the proper heating, pre-oxidation, soaking, cooling, transformation, dipping, wiping and galvannealing conditions requires a reliable method of process parameter verification. Validation on production or pilot lines is neither economical nor efficient. Validation by laboratory scale process simulation however has been recognized to be the most economical, efficient and reliable method along with great time-to-market advantages.

It is in this context of complexity and industrial challenge where the objective of this work is located. The simulator for the HDP (Hot Dip Process) called DIPCA@SIM (Figure 1) located at IDONIAL is a unique research equipment which allows laboratory scale simulations of the coating and the consequent annealing processes occurring in industrial production lines, serving for process and product improvement and development. **This research equipment allows laboratory scale simulation of (reactive) annealing and (hot dip) coating processes occurring in production lines**.

All important functions of the production process such as cleaning, thermal treatment (heating up, soaking, cooling), hot dip coating (Zn, Al, Mg, Si, Ti, etc.), galvannealing, etc. can be simulated in a laboratory scale with DIPCA@SIM . The consumption of operating materials is extremely small compared with production lines and valuable production capacities do not need to be wasted.

As an example for this work hereby presented, to improve and further develop the production and the final coating properties, hot dipping experiments were performed in a DIPCA@SIM simulator using steel sheet substrates, different bath compositions and various hot dipping parameters (such as bath temperature, entry and cooling speed and immersion times) to produce coated sheet steel samples with different coating thickness and microstructures. The results (in terms of surface appearance, corrosion resistance (SST) and microstructure) obtained by these DIPCA@SIM simulations show to be excellent and absolutely transferable to the production process of real continuous galvanizing lines.

Therefore, the **HDP Simulator DIPCA@SIM serve for process improvement and new product development**; the optimized **thermal treatment and coating** parameters obtained by simulation **can be transferred to the production process the existing Continuous Annealing** (CA) **and Galvanizing / Galvannealing Lines** (GI/GA).

DIPCA@SIM anneal and coat steel samples of desirable higher strength to determine the optimum process parameters for the production lines. New products with improved coatings, new coating technologies, modified thermal treatments and process sequences can be tested at very low cost and in a very short time.

Keywords: HDPS, continuous galvanizing, hot dip process, metallic coatings, steel, sheet, continuous annealing.

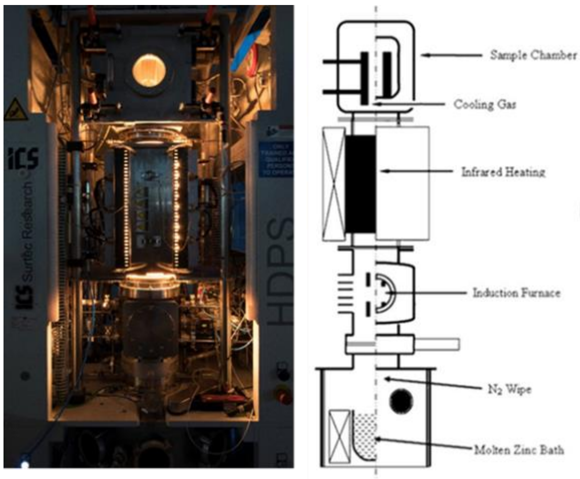

Figure 1: HDPS DIPCA@SIM.

PTFE thin films deposited by Pulsed Electron Beam Deposition

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Abstract:

The use of pulsed electron beam (PED) method offers significant potential for deposition of polymer coatings. This is not only due to its ability to produce coatings and thin films from refractory and insoluble polymers such as polytetrafluoroethylene (PTFE) in an economical and ecological manner, but also because different process conditions enable the production of coatings with different properties. In addition, composite coatings can be produced directly from composite materials using the PED method.

In our studies, we produced a series of PTFE-based thin films that showed different physical and chemical structures depending on the applied electron gun voltage (Figure 1) or nitrogen pressure, which affects the specific power density. In addition, we deposited PTFE-carbon composite thin films using two types of composite materials differing in the carbon filler type and content. The PED processes were carried out under nitrogen pressures ranging from 3 to 12 mTorr and electron gun voltages ranging from 12 to 18 kV.

All films were characterized using the following methods: chemical composition was analysed by FTIR and XPS; physical structure and morphology were investigated by XRD, AFM and light microscopy; coating adhesion was assessed by scratch testing; and wettability was evaluated by contact angle measurements.

Based on the obtained results, we proposed a series of hypotheses to correlate electron beam power, ablation efficiency and physical and chemical structure of PTFE-based thin coatings.

Keywords: pulsed electron beam deposition; PTFE thin films, PTFE/C composites; ablation mechanism; chemical structure.

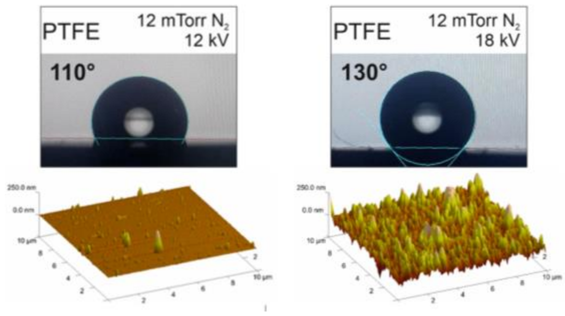

Figure 1: Morphology and wettability of PTFE coatings obtained at different process parameters.

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Enhancement of Sol-Gel coatings for the preservation of quality in high-end products.

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Abstract:
At short wavelengths, light carries more energy and impacts the quality of foods and beverages (1). Photodegradation, originally linked to the UV-B spectrum (280-315 nm), has also been observed at higher frequencies like UV-A (315-400 nm) and even blue wavelengths (420-490 nm) (2). High-end products such as rosé wine and olive oil, often sold in transparent bottles due to consumer preference despite the risk to their quality, are particularly affected (3, 4). Sol-gel coatings with UV-absorbing additives can offer photoprotection (5). This study aims to optimize such coatings, scale them up for bottles, and assess their impact on rosé wine and olive oil (**Figure 1**).

Different amounts of TINUVIN479 and semaSORB20109 were added to a commercial formulation (Hardrise CHUI-R218.01). The solutions were deposited on flat glass by spin coating and cured by UV light. The resulting layers were characterized by chemical, optical and mechanical methods. The most promising coating was applied into bottles by spraying and then, the photoprotective study was carried out using UV accelerated degradation equipment (6). The most photosensitive parameters (polyphenols and color values) in rosé wines (6) and olive oils (4) were spectrophotometrically analyzed.

TINUVIN479 and semaSORB20109 were added to the standard formulation at 0.5%, 0.75%, 1% and 1.5%. Characterization on flat glass showed that for both additives, the 1.5% concentration produced the best results without causing adhesion problems, which is why these concentrations were used for bottle scaling. The coatings showed adequate adhesion behavior to the bottle and after accelerated degradation tests, showed an added photoprotective effect. The addition of TINUVIN479 and semaSORB20109 increases the light protection provided by the starting formulation. This effect is also demonstrated for rosé wines and oils and makes it feasible to scale up in bottle.

Keywords: photoprotection, sol-gel, rosé wine, olive oil, TINUVIN479, semaSORB20109

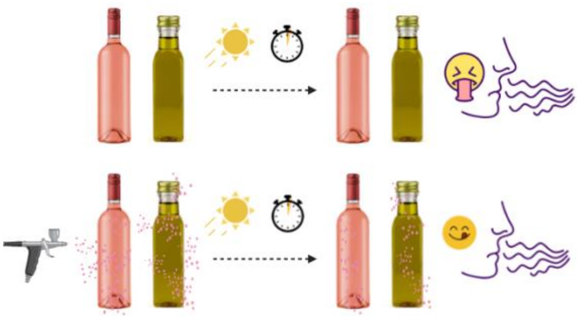

Figure 1: Figure illustrating the fundamental question that we are tempting to solve experimentally: apply sol-gel coatings to flint bottles to photoprotect rosé wines and olive oil.

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Surface Characterization of SiO_2 Thin Film on NiTi Alloy Obtained via Atomic Layer Deposition

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Abstract:
SiO_2 films exhibit remarkable optical, structural, and biological properties, making them promising materials for various biomedical applications. The coatings obtained using the sol-gel method are best described in the scientific literature. For example, SiO_2/ZrO_2 coatings obtained in this way further enhance the biocompatibility and surface properties of metallic implants, promoting cellular interactions and improving osteointegration. Moreover, the synthesis of SiO_2-based materials with functional groups affects their bioactivity, surface hydration and macromolecular interactions. The Atomic Layer Deposition (ALD) method enables precise thickness control and uniformity, even at low temperatures, ensuring their suitability for advanced coating technologies. The physicochemical properties of the SiO_2 coating deposited via ALD on NiTi alloy for blood-contacting implants were thoroughly investigated. The mechanical durability of the coating was evaluated using a scratch test, which allowed for the determination of adhesion strength. Tribological studies provided insights into the wear coefficient, assessing the coating's resistance to frictional forces. Surface morphology and elemental composition were analyzed using SEM and EDS, revealing structural characteristics and chemical uniformity. Wettability measurements were conducted to assess surface hydrophilicity, which is crucial for interactions with biological fluids. Additionally, optical profilometry enabled the examination of surface topography (Figure 1), while corrosion resistance tests in a simulated plasma environment evaluated the coating's ability to protect the NiTi substrate from pitting corrosion, ensuring its long-term stability in biomedical applications.

Keywords: NiTi alloy, SiO_2 thin films, biocompatibility, biomaterials, surface engineering, biomedical applications.

Acknowledgements: The work was funded by the National Science Centre, Poland allocated on the basis of the decision No. 2023/49/B/ST11/03301.

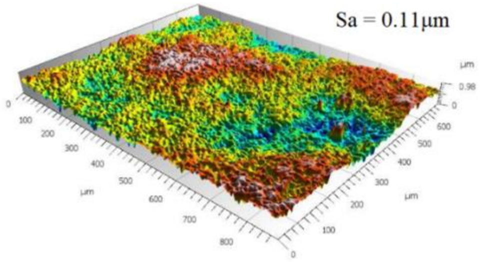

Figure 1: Figure illustrating surface topography of NiTi alloy with SiO_2 coating obtained by Atomic Layer Deposition. Analysis using optical profilometry reveals differences in surface roughness and morphology, highlighting the effect of the SiO_2 layer on the properties of the surface under study.

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Characterization of macro and microstructure, along with corrosion resistance, of super austenitic stainless steel cladding deposited on carbon steel using GTAW

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Abstract:
Industries such as chemicals, paper and pulp, oil and gas, and offshore projects require materials that can effectively resist corrosion, like austenitic stainless steels. However, the high cost of these materials makes them expensive for use in large structures and equipment, often rendering them economically unfeasible. An alternative approach is to use carbon steel for equipment production and apply a thin layer of stainless steel on top. The cladding process reduces manufacturing costs by bonding super austenitic stainless steel to low-carbon steel. Arc welding, particularly Gas Tungsten Arc Welding (GTAW), is commonly employed for this process due to the cost-effectiveness of the equipment. This study focuses on evaluating super austenitic stainless steel coatings applied to low-carbon steels using the GTAW process. For the cladding, a system was developed that consists of a GTAW, a two-dimensional CNC table and an automatic wire feeder. The cladding execution trajectory, welding/deposition speed, and wire feeding speed were controlled using an Arduino (Figure 1). Three different coating conditions were analyzed, with variations in heat input, to identify the optimal parameters for coating. The samples underwent macro and microstructural analysis, along with corrosion resistance testing. Increased heat input impacted the macrostructure, leading to a lower dilution rate. Examination of the heat-affected zones revealed martensite formation associated with cooling conditions. The interface between the cladding and base metal showed heightened microhardness, consistent with the microstructural observations. Additionally, heat input modified the microstructure of the clad layer, altering the austenite morphology. A significant enhancement in corrosion resistance was also noted in the deposited layers.

Keywords: Super Austenitic Stainless Steel; Low Carbon Steel; GTAW; microstructure; microhardness; corrosion resistance; cladding.

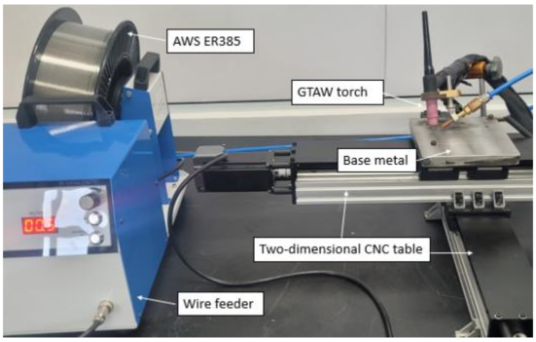

Figure 1: Experimental setup, with its adaptations, for the cladding process.

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The influence of unit pressure on the tribological properties of graphite-modified oxide coatings

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Abstract:

Tribological properties, including wear resistance and friction behavior, are critical factors in determining the performance and durability of materials used in various engineering applications. Oxide coatings produced by Plasma Electrolytic Oxidation (PEO) have been extensively studied for their ability to improve the surface properties of light metals such as magnesium, aluminum, and titanium, enhancing their wear resistance, hardness, and corrosion protection [1]. Modification of these coatings with materials such as graphite (Figure 1) has been shown to further improve their tribological performance by reducing friction and improving lubrication, particularly under dry technical friction conditions [2]. Understanding the effect of applied unit pressure on the tribological behavior of modified coatings is essential for optimizing their performance under real-world conditions, where materials are often subjected to varying loading conditions. This study aims to investigate the effect of different loads on the tribological properties of graphite-modified oxide coatings, providing insight into their wear characteristics under different loading conditions. The coatings were produced by Plasma Electrolytic Oxidation on the AZ31B magnesium alloy, and then modified with a graphite suspension using the ultrasonic method. The graphite processing parameters were selected based on the research plan. The aim of the research was to contribute to the development of more efficient and durable coatings for industrial applications by conducting tribological tests at three different unit pressure using the T17 tester under dry technical friction conditions.

Keywords: Mg-AZ31B, plasma electrolytic oxidation, oxide coatings, tribological properties.

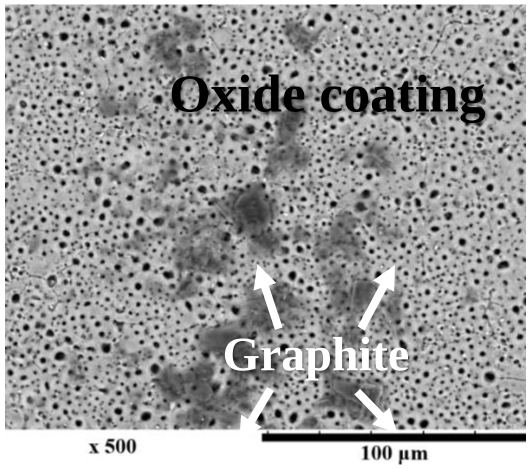

Figure 1: The surface of the oxide coating after modification with graphite.

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Stress and local structure evolution in the sol-gel thin-films during high temperature annealing

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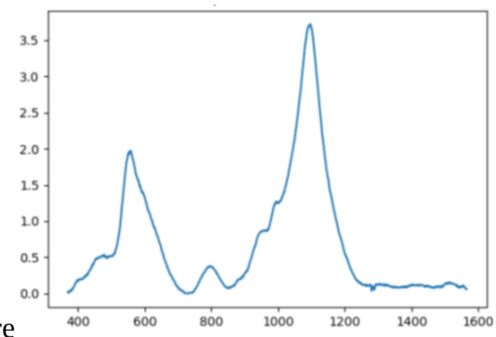
Abstract:
To provide thermal comfort and reduce carbon footprint, many functions are provided to glazing by coating, for applications related to buildings, transport or decoration. In some cases, these glass products must undergo thermal tempering to give the glass better mechanical strength. The development of functional coatings resistant to high temperatures (> 600°C) is thus a major challenge that sol-gel coatings can contribute to address. Indeed, the inorganic nature of the precursors is compatible with temperature resistance and allows good covalent adhesion to glass substrate. However, one of the limitations of these materials is the cracks generated in the layers due to the high tensile stresses that occurs during the condensation of the network and the evaporation of solvents. In addition, two known phenomena occur during tempering: the diffusion of alkali ions from the substrate to the layer and the passage of the melting temperature of the glass, which complicates the mechanics of the problem. This leads to a serious limitation in the achievable thicknesses of coatings and reduces the field of possible applications for the design of new products. The objective of this work is to better understand the relationships between the glass substrate, the structure, and the mechanical properties of the silica-based sol-gel layers during this complex tempering process. To reach this goal, we have developed an original strategy based on the combination of several ex- and in-situ techniques that allow us to follow the evolution of the microstructure of the layer (Raman spectroscopy, Figure 1) [1], the mechanical properties (Nano-indentation) and the stress (curvature measurement) [3] during the tempering coupled with the alkali ions migration from the glass substrate.

Keywords: silica sol gel, alkaline diffusion, glass thin coating, Raman spectroscopy, stress measurement, condensation, structural evolution, fracture



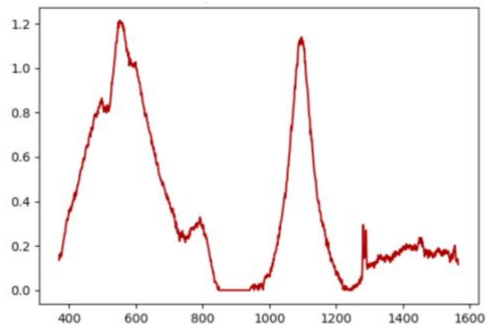


Figure 1: Figure illustrating an NMF decomposition of a silica sol gel on glass Raman spectra. The first figure is the glass component and the second figure is the sol gel component.

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The interface of mating surfaces under extreme tribological conditions

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Abstract:

This study highlights a significant and longstanding question that has challenged scientists and engineers: what occurs at mating interfaces under extreme tribological conditions? We offer a fresh perspective supported by analytical models and microscopic evidence to address this. We synthesize current insights into the rapid physical and chemical processes within complex adaptive systems operating near chaotic thresholds.

Our analysis includes case studies on thin-film coatings and nanomaterials designed for severe tribological environments, such as a nano-multilayer TiAlCrSiYN/TiAlCrN PVD coating, which is utilized in ultra-high-performance dry machining of hardened H13 tool steel. We propose that complex adaptive systems—prevalent in engineering, social, and medical contexts—share fundamental governing principles, many of which intersect with catalytic phenomena observed in specific tribological processes. This review explores experimental data such as tool life and wear rates, SEM and TEM analyses of worn surfaces, XPS data on tribo-films, and chip surface morphology.

Using this data, we investigate the connections between self-organization, self-organized criticality, and various catalytic processes. Moreover, we propose a method to optimize these processes by adjusting machining conditions, such as speed variations, to enhance the design and development of advanced coating systems, ultimately improving manufacturing cost-effectiveness.

Keywords: machining, physical vapor deposition, nitrides, multilayers

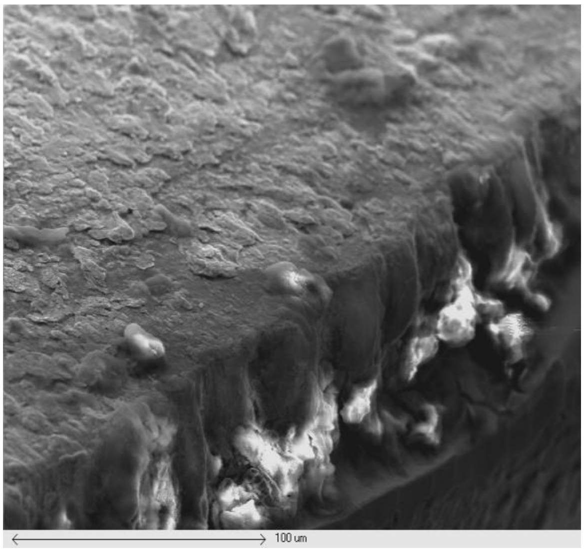

Figure 1. SEM images capturing worn surfaces at the end of the tool's lifespan with a flank wear of 400 microns.

References:

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Surface modification of elastomers via laser structuring and DLC coating for high-performance tribological applications

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[2] Fraunhofer Institute for Mechanics of Materials IWM, Freiburg, Germany
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Abstract:
Even though hard, low friction coatings such as diamond like carbon (DLC) would be beneficial for the performance and longevity of rubber seals, a crucial challenge remains. The elastic mismatch of rubber substrate and DLC coating prevents a fracture free coating application. In this work a nature inspired approach is applied to render the stiff coating flexible and resilient to delamination at the same time by direct laser structuring. Rubber substrates were laser structured with tile patterns and subsequently DLC-coated. Tensile and tribology tests were performed on structured and unstructured samples. Unstructured DLC-coatings showed a crack pattern induced by the coating process, which was further fragmented by tensile stress. Coatings with tile patterns did not experience a further fragmentation under load. During continuous tribological loading, less heterogenous damage is produced for tile structured samples. The findings are ascribed to the relief of induced coating stress by the tile structure, meaning a more resilient coating.

Keywords: diamond like carbon, DLC, Tribology, rubber, flexible, nature inspired, coating, friction, sealing, delamination.

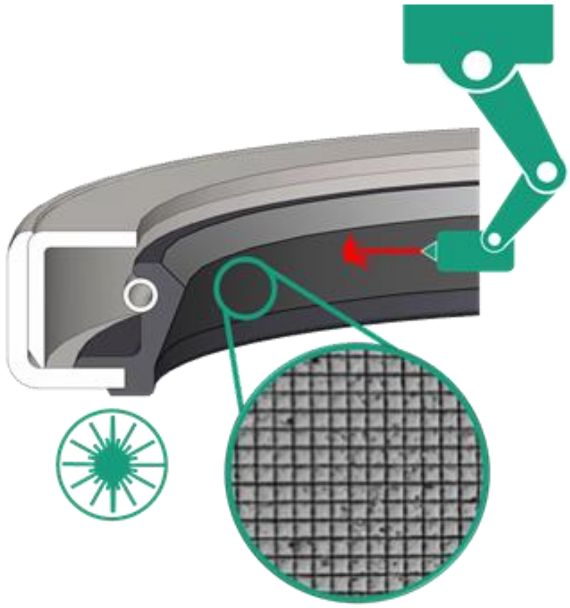

Figure 1: The figure illustrates the process of LASER structuring of a rotary shaft seal together with a SEM image of the subsequently DLC-coated surface.

References:

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Analysis of Vibration Characteristics by Lifetime of Roller Type Linear Motion Guide System

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Abstract:
Linear motion (LM) guide is a mechanical element designed to support precise linear motion and is used in various industries such as industrial automation, mechanical engineering, electronics and semiconductor manufacturing, medical devices, aviation, and automotive industries.

Recently, the interest in the roller ultra-high load type linear rail system, which is mainly used in grinding machines, drilling machines, and milling machines, is increasing. The roller type linear rail system is designed to enable high-efficiency movement with little energy. Compared to a linear rail system using balls, the roller type has improved lifespan, uniform rigidity, and excellent accuracy with smooth movement. It also has the advantages required by the high-tech industry. As shown in Figure 1, the return piece that stably and infinitely circulates the roller in the linear block is integrated with the block guide to perform smooth motion even in horizontal and vertical situations. In addition, a check valve is designed to prevent the lubricant in the block from flowing back, and the lubricant is designed to be transmitted independently of the electric surface.

This study analyzes the vibration characteristics according to the life of the roller type linear rail system. As shown in Figure 2, the LM guide durability test equipment was designed and manufactured similar to the working environment operated in the actual industrial site. For the test, the LM guide for driving is operated at the center of the equipment, with rails and blocks on both sides as shown in Figure 2, and each rail and block is fastened at the bottom, so a total of 4 rails and 4 blocks are tested for life at the same time. At this time, the rail and block are fastened in close contact with a horizontal and vertical fixing jig and fasten the bolts with a prescribed torque. The stroke is 1,800 mm and the maximum speed is 2 m/s. Vibration data in the life ranges of 30, 60, 90, and 100% are obtained with 160 km of the LM guide rated life as 100% life. In the designated life range, an acceleration sensor is attached to the side of each block to acquire data at a sampling time of 8100 Hz and perform FFT analysis.

Keywords: Linear motion guide, Roller type linear motion guide, Durability test, Vibration characteristics.

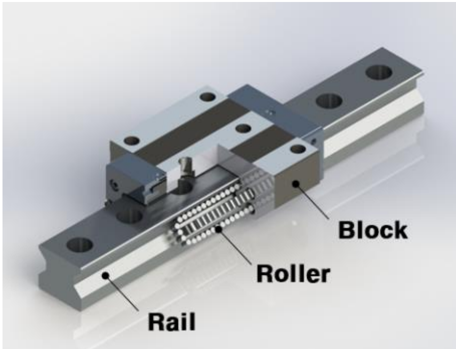

Figure 1: Concept diagram of roller type linear motion guide system

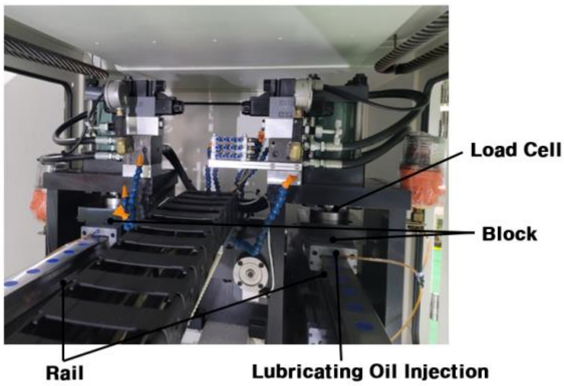

Figure 2: Linear motion guide durability test equipment.

References:

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Twin-Disc Testing for Wheel-Rail Interaction: A Versatile Approach to Wear and Friction Analysis

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Abstract:

Understanding wear and friction behavior in wheel-rail systems is essential for optimizing railway performance and reducing maintenance costs. **Twin-disc testing** provides a controlled and repeatable environment to study these interactions, offering valuable insights into material behavior under various operating conditions. This method allows for precise control of key parameters such as contact pressure, rolling speed, slip ratio, and environmental conditions, enabling the simulation of multiple scenarios.

The twin-disc test machine consists of two independent motors for controlling rotation speed and a hydraulic device for applying load (Figure 1). A pneumatic actuator, attached to a load cell, applies a normal load between the two discs (Figure 2), while a torque transducer measures the torque signal, allowing for real-time calculation of the friction coefficient. The system is designed to control slip rate and load via a computer, where all test data are stored for further analysis.

Figure 1: Scematic twin disc configuration

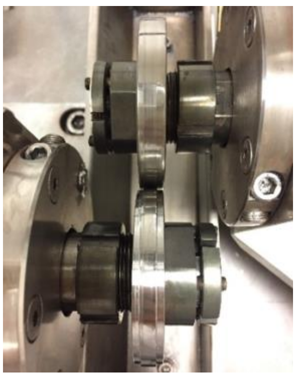

Figure 2: Wheel-rail discs contact during twin-disc experiments.

Wheel and rail specimens are extracted from representative materials to ensure realistic wear behavior (Figure 3).

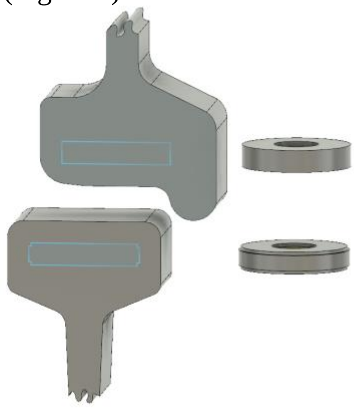

Figure 2: Disc specimens extraction from wheel and rail.

This work highlights the capabilities of twin-disc experiments for evaluating wear mechanisms, frictional response, and material degradation in wheel-rail contacts. Additionally, the flexibility of this approach allows for the introduction of contaminants like **sand, water, and lubricants**—individually or in combination—to assess their influence on friction and wear.

Furthermore, the ability to test different material compositions and surface treatments enhances its applicability in studying wheel-rail material interactions and developing wear-resistant solutions. With its versatility and precision, twin-disc testing stands as a fundamental technique for advancing railway materials research, optimizing wear resistance strategies, and contributing to the development of more durable wheel-rail systems.

Keywords: Wheel-rail, Twin-disc tests, Rolling contact fatigue, Wear.

From current collection to plasma parameters: models

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Abstract:
In our paper we overview different technics used for the plasma diagnostics in the Earth ionosphere, where the measurements of the electric currents and potentials are determined by a number of parameters, such as the plasma density, its temperature and ion composition, the ratio between thermal plasma velocity and the satellite velocity with respect to plasma, the intensity of the photoelectron emission from the surface materials on the day-side orbits, as well as the impact of the plasma sheath formed around the satellite and on-board sensors. Thus, a modelisation of the instrument response is essential for the correct interpretation of the on-board observations. Three instruments commonly used for the plasma diagnostics, i.e. Langmuir probe, retarding analyser and electric field sensors, are in scope of our analysis. The numerical and analytical models developed during past years [1-4] are used to for a deeper understanding the impact of the sensor-plasma electrical coupling through the plasma sheath and the instrumental configurations on the plasma parameters deduced from the sensors measurements. Discussion is illustrated with the observations performed in the ionosphere at the altitude of 700 km on-board the CNES DEMETER micro-satellite.

Keywords: Earth ionosphere, thermal plasma, electric potentials and currents, plasma sheath, sensor-plasma electric coupling.

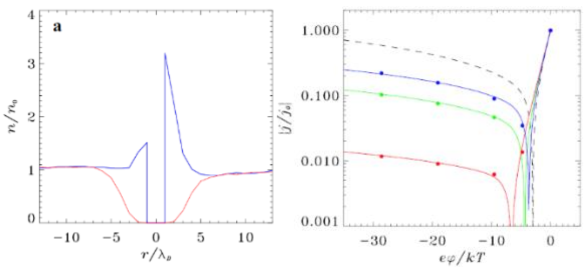

Figure 1: Left: Density distribution around spherical probe with radius of $1\lambda_D$ for O+ ions (blue) and electrons (red), calculated along the flow velocity ($V_0=4V_{Ti}$) and for the probe potential of 20 kT/e. Right: Normalised current versus normalised potential in an H+ plasma with $V_0=0$ (black), $V_0=V_{Ti}$ (blue), $V_0=2V_{Ti}$ (green) and in the O+ plasma with $V_0= 4V_{Ti}$.

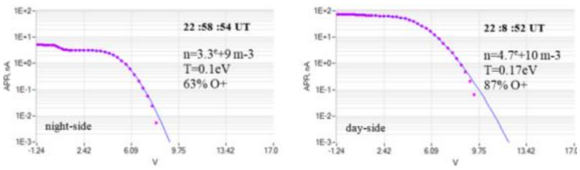

Figure 2: Current measured with the retarding analyser near the equator at the altitude of 700 km and plasma parameters deduced from model.

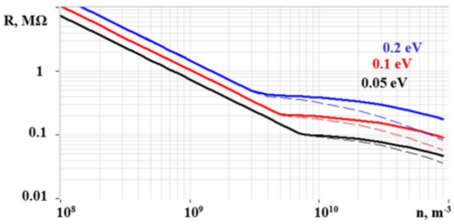

Figure 3: Sensor-plasma coupling resistance versus plasma density and for different plasma temperatures. Solutions for O+ and H+ are shown with solid and dashed lines, respectively. DC injected current is fixed to be equal to 450 nA.

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Electrical Characterization of a Superimposed HiPIMS / RF Deposition Process on a Single Magnetron

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Abstract:
In recent years, high power impulse magnetron sputtering (HiPIMS) [1] has become a promising method to achieve a high degree of ionization of the sputtered material. HiPIMS allows for control of ions in the electric field and therefore enables the fabrication of thin films with high density [2], better crystallinity and stoichiometry. The power is applied in a very short time interval [~10-100µs), resulting in very high peak powers and ionisation grades at the cost of a low duty factor and low deposition rates.
To overcome such drawbacks, we investigated a superposition of RF and HiPIMS on a single magnetron and studied the influence of pressure, target powers and reactive gas flow on process stability, peak currents and pulse form for the deposition of AlN and Al2O3.
For that purpose, we modified a custom-built sputter coater (FHR SV 400) and connected a SPIK3000A-EF-05 HiPIMS Generator (Melec) and a CEASAR 1325 RF Generator (Advanced Energy) to the same source [5]. The outputs of both power supplies can be applied individually, continuously superimposed or synchronized during the off-times of the HiPIMS pattern. The time-resolved HiPIMS signals were recorded (see figure 1). For Al2O3 we found that addition of oxygen significantly decreased the peak voltage and the effective DC-voltage in the HiPIMS-off time; the temporal evolution of the dc-bias is altered upon oxygen gas feed and the superposition of RF and HiPIMS allows for stable operation at lower pressures than with HiPIMS only. Similar findings were made for AlN. Results on transparency and hardness will also be presented

Keywords: pvd, deposition, thin-films, superposition, HiPIMS, RF,AlN, Al2O3.

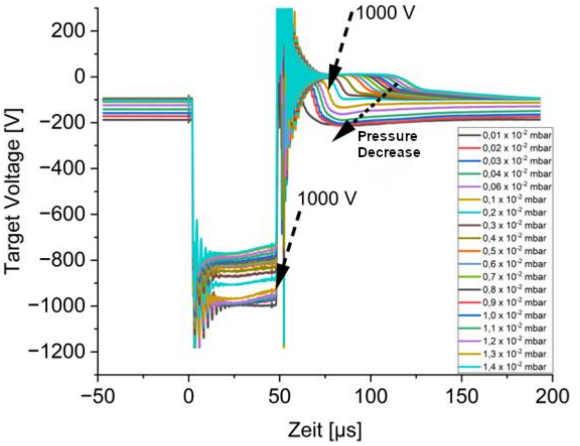

Figure 1:. Measured HiPIMS voltage forms for varying pressure with RF-superposition. Decreasing pressure results in an increase of target voltage. Furthermore, the temporal evolution of the HiPIMS pulse is characterized by a delayed recovery of the electrical voltage, especially at higher pressures.

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Surface functionalization of titanium alloy with biodegradable polymer coatings for medical applications

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[2] Centre for Polymer and Carbon Materials of the Polish Academy of Sciences, Zabrze, Poland
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Abstract:
This paper addresses the modification of anodically oxidized Ti6Al7Nb titanium alloy for osteosynthesis implants. Despite its popularity in orthopaedics and traumatology, due to its degradation in the tissue environment and the resulting release of degradation products into the body, it is necessary to ensure its biocompatibility by surface modification. Another major problem associated with surgical treatment of fractures is the high risk of peri-implant infections and contamination, which can lead to impaired bone fusion, prolonged recovery time and decreased patient comfort. In order to reduce these problems, it was proposed to modify the surface by applying a biodegradable polymer coating containing hydroxyapatite and an active substance (dexamethasone).

Implementation of the developed research program made it possible to evaluate the physical and chemical properties of the biodegradable polymer coating PLGA containing dexamethasone and hydroxyapatite, and to assess its suitability for implant applications in orthopedics and traumatology. In order to implement the undertaken subject matter, physical and chemical properties, corrosion resistance, cytotoxicity and pro inflammatory cytokine determination were carried out for the coating applied by ultrasonic spraying. The obtained coating is characterized by continuity, homogeneity and good adhesion to the substrate. In addition, it exhibits hydrophilic properties. The applied polymer coating improved the corrosion resistance of the alloy and reduced the amount of alloying element ions penetrating into the environment. The dexamethasone contained in the coating has an effect on reducing the activity of pro-inflammatory cytokines, and the produced coating does not cause a cytotoxic effect.

The results obtained in this study indicate that the PLGA coating, containing HAp and DEX, can improve the biocompatibility of osteostynthesis implants by acting as a barrier to alloy metal ions released from the surface. The coating in question may support the recovery process by lowering the risk of peri-implant infection and reducing the need for systemic pharmacotherapy, as well as stimulating bone fusion by hydroxyapatite released from the surface.

Keywords: polymer coatings, ultrasonic spray coating, biomaterials, titanium alloy, drug realese, PLGA, hydroxyapatite

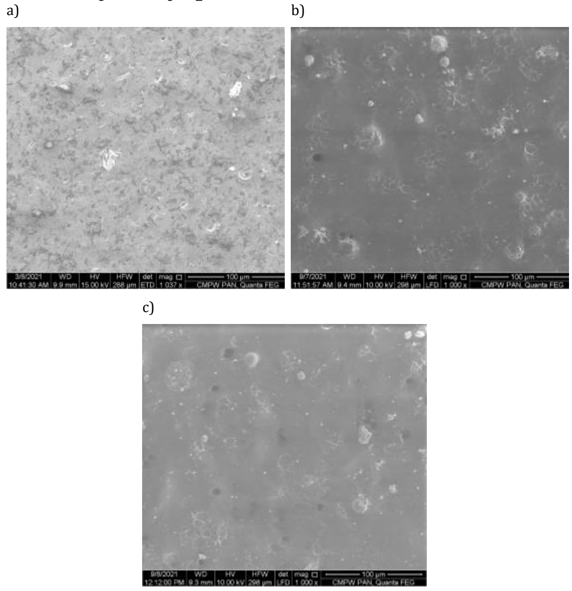

Figure 1: a) anodically oxidized Ti6Al7Nb, b) Ti6Al7Nb with PLGA coating, c) Ti6Al7Nb with PLGA coating containing hydroxyapatite and dexamethasone; SEM

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pH-Responsive Switchable Antifouling and Antibacterial Coatings for Prevention of Catheter Associated Urinary Tract Infections

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Abstract:
Catheter associated urinary tract infections (CAUTIs) are one of the most prevalent healthcare-associated infections, resulting from biofilm formation on catheter surfaces. Some bacteria related to CAUTIs are urease-producing species which can form crystalline biofilms by increasing urinary pH, and eventually result in encrustation and blockage of catheters.
In this work, we successfully synthesized poly(2-azepane ethyl methacrylate)-b-poly (sulfobetaine methacrylate) (PAEMA-b-PSBMA) as pH-sensitive antifouling polymers and quaternary ammonium salt polymer (PQA) as bactericidal polymers via reversible addition fragmentation chain transfer (RAFT) polymerization, with both polymers containing catechol end groups. The resultant polymers can be tethered to the polydimethylsiloxane (PDMS) substrates by a two-step method. In the first step, levodopa/polyethyleneimine (LP) was formed on PDMS by a simple co-deposition process. In the second step, PAEMA-b-PSBMA and PQA were grafted to the LP coating via Schiff base and Michael addition reactions to endow the surfaces with pH-responsive switchable antifouling and antibacterial functionalities, as illustrated in Figure 1. The chemical composition, wettability and thickness of the coatings were characterized by X-ray photoelectron spectroscopy (XPS), ellipsometry and water contact angle (WCA) measurements. The results demonstrated that PAEMA-b-PSBMA and PQA were successfully immobilized on the substrate surfaces and significantly improve the wettability of PDMS surfaces.
The facile two-step coating strategy is promising for development of smart antibacterial coating with biocompatibility on urinary catheters to combat CAUTIs.

Keywords: pH-responsive polymers, antimicrobial coatings, urinary catheter, encrustation, RAFT polymerization.

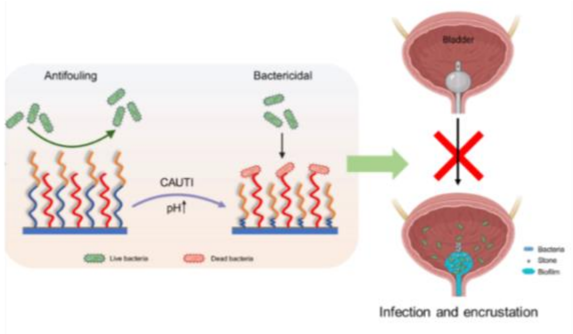

Figure 1: Figure illustrating the pH-responsive switching behavior of the polymer coatings between antifouling and bactericidal properties when catheter associated urinary tract infection occurs, thus prevent biofilm formation and catheter blockage and encrustation.

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Biofouling Mitigation Through Biocidal Coatings: A Nanoscale Perspective Using AFM

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Abstract:

Atomic Force Microscopy (AFM) is a highly effective tool in combating bacterial biofouling due to its ability to provide precise nanoscale information about bacterial modifications upon contact with biocidal agents. This capability enables a detailed assessment of biofilm properties and facilitates the development of more effective antimicrobial strategies [1].

This study addresses the global issue of biofouling on submerged surfaces, which impacts water distribution, treatment systems, and maritime industries, often leading to biocorrosion, biocontamination, and threatening industrial sustainability and public health. In this study, we investigated a silicone-based antifouling coating incorporating the biocide Econea for the prevention of biofouling. The research involved formulating biocidal paints, applying them to acrylic substrates, and evaluating the coatings using AFM to obtain key surface characteristics, including surface morphology and bacterial attachment properties. Measurements included surface morphology, bacterial cell dimensions, and roughness to evaluate the physical stresses on the cells and their relationship with the coating's surface characteristics and biofouling resistance. The diameters and average heights of the bacterial cells were measured both before (Figure 1) and after exposure to the biocide agents.

Results showed that exposure of Methicillin-resistant *Staphylococcus aureus* (MRSA) to the biocidal coatings significantly reduced the number of intact bacteria on the surfaces and altered the diameters and heights of the MRSA cells.

Keywords: Biofouling, multi-resistant bacteria, antifouling coating, nano-surface morphology.

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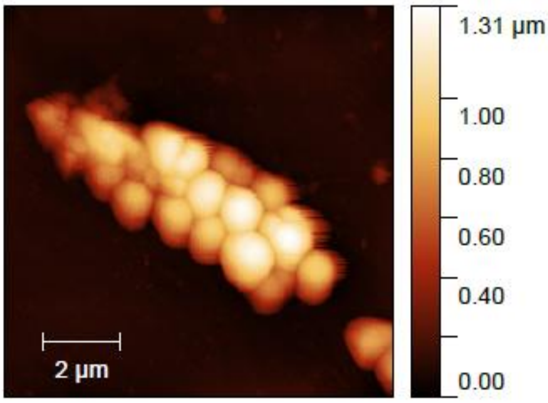

Figure 1: AFM topographic image of *S. aureus* bacteria resistant to methicillin, observed on the surface of the control sample.

Acknowledgements: This work was supported by national funds provided by FCT - Foundation for Science and Technology, I.P., under the project NanoBioMitig – (DOI: 10.54499/2022.06149.PTDC), and through UIDP/04046/2020 and UIDB/04046/2020 (DOI: 10.54499/UIDB/04046/2020) Centre grants (to BioISI). E. R. Silva and A. P. Carapeto thanks FCT for her work contract through the Scientific Employment Stimulus—Individual Calls - DOI: 10.54499/CEECIND/03530/2018/CP1553/CT0011) and 10.54499/CEECIND/00031/2017/CP1387/CT0028, respectively.

The Antifungal Activity of Ag-DHLA Nanoclusters against Fungi Isolated from Indoor Environments

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Abstract:
Harmful indoor moulds can grow on various surfaces when nutrients, water, and appropriate temperature are available. *Aspergillus* and *Penicillium* are the most common indoor fungi. *Aspergillus* species produce a various mycotoxins, such as ochratoxin (1), and can cause aspergillosis in immunocompromised individuals. *Trichoderma* species, which produce toxins, are found in water-damaged buildings (2). Our aim was to investigate the ability of synthesized Ag-DHLA nanoclusters (NCs) to inhibit the growth of indoor fungi on surfaces. Three common indoor fungi were selected for the antifungal tests: *Aspergillus oryzae* VTT D-88350, which is used for fungal resistance testing of paints, *Penicillium roqueforti* VTT D-96662 isolated from a mouldy house and *Trichoderma atroviride* VTT D-061202 isolated from a moisture damaged building. Potato dextrose agar (PDA) Petri dishes were used to grow fungi at 25 °C for the 10 days. Before inoculating spores onto PDA Petri dishes, the PDA surfaces were treated with different concentrations of Ag-DHLA NCs aqueous solution. During the cultures, the fungi were illuminated with blue 405 nm LED light for 15 min daily or with natural light alone. The effective concentration of Ag-DHLA NCs to inhibit the growth of *A. oryzae* was 800 µl/plate (Fig. 1A, C). Inhibition of *A. oryzae* growth was observed on PDA plates coated with Ag-DHLA NCs using either blue light daily (1A) or natural light alone (1C). In contrast, no inhibition of *P. roquefort* or *T. atroviride* growth was observed (Fig. 1). The results showed that natural light alone was effective in inhibiting *Aspergillus* on Ag-DHLA NCs coated PDA plates. These results increase understanding of potential approaches, such as the development of antifungal surfaces, to inhibit the growth of *Aspergillus* species indoors.

Keywords: Nanoclusters, surface, mold, antifungal, indoor air, fungi.

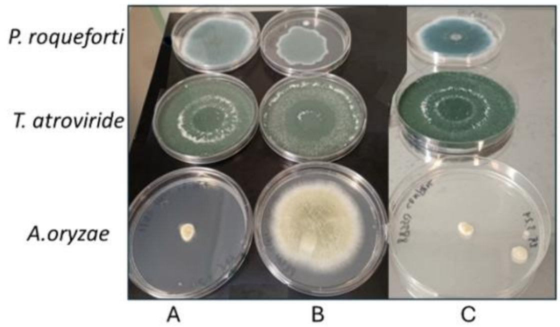

Figure 1: The tested fungi grow on PDA plates. Plates A and C contained Ag-DHLA NCs and B was a control without Ag-DHLA NCs. Plates A and B were exposed to blue light daily and plate C to natural light only.

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A Micropatterning Strategy for Assessing Endothelial Cell Morphology and Topography

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Abstract:
Micropatterning via electron-beam lithography provides a powerful tool for endothelial cells alignment and confinement. In this study, we employed this technique to fabricate high-resolution patterns on glass substrates, enabling a controlled cellular microenvironment for fluorescence and atomic force microscopy (AFM) analysis. Human umbilical vein endothelial cells (HUVECs) cultured on patterned glass surfaces exhibited distinct morphological adaptations depending on the geometric constraints. Microscopy observations revealed that cell adhesion, alignment, and spreading were strongly influenced by pattern dimensions, with effective orientation occurring only for inter-line distances of at least 10 µm. Furthermore, alignment was lost over time on patterns with line widths below 20 µm, indicating critical geometric thresholds for maintaining directed cell organization.

Complementarily, AFM analysis provided a detailed characterization of the three-dimensional surface topography of cells confined within square micropatterns ranging from 10 to 30 µm. Key roughness parameters—including RMS height, RMS slope (Sdq), kurtosis, and skewness—were extracted, and high-pass filtering allowed for precise separation of local surface roughness from overall cell shape. The results demonstrated a strong correlation between available adhesion area and nanoscale topographical features, revealing how substrate patterning modulates cellular surface properties at multiple scales.

By integrating fluorescence and AFM measurements within a single micropatterning-based approach, this study offers a robust and reproducible platform for dissecting the relationship between cell shape, adhesion, and nanometric surface characteristics, advancing our understanding of endothelial cells behavior in controlled microenvironments.

Keywords: Micropatterning, microfabrication, gas-phase silanization, fluorescence microscopy, atomic force microscopy, endothelial cells

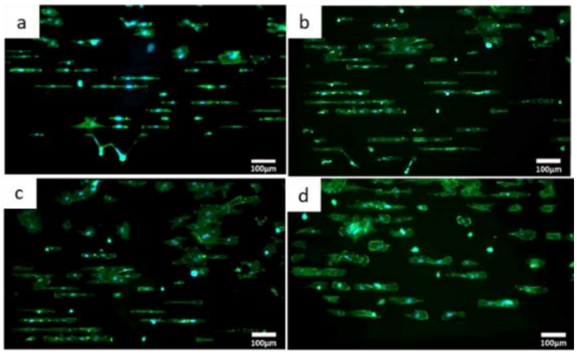

Figure 1: Fluorescence images of HUVECs cytoskeleton and nuclei. Cells have been cultured on linear shaped glass patterns on glass with different width (a, 10 µm; b, 15 µm ; c, 20 µm ; d 30 µm) and distancing (2-5-10-20 µm)

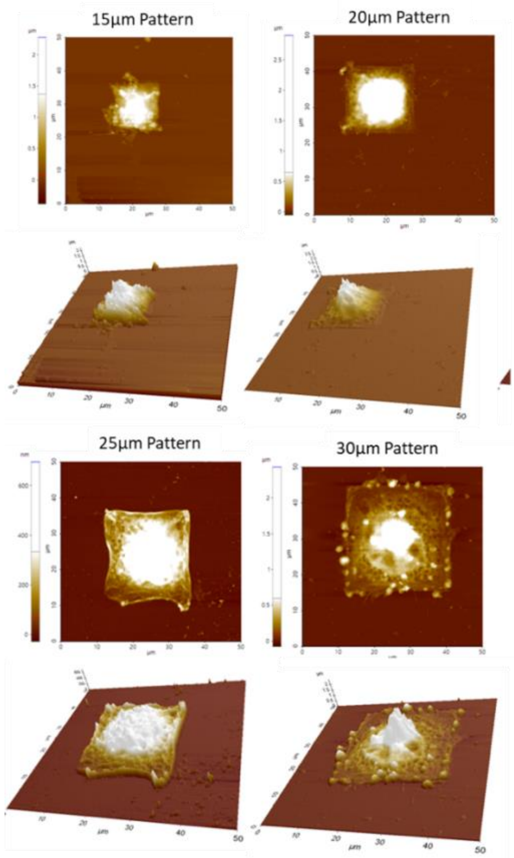

Figure 2: Atomic Force Microscopy of single HUVECs cultured on a squared shape patterns of varying dimensions (15-20-25-30µm)

Improvement of TNZ alloy properties by large deformation and surface treatment

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Abstract:
Statistical data related to the average lifetime and society aging, clearly indicate the necessity to continue scientific works in the area of materials devoted to implants (including dental implants) in order to broaden spectrum of their applications and to improve patients comfort. Functional properties of metallic implants could be enhanced by the proper designing of their chemical composition, microstructure and by the application of surface treatments. The factor, which limits the application area of biocompatible materials such as Ti-13Nb-13Zr alloy, is their low mechanical strength, which is not sufficient in case of load-bearing implants. Mechanical properties of the metallic biomaterials are strongly governed by the number of grain boundaries and dislocation density. Application of the large plastic deformation is an effective approach to increase the content of both microstructure components, which consequently enable to obtain ultrafine grained or nanocrystalline materials with superior mechanical strength. In this work, this approach hase been exploited to create a new class of Ti-based biomaterials, which surfaces will be subjected to further modifications in order enhance their bioactivity. Bioactive glass coatings can be fabricated on the surfaces of metallic biomaterials using the following methods: electrophoretic deposition (EPD), sol-gel techniques, thermal spraying, or laser clad ding [1]. Each of these methods has its limitations, such as the neces sity of post-deposition heat treatment for the sol-gel technique, the formation of micro-cracks during laser cladding, or cracking over time after thermal spraying. Among these techniques, EPD stands out as a cost-effective, simple method that allows BG to be deposited rapidly, even on substrates having highly developed, complex geometries [2].
The aim of this study was to verify how TNZ surface roughness at different scales and surface wettability can affect the quality of chitosan/bioglass EPD coatings. The substrate material was tested in two states before and after large deformation. Surface changes were introuced by combining chemical etching. The effect of the surface pre-treatments on the quality of the coatings was assessed by comparing surface coverage and bioglass distribution (Figure 1), analyzing the adhesion of the coatings to the TNZ substrates. We also report the influence of large deformation on the mechanical properties and effect of TNZ surface treatment. Based on the obtained results, it was concluded that the best adhesion of the chitosan/bioglass coating was observed on the sample treated with hydrofluoric acid, as well as on the surface with micro- and nanometric scale development and hydrophilic characteristics after the two-step Kroll + NaOH treatment.
This research was supported financially by the National Science Centre, Poland under the grant OPUS 23 [2022/45/B/ST5/03398].

Keywords: Ti-alloys, chemical treatment, EPD, chitosan/bioglass coatings, biomedical applications.

a) b)

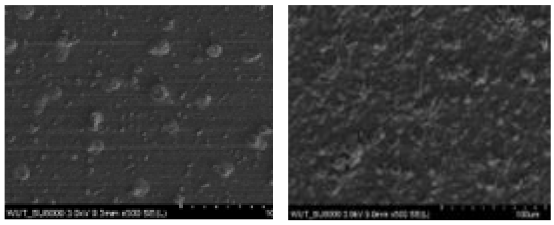

Figure 1: Differences of chitosan/bioglass EPD coatings microstructure: a) before and b) after substrate chemical eatching (Kroll + NaOH).

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Enhancing Zein Biopolymer Performances: Insights from Low-Pressure Cold Plasma Treatment for Sustainable Food Packaging Solutions

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Abstract:
Zein is a biopolymer derived from corn and its utilization as a sustainable food packaging solution presents a promising avenue. Moreover, zein film production is via an entirely green process that allows the recovery of food waste. However, it is important to note that the current properties of zein film do not fully meet the optimal requirements as those of non-biodegradable plastic. Surface proprieties of biopolymers can be modified through cold plasma treatment without damaging their bulk characteristics. In the literature, zein has been treated exclusively with atmospheric cold plasma (ACP). Therefore, this study investigates the potential improvements of film properties and overall performance in food preservation with low-pressure cold plasma (LPCP). This advancement could facilitate the broader adoption of zein-based materials in the packaging industry, aligning sustainability goals while addressing functional deficiencies.

Analytical techniques, including atomic force microscope (AFM), contact angle measurement, Fourier-transform infrared spectroscopy (FTIR), and evaluation of mechanical and barrier properties, reveal significant changes in surface and bulk characteristics of zein after LPCP treatment. Comparisons between ACP and LPCP treatments further highlight distinct chemical and structural impacts on zein. In particular, LPCP treatments efficiently affect zein surface energy i.e. decreasing contact angle without changing its surface morphology. Whereas ACP studies reported significant changes in surface morphology along with enhancement in mechanical and gas permeability of zein due to cross-linking effects.

Keywords: Plasma treatment, Biopolymers, Low-pressure cold plasma,

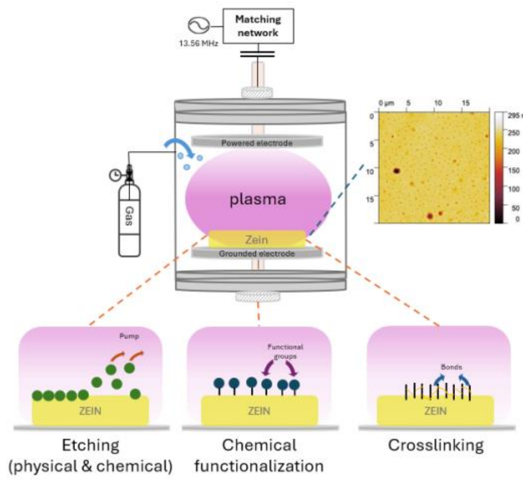

Figure 1: System setup scheme at LPCP for zein treatment. Expected effects outlined below. Top right: AFM image of LPCP-treated zein sample.

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Monosaccharide layers deposited by PLD and PED technique

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Abstract:
The potential application of Pulsed Laser Deposition (PLD) and Pulsed Electron Beam Deposition (PED) techniques was explored and analyzed for their efficacy in producing low-molecular-weight organic films (below 200 Da of molecular weight). For this purpose glucose was selected due to its extensive applications in the medical field and stability in a solid state at room temperature. PVD techniques were investigated due to their advantages over other thin film fabrication methods, such as spin-coating, dip-coating, and spray-coating. These conventional methods often require dissolving organic materials into solvents that may pose environmental or health hazards.

Distinct differences were observed in the glucose films deposited using both methods, primarily in their physical properties. The PLD films exhibit significant crystallinity (Figure 1 A), akin to the original glucose used for deposition. They also possess considerable but uneven thickness. In contrast, the films produced via the PED method are amorphous (Figure 1 B), exhibiting minimal crystallization. They are significantly thinner, but they form an uniform, continuous layer over the entire substrate.

Both PLD and PED techniques produced glucose layers with good preservation of the chemical structure, with some oxidations observed in the PED films. This phenomenon was attributed to the presence of water molecules in the target material, which, in the case of PLD method, can absorb a part of the laser energy decreasing specific power density.

This study demonstrated the viability of employing PLD and PED techniques to fabricate solvent-free, low-molecular-weight organic films. Each method presents unique advantages and limitations, enabling the tailored production of organic coatings for specific applications.

Keywords: pulsed electron beam deposition, pulsed laser beam deposition, glucose layer, physical structure, chemical structure

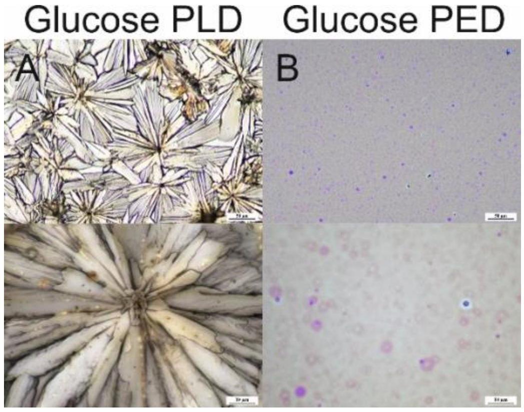

Figure 1: The figure presents optical micrographs of the two glucose coatings deposited using the two methods. a) deposited via the pulsed laser beam deposition method and b) via the electron beam deposition method.

Acknowledgment:

This research was funded by the National Science Centre, Poland, within project SONATA-19 (no. 2023/51/D/ST11/00263).

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Pulsed Electron Beam Deposition of Glucose – the influence of process parameters

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Abstract:
The deposition of organic compounds by pulsed electron beam deposition (PED) is a complex process influenced by several factors, including electron beam interactions with the target material, molecular transport in plasma, and film growth dynamics. During ablation, the electron beam affects both covalent bonds and weaker intermolecular forces, such as hydrogen bonds and Van der Waals interactions. Additionally, the transport and reassembly of molecules impact the structural integrity and crystallization of the resulting coatings (Figure 1).
This study focuses on the PED deposition of glucose under varying process conditions, assessing the influence of key parameters on deposition efficiency and chemical structure preservation. Criteria for evaluation include morphology, topography, and spectroscopy analysis. By examining the role of functional groups in the deposition mechanism, this research aims to expand the understanding of PED for polymer coatings.
PED experiments were conducted under argon pressures of 6–14 mTorr and electron gun voltages of 10–16 kV, with separation distances of 15 or 30 mm. The deposited glucose films were analyzed using FTIR and NMR for chemical composition, while their physical structure and morphology were examined by XRD, AFM, and light microscopy. The correlation between glucose's chemical and physical structure and specific PED parameters was systematically investigated and described.

Keywords: pulsed electron beam deposition, glucose layer, physical structure, chemical structure

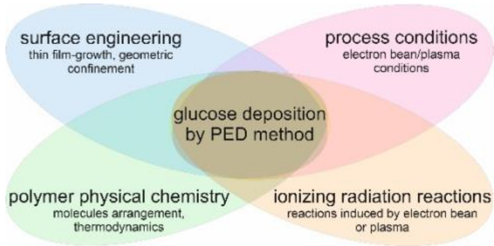

Figure 1: Areas of knowledge required to understand the glucose deposition by PED method.

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4. Niemczyk A., et al. (2024) Comparative Study on Structural Differences in Monosaccharide Layers Using PLD and PED Techniques, *Molecules*, 29, 5095.

Acknowledgment:

This research was funded by the National Science Centre, Poland, within project SONATA-19 (no. 2023/51/D/ST11/00263).

SUPREME – Sustainable nanoparticles enabled antimicrobial surface coatings

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Abstract:

As observed during the last catastrophic pandemic, the spread of harmful pathogens can be fast and facilitated by high traffic surfaces and crowded places, highlighting the importance of an economically and environmentally sustainable solution for antimicrobial surfaces as a potential strategy to mitigate the spread of disease outbreaks.[1] Nanoparticles (NPs) filled coatings, with recognised effectiveness against bacteria, viruses, and fungi, are valuable candidates for developing antimicrobial surfaces and minimising the surface adhesion of pathogens.[2,3] However, due to the many technical challenges, including difficulty to develop nano-coatings with a long-term antimicrobial capability, durability under real conditions and safety assurance, their application at industrial level is still limited.

The SUPREME project aims to develop a platform of efficient and multifunctional antimicrobial nano-coatings, building upon bespoke TiO2 NPs, that have demonstrated an exceptional antimicrobial ability at lab scale (TRL3).[2,3,4] Two sustainable routes: 1) customised core/shell and advanced functional NPs and 2) hybrid fibre-NPs (using sustainable bio-based cellulose materials and NPs) will be pursued.[5,6,7] The production of the SUPREME coating will follow a sustainable-by-design approach, that considers both toxicity and environmental impact. The scaling-up of the nano-coating production and their validation according to the industrial requirements from different market segments (e.g., textile) will enable to reach the TRL6 by the end of the project. The SUPREME consortium consists in 18 partners from 8 EU countries (UK, IT, ES, GR, BE, MT, NL and NO), including research centres, universities, a National Institute, small and medium-sized enterprises (SMEs) and large companies.

Next Technology Tecnotessile (NTT) is involved in technical activities regarding the evaluation of different coating application technologies on textile-based substrates (WP6), including plasma treatments for increasing the adhesion of the coatings on the surface (WP2). The WP6 also aims to implement the design principles and the proof-of-concept nano-coating systems produced by WP2 and verified by WP3-4 in industrial applications.

Keywords: nanoparticles, nanocoating, textile, antimicrobial, plasma treatment.

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Modeling free burning arc radiation with ANSYS Fluent

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Abstract:
Studies on electric arcs, especially fault arcs, are essential in aeronautics, where they pose a significant danger to onboard systems. This issue becomes even more critical as modern aircraft rely on increasingly powerful electrical systems, which heighten the likelihood of arc occurrences. Understanding the behavior and risks associated with these arcs is crucial to ensuring the safety and reliability of aviation technologies. Furthermore, thermal plasmas are fundamental in material processing and the energy industry for applications as welding, cutting, or the manufacture of nanometric powders or nanoparticles. This type of plasma is not easy to study, especially through experimental studies where the setting up of experiments proves to be very complex (large temperature values (several tens of thousands of Kelvin), at large voltage or current values necessary to achieve the breakdown of the arc). Numerical simulation therefore appears to be one of the solutions, enabling us to obtain precise parameters on the arc that would otherwise be impossible to acquire. Once the simulations are validated, it allows us to have access to many parameters, in different regimes, to play quickly with the geometry or even to penetrate the heart of the plasma without disturbing it.
To begin simulating thermal plasmas, it is necessary to study a simple case, widely described in the literature, in order to validate a model. The free-burning arc case appears to be the most accessible. It corresponds to the simulation of a current flowing between a pointed cathode and a grounded flat anode.
To establish this model, we use the software ANSYS® Fluent 2022 R2. Our study focuses here on radiative losses in arc models. This phenomenon alone can account for up to 50% of heat transfer in certain zones of the arc. There are various methods for calculating these losses: the Net Emission Coefficient (NEC), the Mean Absorption Coefficients (MAC), and its sub-method: P1. We then compare these two methods (Figure 1), applying them to the case of a free burning arc in argon other gases (Air, CO_2, …).

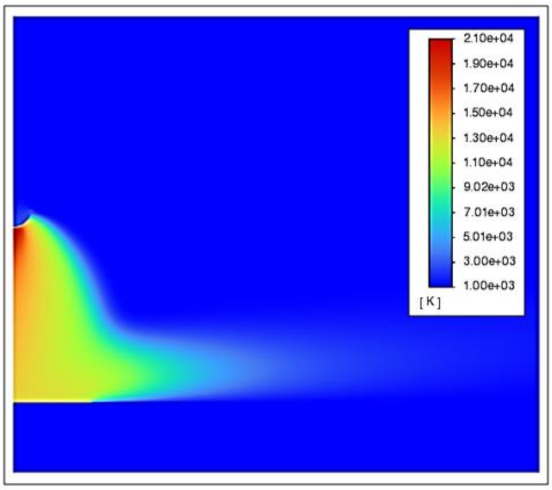

Figure 1: Temperature profile with NEC method in argon at 200A.

Keywords: arc discharge, radiative losses, NEC, MAC, ODM, P1, thermal plasma, aeronautics.

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Thermal Plasma Modeling Using COMSOL: Study of the Radiative Losses in an Arc Between Two Cables in Aeronautical Configuration

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Abstract:
Thermal plasmas are fundamental in the processing of materials and in the energy industry, often used for welding, cutting, spraying, waste treatment, analysis with ICP torches, synthesis of high purity silica or manufacture of nanometric powders or nanoparticles. At the origin of the plasma, the electrical arc is sometimes unwanted.
This is the case for example when a short circuit causes an electric arc leading to a high current discharge. In aeronautics, this problem can occur between two cables of an electrical network, for lifetimes ranging from a few tens to a few hundred milliseconds with the risk of a propagation of the arc along the cables. This phenomenon is called “arc default” or "arc tracking" depending on the arc’s length and lifetime. It is accompanied not only by the ablation of the cables, by the melting and the partial vaporization of the metal and the complete degradation of the insulation, but also by the damage of the immediate environment due to the projection of molten metal droplets and incandescent residues. Thus, the consequences are not only the interruption of the current and loss of information through the circuit, but also the damage caused by the arc, which can be very significant, especially in aeronautics.

In this work, the plasma was assumed to be in local thermodynamic equilibrium (LTE, the electrons and heavy particles temperatures are approximately equal), and the magneto-hydrodynamics (MHD) equations were implemented using COMSOL Multiphysics 6.2. In the equation of energy conservation, we considered the radiative losses using two approached methods: Net Emission Coefficient (NEC) and the P1 method [3] that we compared. This model was first tested on a free-burning arc which is a well-known and widely used case in literature. It is also easy to compare our results and thereby validate our approach (Figure 1). Next, we adapted our model to the case of an arc between two cables in an aeronautical configuration (Figure 2).

Keywords: MHD thermal plasma modeling, COMSOL Multiphysics, Net Emission Coefficient, P1 method, free-burning arc, arc tracking, arc default.

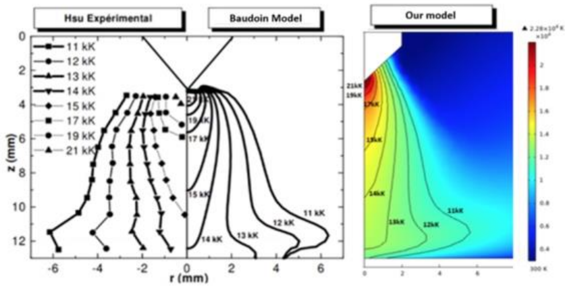

Figure 1: Temperature field in a free-burning arc of argon at 200 A – Comparison with Hsu experiments [1] and Baudoin model [2].

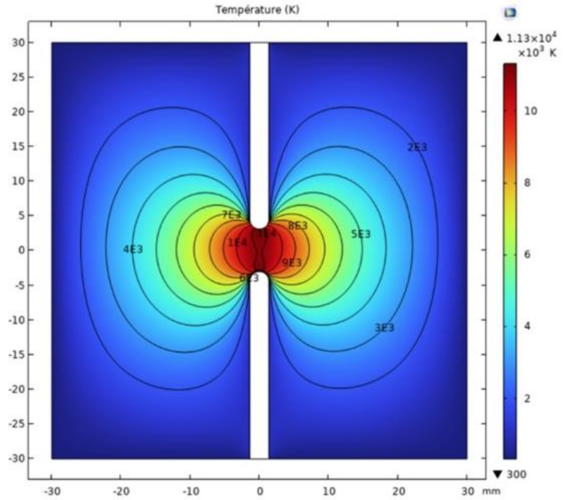

Figure 2: Temperature field of an arc between two cables at 20 A.

References:

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Elucidation of H_2O_2 reaction pathways in plasma-driven biocatalysis

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Abstract:

Plasma-driven biocatalysis combines the in situ H_2O_2 production and enzymatic reactions to convert substrates into more valuable products. Enzymes such as peroxygenases are of great interest for biocatalysis due to their broad application in biotechnology and the green production of oxygenated products [1]. Hydrogen peroxide (H_2O_2) is an attractive electron donor for peroxygenase-catalyzed redox reactions, since it is inexpensive and readily available. However, enzymes are inactivated at high H_2O_2 concentration because the heme cofactor is destroyed (suicide inactivation) [2]. To drive enzymatic reactions, it is thus important to provide H_2O_2 at appropriate concentrations for the enzymatic reaction. Plasma-driven biocatalysis enables the generation of H_2O_2 in situ in a non-invasive way [3] and allows to adjust the H_2O_2 concentration. It is important to understand the reaction pathways for H_2O_2 production to improve H_2O_2 production and limit the formation of other toxic species. Heavy oxygen-labelled water ($H_2{}^{18}O$) was introduced into the plasma system to elucidate the reaction pathways of H_2O_2 in the plasma, gas, and liquid phases. To understand the formation of H_2O_2, heavy oxygen-labelled water was added to make up the buffer and/or supplied in a water-filled bubbler. The ^{18}O in the enzymatic product was quantified by mass spectrometry. When $H_2{}^{18}O$ from stocks was used to make up buffer, product formation was reduced by up to 65%. This is due to isotopic resonance, which describes the catalytic optimum at a specific isotopic ratio and changes in this ratio result in reduced activity. When 100% $H_2{}^{18}O$ was used in the buffer and bubbler, ~70% heavy-labelled (1-$Ph^{18}Ol$) product was formed, which was also the case when using 100% $H_2{}^{18}O$ in the bubbler alone (~65%). In contrast, with 100% $H_2{}^{18}O$ in the buffer, > 90% light product (1-$Ph^{16}Ol$) was formed. This indicates that $H_2{}^{18}O_2$ mainly forms in the plasma phase.

Keywords: isotope tracing, unspecific peroxygenases, reaction pathways

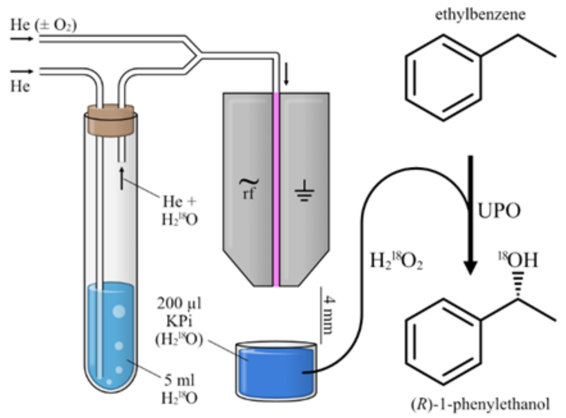

Figure 1: The plasma-exposed buffer is used to fuel the enzymatic conversion of ethylbenzene to (*R*)-1-phenylethanol under consumption of the plasma-generated H_2O_2. To follow the path of H_2O_2 generation, ^{18}O-labelled water is used in the bubbler and/or the plasma-exposed bulk liquid.

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Catalytic Bio-hybrid Coating-based Degradation of Haloalkanes in the Gas-Phase

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Abstract:
Haloalkanes are a group of halogenated hydrocarbons that can be harmful to the environment and human health. Several of these compounds are persistent and can be found in air, water, sediment, and biota globally and are considered as emerging contaminants. While emission of haloalkanes has been severely limited under the Montreal Protocol of 1988, anthropogenic sources are still the main contributor to their occurrence in the environment. Haloalkanes contribute to the depletion of the ozone layer, which has negative impacts on crop production, regional climate, and human health. Exposure to haloalkanes can cause a variety of health issues, including respiratory, dermal, and neurological effects and can contribute the occurrence of cancer. Given that haloalkanes are primarily volatile compounds, targeting their depletion in the gas phase appears to be a practical approach. In the absence of conventional solvents, these systems present numerous benefits, including improved mass transfer, resolution of substrate solubility challenges, and enhanced biocatalyst stability. Since the removal of residual halogenated hydrocarbons from the environment is vital for achieving climate goals and restoring the health of groundwater, soil, air, and the ozone layer, employing bioremediation strategies for haloalkanes is a logical step. To address this global threat we have employed engineered, transgene expressing microbial cells embedded in state-of-the-art coating components to generate a bio-hybrid coating able to detoxify an array of these toxic and environmentally harmful chemicals. This work thus represents a meaningful step in the direction of using genetically engineered, bio-hybrid materials to move towards a more sustainable and healthy future for both the environment and its inhabitants.

Keywords: gas-phase catalysis, haloalkanes degradation, coatings, bioremediation, volatile organic compounds, biohybrid materials

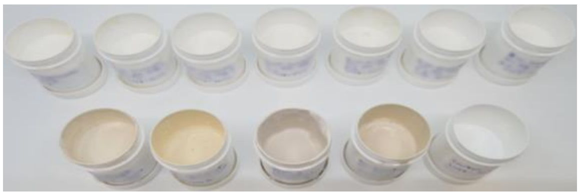

Figure 1: Novel coating formulations containing bio-based fillers (bottom row, 8-11) and fossil control (bottom row, 12). Modification of biomass yields light extender with less impact of formulation rheology (1-7).

Smart materials with depolluting and self-cleaning activity by combining g-C_3N_4-with TiO_2 photocatalysts decorated with Au NPs

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Abstract:

Nitrogen oxides (NOx) are major contributors to air pollution and climate change, necessitating effective reduction strategies. Photocatalytic coatings have emerged as a promising solution for NOx abatement. This study investigates the performance of a surface treatment consisting of g-C_3N_4 -TiO_2 photocatalyst decorated with Au and integrated into a silica sol. TiO_2 is effective under UV light, while g-C_3N_4 operates under visible light, providing a broad-spectrum photocatalytic effect. The incorporation of gold nanoparticles (AuNPs) significantly influences the optical properties of the coatings, as demonstrated by UV-Vis reflectance spectroscopy, which reveals changes in reflectance spectra, band gap, and plasmonic behavior.We carried out a NOx abatement tests in which NO was oxidated by the photocatalytic coating .The results show that the Au/TiO_2/g-C_3N_4 coating exhibits a NO_2 selectivity of 35%, lower than the selectivity values for TiO_2/g-C_3N_4 (61%) and TiO_2-based coatings (56%).A reduction of selectivity means a lower amount of NO_2(the nocive compound) is produced .

Keywords: NO_x degradation, titanium dioxide, graphitic carbon nitride, AuNPs, UV-Vis, , NO_2 selectivity

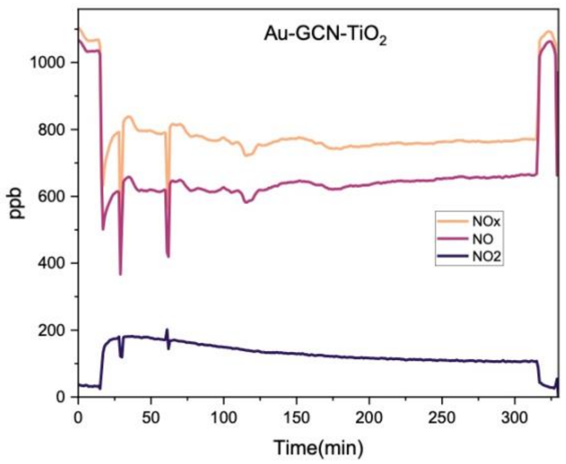

Figure: NO, NO2 and NOx concentration profiles during NO photo-abatement tests.

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Development of g-C_3N_4-TiO_2 visible light active photocatalysts for NO_x depollution applications.

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Abstract:
The use of TiO_2 in photocatalytic pollutant removal applications has been extensively studied since the discovery of its depolluting properties. However, TiO_2 has a major limitation: its activity is restricted to the UV range. In the search for photocatalysts with visible-light activity, graphitic carbon nitride (g-C_3N_4) has emerged as a highly promising alternative [1]. Furthermore, combining TiO_2 and g-C_3N_4 results in hybrid photocatalysts with enhanced performance, thanks to extended light absorption and improved charge separation [2].

This study investigates the effect of precursor type (urea or dicyandiamide) and g-C_3N_4 concentration on the NO_x removal performance of the developed g-C_3N_4-TiO_2 photocatalysts. Photocatalysts synthesized with urea exhibited a higher specific surface area and a more porous g-C_3N_4 structure (Figure 1a), resulting in superior photocatalytic activity. An optimal g-C_3N_4 content of 20% was found to be the most efficient for both precursors. While the optimal photocatalyst showed slightly higher activity compared to pure TiO_2 under UV-Vis irradiation, its NO conversion and NO_x removal were significantly enhanced (by 6-fold and 4-fold, respectively) under visible light (Figure 1b).

These findings underscore the critical role of controlled synthesis parameters in optimizing photocatalyst properties and pave the way for the development of more efficient materials for visible-light-driven environmental applications.

Keywords: Photocatalysis, g-C_3N_4-TiO_2, NO_x removal, air depollution.

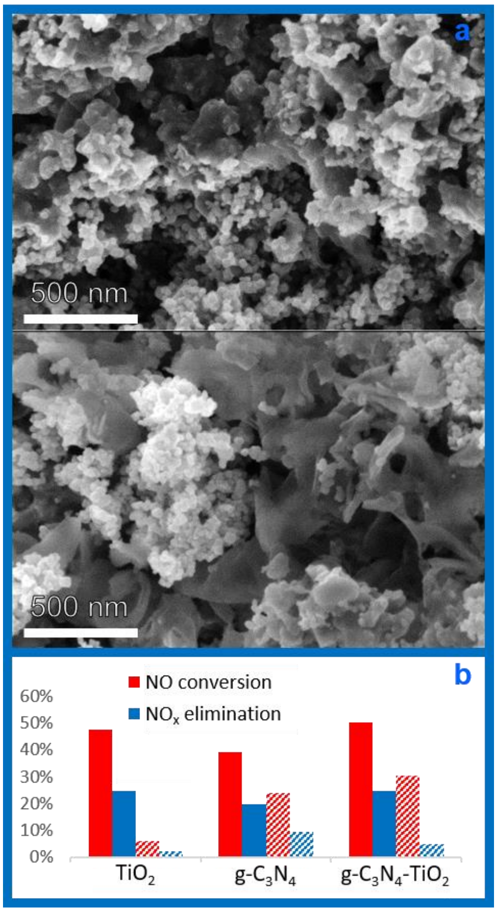

Figure 1: a) SEM images of photocatalysts synthesized with dicyandiamide (top) and urea (bottom). b) NO removal under UV-Vis (solid bars) and visible light striped bars).

References:

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Bluefire CO_2-Loop Based on Carbon Capture and Novel Plasma Technology for Sustainable Synthetic Fuels or CO_2 Neutral Cement Production

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Abstract:
To keep the anthropogenic climate impact as low as possible, we must extract CO_2 from the atmosphere and utilize carbon in cycles. The presented CO_2-Loop consists of a direct air capture coupled with an innovative plasma process to produce synthesis gas (syngas) while burning lime, hence it can defossilize two sectors at once: Firstly, the mobility sector through the synthetic fuel production and, secondly, the construction sector through emission-free cement synthesis.

The mobility sector is responsible for 25% of global CO_2 emissions, and the trend is rising [1]. Besides the transport sector, the construction industry is one of the largest emitters of CO_2, with concrete as commonly used raw material. Concrete production is responsible for 8% of global CO_2 emissions, with around 3 billion tons of cement per year [1,2]. Concrete can only be produced in a very energy-intensive way, using around 3 MJ per m³ of concrete. This is because concrete uses calcium oxide (CaO) as a binder. To produce calcium oxide, lime ($CaCO_3$) must be burned at high temperatures of around 1000°C. This produces emissions in two ways: Natural gas is burned to generate the high temperatures needed for the process. In addition, CO_2 is released from lime during the burning process. Current production processes release 600 kg of CO_2 per ton of cement, 60% of which originates from the chemical reaction and is thus inevitable.

As part of the BlueFire-Project a „Direct Air Capture“ (DAC) system is being designed to create a closed CO_2-Loop. At the same time lime is produced, which is used as binder in concrete. The DAC consists of CO_2 absorption process by air blown countercurrent to an aqueous solution of sodium hydroxide (NaOH), whereby CO_2 from the air reacts to form sodium carbonate (Na_2CO_3). Sequentially, CO_2 is transferred to CaO and reacts exothermically to $CaCO_3$. This product precipitates and can be separated by filtration.

The presented novel plasma process tackles the two main sources of CO_2-emissions simultaneously: The high temperatures of the plasma process are used for lime burning and replaces fossil fuels which are usually used to supply process heat. Hence, the CaO produced by the waste heat of the plasma process is an efficient CO_2 saver. Additionally, the released CO_2 from the $CaCO_3$ conversion can be utilized in the same plasma reactor. The innovative plasma process produces carbon monoxide (CO) from the CO_2, which can be mixed with green hydrogen to yield syngas. Syngas is used to produce synthetic fuels and chemicals such as methanol. The gliding arc discharge reactor developed at the Institute of Photovoltaics (ipv) can provide discharges at normal pressure in large volumes and splitting CO_2 with high efficiency [3-4]. The efficiency is decisive for the energy balance and the large volume of the plasma is a prerequisite for a scalable process [5].

The process can be applied either with focus on production of fuels and chemicals using CO_2 from the atmosphere or with focus on climate neutral lime production for the construction industry.

In the current stage of the project there are two core research tasks to tackle. First, it could be shown that the CO_2 absorption with NaOH and the integrated $CaCO_3$ production is a reliable DAC process to convert CO_2 (CO_2-reduction in air of 30% could be shown) into a valuable product ($CaCO_3$). The influence on the efficiency of a continuous production, the subsequent $CaCO_3$ separation and process coupling with the plasma reactor has to be investigated.

Second focus is on the interaction between the plasma of the gliding arc, the CO_2 as process gas and the solid lime and how the interfaces influence the reactor performance. Furthermore, the mode of operation, reactor geometry, gas flow and efficient supply of $CaCO_3$ are investigated. The goal, a nominal power of 1000 W in the plasma, is already reached. A plant efficiency of η=50% is aimed, while, previously, we were already able to achieve an efficiency of η=40% [4]. The CO_2 is efficiently converted and processed; subsequently, the product gases are analyzed. The solids produced are also tested by XRD-technology for their usability as cement.

Keywords: reaction engineering, CO_2 conversion, glow discharge, direct air capture, CO_2-Loop, plasma technology.

Low-pressure reduction of iron oxides in a hydrogen-containing inductively coupled rf plasma

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Abstract:

Steel production contributes 7-8% to global CO_2 emission due to the traditional coal-coke-based reduction process [1]. Therefore, there is a need for the replacement of carbon as a reducing agent. A promising candidate is hydrogen. Due to its gaseous nature, it can be easily ionized and applied for reduction in its plasma form. At the moment, hydrogen-containing arc discharges are intensively investigated as alternative reduction and heating means in the metallurgical sector [2]. Approaches using non-equilibrium plasmas are also being developed [3]. In this work, we report on a low-pressure reactor for reduction of hematite (Fe_2O_3) using hydrogen-containing plasmas. Although the reduction rate at low pressures is much smaller than under atmospheric pressure conditions, the low-pressure discharges can be easier diagnosed and, therefore, the roles of different hydrogen species in the reduction process can be better tracked and understood. The reactor is a GEC reference cell (Figure 1) in which the rf inductively coupled plasma is produced by a 5-turn-coil antenna placed over a quartz window [4]. The antenna is powered with a 13.56 MHz signal. Typical output power of the rf generator is 100 W. The chamber is filled with argon-hydrogen (9:1) mixture with the pressure of several tens of Pa. At a distance of 4 cm from the quartz window a heater plate is located. A porous sintered hematite sample of sub-g to g weight can be placed onto the plate and heated up during the reduction process. The reduction reactions occur on the surfaces. Sample heating stimulates the diffusion of oxygen atoms providing sufficient oxygen flux from the material bulk. Plasma is diagnosed using the rf IV-probe, emission spectroscopy and microwave interferometry. The outcome of first reduction attempts as well the results of plasma diagnostics will be discussed in this contribution.

Keywords: inductively coupled plasmas, hydrogen, iron oxide, steel, metallurgy, reduction, emission spectroscopy, microwave interferometry.

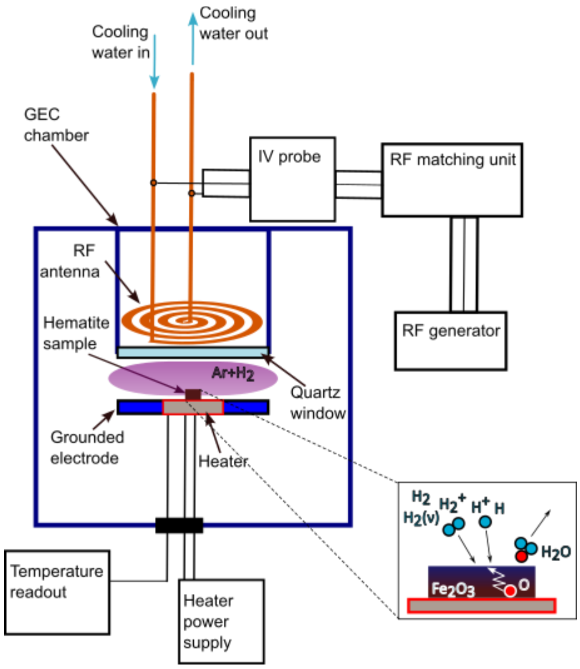

Figure 1: Scheme of the setup for low-pressure reduction of iron oxides with hydrogen-containing plasmas.

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High performance IWO thin films with a new hybrid technology for the deposition of thin films for solar cells application

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Abstract:
Transparent conductive oxides (TCOs) are essential for solar cells, offering high optical transmittance and electrical conductivity. However, conventional deposition techniques such as magnetron sputtering often cause substrate damage due to high-energy particle bombardment, which limits their performance in solar cell structures[1]. To overcome this drawback, we propose a new Hybrid Plasma Deposition (HPD) technique, combining microwave plasma at Electron Cyclotron Resonance (ECR) with DC thermal evaporation[2], as schematized in Figure 1.

In our work, we examined the plasma properties of the HPD system and the resulting IWO films in terms of their structural, electrical and optical properties. Plasma diagnostics were conducted using Langmuir probe and Retarding field energy analyzer, confirming that the ion energy did not exceed 30 eV, sufficiently low to prevent damage to the substrate while still ensuring efficient deposition. The IWO thin films produced exhibit high quality, with structural analysis showing uniform crystallized grains, and optical transmission exceeding 80% across the visible spectrum. Electrical measurements indicate a low resistivity of 4.16×10^{-4} Ω.cm and a carrier mobility (42 $cm^2 \cdot V^{-1} \cdot s^{-1}$) with a corresponding carrier concentration of 3.57 ×20 cm^{-3}, positioning these films as highly suitable for photovoltaic applications.

The IWO films were integrated as transparent electrodes into silicon heterojunction (SHJ) solar cells. The resulting solar cells exhibited a high efficiency of 23.89%, demonstrating the significant potential of HPD-deposited films in enhancing solar cell performance.

Current work aims at improving the performance of the HPD technique and extending the process different TCO compositions and photovoltaic technologies (SHJ, Perovskite, Tandem).

Keywords: Transparent conductive oxides, tungsten-doped indium oxide , solar cells, low-damage deposition.

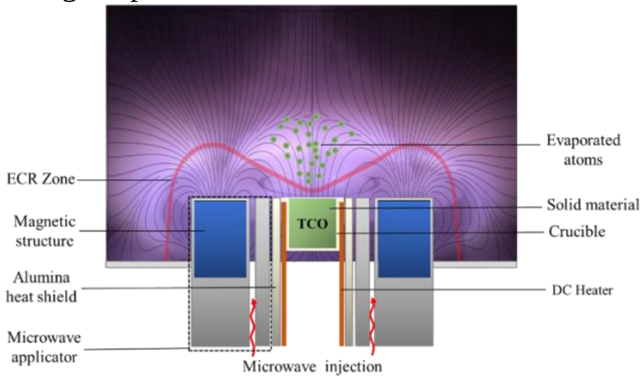

Figure 1: Illustration of the working principle of the HPD technique. The system operates through two integrated components, a coaxial Microwave applicator with a magnetic structure and a DC thermal evaporation device containing a crucible for the TCO material. These two components are separated by an alumina heat shield.

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Computationally supported SSbD design of Solid Oxide Electrolyzer Cell anodes: Integrating Quantum Mechanical calculations with Machine Learning methods

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Abstract:
Solid Oxide Electrolyzer Cells (SOEC) systems represent a promising alternative to traditional energy sources in the energy transition process. These systems are capable of both producing and generating hydrogen in a reversible cycle. Unfortunately, there is still lack of knowledge how to use more efficient SOEC systems. The research employed a computational approach to propose designs for SOEC anode components that are free of lanthanum (REE metal), thereby aligning with the principles of SSBD (Safe and Sustainability by Design) approach. For the first time, we introduce a combined quantum mechanical and machine learning approach to support the SOEC design process. This approach eliminates the need for expensive and resource-intensive experimental studies and significantly reduces the number of structures required for experimental validation.

As part of the research, molecular models were developed for 240 structures that could potentially serve as anode configurations for SOEC cells. The doped Brownmillerite systems are represented by a fragment consisting of 29 atoms (20 oxygen atoms, with 5 in octahedral center positions and 4 in tetrahedral center positions).

Calculations for 240 potential SOEC structures were performed using the Gaussian16 computational chemistry software package, applying density functional theory (DFT) at the MN15/LANL2DZ/6-31G level. From these calculations, a set of quantum mechanical descriptors was obtained. Based on these descriptors, machine learning analysis was applied to characterize and group similar samples according to the QM-derived descriptors. Five groups were identified, and using the k-means method, the most promising representatives were selected for further experimental evaluation.

Keywords: machine learning, SSbD, green deal, quantum chemistry, SOEC, hydrogen energy.

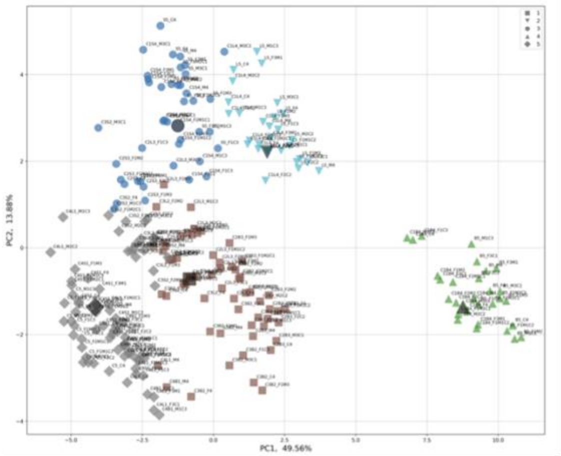

Figure 1: Line plot in the space of two PCs, with k-means cluster coloring

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