BRAGG CENTRE FOR MATERIALS RESEARCH **ANNUAL REPORT** 2024

UNIVERSITY OF LEEDS

Contents

Vision:

The Bragg Centre nurtures a vibrant and innovative materials research community to deliver the greatest impact across disciplinary boundaries.

EDI Statement:

The Bragg Centre is an inclusive, diverse and creative materials research community which attracts and develops students and staff of all identities, characteristics and backgrounds, valuing everyone's contribution and supporting them to thrive.

The Bragg Centre is committed to continuous, ongoing action to improve everyone's well-being and productivity.

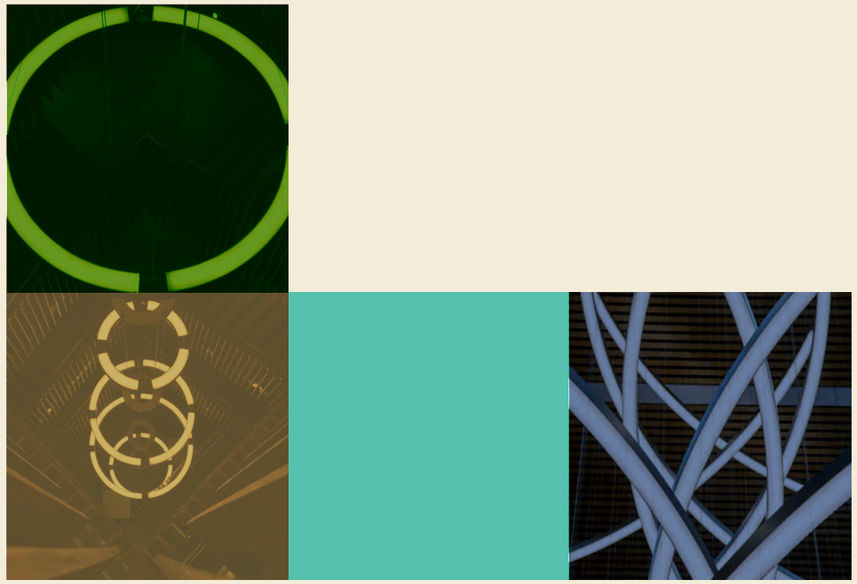
Challenge Areas

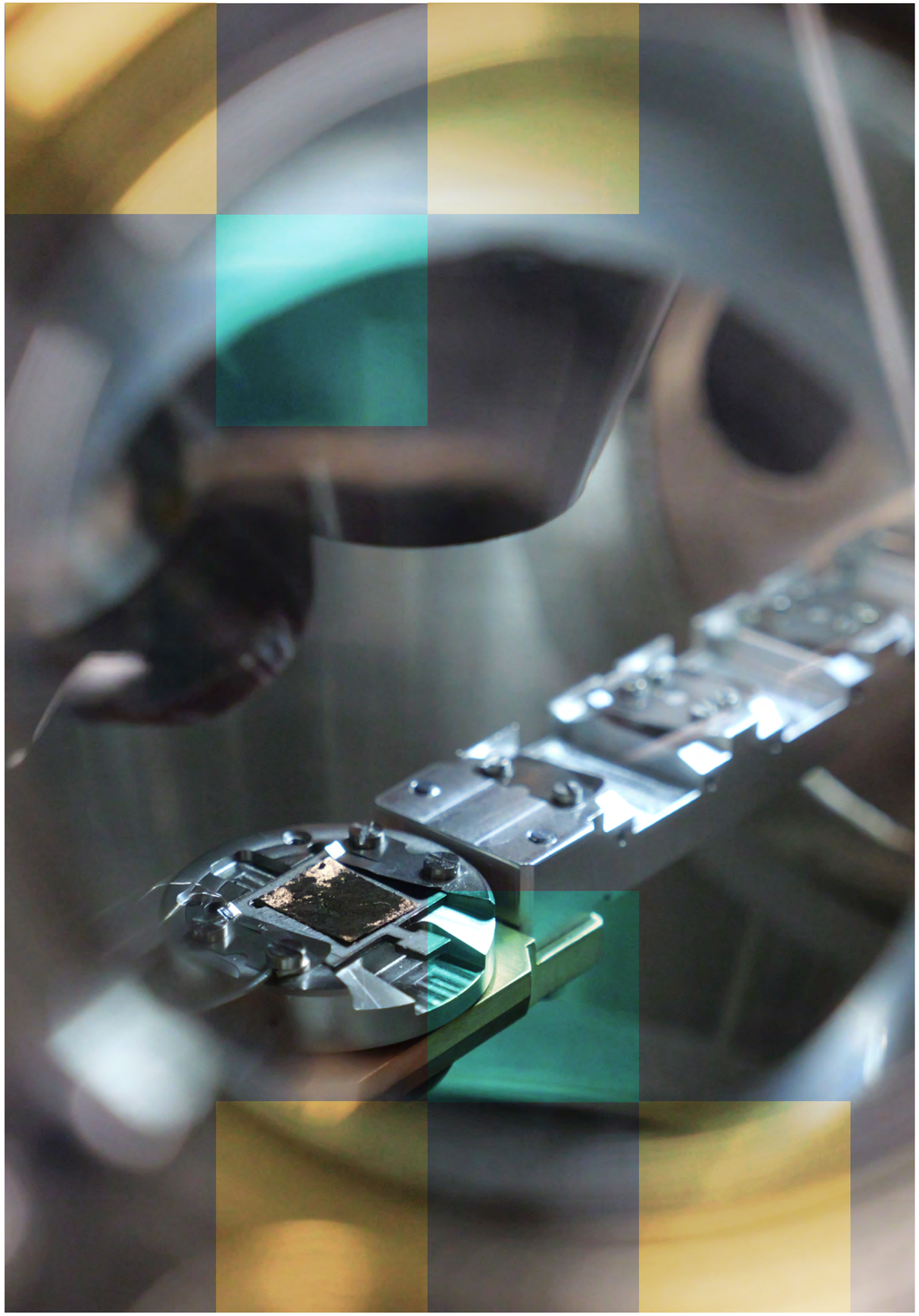
New materials for advanced manufacturing
new tools, future products, and circular economy

New materials for future computing
energy harvesting, power efficiency and quantum technologies

New materials for a healthy society
model systems, diagnostics, and future foods

New approaches to sustainable materials design
AI-assisted prediction, mitigation, and optimisation





Our Progress in perspective.

Directors Summary

Prof. Edmund Linfield,
Director of the Bragg Centre

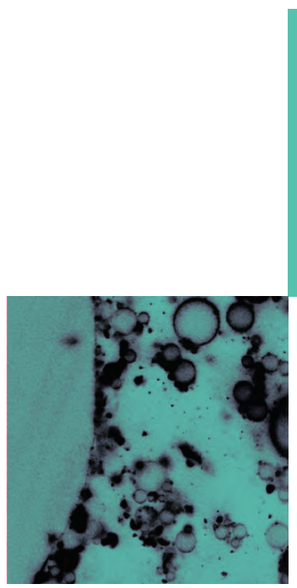
What another amazing year!

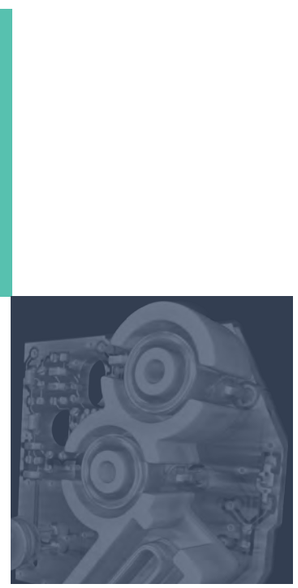
I can't quite believe all that has happened, and it is a pleasure to say a big 'thank you' to all our members. Our community has grown to over 400 people, and we have seen more and more people engaging with our events, publications, public engagement and communications. I hope you enjoy reading just a small selection of our stories in this Annual Report.

Our January 'Bragg Exchange' has now expanded to a two-day event with external sponsorship, and at the time of writing, over 250 people have signed up to attend in-person the 2025 event. We have seen ever increasing numbers of external visitors wanting to see and talk about 'The Bragg Centre', including EPSRC, Innovate and DSIT, and it was a particular pleasure to have Matthias 'land' at the Bragg Centre – Matthias is a Leeds materials science alumnus who spoke about his career and being an astronaut on the International Space Station.

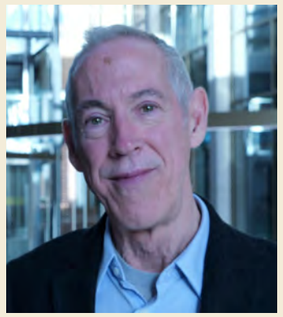
The year has seen the building of a new partnership with the Royal Armouries, the establishment of a monthly commercialisation session, and the start of a facility forum for our Research Technical Professionals. Bragg members presented at the prestigious Royal Society Summer Exhibition, and we launched a new 'thin film' training course focused on our Royce deposition system. We were also delighted to announce a travel fund from a generous alumnus donation, which will allow PhD researchers to present their results, and promote the Bragg Centre, at international conferences.

We are very grateful to the University and our partnership with the Royce Institute for the funding that has allowed us to achieve so much. But, my final thanks must go to the 'Bragg Team' – Andy, Helen, Lucy and Steph, who have made everything happen, and have provided so much support to all our members. It has been a real pleasure to welcome Steph to the team, but it is with sadness that we say 'goodbye' to Andy in January 2025 – we wish you well for your future career as Operations Director of NAPIC (the National Alternative Protein Innovation Centre) and really appreciate all the activities you have initiated as the Centre Manager of the Bragg Centre over the last four years.





Observations from the External Advisory Board



Prof. Rob Hardeman MBE

Chair of the Bragg Centre External Advisory Board

Continuing with last year's theme of building partnerships, 2024 saw a host of excellent developments from the Bragg Centre. It has been a pleasure to see the growth of the number and reach of the community, expansion of the Exchange and Colloquium meetings, large grants being secured, the consolidation and expansion of training courses based on cleanroom and Royce equipment investments.

The critical role of RTPs in the success of Bragg is being increasingly recognised and new the facility forum should provide a good mechanism for further evolution.

Kudos goes to the new team member Dr Steph Foster who is building a highly credible commercialisation and business interaction approach in partnership with many others across the University.

Partnership with the Astbury Centre on Engineering Biology demonstrates the key place of materials as the interface to other disciplines that was always at the heart of the philosophy of Bragg – now coming to the fore.

Another highlight was attracting philanthropic donation in support of travel for doctoral students – a topic of considerable recent concern - so this is a very well-targeted and welcome contribution.

As we look to the next year, external financial constraints on the University will need to be carefully navigated to ensure that the growing reputation of Bragg for excellence and delivery can be maintained and enhanced.

The team has shown that it can rise to the toughest of challenges, even hosting a VIP (ESA astronaut) landing at minimal notice and rightly is taking its place as a key asset for the University as a whole.

To end though, on one bittersweet note we wish Andy Lee all the best in his new role with NAPIC. He will be much missed as a lynchpin at Bragg and we wish him all success as he moves just up the road.

Impact on the Faculty

Prof. Nora de Leeuw

Executive Dean, Faculty of Engineering & Physical Sciences

The Bragg Centre sits at the heart of the Faculty of Engineering and Physical Sciences, drawing together colleagues from all corners of the faculty and beyond. Since its inception, the Centre has provided a key focal point for the outstanding activity in materials characterisation and development across the faculty, including development of the next generation electronic devices, anticorrosion surface coatings for use in extreme environments, and biological tribology of orthopaedic joint replacements, to name but a few areas.

By bringing these areas of activity together into a portfolio, the Centre has substantially enhanced the external visibility of the faculty's materials activity; and supported new, and sometimes surprising, cross-school connections to be formed through opportunities such as its Undergraduate internship and Bragg Studentship programme.

I particularly welcome the Centre's drive for education and training, providing substantive career development opportunities including its well-regarded annual PhD Colloquium, Bragg on Tour initiative and its hosting of the Undergraduate internship celebration on behalf of the faculty. This year I was further pleased to see the development of a Bragg Centre student travel fund through a generous philanthropic donation, which will enable PhD students from across the faculty to attend national and international conferences.

Beyond its core events, training and research programmes, Bragg has acted as a significant ambassador for the faculty, regularly hosting key stakeholders, and most notably this year engaging the whole faculty with a visit from Dr Matthias Maurer, ESA Astronaut. This was a significant highlight, with Bragg organising for Dr Maurer to meet with a range of students and staff, showcasing the faculty at its most innovative.

The Bragg Centre continues to deliver on the promise of interdisciplinary research activity for the faculty, and I look forward to seeing how it evolves in the years to come.

Impact across the University

Prof. Nick Plant

Deputy Vice-Chancellor: Research and Innovation

The University of Leeds is committed to making a positive difference in the world, by delivering transformative, high-impact, interdisciplinary research, innovation and education that addresses local, national and global challenges.

The Bragg Centre is a great example of how this is achieved at Leeds, by bringing together experts from across the university into a dynamic community that creates unique solutions to major societal challenges. This vision is reflected in the sheer breadth of Bragg's research and innovation portfolio which ranges from developing new materials for future computing, to enabling a healthy society with future food systems.

It is this breadth and flexibility of its dispersed community that underpins Bragg's approach, enabling it to react and evolve to innovate, drawing on a wide range of expertise and capabilities. Through collaboration with the whole University community in its materials research activity and by underpinning this engagement with an integrated portfolio of world-class experimental facilities, the Bragg Centre delivers a substantially unique proposition for industrial engagement.

This year, the Bragg Centre has capitalised on this position, introducing a new thin film training course, alongside the highly successful nanotechnology cleanroom training. Coupled with the Centre's extensive programme of public engagement, outreach, internship opportunities and a thriving PhD community, the Centre is ensuring that Leeds plays a key role in delivering the skilled workforce needed to realise the Government's vision to super charge the economy.

The Bragg Centre exemplifies the pivotal role that an interdisciplinary centre can play in enhancing and advocating for its community. Enriching career development opportunities has been a priority, advocating for research technical professionals both within Bragg and across the wider institution, building an integrated community of practice across its facility portfolio.

The Bragg Centre continues to be a valuable ambassador for the University, hosting visits from alumni, partners, key stakeholders, industry and MPs – and this year the Centre even welcomed an Astronaut. Through its engagement with philanthropists, the Centre has secured a significant donation to support student travel to conferences, which will not only positively impact our students' experience during their time at Leeds but will carry the Centre and University's reputation and interests internationally.

As it reaches its 5th year, the Bragg Centre has built an exemplary programme of research, events, innovation, education, training and industrial engagement; substantially enhancing the reputation of Leeds' materials research activity on an international stage. I look forward to seeing the Bragg Centre continue to grow its successful reputation over the next 5 years.

Our Governance

Research Theme Leads

Prof. Rik Drummond-Brydson
Materials Characterisation

Prof. Christoph Wälti
Bionanotechnology

Prof. Christopher Marrows
Electronic & Photonic Materials

Prof. Ardian Morina
Functional Surfaces

Prof. Fiona Meldrum
Multiscale Materials

Prof Daniel Read
Soft Matter

Dr Arwen Tyler
Joint Soft Matter

Prof. Edmund Linfield
Centre Director

Bragg Centre Team

Dr Andrew Lee
Centre Manager

Ms Lucy Leonard
Research & Innovation Development Officer

Dr Stephanie Foster
Innovation & Business Development Officer

Mrs Helen Walters
Research & Events Administrator

Ex Officio Members

- **Prof. Cath Noakes,** Pro Dean for Research & Innovation
- **Prof. Giles Davies,** Deputy Executive Dean, Faculty of Engineering and Physical Sciences
- **Dr Rachel Curwen,** Director of Research & Innovation Development

Management Committee Members by Application

To ensure that the management committee continues to represent a balanced view of the community, including representation from the student, early career researcher (ECR) and research technical professional (RTP) groups, members are appointed by application to sit for a two-year term.

Term: October 2022 – September 2024

- **Dr Razan Aboljadayel,** School of Physics & Astronomy (EDI Lead)
- **Dr Andrew Burnett,** School of Chemistry
- **Dr Robert Davies,** School of Dentistry
- **Dr Timothy Moorsom,** School of Chemical & Process Engineering

Term: September 2023 – September 2025

- **Dr Richard Walshaw,** School of Earth & Environment (RTP)
- **Mr Rob Simpson,** School of Chemical & Process (RTP)
- **Dr Joshua Owen,** School of Mechanical Engineering
- **Dr Alice Macente,** School of Civil Engineering (RTP) (Stepped down August 2024)
- **Ms Victoria Haines-Woolley,** School of Mechanical Engineering (Student representative) (Stepped down January 2024)

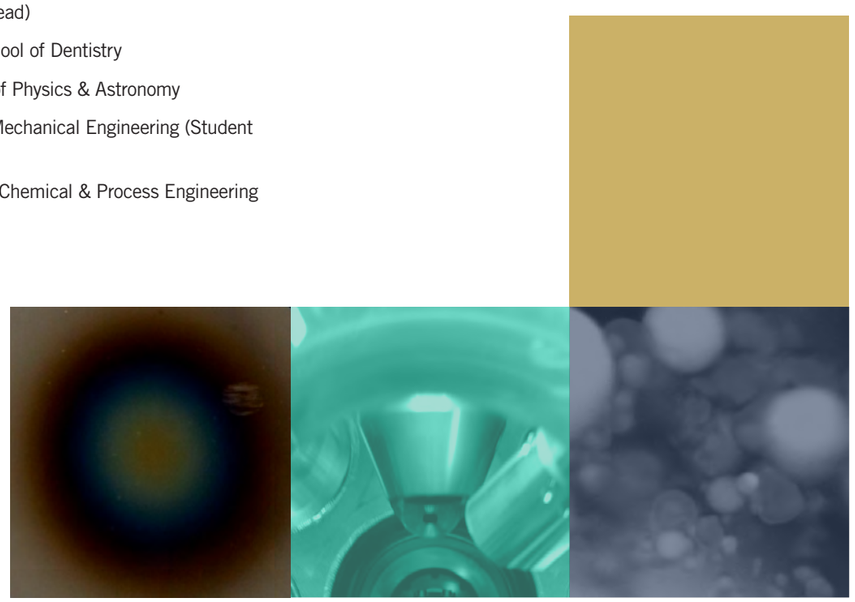
Term: September 2024 – September 2026

- **Dr Wing-Fu Lai,** School of Food Science & Nutrition
- **Dr Adriana Matamoros Veloza,** School of Mechanical Engineering/SWJTU Joint School (EDI Lead)
- **Dr Timothy Moorsom,** School of Chemical & Process Engineering (reapp, Comms Lead)
- **Dr Flavia Pires Rodrigues,** School of Dentistry
- **Dr Thomas Raistrick,** School of Physics & Astronomy
- **Mr Finlay Spence,** School of Mechanical Engineering (Student representative)
- **Ms Mae Jankowski,** School of Chemical & Process Engineering (Student representative)

External Advisory Board

Our external advisory board helps to shape the strategic direction of the Bragg Centre. Drawn from academia and industry, they continue to support the growth of the Centre and its international reputation for materials research.

- **CHAIR: Dr Rob Hardeman MBE,** Independent Technology Consultant
- **Dr Mark Hampden-Smith,** Vice President Business and Technology Strategy (Ceramics), Saint-Gobain
- **Prof. Peter Dowding,** Principal Research Scientist, Infineum UK
- **Dr Sheetal Handa,** Materials Science Advisor, BP (retired)
- **Prof. Mary Ryan CBE FREng,** Vice Provost for Research and Enterprise, Imperial College London
- **Prof. Jim De Yoreo,** Chief Scientist for Materials Synthesis and Simulation Across Scales, Pacific Northwest National Laboratory
- **Dr Charles Footer,** Head of Products , QinetiQ
- **Dr Charles Bragg,** Non-Executive Director and Deputy Chair, Centre for Process Innovation
- **Dr Linda Pravinata,** Lead Scientist, Marlow Ingredients
- **Prof. Melanie Bailey,** Theme Leader for Health & Food Technologies, Reader in Analytical Sciences, University of Surrey (Joined January 2024)



Innovate

Strategic and Industrial Engagement

This year the Bragg Centre welcomed Dr Steph Foster into the Centre's core team. Joining in June 2024 as the Centre's Innovation and Business Development Officer, Steph has immediately set about transforming the Centre's industrial engagement.

From streamlining the stakeholder experience with an upgraded customer relationship management (CRM) system, to positioning the Centre's business offering clearly with a new "menu of services" which untangles the access routes.

Alongside this, the Centre has worked with its facility staff to outline the Centre's unique selling proposition more clearly; thoroughly reviewing the capabilities of its world-leading equipment and state-of-the-art research environment, as well as defining the areas of unique expertise amongst its Research Technical Professionals (RTPs).

To expedite access to its capability, the Centre was delighted to welcome **Royce Application Scientist** Dr Tom Brown in September 2024. Tom will support the smooth delivery of industrial projects across the Bragg Centre's facility portfolio, acting as a rapidly deployable technical resource able to deliver complex industrial projects across multiple capabilities and experimental techniques.

Alongside active lead development, including showcasing at the Materials Research Exchange 2024, the Centre's customer base has continued to grow organically with **11 direct enquiries** from new industry prospects in the last 6 months. Three of these prospects have now established projects ready for delivery from January 2025.

Over the year the Centre hosted **17 strategic visits** from a wide range of stakeholders including industry, international delegations, philanthropic donors and policy makers.

These include:

- A delegation from the Smeatonian Society as part of the Smeaton300 celebration
- Dr Oliver Graydon, Chief Editor Nature Photonics
- Dr Mattias Maurer, European Space Agency Astronaut
- Paul Ramsbottom, CEO Wolfson Foundation
- John Abbott, CEO the Satellite Applications Catapult
- The West Yorkshire Combined Authority Manufacturing task force
- Delegations from the Chinese Consulate, and the State Dept of South Carolina
- Delegations from Shanghai Jiaotong University, South China University of Technology, and Waterloo University, Canada
- Jensen Pharma
- Nestle
- Microneedles Solutions
- TR Advanced
- Twinings
- Royal Armouries

In addition, the Bragg Centre celebrated the awarding of a number of collaborative proposals with industrial partners, these include:

- A **£243,169** Innovate UK knowledge Transfer Partnership (KTP) led by Prof. Richard Barker, (School of Mechanical Engineering) in partnership with Roemex Ltd.
- **£47,997** industrially funded project to develop high throughput defect-free ceramic manufacturing for high performance fuel cells, led by Dr Mirmasoud Jabbaribehnam (School of Mechanical Engineering) and funded by Flexitallic Ltd.
- A **£30,115** Innovate UK funded project to recycle permanent magnets from electronic waste led by Prof. Animesh Jha (School of Chemical & Process Engineering), in partnership with Silex World Ltd.
- A **£20M** industrial consortium project, "Excellence in Conceptual Evolution of Electric Drives" (ExCEED), led at Leeds by Dr Liuquan Yang (School of Mechanical Engineering).

Coffee and Commercialisation

In July 2023, the Bragg Centre established a monthly Commercialisation Drop-in session in collaboration with the University's Commercialisation team.

Hosted in the atrium of the Sir William Henry Bragg building, the sessions provide a regular touch point for the materials community to informally seek advice from commercialisation and business development professionals about their research.

The drop-in sessions have proven to be highly popular, attracting members from right across the Bragg Centre's remit and career stages, including PhD students, post-doctoral researchers, research technical professionals, and established academics.

During the sessions, members are able to talk about their translational ideas with Harry Kingston, Commercialisation Manager for the Faculty of Engineering & Physical Sciences, and Dr Steph Foster, Innovation and Business Development Officer for the Bragg Centre; and discover the next steps in commercialising their research which might include patenting, licensing or forming spin-outs.

Special editions of the drop-in sessions have featured Dr Oliver Prosser, Commercialisation Analyst, to provide rapid prior art searches for attendees; and Alison Maughan, from Northern Gritstone, to provide advice on securing venture capital investment funding.

The sessions continue to provide a friendly setting for researchers to interact with both the Bragg Centre and the University's Commercialisation team, and will continue into 2025.

The Home of X-ray Diffraction

Dr Fanny Costa

Head of X-ray Analytical Facilities
Bragg Centre for Materials Research

This year the Bragg Centre welcomed Dr Fanny Costa to lead our X-ray analytical facilities; providing expert oversight to our diffraction, scattering and spectroscopy techniques.

Fanny brings with her a strong track record in X-ray powder diffraction built across a variety of materials, with a particular specialism in pharmacetucal formulations – work she has continued here in the Bragg Centre.

Over the years, the pharmaceutical industry has worked hard to develop drugs that dissolve well in water and are easily absorbed by the human body. However, the poor water solubility of many formulations remains a significant challenge across the sector.

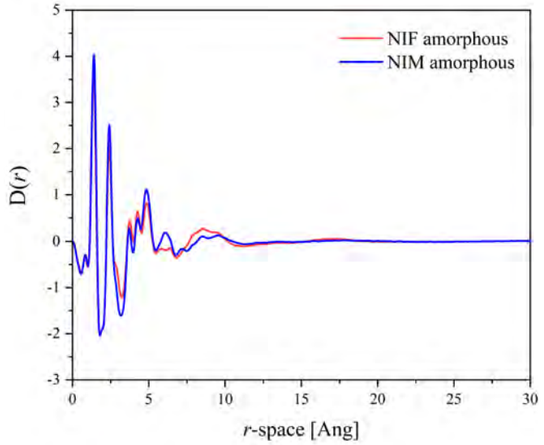
To solve this problem, amorphous drug formulations have become increasingly popular in recent years. Yet it remains difficult to describe the molecular organisation of such formulations; and their potential for re-crystalliation during storage is a considerable hurdle which can influence the final dissolution quality and efficacy of the final drug product.

Total X-ray Scattering techniques are able to detect these subtle and complex surface cyrstalliation phenomena, assisting the development of solid dispersions, nanocrystalline or purely amorphous drug formulations.

More recently, co-amorphisation has been demonstrated to be a promising methodology to produce more soluble formulations by promoting effective drug-drug stabilisation. An example of this is the co-amorphous Nifedipine/Nimodipine, which is prepared by means of a melting and quenching process.

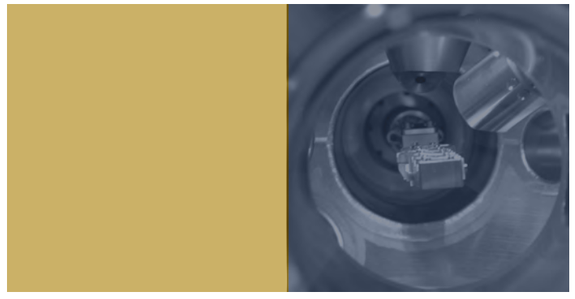
Working with colleagues from the Diamond Light Source, Dr Fanny Costa is now investigating whether there is any phase separation occurring within these co-amorphous formulations.

Using a combination of conventional X-ray diffraction and total scattering techniques across both Diamond and the Bragg Centre, Fanny is examining the structural evolution of these complex formations which could result in the presence of drug-rich domains capable of triggering re-crystallisation and reducing the efficacy of the final drug.



This multidisciplinary work, which spans pharmaceutical, chemical, and physical sciences, epitomises the Bragg Centres vision to drive innovation and deliver impact across disciplinary boundaries.

From the beginning of her academic journey, Fanny was fascinated by the ways in which X-ray diffraction (XRD) can address various challenges in the development of new materials. This technique has dominated her career right from her first research experience, where she utilised X-ray powder diffraction to analyse biominerals within kidney stones and human teeth. It is fitting then, that Fanny now takes up the leadership of this critical technique in Leeds, where it was originally invented by Sir William Henry Bragg.



Embedding Solutions for the Future

Prof. Yu Shi

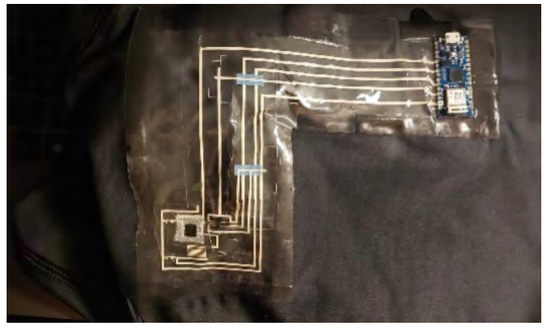
Chair of smart composite and textile materials
School of Design

The Bragg Centre is pleased to welcome Prof. Yu Shi to the materials community at Leeds.

Working across multiple sectors including infrastructure, energy and healthcare, Yu is developing smart materials which embed electronic systems into different composites, including carbon and glass fibre, and textiles to provide energy harvesting or integrated monitoring functionalities.

Recent examples of Yu's work include the integration of circuits within airplane turbine blades, capable of detecting ice formation and responsively provide de-icing with embedded heating elements. As well as printing flexible electronics into structural aerospace composites to produce lightweight body components that integrate antennas and communication systems for future electric or hydrogen aircraft. Elsewhere, Yu has developed ultralightweight and self-powered smart fabrics for animal monitoring, in particular bats, through his "Batman" project.

Yu's approach leverages simulation and modelling within his research, helping his team to develop materials which consider the full life cycle, from manufacture, through operation, to failure and repair or recycling.



His work is supported by a number of large grants, including two major EU projects; "Intake" and "Romain". The former project is providing fundamental research on nanocomposite development for hybrid energy harvesting, and includes partners across Poland, Hungary, Japan and China. Romain, focusses on extending the service lifespan of offshore wind turbine blades. Through a combination of embedded monitoring systems in the blade itself which can self-locate and report deterioration, and the development of robotic repair approaches; this project aims to enhance the safety, operation and lifespan of offshore wind. The Romain project is a collaboration with several industry partners across the UK, Portugal, Spain and Latvia.

Innovating in a different area, Yu's work is developing smart textiles for the monitoring of loneliness in ageing people at home. Funded by the EPSRC, the project "Deloneliness", will develop smart textiles integrated into worn clothing or built into home furnishing, which support social workers and doctors to remotely monitor a patient's mental health. Working with Kings College London and the University of Sussex, this project aims to provide tools that reduce social care burden on the NHS and support people to continue independent living in their old age. If successful, it is hoped that this approach can be further extended to monitor health conditions for chronic disease or rehabilitation stages from the comfort of the patients home, thereby reducing the need for doctors' appointments and re-admission to hospital.

Yu received his PhD from University of Sheffield in 2013 for failure prediction of composite materials used in aerospace. He subsequently undertook postdoctoral research at the Universities of Sheffield, Exeter and Strathclyde; becoming a lecturer in 2015 at the University of Chester. In 2019 he was promoted to Professor and join Leeds in 2023 as Chair of Textile Innovation and Smart Composite Materials in the School of Design. Yu brings with him a strong track record, with over £10M of external funding secured across Innovate UK, DASA, EPSRC, Levehulme trust and the EU, as well as a large network of industrial and international collaborators spanning Europe and Japan.

Getting Her Teeth into Materials

Dr Flavia Pires Rodrigues

Lecturer in Dental Materials,
School of Dentistry

Modern oral medicine aims to treat individuals holistically, considering the wider impacts dental conditions can have on a patient's quality of life.

Beyond facial and oral pain, these conditions can affect their facial aesthetics and self-esteem; their social inclusion due to speech impediments; their ability to maintain good hygiene; and can severely limit their essential oral functions such as mastication and deglutition.

The most common dental conditions are caused by the wear of dental surfaces, which are traditionally treated with dental restorations and implants. However, the poor compatibility of the restoration materials can lead to further complications and limited longevity of the treatment; with dental restorations typically failing due to fracture or debonding of the restoration material from the dental tissue.

To combat this, Dr Flavia Rodrigues is developing bioinspired materials that more closely mimic the natural dental biology. In particular, these biocompatible materials tend to be more flexible and do not shrink as they age, generating lower stresses at the biotic to abiotic interface.

Flavia's contributions include the use of 3D printable and biodegradable titanium and zirconia alloys; the development of flexible bone-like materials which are able to grow with a patient to prevent the need for repeated implant surgeries in children; and the development of ketoprofen impregnated hyaluronic acid hydrogels for treatment of temporomandibular disorder.

Elsewhere, supported by a Kan Tong Po International Fellowship from the Royal Society, Flavia is undertaking work with the University of Hong Kong to predict the performance of ceramic Dental restoration using finite element analysis and physics-informed neural networks.

Flavia's work is truly global, having successfully built a range of international consortia with partners across Europe, Asia and South America to develop her materials solutions.

In recognition of Flavia's significant international contributions, she was appointed as the president of the Dental Materials Group at the British Society for Oral and Dental Research (BSODR) in September 2024. This adds to an already impressive list of accolades including an appointment as a Member-at-Large of the Board of Directors at the American Academy of Dental Materials, and a member of the British Standards Institution.

When commenting on her involvement with the Bragg Centre, Flavia highlighted:

being part of the Bragg Centre Management Committee allows me to share my commitment to advancing materials research and my extensive experience in fostering international collaborations

Originally from Brazil, Flavia began her research career as a Mechanical Engineer, before moving into the field of Dental materials. She moved to the UK in 2007 during the latter stages of her PhD, where she worked at the University of Manchester and completed further PostDoctoral research at the University of Birmingham and Kings College London. Following a short time working at Poznań Institute of Technology in Poland, Flavia joined Leeds in 2023 as a lecturer in Dental Materials.

Taking Inspiration from Nature

Dr Johanna Galloway

EPSRC David Clarke Postdoctoral Research Fellow
School of Chemistry

The UK and EU have set ambitious targets to reach net-zero by 2050. A significant pathway to this goal is to decarbonise energy production, by switching from fossil fuels to renewable sources including photovoltaics and hydrogen from light-driven water splitting.

Plants are natural solar cells, but the photosynthetic molecules they use are too delicate to use for light harvesting on an industrial scale. Instead, artificial solar capture is achieved using semiconductor-based photovoltaics. The current state-of-the-art solar cells use silicon, but to achieve the highly pure bulk silicon required for this application at sufficient scale is very energy intensive.

One alternative is to use semiconductor nanoparticles, commonly referred to as quantum dots (QDs), to capture the light instead of bulk silicon. Their synthesis is less energy intensive, but relies on using polluting solvents, and incorporation of toxic or rare earth elements for their optical properties.

On the other hand, Biology can precisely control material formation at the atomic scale, using aqueous solutions, room temperatures and pressures, and Earth abundant elements. Taking inspiration from nature, Dr Johanna Galloway is developing room temperature aqueous synthesis methods to grow sustainably sourced optically active materials which can be used to make solar cells.

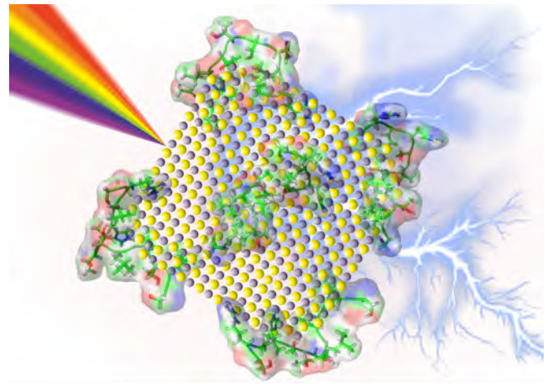
Natural biominerals, such as bones and teeth, are created by organisms using biomolecules to template elements that are readily available in their environment. These biomolecules precisely control the size, shape and crystal structure of the mineral phase, and have evolved to do this in water, without the need for heat or pressure.

Key to natures mineral templating ability is the specific surface structure of the biomolecules which has evolved to provide just the right shape to guide the crystallisation. This has been tuned through evolution to be specific to each mineral species. Unfortunately, to date no naturally occurring biotemplated QDs have been discovered, and so Jo's work is focussed on directing evolution to produce what she wants.

The work, which is at a early stage, requires Jo to screen libraries of billions of biomolecules using Phage display to identify those that specifically bind to the surface of her target QDs. Then working backwards, she tests the resultant binders for their ability to template and grow the desired QDs from solution, subsequently optimising the binder to tune for production of QDs with the best optical properties.

By using biomolecules as the critical templating agent, Jo is able to achieve QD synthesis under ambient aqueous conditions, resulting in materials that are cadmium and lead free, and which do not rely on rare elements to work. As a result, Jo's work is contributing towards achieving environmental targets in three different ways; creating a new sustainable method to make sustainable materials for use in sustainable applications.

Jo's work is underpinned by an EPSRC David Clarke Postdoctoral Research Fellowship, and leverages the characterisation capabilities across the Bragg Centre's facility portfolio. In particular, the X-ray diffraction facility and electron microscopy capabilities which enable her to closely examine the bulk and local crystal structure of her templated minerals. In later phases of her fellowship, she will make use of the nanotechnology cleanroom to fabricate solar cells from her QDs to achieve the overall project goal.



When describing the influence the Bragg Centre has had on her career, Jo explained:

When applying for my fellowship, and since receiving it, I have had excellent support from the people in the Bragg Centre, especially from the Centre Management and Business and Innovation Teams. I am regularly invited to participate in events organised by Bragg, and get opportunities to present research, assess poster competitions, and interview potential students for projects with the Bragg Centre. Academics within Bragg and people from the Management Committee have also been very supportive of my work and my development.

Jo's journey has taken a winding path through a Geological Sciences BSc (Leeds, 2001), PGCE in Secondary Science, (Leeds, 2005), and an Environmental Geochemistry MSc, (Leeds, 2008); before beginning her research career in 2009 with a PhD Biotemplating nanomagnets in the School of Physics & Astronomy at Leeds. She continued her postgraduate work with a Doctoral Prize Fellowship in 2012, before taking up Postdoctoral positions at the University of Bristol (2015) and University of Leeds (2018). In 2023, Jo became an independent research fellow with the receipt of a EPSRC David Clarke Fellowship which champions the development of low carbon technologies.

Industrial Light and Magnetism

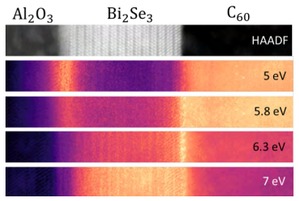
Dr Tim Moorsom

University Academic Fellow
School of Physics & Astronomy

The development and adoption of electronic technologies has continued to accelerate since the 1970s, transforming the modern world. However, this continued progress is threatened by concerns around sustainability and quickly approaching physical limits of the current materials.

The environmental impact of the digital world is not often considered by the consumer. However, as public concern around climate change grows, then the power and resource consumption of the globe spanning network of interconnected electrical hardware that makes up the internet is becoming more widely examined. As the world seeks to go beyond the silicon electronics that have powered the first wave of the digital revolution, there is a need for radically new materials solutions to deliver more energy efficient sustainable devices with ever increasing compute power.

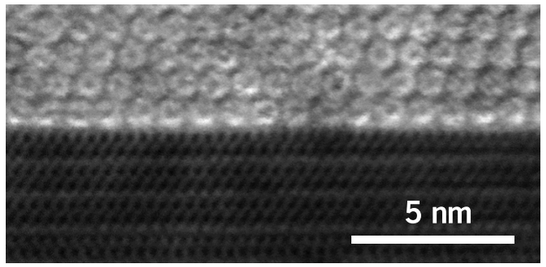
This challenge is being met by Dr Tim Moorsom, who is combining the fields of spintronics and photonics to create radically new super-efficient data infrastructure. Whilst in spintronics the magnetic properties of electrons are leveraged to make circuits and data storage which use far less energy; photonics uses light to efficiently transfer information between systems. Tim's work seeks to integrate these technologies together by generating new materials that allow for very efficient interactions between light, electrical currents, and magnetism.



To do this, Tim and colleagues are working with a newly discovered state of matter called a Topological Insulator (TI). These materials uniquely contain an insulating bulk interior and a conducting surface, whereby electrical and magnetic behaviour is very strongly coupled together. By layering Tis with other materials, Tim's team hope to design systems that have very strong interactions with light at specific frequencies, capable of efficiently transferring information from a photonic to a spintronic system.

The unique capabilities of the **Royce Deposition System** in the Bragg Centre are critical to fabricating these layered materials, being the only growth system that can combine TIs and a range of other materials in a continuous ultra-high vacuum environment. Simply put, this bleeding edge work is not possible anywhere else in the world.

So far, Tim's team have created layered materials combining TIs with various high-quality insulators, semiconductors, 2D materials – such as graphene - and organic dyes. The quality of material growth achieved has been demonstrated to be world leading, with crystals of the carbon material C60 that were so good the team were able to fully resolve individual molecules in the crystal using scanning transmission electron microscopy (STEM), something that has never been achieved before in such a material.



Working across the Bragg Centre's facility portfolio, Tim's team have accessed the world-leading microscopes in the Leeds Electron Microscopy & Spectroscopy facility to further probe the optical and electronic properties of his new materials. Here he has mapped the optical excitations of these materials down to individual atoms, seeing precisely how these materials are bonded together at their interfaces. With these tools, Tim has uncovered that carbon based materials significantly change the properties of TIs, in a way that he expects will be very useful for creating sensors for far-Infra Red (IR) radiation.

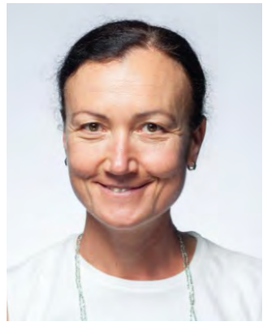
Tim is now exploring the use of controlled doping to make multilayers with alternating topological properties, but that retain very similar chemical structure, with the aim of creating an ideal structure for IR absorption. In parallel, the team is learning to integrate these materials with magnets, and will soon begin exploring how to create magnetic excitations from the absorbed radiation pulses.

When considering the impact that the Bragg Centre has had on his work, Tim commented:

My work wouldn't be possible without cooperation across disciplines and schools. To make progress in my research, I rely on having access to subject matter experts who are willing to collaborate on projects far outside their normal areas of interest. The Bragg Centre facilitates that cooperation both through collecting expertise and equipment under one roof, but also by creating a culture of collaboration where it is easy to share knowledge and ideas across fields.

Tim began his research career in Leeds as a PhD student in the Condensed Matter Physics group where he created an entirely new magnetic material out of carbon and copper. He shifted to a focus on Topological Insulators in 2020, briefly taking up a lectureship position at the University of Glasgow before returning to Leeds as a Bragg University Academic Fellow having secured a prestigious fellowship from the Royal Academy of Engineering.

Membrane Potential



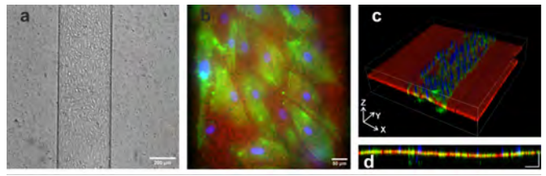
Dr Virginia Pensabene

Associate Professor
School of Electronic and Electrical Engineering, School of Medicine & Leeds Institute of Medical Research at St. James's

Bringing a drug to market is a very long, complex and expensive process which requires significant testing to determine if a candidate is both safe and efficient. Currently, models for testing drugs in the lab are too simple to accurately recreate the complex physiological environment of the human body. The traditional approach to scale this complexity has been to test drugs within living animal models. However, these often fail to predict human specific responses, with most drug candidates then failing at clinical trials with potentially unsafe side effects.

Organ-on-a-chip (OoC) systems are emerging as a solution, enabling the culture of microtissues *in vitro* that more closely mimic the structure and function - of human tissues and organs. Such platforms provide controlled and physiologically accurate environments to develop safe and efficacious therapeutics, faster and more cost-effectively, while reducing the dependence on animal usage.

In the Bragg Centre, Dr Virginia Pensabene is pushing this frontier with innovative OoC platforms which combine sensors, microfluidics and biocompatible materials for a range of tissue systems.



At the core of Virginia's research is the development of an ultrathin, biodegradable membrane that mimics the natural basal membrane (BM) found in human tissues. In the body, the basal membrane plays a crucial role by supporting tissue structures, regulating molecular exchange, blocking the movement of pathogens, and mediating molecular transport in and out of blood vessels.

The goal of Virginia's work is to create a sub-100-nanometer-thick membrane capable of mimicking this key structure; supporting cell growth, forming tight cellular barriers, and remaining optically transparent so that cellular processes can be observed with microscopy.

Through a collaboration with Prof. Toshinori Fujie at the Institute of Science in Tokyo, Virginia's team was able to design and synthesise this novel biodegradable membrane and optimise a nanofabrication process to ensure that the membrane integrates seamlessly into their microfluidic devices, becoming "invisible" under cell cultures.

When integrated into the OoC, Virginia's artificial membrane naturally degrades as cells grow and integrate together to form self-standing layers, more accurately representing the biological system.

Virginia's team are now leveraging the Bragg Centre's electron microscopy facility to investigate the intimate interface between this nanometric membrane and the cultured cells *in vitro*. Working with Dr Nicole Hondow, the team will use advanced microscopy to track the membrane degradation at cellular and subcellular levels to validate the material as safe for use in drug discovery applications.

When commenting on how accessing the Bragg Centre's facilities had supported her research, Virginia highlighted:

Bragg is essential for us having to use different techniques for micro and nanofabrication. More importantly the strength of this project is the opportunity to merge knowledge and experience in polymers, high resolution imaging, interface phenomena at the nanoscale and mechanical and structural characterisation. Our publications and our results were possible thanks to the curiosity and availability of colleagues in Bragg and to the state-of-the-art microscopy suites, tissue culture and fabrication facilities.

Further collaborative work with the Centre for Process Innovation Ltd (CPI), has explored the integration of sensors into the OoC platform. Through this partnership, Virginia's team have combined photolithography and wet-etch microfabrication approaches to develop the first prototype OoC with embedded pH and Oxygen sensors capable of real-time monitoring of embryo health in a OoC uterine model.

Virginia is now leveraging her 15 years experience working across bioengineering, electronics and medicine to translate this research into real world impact, bringing her organ on chip platforms from the lab to the clinic. Here she has established a new company to improve the success rates of *In Vitro* Fertilization (IVF), by supporting and monitoring embryo development using this OoC platform.

A Revolution Unfolds

Dr Matteo Castronovo

Associate Professor of Biomolecular Nanotechnology
School of Food Science and Nutrition

Innovation in Biotechnology is rapidly increasing the precision and throughput of genetic engineering of living organisms, providing important new tools to tackle many of the great global and societal challenges of the 21st Century. From environmentally sustainable food sources derived from plants, microbes and fungi; gene therapies to combat cancer and chronic infection; and green materials for textile and packaging; to name but a few.

In this space, DNA nanotechnology holds unexploited potential to bring disruptive innovation to genetic engineering by offering a robust vehicle to shuttle transgenes into cells and capable of driving sequence-specific genome insertion.

Here rationally designed nanostructures are assembled from a several thousand nucleotide-long ssDNA "scaffold" folded like origami into a complex shape by hundreds of short DNA staples. Whilst structures can be designed to protect and deliver genetic material, they can further carry out programmable functions in living cells by localising chemical reactions on their surfaces through the controlled arrangements of specific molecular cues.

In the Bragg Centre, Dr Matteo Castronovo's vision is to revolutionise the use of DNA nanotechnology in genetic engineering by democratising the design and deployment of DNA nanostructures for non-specialists in the biological sciences.

Matteo's work branches in three directions: The first is understanding how DNA nanostructures interact in biological environments by identifying key structural factors that promote or suppress such interactions in a range of simulated exemplar biological systems. The second is integrating this knowledge within computer design tools that can be used by biologists for the application of DNA nanotechnology to microbes, plants, animals and human cell lines; and the third is developing experimental protocols and laboratory kits that can be adopted by biological researchers.

To pursue this vision, Matteo has pulled together an interdisciplinary consortium, with world-leading expertise across DNA and RNA nanotechnology, single-molecule and lipid biophysics, biopolymers, bioinformatics, microbiology, plant biology, CRISPR/Cas gene editing, gene therapies, AI, computational molecular modelling, and software engineering.

This international team involves universities, research centres and SMEs distributed between the UK, the USA, and the EU; and will provide access to key techniques, including high-resolution and high-speed atomic force microscopy (AFM), optical tweezers, small-angle x-ray and neutron scattering (SAXS/SANS), with key contributions from the Bragg Centre's facilities and members.

Matteo's programme epitomises the Bragg Centre's ethos of enabling the greatest impact that transcends disciplinary boundaries. By working at the interface between experimentation and modelling, biophysical and biological sciences, and fundamental and applied research, Matteo aims to enhance the European leadership in **engineering biology** by extending beyond current genetic engineering tools and paving the way to new DNA nanotechnology-based tools.

When explaining the key role of the Bragg Centre in facilitating his interdisciplinary research, Matteo said:

A strength of the Bragg Centre is that it pulls together a community of scientists from different schools and faculties with diverse interests for materials and provides them with world-leading facilities and collaboration opportunities with the sole aim of advancing their research programs, without forcing them into specific directions. I think this has been key to realise the potential of my research and pursue new directions.

Matteo trained in theoretical physics and nanotechnology, specialising on nucleic acid self-assembly and mechano-chemical behaviour of nucleic acids under nanoscale confinement on surfaces. He carried out postdoctoral work at Temple University (Philadelphia, USA) extending his work to RNA nanostructures on surfaces. Later he moved to the CRO-Aviano Cancer Centre and University of Udine (Italy) to develop diagnostic platforms based on DNA nanostructures. Since joining the School of Food Science & Nutrition at the University of Leeds, he has further expanded his interests, seeking novel applications of biomolecular nanotechnology to biotechnology, food and plant sciences. His interdisciplinary experience has played a key role in shaping his approach of joining fundamental science with applied research with the goal of developing nanotechnology-based methods for applications in synthetic biology, genetic engineering, and medical and food diagnostics.

Space Sensing

Dr Alex Valavanis

Associate Professor
School of Electronic & Electrical Engineering

Traditionally astronomers have utilised infrared, radio and microwave wavelengths to investigate the vast expanse of space. Yet at these frequencies we observe less than half the light in our galaxy. Most of this "missing" light lies in the terahertz (THz) band of the electromagnetic spectrum, which sits between infrared and microwave frequencies with 30 - 300 μm wavelengths.

Within the THz frequency range, the dark interstellar dust and gas clouds that reside between stars all present distinctive spectral fingerprints, providing a wealth of hidden information. Closer to home, these THz fingerprints can be used to reveal the distribution of reactive atomic oxygen and volatile organic compounds (VOCs) in the earth's upper atmosphere. For example, the signatures of formaldehyde and acetaldehyde, and tracer compounds, such as H_2O, HDO and D_2O can all be distinguished clearly at THz frequencies, enabling detailed reaction studies and improved climate models.

Despite the compelling advantages of working in this band, current THz instrumentation is too large, complex, or power-hungry for use outside specialised labs, or lacks the required spectral resolution and sensitivity for gas sensing.

Work by Dr Alex Valavanis is developing a solution to this, using THz quantum-cascade lasers (QCLs). These compact narrowband semiconductor sources measure just 1 mm × 100 μm across and are capable of generating 1 - 5 THz radiation with an output power ~10,000× greater than any other similar source.

These THz QCL systems are intrinsically more compact and robust than other THz sensors, since they are driven electrically and require no external pump laser, making them particularly attractive for satellite or industrial applications.

In recent years Alex and his team have developed new approaches to high-precision THz gas sensing using these QCL systems, including pioneering a "detector-free" feedback interferometry approach, demonstrating measurements of key "tracer" species (D_2O/HDO), and developed the first THz multi-pass gas cell. Through further collaboration with Goethe University, Frankfurt and Vilnius University, Alex has demonstrated the first speciated detection of volatile organic compounds at the $<10^{14}$ molecule/cm^3 level using a novel fast TeraFET detector, enabling studies of these extremely fast reactions for the first time.

Going beyond the lab bench, Alex has further integrated fundamental-mode waveguides, antennas, and modulators, into his THz QCL devices to create a satellite-compatible system the size of a sugar-cube. This work has directly contributed to the design and advancement of the "KEYSTONE" satellite concept, for upper-atmospheric gas-phase measurements; which was recently adopted by the European Space Agency (ESA) for a feasibility study as part of the Earth Explorer 12 programme.

Alex's work is underpinned by a talented team of postgraduate and postdoctoral researchers and is supported by colleagues right across the Bragg Centre, drawing on Chemistry, Physics and Mechanical Engineering expertise. Beyond networking, the Bragg Centre enables Alex's work through access to its facilities; where he makes extensive use of the Centre's state-of-the-art nanotechnology cleanroom to process specialised materials into laser devices. When reflecting on how the Bragg Centre has supported his research, Alex explained:

The Bragg Centre's impact on my work is far greater than the facilities alone, bringing together all aspects of materials research on campus. The Centre's knowledge exchange and showcase events are ideal for sparking discussions between colleagues and the PhD colloquium and Bragg Exchange are particularly helpful for early-career researchers to develop presentation and networking skills.

From an early age Alex had a strong interest in the development of new technology and pursued this through an MEng degree in Electronic Engineering at the University of York in 2004. During this time, he began specialising in the development of semiconductor devices. After a graduate placement developing X-ray detectors at Daresbury Laboratory, he completed his PhD in the theory and design of THz semiconductor lasers at the University of Leeds in 2009. Alex continued his work within the THz photonics lab as a post-doctoral researcher and was awarded a University Academic Fellowship and a UKRI Future Leader Fellowship in 2016 and 2019, respectively. He now leads and co-leads a range of UK Space Agency (CEOI) and ESA funded programmes to develop THz sources, detectors and other critical satellite components; as well as being a co-investigator in the EPSRC ultra-wideband THz communications programme grant.

When describing his career, Alex highlighted:

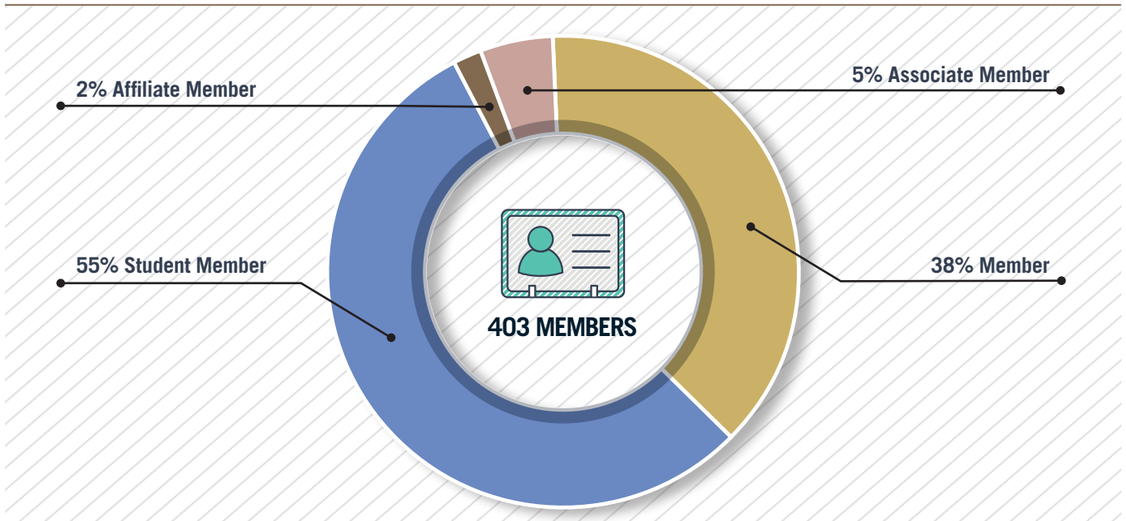
A personal highlight has been joining ESA Astronaut, Dr Mattias Maurer for lunch during his recent Bragg visit. It was a wonderful opportunity to discuss the real detail of manned experimental research activity in space, and better understand the human aspects of space travel.

Collaborate

Membership

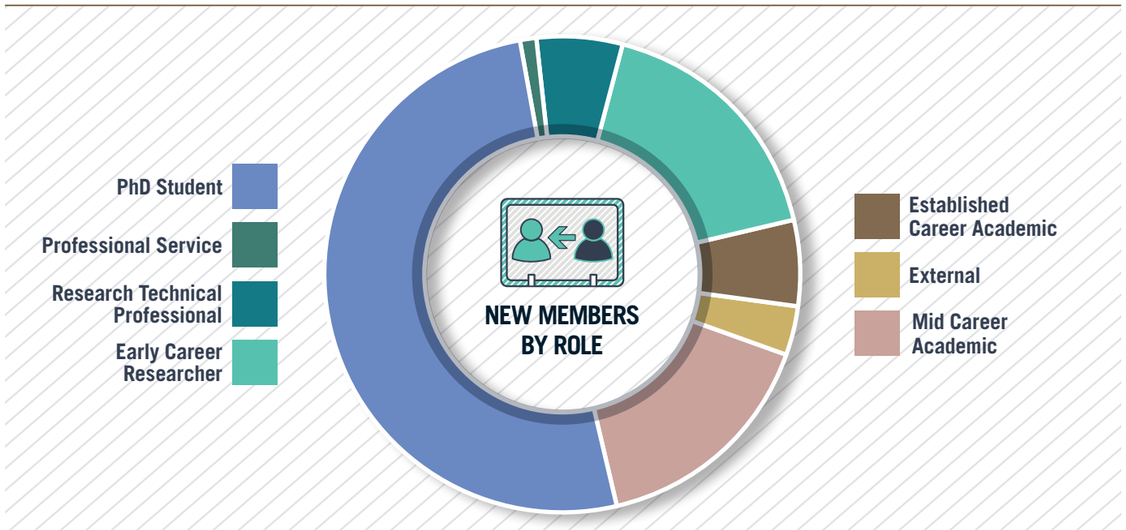
This year the Bragg Centre's membership growth has gradually saturated to reach a stable community of around **400 members** drawn from across the University. Despite an organic membership turnover, driven mainly by student members leaving the University, the Centre has welcomed **104 new members** throughout the reporting period resulting in an overall **community growth of 10%**.

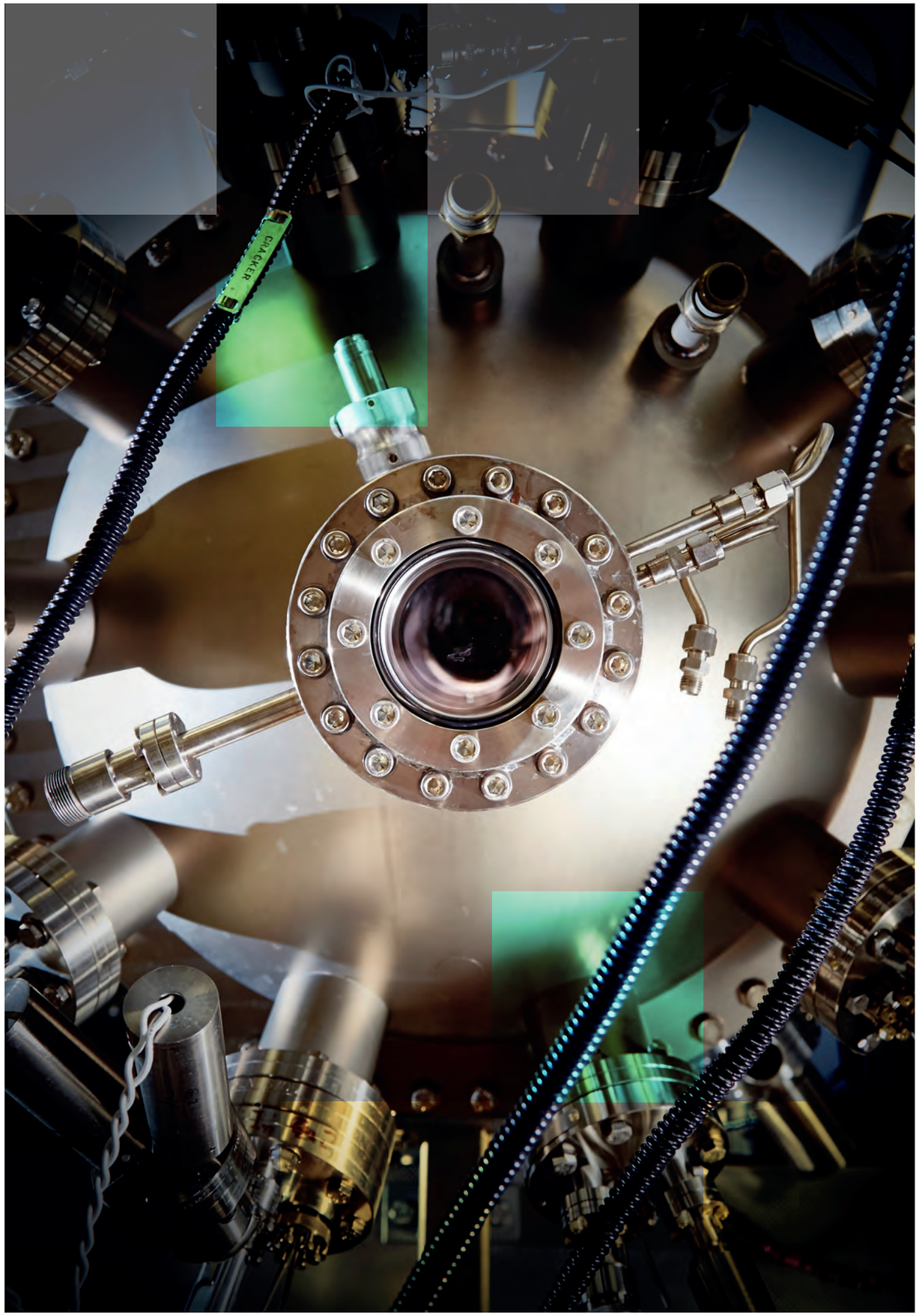
Membership Type



Alongside growth in student members, the Centre is delighted to see an increase in the number of research technical professionals, and mid to early career researchers integrating into the materials research community. Whilst there has been expected growth in the core schools of Chemical & Process Engineering, and Physics & Astronomy; this year has seen a swell of membership applications from strategic research areas including the School of Mechanical Engineering and the School of Food Science & Nutrition.

New Members by Role





Facility Usage

This year there has been a substantial growth in demand for the Centre's state-of-the-art capability and the expertise of its research technical professionals. This has been driven by effective marketing and focussed business development activity across the combined facility portfolio, with the Centre working hard to more deeply integrate an effective pathway for external engagement.

Across the year, the Centre's facilities have provided services to 13 companies, 18 Universities and 4 Research Technical Organisations from around the world; totalling more than 500 days of external work provided!

Some of this work was supported by the Royce Access Scheme, which enabled more than £111K of facility access for UK academic and SME customers in this reporting period.

This activity was split across fabrication services utilising the Physical Vapour Deposition facility, Nanotechnology Cleanroom and Royce deposition system; as well as characterisation with the Centre's Electron Microscopy and Near Ambient Pressure X-Ray Photoelectron Spectroscopy capabilities.

Grant Highlights

Intelligent Engineering of multicomponent drug crystals, EPSRC, Anuradha Pallipurath, **£461,600**

Materials Science Physics Properties Measurement System, EPSRC, EP/Z533312/1, Satoshi Sasaki, **£1,262,500**

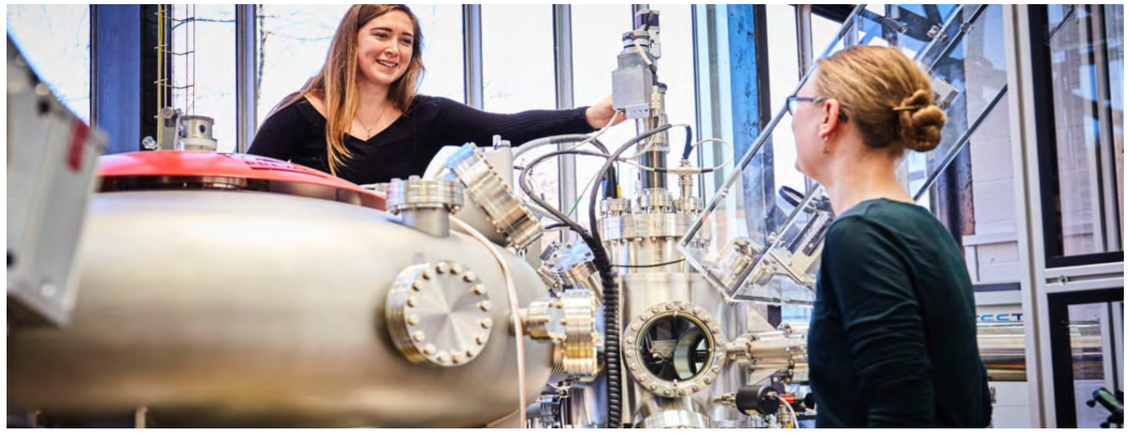
NAPIC: National Alternative Protein Innovation Centre, BBSRC, BB/Z516119/1, Anwesha Sarkar, **£16,001,352**

Analytical electron and ion beam microscopy to enable precision engineering of complex chemical products for high value technology sectors, EPSRC, EP/X040992/1, Rik Drummond-Brydson, **£1,584,600**

Label-free Chemical Imaging with High Temporal Resolution for Application in Advanced Materials, EPSRC, EP/Y01488X/1, Stephen Evans, **£1,698,000**

Combining Advanced Materials for Interface Engineering

Electronic applications and their use are increasing at exponential rates with 6% of the global energy consumed by ICT. As anyone who has used an electronic gadget knows, they rapidly get warm. But the heat is a by-product of the way that they use electric currents which is unsustainably dumped into the environment.



Electric currents are used to transfer information, to store it, retrieve it and to perform operations. As devices become smaller, the problem increases because the materials become more resistive to currents and generate more heat. The scale of the problem is huge. As an example, Google reports that significant amounts of energy are used to cool their server farms. In 2021, they used ~12 TWhr of electricity, about the same as a small country, and the trend is increasing. As a result, the internet currently has a carbon footprint that is substantially larger than that of the airline industry and is predicted to double from 2020 to 2025, with the AI revolution driving ever faster growth of energy consumption. It is therefore imperative to reduce the consumption of energy in ICT for long-term sustainability.

To solve this challenge, the EPSRC Programme Grant 'Combining Advanced Materials for Interface Engineering' (CAMIE) aims to develop new ways to store, manipulate and transport information, based on the researcher's unique approach to materials integration and interface control. A collaboration between the University of Leeds (UoL), Imperial College London (ICL) and Queen's University Belfast (QUB), CAMIE kicked off in 2024 with a total programme value of **£6.4M**.

Spintronics exploits the magnetic property of electrons (spin) for applications. It offers compelling possibilities for new devices that might function at reduced energy, based around combining different materials at the nanoscale with high quality interfaces used to generate, transport, or measure spin currents. Pure spin currents transfer spin without transferring charge so that information can be exchanged without the heat a charge current generates. Using electric fields in devices can have great advantages over magnetic fields, including using less energy, but usually magnetism cannot be controlled by electric fields. Molecular interfaces can be altered by electric fields and ferroelectrics have a polarisation that can be switched electrically hence tuning the behaviour of a magnet when they are connected. A stumbling block to progress is that these different materials require different techniques of preparation and to be useful in ICT they must be thin - of the order of tens of atoms thick. Such thin layers need to be protected during their fabrication and then the different layers combined. The solution requires bespoke designs and breakthroughs in materials science.

At Leeds, the CAMIE leadership team consists of Profs Brian Hickey, Christopher Marrows, Gavin Burnell, Oscar Cèspedes and Drs Thomas Moore, Satoshi Sasaki, Joseph Barker and Philippa Shepley in the School of Physics & Astronomy and Prof. Andrew Bell in the School of Chemical & Process Engineering. They are joined by Prof. Sandrine Heutz and Dr Shelly Conroy at Imperial College and Prof. Marty Gregg at Queen's University Belfast.

The programme fits into Leeds' partnership of **Royce**, as part of the Atoms-to-Devices theme, and relies on the unique capabilities of the **Royce Deposition System** located within the Bragg Centre. This £2.2M suite of deposition chambers each of which is designed to grow a different type of advanced material using a different deposition method and environment for processing. The chambers are connected under ultrahigh vacuum so samples can be transferred whilst being protected from the atmosphere and impurities. As such, this system is capable of growing layers of different materials and bringing them together into a single hybrid structure with the interfaces controlled at the atomic level. The CAMIE programme is based around this approach, and would be impossible without such a facility.

A complete understanding of these hybrid structures will pave the way to exploitable technology where the initial benefits will enable information processing and storage with less energy, reducing carbon emissions and prolonging battery life. This approach has the potential to impact many areas of technology such as data storage, sensors, energy storage, and quantum materials. The industrial partners of CAMIE include multinationals like Intel, IBM, Hitachi, QinetiQ, and Seagate; national laboratories such as NPL, Diamond, ISIS, the Paul Scherrer Institute and Lawrence Berkeley National Lab, instrumentation companies such as Asylum Research; as well as academic partners in Salamanca, the Tyndall Institute and cpp9.

Bringing the Community Together

The Bragg Centre supports a comprehensive events programme, which provides something for every member of its broad materials research community.

Throughout the year the Centre has delivered **29 events** across its remit including **7 Lunch@Bragg seminars**.

The Centre's mainstay monthly Lunch@Bragg series draws the community together to network over food and engage with a range of topics that transcend disciplinary boundaries. This year's topics included a guide to publishing from the Chief Editor of Nature Photonics; how to engage with EU and Global funding opportunities; and a series on "Pathways to commercialisation" which included speakers from Northern Gritstone, HGF and the University of leeds commercialisation team.

Whilst the Centre delivered its flagship annual events - the Bragg Centre PhD Colloquium in June and the Bragg Exchange conference in January - it also supported the delivery of events on behalf of the national materials community. These included a regional workshop on commercialisation on behalf of **Royce**, the UK Metamaterials Industry Day, and seminars from Quantum Design and the Diamond Light Source.

29 EVENTS

LUNCH@ BRAGG

x7

Facilities Open House

This year the Bragg Centre once again threw open its doors and invited colleagues from across the University to explore its full facility portfolio. Promoting the opportunity to "unlock the capability", the Centre's 2nd Facility Open House on 25th July 2024 welcomed **70 attendees** for a two-hour guided tour around the Centre's nine characteriastion and fabrication facilities.

Participants were led by a Student Ambassador in small groups, which left successively every 15 minutes, stopping at the X-Ray Diffraction Facility, Royce Deposition System, Versatile X-Ray Photoelectron Spectroscopy Facility, X-ray Scattering Facility, Atomic Force Microscopy Facility, Leeds Electron Microscopy & Spectroscopy Facility (LEMAS), Leeds Nanotechnology Cleanroom, Advanced Surface Coatings Facility, and the X-ray Computed Tomography Facility. At each stop, delegates were hosted by a Research Technical Professional to discuss the equipment's capability, access routes and the potential opportunities it might present for their research – with delegates encouraged to come prepared with knowledge of the problems they'd like to solve. This annual event continues to be well received by event attendees, securing potential new users for the Centre's facilities.

70 ATTENDEES

The Royce Commercialisation Regional Workshop

Knowledge of commercialisation routes and processes is increasingly important for materials science researchers, to successfully progress a new material innovation from research to product and real-world impact.

This year, the Bragg Centre supported **Royce** to deliver a regional workshop highlighting the commercialisation pathway and raise awareness of the local support that is available.

Aimed at later stage PhD students and Early Career Researchers, this one-day workshop charted a clear path through the complicated process of research translation guided by materials-specific examples.

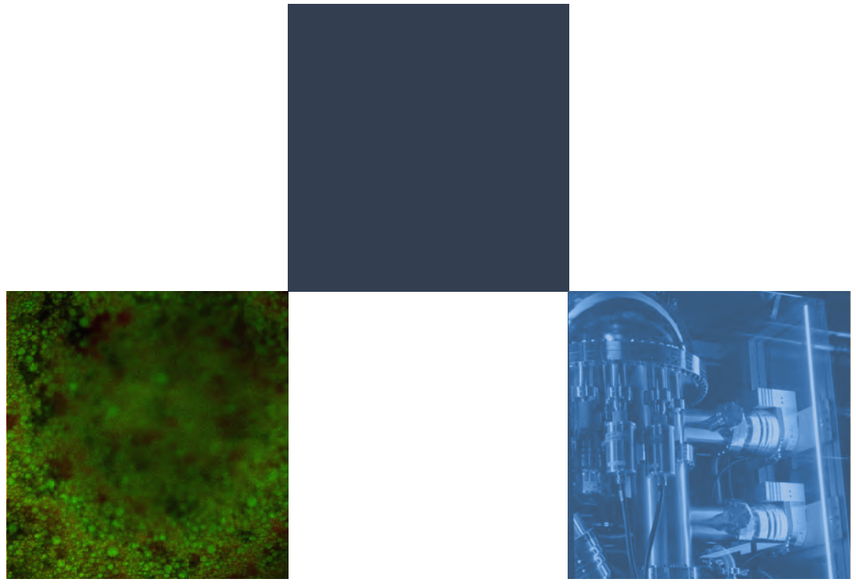
25 DELEGATES

The event, which was led by Royce Student Engagement Officer George Miller, was attended by **25 delegates** from across the region, including Bradford and Sheffield. Throughout the day delegates learned about the process to identify and manage intellectual property; grow entrepreneurship skills; access funding, including the role of venture capital; and a range of alternate routes to market, including knowledge transfer partnerships (KTPs) and spin-out companies. This was accompanied by a discussion on Royce's role in supporting commercialisation in the national materials landscape led by Royce Research and Business Engagement Officer, Dr Alex Gresty.

Emphasising the regional nature of the workshop each session was led by a local expert, with speakers including Andy Camenish, Partner and Patent Attorney at HGF; Dr Blake Prime, Head of Opportunity Development at the University of Leeds; Dr Blessing Mukonoweshuro, Head of Knowledge Transfer at the University of Leeds; Andrew Naylor, Investment Director at Northern Gritstone; and Prof. Anwesha Sarkar, Founder of MicroLub Ltd.

When describing the workshop, George said:

These events aim to invite speakers that are already embedded in the local university, whether that is the TTO [Technology Transfer Office] or a local patent attorney, so that the participants are getting advice that is as relevant as it can be to their current or future plans for research exploitation.



the **BRAGG** exchange

TIME TO **BRAGG** ABOUT MATERIALS

In January 2024 the Bragg Exchange conference returned bigger and bolder than ever, growing to cover to two days. The conference welcomed **240 delegates** from across the country, with representation from **11 external Universities** and **five companies** alongside the Leeds' materials community; delivering a vibrant exchange of ideas across the breadth of materials research.

The event featured **65 contributed posters**, set alongside an exhibition of Industry partners and Bragg Centre facilities, as well as a packed agenda of **18 inspiring talks** split across six thematic sessions. Recognising the growing reputation of the Bragg Exchange on a national stage, this year the Centre was delighted to attract external sponsorship for the event from Quantum Design Ltd and the Royal Society of Chemistry (RSC).

Whilst delegates from across the national materials landscape exchanged the latest materials innovation in person, more than 500 people joined the wider conversation through the Bragg Exchange's public broadcast, lowering the barrier to participation in materials research.

240 DELEGATES

11 UNIVERSITIES

5 COMPANIES

65 POSTERS

18 TALKS

Looking into History

This year the Bragg Centre teamed up with the Leeds Industrial Museum to apply cutting-edge non-destructive imaging techniques to shed new insights on a 200-year-old piece of locomotive history.

The project, which was led by Dr Alice Macente, used X-ray Computed Tomography (XCT) to reveal the internal 3D geometry of the world's oldest locomotive replica. The model, which dates to 1811, was created by engineer Matthew Murray, who designed, a year later, the world's first commercially viable steam locomotive, the Salamanca. The fully working 30 cm long model served as a sales tool for Murray to attract potential investors to fund its full scale counterparts, and forms a critical piece of locomotive history.

Despite its importance, no records of the internal workings of the locomotive exist and the artifact is too rare to cut open, leaving an intriguing mystery for curator John McGoldrick. In a search for answers John pitched the mystery to the Leeds Cultural Institute's Collections Research Fund, where it was picked up by the Bragg Centre's manager, Dr Andrew Lee. The Culture Institutes initiative aims to foster collaboration between academics and museum professionals to advance understanding of historically significant objects using the latest technological advancements. Immediately seeing the potential for the Bragg Centre's analytical capabilities to help, Andrew facilitated the engagement between John and Alice to access the XCT.

Due to the models size and metal content, it was necessary to further team up with Dr Samuel Allshorn in the School of Earth & Environment, to access their larger medical CT scanner. The more powerful X-ray source, and increased dimensions of the source – detector geometry of this instrument enabled the team to overcome the problematic metal lining of the locomotive model, which would typically cause numerous artefacts in the imaging. Following the data collection, Alice was able to process and compile the complex data set, which was interpreted with expertise of early railway historian Dr Michael Bailey.

The resulting output provided the first valuable historical interpretation of the internal geometry and design of the world's first steam locomotive, and will be used to create a unique exhibition at the Leeds Industrial Museum.

The Bragg Centre has now entered into discussions with the Royal Armouries, following publication of this unique story by the BBC, and will now explore opportunities to apply the Centre's analytical capabilities to some of their most enigmatic objects.

Developing future Electric Vehicle technologies with Jaguar Land Rover

One of the major emerging challenges in the race towards net-zero, is transitioning the full automotive drive train into an electric platform.

To solve this, the Excellence in Conceptual Evolution of Electric Drives (ExCEED) project aims to develop a cutting-edge toolkit for Electric Drive Units (EDUs), consisting of a modular family of machines, inverters, and transmissions, enabling the adaptation to a range of future vehicles.

Interestingly, it is increasingly found that current lubricants used on gear surfaces within traditional transmission systems are incompatible with Electric vehicles, owing to the high speed and high torque operating conditions and tendency for the lubricants to be electrically conductive.

The £20M project is funded through the Advanced Propulsion Centre UK (APCUK) and brings together an industrially led consortium including Jaguar Land Rover, Lubrizol, Specialised Electrical Machines Design Ltd, ZeBeyond as well as the Universities of Leeds, Newcastle, and Nottingham.

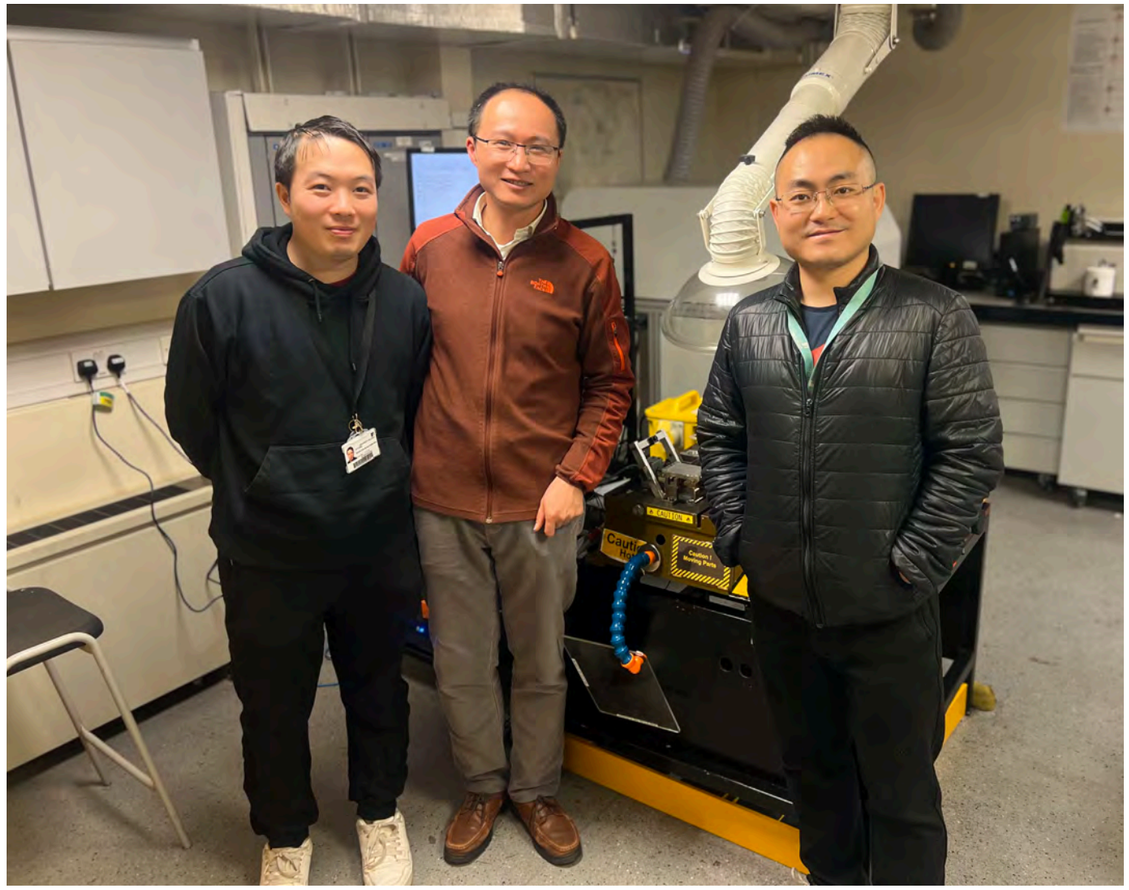
With £10M contributed directly from the Department of Business and Trade, the funding marks the first time that the University of Leeds has successfully secured funding from the APCUK, which is dedicated to supporting industry led high TRL level activities.

Drawing on the collective expertise of the consortium, ExCEED will develop and validate the entire EDU family, paving the way for ground-breaking advancements in electric propulsion technology.

The Leeds component of the programme will see materials researchers in the Bragg Centre develop and validate a set of solid lubricant coatings compatible with electric drive trains. Led by Dr Liuquan Yang, this work will build on the rich 50-year history of pioneering tribology at the University of Leeds.

The project relies heavily on the Bragg Centre's facility portfolio leveraging the industrially-scaled Physical Vapour Deposition advanced coating facility, as well as the extreme environment tribometry platform and in the electron microscopy capabilities to create and characterise the lubricious coatings at full component scale.

The Bragg Centre is proud to support this project which will position the UK as a world leader in electric vehicle production, enabling JLR to produce innovating future vehicles at high volumes.



Integrating with the European Soft Matter Landscape

Soft matter plays an important role in nearly every aspect of people's daily lives from food to healthcare. Despite its undisputed importance, the soft matter research landscape has traditionally been fragmented into various subfields including surfactants, polymers, colloids, and biomatter, amongst many more.

Initiated as an EU funded Network of Excellence (NoE), SoftComp has grown to become a self-sustaining pan-European consortium, bringing together academia and industry to strengthen the soft matter ecosystem. Coordinating a critical mass of resources and expertise, SoftComp provides strategic leadership and promotes the integration of soft matter research across Europe.

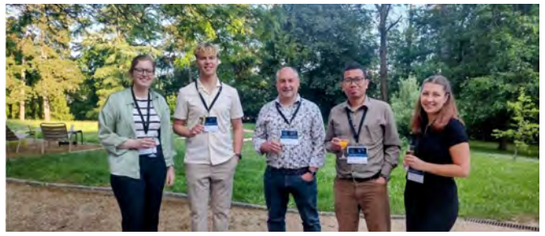
At Leeds, the Bragg Centre funds the University's SoftComp membership, enabling members of the materials community to engage with the wider European Soft Matter landscape, enhancing opportunities to share insights and establish connections.

The **SoftComp Annual Meeting**, held in Lyon, France, in May 2024, brought together over **120 researchers** in soft matter science from across Europe. Hosted by the European Soft Matter Infrastructure (EUSMI) consortium, which is dedicated to providing academia and industry with open-access infrastructure across Europe, the event was designed to promote collaboration and innovation in soft matter through synthesis, characterisation, and modelling.

Prof Paul Beales led a group of early career researchers, including Dr Ben Kew, Niamh O'Donoghue, Lydia Dawkins, and Yoni Atma, to highlighting Leeds' interdisciplinary engagement in soft matter science across their respective diverse fields.

The smaller scale of the SoftComp annual meeting fostered close interactions among participants, allowing them to engage meaningfully during informal sessions and meals. This environment led to networking opportunities, enabling discussions of potential future collaborations with PhD students and postdoctoral fellows from institutions across France, Belgium, Germany, Spain, and the UK. The Leeds team also strengthened interdisciplinary ties within the university, bridging areas such as food sciences, chemistry, and chemical engineering.

The SoftComp Annual Meeting provided an invaluable platform for the Leeds contingent to present their research, receive feedback, and explore emerging trends in soft matter science. Each researcher gained insights from diverse sub-fields, ranging from hydrogels and polymers to food colloids and biomaterials, broadening their perspectives and laying a foundation for future possible collaborative endeavours.



Presentations and Posters:

- Dr. Ben Kew presented for the second consecutive year, expanding last year's work on sustainable plant microgels by focusing on applications particularly highlighting the new Leeds spin out company "Microlub" which has recently raised £3.5m in funding, aligning with EUSMI's goals of advancing soft matter technologies.
- Yoni Atma presented a poster on encapsulating bioactive peptides within composite biopolymers, engaging with researchers from various institutions and exploring potential collaborations with European peers.
- Lydia Dawkins showcased her first-year research poster on using fluorapatites in antibacterial dental implants. This conference marked her initial presentation outside the university and facilitated valuable one-on-one exchanges with experienced researchers.
- Niamh O'Donoghue delivered an oral presentation on cytotoxicity and cellular uptake of lipid nanoparticles. She received insightful feedback, stimulating discussions that deepened her understanding of soft matter's impact across multiple scientific disciplines.

START-SEMI

The START SEMI project is a pioneering initiative designed to empower people with the knowledge and skills needed to thrive in the semiconductor industry.

A collaboration between the Universities of Leeds, Swansea and Warwick, as well as the companies Imersifi and CSConnected; the project aims to develop a pipeline of talent into the semiconductor field, directly supporting the ambitions of the National Semiconductor strategy.

START-SEMI's unique programme is co-designed by academics and industry, and includes a range of blended reality training materials for post-16 participants, from Apprentices, Students, and Reskilled adults. The resources span from taster courses, which promote semiconductor technologies and careers, through to advanced skills training courses to develop technique specific skills.

The programme leverages the latest learning technologies, including VR and AR, to develop training that is accessible and immersive for a wide range of people. Blending these online learning resources with practical application through in-person workshops based at the state-of-the-art facilities of each partner University.

In January 2024, the first VR experience, "Sand 2 Semiconductor" was showcased at the **Bragg Exchange 2024** to an audience of over 200 delegates, and received its first practical deployment during the **Royce National Practical Cleanroom Skills Training Course**.

Working at the start of the talent pipeline this year, Bragg Centre experimental officer and outreach champion Dr Rob Farr led several hands-on work experience weeks as part of START-SEMI; welcoming pupils from Notre Dame 6th Form college and North Halifax Grammar School. The courses, which were highly oversubscribed, saw students working across three Bragg Centre facilities; depositing materials using the Royce deposition system, manufacturing devices in the nanotechnology cleanroom, and characterising devices with electron microscopy.

Elsewhere, the Centre partnered with Oxford Instruments to deliver a seminar on technique specific advanced skills. The event welcomed **63 industrial and academic delegates** from across the country to explore the training requirements for Dry Etching techniques, with the high demand prompting the development of a two-day practical short course for delivery in 2025. This model will be replicated across other advanced cleanroom techniques including reactive ion etching (RIE) and plasma enhanced chemical vapour deposition (PECVD).

Combined, the work across the START-SEMI project is an outstanding example of how the Bragg Centre is working with partners across the UK's ecosystem to affect substantial and long lasting change in an area of critical national importance.

Engineering Biology Network

Engineering biology is the application of engineering principles to biological systems to develop solutions which tackle grand societal challenges. It is a distinct evolution of synthetic biology, which has focussed on the design of biological components and systems; with engineering biology now concerned with predicting and controlling biology with the precision needed for industrial-scale production. This area is rapidly emerging as a national priority with applications in many sectors, including energy, environment, food, healthcare, and manufacturing. In recognition of this UKRI have initiated a National Engineering Biology Programme (NEBP), spanning BBSRC, EPSRC, IUK, MRC, NERC and involving DSTL and DSIT.

In June 2023, the Engineering Biology network at Leeds was initiated by Prof. Paul Beales to drawn together expertise from across the Astbury and Bragg Centre's to address the opportunities presented by the NEBP.

As an active member of both Centres, Paul recognised that Leeds could have an exceptionally strong offering in the Engineering Biology space by joining the bionanotechnology and soft matter materials research and characterisation strengths of the Bragg Centre with the fundamental molecular biology strengths of the Astbury Centre.

The network was officially launched with an exploratory workshop in October 2023, which brought together 37 members of both Centres to discuss what Leeds' unique Engineering Biology offer could be. From this a steering group was formed to take on responsibility for organising future events and maintaining the activity of the network, delivering a further **six workshops to date**. These events have ranged from focussed sessions targeting a specific NEBP application area, to highlighting funding calls and recent successes within the network.

At the time of writing, the network has grown to include **52 academic members** representing four faculties across the University. This excellent example of **cross-centre collaboration** has now supported the development of future large-scale funding bids, with a total of £5M funding already awarded to network members for Leeds-led Engineering Biology projects.

The Bragg Centre looks forward to working closely with the Astbury Centre to support this fruitful network in 2025.

Educate

The Bragg Centre continues its commitment to develop a skills pipeline in materials research and engineering. This year, the Centre supported a further round of the undergraduate internship programme, provided student conference travel awards, welcomed additional students onto the Bragg PhD Studentship, and established a further advanced training course to upskill industry.

Undergraduate Summer Internship Scheme

Throughout the summer of 2024, the Bragg Centre supported a further **nine undergraduate** students to undertake research internships funded through a combination of Bragg Centre and **Royce** funding, five and four places respectively. The scheme supports Undergraduate students to undertake an 8-week research placement, tackling cross-cutting interdisciplinary activity in a materials area.

Alongside their research, the students joined 61 other interns from across the faculty of Engineering and Physical Sciences to engage in two employability skills workshops, including a tour of the Bragg Centre facilities, and six peer-to-peer seminars to practice presenting their research.

The scheme culminated in a **poster showcase** hosted by the Bragg Centre and with poster prizes sponsored by Royce. The event championed the incredible work that student interns completed over the summer, with the students preparing **40 posters** representing a broad range of fascinating projects.

During the poster prize presentations Prof Edmund Linfield said:

As Director of the Bragg Centre and a Research Area Lead for the Royce Institute, I know there is currently a real demand from industry for recruiting and developing the skilled workforce of our future. It was therefore fantastic to see the quality and breadth of interdisciplinary projects presented at the Showcase, with everyone speaking so enthusiastically about their work. I look forward to seeing the participants becoming our future leaders – from academia and education through to industry and government.

The Bragg Centre is proud to continue to support widening participation in research through the provision of events, training opportunities and funding. These internships provide many students with their first experience of real research within a world class environment. Not only do these internships support the talent pipeline, but they provide a test-bed for new ideas and collaborations across the Bragg Centre's remit.

This year's projects included:

Royce Funded:

- Thin Film Microanalysis by EPMA: Development of a New Analytical Capability – *School of Earth & Environment*
- Achieving ultralow friction of carbon coating by tribochemical reaction to meet energy-saving demanding – *School of Mechanical Engineering*
- Development of Experimental Infrastructure for Near-Ambient Pressure XPS Studies of Green Fuel Technology – *School of Chemical & Process Engineering*
- Nanoscale Spectroscopy for the analysis of complex mixtures – *School of Chemical & Process Engineering*

Bragg Funded:

- Mechanochemical activation under CO2 environment for mineral activation and CCUS – *School of Civil Engineering*
- Fabrication of antibacterial nanopatterned coatings inspired by wings of insects – *School of Mechanical Engineering*
- Validation of new methods in quantitative nanomechanics at high modulus – *School of Physics & Astronomy*
- Materials in Spacecrafts – *School of Mechanical Engineering*
- Developing methods for high-speed video analysis – *School of Physics & Astronomy*

Daniel Hopper

Undergraduate Intern

One of the undergraduates embarking on a Summer Internship this year was Daniel Hopper. Daniel is a MEng Chemical and Materials Engineering student and undertook an internship based within the Bragg Centre's electron microscopy facility, LEMAS.

Funded through a Royal Microscopical Society (RMS) grant, Daniel's internship was longer than his peers lasting three months in total. During this time, Daniel worked under the supervision of Dr Nicole Hondow, Associate Professor School of Chemical & Process Engineering, and Stuart Micklethwaite, Senior Technical Specialist in LEMAS, to examine the impact of sample preparation on different polymorphs of pharmaceutical compounds using secondary electron hyperspectral imaging in the scanning electron microscope (SEM).

Not only did Daniel's work secure him a Runner Up Prize at the Bragg Centre's internship poster showcase event, but the findings were further presented by Stuart at the European Microscopy Congress 2024, in Copenhagen, Denmark attended by over 2,500 scientists from 51 countries.

Building on the success of his internship project, Daniel is now undertaking his Masters research project with Dr Hondow, where he is developing an understanding of hydrocarbon contamination and its impact on secondary electron hyperspectral imaging.

Bragg Student Travel Fund

This year the Bragg Centre was delighted to be able to offer **travel awards of up to £2K** to support student member attendance at domestic and international conferences. The fund, which was supported by a gracious philanthropic donation, enabled five students to travel to conferences around the world throughout 2024 to present their research and represent the Bragg Centre's interests.

Following the success of the initial scheme, which was highly oversubscribed, the Centre was grateful to receive a further donation of **£54K** in August 2024 which will support the travel of up to an additional 30 students over three years.

£54K
TOTAL TRAVEL FUND

Students funded:

- Ishmaeel Ghouri attended Eurobrake 2024 in Mainz, Germany
- Atreya Danturthi attended Plasma Surface Engineering 2024 in Erfurt, Germany
- Manoj Rajankunte Mahadeshwara attended Tribiology Gordon Research Conference in Maine, USA
- Chao Sun attended the 9th International Conference on Metal-Organic Frameworks and Open Framework Compounds (MOF2024) in Singapore
- Zhao Jiang attended the Denver X-ray Conference in Colorado, USA

Zhao Jiang
Attended Denver X-ray Conference, Colorado, USA

I attended the Denver X-ray Conference from August 5th to 9th, 2024, in Westminster, Colorado. The conference featured a diverse range of attendees, including representatives from academia, government-funded research institutes, and industry. The first two days focused on workshops covering trending topics in X-ray research, such as AI in XRD data analysis and practical microcomputed tomography. These were followed by two poster sessions on XRD and XRF. From Wednesday to Friday, approximately 70 talks were presented on the latest advancements in XRD and XRF, beginning with a plenary session on biomedical imaging.

I delivered my talk on Thursday morning, presenting my work on observing calcium carbonate transformation under in situ heating using sparsely sampled ptychographic nano-tomography, a newly developed technology. The session attracted about 30 attendees, and the questions posed indicated a strong interest in the capabilities of this technology.

To promote the Bragg Centre, I displayed the centre's logo during my presentation, acknowledged its support, and discussed its capacity and mission in material research during networking opportunities. I engaged with representatives from Keele University (UK), the National Institute of Standards and Technology (USA), the German Electron Synchrotron DESY (Germany), Carnegie Mellon University (USA), and Argonne National Laboratory (USA), showcasing the Bragg Centre's X-ray characterisation capabilities for materials research.

The Bragg Student Travel Award made it possible for me to attend this international conference, enabling me to connect with experts and stay updated on the latest technologies and practices in X-ray characterisation and analysis. The talks on ptychography, particularly from Esther Tsai of Brookhaven National Laboratory, provided valuable insights into this technique, showing me future ideas for my research.

Bragg PhD Studentship Programme

Each year, the Bragg Centre offers several EPSRC funded PhD positions as part of its Studentship Programme. All projects supported by this highly competitive scheme are designed to establish novel connections between disparate research areas under the Bragg Centre's remit, putting our students at the bleeding-edge of materials research and engineering.

The programme encourages peer-support and cross-cohort activities, whilst the students benefit from being embedded within a vibrant interdisciplinary community which provides exposure to a much broader range of expertise and capability than a traditional PhD.

In September 2024, the Centre welcomed a further two students into the Bragg Studentship:

Daniel Norris
Project: "Can dynamic remodelling of fibrin fibres under load account for the remarkable mechanical properties of blood clots?"

Supervisory team: Dr Simon Connell, School of Physics & Astronomy; Dr Timea Feller, Inst Cardiovasc & Metabolic Med (LICAMM); Prof. Daniel Read, School of Mathematics

Luke Benson
Project: "Topological insulator surface acoustoelectric current"

Supervisory team: Dr Satoshi Sasaki, School of Physics & Astronomy; Prof. John Cunningham, School of Electronic & Electrical Engineering

Cohort Networking

In October 2023 the Centre brought together four cohorts of students for a team building workshop and meal. During the workshop the students provided updates on their projects and competed in groups to complete a challenging exercise called "communication builder".

Designed to hone their verbal communication and problem-solving skills, the exercise required the students to recreate a hidden model plane from Lego pieces without any instructions. Here, one person acts as the designated eyes of the team and is allowed to see the final model, whilst the other members of the group act as the hands of the team and can touch the Lego pieces. Using only verbal communication the team must work together to recreate the model plane as accurately and quickly as possible.

Bragg on Tour

The Bragg Centre is proud to connect its staff and students to opportunities for training and career development. In July 2024 the Bragg Centre embarked on its second Bragg on Tour excursion, taking **12 PhD students and Early Career Researchers** to visit QinetiQ in Farnborough, and the National Physical Laboratory (NPL) in Teddington.

The fully funded two-day visit was focussed on exploring potential career and collaboration opportunities for the attendees, whilst supporting the Centre to deepen its relationships with these strategic partners.

During the first day, attendees were introduced to QinetiQ. Spun out of the Ministry of Defence in 2001, alongside its smaller sister DSTL, QinetiQ is a multinational defence technology company headquartered in Farnborough, Hampshire. It operates primarily in the defence, security and critical national infrastructure markets and runs testing and evaluation capabilities for air, land, sea and target systems.

The attendees learned about the history and pedigree of QinetiQ, and then embarked on a full day tour around the outstanding experimentation facilities, which are amongst some of the most advanced in the world. The tour touched upon Forensic Sciences, Advanced batteries and EV platforms, Ceramics and Nanoparticle synthesis, Materials testing and characterisation capabilities; and featured a unique demonstration of novel Elctro-Optics technologies.

The visit was highly productive, with attendees particularly enthused by the career speed dating activity which engaged Bragg Centre members with colleagues across a wide range of career levels at QinetiQ, including technical staff to senior leadership. Discussions and networking further continued into an evening meal, with colleagues from QinetiQ joining.

During the second day, attendees visited NPL, exposing them to the research activity of a public sector research establishment. NPL is the UK's National Metrology Institute (NMI), developing and maintaining the national primary measurement standards, as well as collaborating with other NMIs to maintain the international system of measurement. As an impartial entity, NPL develops the metrology and standards required to ensure the timely and successful deployment of new technologies, products and processes.

Attendees undertook a tour of the advanced laboratories and research activities at NPL, including surface technology, electromagnetic materials, advanced engineering materials and Quantum materials.

As well as networking with a wide variety of experts across a range of career stages, attendees enjoyed hearing several talks from key staff members exploring their career pathways into and within NPL.

Despite a long journey, the visit was well received by all attendees who noted the beneficial exposure to the contrasting environments of industrial and public sector research. The Bragg Centre is committed to enabling similar visits to industrial partners and national facilities in the future.

Thin Film Training Course

Thin films are important as a basis for many different technologies, from biosensors to quantum computers. Despite being integral to modern life, there remains an unfulfilled need across industry and academia for training to help make the most of the advanced deposition techniques for creating these thin films.

This year, the Bragg Centre has worked with colleagues across **Royce** and **Imperial College London**, to address this need by establishing a hands-on training course in thin film deposition techniques for the first time in the UK. Launched in March 2024, this three-day course which leveraged the **Royce Deposition System** was immediately oversubscribed demonstrating the pent up demand from industry.

Housed within the Bragg Centre, the Royce Deposition system is an integrated multi-technique platform for thin film growth and is a key technology platform of the national Henry Royce Institute. This unique setup, comprising four interconnected deposition chambers allows for different techniques to be combined to create multi-layered thin films that exploit interfaces between different types of materials. Novel interfaces can create interesting physical effects, which can be harnessed in future devices to address challenges such as low power electronics as is being explored with the CAMIE programme grant (see page 25)

The course, which joins the highly successful **Royce National Practical Cleanroom Skills Training Course** delivered by the Bragg Centre, welcomed twelve participants from academia and industry for its inaugural run.

Beginning with a series of introductory lectures to physical vapour deposition techniques and a guest lecture from Dr Sebastian Dixon from Paragraf Ltd, the majority of the course rotated around practical tasks in the experimental facilities. Participants learned how to prepare substrates and load them into the vacuum system. They deposited platinum films using molecular beam epitaxy and tried out the effects of different deposition parameters on the microstructure of sputtered tantalum films.

The course leveraged the integration of characterisation and fabrication tools right across the Bragg Centre facility portfolio, with participants accessing the Leeds nanotechnology cleanroom, X-ray Diffraction and atomic force microscopy facilities. Guided by the expertise of dedicated **research technical professionals** at each stage, participants tried their hands at the basics of lithography for device fabrication, and a range of characterisation approaches to study the thin films they had deposited. The course was rounded off with a data analysis workshop and presentations showcasing what the participants had learned.

This first of its kind course was very well received by all the participants, who highlighted the hands-on elements as being fundamental to their learning; and exemplified the span of materials discovery to devices capability that exists within the Bragg Centre. Delivery of the course was a true team effort, requiring the combined contributions of five research technical professionals, five post-graduate and post-doctoral research volunteers, and two external colleagues to deliver.

In relation to the Bragg Centre's delivery of the national thin film and cleanroom training courses, Royce Training and Skills Manager, Tom Hancocks highlighted that:

A key goal of Royce is to support the UK's materials science community in gaining scientific knowledge and developing technical skills to better help drive innovation and the development of new materials. Through our programme of technical skills events – including both the Practical Cleanroom Skills and Thin Film Deposition courses at the Bragg Centre – Royce is able to raise awareness of our equipment capabilities, develop more competent users of our facilities, and help scientists design better experiments in support of their research.

Inspire

The Bragg Centre continues to reach a broad audience through its academic outputs, social media channels and public engagements, with the goal to widen participation in material science.

With the Centre's reputation growing rapidly, our community continues to contribute to the academic conversation publishing more than 310 journal articles in the last year.

This year the Centre has focussed on growing its audience on Linkedin, increasing by 72% to 997 followers with its posts reaching 19,038 impressions and driving 1,330 unique visitors to our pages across the year.

Whilst, throughout the same period, the Centre maintained a steady audience on X with 974 followers; and its video content was viewed 1254 times on its Youtube channel.

310
JOURNAL ARTICLES

+

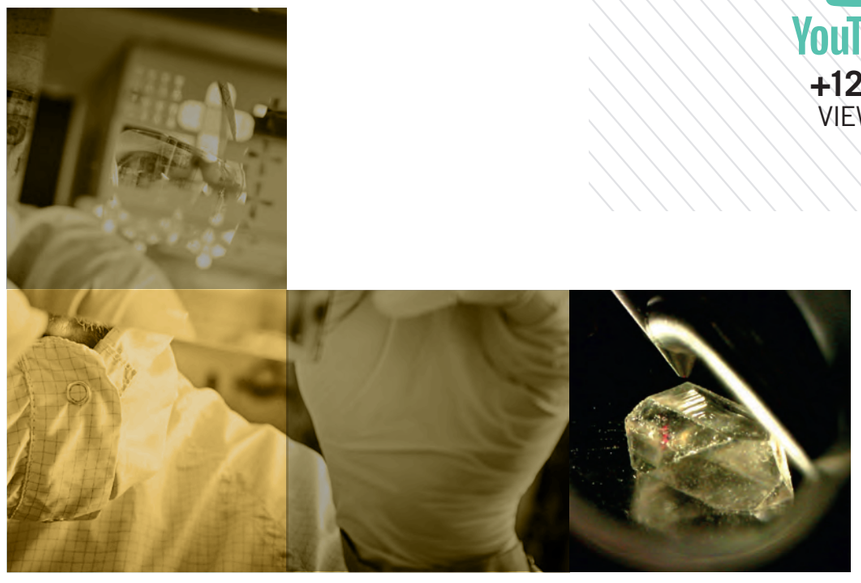
974
FOLLOWERS

+

↑72%
FOLLOWERS

+

YouTube
+1254
VIEWS



Next Generation of Materials Scientists

A core mission of the Bragg Centre is to widen participation in materials science by connecting the general public and school students to cutting edge research and innovation.

Royal Society Summer Exhibition

Held from 2nd to 7th July 2024, the Royal Society Summer Science Exhibition invites researchers from universities and science institutions across the UK to display their research at the Royal Society's free annual celebration of cutting-edge science.

This year, a team led by the Bragg Centre's Dr Philippa Shepley, was invited to host one of only 14 exhibits. The activity, "Engineering Atom by Atom", showcased work from the Nanoscale Advanced Materials Engineering (NAME) programme grant between University of Leeds, Imperial College London and the University of Manchester.

Visitors were invited to experience a VR activity that shrank them to the size of an atom and then implanted them into materials with atomic precision. Visitors also took part in an interactive laboratory to design and engineer nanoscale materials, bringing their creations to life in a giant light cube simulation made of over 18,000 LEDs. Additionally, visitors were challenged to examine a material without seeing it and observed an atomic force microscope (AFM) in action, as it characterised new materials directly from the lab.

Over the course of 1 week the stand was manned by 29 volunteers, and seen by over 10,000 visitors!

When asked about the experience Dr Philippa Shepley highlighted that:

We hope that the exhibit helps people of all ages to visualise science and engineering on the atom-by-atom scale. We want to share the excitement of doing science by showing real measurements and we want people to have a fun, memorable experience.

STEMFest

On the 4th July 2024, a team from the Bragg Centre led by Dr Andrew Lee joined 60 other companies and organisations to deliver hands-on activities at STEMFest 2024.

The event, which was hosted at the Life Centre in Bradford, welcomed over 3000 young people aged 10 – 14yrs from local schools from across the North East, Yorkshire & Humber regions to gain valuable first-hand insights into the exciting career opportunities available across the diverse STEM sector.

The Bragg Centre team delivered an interactive stall as part of the Health and Well being zone showcasing the bionanotechnological and soft matter materials research activity within the Centre.

Students and teachers alike, learnt about materials research as a discipline, explored the potential career paths in research and got hands on with a practical demonstration of the Centre's DNA origami project.

The free event, was a huge success, and the Centre looks forward to returning next year.

DNA Origami

This year the Bragg Centre's nationally acclaimed DNA Origami project completed its final round, reaching a further 100 students from a further 6 schools across the country bringing the total to over 700 students nationally.

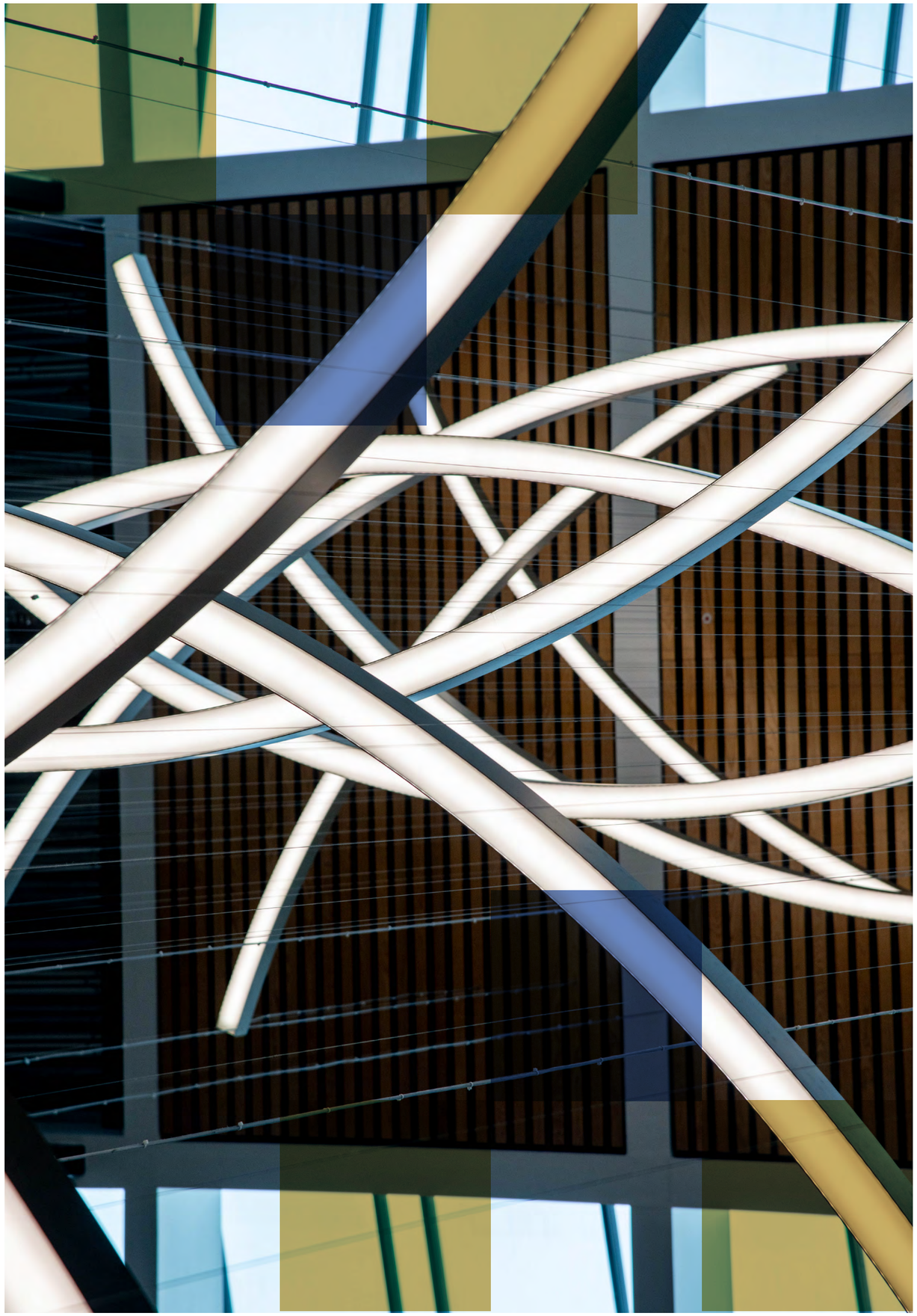
The DNA origami project inspires students to look at the world around them through the lens of materials science, providing students with a hands-on practical perspective that takes them beyond the traditional science lessons.

In addition to delivering the project round, this year, the Bragg Centre manager Dr Andrew Lee travelled to four of the participating schools to host workshops with the students, helping to refine their project ideas as part of the creative design phase of the DNA Origami programme.

Elsewhere, Bragg Centre PhD student Manoj Mahadeshwara joined the career discussion panel and engaged with over 300 A level students at the Institute for Research in Schools (IRIS) annual conference held on the 20th June 2024 in Manchester.

The list of impacts from the DNA Origami project continued to grow, with Dr Lee joined the assessment panel for two A level students undertaking extended project qualification (EPQ). These students had further expanded the ideas that they had originally developed as part of the previous round of the DNA origami project and used them to successfully secure valuable qualifications in addition to their A levels.

As this incredibly successful project draws to a close this year, it will transition to a digital only project hosted through IRIS's online resource centre. Reflecting on the DNA origami project, and the strong partnership developed with IRIS, the Centre continues to explore further opportunities to create future projects around its nanotechnology cleanroom and expertise in low-cost diagnostic sensors.



An Astronaut touches down in Leeds

The University of Leeds was honoured to welcome back alumni and ESA astronaut, Dr Matthias Maurer for a full day visit on Wednesday 9th October 2024. The visit was initiated by the University's Advancement team as part of an evening Alumni Voices event, with the day events coordinated by the Bragg Centre to showcase materials and space research across the Faculty of Engineering & Physical Sciences, and wider University.

Back in 1992, Matthias spent a year studying materials science in Leeds, during which time he also gained a taste for flying thanks to the university gliding club. 30 years later he went on to fly on a SpaceX falcon-9 rocket and spend 175 days in orbit conducting scientific experiments on the international space station.

The day's packed agenda was hosted by the Bragg Centre's manager Dr Andrew Lee, and showcased the work of more than **60 colleagues** from across the faculty, including research technical professionals, academic staff and students.

The visit included an overview of the Bragg Centre's materials research, innovation and training; as well as a detailed tour around the Centre's portfolio of research facilities in the Sir William Henry Bragg building. Matthias was hosted by the dedicated **research technical staff** in each facility, and even got suited up to explore the nanotechnology cleanroom.

An additional visit to the roof of the Bragg building was also included to enable academic colleagues from the School of Physics & Astronomy to showcase their telescopes used in research and teaching.

A wide range of discussions were held over lunch, with 15 colleagues representing space related materials and earth observation research from across the faculties of Engineering & Physical Sciences, and Environment. Specific areas were explored in detail with five academic presentations, including three from the Bragg Centre's remit; advanced coatings for space applications, Dr Liuquan Yang (School of Mechanical Engineering), Satellite-based THz gas spectroscopy, Dr Alex Valavanis (School of Electronic & Electrical Engineering), and studying metal solidification in zero-G, Prof. Andrew Mullis (School of Chemical & Process Engineering).

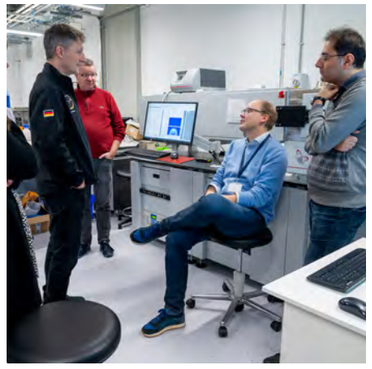
In addition to exploring the Bragg Centre's research, Matthias engaged with the Leeds University Rocketry Society (LURA), based in the School of Physics and Astronomy, as well as meeting with Undergraduate students studying current Materials science courses in the School of Chemical & Process Engineering. Matthias was particularly impressed with the liquid rocket engine that the LURA team had designed and spoke to them about the urgent need to increase the diversity in the space workforce, taking time to talk specifically to the only female student in the LURA group.

The visit culminated in a **special guest lecture** open to faculty staff and students, where Matthias discussed the wide range of scientific experiments that he had conducted on the international space station. The lecture was naturally oversubscribed with **over 300 attendees**.

Throughout the visit, Dr Lee spoke at great length with Matthias about the wide range of research, innovation, teaching, public engagement and research culture activities throughout the faculty.

Matthias expressed how impressed he was with the Bragg Centre's state-of-the-art facilities, the power of its vision to integrate its research capabilities together, and the clear passion of everyone that he met across all levels. He indicated that he had thoroughly enjoyed his first visit back to the University and Leeds in 30 years. In particular, he was keen to note that on typical visits he does most of the talking, yet when visiting Leeds he thoroughly enjoyed hearing about the breadth of research activity. Mattias was notably quick to highlight areas were the Bragg Centre's capability aligned with ESA's interests and strongly promoted engaging with the agency to develop projects for inclusion in future post-ISS space research platforms.

The Centre was thrilled to have hosted Matthias, and wishes him a safe onward journey to the Moon and beyond!



Recognising Impact

Early Career Leadership

Robert Elkington
Post Graduate Researcher
School of Mechanical Engineering

Joint replacement is a major undertaking with typically over 100,000 knee replacement procedures being performed in the United Kingdom in each calendar year. Despite this frequency, there remains significant limitations with the current joint replacement technologies, particularly for patients undergoing only partial joint replacement to treat conditions such as arthritis.

Traditional hemiarthroplasty, which replaces only a portion of the joint, often involves metallic implants that lead to poor patient outcomes. This is due to the mismatch between the soft natural cartilage and the hard artificial materials, which causes increased wear and tear on the surrounding tissue. This often results in reduced function and potentially hastening further cartilage degeneration. As such, there is a significant need for materials that can better replicate the natural properties of cartilage, especially in cases where only part of the joint is affected.

To meet this challenge, work by Bragg Centre funded PhD student Robert Elkington has explored a new generation of soft-matter interfaces with the potential to provide minimally invasive and tissue sparing joint replacement technologies.

Robert's work has focussed on a developing a polyelectrolyte-functionalised biomaterial, SPMK-g-PEEK. This biomimetic surface is designed to emulate the lubricious, hydrated nature of synovial fluid; which is the viscous, non-Newtonian fluid found in the cavities of synovial joints, for example the Knee.

SPMK-g-PEEK replicates this natural system to promote continuous lubrication even under static conditions, utilising a novel mechanism called polyelectrolyte-enhanced tribological rehydration (PETR). PETR supports the recovery of interstitial fluid within cartilage, helping to maintain a low-friction, hydrated surface that reduces wear on both the implant and the remaining cartilage. This mechanism not only improves joint function but also increases the lifespan of the implant, addressing a critical issue in joint replacement surgery.

As part of Robert's effort, significant attention was paid to the application of tribological science to understand the performance of these new materials, which includes the development of a new tribological instrumentation for the assessment of soft-tissue tribo-pairs. Robert's work has made strides in bridging the 'boundary lubrication' and 'fluid-structure interactions' debates pertaining to articular cartilages' impressive tribological properties, which have been hotly debated for decades.

In the broader context, Robert's research contributes to the field of orthopaedics by advancing the understanding of cartilage tribology and by providing new avenues for developing next-generation biomimetic implants. It offers the potential to enhance patient outcomes through less invasive procedures and longer-lasting implants, which are particularly important in an aging population where joint replacement surgeries are becoming more frequent.

Robert's work has been enabled through the Bragg Centre, with the receipt of prestigious Bragg PhD Studentship funding, and access to a variety of cutting-edge facilities, events and community expertise. When commenting on his experience Robert said:

The Bragg Centre has been instrumental in supporting my research through both funding and the vibrant PhD cohort it fosters. Being part of a diverse group of materials students has expanded my exposure to interdisciplinary approaches, enriching my research perspective. The Centre's regular symposiums and events have provided invaluable platforms for refining my presentation skills, contributing to several presentation prizes. Additionally, the supportive community have made it a nurturing environment for collaboration and growth.

This year, as Robert approaches the completion of his PhD, his contributions to biotribology have been recognised with the receipt of the Institute of Mechanical Engineers' (IMechE) prestigious Tribology Bronze Medal 2024. This award recognises significant contributions to the field of tribology at an early career stage, where recipients demonstrate innovation and leadership in their respective areas of expertise. This further adds to a growing collection of publications and accolades that Robert has accrued, including the IMechE DePuy Prize for Best Bioengineering Postgraduate Project and the STLE Richard E Booser Scholarship; firmly establishing himself as an emerging leader in tribology and medical engineering.

Demonstrating Sustained Leadership

Prof. Anwesha Sarkar
Chair in Colloids and Surfaces
School of Food Science & Nutrition

This year the Bragg Centre is proud to celebrate the outstanding achievements of Prof. Anwesha Sarkar, who is the recipient of the Society of Chemical Industry's (SCI) 2024 McBain Medal for outstanding achievements in colloid and interface science.

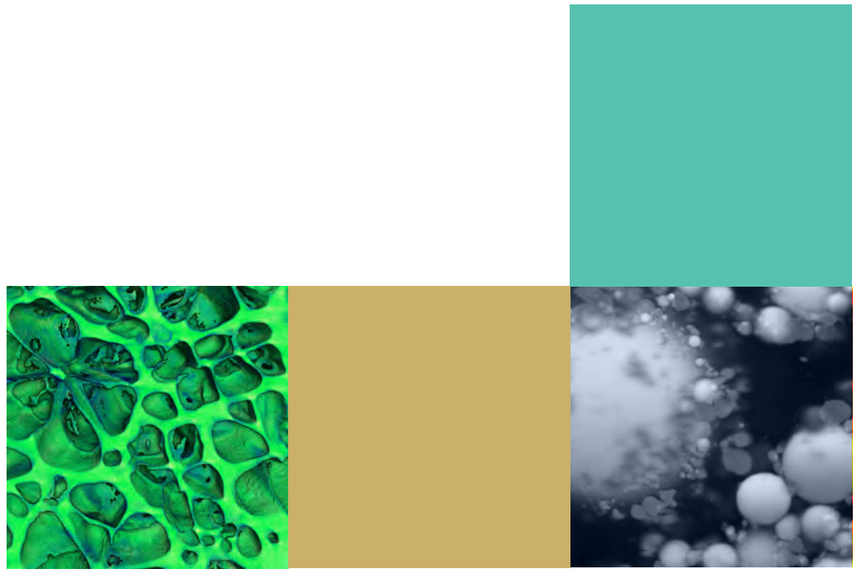
The McBain Medal is awarded to scientists for a significant contribution to colloid and interface science within 15 years of their PhD completion. Prof. Sarkar's achievement marks the first time that this medal has been awarded to a food scientist.

Anwesha's research programme focuses on fabrication of biopolymeric microgels and her research has brought significant advancements towards fundamental understanding of their bulk and interfacial behaviour to answer biophysical questions. Besides fabricating innovative microgels using alternative proteins with tailored performance on lubrication, Anwesha has devised biomimetic soft surfaces with optimised roughness and wetting properties which mimic the surfaces of the tongue and soft pallet in the mouth. This has enabled her team to discover the true behaviour of these microgels at biological interfaces such as orally relevant surfaces across length scales.

These contributions were also recognised by the Institute of Food Technologists' (IFT), with the receipt of the Research and Development Award in April 2024. This award specifically highlights the impact of Anwesha's contribution to the "Oral Tribology" of multiphasic food structure, uncovering a multiscale lubrication mechanism – the missing link that governs mouthfeel. When combined, these awards recognise the profound implications Anwesha's work has for designing healthier food and addressing food sustainability.

Prior to joining the University of Leeds in 2004, Anwesha spent 4 years working in the Nestlé Global Research Centre, Lausanne & Nestlé Headquarters, Vevey (Innovations) in Switzerland. Building on her world-leading expertise across both academia and industry, Anwesha has successfully founded a company and secured prestigious funding to establish an Innovation Knowledge Centre (IKC) in the area of Alternative Proteins.

Whilst the former spin-out company, MicroLub Ltd, successfully secured £3.5M of investment in summer 2024 to commercialise Prof. Sarkar's novel microgel technology as food-grade fat replacers; the £38M National Alternative Protein Innovation Centre (NAPIC) was launched in September 2024 across the Universities of Leeds, Sheffield, Imperial College London and the James Hutton Institute, with 150 industry partners.



Get in touch

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