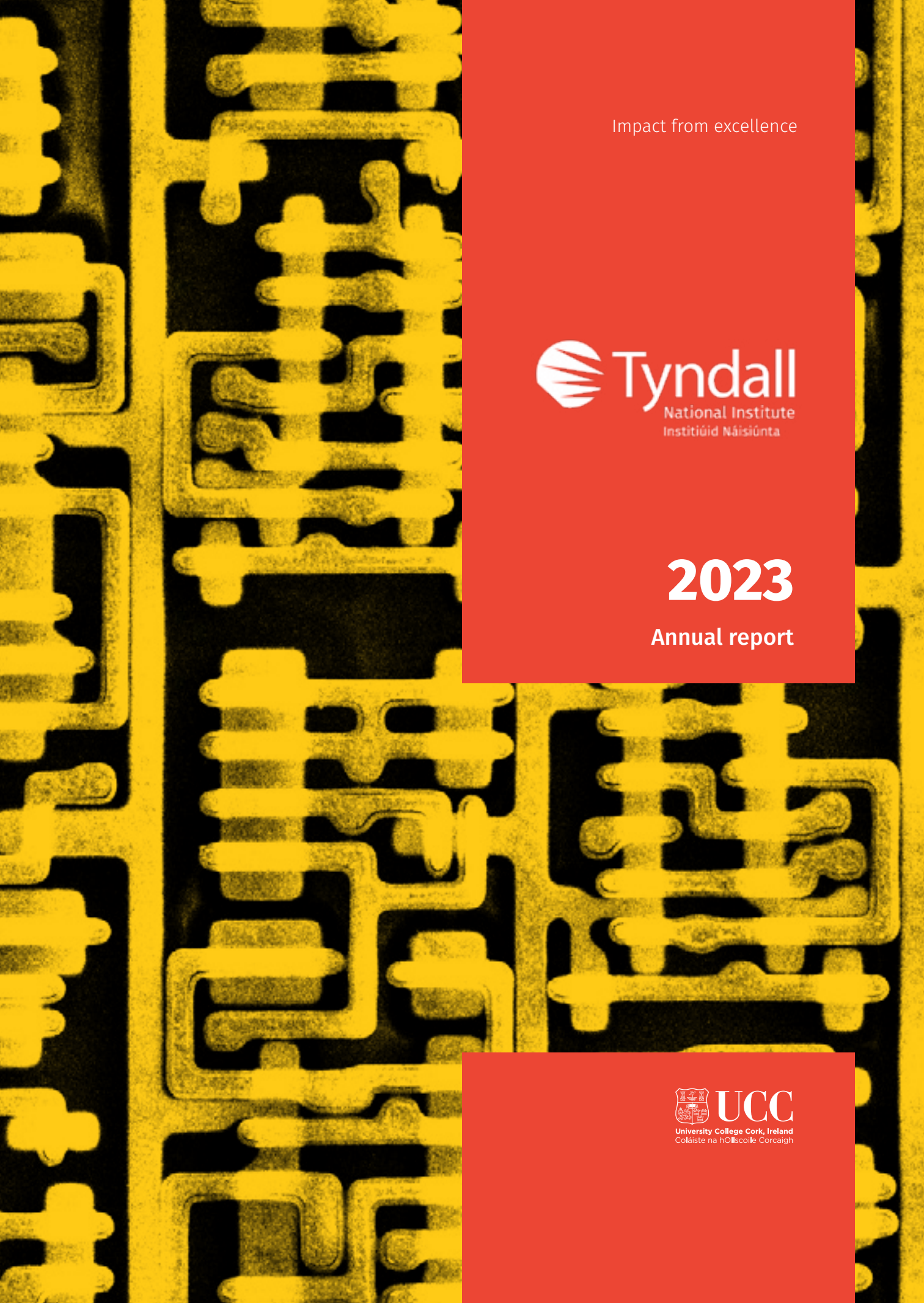


Impact from excellence

Tyndall
National Institute
Institiúid Náisiúnta

2023

Annual report

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Contents

Professor John O'Halloran, President, UCC, Minister for Enterprise, Trade and Employment, Simon Coveney TD and Professor William Scanlon, CEO, Tyndall

Dr Denis Doyle and Professor William Scanlon at the launch of Tyndall's position paper 'Ireland's role in the global semiconductor industry'

Board Chair's message

Tyndall has built an international reputation for the excellence of its research and the quality of its researchers. We are justifiably proud of our world-leading research achievements. Tyndall also has a wider and highly significant role to play in shaping national policy in relation to science and technology.

This is particularly so in the critically important area of semiconductor technology. In August 2023 Tyndall published a position paper calling for Ireland to develop its own semiconductor strategy to take advantage of the opportunities that will be created by the European Chips Act (ECA). Within weeks the ECA itself came into force. I am pleased to report that the national strategy is under development and will be launched in 2024, and I am proud of the leadership Tyndall has provided.

CEO's message

This is by no means the only area where Tyndall has delivered internationally relevant thought leadership. During the year, Tyndall researchers published white papers on the role of the internet of things (IoT) in biodiversity and environmental monitoring as well as on artificial intelligence (AI) for better health.

As we approach the end of our Tyndall 2025 strategy and look forward to developing our next strategic plan, it is heartening to see Tyndall researchers make such an important contribution to Ireland's future economic success.

I would like to take this opportunity to thank my fellow Board members for their support during the year. I would also like to express my appreciation for, and gratitude to, Tyndall's excellent staff and student community for their dedication and outstanding contribution to what has been a remarkably successful year for the Institute. Finally, I must acknowledge the unwavering support of our key stakeholders University College Cork (UCC) and the Department of Further and Higher Education, Research, Innovation and Science (DFHERIS).

By every measure, 2023 was the strongest year in the 40-year history of Tyndall. New records were set across every dimension, including research income, income from industry, European Union (EU) research funding, and staff and student numbers.

Total income exceeded €50m during the year, an increase of 19% on 2022. Funding of €47m was approved for 52 new research proposals, up from €26m for 39 proposals the previous year.

Direct industry income also showed a significant increase to €8m, 16% of total income, during the year. Support for innovative indigenous Irish companies is a key part of our remit and I am pleased to report that of our 99 industry funding partners, more than 50% of them were small and medium-sized enterprises (SMEs) – an all-time high.

An example of the real-world impact of our close collaboration with industry is a new medical device developed by West Pharmaceutical Services, Tyndall and PA Consulting. The smart wearable device uses microneedle technology to painlessly deliver medication through the skin, allowing patients to treat themselves in an at-home setting.

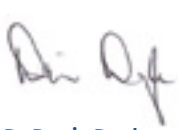
We also maintained our strong track record in EU funding with 22 new projects awarded €30m from the Horizon Europe programme.

In addition, we recorded our highest ever headcount at 533 people, up 6% on 2022, including 160 post-graduate students.

In other highlights during the year, the Science Foundation Ireland (SFI) Research Professor Award for Stefan Andersson-Engels was renewed, while a number of our researchers received SFI-IRC Pathway Awards.

Research excellence is at the heart of everything we do here at Tyndall, and our success is fundamentally due to our people – our research staff, our professional support staff, and our students. Their efforts have helped us progress the goals set out in our current strategic plan and put in place the foundations on which we will build our new strategy.

I would like to conclude by expressing my gratitude to all of our people as well as to our Chair, Dr Denis Doyle, the Tyndall Board and UCC's leadership team for their support and wise counsel during the past year.



Dr Denis Doyle
Board Chair

Professor William Scanlon
CEO

Scorecard

Research excellence

4 **SFI-IRC PATHWAY AWARDS**

Stefan Andersson-Engels
SFI Research Professor Award in Biophotonics renewal

60 COLLABORATIVE PUBLICATIONS IN TOP 10% OF JOURNALS

Salvatore Tedesco
Best Application of AI in an Academic Research Body (Annual AI Ireland Awards)

Impact

100 UNIQUE INDUSTRY PARTNERS ENGAGED FOR RESEARCH AND FACILITIES ACCESS

50% of industry funding partners were SMEs

€8m **RECEIVED IN INDUSTRY FUNDING**

14 industry partners-in-residence

30% 30% of new research projects in the Health & Life Sciences sector

105 industry researchers hosted on-site

International positioning

EU PROGRAMMES

€467m total project value | €30m Tyndall grant value |
>€18m to Irish Partners | >€10m to Industry based in Ireland |
41 projects | 7 projects Tyndall co-ordinated

ASCENT+ CONTRIBUTIONS

46 TRANSNATIONAL ACCESS (TA) PROJECTS
The number of ASCENT+ access projects Tyndall has had so far

155
The number of researchers and students that benefitted

14 COUNTRIES
The number of countries involved globally

MARIE SKŁODOWSKA-CURIE ACTIONS

4 Fellowship projects

1 Doctoral Network project

1 Staff exchange project

1 Co-fund project

People and culture

533
STAFF/STUDENTS

TRAINED OVER
450
STAFF/STUDENTS

Directly engaged with **4,800** students and members of the public

45 nationalities

215 staff / students took part in EPE events this year on behalf of the institute

160 PhD and Master students

OUR EDUCATION STREAMS

20 TY Students
29 Summer Fellowships
18 Vivas

Infrastructure

€10m
AWARDED THROUGH SFI RESEARCH INFRASTRUCTURE PROGRAMME

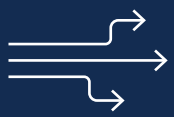
> €600k granted from SEAI for Tyndall Decarbonisation Plan

264 trained in the operation of process or analysis tools

99 new users to the open access labs and cleanrooms

Tyndall National Institute

Research excellence



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Dr Lynette Keeney

Research excellence is a key aim of Tyndall's 2025 strategy and underpins everything we do. We continue to push the frontiers of Tyndall's unique 'atoms to systems' approach to deliver research with impact. 2023 was another successful year for research excellence at Tyndall.

The SFI Research Professor Award for Stefan Andersson-Engels was renewed, while Mike Hayes received the Recognition Award from the Power Source Manufacturers Association (PSMA) for his work with the organisation.

Major nationally funded projects secured include Tyndall's first Irish Research Council (IRC) Advanced Laureate Award for Lynette Kenney, while Emanuele Pelucchi and Saibal Roy secured SFI Frontiers for the Future Awards, all of which advance our excellence in deep-tech research.

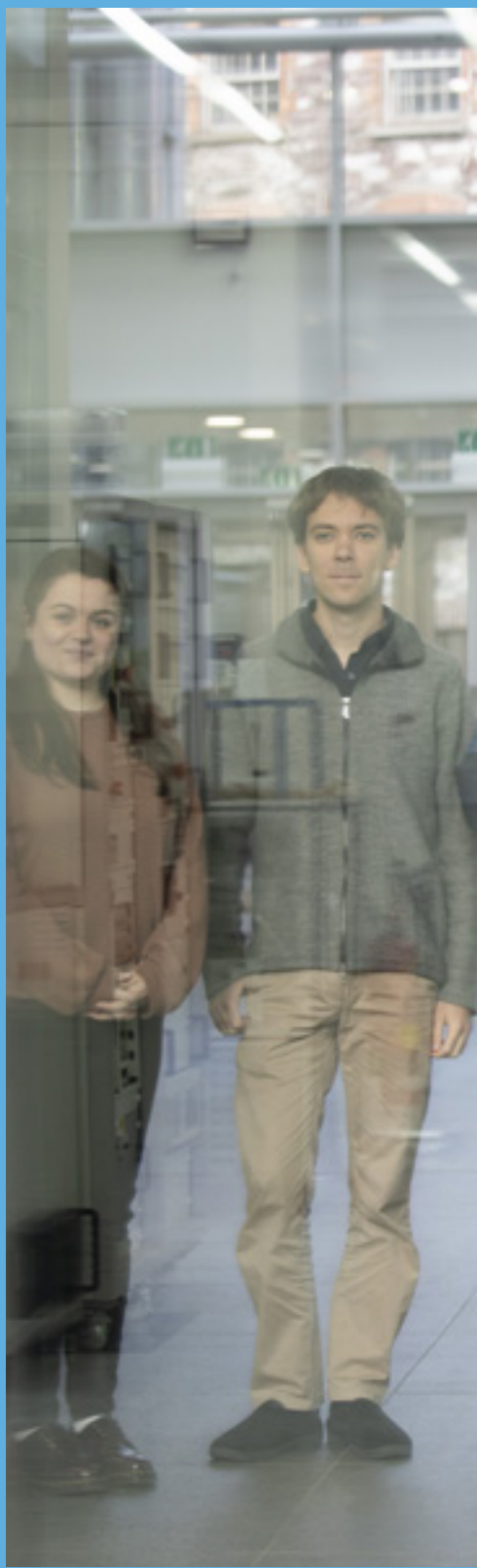
Early-career researcher awards recipients include Alessandra Imbrogno, Alexander Jaeger, Chinmoy Kundu and Zhi Li, who all received SFI-IRC Pathway Awards, which are important awards in Tyndall's talent development pipeline.

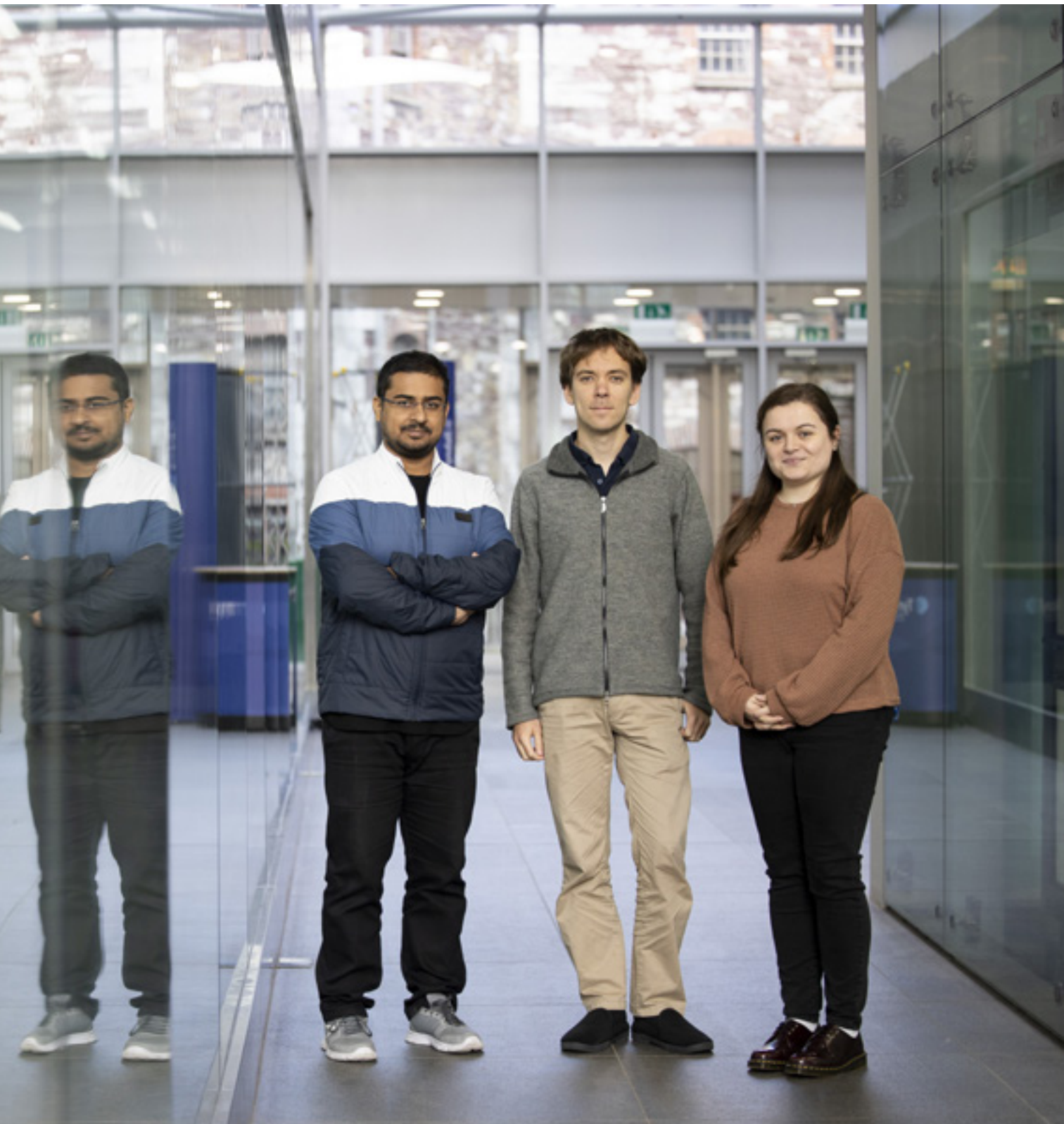
Multiple IRC and Horizon Europe: Marie Skłodowska-Curie PhD and Postdoctoral Fellowships were secured, again highlighting Tyndall's commitment to supporting and developing the talent pipeline.

Professor Luisa F. Cabeza from the University of Lleida, Spain, and Dr Steven Ringel from the Ohio State University, USA, were Tyndall's Distinguished Visiting Fellows for 2023. Professor Gayathri Pillai, from the Centre for Nanoscience and Engineering at the Indian Institute of Science was a Visiting Fellow in 2023.

Student awards included Sandeep Singh's 'Best Oral Presentation' at the 14th International Conference on Nitride Semiconductors, while Dr Salvatore Tedesco won the 'Best Application of AI in an Academic Research Body' award at the AI Ireland Awards.

Tyndall's high achievements in research excellence are evidenced by having 85% of all publications in the top 50% of peer-reviewed scientific journals, with 60 collaborative publications in the top 10% of all peer-reviewed journals. As part of our commitment to excellence, we continue to have a strong focus on ensuring the highest level of integrity in all our research activities.





Dr Anurag Pritam, Dr Karl Rönnby and Hazel Neill, Irish Research Council Funding Awardees

Advanced semiconductor nanowire lithography

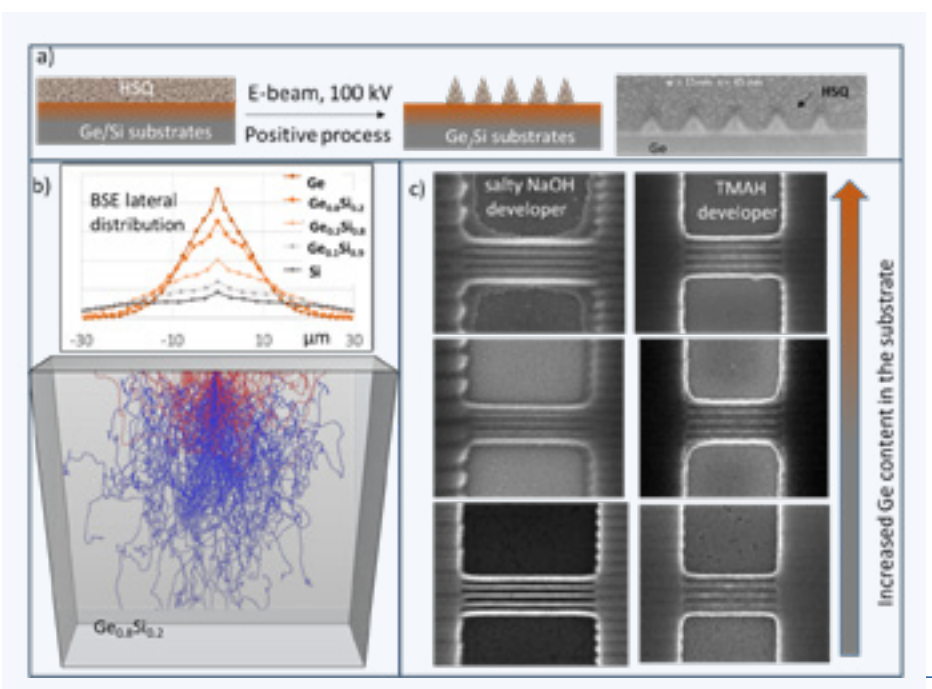
The development of devices with very small dimensions generally starts with lithography definition followed by reactive-ion etching. Electron beam lithography (EBL) has wide applications for device prototyping in research-based laboratories due to its controllable use of tightly focused electron beams with a cross-section down to one nanometre (nm), with added flexibility and adaptability in patterning various design structures.

In this report, we present a systematic study of the EBL process for germanium (Ge) containing substrates, revealing severe limitations in achieving the smallest obtainable features, their uniformity, and fidelity, in comparison to silicon (Si). The effect of diminishing the Ge content in the top surface, where the incident e-beam/substrate interactions occur, was identified as a key parameter for achieving improved fidelity and resolution of the features. This was established by using a combination of Monte Carlo simulations of the e-beam/substrate interactions and extensive dose test exposures of line pattern designs with dimensions down to 10 nm. From a metrology perspective, we show that although line patterns may appear resolved in scanning electron microscope (SEM) images, the variation in the brightness across neighbouring lines in the design is a key parameter for understanding the resist clearance between lines that will have negative effect on the next etching step.

https://doi.org/10.1016/j.mee.2023.112071

Nikolay Petkov, Margarita Georgieva, Sinan Bugu, Ray Duffy, Brendan McCarthy, Maksym Myronov, Anne- Marie Kelleher, Graeme Maxwell, and Giorgos Fagas

"Electron beam lithography and dimensional metrology for fin and nanowire devices on Ge, SiGe and GeOI substrates. Microelectronic Engineering, Volume 280, 2023."



a) Schematics of the electron beam lithography (EBL) process using HSQ resist on substrates with increased Ge content in the top SiGe layers and

b) the corresponding Monte-Carlo simulations of the back-scattered electrons (BSE) distribution that limits the patterning resolution at higher Ge-content and

c) experimental EBL data for line arrays on three different substrates with increasing Ge content, developed by two types of resist developers. The highest patterning fidelity is seen in the bottom left image

Empowering residential prosumers in driving the energy transition

Residential consumers are increasingly playing a role in meeting the technological and environmental challenges facing electricity system modernisation. They are becoming prosumers by supplying power to the grid and are helping to reshape the way the electricity system is managed and operates, while introducing new segments in the energy market.

Implementing an efficient control solution for this active participation is not a trivial proposition, and dealing with real-time operational constraints, and minimising uncertainties in photovoltaic (PV) generation and demand forecast are among the main control design challenges.

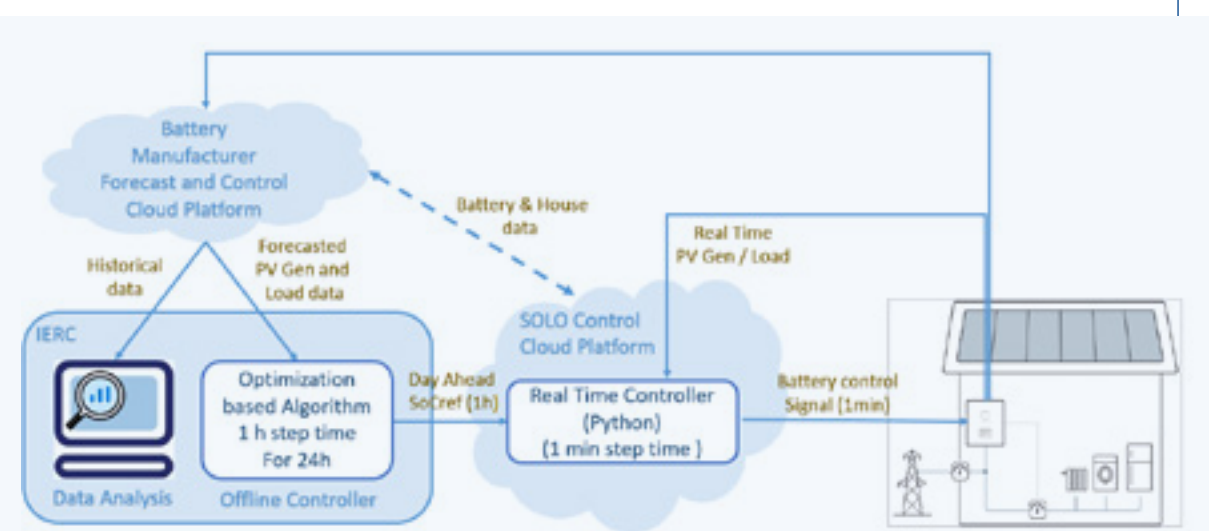
This work presents an innovative approach to the design and real-life field implementation of a hierarchical control solution for a residential energy storage system for consumers/prosumers. It considers a consumer bill minimisation control strategy under the Time of Use tariff scheme. It provides a framework to manage the real-time and efficient power flow between the residential load, the battery, the PV generator, and the grid. This proposed solution consists of an offline controller implemented in the cloud, which works in synergy with a local real-time controller. This work will further ease the integration process of the consumer/prosumer with the future virtual power plant or local electricity market operator. The main concept has been developed for the StoreNet pilot project platform, which is managed by the aggregator (Solo Energy), with support from the network operator (ESB Networks) and utility supplier (Electric Ireland).

https://ieeexplore.ieee.org/document/9854910

Mohamed Bahloul, Liam Breathnach, and Shafi Khadem

"Design and Field Implementation of a Hierarchical Control Solution for Residential Energy Storage Systems. IEEE Transactions on Smart Grid, Volume 14, 2023."

Real-time implementation layout of the proposed control solution for the StoreNet Project



Investigating novel materials for UV emitters

There is a major push to shift ultraviolet (UV) light sources from large and environmentally costly mercury-based lamps to nitride semiconductor-based light-emitting diodes (LEDs).

This is amplified by demand for applications such as air, surface and water disinfection, sensing applications, phototherapeutic treatments and diagnostic biological imaging. However, UV LEDs suffer from significantly poorer efficiencies compared to blue and longer wavelength emitters, due to intrinsic material challenges.

By adding small amounts of boron nitride (BN) to the conventional AlGaN material system, the polarisation fields across the quantum wells, causing reduction in the quantum efficiency, should be reduced through better matching of the lattice parameters. A UV LED with ~1% BN in the quantum wells was grown by metalorganic chemical vapour deposition and fabricated alongside a reference LED. Higher output powers were achieved at lower injection currents with the addition of BN, although the reference AlGaN LED was able to sustain higher powers at increased current. This first demonstration of a boron-containing UV LED highlights the potential benefits of this material, seen by the increased wall plug efficiency, while further optimisation and understanding of the growth dynamics, including boron's surfactant nature, is required in order to optimise boron incorporation and thus device performance.

https://doi.org/10.1049/ell2.12976

Peter Milner, Vitaly Z Zubialevich, Thomas O'Connor, Sandeep M Singh, Davinder Singh, Brian Corbett, and Peter J Parbrook

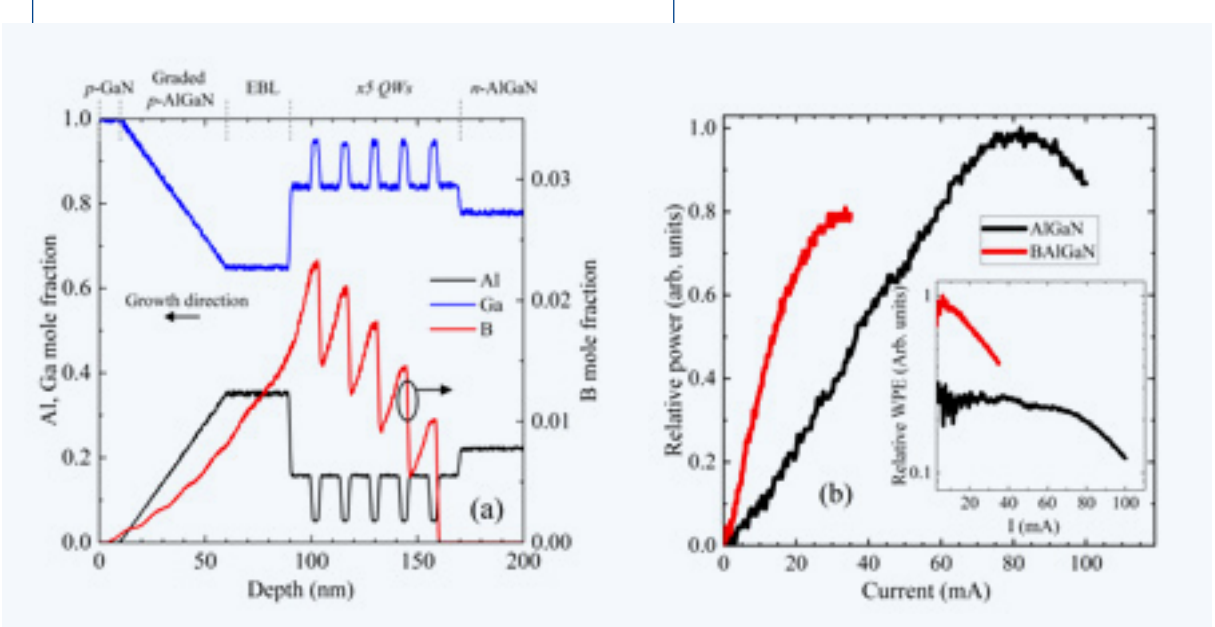
"AlGaN light-emitting diode emitting at 350 nm. Electronic Letters, Volume 59, 2023."

a)

Secondary ion mass spectroscopy measurement of the BAlGaN LED, illustrating the increasing B content with growth

b)

Output power of BN-containing LED compared to reference LED. Inset shows the calculated relative wall plug efficiencies (optical output power/input electrical power)



Dr Veda Sandeep Nagaraja with Lillian Hickey, Tyndall Summer Fellow

Impact

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50% of industry funding partners were SMEs

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14 industry partners-in-residence

30% 30% of new research projects in the Health & Life Sciences sector

105 industry researchers hosted on-site

Dr Justina Ugwah and Dr Yineng Wang

Dr Abhinav Gautam with Anna Sheehan, Tyndall Summer Fellow

Tyndall's unique environment for collaborative research and innovation, built on world-class infrastructure maintained to international standards and supported by world-class research teams, delivered 100 direct industry engagements in 2023.

Our industry partners directly funded €8m in research and support at Tyndall, 16% of Tyndall's total income for the year. Non-domiciled industry income was also strong, at 22% of our total industry funding, and we delivered research and support to 51 SMEs during the year, accounting for more than half of our industry engagements.

Forward-looking industry programme funding commitments remained robust during 2023, a strong indication of Tyndall's critical and expanding role in Ireland's industrial research ecosystem.

Tyndall makes a vital contribution to the research and innovation landscape in Ireland by bringing together SMEs, multinational corporations (MNCs) and the research community on-site for research collaborations. This is evidenced by the presence of 14 industry partners 'in-residence' at Tyndall in 2023, with a total of 105 industry researchers approved for laboratory access, and SMEs accounting for half of the companies on-site.

Confirming Tyndall's global role in the semiconductor research sector, we delivered strong proposals for the EU Chips Joint Undertaking (JU) Pilot Lines, ensuring alignment with the research needs of our strategic industry partners.

Working with UCC Innovation we completed a total of 23 intellectual property (IP) assignments, licences and options as well as 11 new patent filings and received two patent grants.

Deep impact for deep-tech SMEs – five-year study for the period 2018–2022

As the national information and communications technology (ICT) research institute, Tyndall plays a vital role in supporting the growth of Ireland's indigenous technology-led SME community.

Through research excellence, talent pipeline development and pilot line manufacturing and test services, Tyndall ensures that Ireland's ambitious deep-tech SMEs are positioned to achieve international market growth. In 2023, we concluded a study of the impact of this activity for the five-year period 2018–2022.

During this period, the SME community of Tyndall research partners comprised 50% of the total number of companies served. These SMEs accounted for more than one-third of all industry research and services engagements for the period, with a total of 48 research programmes and additional services delivered. This trend for SMEs matching the MNC presence was maintained in the community of industry partners with a physical research presence on-site at Tyndall, with SMEs making up 50% of the 14 companies-in-residence for the period.

Under its remit to create new high potential start-up companies (HPSUs) through spinouts, as of December 2023 Tyndall has created 36 new ventures, of which 14 were spinouts founded by Tyndall researchers and based on Tyndall IP, six of which achieved scale as HPSUs, subsequently leading to acquisition. The Institute has a current pipeline of 18 technologies identified as potentials for spinout.

More than €30m in research funding was secured for Tyndall SME partners under Enterprise Ireland's Disruptive Technology Innovation Fund (DTIF), with 35 SMEs participating in Tyndall-led DTIF programmes (three-times the number of MNCs involved in those consortia). Similarly, Tyndall EU Programmes involved 31 SMEs, delivering €17M in Horizon 2020 and Horizon Europe funding to these research partners.

Tyndall's diverse deep-tech research and engineering community is an essential talent pipeline for our industry partners, with nearly 40% of all staff transfers to industry going to our SME partners (43 people, including 12 PhD graduates). The benefits delivered to the SME community are disproportionally high when compared with the size and purchasing power of MNCs over SMEs and illustrates the strength of the deep-tech SME sector.

Louise Colfer, PhD Candidate, Advanced Materials and Surfaces Group

West Pharmaceutical Services

A new prototype medical device that deploys wearable microneedles to deliver medication to patients in an at-home setting has the potential to support some of the emerging trends in the healthcare sector, according to Tyndall researchers.

The 'smart' wearable drug delivery concept, developed by West Pharmaceutical Services, Tyndall, and PA Consulting, uses microneedle technology to painlessly deliver medication through the skin. Designed to give patients the ability to self-manage their medication, the prototype delivers doses in a timely manner, meaning that patients do not have to worry about remembering their drug regimen. This technology has the potential to be used across a range of chronic conditions, including autoimmune and cancer treatments, enabling patients to self-manage their treatment in an at-home setting.

The project uses precision microneedles to ensure correct depth of medication delivery into the skin, with embedded sensors providing dose control for patients during injection. The working prototype also utilises innovative features such as a micropump for precise fluidic control and connectivity to a smartphone app.

The prototype is designed in two halves. A reusable section including durable components and electronics, and a disposable section that comprises the drug and skin contact parts. Reusability and waste reduction were both key objectives within the project to support the move towards a circular economy.

Project Leader and Senior Manager of Research and Technology at West Pharmaceutical Services, Dr Alex Lyness, said:

'There is now a clear healthcare drive globally to move from hospital to the home to improve the overall patient experience and help reduce healthcare costs. Being a leader in the field of at-home self-injection technologies, West Pharmaceutical Services is investing significantly in research and development (R&D). This highly collaborative initiative with Tyndall and PA Consulting has the potential to have huge societal impact, empowering patients to take their medication at home via microneedles in a more efficient, painless and safe manner. This project is at the forefront of a movement towards more sustainable at-home drug delivery options, which may become the norm as the industry looks to find more sustainable ways to treat patients worldwide.'

Dr Conor O'Mahony, Principal Researcher at Tyndall National Institute, said:

'Utilising our world-leading research expertise in information and communications technology, we have worked with West Pharmaceutical Services and PA Consulting to harness the innovative applications of microneedles to create a prototype drug delivery device that has the potential to transform at-home patient care in an unprecedented way.'

Patent applications have now been submitted by the organisations involved to protect and expand R&D on the technology. Since the initiation of this project in 2017, West Pharmaceutical Services has significantly expanded its R&D operations in Dublin.

The project was a finalist in the 'Collaboration in Medtech' category at the Irish Medtech Awards 2023 as part of Medtech Rising: The Business Leaders' Conference.

In recent years, West Pharmaceutical Services has increased its presence in the Republic of Ireland, expanding the headcount at its Waterford manufacturing plant and in Dublin where its research and development unit is located.

Prototype renderings show possible appearances. Depicted device and connectivity concepts are in development and not approved for use or sale

A multidisciplinary approach to the investigation of seventeenth century Harward's Almanac

In 2020, the National Library of Ireland (NLI) acquired the only known copy of a 1666 Dublin almanac compiled by Michael Harward, renamed Harward's Almanac. The uniqueness and historical value of Harward's Almanac relies on the presence of 19 handwritten poems containing clandestine English satire circulating anonymously in Dublin in the late 17th and early 18th centuries. During conservation work undertaken at the NLI, it became clear that the order of leaves, and thus of the poems, was incorrect.

The aim of this work was to reconstruct the original and correct order of the Almanac leaves, and hence the likely sequence in which the manuscript poems were inscribed. This has been possible through close collaborative work between historians from the NLI, Sorbonne Lafayette College, UCC's Modern Irish Department, researchers from Tyndall and computer scientists from UCC. This study employed a codicological/palaeographic analysis complemented by analytical (X-ray fluorescence, XRF) and statistical (self-organising map, SOM) investigation. Specifically, point XRF analysis was carried out for each handwritten page of the Almanac, allowing identification of ink elemental compositions (iron-based ink) and successfully supporting the validity of historical hypotheses on the poems' order of inscription. The statistical organisation of XRF data by SOMs allowed easy bi-dimensional visualisation of the data set (54 points) and identification of ink similarities, which could be associated with date of circulation, once more validating the historical assessment.

https://heritagesciencejournal.springeropen.com/articles/10.1186/s40494-023-01107-y

Veronica Biolcati, James Woolley, Élodie Lévêque, Andrea Rossi, Anna Grace Hoffmann, Andrea Visentin, Pádraig Ó Macháin and Daniela Iacopino

"Establishing the original order of the poems in Harward's Almanac using paleography, codicology, X-ray fluorescence spectroscopy, and statistical analysis. Heritage Science, Volume 11, 2023."

a)

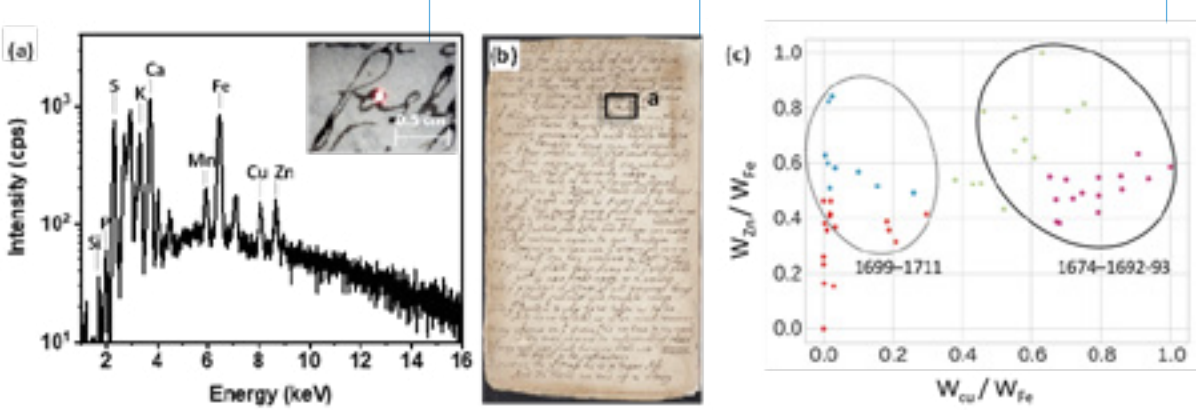
XRF spectrum of an inked area, p. 82 Inset shows a microscopy picture of where the XRF spectrum was taken

b)

Photograph of p. 82 Black box shows the area of XRF analysis

c)

2 x 2 SOM-based clustering showing the date of composition of the poems



New ventures

In 2023, Tyndall's new ventures pipeline consisted of 18 commercialisation projects at varying stages of development.

This figure includes eight Enterprise Ireland's Commercialisation Fund projects, three of which were contracted during 2023 (ENTICE, iSLight and pHetalSafe). Two Enterprise Ireland Feasibility Studies were completed while another two got under way.

Tyndall launched a New Ventures Strategy focussed on increasing the number of HPSUs emerging from spinouts, in line with Impact 2030 objectives.

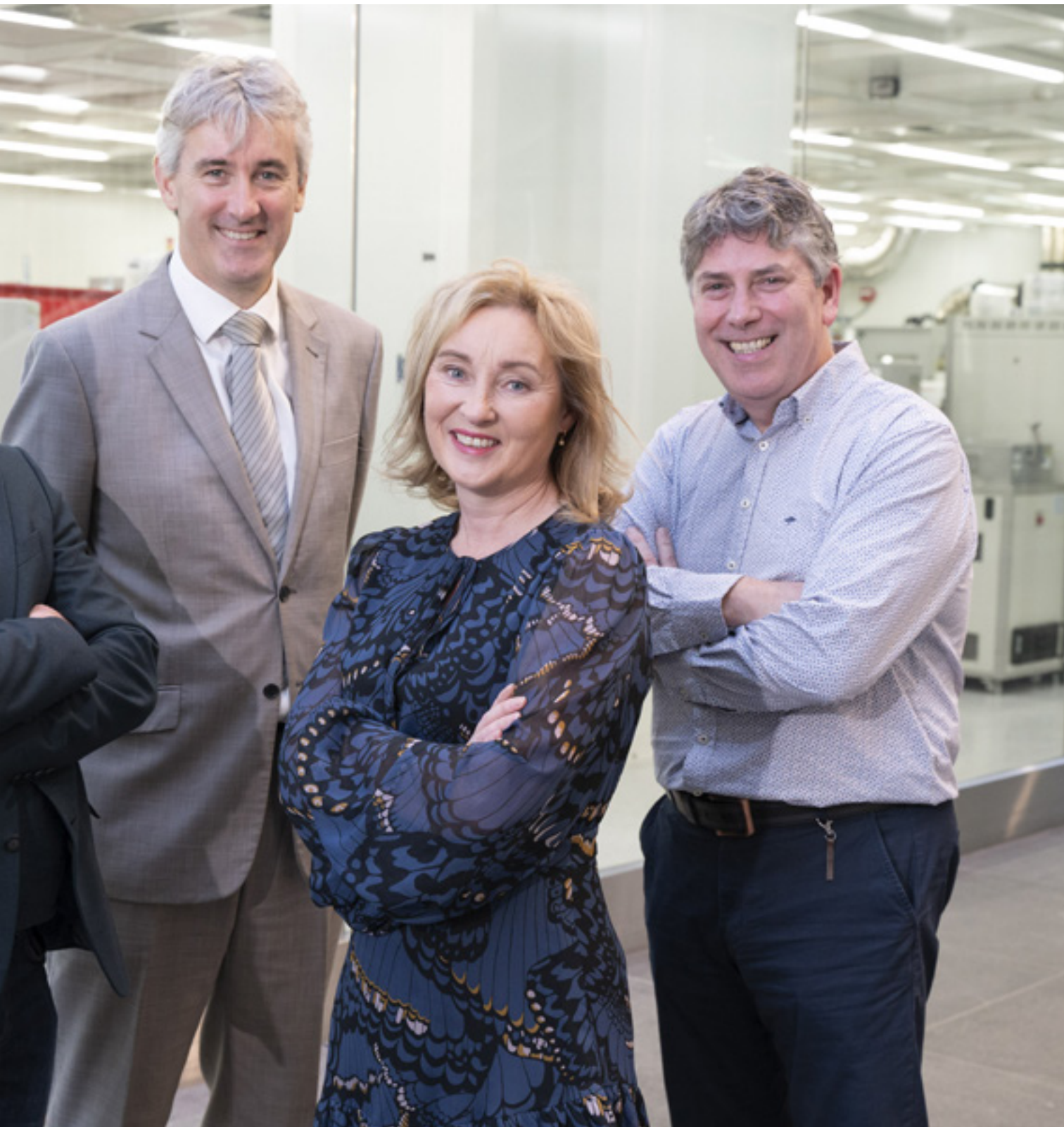
Tyndall was an Associate Partner in the DigiBio Innovators Initiative proposal that was approved for funding by Enterprise Ireland. DigiBio, which will be led by Dundalk Institute of Technology (DkIT), will commence in 2024 and will provide opportunities for Tyndall to support digital health commercialisation projects.

An important development during the reporting year was the expansion of Tyndall's Entrepreneur in Residence Programme with the addition of Denise Tormey and Joe O'Keeffe. They will complement the work that Declan O'Mahoney has been doing in Tyndall for a number of years.

A Commercialisation Workshop was delivered in association with UCC Innovation and attracted personnel from all of Tyndall's research centres.

Two Tyndall projects participated in the Explorer Pre-Accelerator tailored training and mentorship programme.

We have continued to develop Tyndall's relationship with Silicon Catalyst UK by attending the launch of ChipStart UK, a new pre-accelerator programme for semiconductor start-ups. Interactions have started taking place between Tyndall and companies being supported by Silicon Catalyst UK, which will help to extend our international reach and support emerging innovative deep-tech ventures.



Peter Finnegan, Head of New Ventures with Tyndall's Entrepreneurs in Residence Declan O'Mahoney, Denise Tormey and Joe O'Keeffe

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1 Co-fund project

Dr Christopher, K. W. Kho with Tammy Jackson, Tyndall Summer Fellow

Tyndall is recognised internationally as a European research institute of scale. During 2023, significant progress was made towards the international positioning goal and objectives of the Tyndall 2025 strategy. Our thought leaders continued their important contributions to research policy and technology road mapping while our direct engagement and partnerships with global technology leaders has grown.

Thought leadership

In August 2023, while the EU was preparing for the enactment of its much anticipated Chips Act, Tyndall published a position paper calling for Ireland to follow suit and develop its own semiconductor strategy and take advantage of the potential opportunities presented by the legislation. This call to action has been endorsed by the global CEOs of both Analog Devices and Intel, two of the major employers within Ireland's chip sector.

Tyndall researchers have also been involved in white papers on the 'Role of IoT and edge computing in addressing biodiversity and environmental monitoring', on 'AI for better Health' and on a European Technology Platform for Smart Systems Integration (EPoSS) white paper on 'Green electronics, components and systems'.

We also continued to contribute to the Strategic Research and Innovation Agenda of Electronics Components and Systems (ECS-SRIA), leading the chapter on Agrifood and Natural Resources, and the Long Term Vision chapter. The ECS-SRIA underpins the Chips Joint Undertaking (JU) partnership and addresses major challenges for the semiconductor industrial value chains in Europe.

Also in 2023, Dr Giorgos Fagas was elected Director of the SiNANO Institute – the European Academic and Scientific Association for Nanoelectronics comprising of 27 member institutions from 16 European countries and 22 start-ups/SMEs that brings together the European semiconductor science and technology research and academic community.

Partnerships

Tyndall partnerships across the globe have grown in 2023, with significant engagement not only with the EU but also the United States of America (USA), the United Kingdom (UK) and India.

Tyndall has continued to build on its success in winning EU funding for projects spanning all pillars of Horizon Europe as well as projects in the Digital Europe and Institutional Partnerships programmes, with more than €12m in funding secured in 2023. Projects funded include one under the European Chips Skills (ECS) Academy to address the skills shortage in the microelectronics industry in Europe and three Marie Skłodowska-Curie projects which promote doctoral education and postdoctoral training of researchers.

Tyndall researchers secured funding for two projects under the US-Ireland Research Programme. GUIDE which focuses on investigating the properties of Ga_2O_3 for next-generation electronics and CoQREATE which will look at applications that exploit the combined power of quantum and classical networks.

Oxford Plasma Etcher

In January 2023 an 11-strong Tyndall delegation attended the Institute of Electrical and Electronics Engineers (IEEE) APSCON conference in Bengaluru, India and a symposium at the Centre for Nano Science and Engineering at the Indian Institute of Science. Our attendance at these events enabled Indian students and researchers to learn more about Tyndall. The teams explored opportunities to establish student exchange programmes, create consortiums with peers and collaborate on key projects. The visit to India generated significant impact, with Tyndall showcasing its research excellence to an international audience both in academic institutions and industry and delivering opportunities to increase our research collaborations.

Large-scale projects

Key successes include the Tyndall coordinated projects INFRACHIP, BIOSENSEI, INFERNO, HERIT4AGES and Audit-plus.

INFRACHIP will facilitate access to state-of-the-art technologies in the field of semiconductors to accelerate research and innovation and respond to challenges in line with the goals set out in the EU Chips Act.

BIOSENSEI aims to develop a real-time, multiplexed, end-to-end, tailored and reliable biosensor platform, using cellular responses, for detection of abiotic pollutants.

INFERNO will involve developing systems to convert waste heat into electricity to reduce greenhouse gas emissions.

HERIT4AGES will investigate methods for the cost-effective improvement and preservation of cultural heritage buildings.

LIFE-AUDIT-PLUS aims to create tools that will be used to improve energy efficiency in energy-intensive industries.

Tyndall is also leading ENTIRE, a European Digital Innovation Hub which was launched in October 2023 and aims to assist SMEs and public authorities to address digital challenges.

Tyndall is leading Irish clusters in three large-scale European Key Digital Technologies (KDT), CHIPS Joint Undertaking (JU) projects: ARCTIC partnering with Intel, PhotonMed together with Boston Scientific and ficonTEC, and UNLOOC with Abbvie.

ARCTIC aims to develop scalable cryogenic ICT microsystems and control technology for quantum processors; PhotonMed aims to accelerate the uptake of the latest photonics technologies in medical device applications by providing a pilot line; and UNLOOC seeks to develop technology to replace animal and in-human testing of new drugs.

Quantum 2030

In 2023, we welcomed the adoption by the Government of Quantum 2030, Ireland's first national strategy for quantum technologies. The journey of Quantum 2030 started in 2019 with the publication of Tyndall's paper on 'Positioning Ireland for the quantum opportunity'. As Ireland's National Institute in integrated ICT, we were very pleased with the remarks made by the then Minister for Further and Higher Education, Research, Innovation and Science Simon Harris TD at the launch: 'The publication of Quantum 2023 marks the adoption of its vision as a whole-of-government policy goal. The strategy sets out a path for Ireland to be an internationally competitive hub for quantum technologies by 2030.'

Tyndall has been paving the way in this area for more than a decade with leading research in the engineering of quantum materials and devices for qubit realisation. In 2023, we launched four new international partnerships which amplify our critical mass for innovation and enhance our position as a quantum hub.

Funded with €2.6m by the UK Engineering and Physical Sciences Research Council (EPSRC) and SFI, the GeQuantumBus project brings together Tyndall researchers with UK academics from the University of Warwick, University College London, and University of Cambridge to overcome limitations in architectures using germanium hole-spins on silicon as qubits by using coupler quantum dots to control qubit-qubit interaction. The partnership is also supported by a global MNC and a UK SME, and five other international collaborators.

Tyndall also brings its leading expertise in integrated quantum photonics to three large-scale projects funded under the EU's Quantum Flagship programme. The Quantum Secure Networks Partnership (QSNP) brings together more than 40 partners from across Europe, ranging from academic institutions, foundries and research and technology organisations (RTOs), SMEs and spin-offs, to network and cryptography integrators and telecom operators.

Tyndall researchers in QSNP will develop the cryo-packaging and integration required for the target quantum cryptography technology that will secure the transmission of information over the internet. Tyndall teams will also work on the development of general-purpose quantum computing with photonics.

In the QPIC1550 project, a universal quantum photonic integrated circuit (QPIC) platform operating at 1550 nm will be achieved by integrating indium phosphide (InP), quantum dots, and indium gallium arsenide (InGaAs) detectors onto silicon nitride (SiN) photonic integrated circuits (PICs) for the first time. This effort complements the European Photonic Quantum Computer EPIQUE project, which aims to demonstrate essential building blocks for generating and fusing quantum states to entangle >10 qubits, and the critical measurement and feed-forward capabilities required to scale the platform to >1,000 qubits.

Professor Jiri Vala, Associate Professor of Theoretical Physics, Maynooth University, Dr Deirdre Kilbane, Director of Research, Walton Institute, SETU, Minister for Further and Higher Education, Research, Innovation and Science Simon Harris TD, Dr Giorgos Fagas, Head of CMOS++ and EU Programmes, Tyndall, at the Quantum 2030 Launch


Tyndall National Institute

People and culture

533
STAFF/STUDENTS

TRAINED OVER
450
STAFF/STUDENTS

Directly engaged with **4,800** students and members of the public

215 staff / students took part in EPE events this year on behalf of the institute

45 nationalities

160 PhD and Master students

OUR EDUCATION STREAMS

20 TY Students
29 Summer Fellowships
18 Vivas

In 2023 we achieved our highest headcount to date, with 533 staff and students, and our highest ever student cohort, with 160 students. This is the culmination of significant changes in our approach to people and culture and the key initiatives undertaken in the past five years.

The feedback received from Tyndall's inaugural people survey in 2018 ensured that 'people and culture' was included as a key strategic goal in the Tyndall 2025 Strategic Plan. This was followed by the formation of an Equality, Diversity and Inclusion team, securing funding for postgraduate student maternity pay, and the launch of the Irish Management Institute (IMI) Aspiring Leaders Management Training Programme.

Another notable highlight in the past five years has been the establishment of a Tyndall Early Career Researchers' Network (TEC-Net) to enhance both the research and business potential, and capabilities of Tyndall early-career researchers by increasing the exchange of ideas internally and with European peers.

Our recognition programme has gone from strength to strength, with the introduction of the KUDOS recognition platform and the launch of the Tyndall Annual Recognition Awards, the TARAs, in 2022, accompanied by the vibrant showcase of Tyndall's Got Talent. As a result of the establishment of a dedicated Athena Swan equality charter working group and the conduct of surveys and focus groups, we were proud to receive an Athena Swan Bronze Accreditation award. Our work to support and transform gender equality continues as does our commitment to advancing the careers of women within Tyndall.

With a focus on careers in 2023 we put in place a series of career development and progression workshops supported by career path briefings for all staff and students.

Also in 2023, Tyndall was proud to welcome the appointment of Maeve McGinn as our People and Culture Programme Manager, illustrating the Institute's deep commitment to the delivery of our cultural change programme.

Tyndall's Annual Recognition Awards (TARAs)


Tyndall
HALL
IRL


Tyndall
National Institute

Education and public engagement

During 2023, 215 staff and students from across the Institute participated in education and public engagement (EPE) activities. Through these activities we have directly engaged with more than 800 school and undergraduate students, in addition to engaging with 4,000 members of the public.

Among the highlights for 2023 was the return of the Tyndall Transition Year (TY) programme fully in person, co-ordinated by Alida Zauers. Tyndall hosted 20 students from 15 schools across Cork, including several Delivering Equality of Opportunity In Schools (DEIS) schools. Fifty-five per cent of the students were girls. Fifty-two researchers, students and staff supported the delivery of the programme which consisted of laboratory tours (including Wireless Sensor Network (WSN), Life Sciences Interface (LSI) and photonics systems), workshops (including 'Sand to Silicon', 'Nanotechnology' and 'Light into Sound') and the 'Photonics Escape Room'. Students would highly recommend the programme to other TY students 'It's such an amazing experience and you meet so many new people,' said one student.

The Tyndall Annual Recognition Awards (TARAs) were held again in 2023. At the TARAs in the Postgraduate student category, PhD student Ana Claudia Ferreria was awarded EPE/Outreach Person of the Year for her outstanding contribution and commitment to and impact on EPE activities and events throughout the year.

At third level, 29 undergraduate students were awarded places on the 2023 Tyndall and IPIC Summer Fellowship Programme which ran for 12 weeks between June and August. The programme allowed students to work with renowned researchers at Tyndall, IPIC the SFI Centre for Photonics, the Microelectronics Circuits Centre of Ireland (MCCI) and the International Energy Research Centre (IERC). Sixty-four personnel from across the Institute helped develop and deliver the Development Programme. The Development Programme is designed to give interns additional skills that will make them attractive candidates for future scientific careers. The programme has grown since 2017 and now incorporates workshops, training sessions and networking, which run in parallel to the projects over an eight-week period.

Berkay Dogan, Postgraduate student, Tyndall at Science Week 2023

PhD Vivas 2023

Veronica Biolcati

A cross-disciplinary analysis of the materials used in the making of Irish works of art

Marco Cavaliere

Electromagnetic tracking methods and magnetic modelling for distortion compensation

Emma Coleman

Two-dimensional transition metal dichalcogenides as next-generation semiconductor materials

Louise Colfer

Multiferroic investigations of aurivillius phase thin films

Anya Curran

The understanding, control, and application of polycrystalline compound semiconductor thin films

Sarita Das

Theory of tunnelling and transport in emerging narrow-gap semiconductor alloys

Jordan Fordyce

Single-mode inter-band cascade lasers for petrochemical process monitoring

Liudmila Khokhlova

Non-invasive assessment of knee conditions using acoustic emission monitoring

Marinara Marcato

Development and evaluation of tools and methodologies for estimating behaviour and predicting training outcomes from working dogs

Jean de Sousa Matias

Upconverting nanoparticles: Pushing theory and technology towards biomedical applications

John McCarthy

Monolithically integrated, high-coherence frequency comb generation through on-chip gain switching

Tanmay Mondal

High-efficiency ultrasound-powered micro-LEDs for optogenetic applications

Arbresha Muriqi

Multi-scale simulation of hybrid inorganic-organic films

Aidan Murphy

Electrochemical sensor interface

Richard Murray

Laser-induced graphene-like carbon for volatile organic compound sensing

Michael O'Donovan

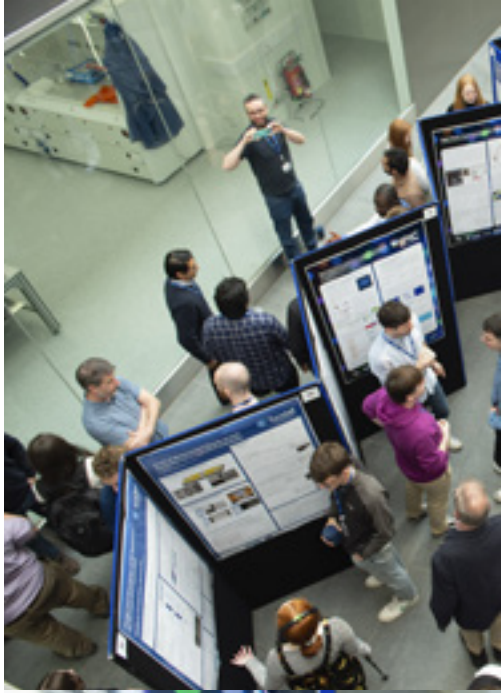
Theory of carrier transport in III-N based heterostructures

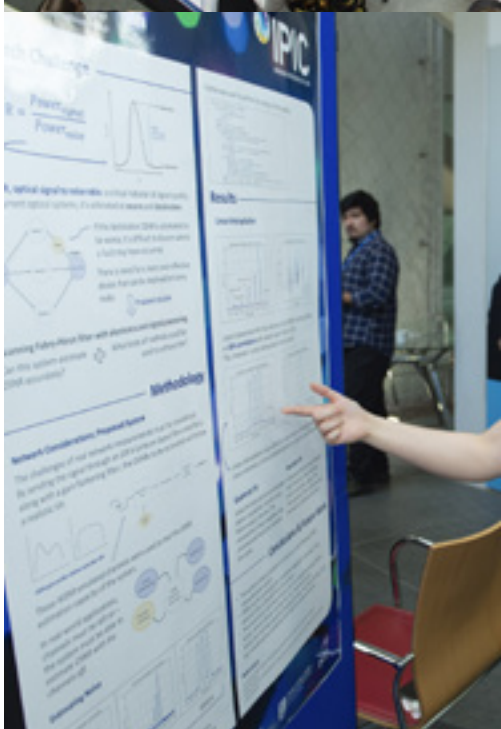
Eoghan Vaughan

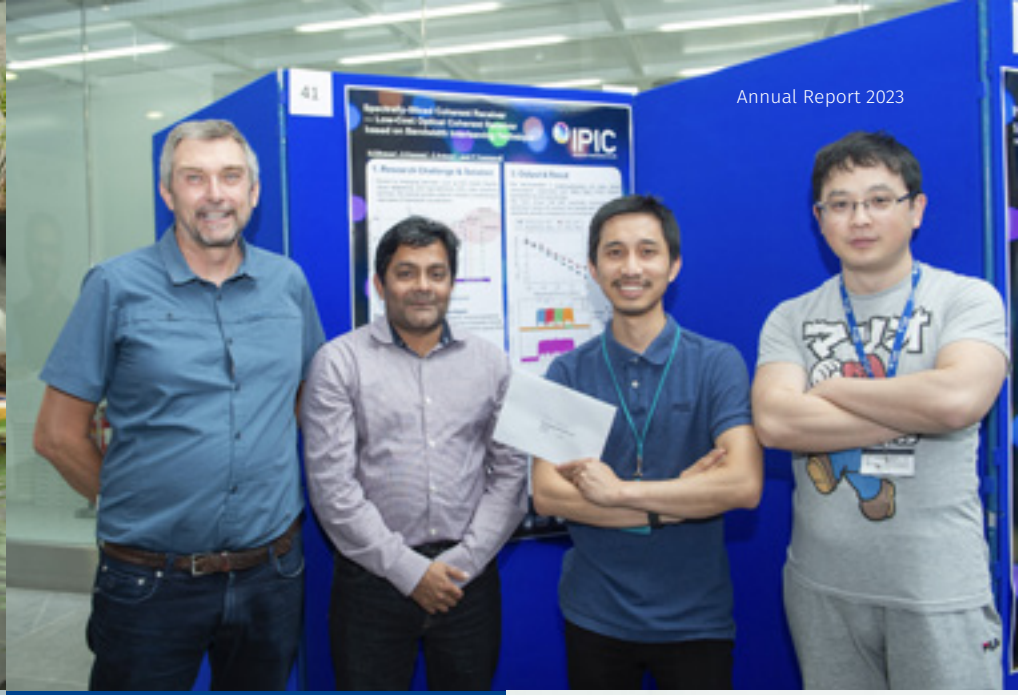
Laser-induced graphene for electrochemical sensing applications

Artem Vorobec

2D materials for hybrid laser wavelength tuning






41
IPIC


IPIC
IPIC

Student awards

2022 Postgraduate Publication of the Year

Winner:

Richard Murray

'Direct-write formation of integrated bottom contacts to laser-induced graphene-like carbon'

https://iopscience.iop.org/article/10.1088/1361-6528/ac7c7b/meta

Runners-up:

Cathal Larrigy

'Porous 3D graphene from sustainable materials: laser graphitisation of chitosan'

https://onlinelibrary.wiley.com/doi/10.1002/admt.202201228

Arindam Samanta

'Generation of microwaves with tuneable frequencies in ultracompact 'magnon microwave antenna' via phonon-magnon-photon coupling'

https://ieeexplore.ieee.org/document/9970245

Wrixon Research Excellence Bursaries

Liudmila Khokhlova

Non-invasive assessment of knee condition using acoustic emission monitoring

Liudmila is researching the development and evaluation of a novel, robust, and reliable non-invasive method for knee status assessment using acoustic emission monitoring. The study identifies optimal frequency range, sensor placement, and metrics for reliable knee acoustic emission monitoring linked to cartilage damage.

Zhongzheng Wang

The design of ultra-low-power electrochemical sensor readout analog front-to-end ICs

Electrochemical sensors are employed for the identification of specific chemical species which are extensively adopted across various fields, including agricultural production, food quality monitoring, and medical diagnostics. They enable the translation of chemical information, for example, nitrate concentration, into electrical signals like voltage or current. A function-specified category of integrated circuits (ICs), called sensor interfaces, is engineered to sample the sensor signals and convert them into digital values. Zhongzheng's PhD work aims to design novel electrochemical sensor interfaces with an emphasis on achieving high precision, less complexity, and ultra-low-power consumption.

Stephen Murphy

Machine learning equalisation for future optical networks

With the rise of remote work and cloud services, access to reliable high-speed broadband has become more important than ever. This has led to the National Broadband Plan in Ireland which will provide every rural home and business in the country with an optical fibre link. These systems are based on 10 Gbit/s XGS Passive Optical Network technology. But the ever-increasing demand for bandwidth to support services such as 8K video streaming, virtual and augmented reality applications, and future mobile services such as 6G, means that researchers are now looking into 100 Gbit/s systems and beyond. Stephen's research focuses on how novel signal processing algorithms based on neural networks could be used to overcome non-linear fibre and photonic device behaviour, and thus enable such ultra high-speed systems.

Wrixon Research Excellence Travel Bursary

Daragh Crowley

Daragh travelled to the Children's National Hospital in Washington DC, where he worked on surgical guidance systems using electromagnetic tracking. The project involved using wireless tracked sensors developed at Tyndall in surgical simulators and preclinical testing.

Saif Wakeel

Saif will travel to Massachusetts Institute of Technology (MIT), Cambridge, USA. He will work on developing a library of multi-photon polymerisation-based 3D printing of novel micro-optic components for pluggable photonic packaging demonstrators.

BOC Gases Postgraduate Bursary

Liudmila Khokhlova

Non-invasive assessment of knee condition using acoustic emission monitoring

Student Poster Competition

Early Student Category:

Joe Steele

Wideband planar baluns using multilayer coupled-line approaches

Suraj Kothuri

Broadband diffuse optical characterisation of human cadaver bone (500–1100 nm)

2nd Year and higher:

Hilmi Othman

Low-cost optical coherent received based on bandwidth interleaving technique

Runner-up:

Nidhya Mathew

Powering for biomedical CMOS image sensor for surgical guidance and diagnostics

Saif Wakeel

Silicon optical coupling for future wafer level packaging applications

Notable Student Awards

Ana Cláudia Ferreira

- 'Best Scientific Picture' (2023), VistaMilk SFI Centre
- 'EPE Activities Champion' 2023, VistaMilk SFI Centre

Siddra Maryam

- Journal publication 'Label-free optical spectroscopy for early detection of oral cancer' was selected as the cover page. Diagnostics, doi:10.3390/diagnostics12122896
- IPIC Industry Workshop 2023 Best Poster Winner, First Prize at IPIC Team day. Mobile multi-configuration clinical translational Raman system for oral cancer application

  https://doi.org/10.1039/D2AN01921
- Researcher Development and Travel Grant, Royal Society of Chemistry 2023
- Best Poster Award at Photonics Ireland Conference, 2023. Title: 'Multimodal optical spectroscopy for oral cancer diagnosis'
- Optica Biophotonics Congress-Photonics in Life Science 2023. Family care grant

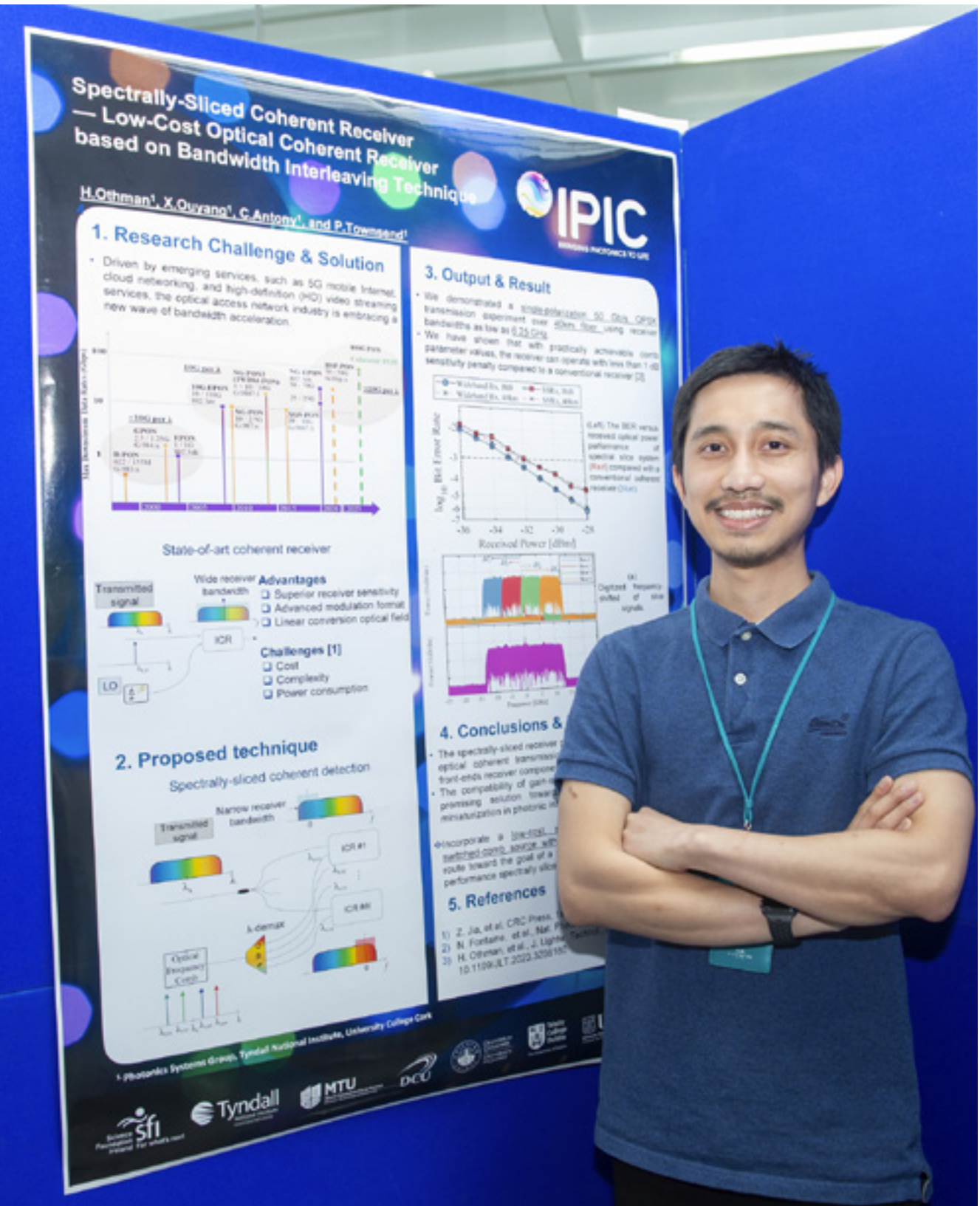
Julie Raulin

Education, Public Engagement (EPE) Champion award, annual Irish Photonics Integration Centre (IPIC) event

Sandeep M Singh

Oral presentation, Best Student Award, 14th International Conference on Nitride Semiconductors, Japan. Title: *'MOCVD overgrowth of μ-honeycomb AlGaN structures'*

Authors : Sandeep M Singh, Vitaly Zubialevich, and Peter J Parbrook, Conference webpage (https://icns14.jp/)



Hilmi Othman, winner of the student poster competition (2nd year and higher category)

Student testimonials

"Every day is a happy day for me at Tyndall!

My PhD supervisor is incredibly supportive. He never says no to any of my ideas or proposals, in fact, he always encourages me to pursue them. I have had many incredible opportunities to collaborate with different universities in China, the UK, and the USA, which has helped me develop a strong technical background and hands-on experience in lasers and opto-electronic systems."

Sini Nanadath Shibu

PhD Candidate, Photonics Packaging Group

"I think what I enjoy most about my postgraduate studies is all the opportunities I have to network with different people.

Each member of my supervisory team has inspired me in their own way, as they all have different ways of mentoring me. They are all very inspiring in their technical ability, and they have also taught me the importance of soft skills and leadership skills."

Julie Raulin

PhD Candidate, Photonics Systems Group

"The best thing about Tyndall is that every day is a school day!

Progress is always recognised here at Tyndall and there are many events throughout the year. One of my favourite events is the postgraduate poster competition, which gives you the opportunity to showcase your research and share your ideas with researchers from different groups across Tyndall."

Zhongzheng Wang

PhD Candidate, Microelectronic Circuits Centre Ireland (MCCI)

Infrastructure

€10m

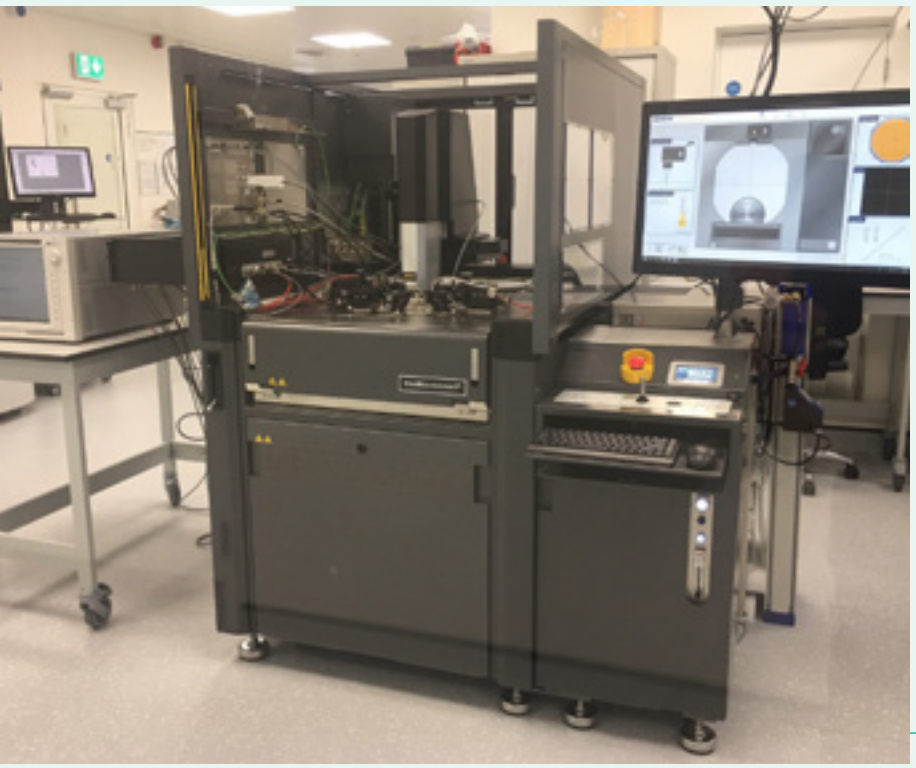
AWARDED THROUGH SFI RESEARCH INFRASTRUCTURE PROGRAMME

264 trained in the operation of process or analysis tools

99 new users to the open access labs and cleanrooms

> €600k granted from SEAI for Tyndall Decarbonisation Plan

Zixiao Zhang, PhD candidate and Tánaiste, Minister for Foreign Affairs and Minister for Defence, Micheál Martin, TD.



High power wafer scale electrical probe station

Tyndall's commitment to research excellence is deeply entrenched in its forward-looking approach to creating and maintaining state-of-the-art research infrastructure.

Our latest investments in infrastructure not only epitomise our dedication to pioneering advanced technologies, but also substantially contribute to positioning Tyndall as a hub for international scientific talent.

The acquisition of a deep-level transient spectrometer (DLTS) heralds a significant leap in our ability to analyse semiconductor defects at an unprecedented microscopic level. This precision instrument allows our researchers to detect and characterise imperfections in semiconductor materials, enabling breakthroughs in electronic and photonic device reliability and efficiency.

Complementing the DLTS is our high-power 300 mm wafer electrical probe system, provided by MPI Corporation. This system stands at the forefront of wafer-level testing, delivering unmatched accuracy and throughput capabilities. By facilitating the examination of electrical properties across large-diameter wafers, this tool is indispensable for our research in scalable semiconductor technologies.

Perhaps most notable is our TeraLab for optical and wireless communications. Featuring a high-speed, real-time sampling system, TeraLab is equipped with 256 GSa/s arbitrary waveform generators and oscilloscopes with up to 110 GHz bandwidth. The integration of an optical modulation analyser for complex waveforms enables TeraLab to pioneer the development of ultra-fast, 1 Terabit/s per wavelength-class systems. This infrastructure is vital for the exploration of next-generation data centre architectures, urban access networks, metropolitan communications, and the rapidly evolving field of optical free-space satellite networks.

These strategic investments ensure that Tyndall remains at the cutting edge of scientific inquiry, providing an environment where researchers are equipped with the tools to push boundaries. This, in turn, makes Tyndall an attractive destination for the best and brightest minds seeking to contribute to transformative research that shapes the future of technology and society.

Tyndall's ongoing engagement with Analog Devices Inc in both Ireland and the USA marked a significant milestone with the renewal of a three-year contract valued at over €1m.

This renewal underscores a partnership from 'atoms to systems' that has flourished for over four decades, highlighting the enduring trust and mutual benefits for the two organisations. It not only signifies a commitment to continued collaboration but also acknowledges the significant R&D work that has been conducted between them over the years.

Spearheaded by the Design Technology Evaluation group (DTE), Tyndall provides indispensable measurement and consulting expertise to the IC design, semiconductor processing and IP management communities. With a proven track record spanning Ireland, mainland Europe, and the USA, the DTE group specialises in precision measurements, consulting, and design support across a broad spectrum of areas such as IC design characterisation and IP investigation.

The renewed contract signifies a continued commitment to excellence and innovation, as Tyndall leverages its expertise to support Analog Devices Inc in the transfer of new IC processes and products to the company's Limerick site. The collaboration will deliver a host of benefits to Analog Device's Limerick operations, including faster ramp time for new products, winning new business for the manufacturing site, and higher manufacturing yields, thereby ensuring the long-term viability of the facility as a major manufacturing location for the company.

This strategic partnership not only fosters technological advancement but also strengthens ties between the academic and industrial sectors, paving the way for further collaboration and groundbreaking achievements in the realm of semiconductor technology.

Tyndall decarbonisation plan

The Climate Action Plan 2023 requires a 51% reduction in greenhouse gas (GHG) emissions by 2030 against a 2018 baseline.

When the new 'Tyndall North' Building is constructed, our footprint will double but our combined CO_2 emissions must halve.

Our natural gas boilers emit 800 tCO_2 annually. To achieve our goal, we must eliminate the use of natural gas on-site and continue to reduce our electricity use. We will achieve this by replacing our current boilers and chillers with multifunction heat pumps.

During 2023, we worked with the Sustainable Energy Authority of Ireland (SEAI) to complete an application for grant support for the project through the EXEED (Excellence in Energy Efficient Design) process.

Our Stage 1 application required a deep dive into our energy use across the site and focused on all energy users, including utilities, process tools, cleanroom and laboratory operations.

In addition to the boiler/chiller replacement project, the application process also identified another 124 opportunities for improvement (OFI) which will yield an additional 400 tCO_2 savings per annum.

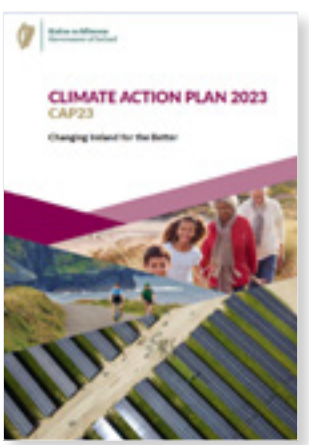
Some of the projects include:

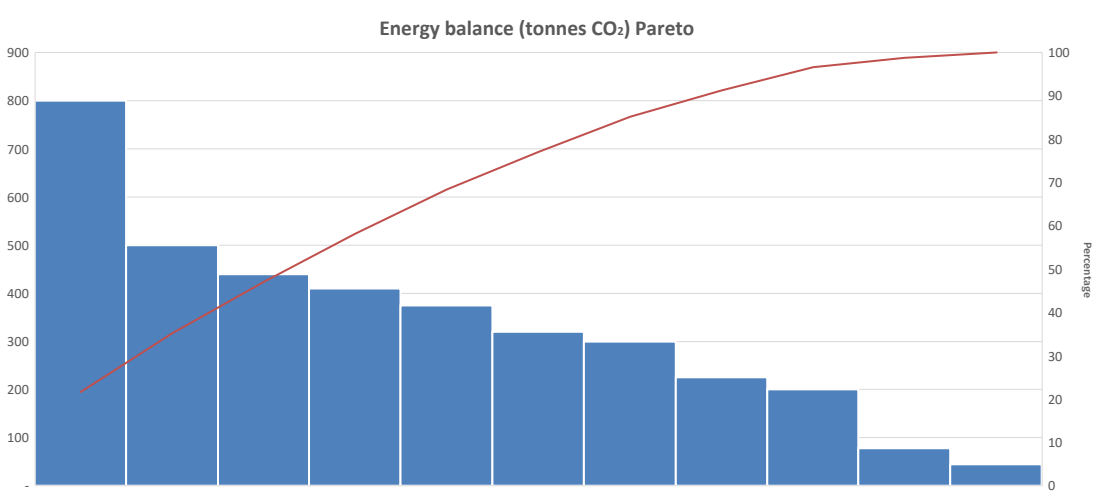
- Reducing the air change rate for cleanrooms when they are unoccupied.
- Replacing gas reactor column filters with unheated units.
- Replacing three port valves on water systems with pressure independent control valves (PICVs).
- Replacing a number of air handling units and adding heat recovery. To others.
- Fabric improvements in cleanrooms to reduce air leakage.

The total investment required to complete these projects is €3m.

In September 2023, SEAI approved grant funding of €560k for the project.

Detailed design is progressing, with tenders already issued for stage 1 of the project, which is on schedule to be completed in Q1 2025.





Dr Graeme Maxwell and Dr Emanuele Pelucchi

In another example of Tyndall's research excellence, two of the Institute's projects were awarded €10m through the SFI Research Infrastructure Programme.

The programme supports the research community in building and sustaining cutting-edge infrastructure in order to accomplish high-quality, impactful and innovative research. In addition, it encourages partnerships and collaboration between different cohorts of researchers in Ireland, across academic institutions and enterprises.

These awards are another example of the research excellence and impact occurring across the board at Tyndall.

The awards went to:

Graeme Maxwell for 'Advanced heterogeneous device integration (AHDI): Enabling TSVs, wafer bonding, and grinding for 2D and 3D integration and next-generation interposer development'; and to Emanuele Pelucchi for 'IQ: the Irish quantum technology facility for advanced qubit manipulation'.

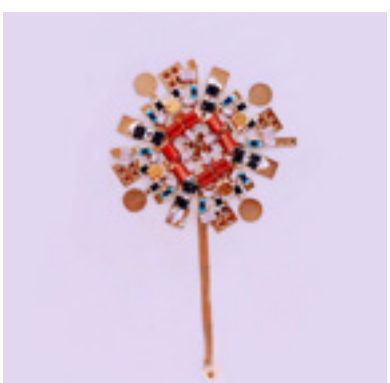
Scientific image competition winners

Co3O4 Daisy Flower

Rupa Ranjani Palanisamy, Advanced Energy Materials, Materials Chemistry and Analysis Group (MCAG)

As part of the EU TRANSLATE project at Tyndall, we aim to design a thermally chargeable supercapacitor: utilising thermally driven ion transport.

This image shows Co3O4 blue daisy flower-like electrodes. These electrodes are thermally chargeable supercapacitors that will be developed and tested for the project.



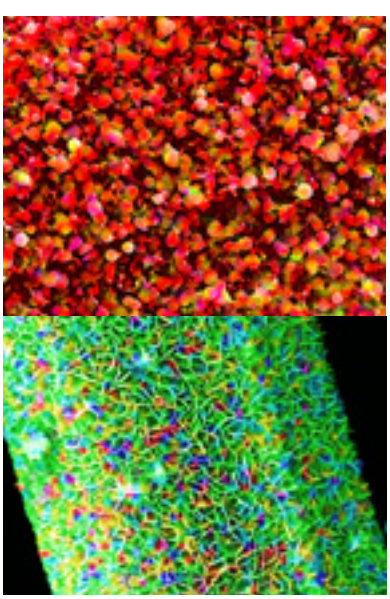
Pink Lollipop

Zixiao Zhang, Advanced RF Technology Group

This scientific image, titled 'Pink Lollipop', shows part of a uniquely co-designed microstrip circuit.

This circuit combines the functionalities of a bandpass filter, phase shifter, and isolator for modern communication systems, operating at a working frequency of 700 MHz.

The circuit's lollipop-like appearance stems from its symmetric and intricate layout, which not only adds visual appeal but also enhances its performance by minimising signal interference and optimising space utilisation.



CoSe Rose Garland and NiSe Red Berries

Rupa Ranjani Palanisamy, Advanced Energy Materials Chemistry and Analysis Group (MCAG)

The conversion and storage of renewable energy sources is an urgent challenge that we have to confront in order to transition from a fossil fuel-based economy to a low-carbon society.

This EU TRANSLATE project aims to convert waste heat into electricity through a thermo-electrochemical cell by applying nanofluidic channels and storing this electrical energy using nanostructured electrode materials such as rose garland-like CoSe-based thermally chargeable supercapacitors (TCSs).

This new kind of energy storage device can convert thermal energy into electricity and store it for future utilisation.

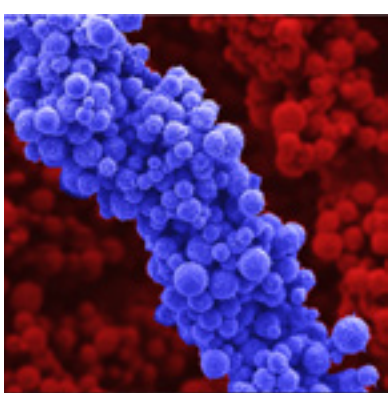
Electronic Cuneiform

Richard Fitzgerald, Design Technology Evaluation Group

This image of autosynthesised CMOS logic from a commercial motor control integrated circuit (IC) was captured using the mosaic builder function Image Snapper on the Tescan Amber plasma focussed ion beam (FIB).

The sample has been delayered to the gate polysilicon level shown by a combination of parallel polishing and selective etching. The image shows a small part of a set of large mosaics created for the purpose of intellectual property (IP) investigation through circuit extraction by the DTE group within the Specialty Products and Services centre.

The modern pattern is reminiscent of ancient cuneiform inscriptions.



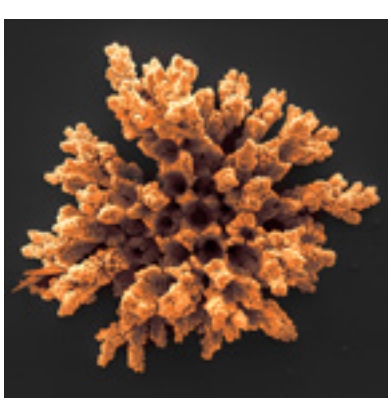
Platinum Cordyceps

Rupa Ranjani Palanisamy, Advanced Energy Materials, Materials Chemistry and Analysis Group (MCAG)

For the first time, the 'TRANSLATE' project at Tyndall aims to introduce transition metal chalcogenides (TMCs) as electrode materials for thermally chargeable supercapacitors (TMSs) in order to efficiently harvest and store the low-grade heat energy into electrical energy for later utilization.

The TMCs have been widely used in energy storage and conversion application because of its excellent electronic conductivity and rich redox states.

The intrinsically multiple valence states, unique morphology and high redox activity of CoS Blue Star Gooseberries makes it a potential electrode candidate for TMSs



Platinum Cordyceps

Ehren Dixon, Electrochemical Materials and Energy Group

In electroplating, sometimes the deposition can go awry, but the results can be interesting.

This object occurred while attempting to grow smooth platinum onto a microdisk. Here, the platinum had other ideas. It took control of the microdisk, bursting out like a fungal growth, forming the cordyceps made of pure platinum that we see in this image.

This image is reminiscent of those seen in the action-adventure video game and Sky TV adaption of 'The Last of Us'.

Beauty Wafer

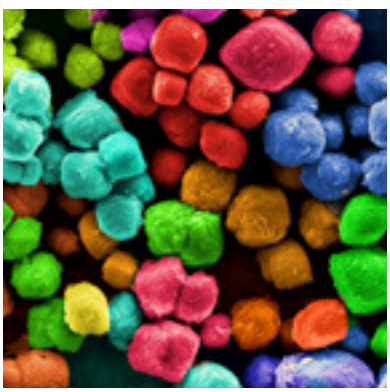
Vuslat Juska, Nanotechnology Group

This image may resemble a pretty flower, but it is actually a device designed as a multiplexed chip for stress biomarkers detection such as cortisol. The related publication is open access and available in BioRxiv.

The circle part of the image has 100 um diameter gold, with a certain recess depth. The stem part of the image is the connection track that is covered with a passivation layer. With this particular device, slight damage on the stem caused cracks.

The deposition process is the hydrogen bubble template, which is a well-established protocol at micro and nano scale. The porous material is electrodeposited gold foam. The growth of the gold foam continued through the cracks during the electrodeposition.

Although the presence of the cracks on the passivation is unfavourable, it represents beauty as an image of a flower!



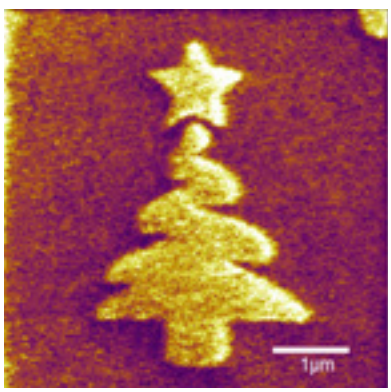
Candy Cubes

Rupa Ranjani Palanisamy, Advanced Energy Materials, Materials Chemistry and Analysis Group (MCAG)

This EU TRANSLATE project aims to introduce novel electrode materials for thermally chargeable supercapacitors (TMSs) in order to efficiently harvest and store low-grade heat energy as electrical energy for later utilisation.

In this regard, TMCs have been employed in the thermal energy storage and conversion application because of their high thermal stability, excellent electronic conductivity and rich redox states.

The intrinsically multiple valence states, diverse morphologies, and high redox activity of zinc-based ‘candy cubes’ makes it a potential electrode candidate for TMSs.



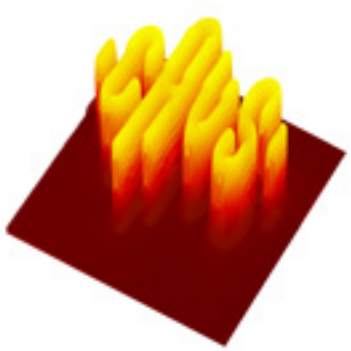
Merry Christmas 2023

Sabir Hussain, Advanced Materials and Surfaces Group (AMSG)

This scientific image was created using piezoresponse force microscopy (PFM) at Tyndall.

It was used to perform ferroelectric lithography to pole a selected area on a 5 nm thick ferroelectric film.

The ferroelectric domains have been switched upwards (north) to form a Christmas tree pattern.



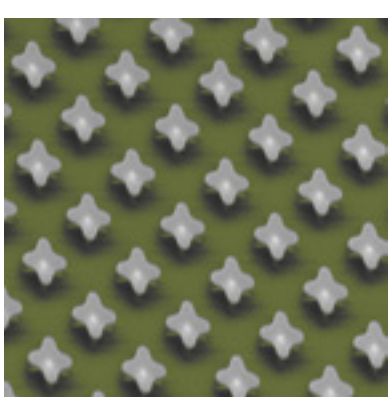
3D Lava Maze

Yide Zhang, Artem Vorobev and William Whelan-Curtin, Photonics, CAPPA Group

This scientific image shows nanoscale chemical imaging using atomic force microscopy-based infrared spectroscopy (AFM-IR). This can distinguish between similar materials that are otherwise hard to separate.

At Tyndall, unique SU-8 patterns (25x20x0.1 µm) were exposed using the Elionix electron beam lithography system (ELS- G100) and then covered with a layer of polymethyl methacrylate (PMMA).

This pattern is crucial for investigating the spatial resolution and intensity of the AFM-IR. A chemical absorption image was recorded at a wavenumber of 1035 cm-1, corresponding to the C-O stretch band.



Bed of Roses

Vuslat Juska and Alan Blake, Nanotechnology Group

Silicon micro-technologies provide outstanding reproducibility for designed patterns. At Tyndall, these patterns have been showcased since 2015, transforming them into biosensors and bioelectronics devices.

The image presented introduces a fresh perspective on the application of silicon technologies specifically designed for biology. It illustrates a recurring pattern, a so-called ‘bed of roses.’ These surfaces are crafted for exploring the interface properties of materials relevant to the immunology of solid tumours.

Agency-funded centres

Collaboration with national centres

In addition to the major agency-funded centre activities highlighted in this section, Tyndall has fostered deep collaborations with a number of other national research centres which have led to many fruitful partnerships and projects. These valuable relationships offer productive interactions and collaborations for researchers and experts in various fields, with access to collective resources such as equipment, technology, and talent. Tyndall researchers have played a significant role in project leadership and activity with the institutions listed and we would like to acknowledge these important relationships.

MaREI Energy · Climate · Marine

AMBER Advancing Materials for Impact

Insight

ICHEC

ADVANCECRT

IPIC, the SFI Research Centre for Photonics, is hosted at Tyndall and in 2023 it continued to strengthen its position as one of Europe's leading photonics research centres while also looking to the future with the new SFI Centres call. The ambition is to establish an internationally leading centre of research excellence and PhD training targeting the disruptive change required to address the era-defining end of the Moore's Law scaling of semiconductor systems.

The Biophotonics Professorship Award Phase 2 for Stefan Andersson-Engels consolidates IPIC's lead in the application of light to develop new medical diagnostics and treatment tools with an award of €5.4m over five years.

IPIC has a strong track record of creating and supporting new ventures. At Photonics West, the emerging spinout iSLight showcased its ground-breaking speckle free, surface-emitting blue super luminescent LED (SLED). In addition eight teams participated in IPIC's Explorer Pre-Commercialisation programme which is designed to help researchers take the first step to commercialise their research through a spinout company. IPIC's close collaboration with industry was recognised with the SFI Industry Partnership Award 2023, which was awarded to Professor Frank Peters, IPIC, in partnership with Rockley Photonics, UCC and Tyndall.

An IPIC delegation travelled with key government stakeholders on a trade mission to the US East Coast where they visited two IBM sites (semiconductor and quantum), ADI and MACOM. This resulted in the forging of stronger relationships and access to other potential collaborators within that ecosystem.

Tyndall's Summer Fellowship Programme 2023 saw 29 fellows selected from 132 applications, 45% of them women. IPIC's EMERGE Awardees have already achieved some notable successes, with Xing Ouyang receiving an IRC Laureate Award and an Enterprise Ireland Commercialisation Fund Technology Development (CFTD) Award. In addition, Zhi Li received an IRC-SFI Pathway Award and Katarzyna Komolibus is recognised as one of only 10 Optica 2024 Ambassadors worldwide. To date four out of the seven successful EMERGE candidates are women.

A total of 183 (67%) of IPIC's PhD and postdoctoral trainees have transitioned to industry, joining global technology leaders such as Agilent, Intel and Meta, and Ireland's scaling SMEs such as Mbryonics and Pilot Photonics.

IPIC team at their 2023 Team Day

CONNECT
Networks of the Future

CONNECT is the SFI Research Centre for Future Networks and Communications. Now in its eighth year, the Centre brings together research expertise from 10 academic institutions with a unified purpose and mission: 'We envision a future of sustainably deployed dependable networks that foster innovation in services and customer experience, empower citizens, and improve quality of life.'

A growing number of Tyndall researchers play leading roles within CONNECT, providing leadership and major contributions to the sustainable IoT theme as well as to the centre's dependable networks, link performance and quantum themes.

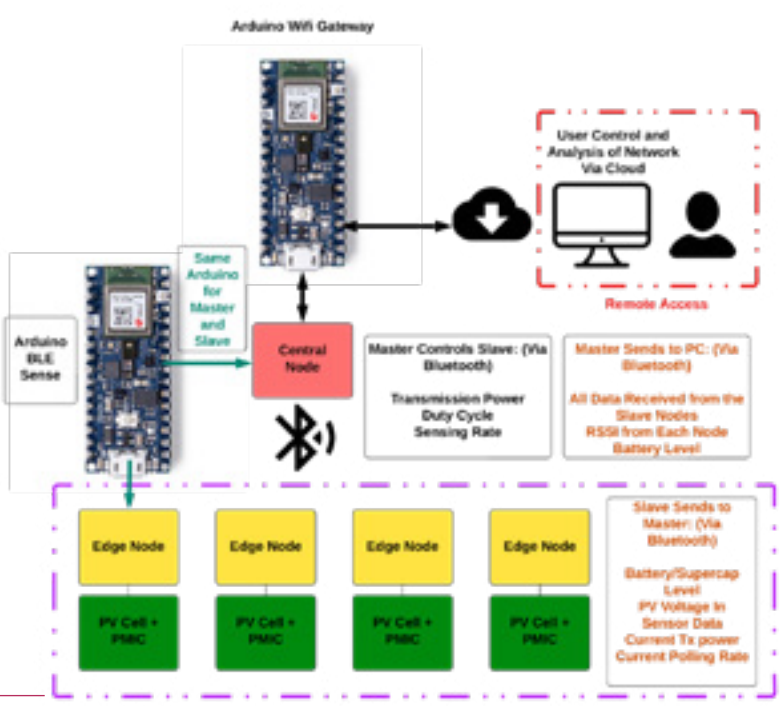
Tyndall's research on energy harvesting, energy storage and sustainable electronics, along with research partners in University of Limerick (UL), National University of Ireland Maynooth (NUIM), and University College Cork (UCC) is central to CONNECT's research activities on sustainable IoT.

In 2023, CONNECT's Future Networks Series was held in Cork. The Resilient Communities event, organised in conjunction with Cork County Council provided an opportunity for industry, local authorities and researchers to uncover the possibilities and potential of the cutting-edge technologies that are shaping the networks of the future.

A presentation and demonstration titled 'EnTiCE – A world first energy harvesting testbed for the internet of things' was delivered to an audience of invited industry and local authority representatives. EnTiCE is funded by CONNECT and led by Tyndall researchers. It affords an opportunity to other researchers and industry partners to explore challenges posed in using energy harvesting in IoT communications networks.

With the support of CONNECT, Tyndall has continued to grow existing engagements and create new collaborations with industry partners through co-funded or wholly funded contracts, building on Tyndall's leading research on the next generation of magnetic components and technologies, wireless technologies and sensor technologies for IoT applications.

Science Foundation Ireland sfi For what's next



Flow chart of the EnTICe energy harvesting testbed, utilising indoor photovoltaic cells to power ultra-low power remote cloud-controlled wireless sensors at the edge

VistaMilk

The VistaMilk SFI Research Centre is an agri-food, ICT, and deep-tech research institute operated in collaboration with leading Irish and multinational food and ICT companies. Funded by both SFI and the Department of Agriculture, Food and the Marine (DAFM), VistaMilk aims to revolutionise the dairy industry through increased innovation and sustainability across the entire dairy supply chain.

Key areas of research at VistaMilk include:

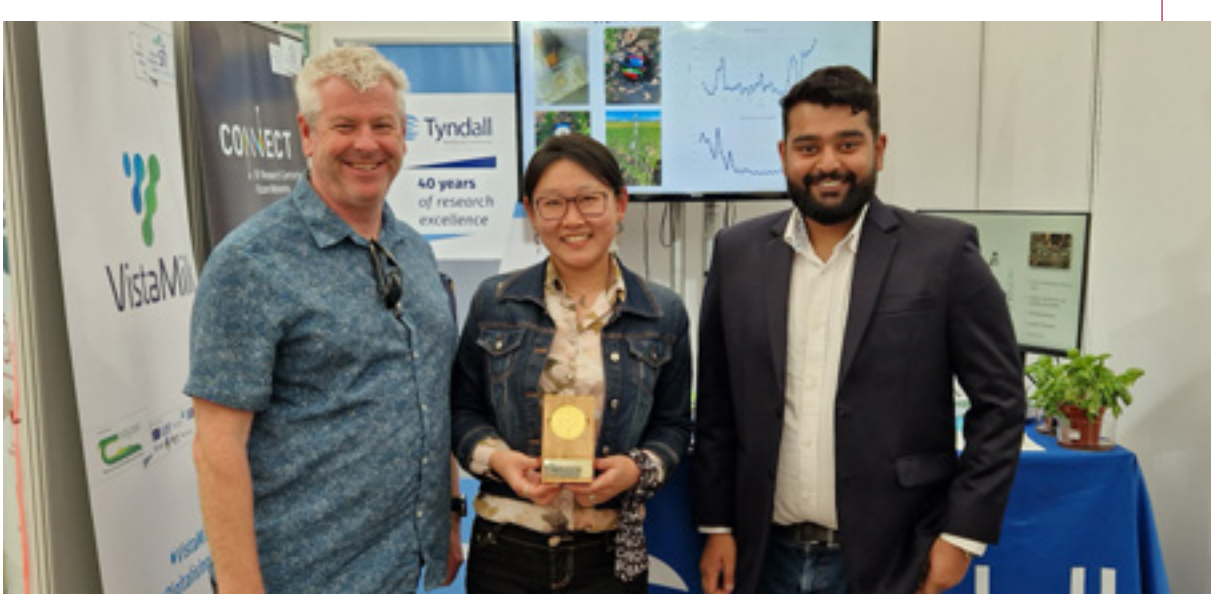
- Pasture and soil management: Investigating sustainable pasture practices, soil nutrient dynamics, and breeding programmes to enhance dairy production
- Animal health and nutrition: Focusing on animal fertility, health diagnostics, and breeding programmes
- Next-generation dairy products: Exploring advanced dairy processes, digestive characteristics of dairy products, and their health benefits for humans
- Agri-tech: Leveraging advanced sensors, data analytics, and systems integration to maximise efficiency throughout the dairy production chain.

Tyndall's contribution during Phase I of VistaMilk centred on development of novel sensors and wearables in collaboration with other researchers and industry. In Phase II of VistaMilk (2024–2030), Tyndall has expanded its focus to include energy and modelling.

VistaMilk's mission extends beyond technological advancements. It aims to positively impact on the environment, animal well-being, and consumer health. By bridging the gap between agri-food and ICT, VistaMilk is at the forefront of precision-based dairy production and processing, ensuring a sustainable and efficient future for the dairy industry.

Science Foundation Ireland sfi For what's next

Dr Alan O'Riordan, Dr Han Shao, and Dr Tarun Narayan, at the 2023 National Ploughing Championships



MCCI
SOLVE THE IMPOSSIBLE

MCCI's mission is to pioneer state-of-the-art microelectronics research through collaborative efforts with industry and other academic institutions. MCCI research strategies span RF/mmW, precision data converters, ultra-low power multi-sensor interfaces, integrated power management and cryo-CMOS with a focus on ultra-low power efficiency.

In 2023, MCCI developed several new industry collaboration engagements with semiconductor MNCs operating in Ireland. These include Analog Devices, AMD, Qualcomm, Infineon, Cadence and many others. MCCI has also developed equally strong engagement activity with Irish-based tech SMEs and is developing a number of research projects in the areas of biomedical, medical and quantum computer applications with companies such as LUMA Vision, BCON Medical, Equal1 and IC Mask Design.

MCCI reached an impressive milestone in 2023, with its 110th researcher transferring to industry since the centre was founded in 2010. One of the key success metrics for the centre is nurturing the next generation of IC design technology leaders for the semiconductor industry.

MCCI PhD student Mikhail Gaidukov was awarded the Analog Devices (ADI) Outstanding Student IC Designer Award 2023 for the EU region for his research on time-based analog front-ends (AFEs).

In 2023, two new IC test laboratories for RF/mmW and integrated power systems were installed in Tyndall. MCCI also secured over €300k in funding as part of the government capital equipment funding call. MCCI will use the funding to grow the cryo-CMOS for the quantum computing research pillar which is currently a very much in demand research topic for industry.

The centre relaunched the IEEE Distinguished Lecturer Series, hosting talks both online and in person. Lectures delivered included:

- 'Transceiver road map to 2035 and beyond': Professor Bram Nauta, University of Twente
- 'Analog compute engine with multi-level cell reRAM': Professor Michael Flynn, University of Michigan
- 'Biomedical and scientific sensing with CMOS SPAD sensors': Professor Robert Henderson, University of Edinburgh
- 'From rocks to chips', a commemorative lecture for the 75th anniversary of the invention of the transistor: Professor Tom Lee, Stanford University.

Enterprise Ireland

Mikhail Gaidukov, PhD student with MCCI and winner of the Analog Devices (ADI) Outstanding Student IC Designer Award for 2023, pictured with Philip Quinlan Analog Devices, John Morrissey MCCI & Daniel O'Hare MCCI

esa space solutions Ireland

Established in 2016, ESA (European Space Agency) Space Solutions Ireland is an innovation and market accelerator platform led by Tyndall with consortium partners Maynooth University, Technological University of the Shannon and University College Dublin (UCD). Local funding support is provided by Enterprise Ireland.

ESA Space Solutions Ireland has supported a total of 35 companies to date through the ESA Business Incubator (BIC). Together these companies have created 165 jobs and raised over €37M in investment to date and each adds to the national cohort of Enterprise Ireland HPSUs.

During 2023, seven early-stage companies joined the ESA BIC programme, receiving a total of €350,000 in funding and access to a network of expert advisors to help accelerate their businesses: Celtonn, Infraprint, MMIC Lab, ServBlock, Solsign, Sports Impact Technologies, and Timing Solutions.

ESA Space Solutions also offers Spark funding for market innovation and two projects, Enbio and PixQuanta, were launched in 2023.

At UCD in May 2023, the Minister of State at the Department of Enterprise, Trade and Employment, Neale Richmond TD officiated at the ESA BIC Ireland Showcase, where he met 25 of the BIC company founders.. The event included an interactive panel discussion and a workshop entitled 'Exploring B2B Business Development for Success'.

A second major in-person gathering took place later in 2023 – the SSI National Networking Event, which was attended by ESA BIC, ESA TTD and ESA Spark Funding recipients and featured in-depth discussions on the challenges associated with scaling a HPSU company.

ESA Space Solutions Ireland also participated in ESA Commercialisation Gateway Network Meetings in Denmark, Norway and Hungary. These annual meetings offer an important opportunity to network with counterparts from 21 other ESA Member States that operate ESA BICs, discuss matters of common interest in the innovation network and build collaboration opportunities between the partners.

Extending beyond the current consortium network, an ESA Space Solutions Ireland 'Tech4Agri' event was hosted in association with the Munster Technological University (MTU) Agri-tech Cluster.

Tyndall and ESA SSI were also delighted to host an inaugural event for the newly-formed Irish Space Association which focussed on empowering collaboration between companies and Irish research performing organisations to drive growth in Ireland's space industry.

Throughout 2023 the Centre also hosted eight 'lunch and learn' webinars, attended by 120 BIC participants, with speakers from the EUSPA (European Union for the Space Agency Programme), Seraphim Capital, Irish Manufacturing Research, Verhaert Innovation and Mindseed, among others.

Enterprise Ireland

Tom Flanagan, UCD Director of Enterprise and Commercialisation; Peter Smyth, Chair, ESA Space Solutions Ireland and Commercial Director, Tyndall; Professor Helen Roche, Interim UCD Vice-President for Research, Innovation and Impact; Minister Neale Richmond TD; Peter Finnegan, Manager, ESA Space Solutions Ireland; Conor Sheehan, National Delegation to ESA, Enterprise Ireland, and Michelle Doyle, Engagement Manager, NovaUCD

Financial report

Income and expenditure summary

Income	2023 €000s	2022 €000s
Government grant	7,000	7,000
Research	41,015	33,009
UCC contribution	2,361	2,241
	50,376	**42,250**

Expenditure	2023 €000s	2022 €000s
Remuneration costs	29,610	27,746
Equipment and infrastructure	2,710	1,462
Consumables and related costs	14,197	12,897
Other operating and deferred costs	3,859	145
	50,376	**42,250**

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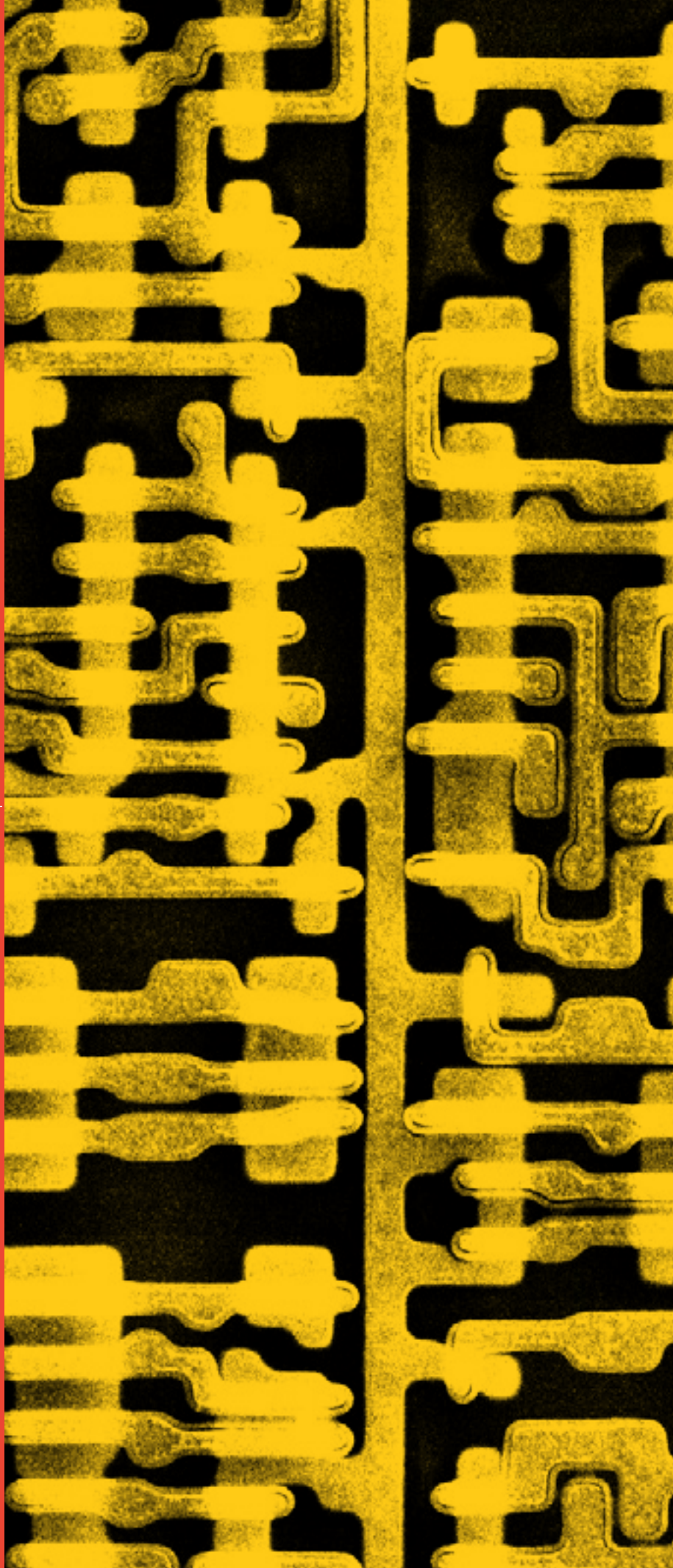
This image, obtained using a Scanning Electron Microscope, shows a detailed view of a small part of the logic area in a power converter integrated circuit. The top layers have been etched away to reveal the gate level, where tiny transistors are located. These transistors act like switches that control the flow of electrical current in the chip. This work was performed to assess manufacturing quality and ensure that the device dimensions meet specifications.



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