AN EPSRC & SFI CENTRE FOR DOCTORAL TRAINING

PIADS CDT

SPOTLIGHT REPORT

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NOVEMBER 2022

Engineering and Physical Sciences Research Council

QUEEN'S UNIVERSITY BELFAST

IPIC BRINGING PHOTONICS TO LIFE

University of Glasgow

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CONTENTS

WHAT IS PIADS?

We are the Photonic Integration and Advanced Data Storage Centre for Doctoral Training

The Centre for Doctoral Training (CDT) in Photonic Integration and Advanced Data Storage is a partnership between Queen's University Belfast, the University of Glasgow, and the Irish Photonic Integration Centre. (IPIC). We aim to tackle some of the challenges created by the increasing quantities of data generated by today's society.

The Centre's focus is on developing highly-manufacturable photonic integration technologies related to the magnetic storage of digital information. However, the development of these technologies will be relevant to a wide spectrum of end-users – from telecommunications to biophotonics, in which optical technologies are applied to living organisms and health care.

Established in 2014 (PIADS 1.0) with substantial investment from the Engineering and Physical Sciences Research Council (EPSRC) and both universities and industrial partners, the centre was successfully renewed in 2019 (PIADS 2.0) with investment from Science Foundation Ireland (SFI), resulting in a vibrant joint EPSRC and SFI funded centre.

It is our aim to help to address a skills shortage in the photonics industry by educating fifty future scientists and engineers over the next seven years.

Our Technical Focus

CDT research students are engaged on a range of challenging doctoral research projects across the Centre's **five main research themes**, with some live projects under each theme detailed below.

All students are jointly supervised by academic staff from the University of Glasgow, Queen's University Belfast and the Irish Photonic Integration Centre.

Themes (A-E)

Live Projects

A. Ultra-Reliable Semiconductor Lasers Operating in Hostile Environments

Dynamic Properties for InGaN/GaN-based Distributed Feedback Laser Diodes
Junction Temperature characterisation of oxide aperture VCSELs
Integrated photonic devices for smart gas sensors

B. Low Cost Planar Lightwave Circuit Platforms Suitable for Volume Manufacture

Integrated Quantum Photonic Sensors and Circuits
Controlling heat flow at the nanoscale using ferroelectric-based thermal mirrors
Temporal Dynamics of strongly coupled epsilon near-zero plasmonics

C. Novel Nanoplasmonic Devices Capable of Operating in Extreme Environments

Novel Materials synthesis for HAMR plasmonics
Inter-metallic plasmonic antennas
Bringing ab-initio design into the lab: design of new plasmonic materials

D. Atomic Scale Analysis Techniques

Characterising nanoscale thermal transport at functional interfaces
Heat generation and tansport in nanostructured materials
Reprogrammable micro-magnetic transport

E. Advanced Materials for Magnetic Recording

Molecule based magnets
Novel magnetic states in 3D nano-magnetic systems
Manipulation and exploitation of the dynamic processes of skyrmions

OUR EDI COMMITMENT

In today's data-intensive world, it is becoming more and more pressing to find efficient, long-term data storage solutions. In order for our CDT to produce as meaningful a contribution as possible towards tackling this problem, we champion and celebrate our staff and students, focusing on supporting the strength of diversity in our team in all its forms. We believe that inclusion of and respect for diverse people, experiences, and ideas lead to truly superior solutions to world challenges. This is why we are very much committed to maintaining an environment in which everyone is welcome to collaborate, to contribute to our community, and to support the growth of all of our members; students and staff alike.

Across the past year, we have continued to review all of our job adverts to increase engagement from all potential applicants and eliminate possible biased language. We have widened funding to support non-UK domiciled students in order to foster a globalised cohort where intercultural exchanges and perspectives are the norm. We have continued to monitor and review interviews and interview questions, in order to make the process more equitable for all applicants. We should also note the outstanding response and feedback to last year's 'PIADS celebrate pride' campaign where we collated movies, TV shows, books, and general media that celebrated, educated about, or simply represented the LGBTQIA+ community.

We would also like to highlight a few activities undertaken by our students that have dramatically shaped our EDI contributions over the past year. Internally, we have seen tremendous effort from PIADS PhD student Emma Crothers who spearheaded the STEMinist Network at Queens University Belfast, organising and delivering events for further education and general discussion of topical issues for women in STEM (fuller details overleaf). We also have seen engagement with the external public, such as participation at science festivals, inspiring future generations to pursue a career in STEM (further details of our activity also included later in this report).

Across the past year we have also seen PIADS members engaging with EDI more broadly. We are delighted that our very own External Engagement Manager and EDI champion (Dr Kirsty Annand and Dr Rair Macedo) have both been appointed to leadership roles within the Athena Swan Committee for the James Watt School of Engineering at UofG, as well as both now being members of the Opening Up Photonics Steering Board. Their participation in these external bodies ought to mediate exchange of best practice that we can all benefit from.

Finally, through our ongoing diversity and inclusion efforts, we hope to ensure the PIADS maximises its impact and success by welcoming, engaging, and rewarding those who contribute to the field in an equitable manner.

If you missed some of our previous EDI activities, or are new to PIADS, you may want to check out our wesbite articles on our 'Women Behind PIADS' campaign where, for International Women's Day in 2021, we celebrated the outstanding support team for our programme, or our screening of the documentary 'Picture a Scientist', (which is now available on Netflix!). This award-winning documentary tackles difficult issues, such as sexism and misogyny within the scientific community whilst providing new perspectives on how to make science itself more diverse, equitable, and open to all.

If you would like to learn more about our EDI vision, or to get involved, please contact our EDI Champion Dr Rair Macedo on Rair.Macedo@glasgow.ac.uk.

putting equality in Maths & Physics under the microscope

STEMinists

Emma Crothers, EngD Student with Causeway Sensors

Connected networks in science communities can have a real positive impact on the experiences of both students and academics, particularly those who identify as one of many gender demographics underrepresented in STEM.

Inspired by conversations with PIADS EDI Champion Dr Rair Macêdo, myself and fellow QUB School of Maths and Physics (MAP) Gender Equality Committee PGR rep. Sinéad Mannion founded the MAP STEMinists Network, an open platform for our academic, student and staff community to share experiences of, insights into and opportunities to support equality in the School, University and the wider STEM landscape. Since its inception, the Network has become a relaxed space for members of our diverse MAP community to support, inform & connect with each other informally on issues & opportunities that matter to them, both online on MS Teams and in-person during our STEMinist Screen Club, where members of the Network meet over coffee and donuts to share their views on that month's Screen Club video. Past topics have included Dame Jocelyn Bell Burnell's discovery of pulsars and PhD student Daisy Shearer's experiences as a neurodiversity activitst in STEM, both of which invited lots of lively and insightful discussion - looking forward to more opportunities to meet in the coming semester!

International Day of Women & Girls in STEM Event alongside PAMSOC, CORGI and the QUB Computing Society

As part of the MAP Gender Equality Committee...

I also spearhead the MAP Period Freedom Initiative, which has enabled the installation of 5 free-of-charge period product dispensers in our campus bathrooms. All products are cruelty-free, sustainable and 100% biodegradable, meaning that we can support the health of our community without compromising the health of our planet. We hope that by improving access to period care across the School, we can positively impact student and staff wellbeing, support period positivity within H.E. & help challenge the stigma that still surrounds menstrual health in the UK.

Join & support an online network of students, staff, academics & allies passionate about equality in STEM

THE FACES BEHIND PIADS

We are proud to have a strong network of academic partners and students as part of our PIADS CDT Team, who regularly communicate their research, industrial outputs and collaborative ventures in brilliant ways.
We are also aware that much of the activity of our centre would not be made possible without the dedication and creativity of our strong support team: the faces behind PIADS. Below is a short bio on each of these key team members, and you should feel free to contact them at their email provided, should you have any questions, or wish to engage with the CDT PIADS programme.

Dr Kirsty Annand

External Engagement Manager - kirsty.annand@glasgow.ac.uk

Kirsty holds a PhD in Materials & Condensed Matter Physics from the University of Glasgow and in her role, works to support Internal Engagement, External Engagement and Science Communication for the centre. She enjoys developing great relationships with our industrial colleagues and is passionate about championing women and girls in STEM.

In her spare time she enjoys hiking around Scotland with her dog Casper!

Dr Caitriona Tyndall

Education and Public Engagement Manager - caitriona.tyndall@tyndall.ie

Caitriona holds a PhD in Epigenetic Mechanisms of Breast Cancer Prevention from Imperial College London. As IPIC Education & Public Engagement (EPE) Officer Caitríona is responsible for delivering an interactive & engaging educational & public engagement (PE) programme through public festivals, school interactions & talks/tours nationally & internationally. Caitríona participates in the PIADS PE programme by providing support & helping develop skills in sci comm & engagement.

When Caitríona isn't delivering innovative public engagement activities she enjoys knitting and relaxing with her cats.

Elisabeth Wintersteller

Training Programme Manager – elisabeth.wintersteller@tyndall.ie

Elisabeth holds a master's degree in political science from University of Innsbruck, Austria. Before moving to Ireland, she worked in academia for 7 years, including positions at the European Molecular Biology Laboratory (EMBL) in Heidelberg, Germany and at Medical University Innsbruck, Austria. She is experienced in coordinating and administering national as well as EU grants and has coordinated the development of online education and training programmes for PhD and postdoctoral students. Elisabeth coordinates the PIADS programme at IPIC.

Elisabeth loves travelling and can't wait to explore the island of Ireland.

OUR INDUSTRY

THE FOUNDATION OF PIADS

The jointly funded EPSRC and SFI CDT Photonic Integration & Advanced Data Storage (PIADS) centre addresses a unique technological opportunity – the intersection of photonic integration and data storage.

The success of CDT PIADS 2.0 is contingent on the continuation & evolution of our unique anchor - tenant partnership model which brings together a range of strategic partners of different shapes & sizes, each making valued contributions to enrich the PIADS 2.0 training environment. The make-up of partner companies mirrors the photonics industry in the UK & Ireland.

The founding vision of CDT PIADS is to train cohorts of high calibre doctoral research students in the skillsets needed by the data storage & photonics partner base & the wider UK supply chain.

Students are trained in an interdisciplinary environment encompassing the five themes of robust semiconductor lasers, planar lightwave circuits, plasmonic devices, advanced characterisation & materials for high density storage.

The programme embeds a strong ethos of intellectual enquiry that empowers students to move between fundamental & applied research through the appropriate combination of high level technical, scientific & research training; courses in innovation, management, leadership & personal effectiveness; industrial seminars & placements; student-led activities such as conclaves, public engagement and winter schools.

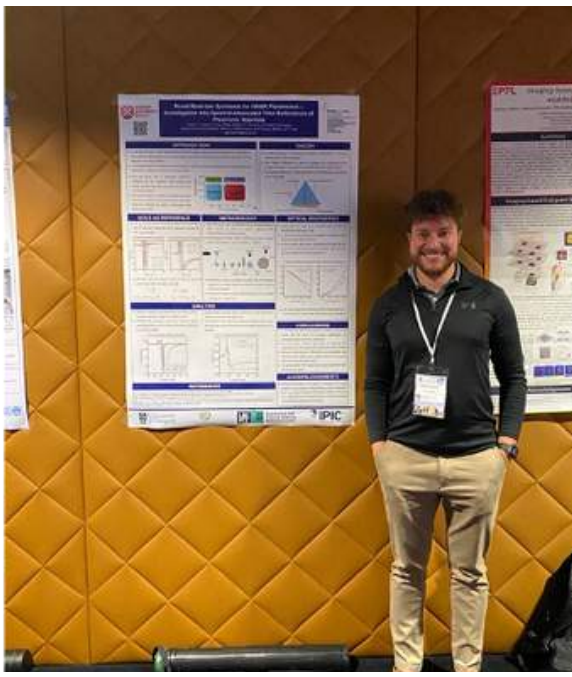
A

SPOTLIGHT

ON OUR STUDENTS

IUVSTA WORKSHOP

by Anna Casey & Arthur Lipinski, 2018 PIADS CDT Students



We attended the 95th IUVSTA Plasmonic Workshop which took place from the 20th of June until the 23rd June 2022 in the historic city of Guimarães, in Northern Portugal. This workshop presented an excellent opportunity for the both of us to gain greater and broader insight into the research within plasmonics. This workshop mostly focused on plasmonic thin films, nanostructures, surface plasmon resonances (SPR), localised surface plasmon resonance (LSPR), Surface Enhanced Raman (SERs) and their applications in real life.

During the workshop, Arthur was given the opportunity to present his current work in form of poster and a flash talk presentation. Additionally, it gave Arthur the chance to present in an academic setting in person.

The gala dinner on the final night of the workshop allowed us to interact with the other PhD students as well as academics. This has given us an excellent insight into their work and what it's like to study and do research abroad as well as highlighting the other research being carried out.

At the end of the workshop, we participated in a special mini course on magnetron sputtering. This was a very valuable addition to us as we are using magnetron sputtering to manufacture samples for our research and we were provided with additional resources which would further improve the management of the equipment.

We could not attend this beautiful region of Portugal without taking part in some activities such as a surfing class at the Matosinhos beach in Porto. We also had many opportunities to explore the historic cities of Porto and Guimarães where we tried traditional Portuguese cuisine such as Francesinhas, Sangria and the regions famous Port wine.

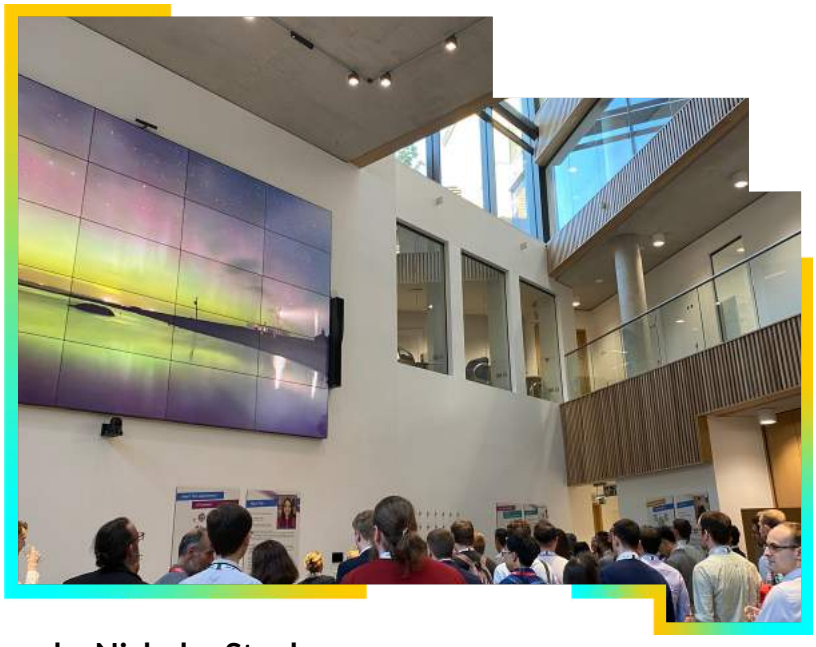
ELECTRON MICROSCOPY & ANALYSIS GROUP (EMAG) CONFERENCE

IMPERIAL COLLEGE LONDON

After two years of having to attend conferences online, me and Ben got the opportunity to go the Electron Microscopy and Analysis group (EMAG) conference at Imperial College London. This meeting brings together the electron microscopy community and had representatives from institutions across the UK and around the World.

Electron microscopy uses electrons to image which can resolve atoms which isn't possible with conventional light microscope. Electron microscopy over the last century has played role in a lot of science, ranging from imaging the spike proteins in COVID 19 to the first observation of carbon nanotubes. The meeting was also very special one as was the 75th Anniversary since the foundation of EMAG. And what better way to mark the occasion then with a cake and wine reception!

The conference also gave a chance to present posters which I was part of. The session gave a great opportunity to show my work and see some of the other work being conducted. One was discussing catalyst an essential part of modern with other looking at the size of milk molecules and for me presenting work on imaging to explain strain in laser structures. On a personal note, it was good experience to hear suggestions for my work and present the work that I have been doing to the microscopy community. The standard of the posters, especially from PhD students, noted by the EMAG organisations was very good and gave them a bit a challenge when it came to awarding poster prizes.



- **by Nicholas Stephen**
  PIADS PhD student
  2019 Cohort

Dinner on the first night was held at the London Canal Museum. It was great to meet with the delegates and enjoy more wine. After the meal, we participated in the most electron microscopy-based quiz in history with questions ranging from when Ernst Ruska won a noble prize work in electron microscopy to trying to identify prominent EMAG members from saying what you see. Unfortunately, despite having one of the quiz setters on our table during dinner, our team STILL didn't win but we had great time!

There were talks on a wide variety of research themes within electron microscopy. There was a strong focus on ptychography and electron holography in both the student talks and the invited speakers. My own talk was on my research into the characterisation of vacancy clusters in half-Heusler alloys. I was very pleased to win the best student talk prize.

Conference dinner on the second night was hosted in the grounds of Imperial University. This was a great opportunity to discuss our work with students and staff in a more relaxed atmosphere.

The conference was rounded off with a 'townhall event' where researchers were invited to have a conversation about the future of electron microscopy research in the UK. The aim of the session was to kickstart a consultation for a UK roadmap for electron microscopy research.

It was clear from the conference that electron microscopy is an exciting and broad area of research. I'm looking forward to EMAG 2023!

- **by Ben Smith**

PIADS PhD student
2019 Cohort

PAUL-SCHERRER INSTITUTE

X-ray Imaging of Magnetic Materials at the Swiss Light Source

by Colin Kirkbride, 2019 PIADS CDT Student

Forming a deeper understanding of novel devices often requires access to state-of-the-art facilities across the globe. In July 2022, alongside collaborators from the University of Glasgow and the University of Leeds, I had the opportunity to spend 6 days at the Paul-Scherrer Institute located just outside the small town of Villigen, 36 km north-west of Zurich, Switzerland. The facility is home to a synchrotron called the Swiss Light Source (SLS), which produces high brightness X-rays for investigating a range of materials across the physical and life sciences. The SLS has 16 experimental beamlines each of which specialise in a variety of techniques including absorption spectroscopy, crystallography, and imaging.

During the visit, we accessed the PolLux beamline to use an imaging technique called X-ray Magnetic Circular Dichroism (XMCD). In magnetic materials, there is an unequal distribution of spin-up and spin-down electrons. The XMCD technique works by scanning a beam of circularly polarised X-rays across the material to collect two images of the transmitted X-rays: one using clockwise polarisation and the other using anticlockwise polarisation. As each electron spin direction interacts with each circular polarisation differently, a resulting image can be formed which highlights only the magnetic structure within the material as shown in Fig. 1. This was useful for us as the materials we were interested in had a multilayer structure. We could then image with X-rays tuned to specific elements in each layer to show that magnetic domains in adjacent layers were antiferromagnetically coupled.

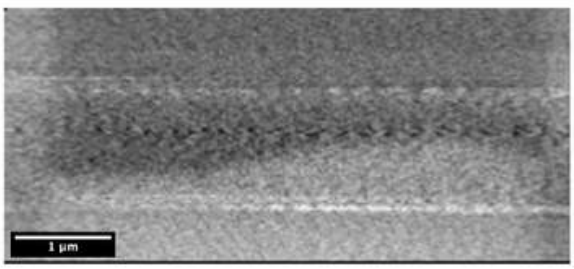


Fig. 1 Out-of-plane magnetic domain imaged using XMCD at the Co L-edge

Image from PSI website (free to download)

Seeing large scale research in action was a fantastic experience and I learned a great deal about the usefulness of international collaborations. Long sessions on the beamline also led to some coffee inspired trips around the campus by scooter. This allowed for some much-needed downtime and let me explore the area. Overall, the combination of intensive research and team-spirit was an exciting environment to be a part of, and the success of the trip has left me hopeful of another visit to a national facility during the final two years of my PhD research.

JEMS 2022

BY JOHN FULLERTON, 2018 PIADS CDT STUDENT

2020/21 could be definitely be described as virtual years for most of us, and so the return of in-person events the year was a very welcome one. And I've been very excited to attend my first conferences in the flesh, by far the biggest of which was the Joint European Magnetic Symposia in Warsaw. The conference brings together over 600 people from all over Europe, and further afield, to share cutting edge research from every corner of magnetism. From topics close to home for us in the CDT PIADS, like magnetic data storage and photonic integration, to those we might be less familiar with, for example the emergent field of altermagnets or superconductivity.

Warsaw itself is famous for being the home of Chopin, but in July 2022 a sound more beautiful than any nocturne filled the streets of the old town: the sound of magnetic discussion! Among this discussion, I was thrilled to be able to present some – hopefully soon to be published – research of my own, covering the simulation of coupled cylindrical magnetic nanowires. As we look towards 3D nanomagnetic devices to provide more efficient computing components, it's important to know how 3D nanowires can interact with each other. My simulations show how varying degrees of coupling can bring about complex 3D magnetic textures, and also how the method of deposition can control their formation.

It was a great experience to be able to present and connect with both other PhD students and some much more established researchers. It was also fantastic to see everyone actively trying to improve the field, whether that was through awarding early career researchers or having an open discussion about gender equality in universities. Hopefully now presenting at conferences will once again be a regular occurrence for all PIADS students!


OLD
LIBRARY
REGISTRATION
DESK

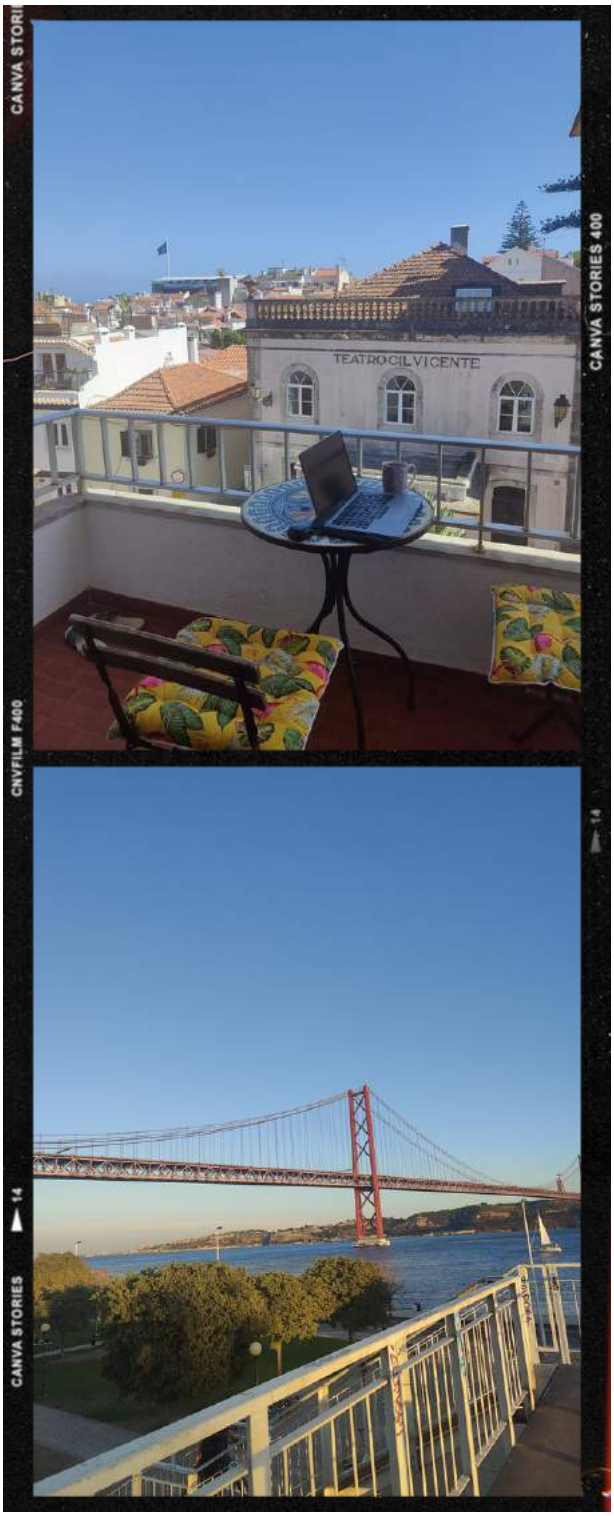
8TH EUROPEAN CHEMICAL SOCIETY CONGRESS, ECC8

BY RHIANNE CURLEY, 2020 PHD STUDENT

From 28th August to 1st September this year I had the opportunity to attend my first international conference, the 8thEuropean Chemical Society Congress, ECC8. This conference was hosted in the Congress Centre in the beautiful city of Lisbon, Portugal. It was a privilege to see in-person talks from researchers I often reference papers from. There was a huge variety of talks on offer with five sessions occurring simultaneously every day before lunch, meaning I learned a huge amount about a broad range of research topics as well as my own!

Aside from the excellent academic talks, the industry-focused workshops hosted by the European and American Chemical Societies were excellent sessions for career development. The lunchtime talks didn't disappoint either, my favourite being the 'Masterclass Chemistry in Space' delivered by Daniel Glavin which included a virtual tour of the Astrobiology Analytical Laboratory at NASA, USA.

I was fortunate enough to be accepted to give a talk on my research 'phototoxicity of membrane permeable ru(II) polypyridyl peptide conjugates in cancer and non-cancer cells'during the week. Although intimidating, this was a great experience! I left the conference with lots of motivation to get back into the lab and new ideas for the future and spending the week in the stunning city of Lisbon was the icing on top of the cake.

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IEE SUMMER MEETING

BY SAMIRA JASTAN, PIADS PHD STUDENT 2019 COHORT

My name is Samira Jastan, I am a PIADS PhD student, cohort 2021. My project is about Narrow Linewidth Blue Laser Systems. In this project, we are working on a passive section to provide feedback to a DFB laser which forces it to lase just in a specific wavelength that is defined by the external cavity. Designing the external cavity is based on Distributed Bragg Reflectors (DBR) that is considered as a reflector, which employs a periodic structure in a waveguide. Using this technique output of the laser will be narrower and also single mode. Working in this wavelength range can be challenging. The most important challenge in this wavelength is absorption which leads to a high range of loss. Another issue to overcome is small structures and difficulties of fabrication.

Attending conferences and meetings during PhD is necessary because you can share your results with other people, and also get familiar with other projects which are running all around the world. This can help to get new ideas that lead to good progress in your project. IEEE summer topical meeting was one of the events that I really wanted to join, because of a keynote speaker in this meeting, and also topics were completely in line with my project, and fortunately, I applied for the “Women in Photonics Grant” for participating in this event. In my application, I wrote a about my project, and explained how attending this meeting can help for the progress of my project. Also, I mentioned about the talks which are critical for my project to know about them. Fortunately, I could get this grant, and I had the honor of giving a talk about my PhD project as an invited speaker in this event. It was a great privilege to present my talk in the presence of Prof. John Bowers, and Prof. Kerry J. Vahala.

MRS SPRING HONOLULU

by Dr. Tamsin O'Reilly, CDT PIADS 2017 Cohort

My name is Tamsin O'Reilly, and I was a member of the 4th CDT intake, joining the program back in September 2017. Prior to this, I achieved an MSci in Chemistry at Queen's University Belfast, but fancied a change in field, and was attracted to CDT PIADS because of the interesting nature of the research and the strong emphasis placed on delivering a multidisciplinary approach. I have thoroughly enjoyed being a part of CDT PIADS, which came to an end following the successful defence of my PhD viva in May 2022. In this short testimonial, I hope to share some of my PIADS experiences, including a report of attendance to MRS Spring 2022. The title of my PhD was 'in situ microscopy studies of BaTiO3', which was supervised by Dr. Miryam Arredondo at Queen's University Belfast and Dr. Damien McGrouther at the University of Glasgow. This project fell under PIADS theme D - 'atomic scale analysis techniques', where the bulk of my research has involved the study of domains in ferroelectric BaTiO3, a highly technologically relevant material, by electron microscopy techniques. This included the use of a state-of-the-art in situ gas and heating climate holder, which was installed at Queen's in 2019.

Over the course of my PhD, I have built great collaborations with other universities and have conducted research trips at the University of Manchester, the Ernst-Ruska Centre (ER-C) Jülich in Germany, and the University of Geneva. These trips were wonderful experiences, which have unquestionably aided my scientific development. I have also been very active at conferences, presenting talks at virtual conferences including EMC 2020, MSI 2021 and MMC 2021. For me, presenting at conferences was an important part of my PhD. However, with the global pandemic, nearly all conferences over the past two years have been held virtually, and I felt that the possibility to present in-person at an international conference was gone. However, the opportunity arose to attend MRS Spring 2022, and I was fortunate enough to receive extra support from CDT PIADS, and a bursary from the Microscopy Society Ireland (MSI), to attend the meeting.

Figure 1: MRS Spring 2022. Top left and right: The Hawai'i convention centre complete with map. Bottom left: A selfie with my PhD supervisor, Dr M. Arredondo, whilst enjoying the entertainment at the conference dinner 'Luau', wearing the traditional Hawaiian Leis

Figure 2: Exploring the island of Oahu. Top left: A short hike for a great view. Top right:
enjoying the scenery after an afternoon of turtle snorkelling. Bottom left: an example of the excellent local cuisine. Bottom right: one of the stops on the car tour of the island.

The Materials Research Society (MRS) Spring meeting and exhibit has been held annually since 1984, boasting more than 60 symposia and 5,000 attendees every year. MRS Spring 2022 was held in hybrid format, comprising both an on-site conference in Honolulu (May 8th – 13th) and an online virtual meeting (May 23rd – 25th). Attendance to the MRS (Spring and Fall) meetings are highly attractive for PhD students, because they provide an international platform for the active dissemination and examination of research across many areas of current and emerging materials science. The five day conference hosted fascinating plenary sessions and the individual sessions were well-planned with interesting talks from invited speakers as well as those presenting contributed talks via accepted abstracts.

As a budding microscopist, my plan for the week was to attend talks where electron microscopy techniques were applied to functional materials. However, considering the strength of the scientific program, I often wandered into sessions that weren't related to my PhD research! Of the many symposia running in parallel, I was naturally drawn to the 'characterization' branch consisting of: 'CH01: Frontiers of In Situ Materials Characterization – From New Instrumentation and Method to Imaging Aided Materials Design', 'CH02: Ultrafast Probes in Emerging Materials' and 'CH03: Advances in In Situ and Operando TEM methods for the Study of Dynamic Processes in Materials'. I gave two contributed talks, one in CH01 and one in CH03, titled 'Investigating the Effect of Atmosphere on Domain in BaTiO3 using In Situ TEM' and 'Thermally Driven Domains in BaTiO3 – An In Situ Study', respectively.

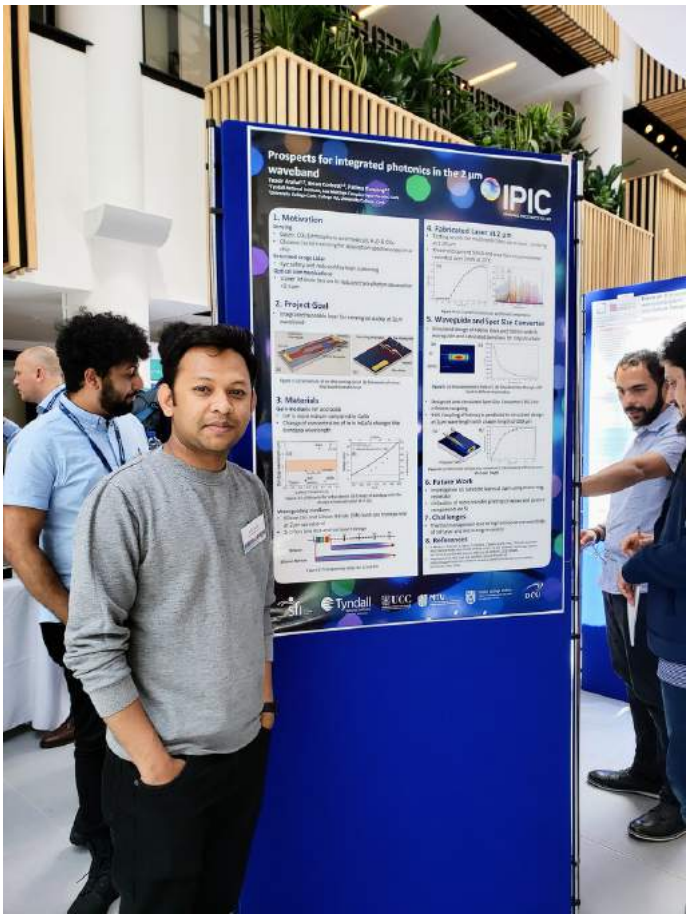
The atmosphere in the conference centre was fantastic, and it was clear that researchers appreciated being back to in-person conferences. Over the course of the week, I made very valuable connections and am thankful for the fruitful discussions following my talks that I had with other scientists and experts of the field. The talks themselves were held in the Hawai'i convention centre, which was a fantastic venue placed in the heart of Honolulu, about a 10 minute walk from my hotel in Waikiki beach. Honolulu itself was a wonderful destination, despite it taking nearly 25 hours of travel from Belfast!

There were many highlights outside of the conference, including the conference dinner Luau, where attendees to MRS 2022 were treated to performances by hula kahiko and acrobatic fire dancers, and authentic Hawaiian dining. I also spent an afternoon snorkelling off the coast of Waikiki beach amongst the protected species of green sea turtles that call Hawaii home. My personal highlight came on the final day of my trip, where I joined another group of researchers on a car tour of the East and North coast of Oahu. Everywhere you looked the scenery was breath-taking and I'm truly humbled by this once-in-a-lifetimeexperience. My attendance to MRS Spring 2022 marked a brilliant end to my PhD journey and I am truly grateful to CDT PIADS and to MSI for the wonderful opportunity afforded to me.

UK SEMICONDUCTORS CONFERENCE SHEFFIELD, UK, JULY 2022

by Yeasir Arafat, PIADS CDT 2021 cohort

This year I have presented a poster related to my PhD work in a conference titled UK semiconductors, which was held in University of Sheffield on 6th and 7th July. It was a great opportunity to attend an international conference in my first year of PIADS CDT. During the poster session, I had many thought-provoking discussions with researchers both from the academic and industry. I also had chance to network with other PhD students from around the globe. In particular during the poster session, where I was able to have discussions on what field other students are working on and their experiences during their PhD. I found some of the works are closely aligned with my PhD project. I also discussed about their future works and possibilities for collaboration. Over the period of the conference, I attended talks on a number of themes such as semiconductor materials and optical devices. The lectures helped me to realize a clear picture of where the current state-of-the-art research is heading to.

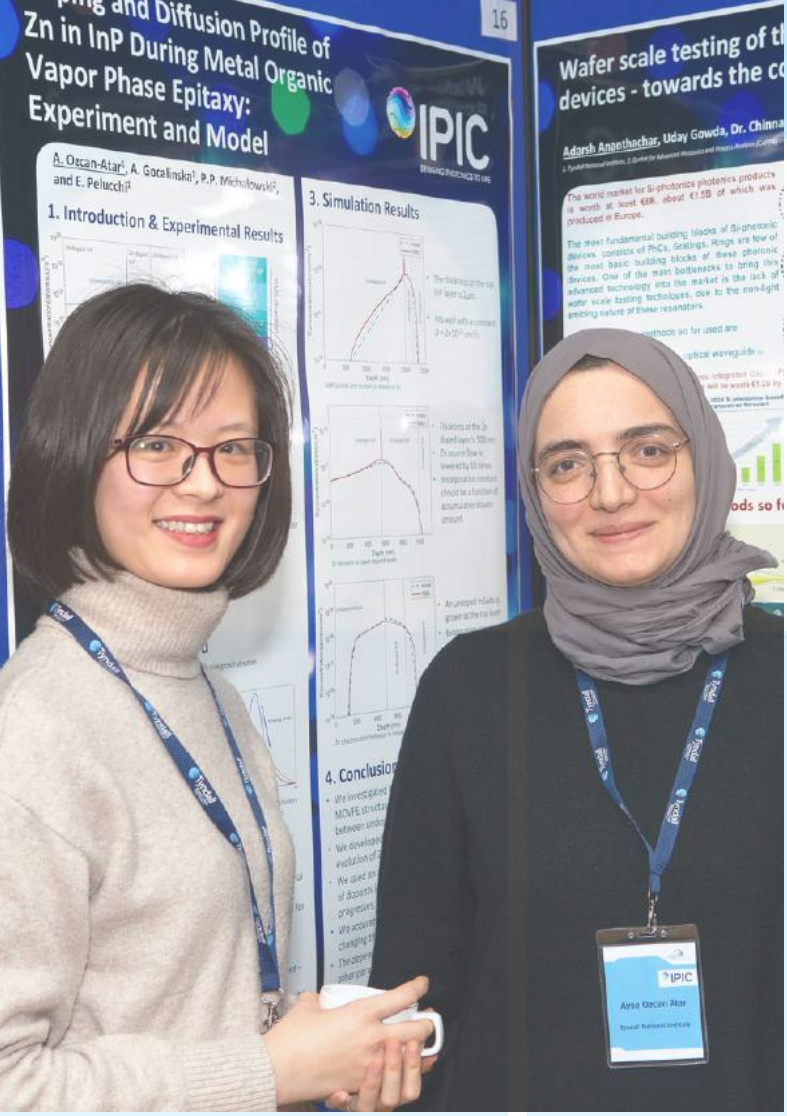


I presented a poster at the conference entitled "Integrated Photonics Sensing Platform at Long Wavelengths". In this work, I explore potential applications on integrated Silicon photonics (SiP) in sensing and biomedical fields. For example, in the field of optical sensing mid infrared (2-8µm) waveband is an excellent candidate due to strong absorption features of molecules in this waveband. Optical device using such spectroscopic sensing mechanism can be realized for the handheld based application which requires compactness and low power consumption. Here the integrated approach comes in play. In my work, I plan to demonstrate integrated tunable laser for 2µm waveband specially for sensing application. Thanks to Tyndall's excellent fabrication facilities, the epitaxial growth and ridge lasers were fabricated and tested. More than 1mW of single mode fibre coupled power has been recorded while testing the lasers. For tuning, micro ring resonator based filters have been designed and simulated. The next challenge is to fabricate passive circuits and integrate with active components. For the passive components silicon has been chosen for low loss and compact design. Micro transfer printing (µTP) heterogeneous integration method will be utilized to integrate active (Laser) and passive (Tuning filter) components.

PIC BRUSSELS

SIMON MUNRO, PIADS CDT STUDENT 2018 COHORT

I presented a poster at the conference entitled “Integrated Photonics Sensing Platform at Long Wavelengths”. In this work, I explore potential applications on integrated Silicon photonics (SiP) in sensing and biomedical fields. For example, in the field of optical sensing mid infrared (2-8μm) waveband is an excellent candidate due to strong absorption features of molecules in this waveband. Optical device using such spectroscopic sensing mechanism can be realized for the handheld based application which requires compactness and low power consumption. Here the integrated approach comes in play. In my work, I plan to demonstrate integrated tunable laser for 2μm waveband specially for sensing application. Thanks to Tyndall’s excellent fabrication facilities, the epitaxial growth and ridge lasers were fabricated and tested. More than 1mW of single mode fibre coupled power has been recorded while testing the lasers. For tuning, micro ring resonator based filters have been designed and simulated. The next challenge is to fabricate passive circuits and integrate with active components. For the passive components silicon has been chosen for low loss and compact design. Micro transfer printing (μTP) heterogeneous integration method will be utilized to integrate active (Laser) and passive (Tuning filter) components.



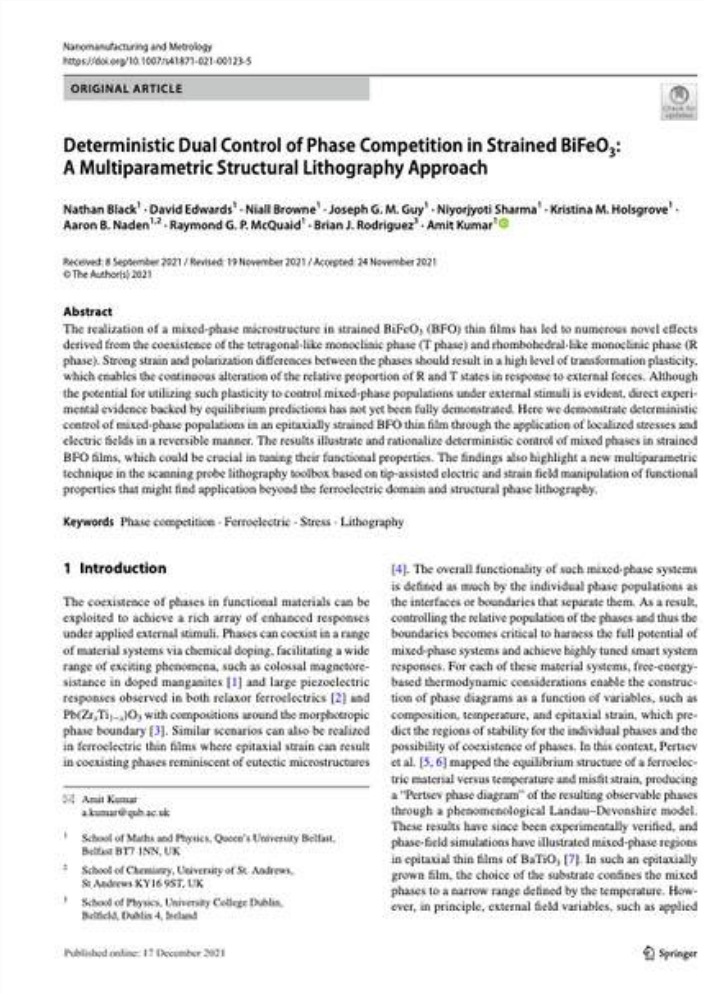
INDUSTRIALLY RELEVANT RESEARCH

Training future photonics professionals for the needs of our industry

DETERMINISTIC DUAL CONTROL OF PHASE COMPETITION IN STRAINED BIFEO3: A MULTIPARAMETRIC STRUCTURAL LITHOGRAPHY APPROACH

by Nathan Black, 2018 PIADS CDT Cohort

Mixed-phase microstructure in strained BiFeO3 thin films and the coexistence of the tetragonal-like monoclinic phase and rhombohedral-like monoclinic phase has led to many new novel effects. A high level of transformation plasticity should result from the strong polarization and strain differences between the phases allowing for a repeated alteration between the relative proportion of the two monoclinic phases under influence from external forces. There is therefore potential to utilize this plasticity and control the mixed-phase populations with external stimuli, here we have provided experimental evidence to demonstrate this potential. Dual reversible control has been demonstrated for mixed phase populations in epitaxially strained BiFeO3 thin films via the application of electric bias and localized stress.



Nanomanufacturing and Metrology
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ORIGINAL ARTICLE

Deterministic Dual Control of Phase Competition in Strained $BiFeO_3$: A Multiparametric Structural Lithography Approach

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Abstract
The realization of a mixed-phase microstructure in strained $BiFeO_3$ (BFO) thin films has led to numerous novel effects derived from the coexistence of the tetragonal-like monoclinic phase (T phase) and rhombohedral-like monoclinic phase (R phase). Strong strain and polarization differences between the phases should result in a high level of transformation plasticity, which enables the continuous alteration of the relative proportion of R and T states in response to external forces. Although the potential for utilizing such plasticity to control mixed-phase populations under external stimuli is evident, direct experimental evidence backed by equilibrium predictions has not yet been fully demonstrated. Here we demonstrate deterministic control of mixed-phase populations in an epitaxially strained BFO thin film through the application of localized stresses and electric fields in a reversible manner. The results illustrate and rationalize deterministic control of mixed phases in strained BFO films, which could be crucial in tuning their functional properties. The findings also highlight a new multiparametric technique in the scanning probe lithography toolbox based on tip-assisted electric and strain field manipulation of functional properties that might find application beyond the ferroelectric domain and structural phase lithography.

Keywords Phase competition · Ferroelectric · Stress · Lithography

1 Introduction

The coexistence of phases in functional materials can be exploited to achieve a rich array of enhanced responses under applied external stimuli. Phases can coexist in a range of material systems via chemical doping, facilitating a wide range of exciting phenomena, such as colossal magnetoresistance in doped manganites [1] and large piezoelectric responses observed in both relaxor ferroelectrics [2] and $Pb(Zr_xTi_{1-x})O_3$ with compositions around the morphotropic phase boundary [3]. Similar scenarios can also be realized in ferroelectric thin films where epitaxial strain can result in coexisting phases reminiscent of eutectic microstructures [4]. The overall functionality of such mixed-phase systems is defined as much by the individual phase populations as the interfaces or boundaries that separate them. As a result, controlling the relative population of the phases and thus the boundaries becomes critical to harness the full potential of mixed-phase systems and achieve highly tuned smart system responses. For each of these material systems, free-energy-based thermodynamic considerations enable the construction of phase diagrams as a function of variables, such as composition, temperature, and epitaxial strain, which predict the regions of stability for the individual phases and the possibility of coexistence of phases. In this context, Pertsev et al. [5, 6] mapped the equilibrium structure of a ferroelectric material versus temperature and misfit strain, producing a "Pertsev phase diagram" of the resulting observable phases through a phenomenological Landau–Devonshire model. These results have since been experimentally verified, and phase-field simulations have illustrated mixed-phase regions in epitaxial thin films of $BaTiO_3$ [7]. In such an epitaxially grown film, the choice of the substrate confines the mixed phases to a narrow range defined by the temperature. However, in principle, external field variables, such as applied

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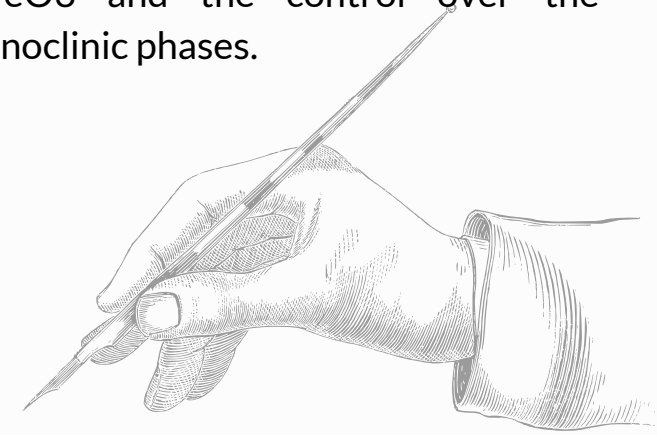
This control was achieved by scanning probe lithography using tip assisted bias and stress application to manipulate the functional properties of the material. Such techniques may even find application beyond ferroelectric domain and structural phase lithography. Experiments were completed to investigate the behavior of both bias and stress induced ferroelectric phase switching within BiFeO3 and the control over the monoclinic phases.



OUR

ANNUAL EVENTS

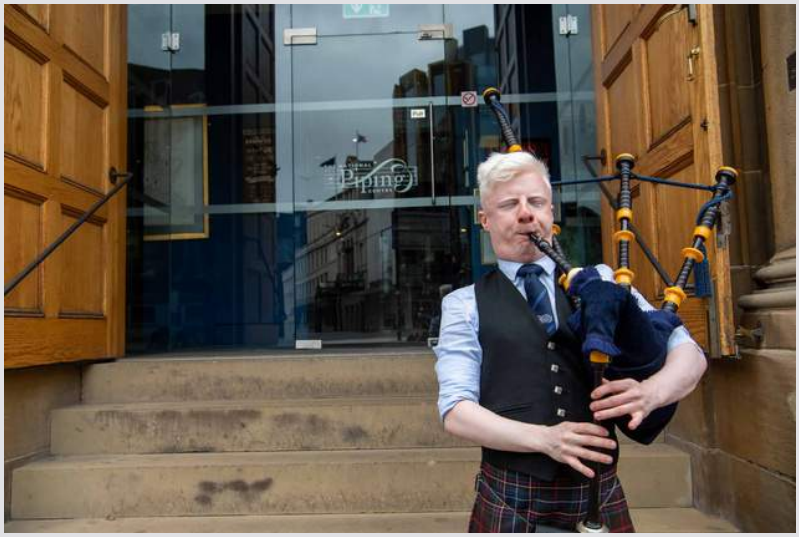
Conclave 2022

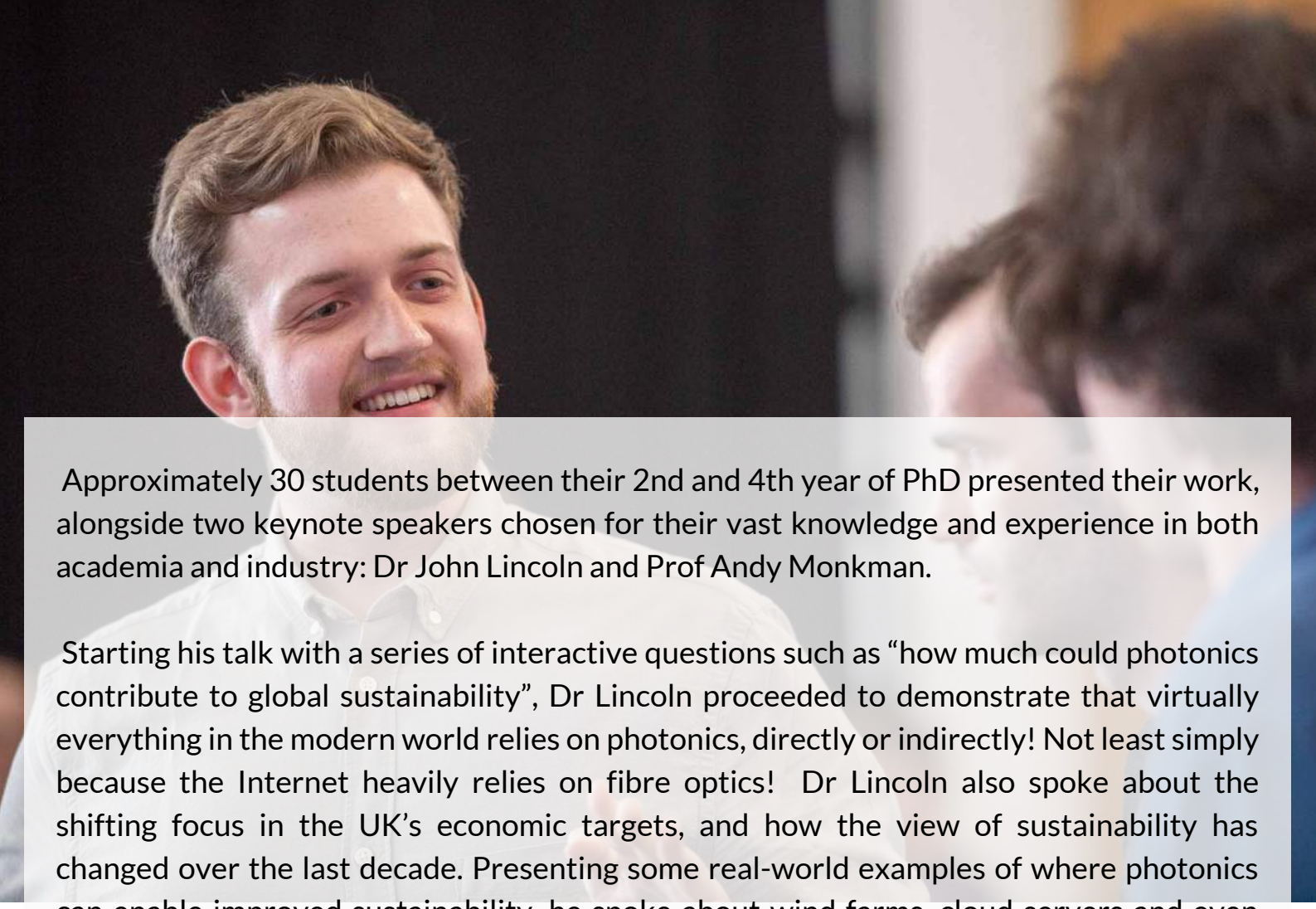
- **by Daniel Kelly, 2021 PIADS PhD Student**

Each summer, our first year PIADS CDT students undertake the momentous task of coordinating our annual student conference, which brings together our 50+ students, alumni, academic colleagues, industry partners and broad PGR communities, to discuss the remarkable research being undertaken by the students in the PIADS CDT programme.

2022's Conclave was a blast – beginning with a real blast of bagpipes at 8:30 am heralding the arrival of the first guests into the National Piping Centre. This famous Glaswegian venue was chosen to celebrate to Scotland's impressive heritage, after the Conclave was held in Belfast for the past two years. This year was centred around a theme of Sustainability in Photonics, and included speakers and presenters from across the UK, Ireland and Switzerland.

The Conclave's theme was chosen for several reasons: firstly, most of PIADS's research is related to photonics. Secondly, this year Glasgow was proud to host many world leaders, who gathered to discuss important issues on climate change and how to achieve the Glasgow Climate Pact. As photonics is often more sustainable than its non-light-based counterparts, all our students are contributing to global sustainability research.





Approximately 30 students between their 2nd and 4th year of PhD presented their work, alongside two keynote speakers chosen for their vast knowledge and experience in both academia and industry: Dr John Lincoln and Prof Andy Monkman.

Starting his talk with a series of interactive questions such as “how much could photonics contribute to global sustainability”, Dr Lincoln proceeded to demonstrate that virtually everything in the modern world relies on photonics, directly or indirectly! Not least simply because the Internet heavily relies on fibre optics! Dr Lincoln also spoke about the shifting focus in the UK’s economic targets, and how the view of sustainability has changed over the last decade. Presenting some real-world examples of where photonics can enable improved sustainability, he spoke about wind farms, cloud servers and even tractors. Day 1 was finally concluded with a feisty ceilidh to continue engaging with the local Scottish culture, where students and professors alike danced their feet off to the sounds of live Gaelic folk music.

Professor Andy Monkman of Durham University rounded off day 2 with a fascinating talk exploring how the near-perfect OLED could be made even better. His talk explained how traditional phosphorescent OLEDs suffer from fundamental quantum yield limitations, and how rectifying those with rare-earth metals doesn’t align with global sustainability. Then, Prof Monkman presented a promising alternative, thermally activated delayed fluorescence. This mechanism is capable of producing deep blue coloured light, and has been rising in popularity over the last 2 decades: and just maybe it will become the new commercial standard for OLED screens.

All five of the key CDT areas of research were reflected by one student or another in presentations and posters. The work covered a diverse array of topics from biosensing, aid cancer detection, patterned VCSEL lasers, to density functional theory to LiDAR and much more. Prizes were awarded based on audience votes – in an impressive clean sweep, Glasgow's Condensed Matter department managed to outshine the competition and win the top three prizes, earning their well-deserved Seagate hard-drives.

Congratulations to the winners, John Fullerton with a talk on strongly coupled magnetic nanowires, Ben Smith with a talk on diffuse scattering in half-Heusler electron diffraction, and Colin Kirkbride with a poster on skyrmions in synthetic antiferromagnetic multilayers.

It was great to finally meet some students and academics from IPIC, as through Covid this has unfortunately not been possible, and for everyone unable to join us, hope to meet you in the future!

We want to thank every attendee and speaker of the Conclave for making it such an amazing event. Huge gratitude goes also to the wonderful staff of the National Piping Centre for hosting the event. And to the next year's PIADS PhD-students-to-be: good luck!

With love,
PIADS 2021 Cohort

IPIC INDUSTRY DAY

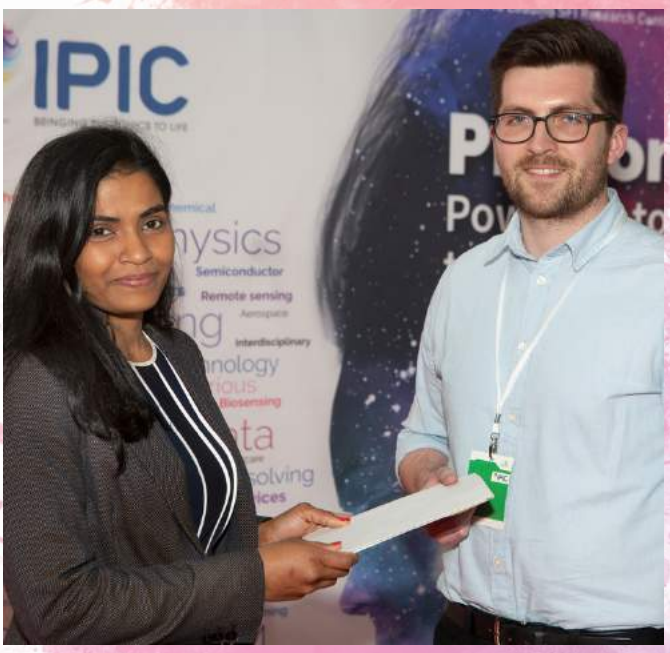
2022

IPIC and its industry partners gathered on 19th May 2022 at UCC for their annual industry workshop, to hear details of our ongoing research projects, meet PhD and Postdoc poster presenters, and hear about emerging start-up opportunities. We were delighted to welcome UK PIADS students to this event as well.

We heard from Dr. Helen McBreen (IPIC Governance Committee Chair and Partner Atlantic Bridge) on the outcome of IPIC's SFI review in late 2021. In summary a lot has been achieved, with the reviewers commenting that IPIC's impact for Ireland as being 'outstanding' and also reflecting positively on IPIC's Education & Public Engagement programme, encouraging further growth and expansion of the activities. The audience heard from Prof. Paul Townsend, IPIC's Centre Director on the Centre's forward momentum, which was followed by updates from Prof. Louise Bradley (Trinity College Dublin) on the new Catalyst Theme – Nanophotonics, and from Paul on the Catalyst Theme – Quantum, which will be led by Dr. Emanuele Pelucchi. We heard from Emerge@IPIC awardees, Xing Ouyang on ChirpComm and Zhi Li on Monolithic Integration Based on Pyramidal InGaN Micro-LEDs for AR/VR Displays.

Dr. Carl Jackson (Entrepreneur) shared with us his journey from Tyndall labs to start-up formation and exit, and how to learn from all experiences, successes and challenges, within the tech innovation space. We heard from Explorer programme 2022 participants, Lorenzo Niemitz on his project Medguide, and Celina L. Li on her project OTMD and experience on the programme. The talks were followed by a vivid poster session, where we welcomed many PIADS students to present their research to representatives from academia and industry. The event was closed with awards for Best Publications, Impact, EPE and Best Posters.

We are delighted to report that IPIC PIADS student Conor Russell received one of the prizes for best poster.



Conor Russell receiving the best poster award from Yalini Brhanavan (Science Foundation Ireland).

PIADS PUBLIC ENGAGEMENT

OUR EPE OVER THE LAST 12 MONTHS

Glasgow Science Festival 2022

"Glasgow's Making Waves"

Launched in 2007, Glasgow Science Festival (GSF) has grown to be one of the largest science festivals in the UK. PIADS CDT were delighted to be welcomed to join the GSF team in delivering an activity to support their "Glasgow Connects" agenda.

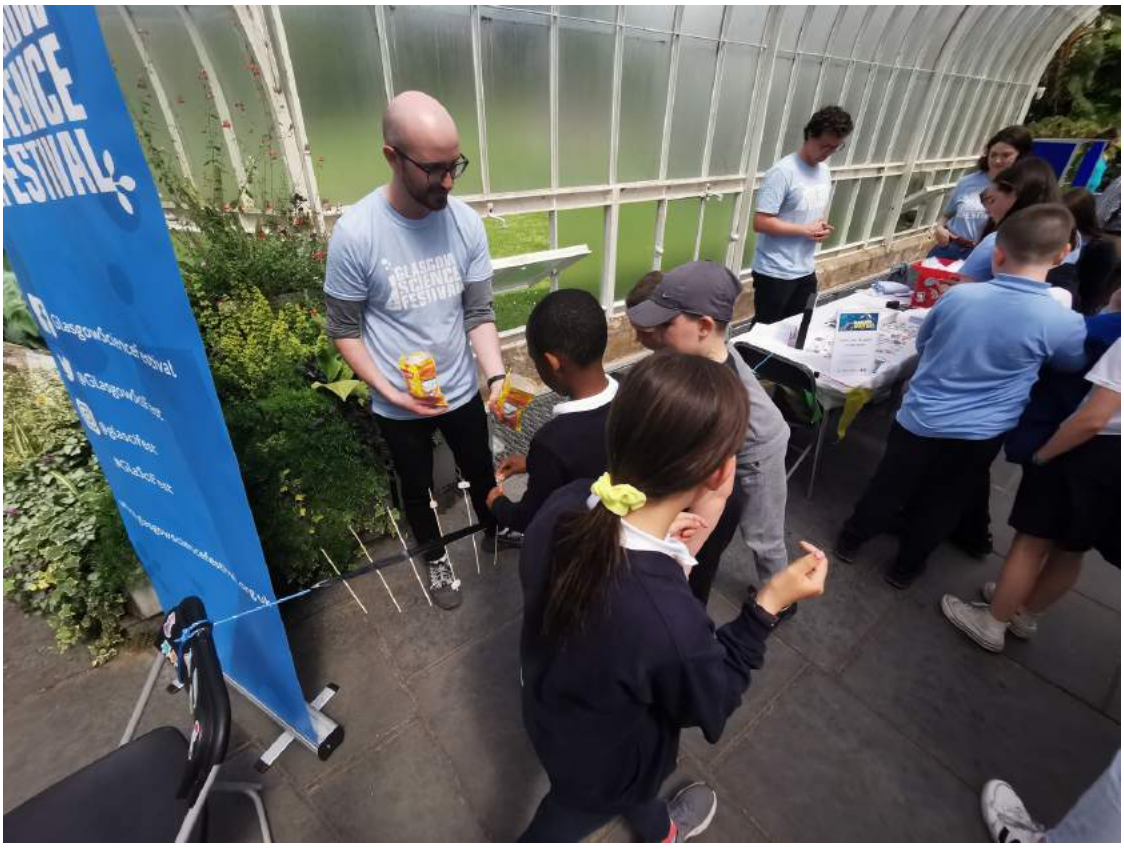
This year GSF was a hybrid event with an opportunity to meet people in person at the Glasgow Botanic Gardens and engage online with Science on the Sofa.

For GSF in person we visited Glasgow Botanic Gardens for 2 days in June. Our activities explored ‘Light as a Wave’ and included a Jelly Baby Wave Machine and Light into Sound activities. We were visited by four schools across the two days and interacted with 173 students from ages 9 to 12. We had kits available for the students to take home, which included our ‘Make a Spectroscope’ activity and fun science stickers.

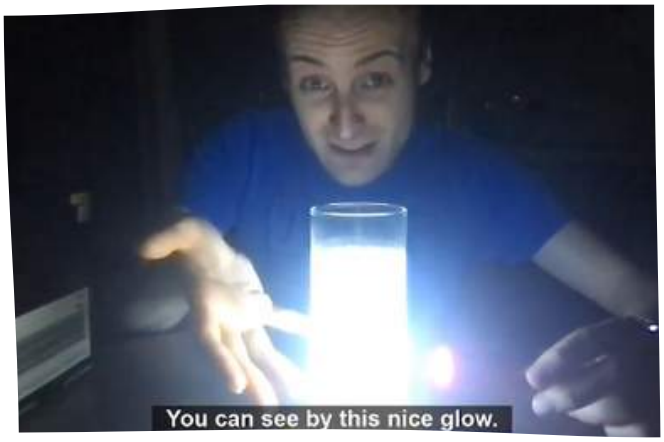
‘With our Nintendo soundtrack filling the Kibble Palace, John and I armed ourselves with jelly babies and braced for an influx of primary school pupils. John was first up to hand out jelly babies and help the pupils skewer them onto our wave machine. With imaginations captured and extra jelly babies consumed, John proceeded to demonstrate the wavelike motion of an oscillating chain of jelly babies to our stunned audience.

Next, it was up to me to explain where the Nintendo soundtrack they were hearing (and in some cases dancing to) was coming from. I showed them that you could convert a digital music signal from a phone into light via an LED, detect this signal on a solar panel and then hear the music coming out of a speaker. Any non-believers in the crowd were then able to test this claim for themselves by either moving the solar panel or blocking the signal with their hand.

These hands-on demos, with the added sweets and music, went down well with pupils, teachers and wider public alike. The other stars of the show were the many stickers we had covering our stall which had pupils continually reappearing for more - definitely a must-have for future science festivals, on the condition that they aren’t stuck all around the event space!’



In addition to the in-person event we were able to engage with a wider audience through the online ‘Science on the Sofa’ event which ran from the 2nd – 30th June. We added to the 2021 making videos we produced to include ‘Fibre Optics at Home’ and ‘The Tyndall Effect’. The online aspect gave PIADS students from Queen’s University to participate in demonstrating fun science experiments to do at home. The videos are still available on the GSF YouTube Channel.



In order to engage more with students in person and at home we produced a PIADS-CDT x GSF workbook, which included bios of four PIADS students and four science experiments – Switching Arrows, Laser Jelly, The Tyndall Effect and Fibre Optics at Home. Each experiment corresponded to a video made for GSF, which are available on the GSF website and YouTube channel. The workbook came in a printed format for GSF at the Botanic Gardens and digital format for GSF Science on the Sofa.

OUR STEERING BOARD

The CDT Steering Board provides important oversight & guidance on the strategic direction of our CDT, ensuring that it remains closely aligned to industry roadmaps.

It has executive & oversight authority over all aspects of strategy, policies & performance, meeting bi-annually to monitor progress against the CDT Key Performance Indicators. These include: the recruitment of a diverse, well-qualified student cohort; the delivery of a high quality & dynamic doctoral training programme; the provision of rich & embedded industrial engagement; the delivery of doctoral research projects that are cutting-edge, innovative & collaborative; & strong & robust governance & management.

Members

Prof Robert Bowman	**Director**
Prof Paul Townsend	**Co Director**
Prof John Marsh	**Co Director**
Dr John Lincoln	**Chair of the Steering Board**
Ms Maryam Crabbe-Mann	**EPSRC Representative**
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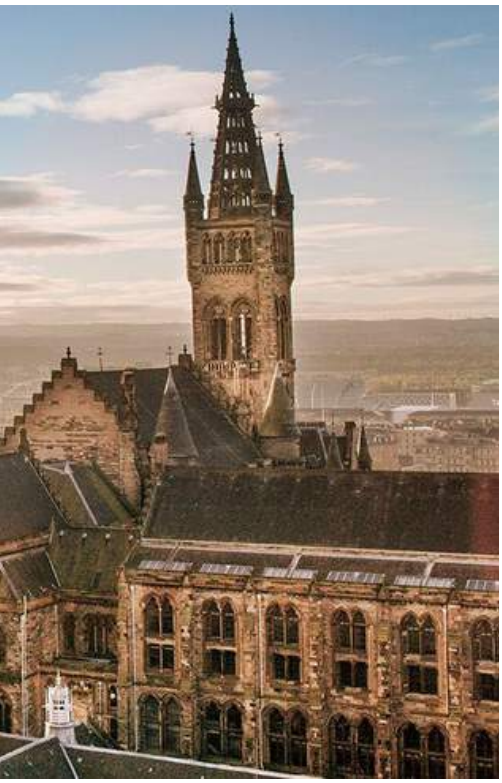

This brochure was created by PIADS External Engagement Manager, Dr Kirsty Annand. If you have any questions or would like to discuss any of the content within, please do get in touch on: Kirsty.Annand@glasgow.ac.uk