MANCHESTER 1824
The University of Manchester

HELLO TOMORROW

Faculty of Science and Engineering

POSTGRADUATE RESEARCH

Department of Materials

Postgraduate Research Conference

20th & 21st May 2026

Contents

Materials Conference 2026
Wednesday 20th – Thursday 21st May
Nancy Rothwell Building

Welcome Statement

Welcome to the Department of Materials PGR conference 2026.

Our Postgraduate Research community has over 500 PhD and MPhil researchers, contributing enormously to research excellence, social responsibility, and teaching delivery - as well as making the Department such a vibrant place to work and to learn.

Our research spans material science, engineering, textiles and fashion management & marketing. These may appear diverse topics, but the power of interdisciplinary exchanges for generating innovation and sharing best practice is exemplified by the range of talks and poster presentations at this conference. We challenge you to find common ground in your projects and consider ways that you could potentially work together in the future!

We hope that you enjoy the conference. To make the most of the experience please ask plenty of questions and engage with other participants. This will be invaluable for building your networking and communication skills as well as your confidence for external conferences.

We have an excellent Plenary session lined up to officially open the conference. Firstly, Dr Melissa Willis, Robotics and Manufacturing Research Lead at Sellafield Ltd, will be delivering a talk about her PhD experience and subsequent career in industry. Her talk promises to be inspiring and helpful for your research and future careers.

Following this we have a panel of recent PhD graduates who will be answering questions on their experiences of the final viva and providing top tips for achieving a PhD. We have some key questions prepared for the panel but we also hope that you will get involved and ask them what you want to know to help demystify the viva.

Best of luck with your poster and oral presentations, we are really looking forward to seeing them!

Dr Rosy Boardman
(Head of PGR)

Drs Alec Davis, Courtney Chrimes, Chamil Abeykoon
(Deputy Heads of PGR)

Conference Overview

Day 1
Wednesday 20th May

09:30 – 10:30	Registration & Display Posters (Y1)	*Nancy Rothwell Event Space*
10:30 – 11:30	Plenary Session	*Blended Th 1 GA.056*
11:30 – 12:30	Lunch	*Nancy Rothwell Event Space*
12:30 – 14:00	Year 1 Poster Session	*Nancy Rothwell Event Space*
14:00 – 14:15	Year 1 Poster Prizes	*Nancy Rothwell Event Space*
14:15 – 15:15	Year 2 Oral Presentations #1	*See presentation schedule*
15:15 – 15:45	Break (Tea, coffee & pastries)	*Nancy Rothwell Event Space*
15:45 – 17:00	Year 2 Oral Presentations #2	*See presentation schedule*

Day 2
Thursday 21st May

09:30 – 10:00	Display Posters (Y3) (Tea, coffee & pastries)	*Nancy Rothwell Event Space*
10:00 – 11:00	Year 2 Oral Presentations #3	*See presentation schedule*
11:00 – 11:15	Break	
11:15 – 12:15	Year 2 Oral Presentations #4	*See presentation schedule*
12:15 – 13:00	Lunch	*Nancy Rothwell Event Space*
13:00 – 14:30	Year 3 Poster Session	*Nancy Rothwell Event Space*
14:30 – 15:00	Year 3 Poster Prizes	*Blended Th 1 GA.056*

Department of Materials Conference 2026
Y1 Poster Session, *Nancy Rothwell Event Space*
Wednesday 20th May 12:30 – 2:15PM

Name	**Year Group**	**Theme**	**Poster Number**
Alice Baxter	1	1. Biomaterials	1
Mingqian Xu	1	1. Biomaterials	2
Susantika Paink	1	1. Biomaterials	3
Chenghao Du	1	2. Coatings and Ceramics	4
Erjona Mulaj	1	2. Coatings and Ceramics	5
Ghazi Salman H Qahtani	1	2. Coatings and Ceramics	6
Guangrui Ai	1	2. Coatings and Ceramics	7
Harry Smith	1	2. Coatings and Ceramics	8
Hehang Zhang	1	2. Coatings and Ceramics	9
Madeleine Hill	1	2. Coatings and Ceramics	10
Pok Man Ethan Lo	1	2. Coatings and Ceramics	11
Rajdeep Sarkar	1	2. Coatings and Ceramics	12
Shenghui Lin	1	2. Coatings and Ceramics	13
Vincent Mika	1	2. Coatings and Ceramics	14
Xiangjie Song	1	2. Coatings and Ceramics	15
Xiaohan Cui	1	2. Coatings and Ceramics	16
Yi Wu	1	2. Coatings and Ceramics	17
Muhammad Ishraq Mamun	1	3. Imaging and Characterisation	18
Jordi Weingard	1	3. Imaging and Characterisation	19
Seviye Bengu Ates	1	3. Imaging and Characterisation	20
Umar Ul-Hassan	1	3. Imaging and Characterisation	21
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Hugo Stephens	1	4. Metallurgy and Corrosion	26
Ibrahim Saud I Alharbi	1	4. Metallurgy and Corrosion	27
Johnny Cooke	1	4. Metallurgy and Corrosion	28
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Karan Aggarwal	1	4. Metallurgy and Corrosion	30
Rahul Bhattaram	1	4. Metallurgy and Corrosion	31
Ramazan Burak Otgun	1	4. Metallurgy and Corrosion	32
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Chloe Casey	1	5. Nano and Functional Materials	41
Emily Johnson-Oughtibridge	1	5. Nano and Functional Materials	42
Henry Davis	1	5. Nano and Functional Materials	43

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Department of Materials Conference
Year 3 Poster Session, Nancy Rothwell Event Space
Thursday, 21st May, 13:00 - 14:30

Name	Year Group	Theme	Poster Number
Ali Sedighi Hasankiadeh	3	1.Biomaterials	1
Bhuvaneshwari Anbazhagan	3	1.Biomaterials	2
Clara Barbut	3	1.Biomaterials	3
Donghuan Yang	3	1.Biomaterials	4
Fatima Kadi	3	1.Biomaterials	5
James Elliff	3	1.Biomaterials	6
Lukas Weber	3	1.Biomaterials	7
Md Arif Mahmud	3	1.Biomaterials	8
Mia Wansbrough	3	1.Biomaterials	9
Rachael Tibbitts	3	1.Biomaterials	10
Xiaojing Gu	3	1.Biomaterials	11
Yi-Ching Chen	3	1.Biomaterials	12
Yiting Chen	3	1.Biomaterials	13
Chu Yang Li	3	2.Coatings and Ceramics	14
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Finley Lloyd	3	2.Coatings and Ceramics	16
Hareem Zubairi	3	2.Coatings and Ceramics	17
Jianxi Wen	3	2.Coatings and Ceramics	18
Md Mirazul Mahmud Abir	3	2.Coatings and Ceramics	19
Peng Tao	3	2.Coatings and Ceramics	20
Peng Zong	3	2.Coatings and Ceramics	21
Rielle Jensen	3	2.Coatings and Ceramics	22
Shuai Zhong	3	2.Coatings and Ceramics	23
Tess Knowles	3	2.Coatings and Ceramics	24
Xiangwei Zhu	3	2.Coatings and Ceramics	25
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Joao Batista Rocha Bezerra Junior	3	3.Imaging and Characterisation	28
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Kun Bai	3	4.Metallurgy and Corrosion	43
Michael Green	3	4.Metallurgy and Corrosion	44
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Day 1: Oral Presentation Sessions (Wednesday 20th May)

Session Theme(s): Polymers & Composites		
Wednesday 20th May, 14:15 – 17:15 Building/Room: Nancy Rothwell Building, 3A.016		
Chairs: Lina Jfairi, lina.jfairi@manchester.ac.uk Christina Picken, christina.picken@manchester.ac.uk		
14:15	Jian Li	Hierarchal Vitrimer Composites
14:30	Akshay Mahale	Valorisation of Thermoset Resin Degradation Products Through Pressurized SteamBased Recycling
14:45	Arvin Jia Qing Chen	Development of nanocomposite coatings for aluminium alloy-based hydrogen storage tanks
15:00	Chloe Smith	How Synergistic Photooxidation and Water Exposure Drive Microplastic Release from Protective Coatings
Break: 15:15– 15:45		
15:45	Dhruve Aidasani	Quantifying & Qualifying Polymer Recyclate
16:00	Edward Savage	Recycled Content as a Driver for Phase Coarsening in Impact Polypropylene
16:15	Haoran Zhang	Flexible and wearable Ecoflex/CNTs/ melamine foam piezoresistive sensor
16:30	Mary Pool	ABS-olutely Recyclable: Breaking down polycarbonate blends using Acetolysis

Session Theme(s): Fashion Marketing and Management & Textiles and Apparel		
Wednesday 20th May, 14:15 – 17:15 Building/Room: Nancy Rothwell Building, 3A.029		
Chairs: Kasey Hatch, kasey.hatch@manchester.ac.uk Phumza Sokhetye, phumza.sokhetye@manchester.ac.uk		
14:15	Emran Hossain	Engineering of textile based smart compression systems for sports and medical applications using computer aided design and 3D printing
14:30	Lena Bartoszewicz	Behind the Gift: Exploring Extended Producer Responsibility as a Mechanism for Fairer and More Circular Charity-Brand Partnerships in the UK Textile Sector
14:45	Md Faisal Mahmud	Tow-Scale Interfacial Toughening of Carbon Fibre Composites through Graphene Nanoplatelets
15:00	Priyadarshini Venkatasalam	Spinning Bacterial Cellulose for Next-generation Sustainable Textile Materials in the Fashion Industry
Break: 15:15– 15:45		
15:45	Tanvir Mahady Dip	Design and Development of Novel Bioactive Dressing for Controlled Drug Delivery in Advanced Multifunctional Wound Care
16:00	Yiyang Zhong	Coaxial Electrospinning of PVA/Chitosan
16:15	Yaxin Lyu	Exploring the development of parasocial relationships with AI streamers in Chinese consumers’ shopping experience
16:30	Ziqi He	Engendering Brands: Moral Controversy at the Brand-Gender Nexus

Session Theme(s): **Metallurgy and Corrosion**		
Wednesday 20th May, 14:15 – 17:15 Building/Room: Nancy Rothwell Building, 3A.052		
Chairs: Mia Maric, mia.maric@manchester.ac.uk Alec Davis, alec.davis@manchester.ac.uk		
14:15	Eamonn Lawlor	Ti-6al-4v Cold Dwell Fatigue: Effect of Stress Concentrations And Fatigue Crack Growth Rates
14:30	Grace Fidler	Using In-Situ SEM to Characterise the Decomposition of Retained Austenite During Tempering of Low-Alloy Steel
14:45	Lingfei Kong	Control of Columnar-to-Equiaxed Transition in Aluminum Alloy Additive Manufacturing through Process Parameter Optimization
15:00	David Champness	Lead in Drinking Water: Reducing/Replacing Phosphate Dosing
Break: 15:15– 15:45		
15:45	Chuyuan Xu	Controlling solidification driving force during additive manufacturing
16:00	Dalal Ali	Linking Corrosion Reactions, Hydrogen Embrittlement, and Adsorption to Surface Passive Film Properties
16:15	George Merryweather	Understanding the hydride distribution in electron-beam welded zirconium
16.30	Hemanth Abhinav Gunthamalla	Nanoindentation of Fusion Steel: Effect of Temperature and Strain Rate
16.45	Bardia Hashemi	Redox-Controlled Corrosion of *CuCrZr* and *EUROFER-97* in High-Temperature Water.

Session Theme(s): **Coatings and Ceramics**		
Wednesday 20th May, 14:15 – 17:15 Building/Room: Nancy Rothwell Building, 3A.057		
Chairs: Chamil Abeykoon, chamil.abeykoon@manchester.ac.uk Simon Hunt, simon.hunt@manchester.ac.uk		
14:15	Amro Bader	Towards a Bayesian Tritium Inventory Modelling Framework
14:30	Charles Edwards	Hydrogen trapping and permeation in metallic and ceramic coatings for fusion powerplant applications
14:45	Chenxi Zhang	Environmental degradation of additively manufactured ABD-900 Ni-based superalloy
15:00	Ke Hu	Development of Vitrimer/GNPs Coatings for Corrosion Protection of Magnesium Alloy AZ31
Break: 15:15– 15:45		
15:45	Seham Alamri	Phase transition and switching behaviors in BiFeO3-SrTiO3
16:00	Erol Cem Ozgor	Coating of SiC Fibers via Electrophoretic Deposition and Processing of SiCf/SiC
16:15	Zongkai Feng	Durable Tungsten Coatings Produced by Aerosol Deposition
16:30	Zhuoyao Li	Distinguishing local deformation responses in ceramic materials using nanoindentation response parameters
16:45	Xiaomu Sui	Understanding the Fundamental Degradation Mechanisms of Thermal Barrier Coating Materials under Combined Steam and CMAS Exposure

Day 2: Oral Presentation Session (Thursday 21st May)

Session Theme(s): Polymers and Composites		
Thursday 21st May, 10am– 12.15 Building/Room: Nancy Rothwell Building, 3A.016		
Chairs: Cristina Valles, cristina.valles@manchester.ac.uk Bill Sampson, william.sampson@manchester.ac.uk		
10:00	Nasser Rehman	Changing the Linear Model: A Path to Circular Lab Plastic
10:15	Sumudu Adikaram	Development of Theoretical and Numerical Models to Expound the Thermal Behaviour of Nanocomposite Phase Change Materials
10:30	Toby Squire	Electrically Conductive Adhesives Based on Nanomaterials For Effective and Sustainable Joule Cfrps Bonding and Selective Debonding
10:45	Wenbo Wu	Using polymer nanoparticles to increase the toughness and stability of Perovskite solar cells.
Break 11:00-11:15		
11:15	Yichi Zhang	Self-repairing Electrically Conductive Epoxy/PCL Nanocomposite
11:30	Yuhao Liang	Investigating the environmental fate and biological impacts of labelled 2 nanoplastics
11:45	John Vickers	2D Materials Enhanced Self-Reinforced Polymer (SRPs), Bicomponent Sheath and Core Monofilament Composites Applications.
12:00	Joseph Bergin	Reducing the environmental impact of single use items in healthcare

Session Theme(s): Metallurgy and Corrosion		
Thursday 21st May, 10am– 12.15 Building/Room: Nancy Rothwell Building, 3A.029		
Chairs: Muhammad Junaid Anjum, muhammadjunaid.anjum@manchester.ac.uk Ed Pickering, ed.pickering@manchester.ac.uk		
10:00	James Butler	The interaction of high-powered lasers with a range of technologically relevant alloys
10:15	Matthew Brayne	The Effect of Surface Preparation and Temperature on the Oxidation of Alloy 800HT in an Impure Helium Environment
10:30	Matthew Warner	An integrated computational risk assessment for fusion material
10:45	Michael Mcglynn	Understanding the Impacts of Irradiation Environment on the Corrosion of Zirconium Cladding Alloys
Break 11:00-11:15		
11:15	William Rudrum	Atomistic Modelling of Hydrogen Isotopes and their interaction with the structural materials in a Fusion Power Plant Environment
11:30	James Cowie	Understanding Performance in Co and Fe-based Alloys under Nuclear Plant-Relevant Conditions
11:45	Adrian Leung	Effect of residual stress on deuterium permeability in tungsten
12:00	Elsa Bohman Verheul	The role of flow and electromagnetic effects on dendrite morphology in fusion steels

Session Theme(s): Imagining and Characterisation
Thursday 21st May, 10am– 12.15 Building/Room: Nancy Rothwell Building, 3A.052

Chairs: Alex Eggeman, alexander.eggeman@manchester.ac.uk Courtney Chrimes, courtney.chrimes@manchester.ac.uk		
10:00	Aidan Neil	Fuel Retention and Release Mechanisms in Breeder Blanket Materials for Nuclear Fusion Devices
10:15	Alhanouf Alrwais	Hyperspectral Radiographic Imaging Using a HEXITEC 6×2 Detector for Material Characterisation
10:30	Emma Buckworth	Characterising Texture Variation in Cross Rolled and Super Plastically Formed Ti64
10:45	Haole Qin	Microstructural evolution and defect formation in aluminum alloy 4043 during molten metal deposition
Break 11:00-11:15		
11:15	Yanxuan Wang	Resolving the Incommensurately Modulated Structure of Labradorite by 3D ED Tomography
11:30	Yunlong Xu	Visualization of interface evolution in solid-state batteries using in-situ electron microscopy

Session Theme(s): Nano and Functional Materials		
Thursday 21st May, 10am– 12.15 Building/Room: Nancy Rothwell Building, 3A.059		
Chairs: Sangeeta Sangeeta, sangeeta.s@postgrad.manchester.ac.uk Alec Davis, Alec.davis@manchester.ac.uk		
10:00	Jacob Young	Synthesis & Characterization of a High Entropy Lanthanide Oxyselenide
10:15	Liting Deng	A Durable Wick-Assisted Solar Evaporator Based on MWCNT/Ecoflex Coated Melamine Foam for Long-Term Seawater Desalinatio
10:30	Michael Hutton	Complex mixtures of organic semiconductors for new optoelectronic devices
10:45	Soumyajit Das	Carbon-Silica Hybrid Nanomaterials: Synthesis and Structural Characterization
Break 11:00-11:15		
11:15	Hongkai Zhou	Plasmonic Diborides and Ultrathin Gold Films: Materials, Fabrication, and Mechanisms
11:30	Merve Seyma Surel	High Entropy 2D Materials for Efficient Water Splitting
11:45	Sruthi Raj Sreeraj	Colloidal Quantum Dots Doped by Single Rare Earth Ions for Quantum Memories and Repeaters

Session Theme(s): Biomaterials		
Thursday 21st May, 10am– 12.15 Building/Room: 3A.071		
Chairs: Md Israil Hossain, mohammadisrail.hossain@manchester.ac.uk Daniel Engstrom, daniel.engstrom@manchester.ac.uk		
10:00	Balint Macsuga	In vitro characterisation of human mesenchymal stem cell responses against the predicted electric field properties during static capacitive electrical stimulation
10:15	Chengliang Song	Tough and stiff injectable gels from inter-linked microgels
10:30	Jiahao Xu	A photosynthetic microneedle patch with in-situ oxygenation to enhance catalytic activity of non-releasing nanozyme for hypoxic diabetic wound healing

10:45	Supanut Kitphaitun	Novel 3D cellulose- Nanocomposite Scaffold for skeletal Muscle Therapy
Break 11:00-11:15		
11:15	Vasiliki Nikolaou	Fast-Forming Tetrazine–Norbornene Gelatine Hydrogels for 3D Cell Culture and Cartilage Applications

Faculty of Science and Engineering

POSTGRADUATE RESEARCH

Presentation Abstracts

Hierarchal Vitrimer Composites

Supervisor：Ian Kinloch, Crisitina Valles

Epoxy resins and their (nano)composites are widely used in industry because of their good physical and chemical properties. However, they cannot be reprocessed or recycled, generating high amounts of waste. Thus, there is an urgent need to replace them with thermoset polymers that can be reprocessed or recycled without compromising their properties. Epoxy vitrimers emerge as an excellent alternative because their reversible chemical bonds allow them to be reshaped, repaired, reprocessed and recycled. This project will investigate the potential of vitrimers to replace currently used epoxy resins for the development of recyclable high-performance (nano)composites, going towards making thermosets more sustainable materials, which will impact strongly academia, industry and society. In particular, we will study hierachial composite structures where graphene, nanotubes and glass fibres are used together within a vitrimer matrices for enhanced mechanical, thermal and electrical properties for potential applications in the automotive and wind turbine industry.

Valorisation of Thermoset Resin Degradation Products Through Pressurized Steam-Based Recycling.

Akshay Dinkar Mahale

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Polymers and Composites.

Year 2 (Talk)

Recycling composites is crucial for achieving environmental sustainability. Although these materials are highly durable, their recycling remains challenging and contributes to increased landfill waste. Repurposing composites can mitigate the environmental impact of these materials, conserve valuable resources, and foster a circular economy by reusing them in manufacturing processes [1].

Various recycling strategies mechanical, thermal, and chemical are currently employed, owing to their scalability and cost-effectiveness [2]. However, these methods face limitations, including high energy consumption, reduced fibre quality, and altered fibre morphology [2][3]. In particular, the deposition of charcoal on fibre during pyrolysis negatively affects the mechanical performance of reclaimed carbon fibre.

To address these challenges, researchers are developing novel approaches for recycling thermoset epoxy resins and composites, with a focus on recovering high-value fibres and resin degradation products for reuse [4]. This work examines the potential of a pressurized steam-based recycling process to valorize thermoset resins used in composite manufacturing [2]. By investigating this innovative approach, we aim to establish a more sustainable and efficient manufacturing paradigm that minimizes waste and environmental impact**.**

References

[1] Heidarian, P.; Mokhtari, F.; Naebe, M.; Henderson, L. C.; Varley, R. J. Reclamation and reformatting of waste carbon fibers: A paradigm shift towards sustainable waste management. *Resour. Conserv. Recycl.* 2024, *203*, 107465. DOI: 10.1016/j.resconrec.2024.107465.

[2] Feng, Y.; Zhang, Z.; Yue, D.; Belko, V. O.; Maksimenko, S. A.; Deng, J.; Sun, Y.; Yang, Z.; Fu, Q.; Liu, B.; Chen, Q. Recent progress in degradation and recycling of epoxy resin. *J. Mater. Res. Technol.* 2024, *32*, 2891−2912. DOI: 10.1016/j.jmrt.2024.08.095.

[3] Zhu, J.; Li, H.; Yi, J.; Chen, Z.; Ge, L.; Liu, C.; Geng, H.; Chen, X.; Li, T.; Deng, D.; Huan, X.; Jia, X.; Yang, X.; Wang, H. Electromagnetic techniques in carbon fibre and carbon fibre composites manufacturing: A review. *Compos. Part B: Eng.* 2025, *296*, 112227. DOI: 10.1016/j.compositesb.2025.112227.

[4] Wang, B.; Wang, X.; Xu, N.; Shen, Y.; Lu, F.; Liu, Y.; Huang, Y.; Hu, Z. Recycling of carbon fibers from unsaturated polyester composites via a hydrolysis-oxidation synergistic catalytic strategy. *Compos. Sci. Technol.* 2021, *203*, 108589. DOI: 10.1016/j.compscitech.2020.108589.

Development of nanocomposite coatings for aluminium alloy-based hydrogen storage tanks

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Research Theme: Polymers and Composites

Year of Study (Presentation Type): Year 2 (Talk)

Polymer nanocomposite coatings using disulfide vitrimer or commercial epoxy with graphene nanoplatelets (GNPs) filler on aluminium alloy substrates were developed to explore their potential as hydrogen barriers. The polymers were either casted in moulds to produce bulk samples or bar coated as thin layers on aluminium alloy 6061 plates. Attenuated Total Reflectance Fourier Transform Infrared (ATR-FTIR) spectroscopy analysis was used to confirm successful curing while Raman spectroscopy measurements checked for successful filler incorporation. Scanning Electron Microscopy images were taken of the sample cross-sections to check their microstructures and electrical tests were used to evaluate their susceptibility to conductivity. Dynamic Mechanical analysis and Differential Scanning Calorimetry provided their glass transition temperatures while Thermogravimetric analysis evaluated their thermal stability. Using optical microscopy and ATR-FTIR, surface scratches on the materials were tested before and after heat treatment for self-healing and new chemical bond formation. Dolly pull-off tests were also performed on the coated plates to test each material's adhesion strength. Future works involve measuring hydrogen diffusion, possibly with either an electrochemical H-cell or gas permeation rig setup. In-situ IR spectroscopy, nanoscale infrared spectroscopy, and nanothermal analysis would also be explored for a more-depth understanding of the disulfide exchange self-healing mechanism in the vitrimers.

How Synergistic Photooxidation and Water Exposure Drive Microplastic Release from Protective Coatings

Name: Chloe Smith
Email: chloe.smith-14@postgrad.manchester.ac.uk

Research Theme:
Polymers and Composites

Year of Study (Presentation Type): Year 2 (Talk)

Paints have recently been identified as a significant source of secondary microplastic release, contributing to the concerning accumulation of particles in ecosystems globally. However, the extent of microplastic release and underlying mechanisms remain largely unexplored, impeding the ability of formulators to measure, predict, and prevent this pollution.
In this study, we examine the progressive degradation of an epoxy-resin coating subjected to a standard cyclical accelerated weathering protocol (ISO 4892-2). Cyclical weathering results in extensive thinning, microplastic release, and superficial crocodile-skin cracking. In isolation however, UV irradiation and water spray do not. Changes in thermal properties and surface chemistry are assessed using thermal and spectroscopic methods, whilst electron microscopy (SEM) and high resolution photothermal infrared techniques (AFM-IR and O-PTIR) of the degraded region reveal the underlying mechanism of accelerated material release. Photooxidation produces a fragile oxidised layer, subsequently removed during water exposure. Oxidation progresses more rapidly around pigment particles, which are then released upon water spray and voids are created. Due to increased internal stress at voids, cracks propagate.
Crocodile-skin cracking and accelerated material release during cyclical aging is driven by repeated swelling of the photo-oxidised layer, where subsequent drying and contraction results in extensive crack propagation.

Quantifying & Qualifying Polymer Recyclate

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Research Theme: Polymers and Composites
Year of Study (Presentation Type): Year 2 (Talk)

Mechanical recycling is the primary apparatus to economically and ecologically reprocess polymers into new products in attempts to combat anthropogenic climate change and pollution. This research investigates use and contamination of chain-extending additives (to counteract degradation) during mechanical recycling of poly(ethylene terephthalate) (PET) bottle packaging. Multifunctional and bifunctional chain-extenders (MCEs/BCEs) were used during simulated recycling of PET to assess variations in degradation when compared to non-chain extended PET. Assessments were made on whether conventional rapid characterisation methodologies are sufficient to detect contamination and predict successive processability. Repeated use of MCEs seemingly improved recyclate as assessed through melt flow index measurements (50% reduction with each addition) and crystallisation rates from dynamic scanning calorimetry (7 °C drop in crystallisation temperature over 4 cycles). However, when processing these materials under high shear and strain rates, as experienced during injection and stretch blow moulding, crystallisation rates surpass those of non-chain extended PET. Furthermore, repeated recycling of resins containing even single CE additions presented detrimental persistence in the resin - through branched structures and high relaxation times (assessed using rheology and natural draw ratio stretch tests) with MCEs, and drastic colouration (measured using spectrophotometry) with BCEs, which will lead to higher recyclate rejection rates.

Recycled Content as a Driver for Phase Coarsening in Impact Polypropylene

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Research Theme: Polymers and Composites.

Year of Study (Presentation Type): Select one of the following and delete the rest:Year 2 (Talk)

Impact polypropylene (IPP) is widely used in automotive applications due to its high impact strength, yet mechanically recycled polypropylene (PP) typically exhibits values an order of magnitude lower. While contamination and thermo-mechanical degradation are often cited as the primary causes of this reduction, the contribution of phase coarsening leading to the brittle–ductile transition (BDT) has been comparatively understudied. This work examines how phase coarsening affects the impact strength of mechanically recycled IPP and how blending with post-consumer recycled (PCR) PP further modifies this behaviour. Changes in ethylene-propylene rubber (EPR) particle size are correlated with impact performance after several melt-processing conditions, showing that high shear and strain rate extrusion preserves toughness whereas low shear and strain rates average impact strength by ~50%. Introducing PCR progressively decreases impact strength, while increasing the interquartile range by ~300%. Analysis of PCR constituents identifies block copolymer as the primary source of this increased variability, likely due to interactions between blocky chains and the rubbery domains that promote coalescence during processing. Overall, this study clarifies how both processing conditions and heterogeneous PCR components drive phase coarsening in recycled IPP, limiting its ability to match the performance of virgin automotive materials.

All PGRs presenting a talk or poster need to submit their final abstract **via the online form** by **17:00 BST 20th April.** Please save the document title as your year group followed by last & first name: Y_ LASTNAME_FIRSTNAME ABSTRACT. If you have any queries, contact fse.doctoralacademy@manchester.ac.uk

Abstract Template:

Flexible and wearable Ecoflex/CNTs/ melamine foam piezoresistive sensor

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Research Theme: Select one of the following and delete the rest:
Polymers and Composites.

Year of Study (Presentation Type): Select one of the following and delete the rest: Year 2 (Talk)

Flexible sensors have attracted increasing attention due to their important applications in human activity monitoring, medical diagnostics, and human-computer interaction. However, the rational design of low-cost sensors with desirable properties (such as high sensitivity and excellent stability) and scalable applications remains a significant challenge. This study presents a novel, straightforward, and cost-effective dip-coating method for fabricating flexible, wearable piezoresistive sensors based on Ecoflex/carbon nanotube (CNT)/melamine foam (ECM) composites. A key innovation of this work is the use of Ecoflex as a binder and protective layer for the CNTs, effectively addressing the common problem of conductive filler shedding in foam sensors. The micromorphology and performance of the ECM sensor can be tuned by adjusting the Ecoflex to CNT mass ratio and the number of dip-coating cycles. The fabricated sensor exhibits robust mechanical properties, capable of withstanding pressures up to 13 kPa at 70% strain, surpassing that of the original melamine foam. The sensor exhibits excellent piezoresistive properties, including a wide detection range (up to 60% strain and 8 kPa), high strain responsiveness (gauge factor (GF) up to 1.87), and a sensitivity of up to 0.02 kPa^{-1}. Furthermore, the sensor has a fast response time of 140 milliseconds and a relaxation time of 240 milliseconds, enabling stable monitoring of dynamic signals.

ABS-olutely Recyclable: Breaking down polycarbonate blends using Acetolysis

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Research Theme: Polymers and Composites.

Year of Study (Presentation Type): Year 2 (Talk)

Polycarbonate acrylonitrile butadiene styrene (PC/ABS) blends are vital to the automotive and electronic sectors, yet their heterogeneous nature disables recycling, ultimately leading to their disposal via landfilling or incineration. This work proposes a novel method to recycle this material via selective chemical recycling whereby the PC is depolymerised by acetolysis, heating the blend with acetic acid and a basic organocatalyst, leaving the ABS untouched. Optimization on PC feedstocks revealed that successful organocatalysts required not only sufficient basicity but also a basic nitrogen incorporated within an aromatic ring. Consequently, activated pyridines such as 4-dimethyl amino pyridine and 4-pyrrolidinyl pyridine provided exceptional catalytic efficacy. Selective acetolysis was demonstrated on both PC/ABS pellets and a PC/ABS automotive part highlighting its suitability for real-world substrates. Separation of the PC monomers from the ABS was achieved with dialysis, with isolated ABS having similar properties to virgin grades. This approach offers a promising route toward recovering value from recalcitrant PC/ABS blends by enabling selective deconstruction of PC to monomers and recovery of ABS, thereby minimising dependence on virgin plastic production.

M. E. Pool, E. Savage, R. Holland, C. W. Lahive and M. P. Shaver, Chemical Recycling of Polycarbonate Acrylonitrile Butadiene Styrene Blends via Organocatalyzed Acetolysis, *ChemSusChem*, 2026, **19**, e202502161.

Title: Engineering of textile based smart compression systems for sports and medical applications using computer aided design and 3D printing

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Research Theme: Textiles and Apparel
Year of Study (Presentation Type): Year 2 (Talk)

Abstract

Compression textiles are rapidly evolving into a vibrant frontier of research, driven by advances in materials, biomechanics, and digital engineering. These garments rely on precisely tuned pressure gradients that enhance circulation, support muscle performance, and enable therapeutic function. However, reliable methods for compression profiling and real-time pressure monitoring remain limited. This study focuses on the engineering of graphene-based, sensor-integrated compression garments with the help of a mechanised test rig for characterising the performance of the compression garment fabrics and for engineering the full system to deliver accurate pressure gradients. A custom test rig with different 3D-printed radii of curvature was designed for compression profiling, and a 3D-printed limb model was utilised to simulate body contours and enable control measurement of pressure distribution in knitted compression fabrics. In parallel, flexible graphene sensors were fabricated and incorporated to detect pressure changes during wear. Sensor performance was evaluated in terms of sensitivity, stability, repeatability, and response under cyclic loading. Preliminary results show that the 3D-printed rig provides consistent compression profiling across different garment zones, while graphene sensors demonstrate strong potential for real-time pressure sensing with high flexibility and durability. The combined system offers a practical platform for optimising compression garment design and validating pressure performance during use.

Behind the Gift: **Exploring Extended Producer Responsibility as a Mechanism for Fairer and More Circular Charity-Brand Partnerships in the UK Textile Sector**

Charity retailers play a vital yet often overlooked role in the UK's reverse textile supply chain through collecting, sorting, and redistributing donated clothing, preventing large volumes from reaching landfill while also generating social value. Increasingly, brands partner with charities to donate unsold, returned, and take-back textiles, presenting these collaborations as examples of circular practice. However, emerging evidence suggests these relationships can be structurally imbalanced, with charities frequently bearing disproportionate operational and financial responsibilities, particularly when managing growing volumes of low-quality or unsellable textiles. This study examines how forthcoming textile Extended Producer Responsibility (EPR) policy could reshape charity-brand textile donation partnerships in the UK by redistributing costs, accountability, and resources across the system. Adopting a critical realist, qualitative design, the research uses semi-structured interviews with charity and brand representatives, alongside policy and sector experts, supported by document analysis of industry and regulatory materials. A systems-thinking perspective is applied to explore how structural conditions, organisational capabilities, and governance arrangements shape partnership outcomes. The research aims to generate insights into how policy design can support more equitable, transparent, and socially grounded collaboration, positioning charities as essential infrastructure within circular textile systems and informing the development of fairer and more resilient reuse networks.

Tow-Scale Interfacial Toughening of Carbon Fibre Composites through Graphene Nanoplatelets

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Research Theme: Textiles and Apparel.
Year of Study (Presentation Type): Year 2 (Talk)

Abstract:
The effectiveness of carbon fibre-reinforced composites largely depends on the properties of the fibre-matrix interface. To identify the precise interfacial improvement strategy, we examine interfacial properties at both micro- and mesoscales. A single carbon fibre was de-sized with acetone, and FTIR confirmed the removal of commercial-size materials. Graphene-based sizing was applied to both the de-sized single fibre and the as-received carbon fibre to evaluate their mechanical properties. Scanning electron microscopy (SEM) was employed to observe the surface topography of de-sized carbon fibres and the fracture surfaces of the lap in the interfacial region of the fibres. The interfacial properties between the carbon fibre and the matrix were examined at the microscale through the micro-bond test and at the mesoscale via the lap shear strength test. The results showed improved tensile properties in the graphene-coated single fibre. Additionally, there was a significant increase in interfacial shear strength (IFSS). Compared to the epoxy-based lap, the graphene-enhanced lap demonstrated the greatest improvement in IFSS. The interfacial shear strength increased by 43.84% with Levidian GNPs and by 12.01% with XG Sciences GNPs. Fractographic analyses revealed that the transient phenoxy interleaf encouraged microscale crack branching and graphene-induced shear yielding at the epoxy–carbon fibre interface. The resulting morphology-property map provides a predictive framework for incorporating dissolvable graphene–polymer fibres with targeted stiffness, strength, or ductility into next-generation composite toughening architectures.

Abstract:

Title: Spinning Bacterial Cellulose for Next-generation Sustainable Textile Materials in the Fashion Industry

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Textiles and Apparel – Year 2 (Talk)

Global fibre demand continues to rise, with the textile sector remaining heavily dependent on synthetic fibres and cotton, feedstocks associated with significant environmental impacts. Although man-made cellulosic fibres (MMCFs) offer a more sustainable pathway, their reliance on wood pulp introduces further resource constraints. Bacterial cellulose (BC), produced by *Acetobacter xylinus*, provides a renewable, high-purity feedstock with an inherent nanofibrillar structure and high crystallinity, supporting its potential for Lyocell-type MMCF development.

This study establishes a systematic dissolution and wet spinning framework for BC-based Lyocell-type fibres using N-methylmorpholine-N-oxide (NMMO) as solvent. BC with a degree of polymerisation of ~1800 was processed across dope concentrations of 6–12 wt%, with dissolution confirmed by optical microscopy and spinnable processing windows defined through rheological characterisation of the resultant dopes.

Fibre structure and properties were characterised using mechanical testing, TGA, XRD, FTIR, and SEM to elucidate structure–property relationships. Process optimisation, including coagulation bath composition, wet twisting, and post-drawing, will be systematically explored to maximise fibre performance. Overall, this work demonstrates a scalable processing route for BC-derived Lyocell-type fibres, positioning bacterial cellulose as a viable and sustainable feedstock for next-generation apparel applications.

Design and Development of Novel Bioactive Dressing for Controlled Drug Delivery in Advanced Multifunctional Wound Care

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Year of Study (Presentation Type): Year 2 (Talk)

Abstract

Achieving multi-faceted benefits for advanced wound care within a single platform poses a critical challenge. Despite significant advancement, scopes for improving mechanical attributes, wound exudate management, infection control and therapeutic performance as a way to prolonging healing activities still persists. Bio-nano fusion-driven wound dressing presents an advanced area that holds great promise to augment healing applications. To that extent, this study aims to design and fabricate a hierarchical, bi-layered nanofibrous structure engineered from bioactive polymers and therapeutic components. Electrospinning is a well-established nanofabrication technique that offers remarkable control over fibre morphology, producing scaffolds with adequate porosity, fluid absorption capacity and bioactivities mimicking native Extracellular Matrix. Bi-layered configuration ensures spatial separation of functionalities. Bacterial Cellulose-based inner layer features a novel biopolymer-therapeutics combination, promoting biocompatibility, breathability and moist environment essential for effective healing. The outer layer forms a protective interconnected web and assists in addressing some of the inner layer's limitations like rapid drying and lack of antimicrobial properties. The developed scaffold will undergo detailed morphological, mechanical, chemical, thermal and biological assessments including microbicidal activities and drug release kinetics. Collectively, this research aims to establish the feasibility and multifunctionality of a nanofiber-based dressing that paves way for next-generation wound care scaffolds.

Coaxial Electrospinning of PVA/Chitosan

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Research Theme: Textiles and Apparel;

Year of Study (Presentation Type): Select one of the following and delete the rest: Year 2 (Talk),

Abstract body text;
A core–shell nanofiber system was developed via coaxial electrospinning using poly(vinyl alcohol) (PVA) and chitosan to construct a dual-phase drug delivery platform with tunable release behavior. In this study, the configuration was optimized by placing chitosan in the core and PVA/PEO in the shell, significantly improving spinnability and jet stability. The shell solution (10 wt% PVA with 0.5 wt% PEO and 5 vol% ethanol) enabled continuous fiber formation, while the chitosan core (2.0–2.5 wt% in 1.5 vol% acetic acid) provided functional properties for controlled release. Uniform, bead-free nanofibers were successfully obtained under optimized flow rates (0.1/0.1 $mL \cdot h^{-1}$) and voltage conditions.

Post-spinning crosslinking was performed using genipin in phosphate-buffered saline (PBS), resulting in enhanced structural stability and water resistance of the fibers. The formation of a core–shell architecture was confirmed by microscopy, while crosslinking was indicated by characteristic color changes and improved integrity in aqueous environments. The resulting system exhibited a distinct biphasic release profile, with an initial burst release attributed to the hydrophilic PVA shell, followed by sustained release governed by the chitosan core and its crosslinked network.

Overall, this study demonstrates that structural inversion in coaxial electrospinning, combined with genipin crosslinking, provides an effective strategy to tailor fiber morphology, enhance process stability, and regulate drug release kinetics. The developed nanofibrous platform shows strong potential for biomedical applications such as controlled drug delivery and tissue engineering.

Exploring the development of parasocial relationships with AI streamers in Chinese consumers' shopping experience

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Research Theme: Fashion Management and Marketing

Year of Study (Presentation Type): Year 2 (Talk)

Artificial intelligence (AI) streamers are AI-powered, computer-generated livestreamers with human-like attributes that interact with consumers in livestreaming e-commerce. This research aims to explore how Chinese consumers develop and experience parasocial relationships (PSRs) with AI streamers in clothes shopping, and how these evolving relationships affect shopping experience. Advanced digital technologies have promoted the development of AI streamers, particularly in China. They are used by fashion brands to provide reliable, efficient and immersive shopping experiences. However, existing research mainly focuses on how AI streamers' characteristics affect consumer behaviours and attitudes in the fashion context. Very little research considers the development process of the long-term relationship with AI streamers. This limited understanding may undermine consumer engagement and negatively affect the quality of clothing shopping experiences. It is therefore necessary to investigate how consumers develop and maintain PSRs with AI streamers and how PSRs affect the clothing shopping experience. The present study responds to calls for longitudinal research to explore how these relationships develop and the evolution of AI streamer marketing effectiveness. This study adopts a qualitative longitudinal diary-interview approach to contribute new insights to PSR theory exploring how Chinese consumers develop PSRs with AI streamers, and how this affects AI streamer marketing effectiveness.

Engendering Brands: Moral Controversy at the Brand-Gender Nexus

Abstract

Gender-related brand controversies have become increasingly prominent, yet existing research explains them primarily through external social divisions, messaging-practice misalignment, or contradictions arising from brands' deliberate cultural commitments. What remains untheorised is the possibility that controversy may be constitutive of the brand-gender relationship itself — emerging not from strategic missteps but from brands' unavoidable participation in producing gender meanings.

This PhD develops the concept of engendering brands to capture the constitutive entanglement between brands and gender, whereby brands are inescapably embedded in the production and contestation of gender as a normative order. The project comprises three stages. The first stage builds this theoretical framework, arguing that brand-gender entanglement inherently tends toward contentiousness. Second stage introduces the concept of gender normative sensibility — a pre-reflective evaluative disposition shaped by the gender normative order and co-produced through market practices — and uses semi-structured interviews to examine how this sensibility is activated in consumers' moral classification processes. The last stage employs netnography to investigate how collective moral contestation functions to re-stabilise the gender order through boundary work.

Ti-6Al-4V COLD DWELL FATIGUE: EFFECT OF STRESS CONCENTRATIONS AND FATIGUE CRACK GROWTH RATES

E. Lawlor[1*], A. Davis[1], J.Q. da Fonseca[1], B. Dod[2], N. Byres[2]

Dwell fatigue, where the maximum tensile stress is held for a period of time during cycling loading, has been known to cause a significant fatigue life debit in titanium alloys, in particular for aerospace components. Although its effect on crack initiation is well known, it is less clear how this loading regime affects fatigue crack growth rates, with some studies documenting that there is an increased crack growth rate, and others reporting no change or slower crack growth rates. In this study, cross-rolled β-annealed Ti-6Al-4V alloy with a lamellar microstructure was subjected to fatigue crack growth (FCG) experiments under normal cyclic fatigue and dwell fatigue to investigate whether there is any change in the FCG rate under dwell. Additionally, high-resolution digital image correlation (HRDIC) experiments were carried out on notched and pre-cracked microtensile specimens using an automated in-situ mechanical testing rig inside an SEM to study the microplasticity during dwell loading. Slip activity induced by the stress fields at notches and crack tips under normal fatigue cycles were compared to those under dwell fatigue loading. Results from the HRDIC experiments showed significant anisotropy in the slip activity around a notch tip, which was attributed to the crystal orientation of the surrounding grains, despite the presence of the stress concentrator. Additionally, it showed that slip bands that were previously active during normal loading were less active under dwell, and that new slip bands are generated under dwell loading. The implications of these results to crack growth rates and fatigue crack surface appearance are discussed.

Keywords: Dwell fatigue, fatigue crack growth, high-resolution digital image correlation, slip activity.

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Using In-Situ SEM to Characterise the Decomposition of Retained Austenite During Tempering of Low-Alloy Steel

Grace Fidler

Retained austenite (RA) is metastable phase that is known to exist in varying quantities in low alloy steels. Such steels typically undergo an austenitisation, quench and temper heat treatment, where the RA is seen in its highest quantities after the quench. Tempering allows for sufficient carbon migration to facilitate the decomposition of the RA, which has been seen to decompose into a variety of microstructures such as ferrite and carbides, bainite, and martensite. Since the exact decomposition mechanisms for RA are not fully understood in some alloys, and the resulting microstructures are likely to influence mechanical properties, this work uses high temperature scanning electron microscopy (SEM) including electron backscatter diffraction (EBSD) to image RA decomposition during heating. A low-alloy pressure vessel steel is used as a case study. Experiments were conducted that used either secondary electron imaging or EBSD imaging as the primary imaging method in-situ, so that observations of RA behaviour could be drawn from each method, and to contrast the relative advantages and disadvantages of each.

Abstract Template:

Control of Columnar-to-Equiaxed Transition in Aluminum Alloy Additive Manufacturing through Process Parameter Optimization

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Research Theme: Metallurgy and Corrosion

Year of Study (Presentation Type): Year 2 (Talk)

Additive manufacturing of aluminum alloys offers a promising route for fabricating lightweight and complex components, while the resulting microstructure is highly sensitive to process conditions. In my project, the relationship between printing parameters, solidification behavior, and microstructural evolution was systematically investigated, with particular emphasis on the columnar-to-equiaxed transition (CET). By varying key processing parameters, the local thermal gradient, cooling rate, and solidification velocity were modified, which in turn influenced grain morphology and growth mode during deposition. The results show that parameter optimization can effectively alter the balance between columnar and equiaxed grain formation, thereby enabling microstructural tailoring. This study clarifies the role of process-induced thermal history in governing CET in additively manufactured aluminum alloys and provides a theoretical basis for microstructure control and performance improvement in aluminum alloy 3D printing.

Abstract Template:

Lead in Drinking Water: Reducing/Replacing Phosphate Dosing

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Research Theme: Select one of the following and delete the rest:
Metallurgy and Corrosion;

Year of Study (Presentation Type): Year 2 (Talk)

Lead is a proven risk to human health, whilst lead in petrol and paint has all but been eliminated in developed countries, there are still over 14 million lead water pipes conveying drinking water in the USA and UK alone. The associated health risk from pipe corrosion is currently mitigated through the addition of sodium orthophosphate. However, the supply chain of the source phosphorus rock is at risk of disruption and dosing is an increasing operating cost.

Studies of the mechanism of lead pipe corrosion have historically analysed water pipes exhumed from the ground after a minimum of 55 years exposure to varying water quality, whereas this study focusses on the fundamental interaction of lead coupons immersed in a standard reference water to which varying concentrations of sodium orthophosphate has been added and left over an extending timeframe. The corrosion scale formed on the coupons has been analysed using the following techniques: Grazing Incidence X-ray Diffraction. Electrochemical Impedance Spectroscopy and Scanning Electron Microscopy.

Controlling solidification driving force during additive manufacturing

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Research Theme: Select one of the following and delete the rest:
Metallurgy and Corrosion.

Year of Study (Presentation Type): Year 2

Abstract

LPBF scan strategy controls local thermal conditions and thereby governs prior-β morphology, texture, and the inherited room-temperature α microstructure in Ti–6Al–4V. Here, bi-directional scanning and a 45° inclined 90° interlayer rotation strategy were compared using correlative microstructural, textural, and local interlayer thermal analyses. Bi-directional scanning promoted coarse, continuous columnar prior-β grains and stronger regional β texture, whereas the 45° strategy produced a finer, more segmented prior-β structure with reduced regional texture variation. The room-temperature α phase preserved the same regional trend, indicating inheritance from the parent β phase. In addition to lowering α texture intensity, the 45° strategy redistributed the α basal texture maxima, giving a more dispersed and less regionally concentrated off-axis texture response. Thermal simulations further showed that the 45° strategy reduced regional differences in cooling rate and temperature gradient. These results show that scan-path repeatability governs the persistence of directional solidification conditions and thereby controls prior-β anisotropy and its inherited α texture response.

Linking Corrosion Reactions, Hydrogen Embrittlement, and Adsorption to Surface Passive Film Properties.

Dalal A. Ali, Prof. Dirk Engelberg

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Metallurgy and Corrosion

Year 2 (Talk)

Abstract

Hydrogen embrittlement remains a critical degradation mechanism in steels exposed to hydrogen-generating environments, particularly under cathodic polarisation. However, the localised nature of hydrogen evolution and its relationship with microstructural features and passive films are not yet fully understood. In this study, hydrogen evolution on steel and stainless steel surfaces were investigated using *in-situ* optical observation during cathodic polarisation.

Experiments were performed on type 316L austenitic stainless steel, 2205 duplex stainless steel, and 0.8 wt.% carbon steel. An agar gel electrolyte provided a stable, semi-solid medium, enabling direct visualisation of hydrogen gas evolution, including bubble nucleation, growth, and detachment at the metal–electrolyte interface. Surface and microstructural characterisation were conducted using optical microscopy, laser-induced breakdown spectroscopy (LIBS), scanning electron microscopy (SEM) with energy-dispersive X-ray spectroscopy (EDS), electron backscatter diffraction (EBSD), and hardness testing.

Hydrogen gas formation was observed on all materials during cathodic polarisation. For duplex stainless steel and carbon steel, hydrogen evolution occurred at discrete surface locations, which were identified as regions of interest for further investigation. This behaviour may be associated with microstructural features, including the presence of ferritic and austenitic phases, which can introduce variations in electrochemical activity, particularly at phase boundaries. These results indicate that microstructure influences hydrogen evolution under cathodic polarisation and highlight the effectiveness of the *in-situ* gel-based method for investigating local hydrogen generation.

Understanding the hydride distribution in electron-beam welded zirconium

Zirconium is an HCP metal used in the nuclear industry for its low neutron cross-section and acceptable corrosion resistance and thermomechanical properties. Over the life of a component, hydrides will form as a corrosion byproduct. These brittle plates predominantly precipitate along the zirconium basal plane, and therefore the microstructure can be tailored to limit their detrimental effect. However, when the microstructure is disrupted, such as in a weld, this protection is lost. It is therefore crucial to understand how microstructures associated with novel, high-speed welding techniques such as electron-beam welding change the hydride distribution. The postweld blocky alpha, Widmanstätten and precursor microstructures have been investigated and found to show a higher radial hydride fraction than unwelded recrystallised zirconium, with similar hydride distributions in each postweld microstructure.

Nanoindentation of Fusion Steel: Effect of Temperature and Strain Rate

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Research Theme: Metallurgy and Corrosion

Year of Study (Presentation Type): Year 2 (Talk)

Nuclear fusion offers high-density, clean energy, but in the absence of fully functional reactors, computational modelling is essential to study material behaviour under extreme conditions. Nanoindentation provides high-spatial resolution insight into dislocation-mediated deformation, enabling calibration and validation of predictive models for fusion materials design. This project aims to evaluate the microstructure-dependent mechanical response of a model BCC matrix as a function of temperature, strain rate, and irradiation. The objective is to generate robust data by considering effects of crystal orientation, pile-ups/sink-ins and plastic zone. Interstitial-Free (IF) steel was selected to represent a pure iron BCC system. A balance between indent size (25µm diagonal) and grain size (30µm) was observed at 3000nm depth. Orientation studies along and between <001>, <101>, and <111> directions showed minimal hardness variation (± 0.3GPa). Constant strain-rate (CSR) tests on <111> direction between 10^{-3}– $10s^{-1}$ indicated strain-rate insensitivity, while constant load hold (CLH) tests showed no creep for loads of 150–500µN at RT. Etching reduced average pile-up relative to OPS, whereas electropolishing reduced scatter. Edge effects diminished beyond10 – 20x max. depth. Future work involves high-temperature strain-rate testing of irradiated and unirradiated IF and RAFM steels combined with 1D/2D/3D HR-EBSD-based GND mapping to evaluate plastic zone evolution.

Material dissolution in fusion-relevant water environment

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Theme: Metallurgy & Corrosion

Water chemistry in water-cooled nuclear fusion systems has not yet been fully defined, and optimisation of coolant chemistry remains an important challenge. Primary water chemistry analogous to that used in pressurised water reactors is currently considered a candidate reference, where corrosion and dissolution behaviour are strongly influenced by redox potential.

In this study, corrosion experiments were performed on CuCrZr and reduced activation ferritic-martensitic EUROFER-97 steel, candidate materials for divertor and breeder blanket applications. Materials were exposed to high-purity water under controlled redox conditions at elevated temperature and pressure. Results demonstrate a strong dependence of dissolution behaviour on redox conditions. Under reducing and low-oxygen environments, dissolution rates were sufficiently low that conventional gravimetric mass change measurements lacked adequate sensitivity. Under oxidising conditions, significant copper and chromium release into the coolant occurred despite minimal measurable surface mass loss.

To address these limitations, gravimetric measurements were coupled with time-resolved inductively coupled plasma mass spectrometry (ICP-MS) and complemented by oxide characterisation using electron microscopy. Selected results from a custom-built high-temperature, high-pressure recirculating water loop developed in this work are presented.

Towards a Bayesian Tritium Inventory Modelling Framework

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To realise viable fusion power through a deuterium–tritium reaction requires detailed understanding of the processes involved in the generation, recovery and loss of tritium throughout the operational cycle to keep the required tritium inventory as low as possible. An important aspect regarding tritium loss is tritium's likely permeation through and retention within a multitude of metallic components [1, 2, 3]. Specifically, the effect of high energy neutron irradiation on in-vessel components is of particular concern as the capacity for retention dramatically increases with several orders of magnitude within the first stages of neutron induced microstructural damage accumulation [4]. As the microstructural evolution – and therefore the hydrogen retention capability – is highly dependent on the combination of neutron energy, fluence, temperature, local stress state and hydrogen concentration present, an integrated and localised approach is required to estimate the effect of irradiation damage on tritium retention level for specific design configurations.

The challenge for this project lies in combining recent advances in fundamental understanding of the materials-tritium interaction at the atomistic scale, together with a computational framework based upon Markov Chain Monte Carlo approaches underpinned by Bayesian Inference. This approach will allow for high-accuracy descriptions of tritium sequestration in materials will low computational overhead offering significant advantages over current methodologies.

[1] https://doi.org/10.1016/j.jnucmat.2025.155629

[2] https://doi.org/10.1016/j.fusengdes.2024.114438

[3] https://iopscience.iop.org/article/10.1088/1741-4326/ab546e

[4] 10.1016/j.fusengdes.2024.114593

Abstract Template:

Hydrogen trapping and permeation in metallic and ceramic coatings for fusion powerplant applications

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Research Theme: Coating and Ceramics
Year of Study (Presentation Type): Year 2 (Talk)

Nuclear fusion has the potential to be the solution to the world's ever-growing energy needs. The two main fuels that nuclear fusion uses to produce energy are two isotopes of hydrogen: deuterium and tritium. Tritium is highly radioactive, so effectively maintaining tritium inventory will be key to the safe operation of any future fusion power plant. Hydrogen and its isotopes readily diffuse through many structural materials such as steel, so barrier coatings are required to inhibit this. However, little is currently known about the behaviour of tritium in the barrier coatings themselves and in larger coating systems. Therefore, my project seeks to investigate these behaviours and determine the optimum hydrogen barriers for fusion powerplant applications.

Gas-driven permeation experiments have been conducted on both coated and uncoated steel to quantify the effectiveness of barrier coatings. Microstructural characterisation has also been performed, enabling the relationship between micro- structural features and tritium transport behaviour to be examined. These results provide insight into how coating systems and material structure influence hydrogen isotope permeation. The collected experimental data will inform and validate hydrogen isotope trapping and permeation modelling, enabling the prediction of tritium inventory over time.

Environmental degradation of additively manufactured *ABD-900* Ni-based superalloy

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Year of Study (Presentation Type): Year 2 (Talk)

Strong microstructural anisotropy is a typical characteristic of additively manufactured (*AM*) nickel-based superalloys. The unique fabrication strategy, accompanied by an extremely high temperature gradient intrinsic to the *AM* process, inevitably produces a particular microstructure and will influence both high-temperature tensile strength and environmental resistance. In this project, a novel-designed *AM*-built nickel-based superalloy, *ABD-900,* is sectioned horizontally (horizontal-cut, *XY*) and vertically (vertical-cut, *XZ*) to the build direction. The 100 hours of exposure reveal an anisotropic oxidation behaviour. *XY* exhibits a higher mass gain and produces a slightly thicker external oxide scale than chemically identical *XZ*. This anisotropy is shown to originate from differences in grain size, grain-boundary characteristics, and texture between the two sections. Mechanisms of intergranular oxidation hierarchy and crystallographic orientation-dependent oxidation are summarized to rationalize the anisotropic mass gain and scale thickness along two sections. The introduction of microstructure-dependent oxidation highlights the potential of microstructure engineering for an optimised environmental resistance of additively manufactured nickel-based superalloys.

Development of Vitrimer/GNPs Coatings for Corrosion Protection of Magnesium Alloy AZ31

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As the lightest metal structural material in engineering applications, magnesium (Mg) alloys possess the advantages of low density, good vibration damping, and excellent electromagnetic shielding performance, which have wide applications in automotive, aerospace and marine fields. However, the poor corrosion resistance seriously limits their wide application. To address this issue, introducing vitrimers into epoxy nanocomposites coatings to protect Mg alloys represents a new breakthrough. The target coating not only benefits from the excellent corrosion resistance contributed by both epoxy resin and nanofillers but also utilizes the dynamic covalent bonds in vitrimers to achieve self-healing.

This project developed a novel self-healing nanocomposite coating utilizing vitrimer to enhance the long - term corrosion resistance of Mg alloys. By leveraging the reversible dynamic disulfide bonds ($S-S$) within the polymer network, the coating is endowed with intrinsic repair capabilities. Graphene nanoplates (GNPs) were incorporated into epoxy and vitrimer matrices to optimize barrier performance. Electrochemical testing identified 2 wt.% GNP as the optimal loading for maximizing corrosion protection. Notably, the 2 wt.% GNP-vitrimer coating exhibited exceptional self-healing properties; it successfully recovered its protective barrier following scratch damage upon mild thermal treatment, ensuring sustained long-term corrosion resistance.

Phase transition and switching behaviors in $BiFeO_3$-$SrTiO_3$

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Year of Study (Presentation Type): Year 2 (Talk)

BiFeO3−SrTiO3 (BF-ST) solid solutions are promising lead-free materials for high-temperature dielectric applications, as an alternative to lead zirconate titanate (PZT), which contains toxic lead harmful to the environment. This study examines two different ball-milling methods that affect the microstructure, resulting in a reduction of grain size from 3.5µm (LEBM) to 1.7µm (HEBM). Dielectric measurements indicate that the LEBM ceramics at 100 kHz exhibit a sharp, high permittivity (ε_r) of ~2500 and low dielectric loss (tan δ) < 0.1 at the elevated temperature of ~430°C. In contrast, the HEBM ceramics exhibit a more stable, diffuse and frequency-dependent dielectric response with low dielectric loss (tan δ) <0.1 across the measured temperature range up to~ 300 °C. P-E measurements show that the LEBM sample has high polarisation, with a wide, clear hysteresis loop and a maximum polarisation of ~25–28 µC cm^{-2}, indicating ferroelectric-like behaviour. In contrast, HEBM yields a narrow hysteresis loop with a maximum polarisation of ~8–10 µC cm^{-2}, which is indicative of relaxor-like behaviour dominated by polar nanoregions. In situ – synchrotron X-ray diffraction (SXRD) of (LEBM) exhibits an irreversible transition from non-ergodic to long-range ferroelectric response under the applied electric field. The peak $\{222\}_P$ exhibits a maximum electrostrain of ~ 0.20% at 80 kV cm^{-1}, enhanced by ferroelectric domain switching, while ~ 0.08% is exhibited in HEBM at the elevated electric field.

Coating of SiC Fibers via Electrophoretic Deposition and Processing of SiCf/SiC Ceramic Matrix Composites

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Research Theme: Select one of the following and delete the rest:
Coating and Ceramics;

Year of Study (Presentation Type): Select one of the following and delete the rest: Year 2 (Talk)

This study investigates the optimization of electrophoretic deposition (EPD) conditions for depositing hexagonal boron nitride (h-BN) and ytterbium disilicate (YbDS) coatings onto silicon carbide (SiC) fibers for the introduction of pseudo-ductility to the brittle ceramic matrix composites (CMC) processed with polymer impregnation and pyrolysis (PIP) method as well as YbDS coating performance in CMCs during 4-point bending test compared to uncoated CMCs. For h-BN deposition, the optimal condition was identified as 1 hour of EPD at a constant voltage of 5 V using polypyrrole (ppy)-pretreated SiC fibers. In contrast, YbDS deposition was optimized at 5 minutes of EPD under a constant current of 1 mA with the same ppy fiber pre-treatment, giving 300-400 nm of coating. The ppy coating significantly enhanced the surface conductivity of the SiC fibers, resulting in an increase in coating thickness of approximately 100 nm in YbDS coated CMCs. In the 4-point bending tests, YbDS coated fibers induced a pseudo-ductility to the CMCs, changing the fracture behaviour from brittle to ductile. These results demonstrate that fiber surface modification plays a critical role in achieving pseudo-ductility and controllable fracture behaviour under bending loads.

Aerosol deposition (AD) is an advanced coating technique capable of rapidly forming dense ceramic or metallic films at room temperature. Compared with conventional plasma spraying methods, the AD process avoids high-temperature-induced oxidation and grain coarsening, thereby helping preserve the intrinsic properties of materials. In this study, targeting the material requirements of fusion reactor first walls, composite SiC and tungsten coatings were fabricated using the AD technique. By optimizing the powder particle size distribution, carrier gas flow rate, and deposition parameters, a tungsten coating with high density and low porosity was achieved. This work provides a feasible new approach for producing first-wall materials.

Abstract Template:

Distinguishing local deformation responses in ceramic materials using nanoindentation response parameters

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Research Theme: Coating and Ceramics;

Year of Study (Presentation Type): Year 2 (Talk)

Abstract body text:

Linking nanoindentation response to local microstructural heterogeneity remains a key challenge in the mechanical characterization of ceramic materials. In practice, commonly used parameters such as hardness and modulus are often strongly correlated, which reduces contrast in the feature space and makes different local deformation responses difficult to distinguish.

In this work, nanoindentation data from gadolinium zirconate ($Gd_2Zr_2O_7$, GZO) were analysed using multiple parameters derived from the indentation response. Statistical analysis and clustering identified a small group of indents with distinct mechanical behaviour. Further analysis showed that one of the main differences was associated with higher σ values, which reflect strong fluctuations during the loading stage of the indentation response.

A comparison between porous and dense GZO helped clarify this behaviour. High-σ responses were clearly observed in porous samples but largely disappeared in dense samples, suggesting that σ is related to defect- and porosity-induced deformation instability, rather than experimental noise.

These results show that the ability to distinguish local mechanical behaviour depends strongly on the information content of the selected parameters. Not all nanoindentation parameters are equally informative, and σ appears to be a useful indicator of local deformation instability in heterogeneous ceramic materials.

Understanding the Fundamental Degradation Mechanisms of Thermal Barrier Coating Materials under Combined Steam and CMAS Exposure

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Year of Study (Presentation Type): Year 2 (Talk)

Thermal barrier coatings (TBCs) are widely used in gas turbines to protect underlying components from high-temperature gases. One of the major degradation mechanisms of TBCs is attack by CMAS (CaO-MgO-Al_2O_3-SiO_2), which can infiltrate the coating, react with the ceramic material, and damage its microstructure. Gadolinium zirconate (GZO) is considered a promising TBC material because of its good resistance to CMAS attack, mainly through the formation of reaction products that can hinder further penetration. However, in future turbine environments with increased steam content, particularly under hydrogen combustion conditions, the combined effect of CMAS and steam on GZO degradation remains unclear. In this study, CMAS attack on GZO was investigated under both air and steam environments at 1300 °C. The results show that steam changes the composition of CMAS, which in turn modifies key properties such as viscosity and optical basicity, thereby affecting the degradation behaviour of GZO. In dense regions, the reaction layer formed under steam is thinner, indicating that the reduced basicity weakens the reaction intensity. In contrast, in loose and porous regions, the lower viscosity of CMAS under steam promotes faster penetration, leading to deeper infiltration. These results suggest that steam does not simply enhance or suppress CMAS attack uniformly but instead changes the degradation behaviour through its influence on CMAS chemistry and properties.

Changing the Linear Model: A Path to Circular Lab Plastics

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Materials science: polymers

Year 2 (Talk)

Plastics are indispensable in scientific research, providing sterile, durable, and versatile solutions for various applications. However, the widespread use of single-use lab plastics within a linear economic model has resulted in substantial environmental and economic concerns. Research institutions worldwide generate an estimated 5.5 million tonnes of plastic waste annually, contributing significantly to global plastic pollution [1,2]. Despite this, lab plastic waste remains largely uncharacterised, with limited data on its composition and potential for circular reuse. Current disposal methods, including autoclaving and incineration, contribute approximately 550 kg CO2 per tonne of waste, exacerbating environmental impact [3]. Moreover, the classification of lab plastics as hazardous waste due to potential chemical or biological contamination presents a major barrier to mechanical recycling, even for widely recycled polymers such as polyethylene (PE), polypropylene (PP), and polyethylene terephthalate (PET) [4]. Mechanical recycling has the potential to reduce emissions by up to 3.0 tonnes of CO2 per tonne of plastic compared to virgin plastic production [5]. This study aims to address critical knowledge gaps in lab plastic waste properties and decontamination methods, facilitating their integration into existing recycling infrastructure.

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Development of Theoretical and Numerical Models to Expound the Thermal Behaviour of Nanocomposite Phase Change Materials

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Research Theme:
Polymers and Composites.

Year of Study (Presentation Type): Year 2 (Talk)

Phase Change Materials (PCMs) store/release thermal energy as latent heat during phase transitions, enabling high thermal energy storage capacity. As a result, PCMs are promising for thermal energy storage and thermal management applications, including building temperature regulation, battery cooling, and food/drug preservation. However, their practical implementation is limited by low thermal conductivity, which restricts heat transfer within the material. To address this, nanofillers with high intrinsic thermal conductivity, such as Graphene Nanoplatelets (GNPs), can be incorporated to form Nanocomposite PCMs (NCPCMs). A key challenge is maintaining good dispersion stability, as nanofiller sedimentation occurs over time. This study investigates the influence of nanofillers on the thermal behaviour of PCMs, focusing on thermal properties and dispersion stability. In parallel, a PCM-based cooling system for lithium-ion electric vehicle batteries is being developed using Computational Fluid Dynamics (CFD) simulations in ANSYS Fluent. Initial results indicate that a 0.6 mm PCM layer surrounding a prismatic Li-ion cell can reduce the cell temperature by 8.3 °C after 30 minutes of operation, compared to an air-cooled cell, which reaches 40 °C under the same conditions. Further numerical and experimental studies will be conducted to evaluate NCPCMs with enhanced thermal performance and stability. The ultimate aim is to develop a composite PCM suitable for practical thermal management applications.

ELECTRICALLY CONDUCTIVE ADHESIVES BASED ON NANOMATERIALS FOR EFFECTIVE AND SUSTAINABLE JOULE CFRPS BONDING AND SELECTIVE DEBONDING

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Research Theme: Polymers and Composites.

Year of Study (Presentation Type): Year 2 (Talk)

Growing demand for lightweight structures and reduced CO_2 emissions is driving rapid expansion in the use of carbon-fibre-reinforced polymers (CFRPs). Traditionally, reliable bonding between similar and dissimilar materials (metals, CFRPs, etc.) relies on highly crosslinked thermoset structural epoxies, requiring energy-intensive autoclave curing.

Electrically conductive epoxy nanocomposites filled with carbon nanomaterials offer a promising out-of-autoclave (OoA) alternative as they can be effectively used as Joule adhesives. These nanocomposites can convert electrical energy into heat through Joule heating of the electrically conductive, percolating network of nanoparticles in the matrix, leading to effective and complete curing of the bonding areas, hence, efficiently bonding complex geometries while preserving adherend integrity and functionality.

These bonded joints can also be reversibly Joule debonded, allowing for easy deconstruction of the joints for the components reuse, supporting circularity in composite manufacturing.

However, the intrinsic brittleness of structural epoxies limits the joint's toughness, urging for the development of both conductive and toughened nanocomposites which can be used as Joule adhesives. This project studies the influence of adding toughening agents on the electrical conductivity, thermal and mechanical behaviour, and Joule heating performance of epoxy/CNT/GNP nanocomposites, and its effect on their performance as Joule adhesives for adherend bonding and selective debonding.

In my research, I use a variety of polymers and block polymers as additives, for example, PGMA50, PGMA100, PBzMA100, and PGMA100–PBzMA50, for the preparation of perovskite films. The grain sizes and UV images of different films were characterized under various concentrations of polymers and block polymers. The results show that polymers and block polymers can increase the grain size of perovskite films, clarify the grain boundaries, and smooth the film surface, thereby improving film quality. In addition, it was found that the humidity stability of perovskite films improved after the addition of these additives. Perovskite solar cells fabricated with a typical n–i–p structure demonstrate that the incorporation of polymers and block polymers can effectively modulate the photovoltaic parameters of the devices. Among these, the G50 and G100–B50 systems enhance the open-circuit voltage, fill factor, and power conversion efficiency at optimized concentrations, achieving a maximum efficiency of 21.65%.

Self-repairing Electrically Conductive Epoxy/PCL Nanocomposites

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Year of Study (Presentation type): Year 2 (Talk)

Abstract:

Global sustainability goals urge the reuse of composite materials to reduce the volume of composite manufacturing and the amount of composite waste, particularly epoxy-based composites, which cannot be recycled or reprocessed. Thus, there is an increasing interest in developing novel approaches to repair epoxy-based composite materials. Herein, a novel approach to repair electrically conductive epoxy nanocomposites based on Joule heating to promote the melting of an integrated thermoplastic (polycaprolactone (PCL)) 'adhesive' coating is investigated. This method tackles the idea of repairing and reusing an epoxy (nano)composite, also promoting highly localised heating, leading to a great reduction in the energy consumption relative to conventional oven/autoclave heating methods. Upon application of an electrical field through a conductive nanocomposite, the electric current is converted into heat via the Joule heating effect, promoting the PCL coating melting, which flows into cracks, filling and repairing them upon solidification. Electrically conductive epoxy/MWCNTs nanocomposites coated with PCL were broken by flexural tests and repaired by Joule heating. Its repair efficiency is evaluated by comparing its flexural modulus before and after being repaired. This proof-of-concept work will provide the foundation of the repair process of real-life industrial composite components, such as carbon-fibre reinforced plastics (CFRPs).

Title: Investigating the environmental fate and biological impacts of labelled nanoplastics

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Research Theme: Polymers and Composites

Year of Study (Presentation Type): Year 2 (Talk)

Abstract

Growing concerns over plastic pollution increasingly focus on nanoplastics, which have been detected across environmental compartments and may enter the human body. Current toxicological studies predominantly employ spherical polystyrene (PS) nanoparticles as model particles; however, these simplified particles lack environmental representativeness in both morphology and physicochemical properties. This project aims to develop a robust method for producing environmentally relevant polyethylene terephthalate (PET) nanoplastics by integrating mechanical fragmentation, photo-oxidation, and hydrolysis. To date, cryogenic milling parameters have been optimised to enable reproducible production of PET microplastics, while high-energy planetary ball milling has successfully generated nanoplastics with irregular, realistic morphologies. Comprehensive characterisation, including scanning electron microscopy and asymmetric flow field-flow fractionation (AF4), has been conducted to evaluate particle size distribution and structure. Future work will focus on optimising the parameters of milling processes, coupling mechanical and photo/chemical degradation processes to better replicate environmentally aged surface chemistry. Meanwhile, the environmental behaviour of nanoplastics including stability and interaction with contaminants will be investigated. Ultimately, labelled PET nanoplastics will be applied in toxicological studies. By comparing realistic PET nanoplastics with conventional PS models, this work aims to provide a more accurate understanding of the environmental fate and biological impacts of nanoplastics.

Title: 2D Materials Enhanced Self-Reinforced Polymer (SRPs), Bicomponent Sheath and Core Monofilament Composites Applications.

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Supervisor: Prasad Potluri.
Research Theme: Polymers and Composites.
Year of Study (Presentation Type): Year 2 (Presentation).

This work investigates the development of self-reinforced polypropylene (PP) bicomponent core–sheath monofilaments enhanced with two-dimensional (2D) materials to achieve tailored mechanical and thermal performance. Two PP grades with contrasting molecular weights (MFI 6 and MFI 50) were selected to form a mechanically robust core and a processable sheath, respectively. Graphene nanoplatelets (GNP) and hexagonal boron nitride (h-BN) were incorporated at 1 wt.% to explore their distinct interfacial, rheological, and reinforcement effects within a bicomponent architecture.

Material formulations were characterised through melt flow index (MFI), differential scanning calorimetry (DSC), and mechanical testing. Results show that graphene significantly reduces melt flow due to chain immobilisation and network formation, while markedly increasing stiffness, with Young's modulus improvements of up to ~93% observed in low-molecular-weight PP. In contrast, h-BN increases melt flow and exhibits a lubricating effect, improving processability but offering limited mechanical reinforcement. DSC analysis indicates that graphene raises melting onset temperatures, particularly in higher molecular weight PP, suggesting stronger polymer–filler interactions, whereas h-BN slightly reduces melting onset, consistent with weaker interfacial bonding.

Building on these findings, a series of bicomponent core–sheath formulations were designed to isolate the effects of filler placement within the core or sheath. Monofilaments targeting 300 denier are considered for manufacturing and specified for subsequent mechanical, thermal, and fracture analysis, with further evaluation planned at fabric and thermoformed composite levels. The results will demonstrate that strategic placement of 2D materials within a bicomponent filament enables performance tuning, offering a versatile pathway toward lightweight, high-performance PP textiles for applications including automotive, defense, sportswear, and protective materials.

Abstract Template:

Title (Times New Roman Bold, Size 12)

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Research Theme: Select one of the following and delete the rest:
Polymers and Composites.

Year of Study (Presentation Type): Year 2 (Talk)

Single-use items (SUIs) are ubiquitous in healthcare, valued for their role in enabling high-quality care, rapid patient turnover, and cost efficiency. However, their linear production-to-disposal model carries significant environmental consequences that can no longer be overlooked. Rather than advocating for an outright ban, this project seeks a more sustainable middle ground, one that maintains clinical standards while meaningfully reducing the environmental impact of the material used in healthcare. This will be achieved through intervention points via reduction, reuse, and recycling, which this talk explores.

To identify where interventions will be most effective, a material flow assessment and environmental impact assessment were conducted in parallel. The findings challenge a common assumption in waste reduction efforts: that mass throughput should be the primary target. Instead, the results indicate that environmental impact is a more meaningful metric for prioritising action. The assessments also revealed opportunities for direct material reduction and identified clusters of items with similar compositions, enabling targeted recycling trials. Beyond material-level findings, the assessments prompted a broader investigation into systemic environmental impact, the results of which have informed the introduction of procurement-level interventions.

All PGRs presenting a talk or poster need to submit their final abstract **via the online form** by **17:00 BST 20th April.** Please save the document title as your year group followed by last & first name: Y_ LASTNAME_FIRSTNAME ABSTRACT. If you have any queries, contact fse.doctoralacademy@manchester.ac.uk

Understanding how metallic structures respond to energy imparted by high-power lasers is of growing importance across many scientific fields. A crucial aspect of this is developing predictive tools that can accurately model these interactions. One of the main challenges for modelling this interaction is the design of experimental setups to capture the complex processes that take place as metal melts and evaporates under rapid transient heating. This difficulty becomes even more substantial when considering the effects of surface conditions and coatings, both of which play a vital role in practical applications. This project aims to further the understanding of the interaction of high-powered lasers with a range of technologically relevant alloys, including steel and aluminium alloys, surface finishes and coatings. Novel instrumentation has been employed to measure key properties (such as burn-through time) during trials at the high-power laser facilities in Manchester for 316 L Stainless Steel and 2024-T3 Aluminium. Use of various devices (such as an oscillating vessel viscometer or a differential scanning calorimeter) to determine the temperature dependence of fundamental thermophysical properties of 2024-T3 Aluminium is currently being conducted at NPL with samples produced at Manchester. These measurements (both for thermophysical properties and from laser trial data) will be used to inform and improve models under development at Manchester to enable more reliable predictions of the effect of laser-based energy on metallic structures.

The Effect of Surface Preparation and Temperature on the Oxidation of Alloy 800HT in an Impure Helium Environment

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Research Theme: Metallurgy and Corrosion;

Year of Study (Presentation Type): Year 2 (Talk)

High-temperature gas-cooled reactors (HTGRs) employ helium as a coolant, introducing unique challenges compared with advanced gas-cooled reactors (AGRs). This study investigates the oxidation behaviour of Alloy 800HT under simulated HTGR conditions in impure helium at 1 bar, containing CO, CO_2, O_2, CH_4, H_2O and H_2. Tests were conducted at 700 °C, 800 °C 900°C for up to 300 h, revealing a strong influence of surface preparation on oxide stability. Ground surfaces promoted the formation of a thin, protective chromia layer, whereas Oxide Polishing Suspension (OPS) surfaces developed a non-protective duplex oxide. Subsurface observations showed oxide instability, Diffusion-Induced Grain Boundary Migration (DIGM), and Preferential Internal Oxidation (PIO) under prolonged exposure. Deep, penetrating PIO was observed along susceptible high-angle grain boundaries, while Σ3 boundaries remained largely inert. The boundary-selective oxidation behaviour exhibits phenomenological similarities to intergranular oxidation reported for Alloy 600 in hydrogenated steam environments, although the mechanistic implications in helium remain to be established. The implications of boundary-connected PIO for long-term structural integrity in HTGR components are discussed.

An integrated computational risk assessment for fusion materials

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Research Theme: Metallurgy and Corrosion

Year of Study (Presentation Type): Year 2 (Talk)

Computational modelling of material deformation is essential for component validation in nuclear fusion applications due to the absence of a fully operational fusion power plant. Crystal plasticity modelling is widely used to simulate metallic microstructure evolution and accounts for material responses caused by mechanical, thermal, and damage effects. Microstructure responses vary depending on the constitutive and hardening laws used to construct a crystal plasticity model, and this variation subsequently leads to different predictions of failure. A comparison between predictions of empirical and physics-based models can therefore determine whether using a more computationally expensive model is justified. In this study, a machine learning-Bayesian inference procedure was employed to calibrate two crystal plasticity models in DAMASK to stress-strain responses of single crystal copper under uniaxial tension. The single crystal parameter sets were then used to simulate deformation of a rolled copper polycrystalline microstructure, with the calibration procedure repeated to identify whether the original parameter sets could be recovered. This study concluded with a comparison of the strain localisation, stress triaxiality, and misorientation predictions from both crystal plasticity models. Future work will focus on developing a framework to determine risk of failure probabilities, agnostic of the material and crystal plasticity model under consideration.

Understanding the Impacts of Irradiation Environment on the Corrosion of Zirconium Cladding Alloys

The oxidation of zirconium cladding alloys is an important process to understand for the efficiency and safety of operating pressurized water reactors (PWRs). Due to difficulties in obtaining samples from reactors, the oxidation process has mainly been studied in autoclaves on both non-irradiated and pre-irradiated samples. It is unclear how the environment inside a PWR impacts the features of the oxidation process described in these autoclave studies. Using samples corroded in the Vogtle Nuclear Power Plant along side pre-irradiated and non-irradiated autoclave samples, we aim to deconvolute these environmental effects to contextualize previous results and better understand the applicability of previous corrosion studies to cladding material in PWRs. A FIB-SEM volume of a nodular oxide feature from a non-irradiated sample corroded in an autoclave will be discussed to illustrate features of interest and planned analysis techniques. Current work on an autoclave study of neutron irradiated material and analysis of Vogtle samples will also be presented and lead into the key questions we plan to answer during this project.

Title: Atomistic Modelling of Hydrogen Isotopes and their interaction with the structural materials in a Fusion Power Plant Environment.

Authors: William Rudrum (UoM), Prof Phil Edmondson (UoM), Dr Eduardo Garciadeigo-Ortega (UKAEA), Dr Duc Nygen (UKAEA), Dr Prashanth Srinivasan (UKAEA).

The future of nuclear energy production appears likely to include a significant component of energy generated through nuclear fusion. For planned deuterium-tritium fuelled reactors a major obstacle is the scarcity of tritium and how difficult it can be to work with. The solution to this is a breeder blanket. A breeder blanket utilises neutrons emitted from the reactor core to split lithium-6 into helium and tritium. One design uses liquid lithium contained inside the walls of the blanket with various Iron alloys (steels) and vanadium currently considered prime candidates for structural materials of the blanket. This work investigates the retention and transport of tritium at the breeder blanket interfaces with the structural materials looking at the permeability (solubility and diffusion) of Hydrogen isotopes through BCC Iron. This has been modelled using Modified Embedded Atom Method (MEAM) interatomic potentials and Molecular dynamics (LAMMPS) to create atomistic simulations, to explore if the isotope effect has a significant impact on diffusion simulations at these temperatures or if tritium can be adequately modelled using existing potentials designed to model protium.

Understanding Performance in Co and Fe-based Alloys under Nuclear Plant-Relevant Conditions

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Research Theme:
Metallurgy and Corrosion;

Year of Study (Presentation Type): Year 2 (Talk)

Hardfacing cobalt-based alloys are used throughout the primary cooling loop of pressurised water reactors (PWRs) due to their exceptional corrosion and wear resistance. However, the activation of wear debris to form Co-60 in the reactor core leads to increased radiation levels throughout the cooling loop, leading to a search for alternative materials. Iron-based hardfacings are a promising option, due to a lack of dangerous radioisotopes and already being used throughout the plant due to their good corrosion resistance.
This project aims to investigate and compare the behaviour of existing cobalt- and iron-based hardfacing alloys in a high-pressure, high-temperature environment simulating that of the primary cooling loop of a PWR. The current work looks to investigate the effect of surface oxides on mechanical wear rate and aims to build up an empirical wear rate equation for the different alloys with different surface preparation and environmental conditions, so that their overall behaviour in the PWR environment can be better understood.
The wear rate of the alloys was quantified using measurements of the wear track obtained using laser scanning confocal microscopy, as well as a qualitative determination of wear behaviour using the coefficient of friction, obtained through torque measurements.

Effect of residual stress on deuterium permeability in tungsten

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Research Theme:
Metallurgy and Corrosion;

Year of Study (Presentation Type): Year 2 (Talk)

Abstract body text;

The understanding of hydrogen isotope permeation is critical to evaluate the loss of tritium within reactor materials to improve fuel management. It is well known that defects generated during irradiation are trapping sites for hydrogen isotopes. However, the effect on permeability is uncertain where in tungsten, defects were reported to have no significant change in permeability [1] or the inverse after irradiation with D_2^+ or C^+ ions [2].

Preliminary experiments have been performed on nickel – a known permeator – to investigate the effect of residual stress on permeability. Nickel samples were polished to produce higher (P1200) and lower (1µm) residual stress samples. Then deuterium was permeated through and indicated that a higher residual stress decreases permeability. X-ray diffraction (XRD) using the $\sin^2\psi$ method was used to measure high angle peaks and calculate the residual stress from the crystalline d-spacing.

From these preliminary experiments, it demonstrates that residual stress influences permeation. Surface modification such as ion irradiation and polishing can be used to introduce residual stress by microstructural evolution and then characterised using XRD. The aim is to repeat this study with the same modification methods to compare nickel with tungsten that has been ion-irradiated at the Dalton Cumbria Facility.

[1] F. Liu et al., J. Nucl. Mater. 542, 152455, Dec. 2020
[2] Y. Oya et al., J. Nucl. Sci. Technol. 53(3), 402–405, Mar. 2016

Modelling Magnetohydrodynamic Effects on
Dendritic Solidification during Additive Manufacturing Processes

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Research Theme: Metallurgy and Corrosion

Year of Study (Presentation Type): Year 2 (Talk)

The construction of a fusion reactor will require the joining or additive manufacture (AM) of alloys to create high-integrity components, which must have the required mechanical properties to keep the plant safe. The evolution of metallic substrates during such processes is governed by the strongly coupled non-linear heat, mass and electromagnetic transport phenomena. Current numerical approaches to predict the magneto-thermo-hydrodynamic (MTHD) behaviour of such systems are typically limited to single phases with weak electromagnetic property contrast, while experimental studies are often very expensive, time-consuming and impractical due to the extreme thermal and electromagnetic gradients involved. These gradients drive complex flow phenomena that strongly influence the evolution of the microstructure during dendritic solidification.

This work presents a high-fidelity numerical framework used to investigate the role of flow and electromagnetic effects on dendrite morphology in fusion steels. The model captures the full effects of fluid dynamics, including turbulence development, magnetic-induction dynamics, heat transfer and solidification. Simulations of liquid steel with applied flow and varying magnetic field strengths show that stronger magnetic fields dampen fluid motion, leading to more vertical dendrite growth. Weaker magnetic fields result in greater lateral growth due to stronger convection near the solidification front.

Fuel Retention and Release Mechanisms in Breeder Blanket Materials for Nuclear Fusion Devices

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Research Theme: Imaging and Characterisation

Year of Study (Presentation Type): Year 2 (Talk)

As global energy demands continue to rise and concerns over climate change intensify, developing a clean and sustainable primary energy source has become increasingly critical. By emulating the fusion processes that sustain the sun, nuclear fusion promises a virtually limitless and sustainable energy solution. Current fusion reactor designs rely on breeder blanket and fuel cycle (BBFC) technologies to generate, store, and supply tritium, a hydrogen isotope used in the fusion process. However, tritium can diffuse into surrounding structural materials within BBFC systems, potentially becoming trapped, weakening mechanical properties through hydrogen embrittlement, and reducing fuel cycle efficiency. This research investigates the release and retention behaviour of tritium in candidate breeder blanket structural materials, and how extreme reactor conditions, such as neutron irradiation, and high temperatures, influence these mechanisms. Gr.91 creep-resistant steel and other reactor relevant materials, such as CuCrZr, were exposed to deuterium, a tritium proxy, via electrochemical charging and will be compared to future exposures using gas loading via a gas-driven permeation system (GDPS) and plasma ion exposure charging using DELPHI-II. The trapping behaviour of deuterium is primarily investigated using NanoSIMS and electron microscopy, with further characterisation to be conducted using Thermal Desorption Spectroscopy (TDS). NanoSIMS, a high-resolution imaging technique, enables nanometre-scale surface mapping of light elements and reveals how deuterium distribution correlates with microstructural features before and after in-operando exposures.

Hyperspectral Radiographic Imaging Using a HEXITEC 6×2 Detector for Material Characterisation

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Research Theme: Imaging and Characterisation.
Year of Study (Presentation Type): Year 2 (Talk).

Hyperspectral X-ray imaging enables the simultaneous acquisition of spatial and spectral information by measuring the energy of individual X-ray photons. Compared with conventional energy-integrating detectors, photon-counting spectral detectors provide enhanced material discrimination through energy-resolved imaging. This work investigates the application of hyperspectral radiographic imaging using a HEXITEC 6×2 detector system for spectral characterisation of materials.

Radiographic measurements were performed using a HEXITEC 6×2 hyperspectral detector capable of recording energy-resolved photon events across multiple spectral channels. A calibration phantom containing materials with different attenuation properties was scanned to evaluate the detector's spectral response and imaging performance. Detected photon events were sorted into discrete energy bins to generate energy-resolved radiographic images, enabling the investigation of material-dependent attenuation behaviour across different energy channels.

Preliminary results demonstrate that the hyperspectral detector can distinguish materials based on differences in their spectral signatures within the radiographic images. Variations in attenuation across energy channels provide additional contrast compared with conventional single-energy radiography. These findings highlight the potential of hyperspectral photon-counting detectors for enhanced material discrimination and spectral imaging applications, contributing to the development of colour X-ray imaging techniques.

Characterising Texture Variation in Cross Rolled and Super Plastically Formed Ti64.

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Research Theme: Imaging and Characterisation.
Year of Study (Presentation Type): Year 2 (Talk)

The safety and reliability of components made from cross-rolled and super plastically formed Ti64 material is of great importance to the reputation of manufacturers and the aerospace industry as a whole. It has previously been determined that microtextured regions (MTRs) occur within Ti64 material after processing [1], and that MTRs influence crack propagation [2], and the fatigue initiation time in this material [3], therefore influencing the predicted lifetime of those components. The overall aim of the project is to determine to what extent the microtexture of Ti64 affects the growth rate of fatigue cracks, especially in material that has been rolled and super-plastically formed.

The first step in achieving this project aim is to characterise the material microtexture. EBSD (electron backscatter diffraction) mapping of the material surfaces along the rolling directions, and normal direction of samples was conducted. The samples studied were cut from cross-rolled and super plastically formed materials supplied by Rolls Royce. The resultant data was computationally analysed to determine the textures present, the variation of texture intensity, and the presence of macrozones in these samples. The textures were represented through IPF (inverse pole figure) maps and quantified using PF (pole figures).

This work also establishes the methodology used to characterise regions of strong microtexture interest that will be investigated later in this project, using fractography and high-resolution digital image correlation.

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Abstract Template:

Microstructural evolution and defect formation in aluminium alloy 4043 during molten metal deposition

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Research Theme: Imaging and Characterisation

Year of Study (Presentation Type): Year 2 (Talk)

Abstract body text:

Molten metal deposition (MMD) offers promising approach to metal additive manufacturing due to its relatively low and controllable cooling rates compared with laser- or arc-based processes. Most investigations related to MMD remain as simulation studies while microstructural and defect-based studies remain limited. The microstructural and porosity details of molten metal deposited aluminium alloy 4043 reveal a direct correlation between grain size and defects, indicating that smaller grain sizes are associated with lower defects content. High substrate temperatures (500–530°C) and higher energy input result in reduced cooling rate, thereby increasing grain size and defect levels. When overall optimising is considered, lowering substrate temperature and energy input to increase cooling rate enable to produce specimens with finer grain structures and fewer defects.

Resolving the Incommensurately Modulated Structure of Labradorite by 3D ED Tomography

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Research Theme: Imaging and Characterisation

Year of Study (Presentation Type): Year 2 (Talk)

Plagioclase feldspars are among the most abundant minerals in Earth's crust, with labradorite ($An_{50–70}$) distinguished by an incommensurately modulated structure characterised by satellite (*e*-) reflections. This structural complexity arises from mutually incompatible Al–Si and Ca–Na ordering of the albite and anorthite end-members, requiring a (3+1)-dimensional superspace description [1, 2]. Despite decades of study using bulk single-crystal X-ray and neutron diffraction, the structure of individual nanoscale Bøggild intergrowth lamellae has never been solved *ab initio* from a single domain [3, 4], leaving composition–modulation–cooling history relationships poorly constrained.

This study applies 3D electron diffraction (3D ED) tomography to natural labradorite to solve both the average and modulated structure from individual Bøggild lamellae. Continuous-rotation data were collected on a ThermoFisher Talos 200X equipped with a Quantum Detectors Merlin hybrid pixel detector. Data will be processed in PETS2 [5], with *ab initio* structure solution via charge-flipping in SUPERFLIP/Jana2020 [6], complemented by 3D-ΔPDF analysis for short-range order characterisation.

This work will establish 3D ED as a viable approach for single-lamella structure determination of incommensurately modulated minerals, providing structural constraints relevant to plagioclase geothermometry in planetary science.

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Visualization of interface evolution in solid-state batteries using in-situ electron microscopy

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Research Theme: Imaging and Characterisation

Year of Study (Presentation Type): Year 2 (Talk)

Abstract:
Solid-state batteries (SSBs) have potential for future batteries compared with liquid-based batteries due to their higher energy density and improved safety. However, interfacial instability and unfavorable contact of multiple interfaces inside batteries will markedly restrict further application of SSBs. As a powerful characterization tool, electron microscope (EM) makes it possible to visualize the evolution of interfaces in SSBs during electrochemical cycling. Its superior resolution allows direct imaging of the solid-solid interfaces and track pathways of ionic diffusion and structural degradation at the atomic level. Furthermore, suitable in-situ EM techniques could be employed to image these progresses dynamically, which could also possibly provide significant insights that will be applied to enhance the battery performance and lifetimes. Therefore, this project will utilize advanced scanning electron microscope (SEM) and transmission electron microscope (TEM) to focus on the connection between the interfacial evolution and electrochemical properties of SSBs systems. The microscopic visualization is expected to complement other macroscopic characterization to more accurately elucidate the evolution mechanisms.

Synthesis & Characterization of a High Entropy Lanthanide Oxyselenide

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Research Theme: Nano and Functional Materials

Year of Study (Presentation Type): Year 2 (Talk)

Lanthanide oxychalcogenides (Ln_2O_2X, where X = S, Se or Te) have a proven track record of possessing interesting optical, electric and magnetic properties. Their high entropy analogues have further demonstrated the ability to tune these properties depending on the composition. However, while high-entropy oxysulfides are now well-established, the synthesis of lanthanide oxyselenides has been hindered by laborious experimental procedures. Here, we present a new family of lanthanide selenourea precursor complexes, **$Ln(NaphtC(O)NC(Se)NEt_2)_3(phen)$** [where Ln = Pr, Nd, Gd, Dy, Er; phen = 1,10-phenanthroline], which function as previously unreported single-source precursors (SSPs) for the direct synthesis of lanthanide oxyselenides. We characterize these precursors with single crystal x-ray diffraction (XRD), elemental analysis and TGA- the latter revealed a clean decomposition pathway leading to oxyselenide formation. The precursor powders are mixed and structural characterisation of the oxyselenide products from solventless thermolysis is achieved using powder XRD. Subsequent Rietveld refinement indicates formation of a single-phase *Ia-3* structure. Electron diffraction and high-resolution TEM further confirm crystallinity, while SEM-EDS and STEM-EDS mapping demonstrate compositional homogeneity down to the nanoscale. This work establishes a versatile precursor platform for lanthanide oxyselenides and provides the first accessible, precursor-driven route to lanthanide oxyselenides- high entropy or otherwise.

A Durable Wick-Assisted Solar Evaporator Based on MWCNT/Eco-flex Coated Melamine Foam for Long-Term Seawater Desalination

Abstract

Water shortage is a significant global issue intensified by climate change and rising demand. Solar steam generation has arisen as a sustainable and energy-efficient method for desalination, utilising solar energy to generate freshwater. Interfacial Solar Steam Generation (ISSG) has exhibited significant potential by improving evaporation efficiency with enhanced photothermal materials. In this study, an ISSG system based on melamine foam (MF) was developed. This substrate was coated with a multi-walled carbon nanotube (MWCNT)/Eco-flex photothermal layer to achieve efficient and stable desalination. To ensure ongoing capillary water flow, a thin Eco-flex network is used to immobilise the MWCNTs while maintaining the porous nature of MF. A wettability gradient is created to control water flow and guide salt crystallisation toward the edges by combining a suspended wick supply configuration with a hydrophilic periphery area. This efficiently reduces salt buildup and preserves a clean evaporation interface. The system demonstrates stable evaporation under solar irradiation and enables reversible salt dissolution during dark conditions, indicating effective self-cleaning capability. In order to address issues like salt deposition and long-term stability, this work emphasises the significance of combining material design with structural engineering. The suggested approach offers more promise for wastewater

treatment and oil-water separation applications, as well as a scalable route for solar-powered desalination.

Complex mixtures of organic semiconductors for new optoelectronic devices

To limit the effects of global warming and climate change, new materials for green energy generation, storage, and usage must be developed. Organic semiconductors (OSCs) are promising candidates because of their tunability, mechanical flexibility, and solution processability, which enable device fabrication with lower energy costs compared to conventional inorganic silicon semiconductors. Blending different OSCs has already been shown to enhance device performance, increasing stability and efficiency. In this work, the concept of OSC blending is extended to high-entropy materials, which are systems composed of five or more individual components combined to form a single phase which possess new properties. Blends containing five OSCs, selected from a library of eight commonly used in organic photovoltaic devices (OPVs), were prepared. Their morphology and structure were investigated using grazing-incidence wide-angle X-ray scattering. Three distinct morphologies were identified: an amorphous phase, a fully crystalline phase, and a mixed phase in which π–π stacking is preserved. Maintaining π–π stacking is particularly important, as it is crucial for efficient charge transport in OSC-based devices. Further work is being done to produce devices based on these blends.

Carbon-Silica Hybrid Nanomaterials: Synthesis and Structural Characterization

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Hybrid carbon-silica nanomaterials have drawn significant interest due to their ability to combine the synergistic benefits of silica and carbon inside a single ordered porous framework. These materials combine the large surface area, adjustable pore architecture, and chemical adaptability of silica with the electrical conductivity, mechanical robustness, and thermal resilience of carbon, leading to applications in catalysis, adsorption, energy storage, and sophisticated polymer composites. The surfactant aided sol-gel synthesis, especially with SBA type mesostructures, enables precise control of three-dimensional pore architecture via the cooperative self-assembly of triblock copolymeric surfactants, silica precursors, and carbon sources. The removal of the template followed by controlled carbonization produces well-structured carbon-silica hybrids. The temperature of carbonization dictates the degree of graphitization thus results partly graphitized carbon-silica nanoscale hybrid with tunable surface functionalities. Detailed spectroscopic, microscopic, and physical characterization provides insight into the morphology, porosity, and interfacial interactions. These synthesis driven structure-property relationships highlight the potential of carbon-silica hybrid nanofillers for high performance elastomeric and polymer composite applications.

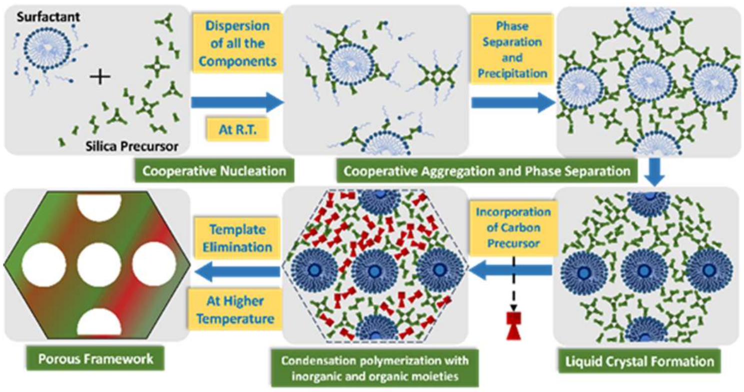

Figure 1: Schematic route of synthesis of hybrid carbon-silica nanomaterials via self-assembly method

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Plasmonic Diborides and Ultrathin Gold Films: Materials, Fabrication, and Mechanisms

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Research Theme: Nano and Functional Materials
Year of Study: Year 2

Plasmonic nanostructures provide a promising candidate to manipulate light-matter interactions through strong light confinement, hot carrier generation, and local electric field enhancement. My research focuses on plasmonics-driven photocatalysis and material fabrication, particularly focusing on binary metal diborides and ultrathin gold films fabrication.

One part of this work investigates plasmonic magnesium and aluminum diboride–based photoanodes for solar-driven water splitting. We demonstrated efficient photocatalytic activity across the solar spectrum and achieved current densities of several mA cm^{-2} at low applied bias on the platform of MgB_2- and AlB_2-based metamaterials combined with suitable cocatalysts. So far, three studies on plasmonic diboride photocatalysts have been completed, one of which has been published, while two further manuscripts are currently in preparation. These results stress the importance of localized surface plasmon resonances, strong internal electric fields, and charge separation in enhancing photocatalytic performance.

In parallel, I am exploring the fabrication of continuous ultrathin gold films (<4 nm) as plasmonic platforms. While optical characterization confirms the formation of ultrathin Au films on the millimeter scale, significant challenges remain in achieving large-area continuity due to mechanical instability and transfer-induced damage.

Finally, ongoing work aims to clarify the mechanism of plasmon-enhanced water splitting by decoupling electric-field effects from electrochemical contributions, using Au–Al_2O_3–Au capacitor-like structures under applied bias. Although photocurrent and bubble formation are observed under illumination, the exact catalytic origin remains under investigation.

High Entropy 2D Materials for Efficient Water Splitting

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Research Theme: Nano and Functional Materials

Year of Study (Presentation Type): Year 2 (Talk)

The global shift toward renewable energy demands efficient and sustainable hydrogen production technologies. Electrochemical water splitting offers one of the most promising routes for green hydrogen generation, yet its widespread usage is hindered by conventional noble metal-based electrocatalysts. Thus, the development of highly active, stable, and cost-effective electrocatalysts remains a critical challenge. In this context, two-dimensional (2D) high-entropy transition metal dichalcogenides (TMDCs) have emerged as promising alternatives, offering tunable properties owing to their abundant active sites and multi-elemental compositions. Furthermore, partial substitution of S with Se modifies the electronic structure and enhances charge transfer properties, thereby further improving the electrocatalytic activity of these systems.

This study focuses on the synthesis and characterization of 2D high-entropy TMDCs. As a preliminary study, a series of single-source precursors (SSPs) was synthesized to produce a high-entropy material (HEM), namely $(MoWReCrMn)S_2$. The SSPs were characterized by elemental analysis (EA) and thermogravimetric analysis (TGA), while the HEM was analysed by XRD, SEM-EDS, and Raman spectroscopy. Results confirmed that high-purity SSPs can be successfully synthesized. Characterization of the HEM revealed the formation of Mo-based phases and a homogeneous elemental distribution throughout the material.

Colloidal Quantum Dots Doped by Single Rare Earth Ions for Quantum Memories and Repeaters

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Research Theme: Nano and Functional Materials.

Year of Study (Presentation Type): Year 2 (Talk)

Singly doped colloidal quantum dots (CQDs) are promising spin-photon interfaces for quantum repeaters and memories for several reasons: the dopant spin couples with an exciton in the CQD via an exchange interaction, resulting in a significantly larger optical cross-section than isolated ions; established CQD synthesis techniques can create a low-spin environment that enhances the dopant spin lifetime; and CQDs' substrate-free nature allows easier integration into photonic structures such as nano-antenna and micro-cavities.

A significant challenge has been the stochastic nature of the doping processes that makes it difficult to achieve reliable single doping and to position the single dopant centrally in the CQD. A recent project demonstrated that CQD growth from a singly doped molecular cluster could solve these problems for doping with Mn^{2+} ions. However, the milli-second spin lifetimes needed for long-range quantum repeaters require rare earth dopants like Pr^{3+} or Er^{3+}.

This project focuses on the fabrication of single rare-earth-doped yttrium oxide materials, selected for their excellent thermal stability and favorable optical properties. A molecular seeding approach will be employed to precisely control dopant incorporation. The aim is to achieve photoluminescence emission in the 1.5–1.6 μm spectral range, targeting applications in quantum communication. Structural and optical characterization will be performed using TEM, SEM, XRD, and fluorescence spectroscopy to evaluate crystallinity, morphology, and emission properties.

In vitro characterisation of human mesenchymal stem cell responses against the predicted electric field properties during static capacitive electrical stimulation

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Research Theme: Biomaterials
Year of Study (Presentation Type): Year 2 (Talk)

Bone is the second most transplanted tissue worldwide, with over 2.2 million grafting procedures performed annually. Autografts are the trusted gold standard solution, yet their limited availability and potential donor-site morbidity drive the need for further regenerative strategies. Capacitive electrical stimulation (CES) is a promising tool for promoting bone formation; however, the translation of the technique requires further characterisation. This research aims to study wide-ranging cellular responses in vitro of human mesenchymal stem cells (hMSCs) under direct current (DC) CES in a custom-designed bioreactor (BR).

To deliver CES, polytetrafluoroethylene 24-well BRs were manufactured. The electric field (EF) was modelled through the electrostatic interface in COMSOL Multiphysics®. The presence and magnitude of the static EF were verified with an electrostatic field meter. The influence of CES on hMSCs cultured on glass coverslips was assessed at 200 mV/mm through metabolic activity, DNA quantification, Live/Dead staining, scratch assay in perpendicular and parallel directions relative to the EF, immunofluorescent staining for proliferation, morphology, and osteogenesis, as well as qRT-PCR for the detection of osteogenic genes.

Finite element analysis revealed the non-uniform distribution of electric field strength (EFS) as well as the linear relationship between the supplied electric potential and resultant EFS. There were no significant differences in metabolic activity and DNA count between non-stimulated and stimulated groups. Furthermore, the tested EFS regimes maintained high viability regardless of their non-uniform distribution, and the migration speed of hMSCs was observed to be unaffected. Moreover, induction of osteogenesis of hMSCs under CES has been shown in our group on conductive titanium disks, and it is hypothesised that CES will also promote osteogenesis on non-conductive glass coverslips.

This research establishes the study of osteogenic differentiation of hMSCs more accurately under DC CES. Additionally, this innovative method promotes osteogenic differentiation of hMSCs without detrimental side effects.

Tough and stiff injectable gels from inter-linked microgels

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Research Theme: Biomaterials;

Year of Study (Presentation Type): Year 2 (Talk)

In order to realise the great promise of injectable gels for rapid, surgery-free tissue repair, there is an urgent need for new systems with high-performance mechanical properties. Due to their excellent compressibility, previously developed injectable double-crosslinked microgel (DXMG) gels have been used to repair damaged intervertebral discs. However, stretchable DXMG systems have not yet been reported. Here, we report for the first time the successful development of a stretchable DXMG based on anionic microgels. Building on our previous DXMG platform, this project aims to create new DXMGs with stretchable properties that meet or exceed the mechanical performance of conventional (non-injectable) double network (DN) hydrogels, while maintaining compressive properties comparable to or superior to those of previously reported injectable DXMGs. The new approach proposed in this work enables the creation of DXMGs with mechanical properties not currently achievable in injectable gel systems. This establishes a new platform for injectable DXMGs with enhanced mechanical properties, offering significant potential for cartilage repair applications.

A photosynthetic microneedle patch with *in-situ* oxygenation to enhance catalytic activity of non-releasing nanozyme for hypoxic diabetic wound healing

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Research Theme: Select one of the following and delete the rest:
Biomaterials;

Year of Study (Presentation Type): Year 2 (Talk)

Diabetic wounds are a prevalent and challenging complication of diabetes. Hypoxia and persistent hyperglycaemia act as major barriers to effective wound healing. Although glucose oxidase (GOx)–catalase (CAT) cascade nanozyme systems have shown promise for glucose regulation, the release of nanozymes into wound sites raises significant biosafety concerns. Herein, a multifunctional living microneedle (CGMNs) patch embedding nanozyme-functionalized *Chlorella vulgaris* (Cv@PLL-MCG) within a non-soluble, gallic acid – modified chitosan oligosaccharides (GA-COS) loaded polymer matrix is developed. This system enables continuous oxygen generation via microalgal photosynthesis, furthermore, this *in-situ* generated oxygen can sustain the catalytic activity under hypoxic conditions. The responsive release of GA-COS cooperates with nanozyme to scavenge ROS, while providing antioxidant, anti-inflammatory, and antibacterial effects. As a result, the catalytic performance of the non-releasing nanozyme-integrated microneedles is comparable to or even exceeds that of conventional nanozyme-releasing systems in diabetic wound environments. By integrating oxygen supply and enzymatic catalysis from Cv@PLL-MCG with the multifunctional bioactivity of GA-COS, the CGMNs effectively modulate the wound microenvironments and accelerate its healing process. Overall, this study establishes a living-material-based therapeutic platform in which microalgae therapy and catalytic nanotechnology are integrated for effective and safe treatment of chronic infected wounds.

Novel 3D cellulose- Nanocomposite Scaffold for skeletal Muscle Therapy

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Biomaterials Year 2 (Talk)

Fabricating functional bio-based scaffold with native physiological-like microenvironment has remained a challenge in skeletal muscle tissue engineering. To go beyond this point, anisotropic core-shell porous scaffold fabricated via 3D bioprinting technique will be explored in this research. It consists of three main biomaterials including cellulose, chitosan and gelatin which are biodegradable biopolymers. This research is based on the concept of improving spin-coating film (2D scaffold) to more biomimetic 3D scaffold and using dynamic 3D cell culture to replicate it as native skeletal muscle in the form of bioreactor. It can be found that 2D scaffold with more components are thicker and provide better mechanical and biological properties. However, 2D scaffolds cannot be implanted into the human body. The process of fabricating 3D scaffold by 3D bioprinting and culturing them in a bioreactor are the next steps in this research. Expectantly, the combination of biomaterial-based properties and advanced fabrication methods can allow this scaffold to be a good candidate for regenerating skeletal muscle in the human body.

Fast-Forming Tetrazine–Norbornene Gelatine Hydrogels for 3D Cell Culture and Cartilage Applications

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Research theme: Biomaterials

Year of study: Year 2 talk

Abstract

Hydrogels are widely used for 3D cell culture and tissue engineering, however, many systems rely on external triggers such as UV light or chemical initiators, which may limit their cytocompatibility. In this work, a biorthogonal hydrogel platform based on gelatine functionalised with tetrazine (Gel-Tz) and norbornene (Gel-NB) is investigated for rapid and mild gelation. The inverse electron demand Diels–Alder reaction between tetrazine and norbornene enables spontaneous crosslinking under physiological conditions, forming hydrogels in under five minutes.

This project focuses on evaluating the suitability of this system for cell encapsulation. Hydrogel formation and handling are first assessed through qualitative gelation studies, and material properties are explored by varying polymer concentration to tune network density. These variations are expected to influence hydrogel structure and mechanical behaviour.

Ongoing work aims to assess the suitability of this system for 3D cell encapsulation by evaluating cell viability within the hydrogel matrix using fluorescence-based imaging. This will provide insight into how rapid gelation and formulation parameters influence cell survival and behaviour within a 3D environment. These findings will inform the design of more advanced hydrogel systems, including the incorporation of hyaluronan–norbornene to develop materials with enhanced relevance to cartilage tissue.

Overall, this study explores a fast-forming, tuneable, and cytocompatibility hydrogel platform for 3D cell culture, with the aim of establishing design parameters for spontaneously crosslinking gelatine-based materials and advancing their application in cartilage regeneration.

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HELLO TOMORROW

Faculty of Science and Engineering

POSTGRADUATE RESEARCH

Day 1 - Wednesday, 20th May

Year 1 Poster Abstracts

A Next-Generation 3D In Vitro Model of Aged Skin for Testing Novel Biomedical Polymers

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Research Theme:
Biomaterials;

Year of Study (Presentation Type): Year 1 (Poster)

Abstract body text; Times New Roman, Size 12; Left Justified; Max. 200 words; No figures or tables to be included.

As populations age, the increasing prevalence of head and neck cancer is driving demand for rehabilitative maxillofacial prostheses. Prosthetic materials undergo degradation during long-term use, typically requiring replacement within 12–18 months. Clinical complications are frequently associated with inflammatory responses arising from chemical leaching and mechanical mismatch between prosthetic materials and skin, effects that disproportionately impact older users. However, platforms for prosthetics biocompatibility testing, such as simple two-dimensional (2D) skin models, fail to represent age-related biological and biomechanical changes.

This project presents a next-generation three-dimensional in vitro model of aged human skin designed to improve the physiological relevance of biocompatibility assessment for biomedical polymers used in maxillofacial prosthetics. Cellular ageing is modelled through induction of cellular senescence in human dermal fibroblasts via stress-induced premature senescence (SIPS); matrix ageing is achieved through tuning of gelatin methacryloyl (GelMA) hydrogel properties. GelMA stiffness is modulated by changing polymer mixing ratios and donor-derived gelatin sources, enabling independent control of matrix mechanics while minimising scaffold contraction artefacts.

A modular experimental framework is used to decouple cell-driven and matrix-driven ageing and evaluate their combined effects on cellular behaviour. The model will be benchmarked against commercial skin equivalents, with the aim of enabling more predictive, age-relevant prosthetic biocompatibility testing.

Sustainable Graphene-Based Coatings on Titanium for Biocompatible Bone Implants

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Year of Study (Presentation Type): Year 1 (Poster)

Abstract
Bone implants must withstand cyclic loads and form a stable interface with surrounding bone. However, implant failure remains a major challenge. This is mainly due to insufficient stability at the bone–implant interface. Although titanium and its alloys are widely used as bone implants due to their excellent mechanical properties and biocompatibility, the naturally formed TiO_2 passivation layer on their surfaces limits their bioactivity.

In recent years, graphene and its derivatives have been widely used in research on titanium surface modification. They have demonstrated potential for promoting bone formation, modulating immune responses and inhibiting bacterial growth. However, results remain inconsistent, as performance depends on fabrication methods and interfacial structures, while the structure–property relationship remains unclear.

This study aims to systematically compare the effects of electrophoretic deposition and laser-induced conversion on the interfacial structure of graphene-based coatings, and to further investigate the mechanisms by which these structures regulate behaviour and responses. By establishing a 'process–structure–biological response' relationship, this study aims to explain the observed discrepancies.

This study will provide a more reliable basis for the design of titanium-based implant surface engineering and promote the reproducible application and engineering development of graphene-based coatings in the field of bone repair.

Biomimetic Co–Cr–Mo Porous Lattice Scaffolds with a Novel Unit Cell for TKA Implants: Linking Architecture and Mechanics

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Research Theme: Biomaterials

Year of Study (Presentation Type): Year 1 (Poster),

Abstract
Porous lattice architectures fabricated using additive manufacturing have emerged as promising solutions for enhancing osseointegration and long-term stability in total knee arthroplasty (TKA) implants. By mimicking trabecular bone structure, these lattices promote bone ingrowth, improve fixation, and reduce stress shielding. In this study, selective laser melting (SLM) was used to fabricate Co–Cr–Mo porous lattice structures with a novel unit cell geometry.

The relationship between manufacturing accuracy, surface properties, mechanical performance, and biological response was systematically investigated. High-resolution micro-computed tomography (micro-CT) with surface deviation mapping revealed negligible geometric deviations between designed and as-built structures, while confirming the presence of both micro- and macro-porosity. Pore network modelling suggested pore diameter ranges between 100 and 1000 µm, with a dominant range of 500–1000 µm, and scaffold porosities from 93% to 50%.

Mechanical testing demonstrated that the scaffolds exhibited Young's modulus values ranging from 0.83 to 15.7 GPa, effectively spanning the properties of trabecular to cortical bone.

Overall, the integrated analysis provides critical insights into the influence of lattice architecture and manufacturing precision on implant performance, supporting development of robust, biologically favourable lattice-structured TKA implants.

Abstract Template:

Factors that Contributing to Fracture and Thermal Stability of SiCf/SiC composites Prepared via polymer infiltration and pyrolysis method

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Research Theme: Select one of the following and delete the rest:
Coating and Ceramics;

Year of Study (Presentation Type): Select one of the following and delete the rest: Year 1 (Poster)

Abstract body text; Times New Roman, Size 12; Left Justified; Max. 200 words; No figures or tables to be included.

Silicon carbide ceramic matrix composites (SiCf/SiC CMCs) are promising structural materials for extreme environments, owing to their low thermal expansion, high melting point, and excellent oxidation and corrosion resistance. The incorporation of SiC fibres enhances fracture toughness from ~2–4 MPa·m$^{(1/2)}$ in monolithic SiC to ~15–30 MPa·m$^{(1/2)}$ in the composite through toughening mechanisms such as fibre pull-out, crack deflection, and microcracking. Among available fabrication routes, polymer infiltration and pyrolysis (PIP) is particularly attractive for its cost efficiency, procedural simplicity, and lower processing temperatures. However, PIP-derived SiCf/SiC composites face critical challenges that compromise long-term performance: PyC and BN interphases oxidise at approximately 400 °C and 900 °C respectively, and the interphase degrades during pyrolysis, leading to loss of toughness. This work proposes a system-engineering approach that decouples the matrix, interphase, and fibre, characterises each constituent independently, and then recouples the findings to quantify individual contributions to the fracture and thermal stability of PIP-processed SiC_f/SiC composites.

<u>All PGRs</u> presenting a talk or poster need to submit their final abstract **<u>via the online form</u>** by **17:00 BST 20th April.** Please save the document title as your year group followed by last & first name: Y_ LASTNAME_FIRSTNAME ABSTRACT. If you have any queries, contact fse.doctoralacademy@manchester.ac.uk

Development of a Near-Infrared Reflectography System for Detection of Corrosion Beneath Protective Coatings

Protective coatings are widely used in industry to prevent corrosion in industrial components. Early degradation often starts beneath the coating before it is visible. Different non-destructive techniques such as portable infrared devices are already being used to assess coatings in other sectors. Aerospace uses portable infrared technology to examine composition of structural components whereas cultural heritage has long exploited near infrared reflectography to reveal hidden features under the artistic paints (Liang, 2012). However, the adaption of these technologies in corrosion monitoring remains limited by the lack of well understood spectroscopic signals. The aim of this work is to design and develop an experimental near infrared reflectography system that can detect early corrosion beneath protective coatings.

A custom NIR imaging setup is being developed, with its main components being a Nikon D80 with a CCD sensor sensitive in 400-1100 nm range, equipped with an IR filter cut-off. Infrared LED illumination at 850 nm and 940 nm provides the infrared source and a pre-corroded panel coated with epoxy coat of 50 µm DFT is the sample.

Early results demonstrate that near infrared reflectography can reveal the corrosion under the coating but is influenced by surface texture and illumination conditions. The images were captured in reflection and transmission mode. In transmission mode infrared light does penetrate the coating; however, this penetration is not sufficient to give a clear contrast between corroded and uncorroded regions in reflection mode.

Liang, H. (2012). Advances in multispectral and hyperspectral imaging for archaeology and art conservation. Applied Physics A, 106(2), 309–323. https://doi.org/10.1007/s00339-011-6689-1

MOF-Loaded Fusion-Bonded Epoxy Coatings for On-Demand Corrosion Protection

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Research Theme:
Coating and Ceramics

Year of Study (Presentation Type): Year 1 (Poster)

Fusion-bonded epoxy (FBE) coatings are widely used for corrosion protection in buried pipelines because of their strong adhesion and barrier performance. However, buried pipelines are exposed to complex environmental and mechanical conditions, including soil heterogeneity, moisture, pH variation, dissolved salts, stray currents, microbiological activity, and coating damage during transport, handling, installation, and service. Under such conditions, coating failure may compromise pipeline integrity, particularly at damaged or cathodic disbandment sites. This project investigates the smart functionalization of FBE coatings using inhibitor-loaded metal-organic framework (MOF) nanocontainers to improve defect tolerance and corrosion protection. UiO-66-NH2 is used as a nanocontainer for 2-mercaptobenzimidazole (MBI), a mixed N/S donor corrosion inhibitor. The work focuses on optimizing inhibitor loading and retention within the MOF, triggered release under buried pipeline service conditions, and deposition of MOF-modified FBE coatings using an in-house fluidized-bed system. Initial results support successful synthesis of UiO-66-NH2, incorporation of MBI, and preparation of uniform coatings on carbon steel. The study aims to establish a transferable framework for integrating MOF-based smart inhibitor systems into industrial pipeline coatings.

Application of Bayesian Optimization in Material Synthesis

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Research Theme: Select one of the following and delete the rest:
Coating and Ceramics;

Year of Study (Presentation Type): Select one of the following and delete the rest: Year 1 (Poster)

Finding the optimal synthesis parameter for material fabrication is important. This is often tedious, as numerous synthesis conditions must be optimized simultaneously. The traditional one-factor-at-a-time (OFAT) method is slow and ignores interactions among factors. With the aid of machine learning algorithms, such as Bayesian Optimization (BO), the optimization process could be accelerated. BO attempts to predict the landscape of the parameter space and iteratively proposes new points to sample. Therefore, BO can iteratively explore the parameter space and attempt to locate the optimal synthesis region. In this work, we will attempt to apply BO to material fabrication. We have determined that initial sampling strategies and the balancing of exploration and exploitation are essential to an efficient BO algorithm. Initial sampling strategies refer to the initial points necessary to start the BO run. Exploration and exploitation balance BO's tendency to explore uncertain regions or focus on unknown optimal regions. Both factors are necessary for a good BO run.

Phase-Field Fracture for Microstructure-Resolved Crystal Deformation Under Tensile Loading

Harry Smith, Dr. Aleksey Yerokhin, Dr. Tom Flint

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Understanding the interplay between damage evolution and plastic deformation in crystallographic materials is central to accurately predicting the macromechanical response of structural components in service. Here, phase-field fracture is implemented within `CPFoam`: an open-source Eulerian crystal plasticity framework, in which grains are represented as advected order-parameter fields. This naturally accommodates the crack as an additional phase φ_{cr}. Constructed from a free-energy functional combining elastic strain energy density and multiphase interfacial energy, the pairwise steepest descent of the phase-wise Euler-Lagrange equations governs crack phase evolution. A $100 \times 100\,\mu$m bicrystal domain under mode I tensile loading is used to benchmark the model. In the decoupled case, the CP solve recovers an LEFM-like stress field, after which the phase-field solve demonstrates φ_{cr} nucleating at the seed notch and propagating along the grain boundary, consistent with thermodynamic favourability for intergranular fracture. In the fully-coupled implementation, stiffness degradation drives extreme property gradients, causing numerical instability and motivating future work on elastic strain energy splitting and implicit time-integration strategies.

Structural changes and solid solutions in perovskites

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Research Theme: Coating and Ceramics

Year of Study (Presentation Type): Year 1 (Poster)

Perovskite is a kind of ceramic material which has a unique crystal structure named by Gustav Rose in 1839 in honor of Count Lev Alekseevich Perovski (1792-1856). The general formula of the perovskite structure is ABX_3. Usually, A is larger metal cation, B is smaller metal cation, and X is oxygen anion. Due to the specific structure of perovskite ceramic, they have been widely utilised in the electroceramic industry, which have subclasses include dielectrics, piezoelectrics, pyroelectrics, ferroelectrics, ion conductors, and magnetic ceramics. Currently, the market for electroceramics is dominated by $BaTiO_3$ (BT) and $Pb(Zr, Ti)O_3$ (PZT). My project will focus on the BF-BT perovskite structure ceramic material, investigate the phase transformation and phase diagram of BF-BT under high temperature and pressure condition. In addition, I will research the solid-solution rule for perovskite materials, starting with BF-BT.

Abstract

Step Changes in Insulation Materials for Thermal Batteries

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Research Theme: Coating and Ceramics

Year of Study (Presentation Type): Year 1 (Poster)

Efficient thermal insulation is critical in systems operating under extreme environments, such as thermal batteries, where minimising heat loss enhances performance and extends device lifetime. Current insulating materials often degrade or lose stability under operation conditions, highlighting the need for new inorganic compounds capable of withstanding severe thermal and mechanical stress.

This research focuses on investigating metal oxides of the $A_2B_2O_7$ structure, which exhibit intrinsic properties, such as large unit cells, structural complexity, and inherent oxygen vacancies, which have been shown by research to suppress phonon transport. By systematically substituting cations across the A and B sites, the study aims to introduce controlled mass disorder and lattice distortion, creating centres for enhanced phonon scattering which ultimately reduce lattice thermal conductivity.

Structural and thermal characterisation will be performed to correlate compositional changes with phonon transport behaviour. The objective is to identify compositions that demonstrate ultra-low lattice thermal conductivity which can be fabricated into architectures with strong mechanical integrity suitable for high-temperature insulation in thermal battery systems.

Ultimately, this work seeks to advance the understanding of lattice thermal conductivity in complex oxides and to provide research to support the design of next-generation metal oxide materials for reliable, long-duration energy applications.

Understanding Grain Boundary Complexion Transitions at Extreme Conditions

<u>Pok Man Ethan Lo [1,*]</u>, Alex S. Eggeman [1], Coşkun Kocabaş [1]and Simon A. Hunt [1]
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Grain boundary complexion transitions (GBCTs) are transitions in which the structure, composition, and properties of a grain boundary change discontinuously. Despite their small volume fraction, GBCTs can lead to material-wide changes, such as the opacity changes (see Fig. 1). At present, little is known about how high-pressure, high-temperature (HP–HT) conditions affect GBCTs and, consequently, grain boundary properties. Here, we are trying to synthesise $SrTiO_3$ (STO) at HP-HT using a 1000-ton large volume multi-anvil apparatus with in-situ impedance spectroscopy to observe potential GBCTs. After the extraction of the sample, a correlative approach will be used to understand the effect HP-HT has on GBCTs. Initial works include the study of STO at 1100 and 1300 °C under ambient pressure sintered for 144 hours. This work is studied under scanning electron microscopy to visualise the effect of the sintering conditions to set a baseline for HP-HT experiments

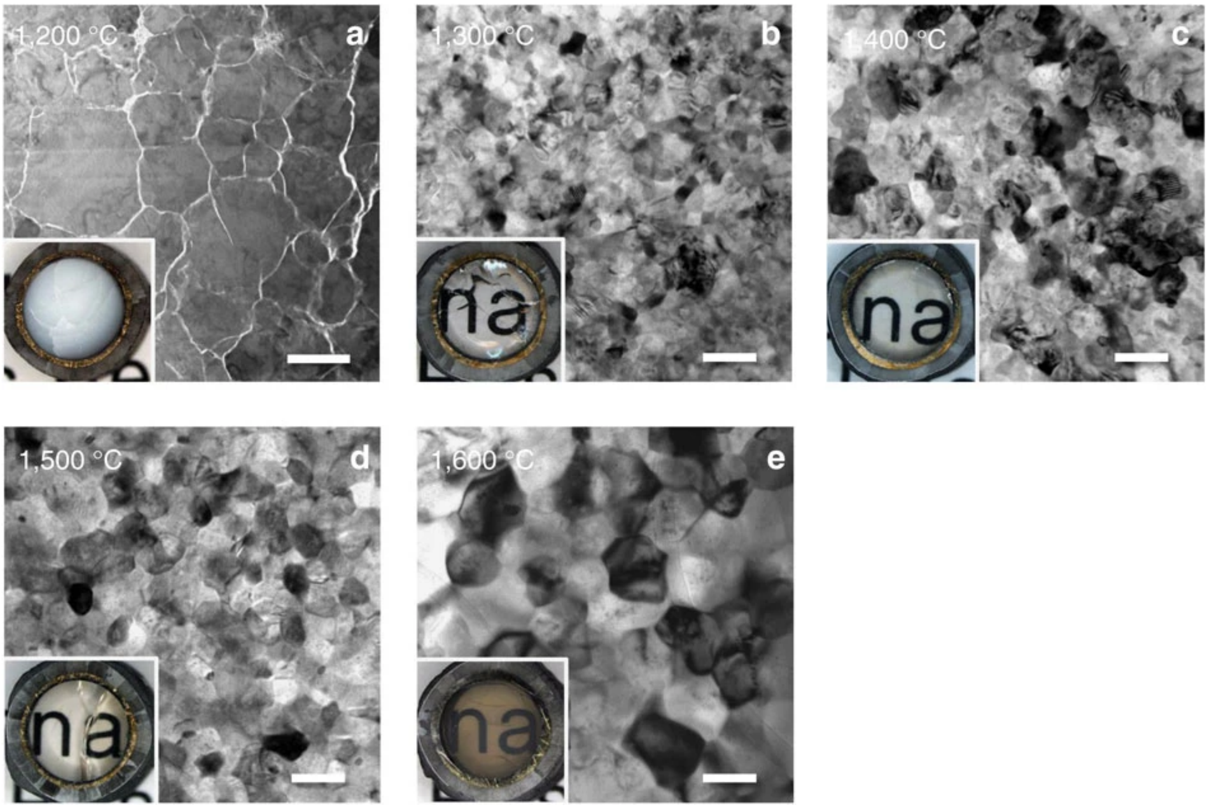

Figure 1 – Reproduced from Irifune et al., demonstrating the effect of pressure on GBCT and subsequently, the materials' transparency.[1]

ABSTRACT

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Research Theme: Coating and Ceramics

Year of Study (Presentation Type): Year 1 (Poster)

The MCrAlY coatings are vital for protecting high-temperature components in harsh environments, but their use is limited to 1,050°C. High entropy alloy coatings such as AlCoCrFeNi show promise for superior oxidation resistance at even higher temperatures. However, finding the optimal AlCoCrFeNi composition remains a challenge due to the vast compositional space. In this study, we combine computational modelling with experiments to search for AlCoCrFeNi compositions with strongest oxidation resistance. We formulate a proxy defined by CALPHAD-derived thermodynamic parameters, including phase fractions, chemical potentials and lattice parameters, for evaluating the oxidation resistance. This proxy was then explored using Bayesian Optimization to identify the compositions showing the slo west oxidation kinetics. The modelling and predictions are validated by experiments. To provide further insight, Molecular Dynamics simulations based on machine-learned interatomic potentials were carried out for selected compositions. The simulations mainly focus on differences in atomic mobility and structural stability, which are expected to influence oxide formation. Overall, this work shows how combining thermodynamic modelling, optimization methods and experiments can help guide the design of oxidation-resistant HEAs.

This study investigates the in-manufacture thermal profiling of Plasma Electrolytic Oxidation (PEO) coatings on light alloys using thermal history nanosensors. Light alloys such as aluminium, magnesium, and titanium are widely valued for their low density and high strength, yet their poor wear and corrosion resistance limit their application in demanding environments. PEO offers an advanced surface engineering solution by forming durable ceramic coatings through plasma-assisted electrochemical processes. However, a key challenge remains in accurately determining the temperature within the reaction zone. Existing techniques present a significant discrepancy, with optical emission spectroscopy suggesting temperatures up to 20,000 K, while thermocouple measurements indicate values below 140 °C.

To bridge this gap, this study proposes the integration of nanosensors into the growing oxide layer to enable non-intrusive, high-resolution thermal measurements. The research focuses on elucidating the mechanisms of nanoparticle incorporation, improving the spatial and temporal analysis of temperature distribution, and examining the effects of electrolyte composition, substrate materials, and electrical parameters on thermal fields. By correlating thermal data with microstructural evolution and coating performance, this study aims to achieve a deeper understanding of PEO mechanisms and to support the optimisation of coating properties for enhanced durability and functionality.

Title (Times New Roman Bold, Size 12)

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Research Theme: Coating and Ceramics

Year of Study (Presentation Type): Year 1 (Poster)

Gas turbine engines require new materials to allow for increased operational temperatures and the resultant increased efficiency. Ceramic matric composites (CMCs) represent a strong potential material class but require environmental barrier coatings (EBCs) to function at high temperatures. These EBCs, in turn, require bond coats to bridge coefficient of thermal expansion (CTE) mismatches and prevent substrate oxidation.

The bond coat requires CTE matching between layers, limited phase changes with volume changes, and strong mechanical behaviour at high temperatures in order to ensure long lifetimes in operational conditions. Silicon fits this—but its thermally-grown oxide (TGO) silica has a phase change upon cooling, and silicon is the limiting factor for temperature in the system. Limiting this phase change to prevent coating failure is critical to achieving next-generation bond coats for EBC systems, and work to identify candidate replacement materials to increase operational temperatures is ongoing within the field.

Xiangjie Song Poster abstract

Aerosol Deposition (AD) represents a disruptive, room-temperature manufacturing paradigm for electroceramics, overcoming the inherent limitations of conventional high-temperature sintering, such as substrate restrictions and elemental volatilization. This study investigates the fundamental mechanisms of AD, specifically how impact consolidation at high velocities facilitates the formation of dense, void-free thick films through severe fragmentation and plastic deformation—often referred to as the hammering effect.

A primary focus is the nanograin advantage, where AD-induced grain refinement to approximately 20nm physically frustrates long-range ferroelectric domain formation. This process induces relaxor-like behavior and enhances energy efficiency without the need for complex chemical stoichiometric tuning. Experimental results highlight a significant boost in breakdown strength (BDS) and a giant energy density. Furthermore, AD enables the direct integration of high-performance functional ceramics onto flexible, temperature-sensitive substrates like polyimide and metal foils. By bypassing traditional thermal processing, AD paves the way for next-generation flexible electronics, IoT self-powering units, and high-density energy storage capacitors.

Understanding the Influence of Pre-Oxidation on the Spallation Behavior of Bond Coats in Thermal Barrier Coatings

Name: Xiaohan Cui Supervisor: Ping Xiao ID:11459030

Abstract

Thermal barrier coating (TBC) systems enable higher operating temperatures in gas turbines, with coating lifetime governed by processes at the bond coat (BC)/thermally grown oxide (TGO) interface. During high-temperature exposure, oxidation of the bond coat leads to TGO formation, whose phase evolution, growth behaviour, and stress development control degradation. β-(Ni,Pt)Al and Pt-diffused γ/γ′-Ni_3Al bond coats exhibit distinct oxidation responses due to differences in aluminium activity and phase stability. Pre-oxidation is often used to promote α-Al_2O_3 formation; however, its effect on TGO evolution and lifetime remains inconsistent across different bond coats. This study aims to elucidate the mechanisms governing early-stage oxidation and subsequent TGO development under pre-oxidation conditions. Attention is given to TGO phase transformation, residual stress distribution, and interfacial instability. By linking bond coat characteristics to oxidation pathways, this work seeks to clarify the role of pre-oxidation in TBC performance.

Energy-based evaluation of fracture toughness from nanoindentation mapping

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Research Theme: Coating and Ceramics

Year of Study (Presentation Type): Year 1 (Poster)

Abstract:
Since the development of the Oliver–Pharr method for extracting mechanical properties from load–displacement curves, nanoindentation has become a widely used technique in ceramic research. However, significant discrepancies between fracture toughness values obtained from nanoindentation and four-point bending tests highlight the influence of size effects, with nanoindentation reflecting local properties while bending tests represent bulk behaviour. To overcome the limitations associated with direct crack length measurements via SEM, energy-based approaches derived from Griffith's theory have been proposed, where pop-in events are considered indicative of crack initiation and are used to estimate fracture energy for subsequent fracture toughness evaluation. In this study, machine learning and statistical methods are applied to efficiently process large nanoindentation datasets and improve the accuracy of fracture toughness estimation. The results are further compared with values obtained from conventional bending tests. This work aims to develop an improved framework for energy-based fracture toughness evaluation from nanoindentation mapping, enabling a more consistent interpretation across micro- and macro-scales.

Exploring the nanoscale structure of multicomponent materials

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Research Theme: Imaging and Characterisation

Year of Study (Presentation Type): Year 1 (Poster)

Multicomponent materials otherwise termed high entropy materials, that contain multiple constituent elements in equimolar or near equimolar ratios that form a single phase. A lanthanide-based high entropy oxysulfide consisting of Pr, Nd, Gd, Dy, and Er, based on a Gd_2O_2S parent material, was investigated. The stoichiometry of the material was analysed using Transmission Electron Microscopy (TEM) and Energy Dispersive X-ray Spectroscopy (EDS). The EDS data was analysed using a Hierarchical Density-Based Spatial Clustering of Applications with Noise (HDBSCAN) and Uniform Manifold Approximation and Projection for Dimension Reduction (UMAP) pipeline. The clustering pipeline was able to accurately differentiate between the composition of different regions of the samples. It was found that the material overwhelmingly tended to form single-phase particles with a similar composition of elements between particles. Density functional theory (DFT) using CASTEP was used to study the structure of the material. All the constituent elements except for Nd were found to be energetically favourable within the Gd_2O_2S parent lattice. Further DFT calculations should be performed to determine the interactions between the various constituent elements, their respective stabilities, and the overall stabilisation mechanism of the multicomponent crystal structure.

NanoSeach: Automated Data Acquisition and Analysis for Scanning Transmission Electron Microscopes

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Research Theme: Imaging and Characterisation

Year of Study (Presentation Type): Year 1 (Poster)

Scanning Transmission Electron Microscopy (STEM) techniques permit atomic-resolution imaging and analysis. However, our ability to analyse atomic-scale features across large regions of a sample is lacking, leading to questions regarding the generality of conclusions drawn, especially for heterogeneous or sparse samples. In my project, I aim to develop NanoSearch, a computer program embedding in a STEM to automatically identify regions of interest, capture micrographs and gain useful data for features within them. Here, I explain my plans to develop NanoSearch into a general-purpose tool for deep-learning-enabled analysis of atomic-scale features over millimetre-sized regions.

Abstract Template:

**Advanced Imaging of Ductile Fracture Mechanisms
Under Controlled Stress**

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Research Theme: Imaging and Characterisation

Year of Study (Presentation Type): Year 1 (Poster)

It is imperative to acknowledge that an accurate prediction of the lifespan of steels and other engineering alloys is contingent upon the assessment and understanding of their structural integrity. It is imperative to recognise the paramount importance of these considerations within a broad spectrum of safety-critical applications. The nucleation, growth and coalescence of voids are the primary factors that govern ductile fracture in pressure vessel steels. The project will utilise cutting-edge laboratory facilities. This study investigates the influence of microstructure and stress state on void evolution using synchrotron in-situ time-resolved X-ray computed tomography (XCT) and scanning electron microscopy (SEM). Preliminary results indicate a significant variation in void morphology with stress triaxiality. The findings presented herein offer significant insights into the mechanisms underlying damage evolution, thereby facilitating a more comprehensive understanding of fracture behaviour.

Developing a Machine Learning based Approach to 2D and 3D Hydride Characterisation in Zirconium Alloys

Quantifying hydrides in zirconium from backscattered electron (BSE) images is often labor-intensive and prone to user bias due to manual tuning. This study addresses these limitations by applying a deep learning–based segmentation approach using the nnUNet architecture to automatically identify hydrides. Segmentation outputs generated by nnUNet were used to compute key microstructural metrics, including radial hydride fraction, mean hydride length, and branch length ratio.

The model was trained and evaluated on a diverse dataset of BSE images, achieving a Dice similarity coefficient of 0.83 on the validation set. Robustness to image degradation was assessed by introducing synthetic noise, including Gaussian and speckle noise. Performance decreased by 18% under high Gaussian noise conditions (variance = 0.5), indicating moderate resilience to image quality variation.

These results demonstrate that deep learning enables a reproducible, less biased approach to hydride segmentation and quantification. The proposed method facilitates consistent comparison across zirconium samples and provides a more reliable basis for analysing the effects of processing and environmental conditions on hydride formation in zirconium alloys.

The Synergistic Effects of Residual Elements and Hydrogen in Microalloyed Steels

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Research Theme: Metallurgy and Corrosion

Year of Study (Presentation Type): Year 1 (Poster)

As the UK transitions to large-scale Electric Arc Furnace (EAF) steelmaking, the demand and cost for high-purity scrap will increase. To remain economically competitive, the industry must utilise more obsolete steel scrap containing elevated concentrations of residual elements (e.g. Cu, Sn, Cr, Ni). Strict industry standards currently limit residual elements in steel, leaving it unclear if higher levels of such elements can be accommodated, particularly under harsh service conditions such as hydrogen transport or offshore environments.

Microalloyed steels, such as API 5L X65 used for natural gas pipelines, will be uniquely sensitive to this transition; residuals segregate to grain boundaries, alter transformation kinetics, and promote hot shortness during thermomechanical processing. Due to their low-carbon design and reliance on precise microstructural control, even trace amounts of residuals can significantly degrade processability and mechanical performance. Most critically, as the UK moves towards a hydrogen economy, the next generation of pipeline steels will likely carry higher residual element contents. The potential synergy between residual segregation and hydrogen may accelerate hydrogen embrittlement (HE). This study aims to evaluate these interactions, focusing on precipitate-hydrogen-dislocation micromechanics to safeguard the structural integrity of the UK's future hydrogen network.

Mechanisms of hydrogen embrittlement in high-strength 7xxx series Al alloys

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Research Theme: Metallurgy and Corrosion;

Year of Study (Presentation Type): Year 1 (Poster)

The latest generation of high strength 7xxx-series aluminium alloys are susceptible to environmentally induced cracking (EIC) in warm, humid air. Compared with previous generation (lower Zn wt%) alloys, these materials demonstrate long crack growth rates up to an order of magnitude faster. Notably, a threshold behaviour is observed when Zn content exceeds ~8wt% there is a negative step change in EIC susceptibility. Which cannot be explained by increasing reactivity of grain boundary precipitates, indicating an alternative mechanism. This project aims to determine the mechanisms behind enhanced susceptibility in high Zn content 7xxx-sereis Al alloys and use this understanding to clarify hydrogen embrittlement mechanisms in 7xxx-series Al more generally.

Initial work will correlate different characterisation techniques with fracture mechanics modelling to quantify stress intensity factor (K_1) associated with distinct crack morphologies formed during EIC of AA7449 and AA7085(high Zn alloys). Further experimental work will investigate the transition from brittle-intergranular fracture to transgranular quasi-cleavage and why increasing Zn content and decreasing temperature promote this behaviour. Finally, electrochemical techniques will quantify the influence of Zn enrichment at the oxide/matrix interface and in solid solution on hydrogen evolution during EIC, linking alloy chemistry, hydrogen production, and fracture behaviour.

Developing a Deterministic Prediction of the specular component of Reflections from an evolving Melting Surface under High-Energy Laser Irradiation.

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Research Theme: Metallurgy and Corrosion;

Year of Study (Presentation Type): Year 1 (Poster)

High-energy lasers (HEL) are widely deployed in modern manufacturing process such as laser welding and laser drilling. However, laser interaction with dynamically evolving molten surface can generate hazardous reflections, causing risk to both the equipment and the operators. This increases the demand for a robust deterministic framework for predicting the reflection behaviour on evolving surfaces.
This study aims to develop a computational approach to quantify specular laser reflection from evolving melt-pool and keyhole geometries. Simulations use the open-source LaserbeamFoam toolkit, which coupled Volume of Fluid (VOF) methods with ray-tracing techniques for laser propagation. Initial work is based on understanding the effect of altering laser and materials properties leading to different keyhole morphology. The sensitivity of the numerical resolution on both rays and mesh is also assessed.
The model captures only the specular reflection behaviour of the laser which would predict the upper bound of the energy density at the hot spot. This enables systematic identification of the high-risk reflection zones and provide a reference for future mitigation strategies in high-energy laser processing.

PGR Conference Abstract:

Chahni, Georges
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April 16, 2026

Reduced activation ferritic–martensitic (RAFM) steels are leading candidates for structural components in fusion reactors; however, their upper service temperature is currently limited to 550 °C due to precipitate coarsening, loss of creep strength, and irradiation-induced embrittlement. In this project, the alloy compositions are modified to promote the formation of high temperature stable nanoscale precipitates, while grain refinement is employed to enhance mechanical performance up to 650 °C. To achieve this, B, Zr and Ti microalloying additions are introduced into base compositions derived from Eurofer 97, resulting in BZirc–RAFM and Ti–RAFM respectively. In addition, rolling parameters are tailored to induce partial dynamic recrystallisation, followed by heat treatment to promote static recrystallisation within the lath martensitic structure, leading to further grain refinement.

Electron Beam Welding RAFM Steels

Name: Hugo Stephens
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Research Theme: Metallurgy and Corrosion

Year of Study (Presentation Type): Year 1 (Poster)

As the world moves towards greener energy fusion is set to play a role, with the UK pushing to build an operational fusion tokamak powerplant (STEP) by 2040. The breeder blanket is a critical component which will be used to breed tritium in fusion reactors. The temperatures, neutron fluxes and magnetic fields experienced by the breeder blanket will be extreme, necessitating the use of specially designed materials. Reduced Activation Ferritic-Martensitic (RAFM) Steels have been designed for use in breeder blankets, using low activation alloying elements to avoid problematic transmutations to long lived radioisotopes. To construct the breeder blanket welding will be required but this will degrade the microstructure in the Heat Affected Zone surrounding the weld. Electron Beam welding has been identified as a possible process because the high-power beam produces smaller (HAZ), minimising the region of microstructural degradation. My PhD will focus on studying the effects of Electron Beam welding on RAFM Steel and optimising the process. The optimization will be done using a combination of direct mechanical testing and microstructural characterization.

Title: Composition control maps to maintain phase balance in duplex stainless steels for oil and gas applications.

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Research Theme: Metallurgy and Corrosion.

Year of Study (Presentation Type) : Year 1 (Poster)

Duplex stainless steel has become one of the preferred choices for oil and gas application due to their balanced composition of 50% ferritic and 50% austenitic phases, which ensures exceptional mechanical properties and excellent corrosion resistance. However, when duplex stainless steels are fabricated via additive manufacturing and welding exhibit poor mechanical properties because of the rabid cooling that encounter during the process causes much ferrite, which disrupting the balance between the phases. This PhD project aims to address this issue by understanding process parameters to control the local cooling rate for wire AM. In addition, evaluate and controlled process parameters and how it is effective on required phase balance, and establish process parameters-phase composition control map for wire AM of duplex stainless steel.

Understanding the irradiation behaviour of Alloy A, a novel zirconium alloy developed for demanding fuel duties and higher burnups

Name: Johnny Cooke
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Metallurgy and Corrosion.

Year 1 (Poster).

Abstract body text; Times New Roman, Size 12; Left Justified; Max. 200 words; No figures or tables to be included.

Zirconium alloys are used in the nuclear industry as cladding material; this is because these alloys have been found to have a low neutron absorption cross-section. This means less neutrons are absorbed than other materials, so the reaction is more efficient. One problem with zirconium alloys is under irradiation they can be prone to irradiation induced growth; this is a shape change in the cladding material caused by irradiation. This shape change can issue for the reactor, so we want to find a way to minimise it. This project is about understanding the irradiation behaviour of an alloy with a unique composition produced by Westinghouse, this alloy is called alloy A. Tests were done in a BOR-60 reactor by Westinghouse that found that the novel alloy A had surprisingly high irradiation-induced growth resistance. As this alloy isn't well understood the goal of this project is to understand why this alloy performed well mechanistically, this will be done using a series of characterisation techniques such as Secondary Electron Microscopy, Transmission Electron Microscopy, Electron Back-scatter Diffraction, X-ray Diffraction, Atomic Probe Topography and more.

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Research Theme: Select one of the following and delete the rest:
Metallurgy and Corrosion;

Year of Study (Presentation Type): Select one of the following and delete the rest: Year 1 (Poster)

This PhD project explores the feasibility of zinc undercoating as a hydrogen permeation barrier for pipelines operating in hydrogen service environments. The theory is based on hydrogen diffusion and electrochemical interactions at material interfaces, where hydrogen ingress into steel can cause degradation mechanisms (hydrogen embrittlement). By introducing a zinc interlayer, the project aims to modify hydrogen transport behaviour, by reducing its diffusivity, or introducing trapping sites through microstructures.

An important aspect of the research is evaluating how hydrogen gas exposure influences both coating integrity and overall corrosion behaviour. Hydrogen permeation is being quantified using an electrochemical setup, allowing for detailed analysis of transport kinetics through coated systems. Also, the composition and surface condition of the zinc coating are critical factors, as they directly influence microstructural characteristics and hydrogen–material interactions.

However, a challenge lies in the electrochemical nature of zinc. When it's exposed to aqueous environments, zinc acts as a sacrificial anode, which can accelerate the corrosion process and promote hydrogen evolution at the underlying steel surface. Understanding and mitigating this trade-off between protection and degradation is a primary focus of the project.

Work completed so far has included sample preparation, including cutting, grinding, and polishing to ensure consistent surface conditions. Experimental studies have also included cathodic charging to simulate hydrogen uptake, which was followed by Laser-Induced Breakdown Spectroscopy (LIBS) analysis to investigate coating composition elemental distribution after incremental periods of charging. These initial efforts provide a foundation for ongoing permeation testing and coating optimisation.

Utilising Non-contact electrochemical decontamination on stainless steel

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Research Theme : Metallurgy and corrosion

Year of study (presentation type): Year 1 (poster)

This project investigates non-contact electrochemical decontamination of carbon steel and stainless steel, with the longer-term aim of extending the approach to irradiated materials. Bipolar electrochemistry (BPE) is being explored as a method for removing contamination and corrosion products from steel surfaces without direct electrical contact. The study builds on previous work on steel components and applies the BPE approach to carbon steel alongside stainless steel. One key advantage of BPE is its ability to achieve both oxidation and reduction on the same material surface, allowing the examination of decontamination and recontamination. Key BPE parameters will be varied to improve decontamination performance, while COMSOL finite element simulations will be used to refine the experimental setup and guide process optimisation. Simulated Contamination (SimCon) will be used as a standardised platform for assessing decontamination. SimCon 1 represents loose surface deposits, while SimCon 2 models contaminants baked into the oxide layer. Due to the characteristics of SimCon 1, SimCon 2 will be the focus of these tests. Experimental monitoring and characterisation techniques, including LIBS, XPS, GI-XRD, and SEM/EDX/EBSD, will be used to evaluate surface changes and decontamination efficiency. Together, these approaches aim to assess whether BPE may offer a practical route for reducing contamination on steel, with potential relevance to future irradiated-material applications.

Deformation Mechanisms of Titanium Aluminide Intermetallics for Aerospace Applications

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Research Theme: Metallurgy and Corrosion.

Year of Study (Presentation Type): Year 1 (Poster)

Titanium aluminide intermetallics are alloys comprising approximately 50 at% titanium and 50 at% aluminium along with other alloying elements. These alloys are increasingly replacing heavier materials used in aerospace applications due to their low density, superior specific strength and moduli. While the bulk fatigue and creep properties are sufficiently studied in a select few alloys for industrial use, key underlying metallurgical aspects, particularly deformation mechanisms are relatively not well understood. Titanium aluminide intermetallics exhibit multiple solid-state phase transformations that can be manipulated through heat treatments. Furthermore, additional alloying elements can be added to improve the alloy performance, but phase transformation and deformation behaviour is further complexified as a result. Therefore, this project aims to study these complex phenomena at the micro/nano scale to help us in understanding the failure mechanisms relevant for long-term performance. Techniques like high resolution digital image correlation can track surface deformation during various deformation modes to analyse this behaviour. This knowledge can help in linking the relationship between microstructure and the bulk fatigue and creep properties. The alloy can then be optimised through thermomechanical processing to achieve the ideal mechanical properties for specific applications. Hence, fundamental characterisation of microstructure deformation mechanisms is key for successful engineering applications.

The Fundamental Mechanism of Grain Boundary-Mediated Warm Deformation

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Research Theme: Metallurgy and Corrosion
Year of Study (Presentation Type): Year 1 (Poster)

Low-melting-point light alloys exhibit enhanced formability during warm deformation due to the activation of grain boundary-mediated plasticity in addition to conventional dislocation slip. While dislocation-based mechanisms are well established at room temperature, the contribution of grain boundary processes such as sliding, shearing, and stress-assisted migration at elevated temperatures remains insufficiently understood. In this study, the deformation behavior of light alloys is investigated with a primary focus on AZ31 magnesium alloy as a model system. Uniaxial tensile tests are performed at warm temperatures across a range of strain rates, with local strain evolution measured using digital image correlation. Preliminary results reveal a strong temperature dependence of the tensile stress–strain response, highlighting the increasing role of grain boundary activity during warm deformation. Ongoing and future work combines in-situ mechanical testing with advanced microstructural characterization techniques, including EBSD, to directly correlate macroscopic deformation behavior with grain boundary structure and mobility. This approach aims to establish mechanistic structure–property relationships to inform the design of light alloys with improved warm-forming and superplastic performance.

Direct Simulation of Liquid Metal Nucleate Boiling in the Presence of Magnetic Fields

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Research Theme: Metallurgy and Corrosion;

Year of Study (Presentation Type): Year 1 (Poster)

Nucleate boiling occurs when a solid surface is heated above an adjacent liquid's saturation temperature. In this scenario, vapour forms at preferential nucleation sites on the heated surface. Compared to regular nucleate boiling, there are fewer studies of computational modelling of liquid metal boiling, especially within magnetic fields. These are relevant to nuclear fusion blanket design and manufacturing processes, such as magnetically modulated welding. Nuclear fusion blankets are chambers behind the plasma facing wall and aim to: transfer heat away to a steam generator; and synthesise tritium via neutron-lithium reactions, which implies lithium based eutectics as a working fluid. However, liquid metal flows within strong magnetic fields may experience magneto-hydro-dynamic effects, such as Lorentz forces which oppose the flow. These effects can degrade the flow rate and heat transfer, leading to first-wall thermal damage. A proposed solution is to allow the liquid metal to boil, which would improve heat transfer via the eutectic's high latent heat of vaporisation, and reduce Lorentz forces due to the presence of vapour phases. This project is focusing on developing, verifying and validating a simulation framework needed to model the phenomena. Afterwards, the physics of the flows, with and without, state transition will be studied.

The first key challenge to an experimental PhD is perfecting sample preparation to get more accurate results from analysis methods sensitive to surface topography. This challenge is particularly important for Zirconium based alloys as they are known for their difficulty to prepare especially in a cold worked state. Traditional mechanical polishing methods provide a sufficient polish for analysis but there is a limitation, this can be seen through EBSD analysis achieving only 70 to 80% indexing. Electropolishing is an alternative preparation method using electrochemical material removal. However, in literature the recording of parameters is non consistent so a systematic investigation to find a set of ideal parameters is required. This poster shows the development of a standardised method of electropolishing with evidence that electropolishing at 18 V for 15 s created the best surface polish seen by its EBSD map achieving the highest indexing (>90%) compared to the other trial parameters. The results from the samples created are then analysed to see the effect of electropolishing vs mechanical polishing. The main difference is seen in KAM analysis where electropolished have a lower surface KAM than mechanical polishing, this showing evidence that electropolishing can remove surface damage induced through mechanical polishing methods.

Modelling the Role of Capacitance in Localised Corrosion

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Research Theme: Metallurgy and Corrosion

Year of Study (Presentation Type): Year 1 (Poster)

Stainless steels have excellent corrosion resistance but suffer greatly from localised corrosion (‘pit’ and ‘crevice’ formation) in the presence of chloride-containing solutions. Initiation of localised corrosion phenomena is poorly understood; pits occur stochastically at miniscule points on the surface and dissolve away a great deal of information about their initiation site. Their high rate of anodic dissolution is supported by current derived from the rest of the surface, which acts as a large cathode. Some authors have suggested that capacitance discharge from the supporting cathode may play a crucial role in the initiation of localised corrosion phenomena. Capacitive current transients have been measured after the initiation of pits, although little is understood about the contribution this supporting current makes relative to faradaic processes. This work uses a numerical finite element modelling approach to understand the dynamics, timeliness and importance of capacitive discharge in the first stages of localised corrosion after surface activation. We find that while capacitive current supports the pits up to the first few hundreds of milliseconds after activation, it is highly limited by the propagation of solution potential outwards from the initiation site.

Understanding the influence of cleaning regimes on the coating/substrate interface for chromium coated claddings.

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Research Theme: Coating and Ceramics

Year of Study (Presentation Type): Year 1 (Poster)

The Fukushima Daiichi accident exposed critical weaknesses in conventional zirconium (Zr) alloy fuel claddings during loss-of-coolant (LOCA) scenarios, where mutually reinforcing creep and oxidation mechanisms resulted in cladding failure at elevated temperatures. In response, accident-tolerant fuel (ATF) concepts were developed to reduce the rate and total generation of heat and combustible hydrogen gas compared with uncoated claddings. Chromium (Cr) -coated Zr alloy claddings are one of the most promising and researched ATF concepts for pressurised water reactor designs, offering enhanced corrosion resistance under both operational and accident conditions. Magnetron sputtered physical vapour deposition (MS-PVD) is a leading coating technique offering precise control over coating thickness and microstructure. Prior to coating MS-PVD coating deposition, Zr substrates are negatively biased and sputter cleaned, typically using argon process gas to remove native oxide and organic contaminants. Although comparative studies of Cr-coated claddings deposited by different techniques and effect of MS-PVD deposition parameters on coating microstructure have been investigated, no consideration has been given to the effect sputter cleaning has on the Zr/Cr interface. This investigation has focused on the influence of argon sputter cleaning bias and time on as-deposited Cr/Zr interfaces and initial coating growth, characterised by transmission electron microscopy techniques.

Multifunctional fibres based on nanomaterials for a new generation of wearable sensors

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Research Theme: Nano and Functional Materials

Year of Study (Presentation Type): Year 1 (Poster)

The development of novel wearable electronics, and wearable pH sensors in particular, are raising an increasing interest as they provide an avenue for non-invasive continuous health monitoring[1], for which strong and flexible fibres with good pH sensing performance are required. In addition, due to the small diameters typically necessary for wearable electronics, nanostructured polymer fibres emerge as the best possible option.

Polyaniline shows promise as the polymer matrix for the development of novel nanostructured pH sensors due to its easily accessible raw materials, electrical conductivity, and intrinsic and reversible pH sensing mechanism, whereas the addition of carbon nanotubes (CNTs) has been probed to enhance the properties and add new functionality.

This project aims to fabricate strong yet flexible, high-performance pH responsive polyaniline and polyaniline/CNTs nanocomposite fibres via wet spinning, using both in-lab synthesised and commercially available polyaniline as the polymer matrix.

The chemical, electrochemical, and mechanical properties alongside the pH performance of the fibres fabricated will be characterised/assessed and related to their microstructure and fabrication conditions, enabling synthesis and property optimisation and to gain control on fibre functionality for particular applications in the wearable electronics sector.

[1] Tang et al., 'Recent Advances in Wearable Potentiometric pH Sensors'.

Peptide controlled growth of photoactive lead halide perovskite materials for solar and photodetector applications

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Research Theme:
Nano and Functional Materials

Year of Study (Presentation Type): Year 1 (Poster)

Lead halide perovskite solar cells (PSCs) exhibit promising features, such as low manufacturing costs and high efficiencies. However, PSCs suffer from defects in the perovskite active layer affecting device efficiency, alongside poor stability, preventing commercialisation. It has recently been shown that peptide hydrogel additives can improve the stability of perovskite active layers and pacify defects in the perovskite crystal structure, with peptide hydrogels offering a sustainable route to achieving defect passivation and PSC device stability. These peptides form self-assembled structures and therefore could guide the growth of the lead halide perovskite, reducing defect formation and enhancing stability through the formation of quantum confined perovskite active layers. First, the adsorption of self-assembled peptide structures to metal oxides will be investigated, since metal oxides are used commonly as electron transport layers in PSCs. Secondly, the controlled growth of lead halide perovskites via self-assembled peptide structures will be explored, with the aim of determining if lead halide perovskite can be templated by self-assembled peptide structures. Finally, PSC devices will be assembled, to determine if controlling the growth of lead halide perovskite through self-assembled peptide structures improves the stability of PSCs and reduces defect formation in the active layer.

Abstract Template:

Thermostructural Study of Olivine-Type Phosphate Cathodes

Name: Beining Wang
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Research Theme: Select one of the following and delete the rest:
Nano and Functional Materials;

Year of Study (Presentation Type): Select one of the following and delete the rest: Year 1 (Poster)

Abstract body text; Times New Roman, Size 12; Left Justified; Max. 200 words; No figures or tables to be included.

Olivine phosphates are key materials bridging energy storage with mineral and planetary sciences. This project systematically investigates the olivine family—including Li- and Na-based phases (Fe, Co, Mn, Ni)—to determine how composition controls phase stability and structural response. Moving beyond a single-material focus, this work treats these phases as a comparative suite to understand the fundamental limits of their performance.

The research integrates X-ray diffraction (XRD), Rietveld refinement, Raman spectroscopy, and high-pressure experiments to map thermal expansion, compressibility, equations of state, and phase relations. Initial results establish structural baselines for LiFePO4, LiNiPO4, and NaFePO4, while variable-temperature studies probe their structural evolution. The long-term goal is to build a comparative framework explaining the links between structural robustness, polymorphic complexity, and degradation across the olivine phosphate family.

References

[1] M. Zhang, N. Garcia-Araez and A. L. Hector. J. Mater. Chem. A 2018, 6, 14483–14517.
[2] Padhi et al. (1997) J. Electrochem. Soc., 144, 1188–1194
[3] B. Meng, D. Fortes, G. Harrison, T. R. McElhinney and S. A. Hunt. Mag. 2025, 105, 1639–1653.

All PGRs presenting a talk or poster need to submit their final abstract **via the online form** by **17:00 BST 20th April.** Please save the document title as your year group followed by last & first name: Y_ LASTNAME_FIRSTNAME ABSTRACT. If you have any queries, contact fse.doctoralacademy@manchester.ac.uk

Functionalized MXenes as An Effective Electrolyte Additive for High-Performance All-Solid-State Lithium Batteries

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Research Theme: Nano and Functional Materials

Year of Study (Presentation Type): Year 1 (Poster)

Abstract body text:
This project investigates the development of functionalized MXenes as high-performance electrolyte additives to address the safety and energy density limitations of conventional lithium-ion batteries. While all-solid-state batteries (ASSBs) offer a safer alternative by replacing flammable liquid electrolytes with solid-state electrolytes (SEs), their widespread adoption is currently hindered by low ionic conductivity, interfacial instability, and the formation of lithium dendrites. To overcome these hurdles, the research focuses on synthesizing two-dimensional transition metal carbides, known as MXenes, through a novel electrochemical etching method that provides a safer, more controllable alternative to traditional hydrofluoric acid treatments.
The project systematically explores the functionalization of MXene surfaces with various terminal groups to enhance their compatibility with solid polymer electrolytes, such as PEO, and inorganic solid electrolytes. By incorporating these functionalized MXenes, the research aims to reduce polymer crystallinity, improve mechanical reinforcement, and establish stable interfaces that effectively inhibit dendrite growth. Through comprehensive electrochemical characterization, including impedance spectroscopy and galvanostatic charge-discharge testing, this work seeks to provide an innovative strategy for the integration of nanomaterials into next-generation energy storage systems, ultimately promoting the commercialization of high-safety, high-performance solid-state batteries.

Additive Manufacturing at the Nanoscale: Direct Writing of Compound Semiconductors

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Research Theme:
Nano and Functional Materials.

Year of Study (Presentation Type): Year 1 (Poster)

The work presented in this poster aims to explore a recently developed additive manufacturing technique for producing transition metal dichalcogenide (TMDC) semiconducting nanowires. Semiconducting nanowires have applications in areas such as optoelectronics and field effect transistors. Direct write electron beam lithography (DWEBL) is an emerging method to produce these features and has advantages over conventional methods, with the main one being the production of nanowires via selective chemical synthesis, rather than removal of material.

With this aim, a molybdenum thiocubane butyl xanthate precursor ($Mo_4S_4(iPrOCS_2)_6$) was synthesised and spin coated onto silicon substrates in order to form thin films which can decompose into MoS_2 under an electron beam. Both TGA and DSC showed that this decomposition took place when the precursor was in powder form – the annealing conditions of the films will be optimised and analysed with Raman Spectroscopy and XRD to ensure MoS_2 has still formed from the films.

The un-annealed films themselves showed through UV-Vis Spectroscopy that the thickness could be changing with the spin speed, as the wavelength of light reflected by the films decreased as the spin speed during coating increased. This would allow thickness control which is crucial for the prediction of the nanowire dimensions.

Enabling high-accuracy first principles modelling of nanoscale systems: many-body quantum embedding in linear scaling dft.

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Research Theme:
Nano and Functional Materials

Year of Study (Presentation Type): Year 1 (Poster),

Precise optical spectra predictions of use to experimentalist require an accurately predicted band gap. The band gap determines a material's electrical conductivity and optical behaviour: conductive materials such as metals have no band gap, while insulators have a large band gap.

Highly accurate computational methods for these predictions, such as the GW approximation and Bethe-Salpeter equation (BSE), are currently too computationally demanding to apply to many materials of practical interest due to cubic or greater scaling with system size.

ONETEP uses linear scaling density functional theory to enable property calculations for very large systems. In this project, we build on this framework to develop a linear scaling implementation of the GW approximation and BSE within Embedded Mean Field Theory to enable optical property calculations for much larger systems.

Point defects in solid state semiconductors are promising candidates for quantum information applications. Among these, is the tin vacancy (SnV) point defect in diamond because for their strong optical properties. However, during the formation of SnV an unknown defect (type II Sn) produces a photoluminescence peak at ~595 nm,[1] that has an unknown structure. This study aims to identify the structure of the type II Sn through computational simulations of candidate structures. The predicted optical and electrical properties are compared to experimental data. Simulations identify that the most promising structure of type II Sn is SnVH, where the H is in one of the half vacancies of the SnV split vacancy structure. Specifically, the positively charged SnVH centre in the triplet state is found to be the most stable configuration. This finding is consistent with experimental observations, where the defect retains C_3 symmetry, while the H causes the loss of inversion symmetry. These results suggest that hydrogen can be incorporated into split vacancy colour centres, breaking its symmetry and modifying its optical and electrical properties in a controlled manner, therefore allowing integration into quantum systems – provided these defects can be reliably engineered during quantum applications.

References

1. X. Cheng et al., Laser activation of single group-IV colour centres in diamond. Nat. Commun. 16, 1–12, DOI 10.1038/s41467-025-60373-5,(http://dx.doi.org/10.1038/s41467-025-60373-5) (2025).

As quantum applications are becoming increasingly developed, therefore, understanding qubits are essential for advancing these systems, in particular, point defects in solid state semiconductors are encouraging. One of the most promising candidates for quantum systems is the SnV point defect in diamond because of their strong optical properties. Specifically, this study aims to identify the structure of the unknown defect (type II Sn) that produces the photoluminescence peak at ~ 595 nm during formation of the SnV defect. Computational simulations were performed to obtain optical and electrical properties of the point defects, to compare with experimental data. This has resulted in the addition of a hydrogen into one half of the SnV split vacancy (SnVH) being the most promising defect candidate - furthermore, the positively charged SnVH defect in the triplet state is the most stable. Moreover, this matches experimental results where it has been found inversion symmetry has been lost while keeping C3 symmetry. This shows that the addition of H+ to the centre is stable, and therefore, there is potential for Hydrogen to be inserted into a known defect changing the properties slightly.

Opening hook is weak — Starting with a broad general statement ("quantum applications are becoming increasingly developed") is very common and doesn't grab attention. Consider opening with what makes your specific problem compelling.

Overall: The content is solid and the findings are interesting, but the abstract has some structural and grammatical issues that would benefit from tightening before submission.

Specific issues to address:

Opening sentence — It's awkward and grammatically fragmented. "As quantum applications are becoming increasingly developed, therefore, understanding qubits are essential" has a subject-verb disagreement ("qubits are" should be "understanding qubits is") and the "therefore" is misplaced. The mention of "qubits" also feels disconnected — your study is about point defects, not qubits directly.

"are encouraging" — Vague. Encouraging for what? Better to say something like "offer promising platforms for qubit implementation."

"because of their strong optical properties" — Slightly generic. If space allows, briefly specify (e.g., coherent spin-photon interface, narrow zero-phonon lines).

"unknown defect (type II Sn)" — Consider briefly explaining what "type II" means or why it's uncharacterised, so readers unfamiliar with the field aren't lost immediately.

"This has resulted in..." — Passive and slightly unclear about agency. Does "this" refer to the simulations? Rewrite as: "Simulations identify SnVH as the most promising candidate, with the positively charged triplet state being the most stable configuration."

"H+" — You've used "hydrogen" and "H+" interchangeably. Pick one convention and stick to it throughout.

Closing sentence — "there is potential for Hydrogen to be inserted into a known defect changing the properties slightly" is underwhelming as a conclusion. "Slightly" sells your result short. Try framing it as a broader implication: e.g., hydrogen incorporation as a route to tuneable defect properties in diamond quantum systems.

NASICON-type $Na_3Zr_2Si_2PO_{12}$ electrolyte for all-solid-state sodium batteries

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Research Theme: Nano and Functional Materials
Year of Study (Presentation Type): Year 1 (Poster)

All-solid-state sodium batteries hold tremendous potential for next-generation batteries owing to low-cost earth-abundant sodium resources. Among different solid-state electrolytes, NASICON (sodium superionic conductor, $Na_{1+x}Zr_2Si_xP_{3-x}O_{12}$, $0 \leq x \leq 3$) is a promising material discovered by Goodenough and Hong in 1976, with the advantages of 3D ion transport framework, wide electrochemical window, and excellent stability. When $x = 2$, monoclinic $Na_3Zr_2Si_2PO_{12}$ (NZSP) can reach the highest ionic conductivity (6.7×10^{-4} S cm^{-1}) at room temperature, which has become the standard material in the research.

However, compared to traditional liquid electrolytes (~ 10^{-2} S cm^{-1}), NZSP has the limitation of lower conductivity. To solve this, doping strategy has been widely studied recently, through which foreign atoms are introduced into the crystal lattice to modify the crystal structure and thus improve the material's overall sodium ionic conductivity. In this project, we plan to start with the basic single Ca-doping NZSP electrolyte, focused on the mechanism of improved conductivity and interfacial failure in the batteries with advanced characterization techniques. After that, multi-doping strategy and interfacial modification will be explored to further enhance the performance of NZSP electrolyte.

Transforming Supercapacitors for Direct Ocean Capture of Carbon Dioxide (SuperDOC)

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Research Theme: Nano and Functional Materials

Year of Study (Presentation Type): Year 1 (Poster)

Abstract:
Direct ocean capture (DOC) offers a promising complement to direct air capture because seawater contains significantly higher concentrations of inorganic carbon, potentially enabling lower-energy CO2 removal. This project proposes a new DOC strategy, termed SuperDOC, which uses supercapacitor-based capacitive swing processes to extract dissolved CO2 from seawater. We hypothesise that charging the electrode modulates local ion concentrations at the electrode–electrolyte interface, perturbs the carbonate equilibrium, and promotes CO2 release. To test this, electrochemical flow cells integrated with CO2 sensor, mass flow control and potentiostats will be developed for operation in simulated and real seawater. Commercial activated carbons will be used as first-generation model electrodes to evaluate capture performance and identify the effects of seawater composition, electrode structure, surface chemistry, pore characteristics, and operating conditions. Mechanistic studies and structure–property analysis will then guide the design of next-generation carbon materials derived from sustainable feedstocks. The project aims to establish the first mechanistic understanding and performance benchmarks for capacitive DOC, providing a foundation for the development of an energy-efficient, scalable, and sustainable ocean-based carbon removal technology.

Using Mechanochemistry to Monitor Polymer Degradation during Mechanical Recycling

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Research Theme: Polymers and Composites

Year of Study (Presentation Type): Year 1 (Poster)

The rise in global plastics use has led to an increase in plastics waste. Currently, mechanical recycling is one of the most environmentally friendly end-of-life pathways for plastics. However, recycled plastics are limited to lower-end applications due to their decreased mechanical properties. Polymer mechanochemistry is an emerging field involving the reconfiguration of molecules through mechanical force to produce materials with a potential for sensors and damage monitoring. Thus, the use of mechanically responsive units (mechanophores) in polymer networks can enable the tracking and quantification of polymer degradation during processing techniques. A system was designed for the mechanophore to be located at the centre of polycaprolactone (PCL) chains. This mechanophore-polymer mix was extruded and the resulting mechanophore activation was determined by fluorimetry. The low activation observed indicated that the stresses experienced by the polymer during extrusion were not suited for this system. Future work investigates how the directionality of the stresses experienced during other processes, e.g. compression moulding, impacts mechanophore activation. Our learnings will facilitate the utilisation of mechanochemistry in more common polymers e.g. polyethylene terephthalate (PET) to produce better quality recycled commodity plastics.

Development of Polymerisation Induced Self-Assembly (PISA) Systems with Controlled Mechanical Stability

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Research Theme: Polymers and Composites

Year of Study (Presentation Type): Year 1 (Poster)

Block copolymers (BCPs), polymers consisting of two or more different monomers arranged in 'blocks', have been extensively studied, ranging from industrial uses including coatings and adhesives to biomedical applications such as drug delivery and tissue engineering. They can self-assemble to form ordered structures via polymerisation induced self-assembly (PISA), an effective technique used to bring about nanoparticles with different morphologies, such as vesicles and cylinders. An intriguing aspect of these BCP nanostructures is how they may respond to mechanical triggers like compression, stretching, and shearing. However, adjusting the BCP's physical properties to achieve control over the resulting mechanical stability of these nanostructures is yet to be explored in detail. This is particularly true when applied in a biomedical setting such as drug delivery. To that end, this project will involve the synthesis of numerous BCP nanostructures via RAFT-mediated (reversible addition-fragmentation chain transfer polymerisation) PISA and investigating how the physical properties of blocks can be tuned to yield different mechanical stabilities. Concerning drug delivery as a potential application, this level of control will be especially crucial such that the resulting nanoparticle formulations can be efficiently administered and the drug released, hence a specific level of mechanical stability will need to be targeted.

Simulating Percolation and Conductivity for 2D nanocomposite systems

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Research Theme: Polymers and Composites

Year of Study: Year 1 (Poster)

Abstract:
This research investigates the electrical percolation behaviour of nanocomposites by systematically bridging microscopic geometric connectivity with macroscopic transport properties through a Monte-Carlo-based resistor network model governed by Kirchhoff's laws. By evaluating the impact of real-world physical constraints, we find that applying a distribution of junction resistances with varying coefficients of variation yields negligible fluctuations in the critical exponent t which is defined by the classical power-law relationship $\sigma_0 = \sigma_0(p - p_c)^t$. Crucially, our results demonstrate that the scaling exponent t is decoupled from both geometric anisotropy and local junction resistance distributions. However, this universality is broken by the introduction of a coordination number limit (Z_{max}), which represents a fundamental topological constraint, which fundamentally reconstructs the network topology and induces a significant decrease in the exponent t. This behaviour is explained by the dual role of Z_{max}, which initially acts as a structural filter to optimise pathway distribution before triggering a rapid deceleration in conductivity growth as the connectivity limit is reached. This comprehensive framework offers a high-fidelity prediction of the electrical properties of anisotropic systems, with future efforts focused on extending this model into the 3D realm to encompass complex geometries such as rods, spheres, and stacked graphene-like polygons.

Deconstructing Blended Textiles via Solvolysis

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Research Theme: Polymers and Composites.

Year of Study (Presentation Type): Year 1 (Poster)

Fossil fuel derived polymers have become almost entirely unavoidable in day-to-day life. Plastics have weaved their way into the human experience, and fashion has been no exception. The textile industry has become increasingly reliant on fossil fuels, with plastic-based textiles making up an increasingly tremendous portion of global fibre production each year. Still, there are no large-scale industrial systems in place to efficiently and effectively recycle textile products at the end of their life. Textiles made up of multiple fibre types are particularly challenging to recycle, but multi-fibre textiles are abundant and currently face incineration or landfilling after their useful life has concluded. This end-of-life fate will persist without a suitable alternative. This research explores routes of solvolysis, a solvent based chemical recycling method, to deconstruct fibrous polymers and recover the individual components of blended textiles, particularly in blends with polyester and cellulosic fibres. The goal is to achieve recovery of the induvial components and to understand their properties to identify applications that allow for new life in a high-quality form.

Machine Learning Approaches for Polymer FTIR Spectra: From Spectral Preprocessing to Property Prediction

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Research Theme: Polymers and Composites.

Year of Study (Presentation Type): Year 1 (Poster)

Fourier Transform Infrared (FTIR) spectroscopy is widely used for polymer characterisation; however, extracting meaningful insights from spectral data remains challenging due to variations in intensity, baseline, and noise. This project investigates the application of machine learning (ML) techniques to enhance the analysis of FTIR spectra of polymers, with a focus on high-density polyethylene (HDPE).

The study systematically evaluates the impact of spectral preprocessing methods, including normalisation, Standard Normal Variate (SNV), and derivative transformations, on data structure and model performance. Unsupervised techniques such as Principal Component Analysis (PCA) are used to explore clustering behaviour, while supervised models are developed for classification tasks, including distinguishing between virgin and recycled polymers.

In addition, the potential of FTIR spectra to predict material properties, such as Melt Flow Index (MFI), is explored. Preliminary results indicate that preprocessing plays a critical role in improving model robustness and interpretability.

This work aims to establish a data-driven framework for polymer analysis, supporting more reliable classification and property prediction, and contributing towards the development of intelligent, AI-assisted spectroscopic tools.

Controlling Y6 Morphology via Solution Processing Engineering to Enable High-performance Organic Optoelectronic Devices

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Research Theme: Polymers and Composites

Year of Study (Presentation Type): Year 1 (Poster)

Y6 has been popular and widely used in the field of organic optoelectronics due to its various benefits like broad and strong light absorption, low energy loss and efficient charge transport. However, the regulation of its microstructure along with how the structure will impact on the performance of relevant devices remains valuable to be study. Here, we have tried different solution processing strategies to control the Y6 morphology. Characterization methods such as cross-polarized optical microscopy (POM) and grazing incidence wide-angle X-ray scattering (GIWAXS) are applied to gain some deep understanding of its self-assembly behaviours. Through POM, some special microstructures and anisotropic features of molecular stacking formed form different processing conditions were found directly; through GIWAXS, some information of molecular aggregation, orientation and crystallinity were revealed. These findings all pave the way for the development of Y6-based optoelectronic devices like organic photovoltaics (OPVs) and photon up-conversion (UC) films. In the future, we will first focus on the optimization of performances of OPVs and UC films based on the morphology we have got now. Moreover, more advanced morphology-controlling methods like additives and high-entropy strategy will be adopted to further control the optimal microstructures to get a better understanding of processing-structure-performance relationships.

A Novel Joining Approach for Braided Composite Tubular Structures

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Research Theme: Polymers and Composites.

Year of Study (Presentation Type): Year 1 (Poster)

Composites are extensively used throughout aerospace and marine industries for their low-weight/high-strength properties, improved stiffness, durability, and wear resistance. When manufacturing more complex shapes and composite structures, effective joining methods are required.

Current methods include mechanical fastening approaches i.e. bolts and rivets, adhesive bonding, and hybrid approaches. However, these methods give rise to issues that adversely affect the mechanical performance of composite structures. Mechanical joints introduce stress concentrations and fibre discontinuity, leading to reductions in strength. Similarly, adhesive bonding may cause disbonding and delamination.

This project aims to develop a novel approach to joining a woven panel to a braided tubular composite. Braided/woven composites will be manufactured via Vacuum-assisted Resin Infusion, to study the manufacturing parameters. Through-the-thickness reinforcement techniques will be considered in the design and manufacture of a novel joint.

Furthermore, the environmental conditions experienced influence the mechanical properties of composites. Therefore, the effects of high temperature and moisture on the mechanical behaviour of braided/woven composites and manufactured joint will be assessed.

Evaluating manufacturing parameters and mechanical properties of braided composites alongside the assessment of different joining techniques provides a model towards adapting enhanced joining techniques for braided composites, a key aspect to improving their performance in industry.

Tools for Predicting and Improving the Quality of Recycled Plastics

Abstract:

The transition towards a circular economy is constrained by the inconsistent quality of recycled plastics relative to their virgin counterparts. Mechanical recycling, while environmentally and economically favourable, induces polymer degradation and introduces contamination from heterogeneous waste streams. This leads to significant batch-to-batch variability. This limits the reliable use of recycled plastics in high-performance applications. To understand the complex structure-property relationships of recycled plastics, strong analytical tools are needed. Current industrial characterisation methods are often slow, low-resolution, and insufficiently sensitive to early-stage molecular degradation.

This poster reviews conventional polymer characterisation techniques and highlights emerging data-driven, multi-modal and high-throughput approaches for assessing recyclate quality. Standard thermal, mechanical, and spectroscopic methods are evaluated alongside machine-learning-assisted strategies and recent technological advancements such as MADSCAN, a new high-volume thermal characterisation technique. Small Punch Testing (SPT) and Optimally Windowed Chirps (OWCh) are presented as promising high-throughput alternatives to conventional methods. Integrating advanced characterisation techniques, data-driven methods, and the use of uncertainty-aware frameworks is proposed as a pathway towards quality metrics capable of supporting industrial decision-making and accelerating the valorisation of recycled plastics.

Modelling and Simulation of Bearings' Failure Modes

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Research Theme: Polymers and Composites.

Year of Study (Presentation Type): Year 1 (Poster)

Bearings are widely used in industries and considered as one of the most frequently replaced parts in rotating machinery. In oil and gas industry, rotating equipment is essential and their unplanned failures could cause safety and financial impacts. Thus, enhancing the reliability of such equipment through identifying the most reliable bearing materials for rotating equipment based on the fleet operating philosophy is imperative to operating organizations. This can be achieved by finding means of minimizing failures and increasing bearing lifetime.

Using Bespoke Copolymers to Improve the Stability of Perovskite Solar Cells

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Research Theme: Polymers and Composites

Year of Study (Presentation Type): Year 1

Perovskite solar cells (PSCs) have achieved remarkably high power conversion efficiencies and can be fabricated through solution processing, making them promising candidates for next-generation photovoltaic technologies. However, poor operational stability remains a major barrier to their widespread application. One important source of instability is the presence of defects within perovskite films. Although small-molecule additives are commonly used for defect passivation, they can suffer from diffusion and migration and are often ineffective at addressing multiple defect sites simultaneously.

This project explores the use of bespoke copolymers as multifunctional additives to improve PSC stability. By tailoring copolymer structure and functional groups, the work aims to target multiple defect sites more effectively than conventional small molecules. The project involves the synthesis and characterisation of selected copolymers, followed by the preparation and analysis of perovskite films containing these materials. Devices will then be fabricated to evaluate the influence of copolymer incorporation on film properties and photovoltaic stability. Establishing relationships between copolymer structure, perovskite film structure, and device performance will provide a basis for designing optimised copolymers for more stable PSCs.

Development of Embedded Microfluidic Platform for Flow-Induced Polymer Degradation Studies

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Research Theme: Polymers and Composites.

Year of Study (Presentation Type): Year 1 (Poster)

In many solution-based processing operations, polymer solutions pass through nozzles or locally contracted flow regions[1], for example in inkjet printing, electrospinning, spray coating, and wet spinning. Under these conditions, polymer chains can experience significant stretching, leading to chain scission, molecular weight reduction, and changes in material performance.[2] Understanding flow-induced polymer degradation therefore requires controllable experimental platforms that can reproduce key features of industrial nozzle flows under laboratory conditions.

Microfluidic platforms are well suited to examine the flow behaviour of polymer solutions because they provide well-defined channel geometries, optical accessibility, and precise control over local flow fields.[2] Microfluidic platforms have already been used to probe flow-induced degradation, viscosity loss, and scission of polymer solutions under controlled conditions.[3][4] However, conventional soft lithography limits rapid prototyping of different nozzle geometries, while 3D printing offers design flexibility but insufficient resolution.[5] An embedded microfluidic platform was developed by integrated a small insert containing precisely defined microscale flow features into a support body. This work will characterise polymer solutions to investigate how nozzle geometry affects degradation. This will address the limited understanding of how mechanical forces are transmitted to polymer chains under realistic processing conditions and how this contributes to polymer degradation during industrial manufacturing processes.

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Title: **The Causes and Mitigation Strategies of Microfibre Release During Textile Manufacturing**

Microfibres are fibres that are 5mm or less (Allen et al., 2024) shed throughout the textile lifecycle during manufacturing, use, and end-of-use stages (The Microfibre Consortium and Fashion For Good, 2025). Since it was discovered that microfibres shed during laundering were present in sewage systems and the environment, research surrounding microfibres has predominantly focussed on the use stage (Browne et al., 2011). Recently, however, Raja Balasaraswathi and Rathinamoorthy (2025) have argued that the shedding of microfibres in the manufacturing stage is of greater concern than in the use stage. These invisible airborne microfibres shed during manufacturing of textile products have the potential to be inhaled by textile workers, resulting in significant health impacts.

This project aims to quantify microfibres shed during textile manufacturing processes and to identify shedding hotspots. Once these hotspots have been analysed, mitigation strategies will be developed to ensure the health of textile workers is not impacted. With 1 in 8 workers globally being involved in textiles production, and with this industry showing no sign of decreasing, it is paramount to address this global problem by establishing ways to mitigate the health impacts of this invisible threat (Common Objective, 2018, Textile Exchange, 2025).

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The Benefits and Limitations to Textile Recycling Technology in Panipat, India

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Year of Study (Presentation Type): Year 1 (Poster)

India has a long-standing reputation for reusing and repurposing textile waste, from the ancient crafts of *kantha* and *chindi* to becoming world leaders in industrial mechanical textile recycling. This traditional culture of reuse and reworking of textiles, alongside the availability of textile technology, has enabled a thriving infrastructure for recycling textile waste. The city of Panipat in Northern India, known historically for its weaving heritage has recently flourished as a textile recycling hub that imports waste globally and is described as world-leading in this field. However, there are limitations to these systems that are hindering the effectiveness of the technology in becoming completely circular. These issues are closely linked to the large informal sector in India, which collects, sorts, distributes, and recycles textile waste. Although many of these industries are silently contributing to a circular economy, justness concerns, such as working conditions and employment security remain a significant problem. The apparent volume of waste imported to Panipat from the Global North is currently neither quantified nor clear. This, combined with the predominance of downcycling over truly circular outcomes in Panipat's textile recycling system, creates gaps in the scholarly research on this subject.

Engineering of Functional 3D Knitted Spacer Fabrics for Medical and Sportswear Applications

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Research Theme: Textiles and Apparel

Year of Study (Presentation Type): Year 1 (Poster)

Abstract
Three-dimensional knitted spacer fabrics have attracted increasing attention for medical support, sports protection and wearable functional clothing because they can provide thickness-direction support, cushioning recovery, air circulation and structural space for functional integration while maintaining textile softness. Unlike traditional two-dimensional fabrics, which often rely on additional foam, padding layers or multilayer composite structures to achieve cushioning and support, spacer fabrics form an integrated three-dimensional support system through two surface layers and an intermediate connecting layer. This structural feature gives them potential advantages in comfort, breathability and mechanical response.
However, their performance in real wearing conditions is not determined by thickness alone. Body surface curvature, soft tissue variation and repeated movement may cause local air gaps, unstable contact and uneven support, thereby affecting pressure regulation, thermal and moisture transfer and functional stability. For medical and sportswear applications, spacer fabrics therefore need to be considered as engineered structures whose thickness, compression behaviour, recovery stability and surface conformity are closely related to knitting parameters. Understanding these relationships is essential for developing locally controlled spacer structures that can better adapt to three-dimensional body contours and provide stable support under practical wearing conditions.

Abstract:

An Asymmetric Sparse-Dense Detection Framework for Yarn Package Defects

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Research Theme: Textiles and Apparel;
Year of Study (Presentation Type): Year 1 (Poster)

Automatic detection of surface defects in polyester yarn packages is vital to modern textile manufacturing but remains challenging because of extreme size and semantic heterogeneity, inter-class similarity, dense targets, and highly repetitive background textures. Although up-to-date transformer-based detectors offer strong global reasoning capability, their one-to-one sparse set prediction paradigm is not efficiently aligned with the defect distribution in yarn package inspection. Within a limited query budget, dense micro-defects and sparse structural defects compete for shared attention capacity, causing inefficient allocation and suboptimal performance.

To address this issue, we propose an asymmetric sparse–dense end-to-end detection framework that incorporates a lightweight high-resolution CNN branch with transformer-based structured reasoning. Rather than directly taking the union of dense and sparse predictions, our proposed framework maintains an end-to-end detection paradigm explicitly through a unified Hungarian matching scheme and a matching-based assignment dense branch supervision strategy. In addition, a reference-guided cross-attention mechanism is introduced to implicitly encourage task allocation between the two branches and alleviate duplicate predictions.

Experiments on a six-class high-resolution polyester yarn package defect dataset prove that our proposed methods increase mAP@50 by 4.6 points compared to baseline RT-DETR, while reducing GFlops by 5%, boosting FPS by 15% and adding only a 3% overhead in model parameters.

Abstract Template:

Multifunctional Ceramic Coatings on Absorbable Mg Based Implants

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Research Theme:
Metallurgy and Corrosion;

Year of Study (Presentation Type): Select one of the following and delete the rest: Year 1 (Poster)

Additive manufacturing (AM) is an increasingly important approach for producing biodegradable magnesium (Mg) implants, as it enables complex, patient-specific designs while taking advantage of Mg's favourable mechanical properties, biocompatibility, and ability to gradually degrade in physiological environments. Unlike permanent metallic implants, biodegradable Mg devices can provide temporary support during healing without requiring secondary removal surgery. Among Mg alloys, WE43 is particularly promising due to its relatively high strength and improved corrosion resistance. Sinter-based material extrusion offers a low-temperature AM route suitable for reactive metals such as Mg, but its influence on WE43 degradation behaviour remains unclear. In addition, Plasma Electrolytic Oxidation (PEO) provides a promising surface treatment for improving corrosion resistance through tailored ceramic-like oxide coatings. This project investigates the combined effects of additive manufacturing and PEO surface modification on WE43 magnesium alloy to develop biodegradable implants with controlled and clinically relevant degradation rates.

Technology and Engineering Integration to Enable Inclusivity in Fashion.

Name: Lucy Parnell
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Research Theme:
Textiles and Apparel;

Year of Study (Presentation Type): Year 1 (Poster),

Advances in 3D body scanning technologies provides product developers and ergonomists the opportunity to capture large amounts of body measurement data, quickly and efficiently. When compared to traditional methods of measuring, scanning provides robust, repeatable results. By embedding 3D scanning into production pipelines these measurements can be used to evolve traditional patternmaking practices to develop bespoke engineered patterns and products.

Processing and analysis of scan data must be considered in production pipelines to further explore the implications of body measurement relationships and ratios observed in population data sets to inform the development of bespoke engineered products.

Body scanning has high-cost implications and is not accessible to all. Large scale national surveys undertaken with the technology are impressive but often behind a pay wall.

This research establishes how 3D body scanning technologies, processes and bespoke engineered patterns can be repositioned to support inclusive, community-centered fashion practice to enable inclusivity within the fashion industry and equitable access to technology and garments engineered to fit.

A Hyperspectral Imaging and Deep Learning Framework for Fabric Composition Verification

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Research Theme: Textiles and Apparel
Year of Study (Presentation Type): Year 1 (Poster)

Abstract
In the context of the global textile industry's transition towards sustainability and supply chain transparency, verifying fabric composition authenticity has emerged as a critical governance challenge. Traditional chemical analysis methods are constrained by their destructive nature, limited scalability, and poor integration with digital product information systems. To address these limitations, this study proposes a fabric composition verification framework that integrates hyperspectral imaging with geometry-aware deep learning. A systematic dataset of 899 fabric samples is constructed under standardised protocols. By introducing K-means clustering for structured spectral abstraction and frequency-domain transformations to characterise intrinsic signal patterns, one-dimensional spectra are reconstructed into three-dimensional point cloud representations.

PointNet is subsequently employed to enable geometry-aware learning of spectral fingerprints. Experimental results demonstrate that the proposed method outperforms conventional statistical models and sequence-based deep learning approaches, achieving 97.33% accuracy at the 5% error tolerance threshold for blended fabric identification. By shifting from direct spectral classification towards structural representation learning, this framework establishes a reproducible and scalable technical pathway for material verification, offering a feasible foundation for enhancing information reliability within Digital Product Passport systems.

TOM BIRD-JONES Y1 POSTER CONFERENCE ABSTRACT

The fashion industry is becoming more conscious of environmental concerns, although bio-based leather substitutes are still not widely used. This study investigates the gap between consumers' claimed values and their actual purchase habits using a phenomenological research approach and industrial experience.

Understanding lived customer experiences with bio-leather is the main goal of the study, which also looks at how decision-making is influenced by perceptions of cost, durability, trust, and material unfamiliarity. Although industry narratives portray bio-leather as a sustainable innovation, consumer reluctance endures, suggesting that technological advancements by themselves are not enough to promote adoption.

A two-stage qualitative approach is used. Wearer trials and diary studies that record how perceptions change as a result of direct interaction with the material come after initial interviews that record baseline attitudes and presumptions. A more thorough examination of the ways in which acceptance, trust, and meaning are created throughout time is made possible by this phenomenological approach.

The results are intended to emphasise the crucial role that perception plays in preventing adoption, supporting observations from industry experience that sustainability messaging frequently fails in the absence of clarity and trustworthiness. Successful bio-leather integration into fashion markets depends not only on material performance but also on matching consumer experience with open communication and trust building tactics.

Self-Powered Janus Piezoelectric Scaffolds for Accelerated Wound Regeneration: Synergizing Stereocomplex Crystallization and Flexible Encapsulation

Abstract: We developed an **asymmetric multilayer self-powered wound patch** for enhanced wound repair by integrating an outer **Ecoflex backing**, an aligned **PLLA/PDLA stereocomplex piezoelectric layer**, an **MXene conductive antibacterial interlayer**, and a **hydrated bioactive wound-contacting interface**. Unlike fully encapsulated systems, this design preserves direct wound compatibility while maintaining mechanical robustness. Under physiological deformation, stress is concentrated onto the piezoelectric layer to generate localized electrical stimulation. The optimized **PLLA/PDLA (5:5)** composition promotes stereocomplex crystallization, leading to improved dipole coupling and piezoelectric performance. The MXene interlayer provides antibacterial protection against **E. coli** and **S. aureus** while maintaining conductive function. Meanwhile, the hydrated wound interface enhances **fibroblast adhesion, spreading, migration, and cell-material interaction**, supporting **Fibronectin and Collagen expression**, extracellular matrix deposition, and tissue reconstruction. This study provides a promising strategy for intelligent self-powered wound dressings with combined electromechanical, antibacterial, and bioactive functions.

Guiding Attitudes Towards AI Agents Enabling Sustainable Fashion Consumption

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Research Theme: Select one of the following and delete the rest:
Fashion Management and Marketing;

Year of Study (Presentation Type): Select one of the following and delete the rest: Year 1 (Poster)

My project aims to generate actionable insights that support the effective adoption of AI agents as tools for guiding more sustainable fashion consumption, for both brands and consumers. Considering on emerging evidence that consumers face a significant attitude-behaviour gap in sustainable decision-making, and that AI systems are increasingly embedded across the fashion value chain (conversational agents, agentic recommendation systems etc), the research will review academic literature alongside contemporary industry journalism and report analyses to map current use cases and identify opportunities for AI-mediated behavioural guidance. Alongside this, interviews with industry professionals (including sustainability strategists, technologists, and brand founders) will identify real-time challenges, barriers to adoption, and strategic imperatives within the sector. This mixed-methods approach will inform a grounded understanding of how AI agents can be designed to translate sustainability complexity into meaningful guidance that supports conscious consumption practices.

Title: Beyond the Wardrobe: Digital Collective Ownership in Preloved Luxury Fashion

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Research Theme: Fashion Management and Marketing

Year of Study (Presentation Type): Year 1 (Poster)

Abstract:

Digital Collective Ownership (DCO) is an emerging phenomenon in the luxury sector, it describes digitally enabled models where multiple consumers can share value, access, and selected decision rights of a single asset. This challenges the traditional assumption of individual ownership. As resale markets grow rapidly and digital platforms reshape exchange, luxury ownership may be moving into a new phase.

The study takes a qualitative management perspective, adopting a three-stage research design focusing on the preloved luxury market. First was a systematic literature review synthesising fragmented work from luxury management, access-based consumption, psychological ownership, platform ecosystems, and digital asset studies. Initial findings from 20 reviewed articles suggest growing tensions between established luxury ownership logics and these newer collective models. Across five strategic domains: ownership structure, governance, value, infrastructure, and identity, the literature points to an evolution of exclusive possession ("MINE") toward more fluid and participatory forms of ownership ("OURS"). This suggests future luxury value may depend not only on scarcity and status, but also on access, community, and coordinated participation. The next stages of the project will use the Delphi technique and speculative futures workshops to explore how brands may respond and what new business models could emerge in post-possession luxury markets.

Beyond Abstraction to Synthetic Photorealism: Consumer Affective and Cognitive Responses to Visual Generative-AI Fashion Advertising

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Research Theme: Fashion Management and Marketing

Year of Study (Presentation Type): Year 1 (Poster)

Generative-AI advertising is rapidly developing, in some cases, AI-generated adverts are evaluated more 'realistic' than human-made (Hartmann et al., 2025), due to advances in AI technology and minimal policy guidance about disclosing creative AI authorship. Specifically, notable fashion brands attained exposure due to artistic uses of AI, eliciting mixed consumer responses (Crawford, 2026). Fashion advertising is an inherently creative domain (Phillips & McQuarrie, 2010), but past research failed to explore the psychological consequences of viewing AI-generated fashion advertising, despite calls for studying advertising in creative contexts (Demsar et al., 2025). This research examines emotional and cognitive responses to such adverts, through abstracted or photorealistic images, assessing effectiveness of realistic representations of humans and fashion products, or abstract artistic images. Drawing on Construal Level Theory (CLT) (Liberman et al., 2007), it will enrich literature on CLT and advertising, particularly deepening understanding about how psychological distance in AI-generated advertising shifts consumer behaviour (Khodakarami et al., 2025), particularly in fashion campaigns. Experimental methodology will uncover neurophysiological reactions to advertisements, alongside qualitative interviews. Findings will inform fashion advertisers on effective creative AI use and adds to a growing demand for empirical methods in fashion research (Hur et al., 2023).

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Fashioning Independence: Investigating how digital wardrobe applications can aid neurodivergent dressing practices.

Abstract

This PhD project on *Fashioning Independence*, explores how digital wardrobe applications can support the dressing practices and wellbeing of neurodivergent individuals. This project aims to address a gap where existing digital wardrobe applications prioritise general organisation and sustainability, while overlooking additional clothing barriers, including sensory, cognitive, and emotional needs that many neurodivergent individuals face on a day-to-day basis. This is a qualitative study that aims to adopt a user-centred, mixed-method approach from social media content analysis, focus groups, and workshops to investigate the lived experiences of neurodivergent individuals and their dressing challenges and explore how digital wardrobes could eliminate any barriers of self-expression through clothing and dress alongside existing coping strategies. This project's aim is to use these insights to produce evidence-based design guidelines to inform which design principles can support digital wardrobe developers and fashion technology companies to create accessible and inclusive digital wardrobe applications that can help in supporting autonomy and self-expression of neurodivergent individuals.

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Faculty of Science and Engineering
POSTGRADUATE RESEARCH

Day 2 - Thursday, 21st May

Y3 Poster Abstracts

A Stable PB/NiHCF–MIP Electrode for Sweat Glucose Monitoring: Toward wearable non-invasive monitoring of diabetes biomarkers

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Research Theme: Biomaterials;
Year of Study (Presentation Type): Year 3 (Poster)

Wearable sweat glucose sensors offer a promising non-invasive alternative to blood sampling, but many enzyme-based systems suffer from poor long-term stability under sweat-relevant conditions. In this work, a flexible carbon-thread electrode was developed using a Prussian Blue/nickel hexacyanoferrate (PB/NiHCF) redox layer combined with a polypyrrole/3-aminophenylboronic acid (PPy/APBA) molecularly imprinted polymer (MIP) for enzyme-free glucose sensing.

Electrochemical testing showed that PB/NiHCF provided substantially greater stability than PB or PB/CuHCF during repeated cycling and at pH 5–7, maintaining the most stable current response at pH 7. Cyclic voltammetry and electrochemical impedance spectroscopy confirmed successful formation of the PPy/APBA MIP layer and the creation of glucose-selective cavities after template removal.

The resulting PB/NiHCF/MIP electrode exhibited a concentration-dependent chronoamperometric response toward glucose in artificial sweat, with a linear range of 0–200 µM, sensitivity up to 0.333 $\mu A\ \mu M^{-1}$, and a limit of detection of 6.3 µM. The MIP electrode showed higher response and improved selectivity compared with a non-imprinted control, with minimal interference from common sweat constituents.

These results demonstrate a stable, selective and enzyme-free platform for future wearable monitoring of glucose and other sweat biomarkers.

Development of advanced bone biomaterials using cell-derived extracellular matrix

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Research Theme:
Biomaterials
Year of Study (Presentation Type): Year 3 (Poster)

Critical-sized bone defects resulting from tumours, infection, disease, or trauma do not heal spontaneously and therefore require advanced strategies for effective repair. Three-dimensional (3D) printed scaffolds offer a promising approach because their porosity, architecture, and geometry can be tailored to match the defect and support tissue regeneration. Human bone marrow mesenchymal stem cell (MSC)-derived extracellular matrix (ECM) provides a heterogeneous mixture of proteins and bioactive cues that more closely mimic the native cellular microenvironment and can support cell adhesion, proliferation, and differentiation. As an initial step, we evaluated the dose-dependent modulation and spatial homogeneity of MSC behaviour using 2D ECM models. The aim of this study was to develop and evaluate a droplet-printed oxidised alginate–ECM bioink that provides a biomimetic microenvironment for bone marrow MSCs and promotes osteogenic differentiation.

Pro-angiogenic brush polymer dermal matrices for enhanced wound healing

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Research Theme: Select one of the following and delete the rest:
Biomaterials;

Year of Study (Presentation Type): Select one of the following and delete the rest: Year 3 (Poster)

The treatment of large skin trauma and burns remains a significant healthcare challenge because the "take" of traditional grafts relies on slow oxygen diffusion. This project developed a bioactive, acellular dermal substitute using a novel bottle-brush polymer enriched with an angiogenic peptide to induce rapid vascularization and improve the integration of skin substitutes.

The polymer was synthesized through a highly efficient five-step process with yields exceeding 90%. Success and purity were confirmed via Nuclear Magnetic Resonance (NMR), Gel Permeation Chromatography (GPC), and FTIR-ATR, while TGA and ICP-MS provided data on thermal stability and elemental composition. Tensile testing further confirmed that the scaffold maintains the mechanical properties necessary for clinical handling and surgical application.

Biological performance was evaluated across three scales. In vitro assays using human dermal fibroblasts and HUVECs demonstrated excellent biocompatibility and cell proliferation. An ex vivo Chorioallantoic Membrane (CAM) assay revealed that the scaffold actively attracted blood vessels and increased vascular branching.

This study successfully demonstrates a novel dermal substitute with potent angiogenic properties. This novel dermal scaffold offers a promising solution for treating large skin defects and severe burns by addressing the critical need for rapid blood vessel integration, ultimately improving patient recovery and clinical outcomes.

Materials for 3D Printed Soft Robotic Phantoms

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Research Theme: Biomaterials
Year of Study (Presentation Type): Year 3 (Poster)

A MRI phantom is a that replicate tissue imaging characteristics such as contrast and signal intensity. They provide standardized images for scanner calibration, personnel training, the development of new imaging methods. Conventional MRI phantoms use simple moulds (e.g. cylinders) filled with aqueous fluids such as Gd^{3+}, Cu^{2+}, Mn^{2+} salts, or gels such as agarose, gelatin, carrageenan to enable specified MR T_1 and T_2. However, water-based phantoms can neither produce anthropomorphic phantoms, nor simulate the regional heterogeneity, nor the anisotropy of human tissue physiology.
Here we reported a silicone–silicone oil–gelatin (SSOG) system for anthropomorphic phantoms manufacture. This allows a variation in T_1 ranging from 1245 ms to 2242 ms, and T_2 ranging from 14.4 ms to 389 ms. The T_1 and T_2 values of the SSOG materials both increased as the weight fraction of gelatin gel increased. By varying the composition of the gel formulations, it is possible to mimic the T_1 and T_2 values of a range of human tissues and with and without disease pathology. Finally, we fabricated human brain MRI phantoms using extrusion-based 3D printing, these successfully demonstrate MRI visibility and tissue matched contrast.

Gelatin/Hydroxyapatite Composite Cryogel Scaffolds for Bone Tissue Engineering

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Research Theme: Biomaterials.

Year of Study (Presentation Type): Year 3 (Poster)

Bone tissue engineering requires porous, biocompatible scaffolds that support cell infiltration, attachment, and mineralisation. This study investigates the fabrication and characterisation of gelatin/hydroxyapatite (HA) composite cryogel scaffolds produced via thermally induced phase separation (TIPS) and freeze-drying. Fish gelatin concentrations of 10%, 20%, and 30% w/v were combined with micro-HA (60 µm) and nano-HA (20–50 nm) at loadings of 0, 5, 10, and 30 wt%, and frozen at two rates, liquid nitrogen and −80°C to systematically investigate the effects of composition and freeze rate on scaffold pore architecture and morphology.
Scanning electron microscopy revealed a clear concentration-dependent structural transition: 10% gelatin produced anisotropic lamellar pores, 20% yielded an equiaxed honeycomb morphology, and 30% formed a dense interconnected sponge. Rapid freezing in liquid nitrogen generated finer, more directional pore structures compared to the slower −80°C freeze rate, demonstrating that thermal history critically governs scaffold architecture.
Building on this platform, cryo-clicked porous hydrogels are being developed via tetrazine–norbornene click chemistry, exploiting a controlled six-stage temperature protocol from liquid nitrogen through −80°C, −20°C, −8°C, and 4°C to room temperature to crosslink the network in situ during gradual thawing, eliminating freeze-drying. Future work will extend this approach to additively manufactured three-dimensional composite scaffolds targeting clinically relevant bone repair.

Optimisation and Characterisation of Sustainable Medical use Disinfection Wipes

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Research Theme: Biomaterials;

Year of Study (Presentation Type): Year 3 (Poster)

The environmental impact of petrochemical products, in particular, single-use disinfectant wipes has been well documented, leading to their eventual phase-out and replacement with more environmentally friendly alternatives. Cellulose and its derivatives like viscose and rayon are now the primary fibre of choice for biodegradable wipes.
Soiled medical products have strict disposal policies, often ending up incinerated, or adding to active landfill sites. However, an unexplored route is home disposal of biodegradable wipes. Home composting sites have their own unique microbiome which could be capable of degrading cellulose-based wipes if the cellulase enzyme complex is present.
To investigate this, ISO 20200 was adapted into a scaled down, laboratory appropriate method in which 10 wipes were subjected to home composting conditions in home-made reactors for 12 weeks. Saraco, the industry partner associated with this project, requested the inclusion of 6 of their domestic, biodegradable wipes as well as providing competitor products for comparison, resulting in 8 biodegradable wipes and 2 plastic-based wipes being investigated.
The physical composition of the wipes will be analysed as well as including next generation sequencing of the reactors to further investigate the capabilities of the compost microbiome.

More than just “bacterial fat”? – Melt electrowriting of medium-chain-length polyhydroxyalkanoates

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Research Theme: Biomaterials

Year of Study (Presentation Type): Year 3 (Poster)

Bacterial polyhydroxyalkanoates (PHAs) are sustainable, biocompatible, and bioresorbable polymers with growing potential in biomedical applications. However, their use in high-resolution biofabrication techniques such as melt electrowriting (MEW) remains limited due to insufficient understanding of their processing behaviour compared to established materials such as polycaprolactone (PCL).

This study evaluates the suitability of a medium-chain-length PHA (mcl-PHA) for MEW by linking thermal and rheological properties to processing performance, structural fidelity, and biological response. mcl-PHA was synthesised via microbial fermentation and characterised using thermogravimetric analysis, differential scanning calorimetry, and oscillatory rheology. These data informed the MEW processing window, with fibre morphology assessed by light and scanning electron microscopy. Biocompatibility was evaluated with a resazurin-based metabolic assay and LIVE/DEAD™ fluorescence staining.

mcl-PHA showed low crystallinity, a negative glass transition temperature (~ −40 °C), and low melt viscosities (300–550 Pa·s), enabling MEW at 40–50 °C and 0.1–0.3 MPa. Stable fibre deposition was achieved at 10–15 $mm \cdot s^{-1}$, producing fibres down to ~20 µm. However, delayed solidification limited fidelity at higher layer counts. Osteosarcoma (Saos-2) and fibroblasts (NHDF) remained viable and aligned along parallel fibre architectures.

Overall, mcl-PHA enables low-temperature MEW of fine architectures but requires adapted processing strategies.

Abstract Template:

Water-Free Photocurable Systems for Starch-Integrated Composite Networks
Structure–processing–property relationships governing bio-based Photocurable resins

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Research Theme: Biomaterials

Year of Study (Presentation Type: Year 3 (Poster)

Since starch is one of the most plentiful and renewable biopolymers, its use in photocurable resins is restricted by its hydrophilicity, phase separation, and poor compatibility, which frequently require aqueous processing or multi-step chemical modification. This study investigates the in-situ incorporation of starch into polymer networks through the development of water-free photocurable composite systems based on polyol-based, ionic-based, and methacrylate-based reactive media. Phase behavior, mechanical performance, viscoelastic properties, and processability were assessed for the developed systems. The results showed that while starch increases tensile strength, it also causes increased brittleness and phase separation at higher loadings. Systems with higher viscosity and reactive interactions showed better dispersion and more stable network structures. The findings provide a foundation for the design of water-free bio-based photocurable materials for additive manufacturing by demonstrating that overall performance is more controlled by network homogeneity and phase behavior than by starch content alone.

Reverse Engineering the golden Christmas Beetle

Name: Mia Wansbrough

Theme: Biomaterials

Across beetle species, a striking diversity of structural arrangements produces intense golden colouration - natural designs that could guide the creation of synthetic materials. Although human-fabricated materials can be engineered to produce tuneable hues, they seldom achieve the saturation and brightness of beetle structural colour without complex fabrication. We are aiming to identify and replicate a feasible and e>icient way to maximise the broadband reflectance of cellulose nanocrystals (CNCs). The Australian golden Christmas beetle *Anoplognathus aureus*, generates gold using only a single chiral material, arranged in a sandwich-like structure where layers of larger pitch bookend layers of smaller pitch, providing a feasible blueprint. Drawing on this natural architecture, we designed a ‘sandwich’ arrangement of self-assembled CNC layers that mimics the organisation of *A. aureus*. To realise this design, we assembled CNC layers of larger (red-shifted) and smaller (blue-shifted) pitch, separated by a thin layer of shellac and stabilised with glutaraldehyde as a crosslinker. The resultant stack possessed similar broadband and intense gold reflectance as has been observed in beetles. Further work will focus on the optical characterisation of these films to quantify how this design provides a more e>icient route to enhancing broadband reflectance and intensity in CNC-based thin films. This will expand our ability to tune not only colour but also brightness and amount of light reflected in self-assembled, human-fabricated materials.

Abstract Template:

Developing a 3D skin model to analyse the cellular and epigenetic effects of interleukin-17 inhibitors in psoriasis

Name: Rachael Tibbitts
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Research Theme: Select one of the following and delete the rest:
Biomaterials;

Year of Study (Presentation Type): Select one of the following and delete the rest: Year 3 (Poster)

Abstract body text; Times New Roman, Size 12; Left Justified; Max. 200 words; No figures or tables to be included.

Psoriasis is a chronic autoimmune skin disease, usually resulting in inflamed red and white scaly patches of skin. Psoriasis has no known cure, but symptoms can be controlled by treatments such as steroid creams and UV light. Biological therapeutics have revolutionised the treatment of psoriasis, but long-term drug free remission is not readily achievable. There is evidence suggesting skin from psoriasis patients is differentially methylated compared to that of healthy skin, with the implication that this methylation may maintain keratinocytes in a hyper-inflammatory state. Long term treatment response may therefore be dependent on the control of this methylation state.

This project aims to develop a full-thickness 3D skin model to investigate how interleukin-17 (IL17) inhibitors, a successful therapeutic in the treatment of psoriasis, can alter the epigenetic profile of keratinocytes, and how this then could maintain these cells in a less inflammatory state. The finished skin model will consist of fibroblasts and immune cells encapsulated in a GelMA hydrogel, with keratinocytes seeded on top to produce a fully stratified epidermal layer, resulting in an immunocompetent bilayer skin model. CRISPR gene editing of T cells is being used to induce a psoriasis phenotype within the model.

Thus far, the material has been successfully synthesised with a high degree of consistency between batches. The rheological properties of the GelMA have been measured, demonstrating the ability to photo-crosslink with blue light and establishing the viscoelastic properties of the material. Cell viability of primary human dermal fibroblasts has been measured over a 28-day period, demonstrating excellent viability, while the gel remains solid. Finally, successful CRISPR knockout in primary T-cells has been achieved.

Abstract Template:

Title (Times New Roman Bold, Size 12)

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Research Theme: Biomaterials

Year of Study : Year 3 (Poster)

Stimuli-responsive microgels undergo reversible morphological or functional changes according to changes in the external environment (such as temperature, pH, ionic strength, light, magnetic field, electricity, enzyme or biological stimulation, sound waves, and reductants/oxidants). In this study, I combined pH-responsive microgels (poly(ethylacrylate-co-methacrylic acid-co-divinylbenzene) (PEA-MAA) with temperature-responsive microgels (poly(N-isopropylacrylamide-co-methylene-bis-acrylamide) (PNIPAM) to form physical gels that respond to both pH and temperature. The mixed gel exhibits significant pH and temperature-responsive properties, with physical gel formation primarily dominated by the swelling of PEA-MAA-DVB microgels. Rheological test results also show that the mixed gel has synergistically enhanced mechanical properties. Due to its adjustable mechanical properties, dual stimulus responsiveness, and good biocompatibility, this physical gel has the potential for tissue engineering applications, such as spinal repair.

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Research Theme: Biomaterials

Year of Study (Presentation Type): Year 3 (Poster)

Investigating the Degradation Mechanisms and Structural Properties of Decellularised Porcine Placental Extracellular Matrix for Chronic Wound Healing

Chronic wounds are characterised by prolonged inflammation, impaired cellular responses, and disrupted extracellular matrix (ECM) remodelling, leading to delayed healing and poor outcomes. Decellularised ECM-based dressings aim to provide a biomimetic environment supporting cell attachment, migration, and tissue regeneration, yet relationships between surface properties, structure, and early cell interactions remain unclear. This study investigates nanoscale surface characteristics and in vitro cellular responses of a decellularised porcine placental ECM (PPECM) dressing.

Surface topography was analysed using atomic force microscopy (AFM). Human wound-relevant cells were cultured on ECM dressing, collagen-coated glass, and uncoated glass controls. Cell viability and morphology were evaluated over 7 days using LIVE/DEAD staining and quantitative image analysis.

AFM showed a predominantly smooth, uniform surface with localised variations. Cells on the ECM dressing maintained high viability, confirming cytocompatibility. Compared with controls, cells exhibited enhanced early spreading and elongation, reflected by increased spreading area and reduced circularity. At later time points, differences diminished, with all substrates supporting comparable cell behaviour.

Overall, the ECM dressing provides a cytocompatible, structurally supportive surface that promotes early cellular responses, functioning as a biomimetic scaffold for wound healing.

Abstract Template:

Exploiting the use of self-assembly peptide hydrogel for in vitro liver modelling

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Research Theme: Select one of the following and delete the rest:
Biomaterials

Year of Study (Presentation Type): Select one of the following and delete the rest: Year 3 (Poster)

Due to an increase in the number of liver disease patients, there is an urgent need for alternatives to liver transplantation. Liver tissue engineering offers a more rapid, safer replacement. Self- assembling peptide hydrogels (SAPH), due to their high biocompatibility and physical properties, have emerged as a suitable candidate for liver tissue engineering. In this study, SAPH was exploited as a liver modelling platform.

Various SAPH was seeded with HepG2 (ECACC) to examine its suitability as a Hepatic cell culturing platform. Various tests were conducted to examine the viability, spheroids formation and key marker productions. In addition, examination of a suitable SAPH for culturing Human Umbilical Vein Endothelial Cells (HUVEC) was also carried out to explore the potential of SAPH in an indirect co-cultured model.

Current observations demonstrated HepG2 cultured in PeptiGel® Alpha 8™ maintained high viability with the formation of spheroids in 28 days. Other results also showed an uplift in various key marker production compared to 2D controls. Viability and proliferation of HUVEC seeded in PeptiGel® Alpha8™, Alpha 4™ and Alpha4 Plus™ were also tested to determine the most suitable SAPH for HUVEC culturing.

Environmental Degradation Mechanisms in Next-Generation High-Temperature Ceramic Coatings

Name: Chu Yang Li

Research Theme: Coatings and Ceramics

Abstract

$Yb_2Si_2O_7$ (YbDS) is a promising material to be used in environmental barrier coatings (EBCs) to protect Si-based ceramic matrix composites from oxidation and corrosion in gas turbine engines. However, YbDS is susceptible to degradation caused by steam and calcium-magnesium-aluminum-silicate (CMAS). Although the degradation of YbDS caused by these two factors have been investigated separately, the synergistic effect of these two elements on YbDS is largely unknown. In this study, the differences between the degradation of YbDS when exposed to CMAS in air and in steam are examined systematically. The results show that in air, YbDS exhibits little resistance to the infiltration of CMAS. On the other hand, steam slows down the infiltration of CMAS into YbDS, indicating reduced thermochemical degradation. However, exposure to steam induces microstructural changes in YbDS that promotes the formation of cracks due to the thermal mismatch between the different phases. Accordingly, the failure mode of YbDS also changes. In summary, this work demonstrates that CMAS-induced degradation of YbDS occurs differently in air and steam due to different thermodynamics and kinetics of the interactions between YbDS and CMAS.

Next-Generation Thermal Barrier Coatings via Co-Doping

Name: Daniel Thomas
Theme: Coatings and Ceramics

Abstract

Thermal barrier coatings (TBCs) are undergoing a critical evolution towards enabling higher operating temperatures to improve fuel efficiency, thereby reducing emissions and operating costs. Among the most promising next-generation TBC materials are high-entropy oxides and rare-earth zirconate pyrochlores. Despite their high-temperature phase stability and, in some cases, resistance to calcia–magnesia–alumino–silicate (CMAS) attack, their fracture toughness remains insufficient. Consequently, research is currently directed towards improving this, and yttria-stabilised zirconia (YSZ) continues to dominate aerospace applications.

In this work, an alternative strategy is presented, shifting the focus from mechanical property improvement towards improving the high-temperature phase stability and CMAS resistance of YSZ. Through targeted micro co-doping, phase stability, CMAS resistance, and mechanical properties were systematically evaluated, revealing improvements or retention across these three critical focus areas. Results indicate that minimal dopant inclusions can uplift YSZ at elevated temperatures (1450 °C).

A Cheap, Simple and Scalable Technique for the Production of Ceramic Coatings

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Research Theme: Coating and Ceramics
Year of Study (Presentation Type): Year 3 (Poster)

Ceramic Matrix Composites (CMCs) are the next generation of materials for extreme environments, such as the hot section of a gas turbine engine. Replacing currently used Ni superalloy components in gas turbines with CMCs facilitates both a reduction in weight and increased operating temperatures, thereby increasing engine efficiency and reducing fuel consumption. But CMCs are known to degrade when exposed to the high temperatures, pressures and corrosive/oxidizing species present in a gas turbine, to protect them Environmental Barrier Coatings (EBCs) are applied to the surface of CMCs. Air Plasma Spraying (APS) is considered the standard technique for EBC production but presents various challenges such as lack of microstructural control, inability to homogenously add secondary phases and poor coating of complex components leading to coating failure. Electrophoretic Deposition (EPD) is a simple, cheap and easily scalable coating processing technique that is adaptable to a variety of applications. This research shows EPD to be a strong alternative technique for EBC processing as it can produce dense, homogenous, and smooth ceramic coatings on complex surfaces within minutes under ambient pressures and temperatures without the fundamental challenges of APS.

Engineering Dynamics through Field-Induced Transformations in Lead-Free NBT Piezoelectric Ceramics

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Research Theme: Coating and Ceramics;

Year of Study (Presentation Type): Year 3 (Poster)

Abstract: The structural and functional evolution of the lead-free ceramic system (1–x)$Na_{0.5}Bi_{0.5}TiO_3$–6%$BaTiO_3$–x$Bi(Mg_{0.67}Nb_{0.33})O_3$ (NBT–6BT–xBMN) was investigated with a focus on compositions at x = 0, 1, and 2 mol%. While all three samples exhibit comparable dielectric properties, our analysis reveals that the source of exceptional piezoelectric performance is a field-induced, irreversible structural transformation. For the base NBT–6BT (0% BMN), the piezoelectric coefficient (d_{33}) is 125 pC N^{-1}, a baseline value for this material. A minor compositional tweak to 1% BMN dramatically increases the d_{33} to a peak of 183 pC N^{-1}, representing not only a 46% enhancement over the base material but also the highest d_{33} for un-textured bulk ceramics ever reported to date. This remarkable improvement is directly linked to an observed irreversible pseudocubic-to-tetragonal+rhombohedral (T-R) "switch", followed by strong domain switching and lattice deformation. In stark contrast, the 2% BMN sample remains structurally locked in a stable pseudocubic phase, exhibiting minimal functionality with a d_{33} of just 35 pC N^{-1}. This study powerfully demonstrates that optimised piezoelectricity in this system is not an inherent property but is engineered by facilitating dynamic structural transformations under an electric field. The 1% BMN composition emerges as an up-and-coming candidate for applications requiring strong direct piezoelectric properties, such as medical ultrasonic devices.

Structural and Electrical properties of
$K_{0.5}Bi_{0.5}TiO_3$ -Based Ceramics

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Research Theme:
Coating and Ceramics

Year of Study (Presentation Type): Year 3 (Poster)

Structural and electrical properties of lead-free $K_{0.5}Bi_{0.5}TiO_3$-based ceramics were investigated with the aim of improving dielectric and ferroelectric performance and affect the conduction mechanism through compositional modification. This work focused on the KBT–BFO system with Mn doping and additional $Nd(Li_{0.5}Ta_{0.5})O_3$ (NdLT) modification, using a conventional solid-state reaction route. X-ray diffraction showed that the ceramics remained predominantly perovskite after Mn and NdLT addition, with no major structural transformation observed. Dielectric measurements revealed broad, diffuse permittivity maxima in all compositions, indicating relaxor-like behaviour. Mn doping reduced room-temperature dielectric loss and increased dielectric diffuseness, suggesting that it effectively suppresses conduction-related effects by modifying defect chemistry. In contrast, the addition of NdLT to 0.9KBT–0.1BFO–0.10 wt% Mn maintained diffuse dielectric behaviour but produced lossy and distorted P–E loops, indicating increased leakage and non-ferroelectric contributions. Overall, Mn is beneficial for improving the electrical performance and suppressing conduction mechanism of KBT–BFO ceramics, while NdLT addition requires further optimisation. These findings contribute to the development of lead-free dielectric and ferroelectric ceramics for future electronic applications.

Alumina-hBN Composite Coating Developed by Aerosol Deposition Method

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Research Theme: Coating and Ceramics

Year of Study (Presentation Type): Year 3 (Poster)

Composite Al_2O_3 coatings incorporating hexagonal boron nitride (hBN) were produced via room-temperature aerosol deposition (AD) to evaluate the influence of hBN content on microstructural integrity and functional performance. By varying the hBN ratio, it was observed that coatings with 5 wt.% hBN exhibited superior performance, characterized by increased hardness, improved wear resistance, and reduced structural defects. This enhancement is attributed to the formation of a dense microstructure with minimized pores and cracks, resulting from the uniform dispersion of hBN within the Al_2O_3 matrix.
The high-energy particle impact inherent to the AD process facilitated strong mechanical interlocking at the interface between hBN and the ceramic matrix, promoting improved interfacial bonding. This synergistic effect of optimized hBN distribution and robust adhesion highlights the critical role of processing conditions in tailoring coating performance. However, beyond 5 wt.% hBN, performance deteriorated, likely due to hBN agglomeration and excessive solid lubrication, which compromised coating integrity. Overall, the results demonstrate that a small addition of hBN effectively balances hardness and lubrication, confirming aerosol deposition as a viable technique for producing high-performance, defect-free Al_2O_3-based composite coatings.

Abstract Template:

To investigate the cation doping effect on the mechanical property of high temperature oxide material

Name: Peng Tao

Research Theme: Select one of the following and delete the rest:
Coatings and Ceramics;

Year of Study (Presentation Type): Select one of the following and delete the rest: Year 3 (Poster)

Abstract body text; Times New Roman, Size 12; Left Justified; Max. 200 words; No figures or tables to be included.

Rare earth zirconates (REZOs) are promising next-generation thermal barrier coating (TBC) topcoat materials due to their low thermal conductivity, superior CMAS resistance, and excellent phase stability compared with conventional 6–8 wt.% yttria-stabilized zirconia (YSZ). Among REZOs, gadolinium zirconate ($Gd_2Zr_2O_7$, GZO) exhibits particularly low thermal conductivity and a relatively high coefficient of thermal expansion (CTE), making it a strong candidate for advanced TBC applications. However, its relatively poor mechanical properties, especially low fracture toughness, remain a major limitation. Cation doping has been recognized as an effective strategy to tailor the structural and mechanical properties of ceramic materials. In this work, the effects of cation doping on the composition, microstructure, and mechanical properties of GZO are systematically investigated. Particular emphasis is placed on correlating doping-induced changes in lattice disorder, grain growth, crack and dislocation behaviour. This study provides insight into the role of cation doping in improving the mechanical reliability of GZO for next-generation TBC applications.

Synthesis and Optimization of a Novel Core-Shell Architecture for Advanced Thermal Barrier Coating

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Research Theme: Coating and Ceramics

Year of Study (Presentation Type): Year 3 (Poster)

This study aims to develop durable thermal barrier coatings (TBCs) based on a novel core-shell structure system. Currently, yttria-stabilized zirconia (YSZ) and gadolinium zirconate (GZO) are widely used TBC materials. However, YSZ is vulnerable to calcia-magnesia-alumina-silicate (CMAS) attack, while GZO suffers from low fracture toughness. To address these challenges, we propose a core-shell structured TBCs wherein each unit comprises a YSZ or GZO core encapsulated by a $GdAlO_3$(GAP) shell, which simultaneously offer good CMAS resistance and fracture-tough property.

YSZ-GAP and GZO-GAP core-shell powder were synthesized successfully via a sol-gel method. Following a single coating cycle, the GAP shell coverage reached 72%, and the shell thickness increased to 680 nm after three cycles. To further optimize the powder synthesis process, an electrical treatment was introduced. With this approach, the initial shell coverage significantly improved to 91% after just one cycle, achieving a thickness of 220 nm.

Subsequent CMAS test confirmed that the core-shell structure possesses superior resistance compared to traditional YSZ, demonstrating a 45% improvement in overall mitigation effectiveness. Notably, at comparable thicknesses, the electrically treated core-shell structures exhibited a 200um reduction in CMAS penetration depth compared to their untreated counterparts. Ultimately, this core-shell design presents a highly promising strategy for next-generation TBCs.

Effects of Process Heating Conditions on the Properties of SiC_f/SiC

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Research Theme: Coating and Ceramics
Year of Study (Presentation Type): Year 3 (Presentation)

Ceramic silicon carbide (SiC) has excellent capabilities to withstand high temperatures but it possesses low fracture toughness. The mechanical behaviour can be improved by reinforcing the SiC ceramic matrix with ceramic fibres to create a SiC ceramic matrix composite (CMC). The high temperature resistance and toughness of SiC CMCs make it a suitable candidate as a structural material for extreme service conditions such as nuclear reactor cladding. However, the fabrication of SiC CMCs is highly complex which hinders its widespread use in industry. Polymer Infiltration and Pyrolysis (PIP) has shown great promise as a relatively simple processing option but needs further improvement to be able to consistently produce quality SiC CMCs. Previous work on PIP made great strides at improving the SiC matrix purity, however it has produced incidental effects on the fibre-matrix interface which reduces the composite's fracture toughness. The current work is to adapt the processing conditions to mitigate the negative effects of the updated PIP process while maintaining the already ideal matrix properties. By systematically studying the processing parameters of PIP, the process can be adapted to the alleviate the disadvantageous interfacial effects to fabricate a quality SiC CMC suitable for industrial use.

Disorder-driven Mechanical Behaviour in High-entropy Pyrochlore Ceramics

Researcher: Shuai Zhong

ID number: 11028012

Year 3

Abstract:

High-entropy ceramics (HECs) show excellent phase stability, but their mechanical behaviour remains unclear due to disorder–microstructure coupling. Here, a model pyrochlore system ($Gd_2Zr_2O_7$, $(Sm_{0.2}Eu_{0.2}Gd_{0.2}Tb_{0.2}Dy_{0.2})_2Zr_2O_7$, $(Sm_{0.1}Eu_{0.1}Gd_{0.1}Tb_{0.1}Dy_{0.1}La_{0.1}Nd_{0.1}Y_{0.1}Er_{0.1}Yb_{0.1})_2Zr_2O_7$) was designed to isolate configurational entropy as the sole variable using dense, coarse-grained samples by sparking plasma sintering. XRD and EBSD confirm single-phase, microstructure-invariant materials. Nanoindentation reveals increasing modulus and hardness with entropy, indicating solid-solution strengthening via lattice distortion. Microcantilever tests show a stronger increase in intrinsic fracture toughness, associated with crack deflection and increased tortuosity. These results demonstrate that configurational entropy decouples strengthening and toughening by governing deformation and crack propagation at different length scales.

Tribological behaviour of plasma electrolytic oxidised coatings for enhanced lubricity and wear resistance

Name: Tess Knowles
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Year of Study (Presentation Type): Year 3 (Poster)

Plasma electrolytic oxidation (PEO) is an advanced surface treatment method used to produce stable barrier oxide coatings on light alloys.
These coatings show promise across many sectors but faces limitations as they can only do so much as a passive protective layer, making further engineering very important for performance enhancement.

In sliding contact environments these coatings must be adapted for changing conditions. To account for this, adaptive lubricants are often utilised.

Common examples of these include graphite or molybdenum disulphide-based solid lubricants, but they have limited long-term capabilities. We are investigating if MXenes, a class of 2D materials, can perform better where the current examples are limited due to the comparative increased bonding strength between layers of transition metal compounds within their structure, providing more resistance to delamination under repeated sliding contact.

To improve and assess the performance we are optimising the PEO surface characteristics and the method of incorporating the lubricant to enhance compatibility with MXene additions, followed by performing reciprocating sliding wear tests under altering conditions.

We anticipate that incorporating MXenes into PEO coating systems could provide more consistent wear resistance enhancement over time and additionally withstand increased loading compared to the current common solid lubricants.

Abstract Template:

Refractory Metals-based Coating Compositional Design By High Entropy Engineering

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Research Theme:
Coating and Ceramics;

Year of Study (Presentation Type): Year 3 (Poster)

Refractory alloys have drawn particular attention due to their high melting points and excellent creep resistance, which are the two key requirements for high-temperature applications. However, refractory alloys often exhibit apparent brittleness and oxidation susceptibility, which remain important challenges for their processing and application. An alumina-forming coating can provide oxidation resistance, but discovering a suitable Al-containing refractory composition remains a challenge. The approach is attributed to a high-entropy-induced, element-dependent sluggish-diffusion effect that slows the diffusivity of heavy refractory metals and increases the outward mobility of aluminium. To demonstrate the feasibility of this design, we select natural mixing Al among refractory metals to form a multiphase alloy, and phase-specific oxidation is established by correlative microscopy to confirm that a protective α-Al_2O_3 scale forms from the Al-containing RMs-rich phase. Then, a new alloy with this phase composition was manufactured to confirm its long-term oxidation resistance. The results reveal that the scale formed and that its growth was controlled by diffusion, with low residual stress.

The Effect of Tungsten-Precursor Additions on the Thermoelectric Properties of Nb-doped $SrTiO_3$ Ceramics

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Research Theme: Coating and Ceramics;

Year of Study (Presentation Type): Year 3 (Poster)

Thermoelectric (TE) materials are alternative renewable energy sources, that can convert waste heat into electricity. Non-toxic oxides are very attractive TE materials, especially for high temperature applications, because they have superior thermal and chemical stability. The n-type $SrTiO_3$ (STO) possesses a large Seebeck coefficient and a good power factor (σS^2), which is comparable to that of commercial Bi_2Te_3. However, the extremely low electrical conductivity and high thermal conductivity of STO limits TE performance. In this work, we enhance the thermoelectric performance of niobium-doped STO ceramics by sintering under a highly reducing atmosphere, while simultaneously introducing phonon scatterers at grain boundaries using ammonium tetrathiotungstate (ATT). The maximum power factor was obtained with 2 wt% precursor addition, reaching 1411 $\mu W/mK^2$ at 323 K due to increased weighted mobility (μ_w). Total thermal conductivity decreased with increasing precursor content, reaching a minimum of 3.92 W/mK at 873 K for 2 wt% ATT sample. Consequently, a maximum zT value of ~0.21 at 873 K was recorded for the optimal 2 wt% ATT sample. The polycrystalline ceramics exhibited thermoelectric behaviour comparable to that of single crystals, potentially expanding the operational window of $SrTiO_3$-based materials towards near-room-temperature applications.

Micromechanical actuation mechanisms in piezoelectric $BiFeO_3$-$BaTiO_3$ Ceramics

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Research Theme: Coating and Ceramics;

Year of Study (Presentation Type): Year 3 (Poster)

Perovskite structured bismuth ferrite-barium titanate (BF-BT) ceramics are suitable for applications in electro-mechanical sensors and actuators due their excellent piezoelectric properties and stable performance at high temperatures exceeding 500 °C. In this study, the underlying mechanisms responsible for the electric field-induced strain in rhombohedral BF-BT ceramics were evaluated by high-energy synchrotron X-ray diffraction over a range of applied electric field values from sub- to super-coercive levels. The corresponding ferroelectric domain structures before and after electric field application were also compared by SEM observations.

The electric field-induced strain in piezoelectric ceramics is considered as the summation of intrinsic (lattice strain) and extrinsic (ferroelectric domain switching) contributions, which vary for different crystallographic orientations. Current methods of calculating the total (macroscopic) field-induced strain from diffraction data are based on either the Daymond method, which considers the combined strain of grain families having different crystallographic orientations, or the Jones method, which involves integrating the intrinsic and extrinsic contributions for the polar <111> directions over the complete range of azimuthal angles (0 to 90°). A new analytical approach is proposed in this study, which offers the capability to perform the evaluation of intrinsic and extrinsic contributions for specific crystallographic orientations. These new results provide further micromechanical insights into the origins of the electrostrain in BF-BT ceramics.

A cross-domain pipeline for nanoparticle detection and segmentation in STEM images

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Imaging and Characterisation

Year 3

Accurate segmentation of nanoparticles in HAADF-STEM images is essential for quantitative materials analysis, yet manual annotation remains slow, subjective, and inconsistent across operators. We develop a fully automated segmentation framework that requires minimal supervision and generalizes across multiple catalytic nanoparticle systems. The method produces smooth, physically realistic particle boundaries and maintains high accuracy even on materials not included during development. The approach remains robust under variations in particle size, contrast, support texture, and imaging conditions, enabling reliable extraction of particle statistics such as size distributions and spatial organization. Evaluation across three trained systems and an unseen fourth material demonstrates consistent performance and strong cross-material generalization. These results highlight a practical, annotation-efficient strategy for high-fidelity nanoparticle segmentation in heterogeneous electron-microscopy datasets, supporting scalable and reproducible quantitative analysis.

Understanding the Behaviours and Factors Influencing Detritiation During Thermal Treatment of Materials

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Research Theme: Select one of the following and delete the rest:
Imaging and Characterisation;

Year of Study (Presentation Type): Select one of the following and delete the rest:
Year 3 (Poster)

Understanding the factors controlling detritiation of hydrogen isotopes from tungsten is critical for tritium inventory management, fuel recovery, and safe disposal of plasma-facing components in fusion devices. Tungsten will experience high particle fluxes, elevated temperatures, neutron damage, and microstructural and compositional evolution, all of which can modify hydrogen isotope retention and release.

This research will investigate deuterium retention and desorption kinetics in recrystallised, rolled, alloyed, and irradiated tungsten. These conditions represent key fusion-relevant material states: recrystallised tungsten as a reference microstructure, rolled tungsten as a deformation-induced microstructure, W-5Re as a model for alloying and transmutation effects, and irradiated tungsten as a proxy for in-service damage.

Samples will be characterised using SEM and exposed to deuterium using DELPHI-II, a plasma exposure device, under fusion-relevant fluence and temperature conditions. Thermal Desorption Spectroscopy (TDS) will quantify deuterium retention and release kinetics. FESTIM will be used to model and fit desorption peaks, enabling extraction of trap energies, trap densities, and detrapping behaviour.

This combined experimental and modelling approach will support physics-based models linking microstructure, composition, and tritium retention in W-based alloys. These models will inform STEP operational limits, help ensure local tritium inventories are not exceeded, and aid tritium recovery during waste handling and processing.

A Near-Atomic-Scale Study of the Microstructure and Mechanical Properties of Tungsten and Tungsten-based Alloys

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Year of Study (Presentation Type): Year 3 (Poster)

Tungsten is the primary candidate for plasma-facing-materials in a fusion power device due to tungsten's exceptional properties. However, their mechanical properties including ductility and fracture toughness, severely degrade under the extreme conditions experienced. Tungsten alloys represent a potential solution: W-K alloy, demonstrates high thermal shock resistance and fracture toughness, whereas nanoengineered W-Ti-Cr alloy offers improved thermomechanical properties and higher resistance to detrimental surface morphology evolution. This study aims to characterise the mechanical properties of tungsten and tungsten-based alloys focussing on grain boundary behaviour, dislocation motion and pile-up under tensile testing. Testing was conducted in-situ of a scanning electron microscope combined with Electron Backscatter Diffraction to observe deformation. High-Resolution Digital-Image-Correlation allowed for the measurement of full-field surface deformations and strains at the nanoscale providing insight into atomistic behaviour during deformation. The results will be discussed with relevance to understanding the deformation behaviour of tungsten alloys under these conditions, predicting and mitigating potential failures during operations, thus enabling of development of new alloys and predictive models thereby enhancing the reliability of W-based materials for future reactors.

Understanding Tritium Behaviour in Plasma-Facing Materials for Nuclear Fusion Applications

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Year of Study (Presentation Type): Year 3 (Poster Presentation)

The generation of clean electricity through nuclear fusion is reliant on the fusion of deuterium and tritium, both isotopes of hydrogen. A critical knowledge gap exists in understanding how tritium is retained in materials, and the mechanism surrounding its behaviour in trap sites, particularly regarding those that are induced by low-energy radiation damage. This understanding is critical for predicting and managing fuel retention in fusion reactors, which has both safety and economic implications. This PhD aims to investigate the relationship between surface morphology changes of Eurofer-97 & Grade-91 SS exposed to low-energy deuterium and tritium plasma, near-surface trapping sites and deuterium/tritium retention, as well as any influence of the isotope effect on the morphology changes and trapping. Microstructural and topological characterization was performed on a Grade-91 stainless steel specimen before and after an deuterium plasma exposure over a range of temperatures. Initial characterization of the resulting nano-textured surface morphological changes has been performed.

Understanding the reliability of 2D characterisation in melt pool grain networks of LPBF AlSi10Mg using 3D analysis

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Research Theme: Imaging and Characterisation

Year of Study (Presentation Type): Year 3 (Poster)

Abstract: Additive manufacturing, particularly laser powder bed fusion (LPBF), enables the fabrication of complex AlSi10Mg components with refined microstructures and improved mechanical performance compared to conventional casting. During LPBF processing, overlapping melt pools generate melt-pool boundaries (MPBs) that experience repeated thermal cycling, leading to microstructural heterogeneity and influencing mechanical anisotropy. While 2D characterisation reveals features such as fish-scale morphologies and orientation-dependent grain structures, it does not fully capture the true 3D grain architecture. In this study, large-volume 3D electron backscatter diffraction (EBSD) using plasma focused ion beam (PFIB) serial sectioning was employed to investigate the grain structure of LPBF-processed AlSi10Mg. The reconstructed 3D microstructure enabled analysis of grain morphology, size distribution, and spatial connectivity across melt-pool regions. Grain segmentation was used to distinguish melt-pool boundary and melt-pool centre grains, allowing statistical comparison with conventional 2D analysis. Additionally, the relationship between grain morphology and silicon distribution was examined. This work highlights the limitations of 2D characterisation and demonstrates the importance of 3D analysis for accurately interpreting microstructural features in LPBF materials.
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Insight of second phase precipitation in Cu-Cr-Zr alloys with the use of advanced transmission electron microscopy

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Research Theme: Imaging and Characterisation

Year of Study (Presentation Type): Year 3 (Poster)

Cu alloys present excellent thermal and electrical conductivity along with relatively good mechanical strength making them target materials for use in the next generation of fusion reactor, ITER. Age hardening is introduced to improve the mechanical performance meaning understanding of the evolution of microstructure of the alloy during heat treatment is essential to predict its behaviour under the extreme environments of a fusion reactor.

This was undertaken through the use of advanced STEM imaging, STEM-EDX and 4D-STEM to explore the structure and composition of the samples during ageing.

Cr has a very low solubility in copper and the equilibrium phase diagram suggest no intermetallic compounds between these elements. Instead a cube-on-cube orientation relationship (OR) between the FCC matrix and BCC chrome phase precipitates is suggested, namely the N-W OR[1]. while 4D-STEM results from aged samples show the expected cube-cube orientation. However, the pattern also shows a clear superstructural ordering with the additional sharp reflection. This suggests the Cr phase is in fact occupying the ordered B2 structure which is proposed but rarely reported for this system. Such anti-phase boundaries (APBs) are likely to exist. To understand this structure an atomic resolution STEM image of the material was prepared.

3D Imaging Reveals Structure–Property Links for FRP Composites Containing Spliced Yarn Reinforcements

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Research Theme: Interdisciplinary at the intersection of a) Imaging and Characterisation and b) Polymers and Composites

Year of Study (Presentation Type): Year 3 (Poster)

Abstract:

Spliced yarns are widely used to enable continuous processing in textile and composite manufacturing, yet their internal architecture remains inadequately characterised. In particular, no volumetric X-ray CT-based method has been established for resolving the three-dimensional filament structure, void distribution, and local fibre volume fraction within the splice zone of fibre-reinforced polymer (FRP) reinforcements. Splicing is critical for converting fibre waste into quasi-continuous yarns of near-uniform density, supporting resource-efficient and sustainable manufacturing. However, characterisation of splice regions remains largely limited to 2D and surface-sensitive methods, such as mechanical testing, optical and electron microscopy, thermography, and image analysis. Here, mechanical testing was combined with laboratory X-ray computed tomography (CT) to quantify the internal 3D architecture of spliced regions and relate process parameters to local structure and tensile performance. The CT results show systematic variations in fibre alignment, splice compactness and void content with splicing pressure and overlap length, which correlate with splice strength and failure mode. These findings demonstrate that integrated CT and experimental mechanics can support predictive design of splice architectures for load-bearing FRP components manufactured with spliced reinforcements. (178 words)

Keywords: Pneumatic splicing, X-ray CT, filament migration, void distribution, mechanical characterisation, splice retained strength, fibre reinforced polymer

Extraction of Tritium from the Molten Salts

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Year of Study (Presentation Type): Year 3 (Poster)

The extraction of hydrogen isotopes (Q) from the breeder blanket is essential for ensuring plentiful supply of tritium required to sustain nuclear reactions in fusion power devices. The technology to efficiently extract and harvest Q can vary depending on the breeder blanket design. This study aims to determine how viable Permeator Against Vacuum (PAV) extraction technology is with the candidate breeder material FLiBe, a fluoride molten salt. The PAV extraction method was chosen to compare to other typical methods of Q extraction, such as the sweep gas method.

Here, a literature review and experiments using a Gas Driven Permeation System (GDPS) were conducted to identify the transport properties of Q in different permeator window materials to identify suitable for PAV applications. This experimentation aims to investigate how properties such as grain size, defect microstructure, and topography of these materials impact the extraction of tritium. The selected materials for the permeation window are nickel and niobium, and the structural materials are grade 91 steel and stainless stell 316. These materials are to be tested on the GDPS to get initial results identify how Q permeation could change within the operational environment before being deployed in an active FLiBe PAV system.

Understanding the development of abnormally coarse-grained structures during β annealing of Ti-64

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Research Theme: Metallurgy and Corrosion.

Year of Study (Presentation Type): Year 3 (Poster)

After thermomechanical processing and β annealing, abnormally coarse grains (ACGs) have been observed in Ti-6Al-4V products. The ACGs appear in the mid-plane of forgings and rolled products, within a matrix of fine cube (or rotated-cube grains in rolled material). Byres et al. (2021) found that grains within a "goldilocks" misorientation range ~20° – 30° around the cube component as well as γ-fibre grains (~40° - 60°) grow rapidly during annealing. However, ultimately, only "goldilocks" grains develop into the ACGs, whereas the γ-fibre grains are eventually consumed by the surrounding matrix. This work investigates the texture evolution in both in-situ and ex-situ heating experiments on a piece of Ti-64 forged to varying reductions. We notice that the texture change to goldilocks zone orientations occurs throughout the length of the material, however, there appears to be drastic differences in grain sizes within the same reduction step. It is also notable only specific orientation within the goldilocks ring- namely within preexisting fibres linking the cube component with intense spots within the γ-fibre, would go on to develop into abnormally coarse grains. The textures were then sampled and implemented in a phase field model simulating the grain growth.

Petrophysical response of Li-bearing granites to elevated temperatures: Implications for Li-brine extraction

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Research Theme: Metallurgy and Corrosion

Year of Study: Year 3 – Poster presentation

The global transition towards decarbonisation and renewable energy systems has driven unprecedented demand for a broad range of raw materials. The uneven geological distribution of mineral resources, compounded by geopolitical constraints, creates supply vulnerabilities. To address these risks, critical raw materials (CRM)—defined as materials of high economic importance and supply risk—are identified to inform resource strategies. Lithium is classified as a CRM due to its central role in battery technologies underpinning green technologies. Projected to exceed supply by 2030, previously uneconomic resources are being exploited to satisfy demand.

Within the UK, the Li-bearing Cornubian granite batholith represents the greatest potential for Li extraction via delithiation of geothermal brines. These crystalline systems have low permeability, with fluid flow largely restricted to fracture networks comprising a small volume of the rock mass. To understand Li recharge rates and brine supply, the petrophysical properties of the unfractured rock mass must be characterised

In this study, a suite of unfractured Li-bearing granites from the Cornubian Batholith were analysed using porosimetry, permeametry and ultrasonic techniques at temperature increments reflecting elevated isotherms. Results indicate that temperatures above 150°C increase permeability of unaltered granites, with progressive fracture generation until 400°C, where wave velocity decreases sharply.

DoM Y3
Das_Avijit POSTER abstract
Theme: Metallurgy and Corrosion

Human lead exposure is a significant public health concern due to its cumula6ve toxic effect affec6ng the human bone, kidney, brain, and heart. Although the WHO has specified the current acceptable limit of Pb in humans as 10 µg/L, there is no safe limit for the intake of lead. High-profile Pb contamina6on in drinking water distribu6on systems in Flint, Michigan (2016) and in Washington (2003) have been reported and studied. The electrochemical corrosion of lead pipes, leading to Pb leaching and the formation of scales, is dependent on water quality parameters such as pH, the presence of disinfectants (e.g., free chlorine, chloramines), and inhibitors such as orthophosphates.

The primary goal of this research project is to develop a founda6onal understanding of how lead corrosion progresses in a reference drinking system. This research was ini6ated to develop a mechanis6c understanding of the temporal evolu6on of Pb scales and their characterisa6on in a well-defined laboratory drinking-water system. In the second year, an effort was made to set up the Pb immersion experiments and scale characterisa6on procedures in the reference water dosed without phosphate. The evolution of the Pb scale was studied over time and the formed Pb scale was characterised using grazing-angle X-ray diffraction, X-ray photoelectron spectroscopy, and electron microscopy.

Progress has been made in understanding scale evolution and surface characterisation, including the electrochemical study of the formation of lead on the substrate in reference drinking water (RW). A major finding so far is that hydrocerussite forms first when lead is immersed in drinking water. Electrochemical Impedance Spectroscopy of the Pb-RW system demonstrated the formation of hydrocerussite as the dominant lead substrate after 7 days of immersion.

Investigation of HCl Vapour-Driven Stress Corrosion Cracking of 316L Stainless Steel

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The nested Type 316L austenitic stainless-steel can design, where the lid is seal-welded, and the internal environment is characterised by low oxygen levels (<10 ppm), low relative humidity (<10% RH), and elevated temperatures typically in the range 80–120 °C, is adopted for severe nuclear materials storage. Under these conditions, degradation of PVC-based packaging materials may lead to the release of chloride species in the form of HCl vapour, raising concerns regarding stress corrosion cracking (SCC) of the type 316L stainless steel. This study examines the corrosion behaviour of Type 316L stainless steel in HCl vapour exposure by systematically controlling oxygen concentration. The experimental setup comprises a glass exposure cell in which temperature was regulated using a double-jacketed configuration, while oxygen concentration was controlled by nitrogen purging. Post-exposure surface analysis was performed via confocal microscopy, XRD, Raman spectroscopy and XPS. The effect of oxygen in forming corrosion products in this setup will be discussed. To assess the nature of the surface film, potentiodynamic polarisation tests of type 316L stainless steel were conducted in HCl using bulk and localised electrochemical scanning techniques

Corrosion Inhibition by DDTMAC in Acidic Solution

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Research Theme: Metallurgy and Corrosion;

Year of Study (Presentation Type): Year 3 (Poster)

Electrochemical measurements, combined with interfacial interaction studies, have been used to investigate the interaction of a model quaternary ammonium-based cationic surfactant, Dodecyl trimethylammonium Chloride (DDTMAC), a corrosion inhibitor, with carbon steel (C1010) across different acid concentrations. Critical micelle concentration (cmc) values and corrosion inhibition efficiencies (η%) were determined in aqueous solutions of hydrochloric acid, sulphuric acid, and acetic acid using surface tensiometry and linear polarisation resistance (LPR) measurements. The corrosion inhibition data indicate that excellent results are achieved at the CMC in strong acids (HCl and H2SO4). Conversely, DDTMAC performs less effectively and can even increase the corrosion rate in a weak acid (HAc). Potentiodynamic polarisation (PDP) analysis shows that DDTMAC acts as a mixed-type inhibitor in all media.

Bipolar Electrochemistry for Probing the Effect of Anodic and Cathodic Polarization on Hydrogen Embrittlement (HE) and Stress Corrosion Cracking (SCC) of Stainless Steel

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Year of Study (Presentation Type): Year 3 (Poster)

This study explores the application of bipolar electrochemical methods to evaluating the effect of anodic vs. cathodic polarization on strained type 316L austenitic and type 420 ferritic stainless steels. The goal is to utilize this method to investigate differences in the anodic stress corrosion cracking (SCC) and HE behavior corrosion of stainless steels and compare it to the same condition under cathodic polarization.
A novel bipolar electrochemical test method for strained samples was designed, using de-coupled electrochemical reactions. The new bipolar set-up is introduced, with a view of how this technique can be further expanded to study the effect of electrochemical polarization on fundamental failure mechanisms. Current research focuses on quantifying and measuring the bipolar electric field acting on the sample surface, for understanding threshold conditions in materials subjected for SCC and HE testing.
This study employed four-point bending loading to conduct bipolar electrochemical experiments on the 420 and 316L models to demonstrate their localized corrosion and crack initiation responses, and to construct a controllable theoretical system combining stress chemistry and electrochemistry. Experimental results show that the passivation film rupture and repassivation process induced by mechanical stress can be captured in real time using potential and current signals.

In-situ Raman Spectrometry of Passive Surface Layers on Stainless Steel

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Research Theme: Metallurgy and Corrosion

Year of Study (Presentation Type): Year 3 (Poster)

A duplex oxide layer with complex microstructure typically forms on the surface of stainless steels. The inherent self-healing behaviour renders this layer central to the corrosion resistance of these alloys. These films comprise oxides and hydroxides and are at macro-scale considered as primarily Fe-doped chromium oxides. This means that a thin oxide-based ceramic layer is bonded to a bulk metallic substrate of dissimilar properties, which represents a snapshot of the material state at the surface.

Raman spectroscopy offers a non-destructive route to stress quantification in such oxides via the stress-induced shift of characteristic vibrational modes. Existing calibrations for chromium oxide rely upon hydrostatic compression of pure synthetic Cr_2O_3 at pressures of tens of GPa. These calibrations implicitly assume direct transferability to passive films under service or residual stress conditions. This idea is further examined here in our work, to understand whether the stress of this layer can be determined. The passive film differs from bulk synthetic oxide in composition, crystallinity, thickness, and constraint. It differs from its metallic substrate in these respects and additionally in elastic modulus. The stress state in a substrate-bonded thin film is not hydrostatic. Service stresses in the substrate reach only hundreds of MPa before plastic deformation, far removed from the GPa regime of hydrostatic calibration. The presence of micro-cracks in the passive layer may further complicate stress transfer.

This work investigates the relationship between bulk substrate stress and passive film stress via in-situ uniaxial loading. In-situ Raman spectrometry was carried out to observe changes in surface stress condition with loading. The method permits this relationship to be established under conditions representative of service, rather than inferred from surrogate materials under non-representative stress states.

In-situ Hardness Testing Under Polarisation Control

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Research Theme:
Metallurgy and Corrosion;

Year of Study (Presentation Type): Year 3 (Poster)

This study investigates the coupled relationship between localised mechanical deformation and electrochemical behaviour in austenitic stainless steels (316L and 304L) within hydrogen-containing environments. Initial microstructures were characterised using EBSD. By monitoring 316L in a 1 M NaOH electrolyte, baseline polarisation behaviours were established, confirming the dominance of diffusion-controlled oxygen reduction in the cathodic region.

In situ monitoring during localised indentation revealed significant, load-dependent transient negative shifts in open-circuit potential (OCP). This indicates that passivation layer disruption and subsurface plastic deformation perturb interfacial electrochemical equilibrium. Multiple indentations exhibited cumulative effects, potentially compromising measurement stability in low-potential regions.

Concurrently, in situ microhardness testing during electrochemical hydrogen charging showed that 304L exhibits higher overall hardness and more pronounced transient fluctuations than 316L. These variations align with microstructural differences in grain size and boundary density, highlighting their influence on hydrogen sensitivity. Furthermore, a novel apparatus for gaseous hydrogen permeation coupled with in situ hardness testing was explored.

This research reveals intrinsic correlations between mechanical perturbations, passivation stability, and hydrogen-related mechanical responses, providing crucial insights into localised failure mechanisms of stainless steels in complex hydrogen environments.

The Influence of Hydrogen on Irradiation Damage Features in Zirconium Alloys

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Theme: Metallurgy and Corrosion
Year of Study (Presentation Type): Year 3 (Poster)

Zirconium (Zr) alloys serve as essential components in light water reactors, tasked with upholding structural integrity over their operational and storage lifetime. Due to the anisotropic nature and typical crystallographic texture of Zr alloys, prolonged irradiation leads to irradiation-induced growth (IIG). Breakaway growth during IIG occurs at high fluences and has been linked to the formation of <c> type dislocation loops.

Various factors have been shown to affect IIG, but for some alloys the hydrogen (H) content has been identified as a crucial factor, particularly at high fluence levels. Studies indicate that hydrogen contents exceeding 100 ppm result in faster growth rates and accelerated breakaway growth. The mechanisms underlying this observation remain unclear but are suggestive of a relationship between c-loop formation and hydrogen content.

In this study, to investigate the relationship between c-loops and hydrogen content, hydrogen charged low-Sn ZIRLO samples will undergo heavy ion irradiation with 20 MeV tin ions to a range of doses, where <c> loop formation is expected. Initially, the influence of irradiation on hydride precipitation behaviour will be characterised with scanning electron microscopy and transmission electron microscopy (TEM) where differences in the hydride distribution, orientation and morphology before and after irradiation will be discussed. TEM and X-ray diffraction will then be employed to understand the impact hydrogen, present in solution and as hydrides during irradiation, has on the density and distribution of the <c>-loops as a function of irradiation dose.

Investigating the Effect of Hydrodynamics and Coolant Chemistry on CRUD Deposition in Regions of Accelerating Flow

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Research Theme:
Metallurgy and Corrosion;

Year of Study (Presentation Type): Year 3 (Poster)

Corrosion related unidentified deposits (CRUD), formed from soluble and colloidal corrosion products in pressurised water reactor (PWR) primary coolant, can adversely affect plant operation through reduced heat transfer efficiency and increased radiation fields. Lithium hydroxide (LiOH) is conventionally used as a pH-raiser. Potential supply constraints have motivated investigation of potassium hydroxide (KOH) as an alternative. This study examines the influence of coolant chemistry on CRUD deposition in regions of accelerated flow, with a particular focus on electrokinetic deposition (EKD).
Deposition experiments were conducted in a high-temperature autoclave flow loop using 300 µm 304 stainless steel orifices exposed to a flow velocity of 35 m/s at 230 °C and 100 bar. A constant $pH_T = 7.6$ was maintained using either 2 ppm Li as LiOH or 11.3 ppm K as KOH. CRUD build-up rates were quantified by white light interferometry, supported by scanning electron microscopy and corrosion product analysis. Streaming potential measurements were used to determine magnetite zeta potential under representative conditions. A statistically significant reduction in CRUD build-up rate of 23 ± 3.3 % was observed in KOH compared to LiOH, accompanied by a 22 ± 3.1 % reduction in zeta potential. These results indicate that coolant chemistry influences CRUD deposition through electrokinetic mechanisms rather than changes in corrosion product availability.

Visualisation and Quantification of Hydrogen Effusion in Aluminium Alloy 7075-T6

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Al7075-T6 is generally utilised in the aviation industry, owing to its excellent strength-to-weight ratio and availability. However, this alloy is susceptible to localised corrosion and hydrogen embrittlement (HE) under humid conditions. H-atoms can enter and be trapped in Al alloys readily in electrochemical environments. The presence of aluminium oxides provides strong hydrogen diffusion barriers and enhanced corrosion resistance. However, local surface pH variations induced by redox reactions in electrochemical environments can degrade the aluminium oxides, making it challenging to prevent corrosion in this alloy.

This project studied the behaviour of Al7075-T6 in the cathodic region in a marine environment. The formation of surface smut layers and films and their effect on hydrogen diffusion were analysed at room temperature. Electrochemical polarisation tests were associated with the appearance of the smut layer and hydrogen effusion. Surface changes were captured during electrochemical polarisation, and subsequent hydrogen emission was characterised using image analysis methods. The volume of effused hydrogen gas was collected in measuring cylinders using the drainage method and correlated with weight-loss and image-analysis results.

The measured hydrogen diffusivity (derived from effusion measurements) of Al7075-T6 was in the region of $2*10^{-13}$ m^2/s. Laser-induced breakdown spectroscopy (LIBS) was used to obtain further insight into (i) hydrogen effusion rates, (ii) diffusion depths, and (iii) local surface film variations.

Sigma Phase Formation and Evolution in Duplex Stainless Steel

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Research Theme
Metallurgy and Corrosion
Year of Study (Presentation Type
Year 3 (Poster)

Abstract:

Duplex stainless steels are widely utilized in demanding engineering applications due to their superior combination of mechanical strength and corrosion resistance. However, their structural integrity is fundamentally threatened by the precipitation of the brittle intermetallic Sigma phase during thermal processing. While the kinetics of advanced-stage phase growth are often discussed, the critical "induction" period, the transition from initial atomic nucleation to sustained kinetic growth remains a major concern for the quality control of welding and heat treatment procedures.

This work systematically investigates the early-stage precipitation kinetics of the Sigma phase in 2205 duplex stainless steel. To characterize this transition, specimens were isothermally aged across distinct temperature regimes: 700°C–780°C (for 2 hours) to target early nucleation, and 800°C (for 1, 2, and 3 hours) to analyse subsequent growth behaviour. Utilizing a multi-modal analytical approach, this study integrates Electron Backscatter Diffraction (EBSD) to map phase distribution, X-Ray Diffraction (XRD) for precise phase identification and quantification, and tensile testing to correlate microstructural evolution with mechanical degradation.

The findings provide a precise mapping of the critical temperature-time threshold for the onset of embrittlement. Results demonstrate that even limited thermal exposure at these temperatures triggers sufficient Sigma phase precipitation to substantially reduce material ductility. These insights offer actionable data for optimizing thermal processing cycles and controlling heat-affected zones in industrial applications, ultimately facilitating the production of more reliable and robust duplex stainless steel components.

Model Development for Localized External Corrosion of Buried Pipelines

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Research Theme: Metallurgy and Corrosion;

Year of Study (Presentation Type): Year 3 (Poster)

Corrosion is big challenge that affects everything from government infrastructure and industrial facilities to private property. For buried pipelines in particular it can lead to environmental contamination, down time and extensive repair costs. Industry data shows that for transmission pipelines, external corrosion far more prevalent than internal corrosion. Additionally, uniform corrosion is essentially a non-factor when it comes to buried pipelines. It is localized corrosion that causes failures. The main mechanism driving localized corrosion in soil is differential aeration where one part of the pipeline has a higher oxygen concentration than an adjacent part. Although there have been many attempts to model corrosion by industry and academia, external corrosion was largely overlooked in favor of more aggressive environments. Therefore, this project aims to build a model capable of predicting the external corrosion behavior of buried pipelines using information about the external environment (soil). The presentation will cover an update to my progress so far including an overview of the experimental approach and recent results.

Homogenization Treatments for LPBF 316 Stainless Steel and Their Effect on PWSCC

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Research Theme: Metallurgy and Corrosion;

Year of Study (Presentation Type): Year 3 (Poster)

Additive manufacturing, specifically Laser Powder Bed Fusion (LPBF), offers a variety of benefits such as faster processing times, less material waste, and less post processing (Stull, 2018). In this study, the Stress Corrosion Cracking (SCC) performance of 316 stainless steels (316SS), used as structural components (Féron, 2012), is tested in simulated Pressurized Water Reactor (PWRs) primary water. Because of this, the SCC performance of LPBF 316SS is important to understand while considering its utilization. Additionally, when trying to reduce the high dislocation density of the laser scanning tracks of LPBF's microstructure by post-processing heat treatments to induce recrystallization; 316SS showed slower recrystallization kinetics and retained elements of the laser scanning build tracks, resulting in an SCC susceptible inhomogeneous microstructure (Aota, 2021). To improve these kinetics, cold work can be induced into the microstructure pre-heat treatment to increase the energy stored between the grains, inducing the grain boundary movement (Aota, 2021). Through this thermomechanical processing, it is predicted that through retaining as many low angle grain boundaries as possible, while transforming most high angle grain boundaries into coincidence site lattices would result in a microstructure resistant to both SCC initiation and propagation.

Sealing Post-treatments for Corrosion Protection of Anodised Aluminium

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Research Theme: Metallurgy and Corrosion

Year of Study (Presentation Type): Year 3 (Poster)

Surface treatments are widely applied to aluminium components in the transport industry to improve corrosion and wear resistance and, ultimately, to extend service life. Anodising is a commonly used technique that increases the thickness of the native oxide layer. However, conventional anodic coatings exhibit a porous structure that limits long-term protective performance due to the penetration of aggressive ions through the pores. Consequently, an effective sealing post-treatment is necessary.
This study aims to develop environmentally friendly coating technology to enhance the durability of aluminium. The coatings are fabricated by anodising in phosphoric acid, followed by an in situ sealing post-treatment using fibrous silica (KCC-1). The effects of anodising parameters on pore size and morphology are systematically investigated to optimise the incorporation of fibrous silica within the anodic coating. The influence of both anodising and sealing post-treatments on corrosion resistance is evaluated. The resulting coatings are comprehensively characterised in terms of composition and morphology, demonstrating significantly enhanced durability and corrosion protection of aluminium.

Abstract:

Graphene Oxide-Enhanced Ultra-High Molecular Weight Polyethylene Oxide and Tannic Acid Innovative Nanocomposites

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Research Theme:
Polymers and Composites.

Year of Study (Presentation Type): Year 4 (Poster)

This study investigates the synthesis and characterization of innovative polymer nanocomposites, specifically focusing on ultra-high molecular weight polyethylene oxide (UHMW PEO) and tannic acid (TA) reinforced with graphene oxide (GO). The incorporation of GO and TA into UHMW PEO matrices aims to enhance the mechanical properties and functionality of the resulting nanocomposites. Through a series of experiments, different processing conditions, including various mixing and drying methods, were explored to optimize the dispersion and interaction of the nanomaterials within the polymer matrix. The results reveal that the addition of GO and TA significantly improves the mechanical strength average elastic modulus increased by almost 250%, yield strength increased by almost 183%, ultimate tensile strength increased by 154% without reducing elongation and stability of the composites, particularly under specific processing conditions. However, challenges such as precipitation, agglomeration, and dispersion issues at higher additive loadings were encountered, adversely affecting the mechanical properties. This research provides valuable insights into the intricate interplay between processing parameters, nanomaterial content, TA content, and the unique characteristics of UHMW PEO. The findings lay a foundation for further research to optimize these materials for a wide range of potential applications, contributing to the advancement of polymer nanocomposite technology.

References

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[2] Chen. et al. RSC Advances, 12(13), (2022) p.7689–7711.
[3] Jirásková, A. et al. Materials, 15(3), (2022) p.920.
[4] Kai Chen, et al. ACS Applied Polymer Materials 2022 4 (3), 2036-2046.

A Synthetic Strategy for Metal-Sulfide Quantum Dots of Complex Composition via Hot-Injection Approach

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Research Theme: Nano and Functional Materials;

Year of Study (Presentation Type): Year 3 (Poster)

A high-yield approach to I-III-VI and II-VI alloyed semiconductor quantum dot synthesis is presented. The role of the capping agent, temperature and precursors are discussed along with how conditions can be varied to achieve size control. STEM-EDX, pXRD are presented as evidence of a successful synthesis of 5-metal sulfide nanoparticles - (AgMnZnInGa)S - with the same crystal structure, but smaller unit cell as AgInS.

Advanced characterisation of iridium-based catalysts using graphene liquid cell TEM

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Research Theme: Nano and Functional Materials
Year of Study: Year 3 (Poster)

Nanoparticles of iridium and its oxides have a wide range of catalytic and electrocatalytic applications in areas such as pharmaceutical synthesis and green hydrogen production.[1] Despite this, their structures and how they evolve under reaction conditions are poorly understood compared to other precious metals. This is a barrier to the rational design and synthesis of more active and stable catalysts, which is crucial to meet increasing demand in the fine chemicals and energy industries with an already scarce supply of iridium.

Controlled volumes and concentrations of solutions can be encapsulated in lithographically defined hexagonal boron nitride wells sealed with few-layer graphite windows.[2] These custom-fabricated 'engineered graphene liquid cells', with a thickness below 50 nanometres, can be used to structurally characterise and observe dynamics of iridium nanostructures in liquid environments with atomic precision via aberration corrected scanning transmission electron microscopy.

This collaborative project between Johnson Matthey and The University of Manchester aims to combine the graphene liquid cell platform with advanced image processing techniques to improve fundamental understanding of iridium-based nanoparticle synthesis and the operando behaviour of these materials under aqueous conditions.

[1] J. Quinson, *Adv. Colloid Interface Sci.*, 2022, **303**, 102643.
[2] N. Clark et al, *Nature*, 2022, **609**, 942.

Two-dimensional Clay Channels for Tunable Nanofluidic Memristor

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The dynamic reconfiguration of charge carriers within confined ion channels under electrical stimulation leads to memory effects, wherein the internal resistance state is modulated by the history of the applied electric field. The memory effect exhibited by vermiculite (VM) nanofluidic devices can be harnessed for information storage and processing using a single nanofluidic component. Herein, we report the switching between different memory loop types by tuning ion transport pathways through the channels. The asymmetrical architecture, combined with the intrinsic surface charge of the VM channels, enables voltage polarity-dependent memory switching behaviour: from crossing-1 to crossing-2 loops, and *vice versa*. Furthermore, we demonstrate the evolution of hysteresis properties and rectification across varying voltages, frequencies, and ionic concentrations. The inherent memristive nature of the VM channels is demonstrated using different *in-plane* and *out-of-plane* channel configurations, prepared *via* re-stacked VM membranes and ultramicrotomy, with channel length scales ranging from nanometer to micrometer to centimeter. The VM device also demonstrates essential neuromorphic functionalities, such as, synaptic potentiation-depression and memory retention with programmable retention time scales. The reversible and programmable memory nature of our vermiculite memristors can be optimised based on the application specific use such as cache-like operations and real-time signal processing using STM states or artificial neural networks using LTM states by merely changing the crossing-type. Thus, our memory device offers a cost-effective, scalable fabrication process using natural materials, paving the way for next-generation bio-inspired computing systems.

Nanobody-conjugated graphene based electromechanical biosensors

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Year of Study (Presentation Type): Year 3 (Poster)

The use of graphene and related materials has been extensively explored by many researchers for their attractive intrinsic properties. This project aims to develop novel graphene-based biosensors with nanobody probes as a potential universal immunoassay platform to detect analytes in both buffer and serum solutions. Graphene-based materials, particularly graphene oxide, and reduced graphene oxide functionalised with polymer, are spin-coated to produce controlled films for biomolecule functionalisation to attach the protein probes. Currently, characterisation methods including scanning electron microscopy, atomic force microscopy, and super-resolution microscopy are employed to evaluate the graphene surface before and after biofunctionalisation. The preliminary results so far have laid the groundwork towards our goal of delivering a tool for mass screening of diseases with rapid and quantitative results.

Abstract Template:

Pre-insertion of Ca^{2+} in vanadium oxide as one of the potential high-performance cathode materials for organic calcium ion battery

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Research Theme: Select one of the following and delete the rest:
Nano and Functional Materials;

Year of Study (Presentation Type): Select one of the following and delete the rest: Year 3 (Poster)

Recent advancements in rechargeable battery technology are shifting focus from traditional lithium-ion (Li-ion) batteries to multivalent ion batteries for higher energy density in electric vehicles and portable applications. Calcium-ion Batteries (CIB) are particularly promising due to their abundance and the high theoretical electrochemical performance of the Ca metal anode.

The choice of cathode material is critical for battery performance. Vanadium oxides, with their layered structures and variable oxidation states, facilitate electron transfers in redox reactions, making them potential high-capacity cathode materials. However, they suffer from poor cycling performance due to crystal structure instability during ion transport.

The ion pre-intercalation method has been shown to stabilise the crystal structure of V2O5 during redox reactions in Li+ and Zn2+ ion batteries. This study examines CaVO, a pre-intercalated vanadium oxide, using SEM, EDX, and XRD, along with electrochemical tests such as CV and GCD in Ca electrolytes, to evaluate its performance.

High Selectivity 2D-Layered Double Hydroxide Hybrid Membranes for Redox Flow Battery

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Research Theme: Polymer and Composite
Year of Study (Presentation Type): Year 3 (Poster)

Alkaline zinc–iron flow batteries are promising for large-scale energy storage due to their high cell voltage, low cost, and environmental friendliness. However, crossover of redox-active species remains a key challenge that reduces ion selectivity and overall performance.

In this study, layered double hydroxide (LDH) was incorporated into PFSA-based membranes as a strategy to suppress crossover and enhance battery performance. Mixed-matrix composite membranes with varying LDH loadings (0.1–0.3 wt%) were fabricated via a drop-casting method. The membranes were evaluated in terms of physicochemical properties, permeability, and electrochemical performance, including charge–discharge behavior and impedance analysis.

The results show that LDH incorporation improves membrane hydrophilicity, water uptake, and ion selectivity, leading to reduced crossover. Consequently, LDH-modified membranes exhibit enhanced electrochemical performance and stability compared to plain PFSA. These findings demonstrate that LDH is an effective filler for tuning membrane properties and improving the performance of alkaline zinc–iron flow batteries.

Abstract Template:

Not all Biocarbons are made equal: Biocarbon as a biogenic nucleating agent

Name: Dominic Harris-Jukes
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Research Theme: Select one of the following and delete the rest:
Polymers and Composites.

Year of Study (Presentation Type): Select one of the following and delete the rest: Year 3 (Poster)

Abstract body text;
Plastic waste is ubiquitous, an ever-present reminder of the perpetual extraction of fossil resources and consequent climate decline. Current waste management strategies include mechanical recycling, which reduces demand for virgin plastic production, incineration for energy recovery, or landfilling. While recycling has long been considered the predominant solution for plastic sustainability, challenges in separation and sorting result in poor properties relative to virgin plastics. Complementing circularity, bioplastics have emerged as a promising, potentially lower-carbon, alternative to petroleum-derived plastics. For select bioplastics, biodegradation is a viable end-of-life (EOL) option.

But to envision a future fundamentally decoupled from fossil resources, bioplastics must meet the demanding applications of commodity plastics, extending to applications they can remain in use longer, thereby increasing carbon sequestration.

As plastics are complex, formulated compositions whereby their parent polymers are the principal component, additives are now synonymous with modifying polymer properties. However, bioplastics are currently underserved by the additive industry. This work thus explores the critical role that additives can play in overcoming challenges with poly(lactic acid) (PLA), the most common bioplastic. We explore the use of biochar as a novel nucleating agent, assessing the impact of biochar sourcing and loading on additive performance and carbon emissions.

Times New Roman, Size 12; Left Justified; Max. 200 words; No figures or tables to be included.

Abstract Template:

Understanding the Effects of Polyethylene Terephthalate (PET) Nanoplastics on *Daphnia magna*

Name: Ellie L. Wilson, Stewart J. Plaistow, Tom O. McDonald
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Research Theme: Select one of the following and delete the rest:
Polymers and Composites.

Year of Study (Presentation Type): Year 3 (Poster)

Plastic pollution in the world is now ubiquitous to every environment across the globe, with their degradation leading to micro- and nanoplastics (MNPs). Research on the effect of nanoplastics on biological systems is still in its early stages, with most nanoplastic research being dominated by polystyrene nanoparticles due to their commercial availability. In terms of global plastic production, polystyrene is not one of the top five plastics, so it is less likely to be found as MNPs compared to more widely used plastics. Our research will address this limitation by producing nanoplastics (NPs) of polyethylene terephthalate (PET), one of the top five most widely used plastics, with the PET-NPs produced using a nanoprecipitation method for comparability to literature.
Within this study, the effect of water chemistry on colloidal stability is investigated through the aging of PET-NPs in various water samples, collected from six locations in the UK. *Daphnia magna* are a keystone species in the environment, and a key model organism in laboratory experiments, due to their simplicity and high sensitivity to changes in their environment. Within our study, *D. magna* were chronically exposed to PET-NPs aged in different environmental water samples to see the effects of PET-NPs on life history traits. We found that water chemistry and the colloidal stability of the PET-NPs had a significant effect of life histories of the *D. magna*.

Thermochromic hybrid gels constructed from cellulose and morphologically shifting block copolymer nano-objects.

Francesca Patel-Burrows, Ahu Gümrah Dumanli*, Lee Fielding*

This work demonstrates the feasibility of structurally colour shifting materials by harnessing the interfaces between synthesised block copolymers and cellulose through the construction of nanocomposite cholesteric media.

Colouration through structural mechanisms shows great potential in the food and pharmaceutical industries due to its unique dye-free optical properties.(1) Cholesteric cellulose, extracted from widely abundant biomaterials, exhibits structural colouration through self-assembly in the chiral nematic liquid crystal phase. This imparts vivid iridescent colours with stimuli responsiveness in the solution phase.(2)

Self-assembled block copolymers (BCPs) are useful platforms for developing biologically compatible materials and nanocomposites with enhanced properties such as undergoing morphological phase transitions as a response to external stimuli.(3) Specifically, in this work thermally responsive diblock copolymer nano-objects have been synthesised using reversible addition-fragmentation chain-transfer polymerisation induced self-assembly (RAFT PISA).

Structurally coloured BCP/cellulose hydrogels have been fabricated using 50- 68 wt% cellulose and 10-30 wt% BCP. As anticipated, temperature-induced reflective red-shift has been observed and attributed to thermal expansion of the mesophases. Furthermore, colour shifting capabilities resulting from chiral nematic pitch compression have been observed by applying mechanical pressure to the hydrogels.
Interestingly, the block copolymer does not impact the cellulose self-assembly process, which is responsible for the observed structural colouration. However, the introduction of BCP improves the mechanical strength of the nanocomposite hydrogel when compared to a cellulose control gel. Ongoing investigations aim to optimise the hue and explore printing capabilities for scalable commercial applications.

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2. R. A.-O. Parker *et al.*, Bioinspired Photonic Materials from Cellulose: Fabrication, Optical Analysis, and Applications. *Accounts of Materials Research* **4** (2023).
3. S. J. Hunter, S. P. Armes, Shape-Shifting Thermoresponsive Block Copolymer Nano-Objects. *Journal of Colloid and Interface Science* **634**, 906-920 (2023).

Design and synthesis of silica-based nanoscale ionic colloids of poly(acrylic acid) solutions

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Research Theme: Polymers and Composites.

Year of Study (Presentation Type): Year 3 (Poster)

Nanocomposites combine organic polymer matrices with inorganic nanoscale fillers to create materials with enhanced and tuneable properties. Nonetheless, their design is challenging, as intrinsic polymer-nanomaterial incompatibility often causes filler aggregation, limiting the achievable enhancement. A viable strategy to address this challenge is to establish complementary ionic interactions between nanomaterial surfaces and functional groups along polymer chains. Such interactions form effective interfacial bridges that enhance phase compatibility and promote the formation of single-phase hybrid materials. Supported by literature, our results show this approach not only reduces nanomaterial aggregation, but can also induce the formation of new functionalities, including shape-memory and scratch-recovery. Overall, this design enables ad hoc tuning of material properties, providing a versatile pathway for developing advanced materials capable of addressing future engineering challenges. This paper focuses on poly(acrylic acid)-silica nanocolloids, where carboxylic acid groups on PAA chains interact ionically with the amino-functionalised silica surfaces. This promotes uniform nanoparticle dispersion and strong interfacial adhesion. As a result, aggregation is suppressed and rheological properties are significantly improved. Additionally, these dynamic interactions enable stimuli-responsive properties, allowing tuneable stiffness and enhanced solid-like behaviour.

Pyrene-end functionalised multiblock copolymers by sequential RAFT emulsion polymerisation

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Abstract

Thermoplastic elastomers (TPEs) are copolymers or mixtures of polymers with both elastomeric and thermoplastic properties. They have advantages over conventional elastomers in terms of (re)processibility due to their thermoreversible properties. A traditional method to synthesize commercial TPEs is anionic copolymerisation in hydrocarbon solvents initiated with organolithium.[1] This is hazardous to environment, the synthesis is sensitive to water and air, and the choice of monomers which can be used in such syntheses is relatively limited. Reversible Addition-Fragmentation chain-Transfer (RAFT)[2] emulsion (co)polymerisation in low alcohol or predominately aqueous systems is a potential synthetic strategy to overcome these drawbacks. This presentation outlines our recent work on the synthesis of fully methacrylic tetrablock copolymer materials using this approach and investigations into the resulting material properties. Specifically, RAFT solution polymerisation of a hydrophilic block followed by sequential monomer addition of two hydrophobic methacrylate monomers in a predominately aqueous RAFT emulsion polymerisation allows the production of tetrablock copolymers with TPE-like chemical structures. Moreover, these polymers were produced with excellent block size control and full conversion monomer in relatively short timescales. The resulting copolymer nanoparticles have relatively narrow size distributions and are 50-100 nm in diameter, depending on target composition. Extensive investigation of their nanoscale structures, thermal properties and mechanical properties after film formation was conducted. With the resulting materials showing interesting elastomeric behaviour and (nano)structural features. Thus, RAFT emulsion copolymerisation to form water-based nanoparticles is a promising approach for the design and preparation of TPE materials. Recent successful synthesis of nanoparticles with very similar designed copolymer structure with different degrees pyrene end group substitution has been achieved, and initial tests showed they have some compatibility of graphene nanoplatelet stabilisation in aqueous dispersant.

1 Maji, P. & Naskar, K. Vol. 139 (John Wiley and Sons Inc, 2022).

2 Chiefari J, C. Y., Ercole F et al. Living Free-Radical Polymerization by Reversible Addition-Fragmentation Chain Transfer: The RAFT Process. (1998).

Rational design of nanogel particle composition to control halide perovskite growth, structure and increase solar cell efficiency

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Research Theme:
Polymers and Composites.

Year of Study (Presentation Type): Year 3 (Poster)

ABSTRACT

The purpose of this study is to apply pH-responsive nanogels, previously used for load-bearing biomaterials and colloidosomes, to the challenge of improving the properties of halide perovskite (HP) films and perovskite solar cell (PSC) power conversion efficiency (PCE). Our results show that nanogel composition is critical for their use in the HP precursor solutions and that methacrylic acid (MAA) has multiple beneficial effects. MAA groups catalyze HP crystallization and increase conversion of PbI_2 to HP. By varying the composition of the nanogels we identify PEA-MAA-DVB (EA and DVB are ethyl acrylate and 1,4-divinylbenzene) as an optimal nanogel system in terms of PCE. The nanogels are shown to bind HP grains to each other as well as to the underlying SnO_2 transport layer. The nanogels decrease the rate of HP film degradation to moisture. They are also shown to passivate defects at the HP surface decreasing non-radiative recombination which increase the PCE to the highest value achieved for PSCs containing nanogels. We conclude that all parts of the nanogel structure are essential for these adhesive and binding colloidal additives to improve HP properties and PSC performance. The results of this study provide a pathway to future nanogel design improvements for use in PSCs.

Metrology and Mixing in Plastics Recycling

Name: Saleh Soomro
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Research Theme: Polymers and Composites
Year of Study: Year 3 (Poster)

The increasing demand for plastic products has generated unprecedented amounts of plastic waste. A significant proportion of plastic waste is landfilled, carrying both short and long term physical and chemical risks. To reduce the impact of plastic waste, recycling has emerged as an effective tool to recover waste and lower demand for unsustainable virgin plastics production. Recent recycled content (RC) legislation implemented across the UK, EU and the US has given further precedence for the incorporation of plastic waste in new materials. However, both the metrology and the mixing mechanisms of RC with virgin grade plastic is understudied, despite both being necessary to prevent greenwashing whilst improving performances of recycled materials. This Hyundai funded project first aims to study metrology in recycling by quantifying RC in automotive plastics using 4,4′-bis(2-benzoxazolyl) stilbene (BBS), a fluorescent tag that exhibits distinct fluorescence patterns above threshold concentrations. Subsequently, this project aims to study mixing in plastics recycling by using the variability in fluorescence response of BBS after mechanical recycling in different conditions and with different materials. By understanding how RC mixes and is measured, the use of plastic waste can be incentivised to promote an authentically circular future.

Towards Multifunctional Sustainable PLA Filaments for Additive Manufacturing through Natural Filler Reinforcement and Bio-Derived Colouration

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Research Theme: Polymers and Composites.

Year of Study (Presentation Type): Year 3 (Poster)

The development of multifunctional 3D printing filaments from sustainable sources has emerged as an important strategy for advancing environmentally responsible additive manufacturing. This study proposes a novel integrated approach for the design of biodegradable polylactic acid (PLA)-based filaments through the combined use of natural filler reinforcement and naturally derived colouration, supported by comprehensive material characterisation to assess their ability for diverse functional applications. The novelty of this work lies in the development of a unified multifunctional filament concept that integrates sustainable material selection, functional performance, and advanced structural characterisation, thereby offering a promising route for the next generation of sustainable filaments for additive manufacturing. In contrast to most previous studies, which have treated reinforcement, natural colouration, and structural characterisation separately, this work unifies these aspects to establish a multifunctional filament system with both technical and environmental value. Natural fillers and bio-derived colourants were incorporated into PLA through physical blending and chemical modification routes, followed by filament extrusion to produce composite filaments suitable for fused deposition modelling (FDM) 3D printing. Representative natural fillers investigated in this work include plant-, animal-, and mineral-based materials, such as barley grass, wool keratin, and eggshell powder, whilst the natural colourants include curcumin and kamala. This demonstrates the feasibility of producing multifunctional composite filaments from renewable and naturally derived sources. The developed materials were designed not only to improve sustainability, but also to deliver application-oriented functionalities, including enhanced mechanical performance, colour stability, pH-responsive behaviour, migration performance, and degradability. X-ray CT was further employed as a non-destructive technique to investigate internal features such as porosity, filler distribution, interlayer bonding, and damage development, thereby providing deeper insight into the structure–property relationships of the printed composites. The proposed material platform demonstrates strong potential for applications requiring lightweight, customisable, and environmentally friendly components, including consumer products, personalised healthcare devices, smart packaging, and low-load engineering structures.

Keywords: Sustainable composites; Multifunctional filaments; Natural fillers; Natural dyes; Comprehensive material properties; Additive manufacturing; FDM 3D printing.

Synthesis of pH-responsive Amphiphilic Copolymer Nanoparticles with adjustable blue light fluorescence by polymerisation-induced self-assembly

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Research Theme: Polymers and Composites.

Year of Study (Presentation Type): Year 3 (Poster)

Abstract:

The combination of aggregation-induced emission (AIE) materials with stimulus-responsive hydrogels has become a popular research trend in the past decade, as the intrinsic flexibility of hydrogels provides AIE luminogens with highly tunable optical functions. In this work, we report a pH-responsive triblock nanoparticle system exhibiting adjustable blue emission from tetraphenylethylene methacrylate (TPEMA), prepared via polymerisation-induced self-assembly (PISA) under reversible addition–fragmentation chain-transfer (RAFT) control. An anionic poly(3-methylpropyl methacrylate potassium) (PKSPMA) macro-CTA was first synthesised via RAFT solution polymerisation as the hydrophilic block, after which the AIE-active poly(tetraphenylethylene methacrylate) (PTPEMA) and the pH-responsive poly(methacrylic acid) (PMAA) were copolymerised into a single middle block, followed by the formation of a hydrophobic poly(benzyl methacrylate) (PBzMA) core. By modulating the swelling degree of PMAA at different pH values, the distance between PTPEMA units can be altered, enabling controllable fluorescence quenching. The nanoparticle morphology, fluorescence emission, and their correlations were analysed using DLS, TEM, SAXS and fluorescence spectroscopy. Overall, this study demonstrates that pH-responsive block copolymers are highly effective for regulating both fluorescence quenching and enhancement of AIE components in aqueous environments over a broad pH range of 4–10.

Towards Zero-Waste Weaving: Seamless Garments via On-Loom Shaping

Department of Materials
Research Theme: Textiles and Apparel
Dewan Murshed Ahmed (11470701)
Supervisor: Professor Prasad Potluri

Abstract

This research presents a novel dobby-based loom for producing seamless, shape-engineered woven garments with zero-waste potential. A two-piece inclined reed enables dynamic width variation, while a segmented warp system provides zone-wise tension control. A control strategy maintains consistent EPI, PPI, and cover factor during shaping. Proof-of-concept samples demonstrate the feasibility of weaving pre-shaped panels without cutting or sewing. The system offers a scalable approach to sustainable garment manufacturing and provides a platform for integrating functional and smart textiles.

Flexible-ultrathin radiative cooling metamembrane for wearable thermal management

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Research Theme: Textile and Apparel
Year of Study (Presentation Type): Year 3 (Poster)

Passive daytime radiative cooling (PDRC) offers a sustainable cooling technique to reduce energy consumption and carbon footprint by simultaneously reflecting sunlight and emitting thermal radiation. However, the conventional passive radiative cooling materials pose challenges for large-scale applications by neglecting impacts on various environment. Herein, we demonstrate a simple strategy to form hierarchically porous structured polymer microfiber-based photonic nanoparticle metamaterial (PPM) film for highly efficient PDRC, which still guarantees a superior high solar reflectance and MIR emission under complex environment. Moreover, featuring excellent durability, compatibility and stability, PPM offers a scalable solution for energy-efficient and structure-flexible radiative cooling in electronic devices, textiles, building and beyond, advancing passive radiative cooling technologies towards diverse real-world implementations.

From Size to Shape Morphology-Driven Apparel Engineering for Improved Fit in Womenswear

Name: Phumza Sokhetye
Theme: Textiles and Apparel

Abstract

This research proposes a morphology-driven approach to apparel engineering that shifts garment design from traditional size-based systems to shape-based methodologies in womenswear. Conventional sizing assumes that bodies within the same size category share similar proportions; however, significant variations in body shape often led to poor garment fit, discomfort, and reduced functionality.

To address this issue, the study introduces a workflow that integrates 3D body scanning, morphological analysis, and parametric pattern design. High-resolution body scans capture detailed geometry, which is then analysed to extract cross-sectional shapes and key morphological features. These features are consolidated into a 'fit fingerprint,' a shape-based representation that more accurately reflects individual body characteristics than standard measurements.

This fit fingerprint informs parametric pattern generation, enabling garments to be structurally adapted rather than simply resized. The approach is validated through digital and physical prototyping, demonstrating improved alignment between body and garment. Initial findings from digital modelling suggest that the morphology-driven approach has the potential to improve shape-garment alignment and reduce fit-related issues, pending further validation through physical prototyping.

This research establishes a scalable, morphology-driven framework that has the potential to transform apparel design and improve fit outcomes in the fashion industry.

Key words: Morphology-driven design, Body shape analysis, 3D body scanning, Fit fingerprint

Establish an Engineering Design Principles and Methods for the Transformable Apparel for the Specific Cultural Contexts

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Research Theme: Textiles and Apparel
Year of Study (Presentation Type): Year 3 (Poster)

This study aims to enhance the functional performance of suit jackets for Chinese professional women balancing formal dress requirements with cycling as a commuting mode. It investigates the evolution of apparel pattern development within a parametric system, transitioning from a bespoke jacket (B-JKT), developed using conventional drafting methods, to a transformable jacket (T-JKT) incorporating cycling functionality. This process is enabled by three-dimensional (3D) body scanning and computer-aided design (CAD) technologies.

Methods: Phase One integrates 3D scanning data into conventional B-JKT drafting within a CAD system to improve body-to-pattern relationships. Phase Two compares bodice block measurements from physical draping on three mannequins with corresponding 3D scan data, establishing refined relational models. Phase Three transforms the optimised B-JKT into T-JKT blocks based on cycling-specific anatomical requirements and evaluates both designs through virtual simulations using 30 avatars.

Findings: The parametric B-JKT significantly improves body-to-pattern ratios and shaping accuracy, validated across four diverse body types. Consistent relational trends are identified, forming a robust framework. These relationships are translated into T-JKT design within CAD. A cycling-specific anatomical measurement framework is also developed to support T-JKT pattern construction.

Abstract Template:

Effect of Fabric Structure Changes During Manufacturing and Finishing on Fabric Hand and Skin Comfort

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Research Theme:
Textiles and Apparel;

Year of Study (Presentation Type): Year 3 (Poster)

Unlike colour, which has already been widely digitised and standardised in the textile industry, fabric hand feel and skin comfort remain weakly standardised and digitised. The hand feel properties of fabrics are highly sensitive to structural changes induced by finishing processes, making it challenging for manufacturers in the wool textile sector to consistently reproduce the desired hand feel characteristics when processing new samples. Motivated by this gap, this study proposes a structure-centric framework, utilising SEM and the Fabric Touch Tester (FTT) to correlate processing-driven micro/meso-scale alterations with hand feel and skin comfort performance, enabling standardisable measurement and predictive control. A double-faced semi-worsted fabric (80% wool, 20% Tencel) was sampled across 12 manufacturing and finishing processes. This study quantitatively characterises and focuses on three structure-related descriptors: total fabric hair thickness (T_hair), fabric core thickness (T_core) and surface fibre alignment dispersion, and relates them to fabric hand and skin comfort primary sensory indices as well as instrumental parameters measured by the FTT. Across the sample, T_hair was strongly and positively associated with CW ($R^2=0.87, p<0.0001$), CRR ($R^2=0.93, p<0.0001$) and hand feel warmness index ($R^2=0.93, p<0.0001$). Fabric core thickness was positively associated with skin comfort softness and the total indices, and exhibited non-linear relationships with bending-related indices: BARe ($R^2=0.97, p<0.0001$) and BWe ($R^2=0.92, p<0.005$). By quantifying structural properties of wool textile during production, the study establishes predictive links from structure to hand feel/skin comfort performance and defines actionable set points for finishing. This supports target-based control, improves consistency and energy efficiency in line with the ESPR, and advances digital, performance driven manufacturing.

Exploring the Impact of Generative AI Chatbots' Emotional Expressions on Consumers' Emotional Responses, Satisfaction, Trust, and Intention to Use in Online Fashion Retail

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Year of Study (Presentation Type): Year 3 (Poster)

Abstract

Generative AI (GenAI) chatbots using emotional intelligence are increasingly deployed as frontline support in online fashion retail, yet UK consumers often report discomfort or dissatisfaction when chatbots display emotional expressions. Appyling Expectancy Violations Theory (EVT) to emotional expression in online fashion retail customer service, this study explores how consumers form expectations about emotionally expressive chatbot tones, how they appraise tones that exceed or fall short of those expectations, and how these appraisals shape emotional responses, satisfaction, and trust. Adopting an interpretivist, abductive approach, the study focuses on three tones: encouraging, reassuring, and neutral. Data are generated through an online Wizard-of-Oz (WOz) simulation followed immediately by semi-structured interviews. Each participant completes three short chats with a tone-manipulated "chatbot" in a simulated online fashion shopping scenario, followed by an interview to elicit their emotional responses and interpretations of the chat experience. Theory-informed thematic analysis links expectation formation, appraisal, and discrete emotional responses. The study contributes theoretically by extending EVT to emotionally expressive human–AI service interactions and by exploring how tone-based expectancy violations shape consumers' emotional and evaluative responses in online fashion retail.

Key words: Generative AI, Chatbots, Emotional tone, Expectancy violation theory, Online fashion retail, Customer service, Qualitative, Wizard-of-Oz, Semi-structure interview, Interpretivism.

AI vs Human-Based Authentication is Second-Hand Luxury Live-streaming

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Second-hand luxury consumption is gaining social value within the circular economy, with live-streaming commerce rapidly emerging as a primary sales channel, particularly in China. However, widespread counterfeiting remains a critical barrier, with 42% of consumer complaints about second-hand luxury products concerning authenticity issues (China Consumer Association, 2024), creating a persistent consumer trust deficit that undermines purchase intention and market growth.

Despite growing scholarly attention, significant literature gaps remain. Although authentication certificates have been shown to reduce consumer uncertainty in static e-commerce settings (Pandey et al., 2024), how specific authentication technologies — particularly AI-based versus human-based approaches — shape consumer trust and behavioural intentions within live-streaming contexts remains unexplored. Scholars explicitly call for innovative and efficient authentication solutions to boost consumer trust in second-hand luxury platforms (Jang and Kang, 2025; Thanasi-Boçe and Al-Issa, 2025).

Grounded in Social Exchange Theory, this sequential mixed-methods research investigates how perceived benefits and costs of AI versus human-based authentication services shape consumer trust — examined as transferable across authentication services, retailers, and products — and how this trust subsequently drives behavioural intentions. Study 1 employs qualitative semi-structured interviews (n=30) and Study 2 adopts a quantitative experimental survey (n=400) with female second-hand luxury live-streaming consumers.