BRAGG CENTRE FOR MATERIALS RESEARCH
ANNUAL REPORT

2020/2021

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.”

Director's Summary

Prof. Edmund Linfield,
Director of the Bragg Centre

Welcome to the Bragg Centre's annual report 2020 - 2021

The word of the year is growth!

It is reflected in everything that the Bragg Centre has achieved this year; growth in our membership, growth in our research, growth in our industrial partnerships, growth in our brand recognition, the outgrowing of our existing space and moving into a new home, and a big emphasis on growing back stronger following a tumultuous time.

We have focussed on supporting our community to get back to its best, taking every opportunity to bring our members together by leading the way with creative virtual and hybrid events. We have placed great importance on recognising and raising awareness of the mental health impact of the pandemic on our members, and have worked hard to develop a new equality, diversity and inclusion strategy for the Centre.

This focus on people has been reflected in the growth of our membership, with a 46% increase over last year, principally in our student population. As part of this, we have welcomed our second cohort to the Bragg Studentship programme, organised our first annual PhD conference in July, and celebrated the success of Bragg members in securing fellowships.

Our relationship with the Henry Royce Institute has gone from strength to strength. We have supported five summer interns, and their participation in an annual Royce conference. We began a new major national public engagement initiative – 'DNA origami' – in partnership with Royce and the Institute for Research in Schools, which featured on BBC Look North. And we have continued to provide substantial facility access to external academic and industrial users, benefiting from £58K funding from Royce access schemes.

The productivity of our community has increased considerably with a growing portfolio of active grants (in excess of £84M), and over 380 academic outputs. We have also led outreach projects, including our "What is a Scientist?" video series and the Bragg Maker kits.

Of course, a major highlight of the year has been the migration of our facilities into the Sir William Henry Bragg building. This has not been without its complications but makes a significant leap forwards in terms of establishing the Centre's identity and presence as a place to do world leading collaborative materials research.

Finally, there have been some significant changes to the Centre's support team this year – Mike Daw left to focus on his PhD and Katharina Zeissler to become an Editor at Nature Electronics. We thank both for their substantial contributions to the Centre's journey. We have also celebrated Helen Walters taking maternity leave, and welcomed Lucy Leonard (May 2021) and Daniel Paterson (January 2022) to work alongside Andrew Lee.

Much has been achieved by the Bragg Centre over the last year, and we are looking forward with excitement to what 2022 will bring!

Our progress in perspective

Perspective from the External Advisory Board

Prof. Dame Julia Higgins DBE FRS FREng,

Chair of the Bragg Centre External Advisory Board

On behalf of the External Advisory Board (EAB) it is a pleasure to welcome the great progress the Centre has made despite this second year of the pandemic.

The EAB has, sadly, been frustrated in its desire to meet personally with staff and students, and to explore and celebrate the new building. We have nevertheless been kept informed of progress and been well able to fulfill our advisory role, while working from the sidelines.

Congratulations are due to all involved for the substantial progress made in very difficult circumstances. The successful move into the Sir William Henry Bragg building has provided the anticipated focus for the Centre's activities. The Bragg community has grown substantially with a corresponding increased success in funding applications and industrial partnerships.

The EAB has been involved in discussions about the Centre's Vision and notes the increasing recognition of the Bragg Centre brand. Whilst the implementation of the new Equality, Diversity and Inclusion strategy following extensive internal discussions and interactions with EAB will support the Centre's community as well as providing models for action in the wider University.

With all these positive developments, the Centre is moving into 2022 on a strong footing. EAB looks forward to further progress, and finally to visiting the new building and meeting in person later in the year.

Comment from the Deputy Vice-Chancellor

Prof. Nick Plant,

Deputy Vice-Chancellor: Research and Innovation

The Bragg Centre continues to make significant progress and embodies the University Strategic Plan's central pillars of culture, community, and impact.

The inspiring community of researchers, new material scientists and engineers across the Bragg Centre has resulted in the growth of the Centre's already highly regarded brand and the successful translation of research into public impact through major outreach projects. The Bragg Centre has settled into its new home, the Sir William Henry Bragg building, which has provided a focal point to all its transformative activities, establishing even stronger connections across Schools and Faculties. This new central hub has helped the Centre achieve an impressive 46% growth in its community, despite a very challenging year.

The implementation of the Bragg Centre's new Equality Diversity and Inclusion Strategy, coupled with their active promotion and development of researchers at all stages of their career, is creating a strong, positive research culture. This will build on an already cohesive community and provide a strong footing for the Bragg Centre to continue to move forward.

The continued growth of the Bragg Centre's grant portfolio and the development of new industrial partnerships has enabled the Bragg Centre to remain at the heart of world leading interdisciplinary materials research. Through this, the Bragg Centre has significant impact, pushing the boundaries of fundamental knowledge; translating research into real tangible benefits for local, national, and global challenges; and inspiring the future generation of materials researchers.

Our governance

Research Theme Leads

Prof. Rik Drummond-Brydson
Analytical Science

Prof. Christoph Wälti
Bionanotechnology

Prof. Christopher Marrows
Electronic & Photonic Materials

Prof. Ardian Morina
Functional Surfaces

Prof. Fiona Meldrum
Multiscale Materials

Prof. Brent Murray
Soft Matter

Prof. Edmund Linfield
Centre Director

Bragg Centre Support Team

Dr Andrew Lee
Centre Manager

Mr Mike Daw
Senior Research & Innovation Development Manager
(until May 2021)

Ms Lucy Leonard
Research & Innovation Development Officer

Dr Katharina Zeissler
Research & Innovation Development Officer
(until August 2021)

Mrs Helen Walters
Research & Events Administrator
(on maternity leave)

Ex Officio Members

- **Dr Oliver Harlen,** Pro Dean for Research & Innovation
- **Prof. Giles Davies,** Pro Dean for Research & Innovation
- **Dr Ceri Williams,** 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, members are appointed by application to sit for a two-year term. This year we have increased the breadth of the committee with the appointment of student and technical staff representatives.

Term: October 2019 - September 2021

- **Dr Joseph Barker**
- **Prof. Susan Bernal-Lopez**
- **Dr Steve Fitzgerald**
- **Dr Robert Menzel**
- **Dr Helen Freeman**
- **Dr Elena Simone**

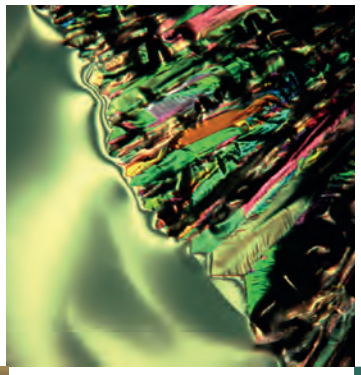
Term: October 2020 - September 2022

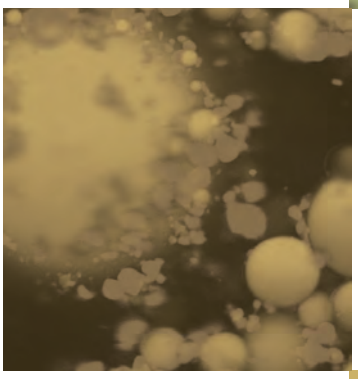
- **Dr Maisoon Al-Jawad**
- **Dr Sean Collins**
- **Dr Adam Sweetman**

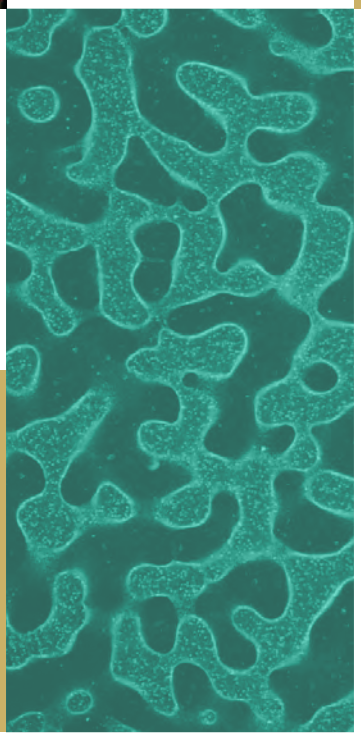
External Advisory Board

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

- **Chair: Prof. Dame Julia Higgins DBE FRS FREng**, Imperial College London
- **Prof. Jeremy Baumberg FRS**, University of Cambridge
- **Prof. Peter Dowding**, Infineum UK
- **Dr Mark Hampden-Smith**, Saint-Gobain Innovative Materials
- **Dr Sheetal Handa**, BP International Centre for Advanced Materials
- **Dr Rob Hardeman MBE**, Independent Technology Consultant
- **Prof. Mary Ryan FREng**, Imperial College London
- **Prof. Adrian Sutton FRS**, Imperial College London
- **Dr Alan Turnbill OBE FRS FREng**, National Physical Laboratory
- **Prof. Jim De Yoreo**, Pacific Northwest National Laboratory







Invest

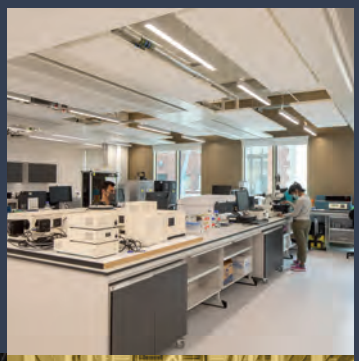
New Home

This year the Bragg Centre moved into its new home, located in the North-East quarter of the University of Leeds Campus. The £97M Sir William Henry Bragg Building was completed in February 2021 and offers 16,200m² of sustainable BREEAM excellent, purpose-built research and teaching space split across 7 storeys.

Named after the pioneer of X-ray diffraction whose Nobel Prize winning work was conducted at the University in the early 1900s, the building co-locates the schools of Physics & Astronomy and Computing, alongside the Bragg Centre, and directly connects into the School of Chemistry and the Faculty of Engineering.

The Bragg Centre will continue Sir William's legacy in its new home, with facilities spread across the 1st and ground floors, along with an extensive 2,300m², 5.1m deep basement complex. These include: the Royce deposition system, Atomic force microscopy facility, Leeds electron microscopy and spectroscopy (LEMAS) facility, X-ray facilities and Nanotechnology cleanroom. The basement itself, offers a hermetically sealed, negatively pressured, electrostatic-free environment which is anchored directly to the bedrock enabling it to achieve the lowest international vibration criterion VC-D/E specification. This criterion is challenging to achieve and sets the Bragg Centre facilities apart, enabling extraordinary dynamic stability for our most demanding and sensitive equipment, unabated by passing traffic or people within the building.

Despite the COVID-19 pandemic, the four-year construction project was delivered with minor delays and work began to transition facilities, offices, and people into the building throughout 2021 coinciding with a structured return of activity to campus. Unfortunately, substantial delays to the equipment migration have been experienced due to the travel restrictions which have remained throughout 2021. This has limited specialist engineers from being able to decommission and recommission highly sensitive pieces of equipment, with the migration timetable now extending well into 2022.



Facility Highlights

Cleanroom

At the heart of the Bragg Centre is a new 800m², state-of-the art Leeds Nanotechnology Cleanroom. The Cleanroom is a chase-and-bay arrangement, comprising 414m² of equipment and processing bays, 222m² of clean service chase and 94m² of gowning and corridor, with a further 99m² of fallow space for future expansion.

Serviced by a central corridor, the cleanroom is divided into seven rooms which broadly separates equipment into specialisation, including: Wet Etch, Dry Etch, Photolithography, Electron-beam Lithography, Metrology, Deposition, as well as Test and Packaging.

The cleanroom design incorporates a range of classes and environmental control, designed to facilitate ease-of-access whilst maintaining cleanliness at its heart. The processing bays are split into: 96m² rated at ISO 4 (Class 10) with a temperature stability of either 0.1 °C/hr or 0.5 °C/hr; a further 275m² are ISO 5 (Class 100) with a temperature stability of either 0.5 °C/hr or 1.0 °C/hr; and the remaining 43m² are ISO 7 (class 10,000) with a temperature stability of 1.0 °C/hr. Service chases are maintained at Class 10,000.

> ***The move… represents a transformative upgrade in our processing capabilities, more than doubling our cleanroom footprint, increasing our daily occupancy by 200%, and allowing processes that, up to now, were simply not possible.***
>
> **Dr Chris Wood**
> Cleanroom Manager

The Cleanroom has already underpinned over £3M of UKRI investment in new microfabrication equipment, including a £2.6M EPSRC strategic equipment grant for dry etching and deposition systems. Whilst, in partnership with the **Royce Institute**, the Bragg Centre is already supporting 12 companies and 25 academic partners, both UK and international, through cleanroom access.

Versatile X-ray Spectroscopy Facility (VXSF)

The Bragg Centre's bespoke X-ray phtotoelectron spectroscopy instruments were relocated to the Sir William Henry Bragg building in September 2021 as part of the Versatile X-ray Spectroscopy Facility.

Funded by the **Royce Institute**, the VXSF is the world's first multi-technique X-ray core level spectroscopy facility. The move not only co-located the instruments, but the facility staff as well, from the SCAPE and Energy buildings into a single space for the first time, making it easier to use them in combination as intended.

> ***The relocation has vastly (literally… vastly) improved the quality of life for the instruments, facility staff and, once the lab is handed over, will improve it for users.***
>
> **Dr Beth Willneff**
> VXSF Manager

Within the new facility, the instruments benefit from improved temperature control, ventilation, gas delivery, lighting, and space. The VXSF is now co-located alongside other Bragg Centre facilities, including the Royce Deposition System, enabling seamless interfacing between facilities, and the pooling of resources and expertise.

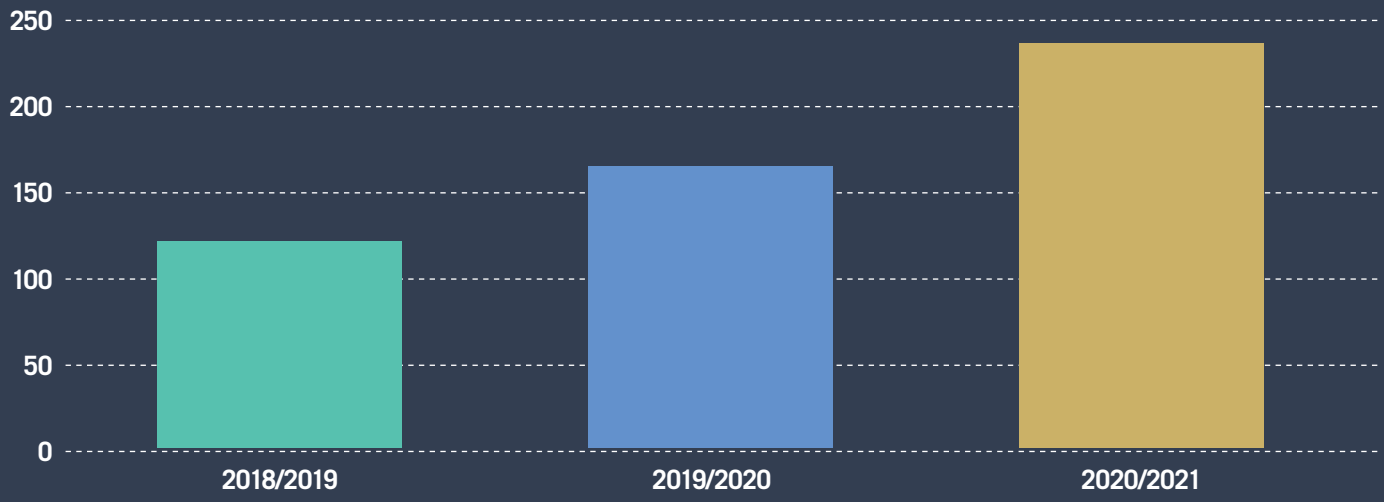
Collaborate

Membership

This year the Bragg Centre's membership process has been overhauled to create a dynamic system that tracks each member from application to departing the University. This now enables the Centre to integrate with other University systems to more clearly understand our members activity and better serve their needs.

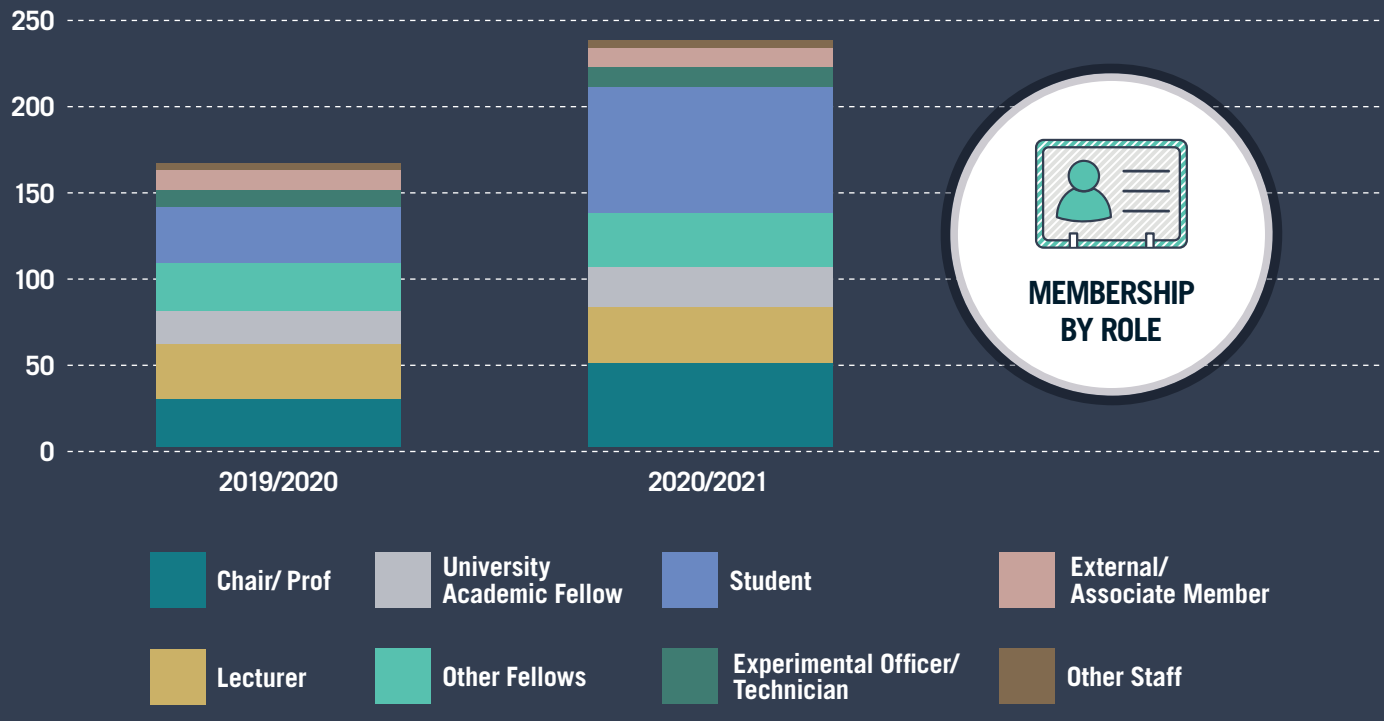
The Bragg Centre community grew by 46% to a total of 238 active members across 16 schools within the reporting period. 40 members left the University, during and prior to this current reporting period (only noted late due to the change in membership process), with the main source of membership attrition being as a result of PhD students graduating.

Membership Growth



There has been notable growth in our Student membership, with an increase of 86% over last year. Whilst an influx of members at associate professor level and above has been balanced by an attrition of external memberships.

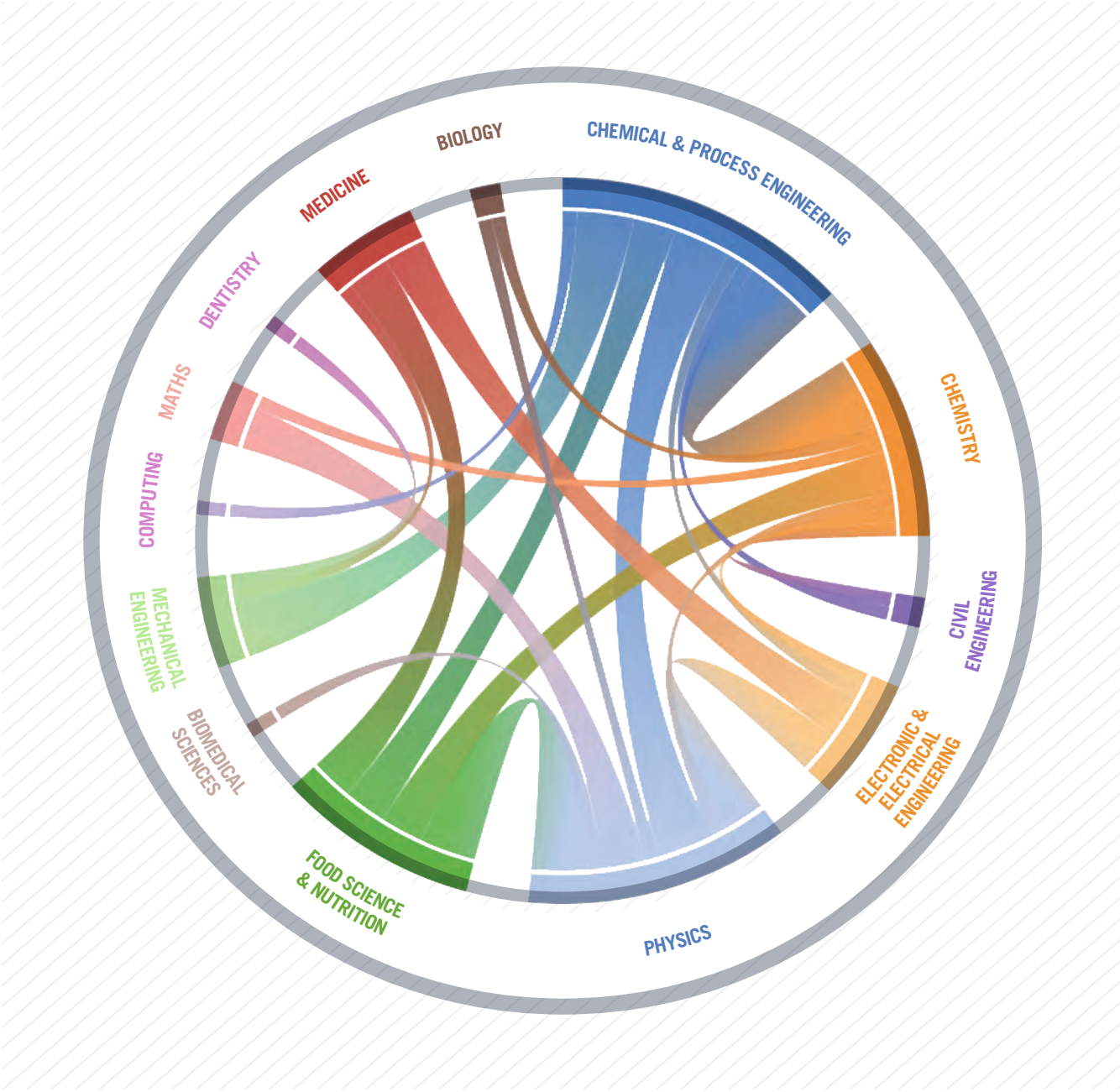
Membership by Role



Forging Connections

The Bragg Centre aims to facilitate the discovery and sustainability of collaborations across disparate pockets of advanced materials research within the University. This year 22 totally new inter-school links have been explored through the Bragg PhD Studentship project proposals.

The diagram below highlights these developing connections between 13 schools, where the number of collaborations proposed is represented proportionally by the thickness of the connecting lines. It is notable that new links are being drawn outside of the Centre's core physical science and engineering areas into the faculties of Medicine and Health, and Biological Sciences.

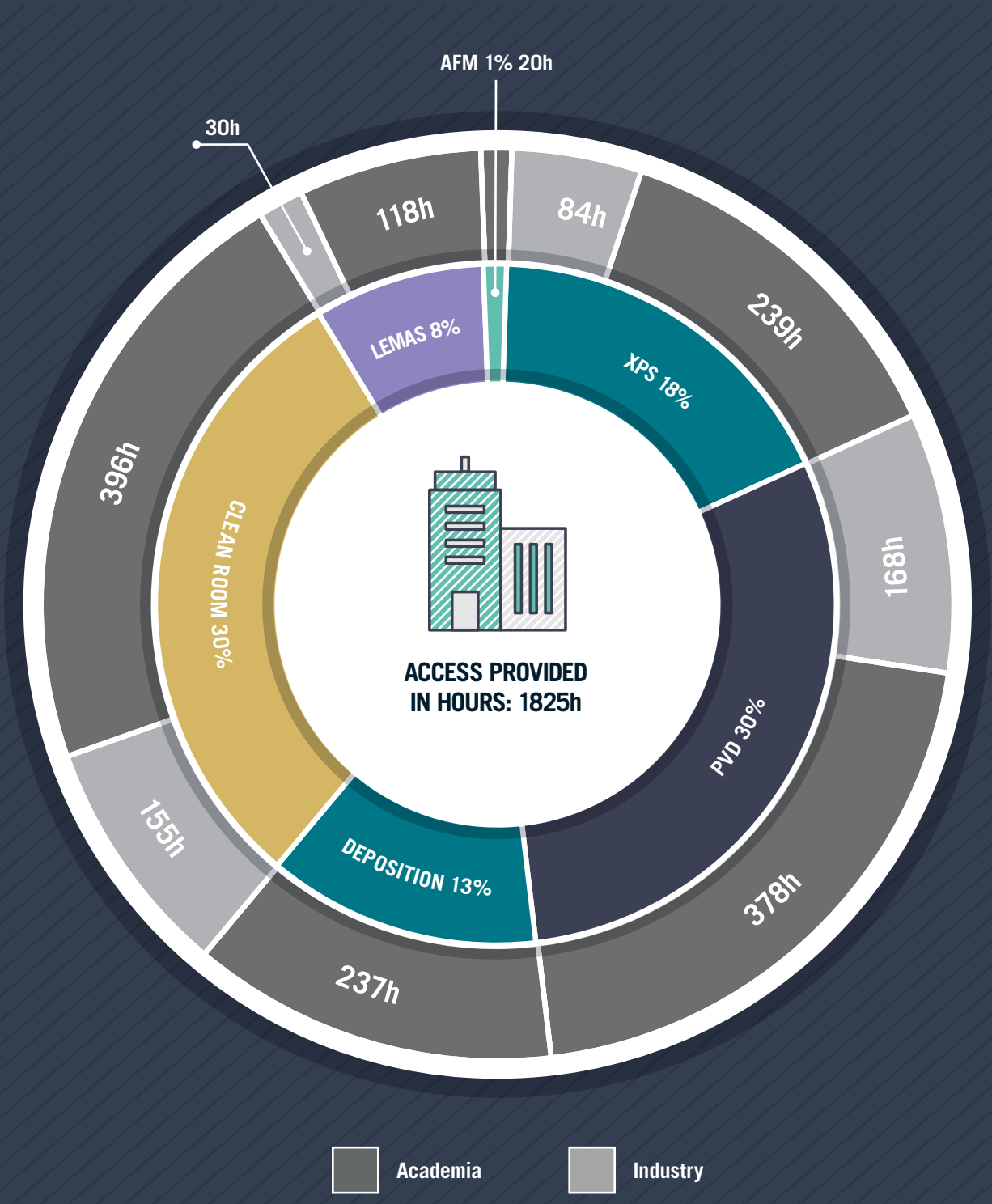


External Facility Usage

Over the past year, the Centre has continued to support external users to access our facilities, with many being funded and arranged by the Royce Institute. We have provided over 1800 hours of access to researchers from higher education institutions, RTOs, SMEs, and Industry. This represents a 120% year over year increase.

Researchers from institutes large and small make use of our cutting-edge facilities, with Industrial partners accessing over 400 hours of use. Our facilities were used by research organisations from across the UK and Europe including; Denmark, France and Switzerland. In the UK, leading Research Organisations such as the Rutherford Appleton Laboratory and the Diamond Light Source used our facilities. Combined with Universities, researchers from these institutes accessed over 1300 hours of facility use.

The Royce Institute funded £58,241 worth of innovative research at our facilities, through the Student, Researcher and SME Access Schemes. This represents a substantial 128% increase over the previous year.



Managing Our Facilities

Dr Lekshmi Kailas

Experimental Officer in AFM

Even the most complex phenomena of the physical world can be traced back to simple beginnings. In the case of materials, an understanding of the structure and properties at the nanoscale can help improve their performance in various applications and make way for improved technology.

The atomic force microscope (AFM) is a critical analytical technique to better understand the morphology and structure of material surfaces at the nano and micro dimensions. In the Bragg Centre, Dr Lekshmi Kailas takes care of our AFM facility, providing support and training for researchers and students as well as microscopy services to external users.

The facility comprises a suite of seven state-of-the-art AFMs optimised for high resolution imaging, sensitive and accurate force measurements as well as high throughput and high speed imaging. In addition, there are also several combined instrument platforms integrating AFM with advanced optical microscopy techniques.

Through the Bragg Centre, the AFM facility caters to researchers from various departments including; Chemistry, Mechanical Engineering, Chemical Engineering, Electronic Engineering, Biomedical Engineering, Civil Engineering, Biomedicine, Biological Sciences, Earth and Environment, Food Sciences and Dentistry; touching on all six of the Bragg's research themes.

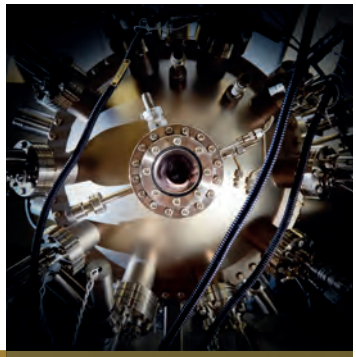
The collaborative interdisciplinary research conducted through the AFM facility falls within the EPSRC themes of physical science, engineering, manufacturing the future and healthcare technologies, with specific research areas of biophysics and soft matter, biomaterials and tissue engineering, magnetism and magnetic materials, spintronics, polymer materials, particle technology, surface science and synthetic biology.

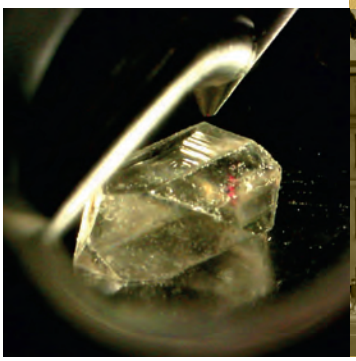
Some of Lekshmi's recent work in the facility has included antimicrobial polyelectrolytes with Newcastle University, ZnO Quantum dot thin films with Brunel University London and bilayer membrane studies on stretched flexible PDMS with Durham University. The AFM facility has also worked with a wide range of industrial partners including, PepsiCo International, Pfizer, Syngenta, Johnson Matthey, P&G, Merck and Astra-Zeneca in recent years.

Through her role managing the AFM facility, Lekshmi reflected on how it provides a unique opportunity to interact with people from different fields of study with common interest and enthusiasm for materials research;

> ***As a member of the Bragg Centre, I find that it is an enriching experience to be able to contribute to new scientific developments and help pave the way for emerging technologies.***

Originally from India, Lekshmi moved to Belgium to complete a PhD in Materials Physics, and subsequently conducted post-doctoral work at the Universities of Sheffield and Limerick before joining the Bragg Centre in 2019.

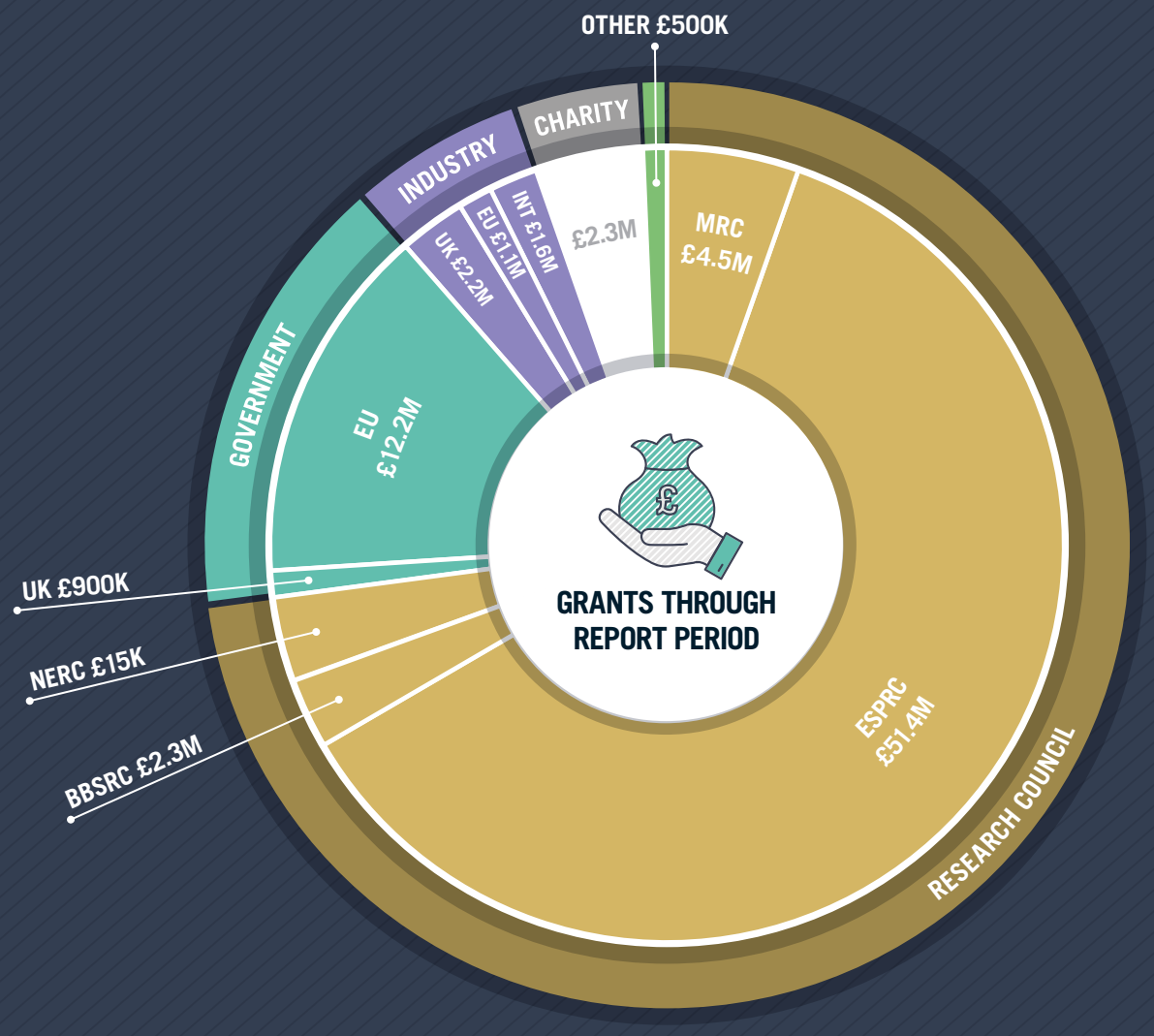




Grant Portfolio

Throughout the recent challenging times, the Bragg Centre has continued to develop a strong portfolio with 207 grants active during the reporting period September 2020 – September 2021, totalling £84M. This represents an overall portfolio increase of £1.89M over the previous year with a further £17.5M of new awards being secured within the reporting period and set to start in the near future.

Our diverse portfolio boasts £5M of direct industry funding from 52 companies across the globe, including British Telecom, Infineum Ltd, Total, BP International Ltd, Teer Coatings Ltd, and Arla foods. Whilst £908K of funding is contributed from UK government agencies, including the UK space agency.



Grant Highlights

- Creatively creating the materials of the future, Royal Academy of Engineering, ING2021\15\182, Lorna Dougan, £29,969
- Nanoscale Advanced Materials Engineering (NAME), EPSRC, EP/V001914/1, Edmund Linfield, £2,350,170
- 3D Nanoscale chemical analysis: a FIBSEM-SIMS facility optimised for soft and composite materials, EPSRC, EP/V028855/1, Richard Drummond-Brydson, £1,726,122
- Self-induced transparency modelocking of terahertz quantum cascade lasers, EPSRC, EP/T034246/1, Paul Dean, £1,127,383
- Smart, Multifunctional Dental Implants: a solution for peri-implantitis and bone loss (I-SMarD), EU, 953128, Animes Jha, £992,385
- NanoMan, EPSRC, EP/V055089/1, Nicholas Warren, £889,538
- EXTREME, EU, 964735, Joshua Freeman, £584,178
- Non-volatile programmable components for the superconducting computer, EPSRC, EP/V028138/1, Gavin Burnell, £513,530
- Porous 3D Superstructures as Implants for Brain Cancer Drug Delivery, EPSRC, EP/V009516/1, Zhan Yuin Ong, £393,881
- Multiplexed AKI biomarker detection with a single molecule biosensor, EPSRC, EP/W004933/1, Paolo Actis,, £299,971
- Plant Meat Ltd KTP, Innovate UK, Brent Murray, £109,589
- A Merck Centre for non-display applications of liquid crystals, Merck KGaA Carsten Fritzsch, Helen Gleeson, £81,443

Facilitating Innovation

Dr Alastair Marsh

Research Fellow

Cement is sometimes considered to be the 'villain' of construction materials, due to the high carbon emissions of its production and use. But in reality, it is essential in building a sustainable future; from low-carbon electricity solutions, public transport infrastructure, and the housing of a growing global population.

To help reduce the carbon impact of this critical material, Dr Alastair Marsh is exploring different processing methods, which will enable clays to be used in the manufacture of future low-carbon cements.

Clays have great potential, but questions remain around how to optimise the reactivity of these minerals across the wide range of clays found in nature as they're just not reactive enough straight out of the ground. Supported by a White Rose Collaboration Grant, Alastair's work is exploring mechano-chemical activation (or in less scientific terms, 'bashing') for those Clays that cannot be activated by heat in conjunction with colleagues from the Universities of York, Sheffield, Newcastle and the James Hutton Institute.

Alastair's work is a prime example of the Bragg Centre's multiscale materials theme and is showing that different processing routes impact the structure and properties of clays across multiple length scales; from the mineral crystal structure (on the nanoscale), to the particle size and shape (on the microscale), and the overall performance in low-carbon concrete structures (on the macroscale).

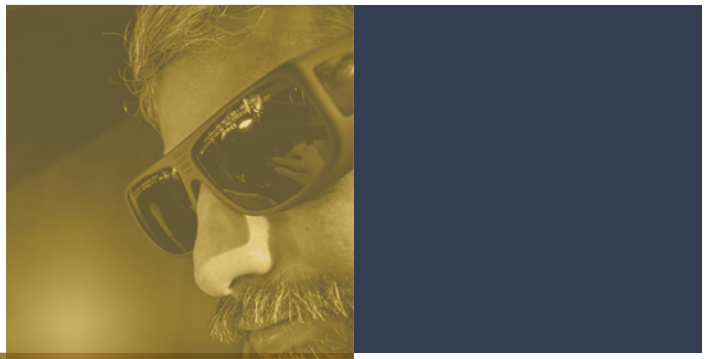
This research relies heavily on advanced microscopy and spectroscopy capabilities at the Bragg Centre, in particular scanning transmission electron microscopy and electron energy loss spectroscopy (STEM-EELS), focussed ion beam scanning electron microscopy (FIB-SEM) and atomic force microscopy (AFM). When reflecting on how the Bragg Centre's facilities enable his work, Alastair highlighted that the staff's expertise and flexibility were key;

> ***Obviously the facilities, but their great strength is how they are run by research-intensive instrument staff, who are willing to try new things.***

It is hoped that the techniques being developed here will play a crucial part in achieving rapid decarbonisation over the next 10 years in the cement industry – a sector which is notoriously hard to decarbonise – and that in the long term their application to other fields may lead to broader impact, such as carbon sequestration in soils.

Alastair has, by his own admission, taken a meandering path to get to where he is now; with a degree in Materials Science, experience working in an engineering consultancy and time spent as an English teacher overseas. Now, working together with the Bragg Centre Alastair is generating hugely impactful solutions which deliver on his personal mission;

> ***What gets me out of bed in the morning… is working towards a sustainable future for humanity.***



Working with Industry

Kate Lefroy
PhD Student

The Excessive fat and sugar content of food is high on many people's list of concerns yet trying to replace these ingredients without compromising on taste is difficult. This becomes an even greater challenge where these substitutes must also be renewably sourced and sustainable.

PhD student, Kate Lefroy has taken on that challenge at the Bragg Centre. Her project, co-supervised by Bragg members Prof. Brent Murray and Prof. Mike Ries and designed in conjunction with Dr Thomas Curwen from Mondelēz International, was offered as part of the Soft Matter & Functional Interfaces (SOFI) centre for doctoral training.

Kate's work to find sustainable substitutes has focussed on cellulose as a relatively cheap and vastly abundant biomaterial that so far has been relatively underutilised. In this case, cellulose microgels were developed by Kate as highly effective stabilisers of water droplets in fatty/oil phases. The development involved the novel use of ionic liquids to solubilise and re-precipitate the cellulose into microgels, avoiding the use of harsh and environmentally damaging chemicals currently used in most other cellulose processing methods which are not compatible with food production. The methodology being developed in this project has broader applications in other areas, including pharmaceuticals, and has so far led to four publications.

When speaking about the advantage that working with the Bragg Centre has provided Modelēz, Dr Curwen said;

> ***Mondelēz recognise the significant advantages that Kate has drawn on as a member of the Bragg community, both in terms of the exposure to a wider range of knowledge and expertise… plus awareness and access to the world-class instrumental facilities that are part of Bragg.***

Foremost amongst these have been the electron microscopy suite which has enabled Kate to characterise her cellulose-based microgels in the bulk and at interfaces, as well as access to NMR and FTIR facilities in Physics and Chemistry that the Bragg network enables. Mondelēz told us that they highly value their relationship with The University of Leeds and anticipate a pipeline of future projects, adding that they;

> ***would certainly recommend other colleagues in industry engage with the Bragg Centre.***

The project, which was jointly funded by the EPSRC and Mondelēz International (contributing £50k each), has enabled Kate to spend time within the company, gaining an experience of industrial R&D whilst attempting to translate her findings to real food systems. Kate highlighted that this opportunity was a big draw for her when choosing projects;

> ***I was particularly drawn to the programme because of the link with industry… I was interested in doing a project for which I could see for myself the potential real-world applications.***

Kate explained that it seemed to her that Leeds had a strong track record with this particular combination of fundamental and applied research, and that this was typified by the development of the Bragg Centre over the last few years.

Translating Research

Dr Nicholas Furtak-Wells

CEO & Co-Founder, NIQS Technology Ltd

Living with diabetes currently requires the frequent use of needles to draw blood for individuals to stay in control of their glucose levels. Yet this is set to change, with the radical new non-invasive glucose sensing technology currently being commercialised by NIQS Technology Ltd.

Officially incorporated in September 2020 by inventor and CEO Dr Nicholas Furtak-Wells and based on the quantum sensing technology developed between the research groups of Dr Almut Beige and Prof. Gin Jose at the Bragg Centre, NIQS represents the next generation of optical based biomarker monitoring.

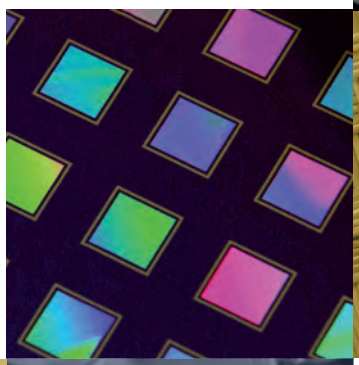
The company's main goal is to provide truly non-invasive, accurate and easy-to-use glucose sensors that will help people living with diabetes to make measurements more frequently and more easily. Ultimately, providing more effective management technologies and enabling people living with diabetes to have better glycaemic control, greater freedom in their day-to-day lives, and considerably more peace of mind.

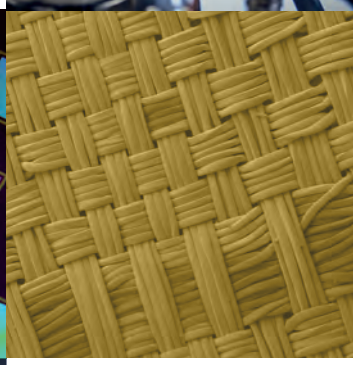
Nick is currently supported by a Royal Society of Edinburgh Enterprise Fellowship, which will help to accelerate NIQS' commercialisation journey and get the technology to an investable stage.

These prestigious fellowships offer a leading business development training programme for the higher education sector and will help to secure crucial Innovate UK grant funding to de-risk NIQS for private investors.

Nick has many close ties with the University of Leeds, having completed a masters in theoretical physics in 2015, followed by a PhD in quantum optics. He was subsequently awarded an EPSRC-funded QTEC fellowship which enables entrepreneurs to develop their business ideas through MBA-level training, as well as funding from Innovate UK's ICURe programme to explore potential markets. Reflecting on this support, Nick said;

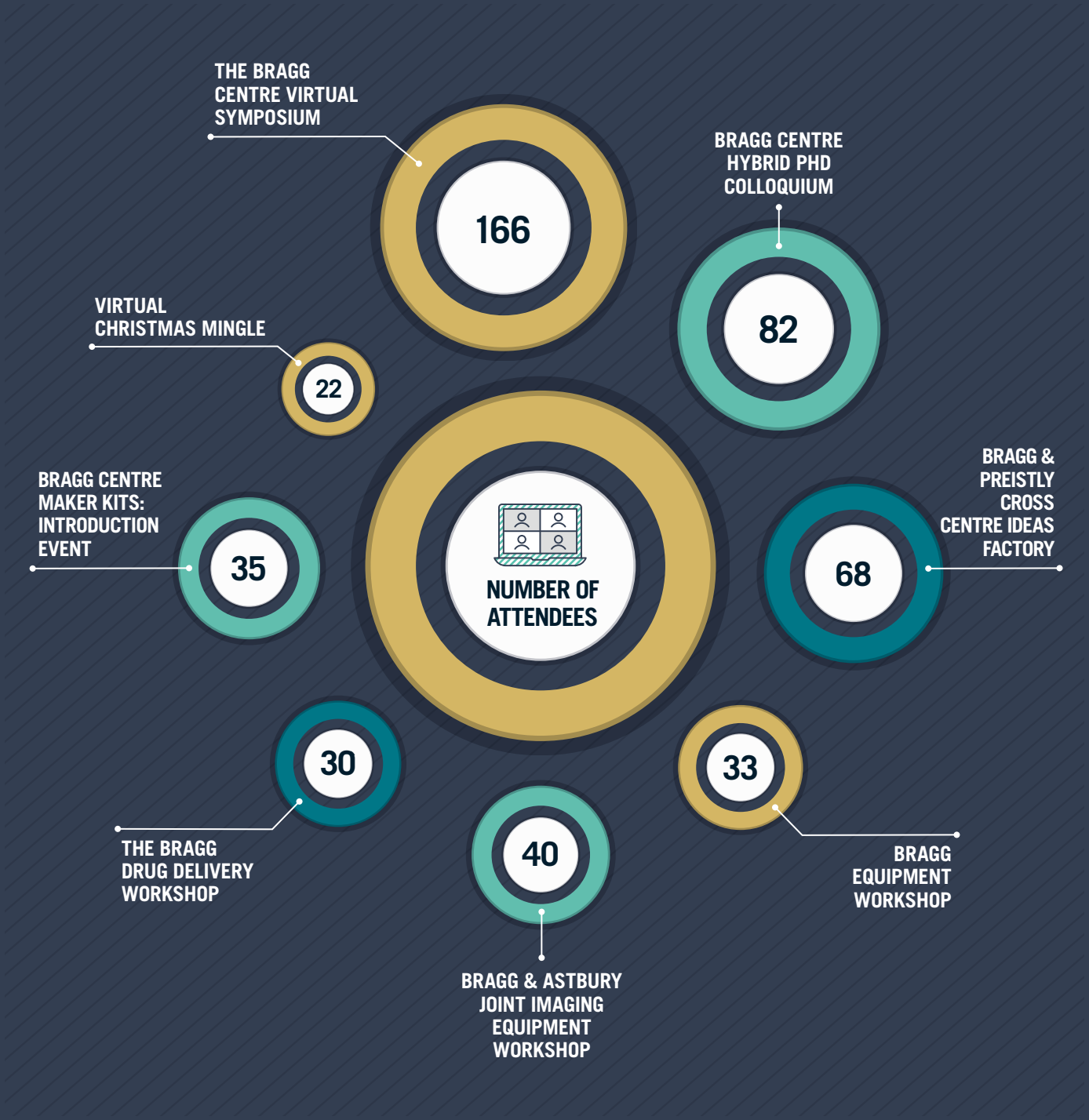
This [QTEC fellowship] programme allowed me to pursue my entrepreneurial ambition and broaden my skill set in preparation for starting and running a quantum technology company.





Hosting Events

This year the Bragg Centre has had to be creative in developing new opportunities to bring its community together during the ongoing pandemic. Alongside our internal events, we have worked closely with our colleagues in the Priestley and Astbury Centres to deliver several engaging cross-cutting interactions with new connections being established as a result. With activity on campus being heavily reduced, many of our events have been held virtually or in a hybrid mode, yet despite these challenges, our community has continued to benefi from a varied programme.



The Benefits of Getting Involved

Dr Frederick Pessu

Lecturer in Corrosion Engineering

This year the Bragg Centre for materials research and the Priestley Centre for Climate worked closely together to deliver a workshop cutting across both of their remits. The aim was to bring both communities together to explore areas for new collaboration in developing materials for the future energy transition or applying analytical characterisation approaches from material science to study climate related challenges.

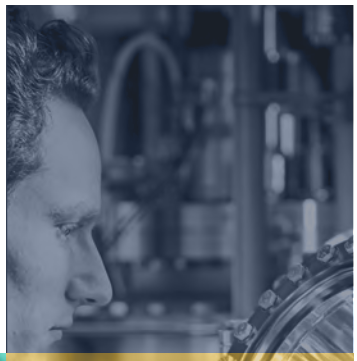
The workshop was designed to be a conversational exchange of ideas with talks presented by experts from both communities. On behalf of the Bragg Centre, Dr Frederick Pessu from the School of Mechanical Engineering, presented his portfolio of research and his future vision around material degradation in demanding energy production environments.

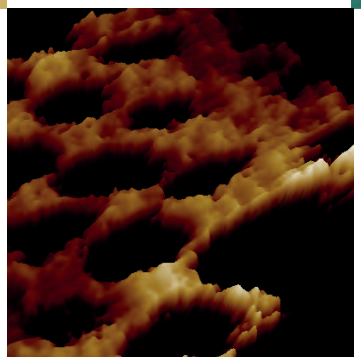
Frederick's work explores the corrosion and degradation that occurs at material interfaces within molten salt-based energy systems, including concentrated solar power and next generation nuclear reactors. This particular topic sparked considerable discussion at the workshop.

As a result of the workshop, Frederick has drawn new connections with Professor Sandra Piazolo and Dr Natasha Barlow, both of School of Earth & Environment, to explore the resilience of materials within wind energy systems. These collaborations are already bearing fruit with an Undergraduate Internship and several Level 3 research projects being developed by the team to explore this topic.

When reflecting on the outcome of the event, Frederick said;

> ***I think it has been a good vehicle for establishing a cross-disciplinary approach to research, especially in relation to the [ROYCE INSTITUTE] Materials for Energy Transition theme. I will definitely try to participate [in future events].***





Educate

The Bragg Centre is committed to developing the expertise of our community and training the future generation of materials researchers through its PhD studentships and Royce funded internship programmes.

Royce Undergraduate Summer Internships

Throughout the summer of 2021, the Bragg Centre supported a further five undergraduate interns through the Royce Undergraduate Summer Internship programme. This scheme offers materials science-related research projects to students about to enter their final year of study. The students undertake a 10-week research placement culminating in a mini conference and poster presentation session attended by their fellow interns, supervisors, and Royce staff.

This year's projects hosted in the Bragg Centre included;

- Modelling the slag phase in low carbon cements using PONKCs and Rietveld analysis
- Topological insulators and the extreme-infrared
- Modelling the separation of forces at the atomic scale
- Liquid crystal modulators for terahertz space research
- Advanced tools for assessing biomedical device biocompatibility

Project Spotlight:

Undergraduate student Natalia Wolfe's project, 'Modelling the slag phase in low carbon cements using PONKCs and Rietveld Analysis' was supervised by Dr Sam Adu-Amankwah and Prof. Susan Bernal-Lopez. The project used computer software TopasAcademic to model the highly amorphous slag phase in low carbon cements from X-ray powder diffraction (XRD) data. Though a challenging toolset to adopt, Natalia was able to successfully produce a model within the project timeframe and develop an understanding of how key variables may affect the stability and efficacy of the studied system.

Natalia described how the experience of the internship has helped her with future career choices;

> ***I would definitely recommend learning from and being inspired by the projects of other interns. Your supervisor is there to help you and it is a great opportunity for you to ask questions regarding career choices/ PhD experiences.***

ADVANCED MATERIALS RESEARCH & INNOVATION

ROYCE

Bragg PhD Studentship Programme

The Bragg Centre offers up to five EPSRC funded PhD positions each year as part of its Studentship Programme. This highly competitive scheme funds projects that cut across disciplinary areas within the Bragg Centre and each project is required to forge a new connection between constituent schools at the University.

The students are supported by an in-house training programme in their first year and engage in a monthly student led discussion forum. In addition, the students benefit from the activities of the wider Bragg PhD community, including the annual Bragg Centre PhD Colloquium.

This year the Centre has welcomed a second cohort of three students into the programme. Whilst members of the first cohort have become involved in key activities at the heart of the Centre, with two students joining the new communications working group and with another being appointed as the student representative on the Bragg Centre management committee.

2020 Cohort Progress

Rachel Bocking

As one of the first cohort of the Bragg Centre Studentship, I am now just over one year into my PhD. My work focusses on developing nanocarbon-functionalised carbon nanoelectrode sensors for novel metabolite sensing applications, with the aim of using these nanosensors for *in-situ* measurements of oxygen consumption in bovine embryos.

During the first year I have successfully begun to work in the labs across two departments. I have developed experience in fabricating and characterising carbon nanoelectrodes and synthesising metal nanoparticle-nanocarbon composite materials, and have worked on creating a suitable deposition process to adhere these composites to the nanoscale electrode tips. I have recently begun to work on simple electrochemical metabolite sensing, developing further skills in electrochemistry. Use of wider Bragg facilities and contacts has enabled me to progress well with such an inter-disciplinary project.

The Bragg Centre has also given me the opportunity to present my work to a wider audience – even in person during the pandemic. I am also involved within the wider Bragg Centre community as the student representative in the Bragg Centre Management Committee, where I can feed back and contribute suggestions from the post graduate student perspective.

2021 Cohort

Callum Brennan-Rich

I completed a physics undergraduate and masters at the University of Oxford in 2021, with a thesis titled "Characterising and Controlling the Transient Behaviour of Self-Exciting Induction Generators." My main interest is in solid state physics, specifically the structure of magnetic materials; their transport properties; and their applications.

My PhD is focussed on observing skyrmions, a quasi-particle "knot" in a materials magnetisation within the frustrated antiferromagnet Fe_3Sn_2. Previous work has shown the FeSn alloy to hold room temperature skyrmions and due to a comparable (though more complex) structure Fe_3Sn_2 seems like a viable candidate to also hold this magnetic effect.

The interdisciplinary nature of the Bragg centre opens up analytical techniques and expertise from beyond the School of Physics and Astronomy and will allow me access to high resolution TEM to determine the structure and quality of my material samples.

Amir Rahmani

I obtained a bachelor's in Physics and a master in Photonics both in Shahid Beheshti University, Iran. The two internships I did were at EMBL (Germany) and ICFO (Spain) for approximately 9 months. All these programs have given me lots of experience in super-resolution microscopy of biological structures and their dynamics.

In the Bragg Centre, I am currently working on development of a novel microfluidic device to sort cells which aims to have single-molecule sensitivity thanks to the fast single-molecule fluorescence microscopy techniques. By applying developed tools in medical diagnostics, then using them to come up with new drug therapies, we will be able to provide better answers to biological questions and improve the quality of life for people.

I'm now glad to join researchers from interdisciplinary backgrounds that have been collaborating at Bragg Center in order to learn from each other's experience and better approach their scientific problems. In addition to that, the Bragg Center has outstanding facilities that allow me to conduct cutting-edge experiments.

Emily Newcombe

I come from an interdisciplinary background here at the University of Leeds with my undergraduate degree in Food Science & Nutrition, which also involved a year in industry at Cranswick Plc., one of the UK's largest pork producers. I have also recently finished a Masters, based primarily in Biology, where I assessed the potential of plant waste for utilisation in cellulosic materials.

I was excited at the prospect of a studentship within the Bragg Centre as I was keen to expand and continue research in the area of sustainable materials. I was also excited to have the opportunity to engage and work within an interdisciplinary network involving close contacts with industry.

My project involves looking at the structural factors controlling the mechanical properties of plant cell walls and exploiting this knowledge to modify the properties of cellulosic biomaterials.

Training programme

The training component of the scheme aims to lay the foundation for a new researcher, from the discovery of helpful experimental techniques, to approaches for disseminating outputs clearly and the importance of delivering wider impacts.

The following training sessions are included for this year's cohort;

- Things I wish I'd known at the start of my PhD, **Dr Christopher Marrows**
- Introduction to common theoretical/computational tools, **Dr Steve Fitzgerald**
- Introduction to common experimental/analytical techniques, **Dr Robert Menzel**
- Presenting scientific research, **Dr Joseph Barker**
- How to write compelling publications, **Dr Aleks Ponjavic**
- How to review an academic paper: an editor's perspective, **Dr Yoselin Benitz Alfonso**
- How to communicate science to the public, **Public Engagement Team**

Summer PhD Colloquium & Mental Health Awareness

In order to provide a voice to our vibrant and growing student community in 2021 the Bragg Centre introduced a new annual event, the PhD Colloquium. Following the inaugural event summer, the Colloquium will continue alongside the Bragg Centre's annual symposium, forming a pair of annual events that showcase the breadth of the Centre's research across all career levels. With a student led focus, the Colloquium offers the opportunity to deliver additional content, including career focussed talks from industry leaders and sessions focussing on health and wellbeing during the student studies.

Dr Zoë Ayres

Independent Mental Health Advocate

The pandemic has been exceptionally challenging for our PhD students, who have struggled to continue their research and education all while battling total isolation. This has undoubtedly placed huge burdens on their mental health, with depression and anxiety levels increasing. When organising our PhD Colloquium, the Bragg Centre wanted to confront this head on and not only bring the students together in person for the first time in a year, but to encourage them to talk about their struggles openly.

The Centre engaged an independent mental health advocate, Dr Zoë Ayres to speak at the event. Zoë delivered a very engaging and thought-provoking talk, undeterred by the challenges of a hybrid conference setup. The audience, students and supervisors alike, were stirred by the topics discussed and the fruitful discussions stimulated during the talk have continued within the Bragg Centre long after.

Zoë's contribution opened the doorway and revealed that there were many people who wanted to discuss these ideas but didn't know where to turn. The Bragg Centre hopes to become a beacon of best practice in this area for the benefit of its members and will continue to facilitate workshops for all members in partnership with the University counselling services.

You can find out more about Dr Ayres work by scanning this code:

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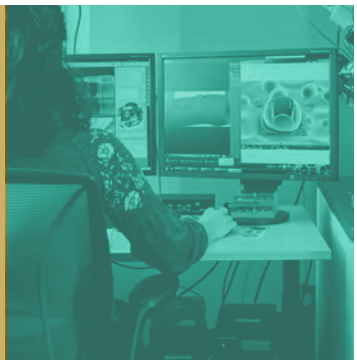
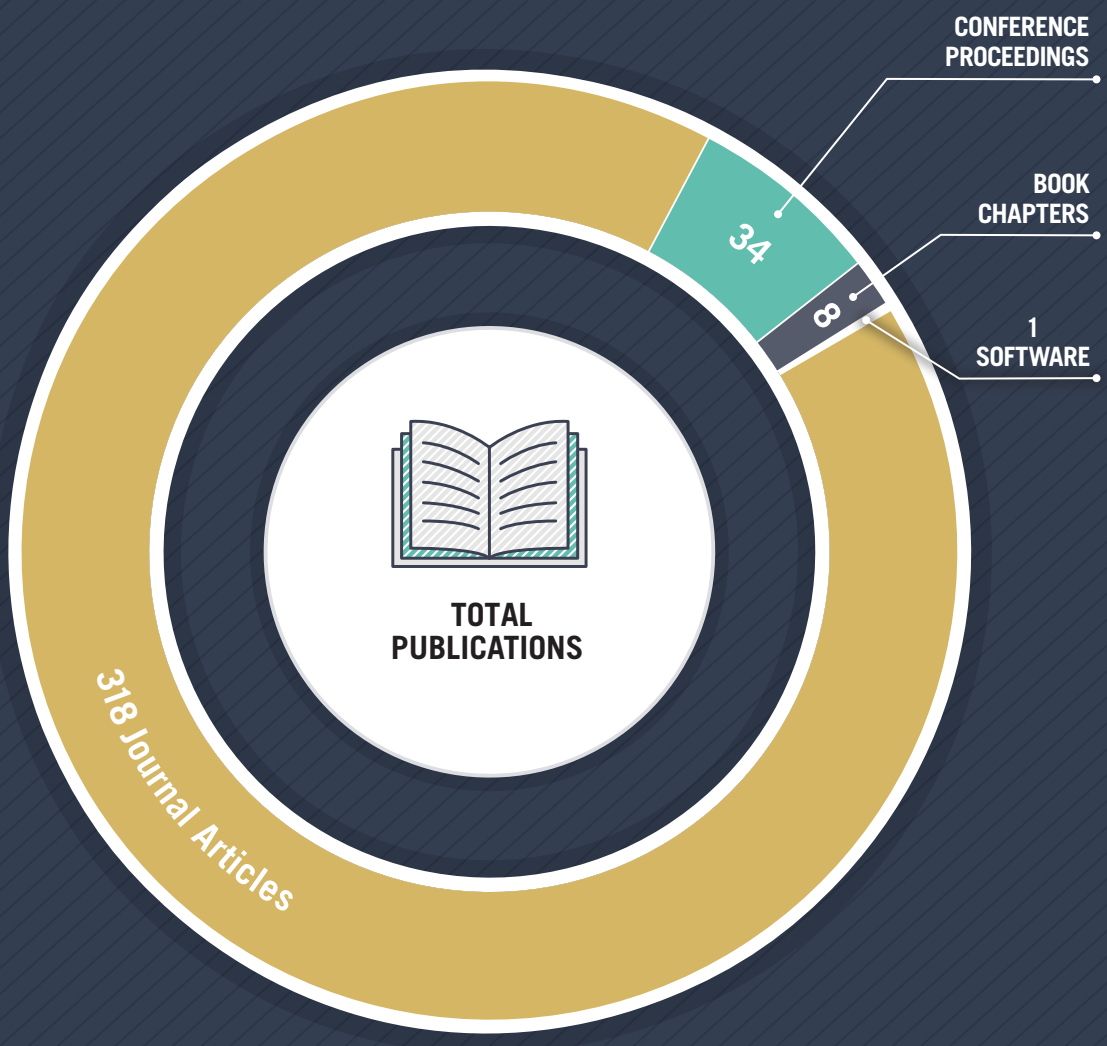


Inspire

The Bragg Centre has continued to reach a broad audience through its academic outputs, social media channels and public interactions in spite of a hybrid working modality. In particular this year, the Centre has worked hard to grow its audience, solidify its brand and identity, and developing new partnerships which expand the Centre's sphere of influence to younger audiences.

Publications

This year the Bragg Centre community has published an impressive 361 academic outputs across the breadth of our research activity, whilst the importance of our community's work continues to be recognised globally with a combined cumulative citation count of 2411 between September 2022 and September 2021.



Expanding Our Reach

The Bragg Centre has focussed on developing its social media presence to increase our reach to a more global audience. The Centre has worked hard to grow its established Twitter account, with a particular focus on student and academic audiences, whilst the Centre also created a Linkedin account to interact with start-ups, small medium enterprises, and larger industrial audiences.

In support of this, the Bragg Centre established a communication working group in summer 2021 tasked with sourcing and disseminating news from within the Centre through its social media channels. This volunteer group is set up to act as the mouthpiece of the community and works with the Centre team to ensure the activity of the community is represented in a timely fashion and with a consistent identity and voice.

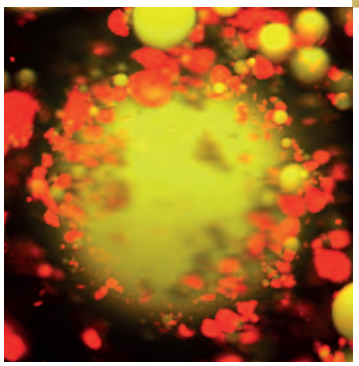
113
TWEETS

>100K
VIEWINGS

9.8K
VISITS

+20%
FOLLOWERS

Within the reporting period, the Bragg Centre communications working group has posted 113 tweets, which have been seen by over 100,000 people and generated 9.8K unique visits to the Centre's profiles. This has resulted in a 20% increase in the Centre's Twitter following this year.



What is a Scientist?

The Bragg Centre believes that materials research should be inclusive. As part of our equality, diversity and inclusion goals, this year the Centre developed a video series to tackle the pre-conceptions of who can work in science and what a career in science involves.

The project, titled "What is a Scientist?" , was funded through an Engagement Excellence Fellowship awarded to Dr Andrew Lee and involved 100 14 – 16-year-olds in the co-production of the video series. Five Bragg Centre members were interviewed, to produce over 40 short videos which responded to the students' pre-conceptions about scientists. The project revealed many misconceptions about what it takes to enjoy a career in science, and it is hoped that these ideas can be challenged through wider dissemination of the video series.

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Scan the QR code to watch the full series on the Bragg Centre's YouTube channel.

Bragg Centre Maker Kits

Following on from the very successful Bragg Centre Creative Labs, the Maker Kit project was developed by Prof. Lorna Dougan to deliver public engagement activities to young people and families, helping them to explore innovation in material design by embracing creativity and creative thinking.

Each Maker Kit supports a discovery-led approach to exploring an aspect of materials research. These kits were developed in partnership with the University of Leeds Public Engagement team, with each Maker Kit containing materials and equipment, a postcard with instructions for the activity, information about the related research, a weblink to access more detailed information and a QR code to upload evaluation and feedback for the activity.

In the last year five different Maker kits have been shared with 300 families in the Leeds and Bradford area, around 300 students in local schools and with over 100 members of the public. These kits explore a diverse range of topics including the properties of diffraction, self-avoiding random walks, network formation in hydrogels and the mechanics of different materials. The Maker Kits have have also contributed to a national project which provides activities and materials through the Local Cultural Education Partnership, reaching ~8000 young people across Yorkshire and Humber.

The Bragg Centre Maker Kits have provided an important focus on the creativity and curiosity involved in research and has influenced internal policy.

Dr Alexa Ruppertsberg,
Head of Public Engagement with Research at University of Leeds

Scan the QR code to find out more on the Maker Kits website

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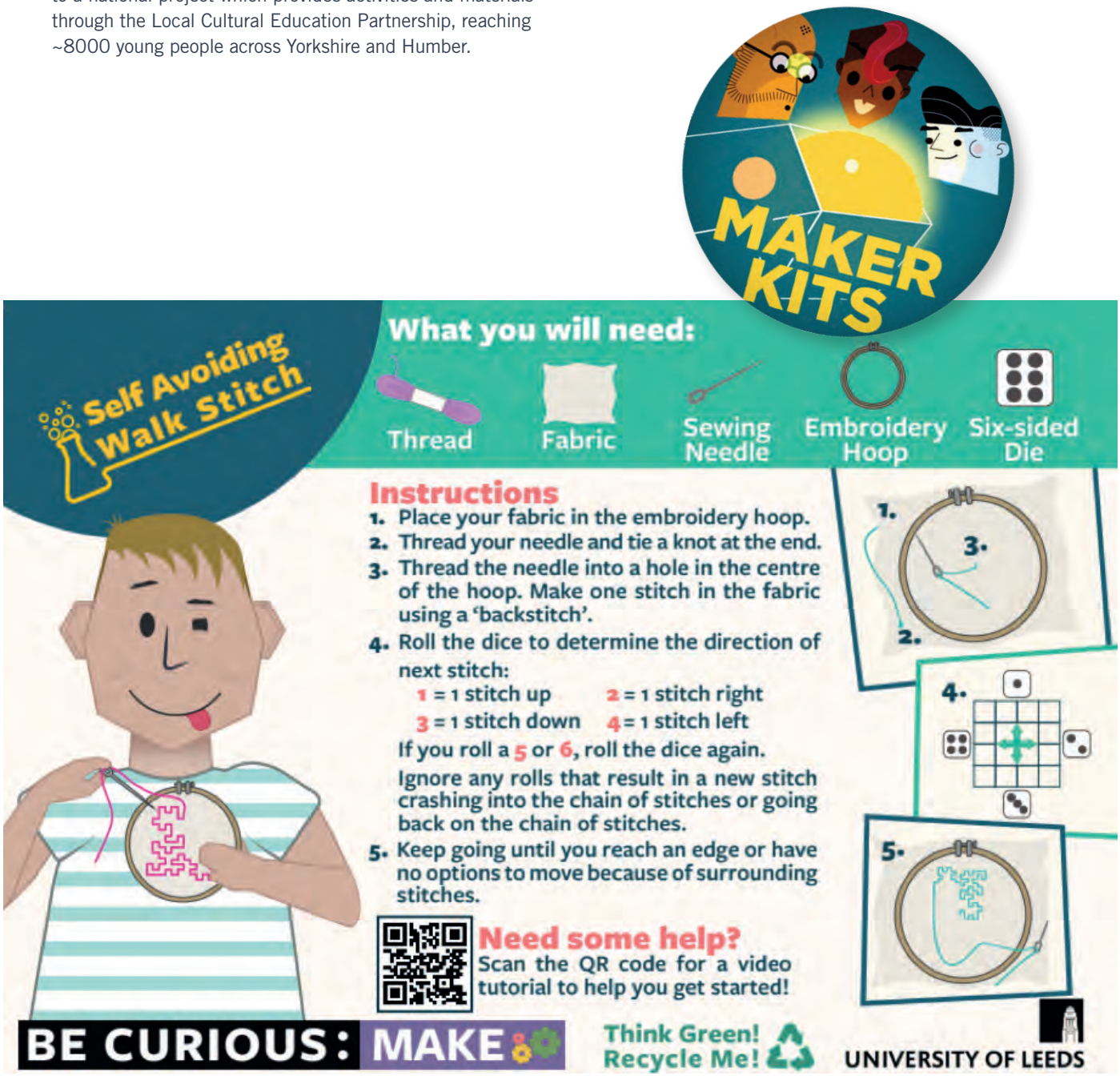
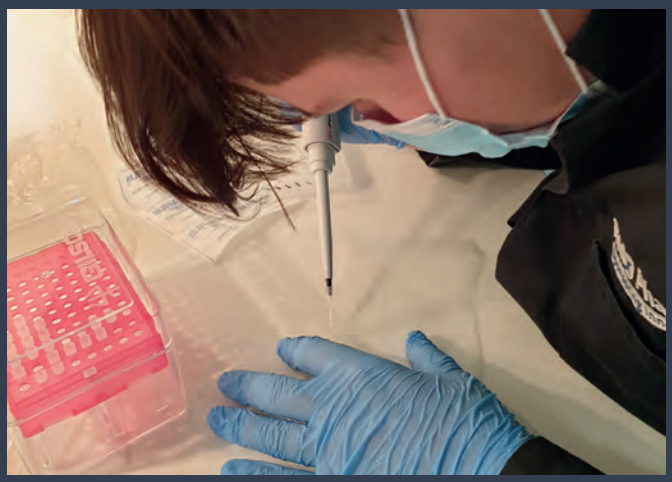


Engaging High School Students with Materials Research

This year, the Bragg Centre has developed a new partnership with the Institute for Research in Schools (IRIS) to engage A level students with cutting edge materials research. The project, created by the Bragg Centre's manager Dr Andrew Lee, introduces the students to the concept of DNA nanotechnology and aims to broaden their horizons beyond the school textbook.

The project, called DNA Origami, is underpinned by £65K funding from the **Royce Institute**. Having successfully reached 5 schools from Liverpool to Wolverhampton in its pilot stage this year, DNA origami will roll out to 40 more schools nationally over the next 2 years.



DNA origami teaches students about materials research by taking something they are familiar with, DNA, and showing how it can be used in a different way, as a material. The project is delivered in phases; teaching the students how to computationally design and evaluate DNA based structures with guided video tutorials; practical application of this knowledge to create a novel design of their own; the synthesis of a real DNA nanostructure within the school lab using kits provided by the Bragg Centre; and finally, analysis of the samples at the Bragg Centre with the students disseminating their work though posters and a final report. When reflecting on the progress the students had made, one teacher said;

> ***The lab work has been a real high for the students - their skills have come on a long way and they can really see how much it's likely to push them as they move forwards in their studies … There was a great deal of pride, achievement and gratitude tied up in all the hard work they had completed … Ours has been an overwhelmingly positive experience thanks to the hard work from [the Bragg Centre].***

Despite the pressures of the pandemic, the students were incredibly engaged by the pilot project, with much of the work being run in afterschool science clubs. The aim of the project is to broaden students' horizons and introduce the concepts of interdisciplinarity in science, something that is often not understood at a high school level. Many of the students indicated that they had been inspired to find out more in the future, with one student noting;

> ***It has broadened my scope of science and made me appreciate the fact there are many different areas of science I'm yet to learn about… keep it up it's awesome, like Sci Fi movies in real life.***

The impact of this work has been far reaching, even featuring on the regional BBC News, raising the profile of the Bragg Centre and its materials research. The Bragg Centre recognises the value of excellent science communication in inspiring future generations of material scientist and will continue to build on its strong relationship with IRIS to support this project and others like it in the future. When considering the collaboration with the Bragg Centre, IRIS director Jo Foster commented;

> ***Working alongside Dr Lee at the Bragg Centre to develop the DNA Origami project has been a perfect example of how, with the right idea and support, it is possible to engage young people with cutting-edge research. The students who have taken part so far have gained a unique insight into the world of materials science which would otherwise not have been possible without this collaboration.***

Scan the QR code to find out more about the DNA Origami project on IRIS' website.

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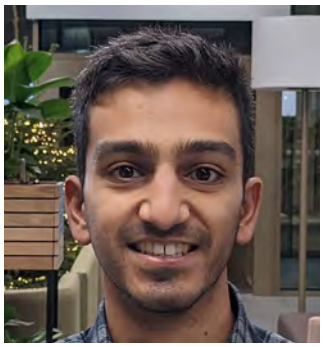
Celebrating Fellowships



Dr Devesh Mistry

University Academic Fellow

The natural world is filled with structures that are ordered over several length scales. Sometimes these structures have a functional purpose, such as the famous optical diffractive wings of some butterflies. But in other cases, the functional need for the structure may be unclear and its presence is more a consequence of what is naturally processable. In comparison, human-made materials are often structurally simple when compared to the hierarchical systems found in nature.

Dr Devesh Mistry is interested in developing new materials and processing approaches at junctures between natural and synthetic materials, to combine the properties of both systems.

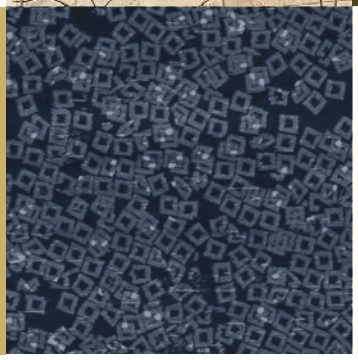
Devesh spent his PhD at Leeds studying the mechanical properties of structured anisotropic elastomers, in particular liquid crystal elastomers (LCE), where he discovered a new mechanical phenomena within this class of synthetic materials. Devesh found that when placed under strain, the polymer rearranges or flows to increase the material dimensions in the direction perpendicular to that of the applied strain as opposed to continuing to contract. This counterintuitive and so-called "auxetic" behaviour remains poorly understood, and it is not yet known if this property relates to the chemical structure of the monomers or the macroscopic ordering of the polymer backbone, or an interplay across both these length scales.

Following time spent working at the University of Colorado Denver where he investigated new ways to synthesise, mould and 3D print LCEs, Devesh now returns to Leeds with a Leverhulme early career fellowship.

As part of the Bragg Centre, Devesh aims to build on his work by combining multiple types of LCE together into composite materials which feature the molecular orders and dissipative properties of one type of LCE, with the tough, semicrystalline, and re-programmable properties of another type of LCE. By combining these new hybrid LCE formulations into layered structures through 3D printing, Devesh will create components with enhance shock absorbing properties across multiple length scales.

When thinking about the future impact of his work, Devesh indicated his intentions to interact with industry through the Bragg Centre. He told us;

A desired outcome is to liaise with industry to identify examples of where their existing materials are lacking in some way, and then to work to understand if we can address this problem by looking at structuring materials.



Guiding Policy

Dr Helen Freeman

Parliamentary Academic Fellow

The Parliamentary Office of Science and Technology (POST) is an office of both Houses of Parliament, charged with providing independent and balanced analysis of policy issues that have a basis in science and technology. POST produces impartial, non-partisan, and peer-reviewed briefings, designed to make scientific research accessible to the UK Parliament. The briefings come in the form of POSTnotes and POSTbriefs and are publicly available. Timely and forward thinking, they cover the areas of biology and health, energy and environment, physical sciences and computing, and social sciences.

This year, Bragg Centre member Dr Helen Freeman undertook a Parliamentary Academic Fellowship to develop a POSTbreif, supported with funding from Research England's Quality-related Research Strategic Priorities Funding (QR SPF).

Helen's POSTbrief titled "Reducing the Whole Life Carbon Impact of Buildings" was published on 4th November 2021, in support of the Environmental Audit Committee's inquiry on Sustainability of the Built Environment and the "Cities, Regions and Built Environment" day at COP26.

To prepare a brief, Helen undertook a detailed literature review, along with over 20 interviews with experts in the field (including the Bragg Centre's Prof. Susan Bernal Lopez for her expertise in cementitious materials). Once drafted, the brief was peer reviewed by a group of 30 experts and POST advisors. While this made for a somewhat arduous and iterative writing process it demonstrates the reassuringly high levels of scrunity Parliamentary publications go through!

Through dissemination to members of the House of Commons and House of Lords, Helen's brief is expected to support the Government's Net Zero Strategy for the built environment. It will also be widley disseminated to campaign groups, industry bodies and profesional institutions to become the go-to evidence document for the sector. While such POST publications cannot make recomendations directly to Government they can highlight the recomendations made by the community.

Helen's breif highlights that the expert community are advocating for an increased focus on the whole life carbon emissions of buildings, including embodied carbon emissions (those associated with the extraction, manufacture and assembly of a building's materials and components as well as it's repair, maintenance and refurbishment, and end of life activities). This is particularly relevent for the **Royce** and Bragg communities whose materials innovations can improve the energy efficiency of buildings and reduce the environmental impact of construction materials. Helen's work provides three key recommendations;

- To use materials with low emboided carbon (that is with low extraction, transport and processing emissions);
- To use materials that are durable, re-useable and recyleable (prioritised in that order, to work towards a zero-waste circular economy);
- To further develop carbon capture and hydrogen technologies to support hard-to-abate construction material industries (but to minimise the need for offsetting in the first place).

Helen has over ten years research experience with electron microscopy, where she has studied nanoscale material processes invovled in nuclear engineering, geosciences, and crystallisation. This fellowship has marked a shift away from the lab bench to follow her deeper interest in translating research findings into societal impact.

Scan the QR code to read Helen's POSTbrief.

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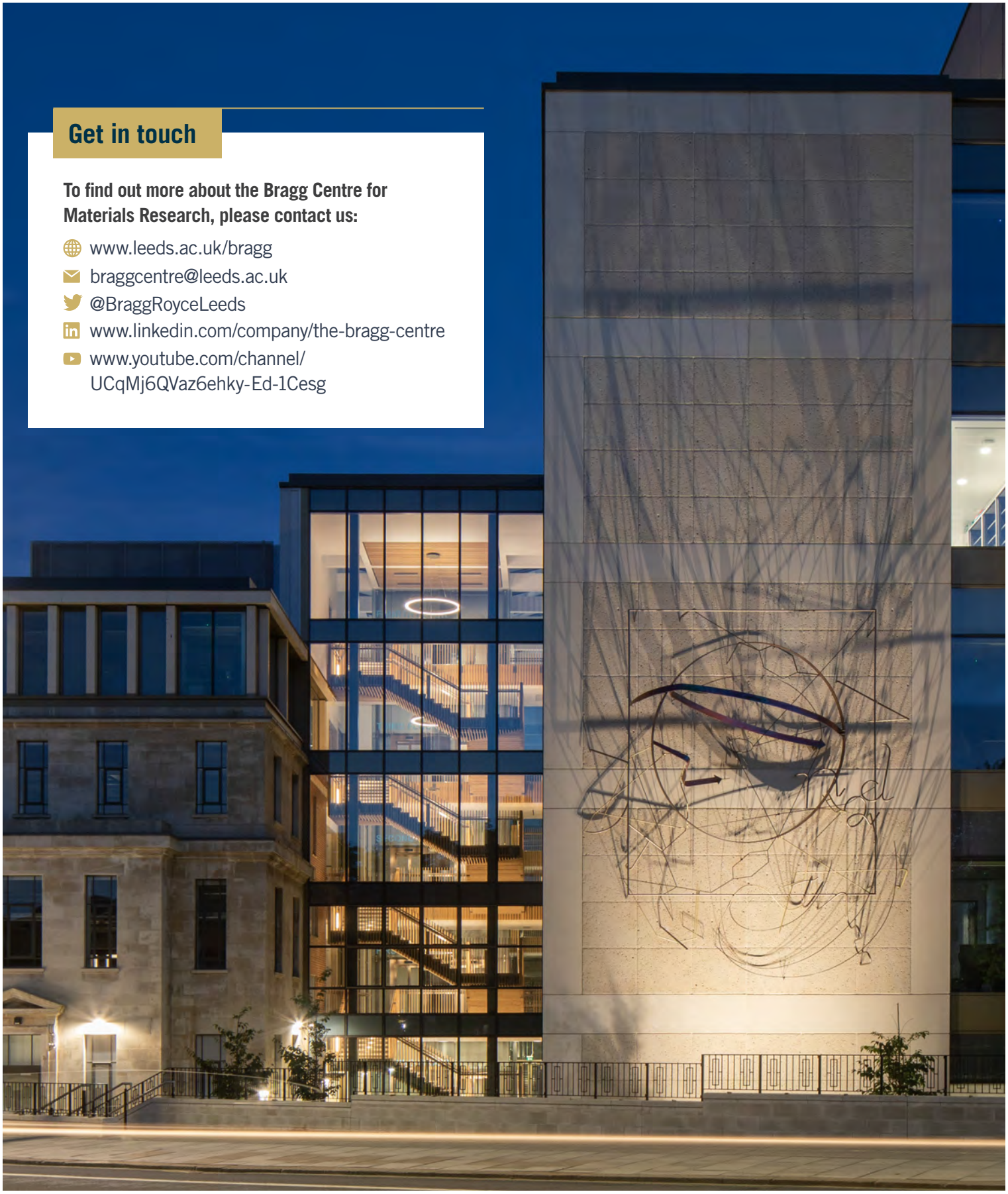

Get in touch

To find out more about the Bragg Centre for Materials Research, please contact us:

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- www.youtube.com/channel/UCqMj6QVaz6ehky-Ed-1Cesg

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