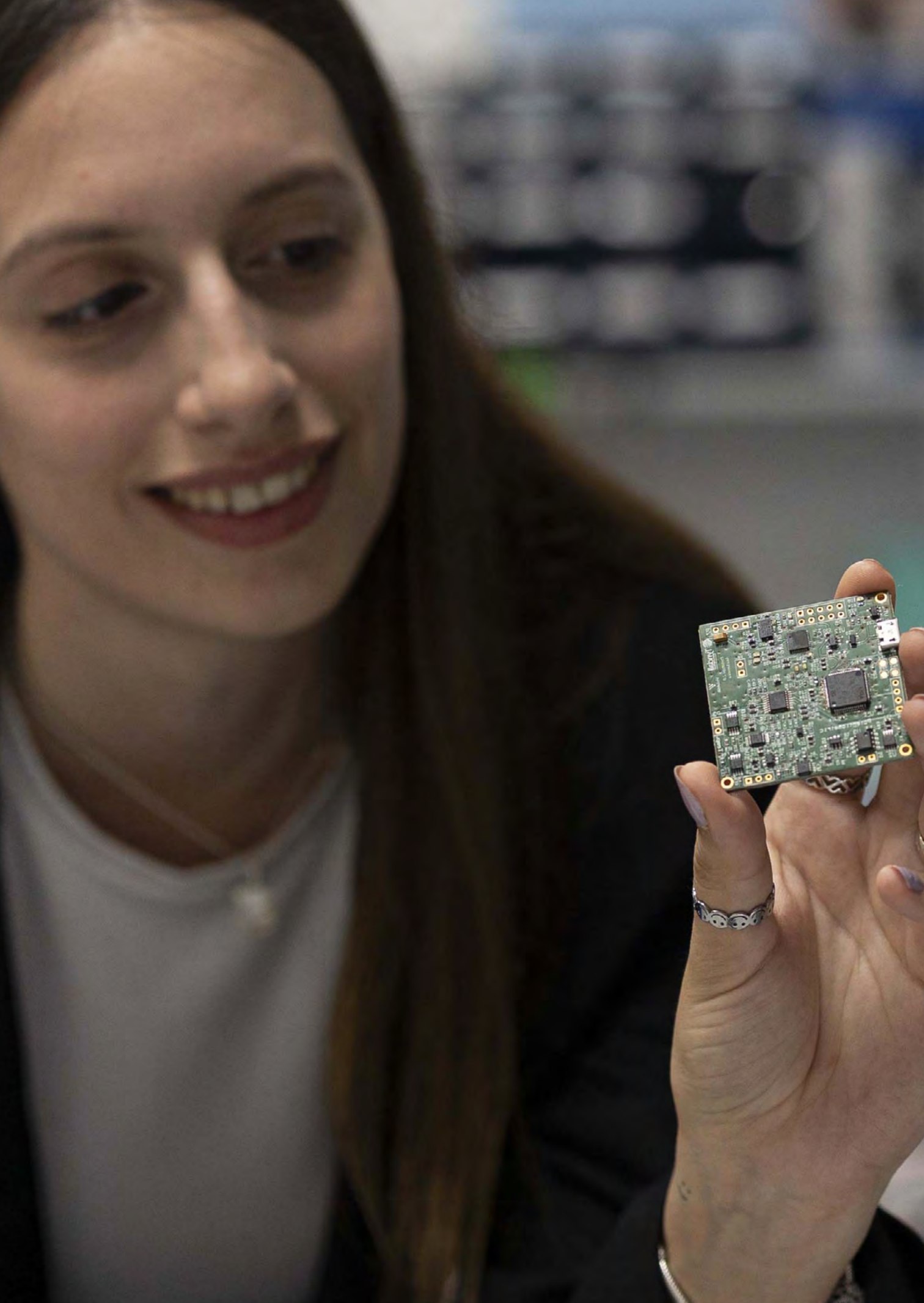
Impact from excellence

Tyndall
National Institute
Institiúid Náisiúnta

2024

Annual report

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh



Contents

Professor William Scanlon, CEO, Tyndall, EU Commissioner Mairéad McGuinness, Professor John O'Halloran, President, UCC, and Dr Denis Doyle, Chair Tyndall Board

Board chair's message

Research excellence is at the heart of everything we do at Tyndall. During 2024, our researchers continued to win prestigious international funding awards and have their research published in top-rated journals. But excellence without impact is of little value and I am pleased to note that Tyndall is now set to play a pivotal role not only in Ireland's future industrial and economic development but Europe's as well.

The European Chips Act is one of the most important pieces of legislation to be enacted in Europe for many years. Semiconductors are central to digitalisation, artificial intelligence (AI), smart manufacturing, quantum computing and all of the other technologies that will shape the world of tomorrow.

CEO's message

Among Tyndall's many outstanding achievements during 2024 was to be chosen as a hosting site for three of the five Chips Joint Undertaking (Chips JU) Pilot Lines under the European Chips Act. Tyndall has also been selected as Ireland's National Competence Centre for semiconductors. In effect, Tyndall has become the portal through which the European Chips Act will be implemented in Ireland. We have also helped to inform and shape the Irish Government's own chips strategy.

During 2024, we began work on our new 5-year strategy that will cover the period from 2026 to 2030. A core element of that strategy will be Tyndall's continued support for Ireland's semiconductor ecosystem, both in the form of our leading-edge research and the highly qualified talent we produce.

I would like to take this opportunity to express my gratitude to Professor William Scanlon and his team, as well as to our students, for their hard work and commitment during what has been another very successful year for Tyndall. That success would not have been possible without the steadfast support of our key stakeholders University College Cork (UCC) and the Department of Further and Higher Education, Research, Innovation and Science. On the same note, I wish to pay tribute to the sterling work of Board Secretary Cormac Harrington who retired from this role after 20 years in October 2024 having never missed a single board meeting during that time.

2024 was another highly successful year for Tyndall. We achieved growth across all pillars of our current strategy, which runs until the end of 2025.

In terms of funding, 2024 was another outstanding year overall. Total funding received by Tyndall in respect of Horizon Europe projects by the end of 2024 reached €43m while our industry partners received a further €23m across 66 projects. That excludes the €78m value of the three Pilot Line projects awarded to Tyndall under the European Chips Act.

However, we are mindful that the industry funding landscape will become much more competitive, and our job will be to ensure that Tyndall has the strongest possible proposition to offer to our partners.

Staff and student levels also set new records in 2024. The total headcount of 580 was the highest ever, while the number of postgraduates also reached a new high.

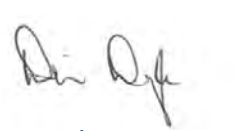
Gender balance is very important and 36% of our postgraduates were women at year end. While this is above average for the science, technology, engineering, and mathematics (STEM) area, it is still short of the 40% target we set ourselves in our current strategy. We must redouble our efforts to meet that target in the years ahead.

Our unwavering focus on research excellence was exemplified by the European Research Council (ERC) Starting Grant award received by Dr Sanathana Konugolu Venkata Sekar and the Research Ireland-Royal Society University Research Fellowship awarded to Dr Boris Galkin.

2024 was also a very good year from a commercialisation point of view. We had one confirmed spin-out company during the year, and two more companies have spun out since the period covered in the report.

During the year, we were delighted to welcome Minister Patrick O'Donovan during his time at the Department of Further and Higher Education, Research, Innovation and Science; outgoing European Commissioner Mairéad McGuinness; and the Board of IDA Ireland – who were able to view our facilities and work at first hand.

Looking to the future, there will undoubtedly be challenges to face, but I am confident that with the continued support of our excellent staff, students, and Board, as well as the Irish Government and UCC, Tyndall will continue to go from strength to strength.



Dr Denis Doyle
Board Chair

Professor William Scanlon
CEO

Scorecard

RESEARCH EXCELLENCE

295 publications

30% in top 10% of all journals

ERC Starting Grant to Dr Sanathana Konugolu Venkata Sekar

Research Ireland-Royal Society University Research Fellowship to Dr Boris Galkin

3 **SFI (Research Ireland) Pathway Awards**

Tyndall-Intel IEDM Paper on 2D Materials

Dr Luiza Wasiewska IRC 2024 Thomas Mitchell Medal of Excellence

IMPACT

87 unique industry partners engaged for research and facilities access

48% of industry funding partners were small and medium-sized enterprises (SMEs)

€8.3M **received in industry funding**

10 industry partners-in-residence

83 industry researchers hosted on-site

1 spin-out launched (HyperPath)

37 industry partners across 10 Disruptive Technologies Innovation Fund (DTIF) projects

INTERNATIONAL POSITIONING

EU PROGRAMMES

€565m total project value | €43m Tyndall grant value |
>€23m to Irish Partners | >€10m to Industry based in Ireland |
66 projects | 15 projects co-ordinated by Tyndall

ASCENT+ ACCESS PROGRAMME

146 granted Transnational Access projects

32 Countries
acquiring access

584 Researchers
benefitting

MARIE SKŁODOWSKA-CURIE ACTIONS

5 Fellowships

2 Doctoral Networks

1 Staff exchange project

1 Co-fund project

PEOPLE AND CULTURE

173
Postgraduate students
(**158** PhDs & **15** Masters)

580
staff/students
51 nationalities

OUTREACH
Engaged with over **1,300** students directly

over **600** primary school students

575 second-level school students

131 undergraduates

Engaged with **4,900** members of the public directly

120 staff/students participated in public events

160 staff/students participated in schools events

27 interns participated in the 2024 Summer Fellowship Programme

78 Transition Year (TY) students participated in TY programmes at Tyndall

INFRASTRUCTURE

327
users trained in the operation of process and analysis tools

377
users to the open access laboratories and cleanrooms

Research excellence

295 publications

30% in top 10% of all journals

ERC Starting Grant to Dr Sanathana Konugolu Venkata Sekar

Research Ireland-Royal Society University Research Fellowship to Dr Boris Galkin

3 **SFI (Research Ireland) Pathway Awards**

Tyndall-Intel IEDM Paper on 2D Materials

Dr Luiza Wasiewska IRC 2024 Thomas Mitchell Medal of Excellence

ERC Starting Grant Awardee Dr Sanathana Konugolu Venkata Sekar

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. 2024 was another successful year for research excellence at Tyndall, with 295 publications, of which 30% are in the top 10% of all journals and 70% in the first quartile, an indication of the quality of research publications.

As part of its continuing commitment to excellence, Tyndall focuses on ensuring the highest standards of integrity in research, and in 2024 it began a series of researcher training programmes to enhance and support the development of researchers. These include the Tyndall EMERGE programme to identify and support promising early-career researchers.

Securing prestigious funding awards is a key ambition, particularly for early-career researchers, and in 2024 Dr Sanathana Konugolu Venkata Sekar was awarded an ERC Starting Grant for his NOBIAS project, while Dr Boris Galkin was awarded a Research Ireland-Royal Society University Research Fellowship.

From the 2024 call, three Research Ireland Pathway awards were secured for Dr Rehka Gautam, Dr Shree Krishnamoorthy and Dr Sabir Hussain. Three Research Ireland PhD and three postdoctoral fellowships were also secured. These awards demonstrate the high quality of early-career researchers at Tyndall and the importance of delivering support for the next generation of research leaders.

Highlights from our 2024 research publications include an International Electron Devices Meeting (IEDM, the leading global semiconductor device conference) paper with Intel on 2D materials. Other publications include Nature Electronics, ACS Nano, and Nanoscale.

Tyndall's research excellence track record was recognised by our participation as a hosting site in three of the five Chips JU Pilot Lines, NanoIC, FAMES and PixEurope under the European Chips Act, which span the research areas where Tyndall is globally recognised.

Dr Luiza Wasiewska was recognised in the IRC Researcher of the Year 2024 awards with the Thomas Mitchell Medal of Excellence for being the top-ranked postdoctoral researcher in the STEM category. Tyndall alumna and former Board member Dr Ann Kelleher (Intel) was awarded the Irish Academy of Engineering (IAE) 2024 Parsons Medal.

Dr Xiuyun He and
Dr Matthew Hall

Tuning magnetic interactions at the nanoscale paves the way for smaller, smarter, and more efficient technologies

Magnetic materials are essential for technologies like computer memory, wireless communication, and energy-efficient electronics and beyond. However, improving their performance requires innovative ways to control their magnetic behaviour at the smallest scales.

In the study, we developed a new type of magnetic material using an affordable and scalable method called electrodeposition, which allows precise control over its structure at the nanoscale. We explored a special kind of magnetic interaction known as an exchange-spring effect, which combines two different magnetic materials at the nanometre (1 nm = 10^{-9} m) level to improve energy efficiency and tunability.

Our research revealed a unique behaviour, called transverse exchange-spring, where magnetic properties can be adjusted without the need for complex multi-layer structures. This discovery was made possible through advanced high-resolution magnetic measurement techniques and computer simulations, which helped us understand how magnetism behaves in these materials.

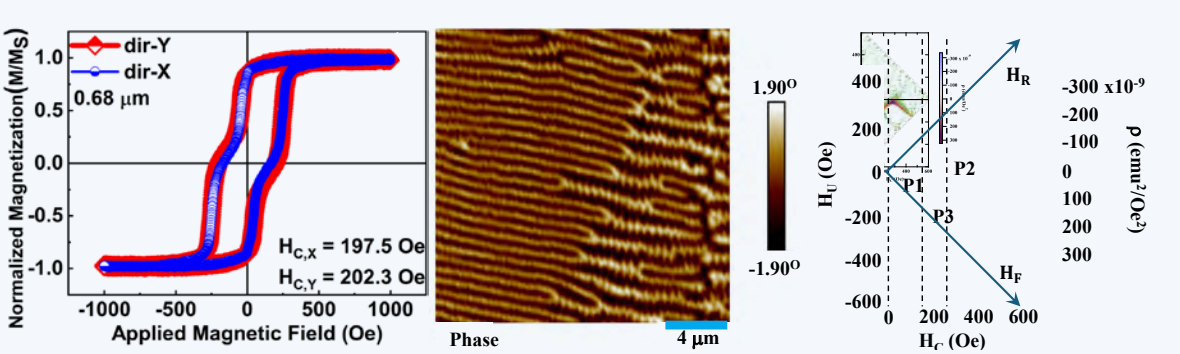
This breakthrough has significant implications for the future of energy-efficient computing and wireless communication. The ability to fine-tune magnetic properties at the nanometre level in a simple, cost-effective way could lead to improved memory devices, faster data storage, and next-generation computing systems that consume much less power. Our findings pave new ways for developing smaller, smarter, and more efficient technologies in the future.

https://pubs.aip.org/aip/apm/article/12/9/091118/3313235/Investigation-of-transverse-exchange-springs-in

Arindam Samanta, Saibal Roy

"Investigation of transverse exchange-springs in electrodeposited nano-heterostructured films through first-order reversal curve analysis." APL Materials 2024

Characteristic stripe-domains in exchange-spring magnetic nano-hetero-structures



New methods of photonic integrated circuit packaging

Integrated photonics, the optical counterpart of electronic integrated circuits (ICs), is a transformative technology that is revolutionising many aspects of optics, such as communications, computing, sensing, spectroscopy, imaging, beam steering, and quantum information.

These far-reaching impacts are made possible because photonic integrated circuits (PICs) can be manufactured capitalising on standard semiconductor fabrication technologies in foundries. Unlike PIC chip manufacturing, photonic packaging, which creates optical, electrical, thermal, and sometimes even chemical interfaces of PICs with other components in an optoelectronic system, is subject to a significant bottleneck attributed to the unique technical challenges.

Tyndall researchers are at the forefront of tackling those challenges by developing novel types of optical interfaces with the PICs that allow them to be deployed in a pluggable manner, similar to how various interfaces on a computer allow the extension of their functionality or communication with peripherals. This is achieved by employment of microscopic lenses that manage the optical connection between the chip and (typically) a fibre network.

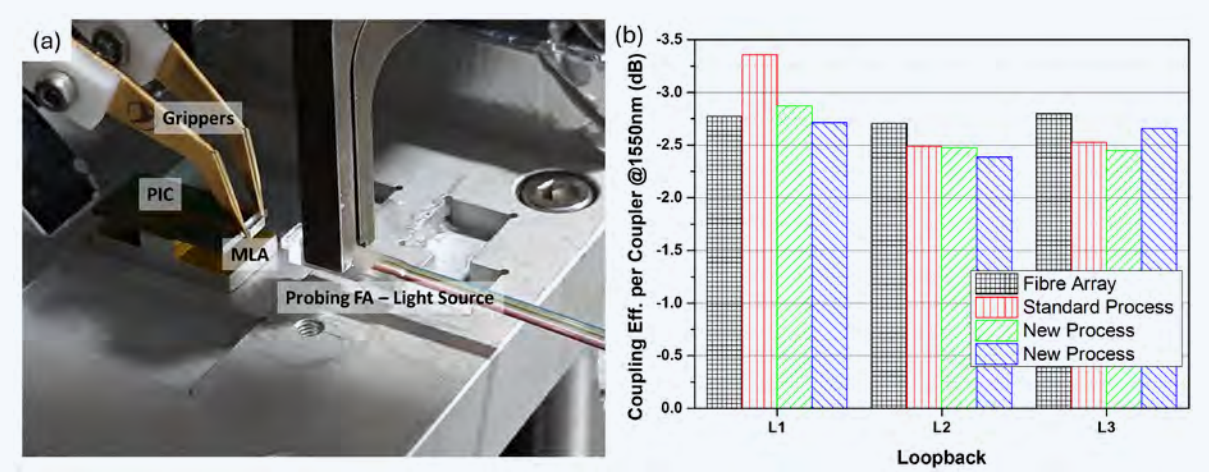
The assembly of these lenses to the PICs is currently labour-intensive, which is why our research concentrates on developing methods for automation that will allow for high-volume manufacture of cost-effective photonic devices.

https://iopscience.iop.org/article/10.1088/2515-7647/ad5bd2

Kamil Gradkowski, Patrick Morrissey, Peter O'Brien

"Packaging of micro-lens arrays to photonic integrated circuits using beam shape evaluation." JPhys: Photonics 2024

New processes for attachment of micro-lenses demonstrate good, reliable performance of the optical link



Improving electrophysiological monitoring with flexible and conductive fabric-backed microneedles

The aim of this work was to develop microneedle-based electrodes usable for electrophysiological monitoring applications, including electrocardiogram and electromyography (ECG and EMG) diagnostics.

These painless devices provide a better long-term alternative to commonly utilised wet electrodes not only by removing the need for skin preparation, which is time consuming and often uncomfortable for the patient, but also by avoiding the use of gel to improve signal quality.

The needles' substrate, which is formed from a conductive fabric, renders the electrodes flexible and able to easily conform to the curved surface of the body. In addition, the simplified production process results in a reduction in fabrication costs and time when compared with that of other dry electrodes.

Finally, being textile-backed, these devices have the potential for integration with clothing, making them ideally suited for use in continuous monitoring and consumer lifestyle applications.

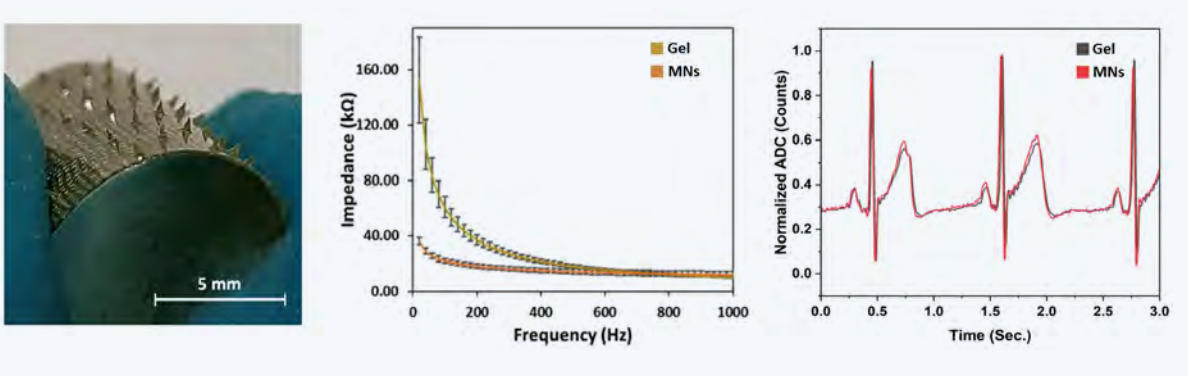
Following ethical approval, the electrodes were tested on a small cohort of healthy volunteers and showed excellent performance under both static and dynamic conditions, with no skin irritation after a 48-hour wear period. This comprehensive study illustrated the compatibility of the devices with normal daily activities, as well as their significant promise for use in long-term wearable applications.

https://advanced.onlinelibrary.wiley.com/doi/10.1002/admt.202301606

Om Prakash Singh, Andrea Bocchino, Theo Guillerm, Yuan Hu, Frank Stam, Conor O'Mahony

"Flexible, conductive fabric-backed, microneedle electrodes for electrophysiological monitoring." Advanced Materials Technologies 2024

Use of Tyndall's novel fabric-backed, microneedle-based dry electrodes (left) results in a significant decrease in skin-electrode impedance when compared to conventional wet electrodes (centre), and facilitates the capture of ECG signals with a resolution comparable to that of commercially available electrodes, but without the requirement for skin abrasion or the use of wet gel (right)



Advancing 2D materials for semiconductor integration: A collaborative project with Intel

Two-dimensional (2D) materials hold immense potential for CMOS (complementary metal–oxide–semiconductor) technology scaling, offering advantages for next-generation nano-electronic devices.

However, the inevitable formation of grain boundaries (GBs) in large-area grown films remains a critical yet underexplored challenge, impacting device electrical properties. Through a collaborative project with Intel, we aim to address this fundamental barrier, paving the way for their seamless integration into semiconductor manufacturing.

This work advances the understanding of GB-induced performance variations in ultra-scaled 2D transition metal dichalcogenide (TMD) devices. Specifically, it investigates the impact of GBs on NMOS and PMOS transistors through a combination of Density Functional Theory (DFT) simulations and experimental validation. The findings provide crucial insights into defect-engineering strategies to enable next-generation 2D CMOS technology.

A key outcome of this project was the presentation of our results at the prestigious IEDM, underscoring its novelty and technological relevance. Additionally, the work establishes a strong correlation between theoretical predictions and experimental observations, offering a clearer understanding of how defects influence charge transport. A significant breakthrough was the development of an Atomic Layer Deposition (ALD) decoration technique, enabling the visualisation and characterisation of linear defects in MoS2 transistors. Furthermore, advanced quantum transport simulations were conducted to analyse the effects of GBs on the electrical performance of NMOS and PMOS devices. These contributions directly address variability challenges in 2D materials and have significant implications for their practical adoption in semiconductor manufacturing.

https://ieeexplore.ieee.org/abstract/document/10873322/

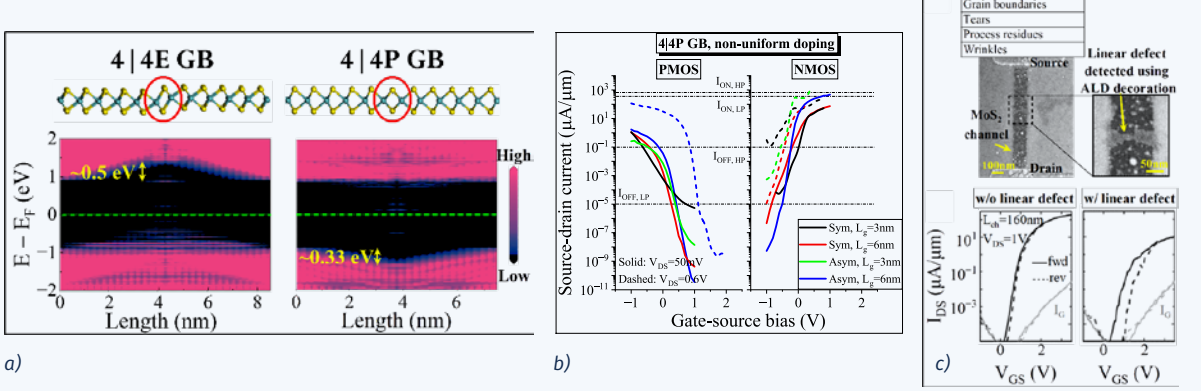
Lida Ansari, Andrey Vyatskikh, Chelsey Dorow, Saurabh Kharwar, Sharieh Jamalzadeh Kheirabadi, Paul K Hurley, Luca Camilli, Manuela Scarselli, Matthew Shaw, Lutfe Siddiqui, Ashish Penumatcha, Kevin O'Brien, Carly Rogan, Scott B Clendenning, Jessica Torres, Uygar Avci, Farzan Gity

"Correlation of TMD Defects with Device Performance in Ultra-Scaled Channels: Theoretical Insights and Experimental Observations." 2024 IEEE International Electron Devices Meeting (IEDM)"

a) Projected local density of states (PLDoS) of intrinsic structures, highlighting the impact of two GB types on the conduction and valence bands

b) Transfer characteristics of PMOS and NMOS devices with a monolayer MoS2 channel, illustrating the effect of the 4|4P GB type on device performance

c) MoS2 channel decorated using Al2O3 deposited with ALD, illustrating four possible linear defects. (Bottom) Transfer characteristic curves of devices with and without linear channel defects, demonstrating their impact on performance




MCCI
ASIC Architecture and Packaging for Enhanced Intravascular Echocardiography
DIFGUARD
Tyndall

Impact

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Chinnu Liz Babu

Tyndall makes a vital contribution to the research and innovation landscape in Ireland by bringing together small and medium-sized enterprises (SMEs), multinational corporations (MNCs) and the research community on-site for research collaborations. 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 87 direct industry engagements in 2024.

During 2024, there were 10 industry partners 'in-residence' at Tyndall, with a total of 83 industry researchers approved for laboratory access, and SMEs accounting for half of the companies on-site. Working with UCC Innovation, we completed an intellectual property (IP) assignment as well as 4 new patent filings, and we received 1 patent grant.

Our industry partners directly funded €8.3m in research and support at Tyndall, which represented 15% of Tyndall's total income for the year. Non-domiciled industry income was also strong, at 21% of our total industry funding, and we delivered research and support to 42 SMEs during the year.

Forward-looking industry programme funding commitments remained healthy during 2024, a strong indication of Tyndall's critical and expanding role in Ireland's industrial research ecosystem.

Under the current Strategic Plan, Tyndall recognised the need to diversify its industry partner base with a focus on international reach. The target set for non-domiciled industry income is 20%, which we have exceeded each year. Of particular focus has been Asia, specifically Japan, where together with Japanese industry partners like Tokyo Electron we have secured new partners such as Taiyo Yuden, with which we are now into our fourth year of joint research. We have also developed a very strong pipeline of deep tech Japanese companies in both photonics and magnetics. We have partnered closely with other state agencies, such as the IDA, which has supported visits to Japan.

Visit by Patrick O'Donovan TD, Minister for Further and Higher Education, Research, Innovation and Science

Spotlight on DTIF-funded technological innovations

In 2024, Tyndall held an event to showcase its groundbreaking research developed through the Department of Enterprise, Trade and Employment's Disruptive Technologies Innovation Fund (DTIF) programme.

The Fund, which is administered by Enterprise Ireland, has allocated €371m to 104 successful projects approved under six DTIF calls thus far. The projects cover areas such as life sciences, medical devices, information and communications technology (ICT), artificial intelligence (AI), manufacturing, and environmental science.

Tyndall has actively contributed to the DTIF programme, participating in 10 projects to date, and we plan to submit further proposals under the current DTIF call.

The showcase event highlighted technology advancements in the areas of medtech, maritime surveillance and drug interdiction, and photonics manufacturing.

One of the showcase projects was GUARD, which has developed world-leading smart drone technology that can efficiently survey large areas of coastline. The aim of the project is to enhance maritime surveillance and drug interdiction through equipping new medium-range drones that have vertical take-off and landing (VTOL) capability, can travel 800 km and can land safely at sea on vessels or on land. The GUARD project is a collaboration between Tyndall, A-techSYN, VRAI, WAZP, University College Dublin (UCD), and University of Limerick (UL), with significant input from the Irish Naval Service.

Other projects on showcase at Tyndall's event were the Perceive and Photonics Pilot Line projects.

The Perceive project, a collaboration between Tyndall, Microelectronic Circuits Centre Ireland (MCCI), Lumavision and Freudenberg, is developing an ultrasound-based catheter imaging system to improve the treatment of atrial fibrillation – a heart condition which causes an irregular heart rhythm that can lead to heart failure or stroke.

The Photonics Pilot Line project has established a dedicated open-access facility for early-stage manufacturing of emerging photonic-based products, which will address key technological and manufacturing challenges for the second digital revolution. This project is a collaboration between Tyndall, ficonTEC Service GmbH, mBryonics, Eblana Photonics, Sanmina and Optics11.

Speaking at the DTIF showcase event, Dr Imelda Lambkin, Manager of the Disruptive Technologies Innovation Fund at Enterprise Ireland said:

"It is fantastic to see the first ground-breaking technologies emerging from the DTIF portfolio. My congratulations to all of the consortium partners on these projects. With the announcement of the latest Call 7 for applications we're open for business and looking for new collaborations between companies and researchers to develop and deploy disruptive technologies and applications on a commercial basis."

Denis Collins, A-techSYN, Gokhan Celik, CEO, A-techSYN and Mark Mellet, Chair of the Maritime Area Regulatory Authority at Tyndall's DTIF showcase event

ANDES: Advancing 5G and beyond with realistic network simulation

The ANDES project is a collaboration between Tyndall's Wireless Communications Laboratory and Analog Devices, focused on developing an innovative and highly flexible 5G network system simulator. It is jointly funded by Analog Devices and the Research Ireland CONNECT Centre. As next-generation wireless networks grow in complexity, there is an increasing need for advanced tools that can model, evaluate, and optimize their performance under realistic conditions.

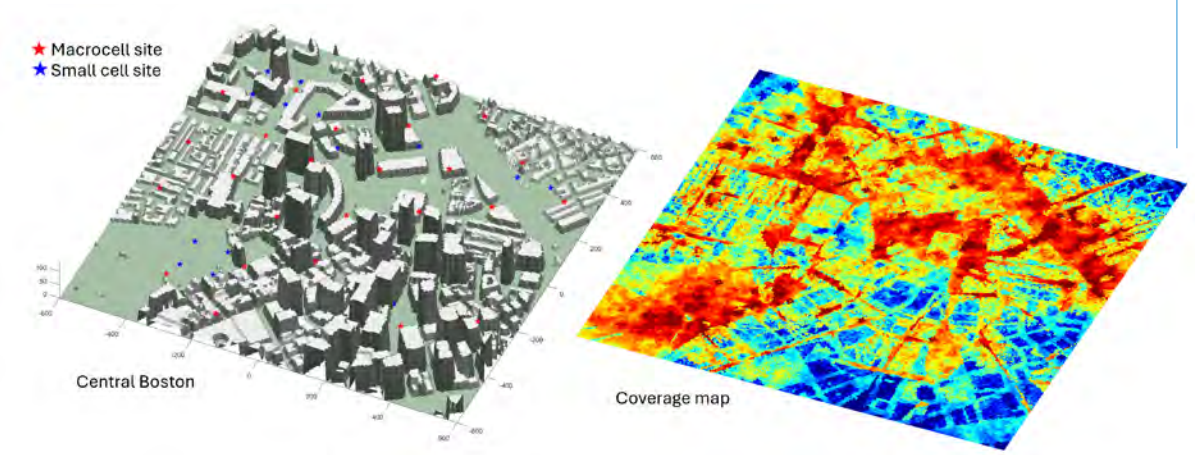
ANDES addresses this challenge by integrating comprehensive models of the radio environment, network infrastructure, and user behaviour into a unified simulation framework.

ANDES captures the detailed interactions that shape the end-to-end performance of 5G networks using ray tracing, stochastic or hybrid channel models. By leveraging open-source databases, it can automatically configure and simulate real-world network scenarios in a wide range of scenarios, ranging from large-scale heterogenous outdoor deployments to complex indoor factory deployments.

A key strength of ANDES lies in its ability to support rapid prototyping and validation of novel technologies for both 5G and future 6G networks. Researchers and industry partners can use the simulator to develop and validate novel technologies, from advanced radio access techniques to intelligent network automation, within a realistic and controlled environment. This accelerates the innovation cycle, reduces development costs, and bridges the gap between theoretical research and practical deployment.

The ANDES project exemplifies the power of industry-academia collaboration in driving technological advancement. By combining Analog Devices' expertise in high-performance wireless systems with Tyndall's research excellence in network optimization and simulation, ANDES is poised to become a vital tool for the design and evolution of future communication networks.

Automatically generated cellular network layout of central Boston and its corresponding coverage map, computed using the ANDES simulation tool



New ventures

In 2024, one new spin-out was created in Tyndall. HyperPath executed a Licence and Shareholders' Agreement with UCC in December 2024. The company is the first new venture to emanate from Tyndall's Wireless Communications Laboratory in Dublin. The spin-out's co-founders are Professor Holger Claussen, Dr Kariem Fahmi and Ger McNamara. Holger and Kariem are Tyndall researchers while the company's CEO, Ger McNamara, was recruited through Enterprise Ireland's Business Partners Programme.

HyperPath's proprietary software solution addresses the issue of poor connectivity. The team has developed software that allows users to connect devices in any location with high reliability and minimum delay using a novel combination of link bonding, peer-to-peer communication, and software-defined networking. The net effect of HyperPath's solution is that it seamlessly boosts connectivity, reduces cloud costs and minimises latency. The project was supported by the Enterprise Ireland Commercialisation Fund. An early win for the company was its selection to become part of the ESA BIC (European Space Agency Business Innovation Centre) Ireland network, which will see the company securing a number of business, technical and financial supports.

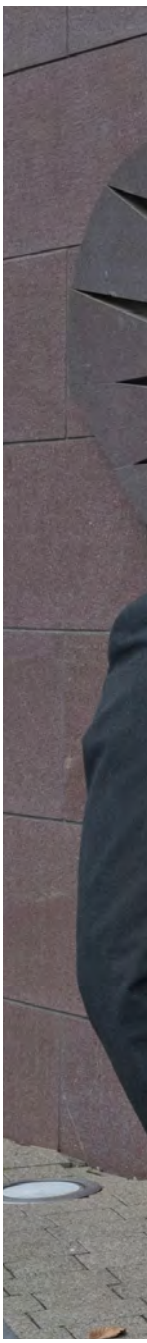
There were significant developments in relation to two other emerging spin-out opportunities from IPIC, the Research Ireland Centre for photonics and MCCI during the reporting year, both of which were completing Enterprise Ireland Commercialisation Fund projects. It is envisaged that this will result in the creation of two new spin-out companies during the first half of 2025.

A total of nine Enterprise Ireland Commercialisation Fund projects were ongoing or completed during 2024, while three new feasibility studies were completed in the field of biophotonics and nutrient sensors.

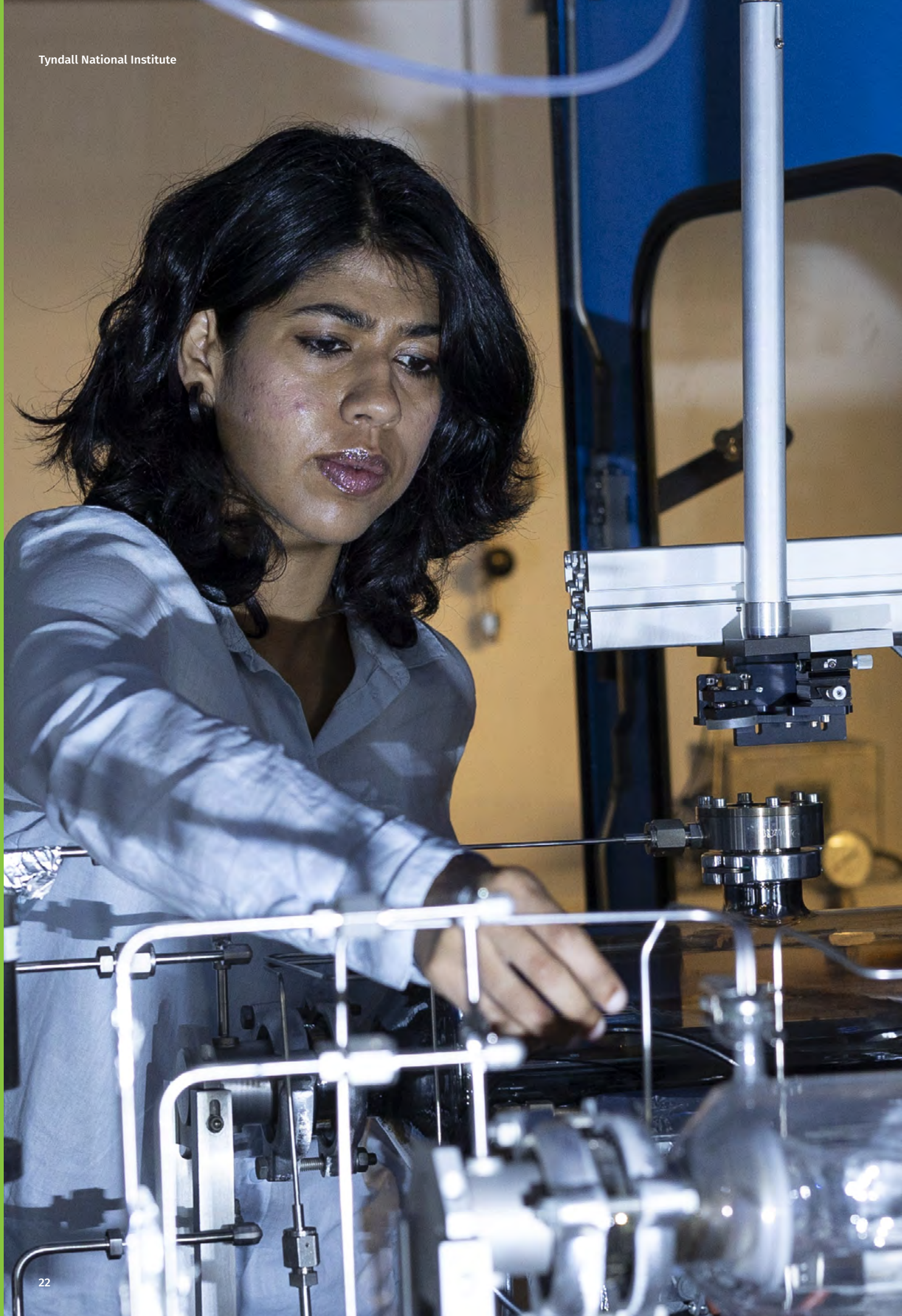
In Q1 2024, Tyndall hosted the second Partner Opportunity Platform event, which attracted 20 commercialisation teams from across the island of Ireland and over 50 prospective commercial leads and business advisers. The objective of this event was to forge relationships between researchers engaged in the development of commercialisation projects with individuals interested in becoming a member of a spin-out team or providing advisory support to that team. Four Tyndall commercialisation projects were showcased at this event.

The fourth edition of the Explorer Pre-Commercialisation Programme was also delivered during 2024. The Explorer Programme is a collaboration led by the IPIC, together with Tyndall National Institute, ams-OSRAM, CONNECT Centre, and supported by Enterprise Ireland, Atlantic Bridge Ventures, Important Projects of Common European Interest (IPCEI), NovaUCD, eg technology, Ireland's microelectronics industry association MIDAS, and Research Ireland. A total of seven teams completed the 12-week programme, of which four were from Tyndall. The Explorer Showcase was held for the first time in Enterprise Ireland's headquarters at Eastpoint, Dublin.

Another important development during the year was the announcement that the funding application to deliver the I-C3 EU Competence Centre was successful. This will positively impact on Tyndall's new ventures agenda, with the recruitment of an Investor Relations Executive during this 4-year initiative.



Míchéal Collins, UCC, Peter Finnegan, Tyndall, and Simon Factor, UCD



Tyndall National Institute

International positioning

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1 Staff exchange project

1 Co-fund project

Swati Mukherjee,
PhD student

Visit of his Excellency Shri Akhilesh Mishra, Indian Ambassador to Ireland

During 2024, significant progress was made towards positioning Tyndall as a European R&D Hub that is internationally recognised for driving research and innovation to address global challenges. Our thought leaders have remained instrumental in shaping research strategic agendas and technology roadmapping, while our direct collaborations and partnerships with global technology leaders have expanded.

Thought leadership

Tyndall continued to provide support to Irish policymakers by submitting a consultation document on Ireland's semiconductor strategy which has been launched in response to the European Chips Act. A separate submission was made by Tyndall on Ireland's Draft Cyber Industrial Strategy.

Tyndall researchers have also been involved in Alliance for AI, IoT and Edge Continuum Innovation (AIOTI) white papers on the 'Role of 6G in agriculture', 'Edge IoT in industrial technologies' and an ICOS white paper on 'Generic challenges and international cooperation in semiconductors'.

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

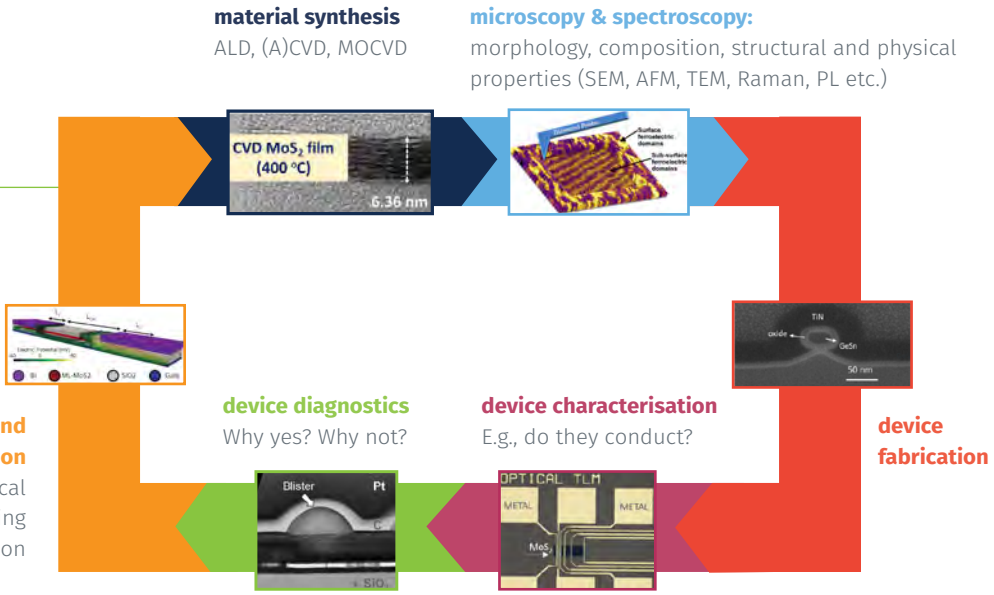
In 2024, our researchers were invited to lead the 'More than Moore' chapter in the International Roadmap for Devices and Systems (IRDS), a 15-year roadmap under IEEE sponsorship that outlines industry indicators and trends to quantify technology and system requirements.

Partnerships

Tyndall partnerships across the globe grew during 2024, with significant engagement not only within the European Union (EU) but also within the United States of America (USA), Japan 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 €14m in funding secured in 2024. Projects funded included UniversWater which aims to develop and improve technologies to optimise water resource use, QCEED which aims to create semiconductor quantum dot systems that will pave the way for scalable quantum photonic computation, and BUSHROSSs which aims to assist homeowners achieve energy efficiency improvements during the residential building refurbishment process.

Dr Sanathana Konugolu Venkata Sekar, a researcher at IPIC has received a prestigious ERC Starting Grant award to support his groundbreaking research that aims to eliminate skin colour bias in healthcare.

Tyndall's agile lab-to-fab feedback loop for new materials integration into devices in the NanoIC pilot line



Our links with India continued in 2024 with a Tyndall delegation visiting the Indian Institute of Technology (IIT) Hyderabad and the Indian Institute of Science (IISc) to enhance our partnerships through signed memorandums of understanding (MoUs), including adjunct professorships. In March 2024, his Excellency Shri Akhilesh Mishra, the Indian Ambassador to Ireland visited Tyndall to promote collaboration between the two countries.

Links have also been formed between Tyndall and Keio University in Japan and there are now plans in place to increase research collaborations in the areas of semiconductors, photonics, and advanced packaging as well as on the development of new training programmes for students and the future workforce.

In the USA, Tyndall has partnered with the Massachusetts Institute of Technology (MIT) to develop sustainable semiconductor chips production processes, and with Ohio State University on innovative photonics research.

Large-scale projects

Tyndall leads access programmes that offer an entry point for academic and industry researchers to state-of-the-art tools, platform technologies and expertise at leading European research and technology organisations. The ASCENT+ research infrastructure project drew to a close during 2024. This was followed by the commencement of the larger research infrastructure project, INFRACHIP.

Responding to challenges set out in the EU Chips Act, work on the INFRACHIP project got underway in 2024 and facilitates access to state-of-the-art technologies in the field of semiconductors to accelerate research and innovation for the sustainable development of next-generation and future semiconductor chips.

Aligning further with the European Chips Act, 2024 marked Tyndall's participation in pan-European initiatives with significant impact on research and innovation capacity under the Chips JU. The Chips JU is the primary implementation body of the Chips for Europe Initiative which is supported by €3.3bn of EU funds. Tyndall is hosting partner in three of the Pilot Lines foreseen under the Initiative. The aim is to bridge the gap between research and innovation (R&I) and industrial activities, and to promote the adoption of innovative technologies by EU businesses. Tyndall also partners in the Chips JU project GENESIS which brings together a consortium of 60 members to tackle the challenge of green manufacturing and the development of PFAS-free materials for the semiconductor industry.

Chips Joint Undertaking Pilot Lines

Tyndall participates in three out of the five Pilot Lines approved by the Chips JU. The Pilot Lines are led by EU research and technology organisations and co-funded by the European Council and the participating Member States, including Ireland. The Pilot Lines will be the key aggregators of semiconductor R&I capacity and will drive the closing of the innovation gap from lab-to-fab by translating lab research into manufacturable semiconductor technologies and delivering prototype products for industry uptake.

Tyndall is a hosting partner in the NanoIC, FAMES and PixEurope Pilot Lines. NanoIC, led by imec, focuses on state-of-the-art research on systems-on-chip based on beyond-2nm logic nodes and includes Tyndall pathfinding on the integration of emerging materials for embedded DRAM.

FAMES, led by CEA-Leti, has a focus on advanced fully depleted silicon-on-insulator nodes integrated with non-volatile memories and 3D options, RF components and smart power management for integrated circuits (PMICs). Tyndall will improve power delivery by advancing our integrated magnetics platform for high-performance miniaturised inductors and developing micro-transfer-printing technology for the on-chip integration of passive components.

Finally, PIXEurope PL sets the foundations for advanced photonic integrated circuits, including standards for their design and fabrication, assembly, packaging and testing. Tyndall leads the development of packaging technologies and has a significant role in the delivery of the gateway for prototyping and technology transfer, including training.

Dr Dominique Noguet, CEA, Dr Inge Asselberghs, imec and Eimear O'Mullane, Tyndall

ASCENT+: An EU-funded platform enabling access to infrastructures for research activities

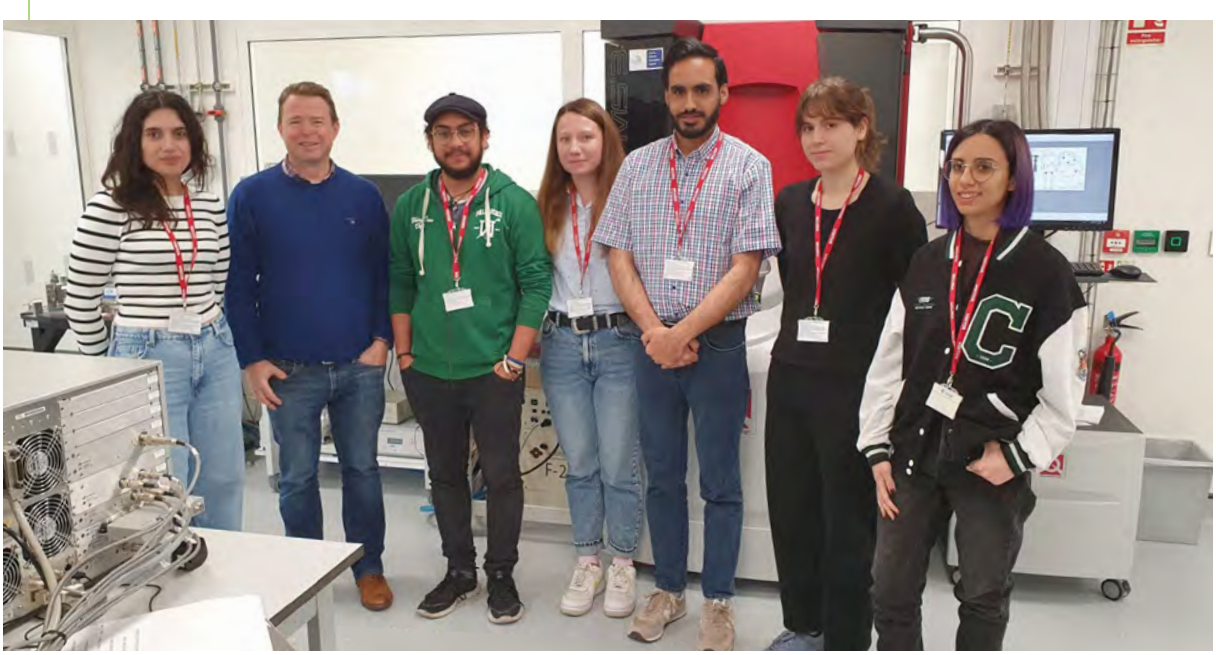
The aim of the ASCENT+ programme, funded by the EU under Horizon 2020, was to accelerate innovation in micro and nano-electronics by providing access to leading European research infrastructures: Tyndall National Institute (Ireland), CEA Leti (France), Fraunhofer Mikroelektronik (Germany), INL (Portugal/Spain), and imec (Belgium).

Building on the first ASCENT programme, ASCENT+ increased its impact over four and a half years, creating a European platform with 14 partners and a strong community of 3,000 members. Through its Transnational Access (TA) programme, ASCENT+ offered more than 70 research platforms, using approximately 140 tools, at no cost to researchers. Over 550 researchers, including 65 PhD and 32 Masters students, benefitted from the programme, with 20% of the access projects supporting industry, particularly SMEs.

ASCENT+ also launched the Research Accelerator Programme, which enabled selected early-career participants to visit research facilities, receive training, and enhance their technical skills. This initiative strengthened collaboration and provided valuable insights into European research infrastructure.

The project resulted in 60 scientific publications, including 14 directly linked to TA projects and 40 from joint research activities (JRAs). These JRAs contributed to technological advancements, improved TA services, and facilitated knowledge exchange between researchers and infrastructure providers. Several proof-of-concept technologies developed under ASCENT+ are now progressing towards higher technology readiness levels.

More than 100 professionals were involved in implementing the project, fostering collaboration across academia, research institutes, and industry. Notably, 62% of completed TA projects led to further joint efforts, highlighting ASCENT+'s success in building lasting partnerships. The achievements of ASCENT+ will support further investment in other EU initiatives to continue accelerating European innovation, in line with the ambition of the European Chips Act.



Eoin Sheehan with ASCENT+ visitors attending the Researcher Accelerator Programme

People and culture

173
Postgraduate students
(**158** PhDs & **15** Masters)

580
staff/students

51 nationalities

OUTREACH
Engaged with over **1,300** students directly

over **600** primary school students

575 second-level school students

131 undergraduates

Engaged with **4,900** members of the public directly

120 staff/students participated in public events

160 staff/students participated in schools events

27 interns participated in the 2024 Summer Fellowship Programme

78 Transition Year (TY) students participated in TY programmes at Tyndall

Tyndall's Cultural Day

In 2024, Tyndall had 580 staff and students, including 173 PhD and Masters students.

Tyndall was delighted to welcome Claire Cooke to the role of People and Culture Manager. Claire joined us from Munster Rugby where she was Head of Human Resources for over 23 years.

The second Tyndall People Survey was undertaken in January 2024. This survey offers all staff and students the opportunity to share their experiences of working and studying in Tyndall. Following the survey, working groups were established to review the feedback received. An action plan has been finalised and incorporated into the People and Culture Programme Plan, reinforcing our commitment to culture change.

Other notable initiatives from the People and Culture Programme included the launch of a new communications campaign, 'Good to Know', raising awareness of the important benefits and policies in place to support staff and students. A Leadership Forum was established to strengthen our community of leaders at Tyndall. Our Equality, Diversity and Inclusion (EDI) team continued to go from strength to strength, championing EDI and celebrating the vibrant mix of cultures here at Tyndall. With a focus on positive behaviours in 2024, the Bystander Intervention Training and the Duty of Care and Right to Dignity policy were strongly promoted.

Our recognition programme continues to evolve, and 2024 saw the introduction of two new awards at the Tyndall Annual Recognition Awards (TARAs): People and Culture Champion (team and individual). These awards recognise the importance of creating and championing positive culture in the workplace, and we were delighted to acknowledge and celebrate this.

The work on gender equality continued in 2024, as we continued to make progress on our Athena SWAN Action Plan, following our Bronze Award in 2022. The Athena Swan Charter is a framework used around the world to support gender equality in higher education and research.

Tyndall's Annual Recognition Awards (TARAs)


Tyndall National Institute


People & Culture Team of the Year
Award Winner
Biophotonics Team
Photonics
TARA
Tyndall
Tyndall
Tyndall
Tyndall
Tyndall


PUMA

Education and public engagement

In 2024, 280 staff and students from across the Institute participated in education and public engagement (EPE) activities. These efforts allowed us to directly engage with over 1,300 school and undergraduate students, as well as 4,900 members of the public.

A highlight of 2024 was the return of our in-person Culture Night event, co-ordinated by Alida Zauers. This was the first time since 2019 that the event took place on-site after the COVID-19 pandemic. On 20 September, Tyndall opened its doors from 5pm to 7pm for an evening dedicated to celebrating science and technology. During this event, 121 members of the public had the chance to meet 43 of our scientists, who presented their cutting-edge research. Attendees learned about electronics and photonics (the science of light) through nine demonstration stands, three short talks, and four STEM activities designed for children. Children were particularly engaged, as they created their own illuminated greeting cards and spectroscopes to explore the science of light and electronics.

At the Tyndall Annual Recognition Awards (TARAs), PhD student Hati Yavari was recognised as the EPE/Outreach Person of the Year for her outstanding contribution and commitment to EPE activities and events throughout the year.

At third level, 27 undergraduate students were awarded places in the 2024 Tyndall and IPIC Summer Fellowship Programme, which ran for 12 weeks from June to August and was coordinated by Dr Caitríona Tyndall. The Summer Fellowship Programme received the STEM in Education: Educational Initiative of the Year award at the STEM South West Awards 2024. This award celebrates educational institutes, departments, and classroom-led initiatives (at primary, second level, and third levels) that promote the creation of inclusive and supportive educational environments for STEM.

Culture Night 2024 at Tyndall


Tyndall
National Institute
Addressing
Societal Challenges
Through Deep-Tech
Innovation
Materials | Devices
Circuits | Systems
www.tyndall.ie
UCC
2040
Tyndall CONNECT
STEM
IPIC
Classmaster

PhD Vivas 2024

Aaron O'Donoghue

Nanoscale energy storage materials and architectures

Ali Uzun

Quantum dot laser integration on silicon photonics using transfer printing

Amit Tanwar

Development of micro-thermoelectric generator (μ-TEG) for powering wearable devices

Arindam Samanta

Nanostructured magnetic materials for integrated magnonic devices

Ayse Atar

Surface dynamics in III-V epitaxy and its device implications

Celina Li

The potential role of optical guidance for bone-related biomedical applications in orthopaedics and neurosurgery

Giovanna Ricchiuti

Novel approaches in mid-infrared photothermal spectroscopy (PTS): from the benchtop to the chip

Hemalatha Muthuganesan

Micro-transfer print integration of high-speed photodetectors to SOI platform

Hilmi Othman

Ultra-low cost burst mode coherent transmission system with digital optical bandwidth interleaving receiver

Iman Ranjibar Jahromi

Evaluation and properties of site-controlled pyramidal quantum dots for quantum information processing

Joshua McMahon

Theory of radiative and non-radiative recombination processes in nitride-based heterostructures

Lorenzo Niemitz

Micro-cameras as adjunctive tools in biomedical applications

Megan O'Brien

Towards a GaN-on-sapphire photonic integrated circuit via micro-transfer printing

Nadeem Rather

AI-enabled chipless RFID sensing system for reliable IoT applications

Natalia Canas Estrada

Enabling high band rate terabit superchannels

Niall Boohan

Design and modelling of feedback insensitive lasers

Rita Mullins

Modelling of thin film oxide growth and etching

Sandeep Singh

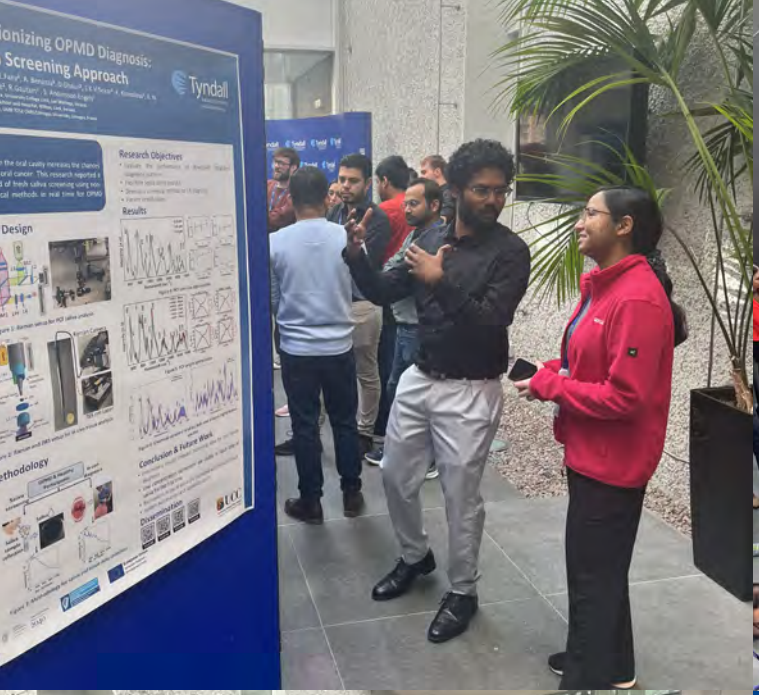
Preparation and characterisation of AlGaN structures for UV Lasers

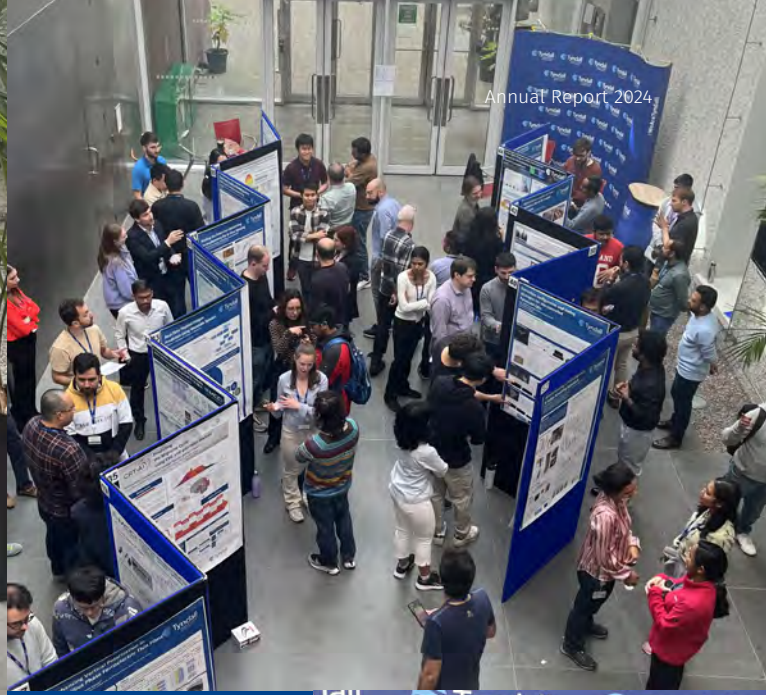
Sini Nanadath Shibu

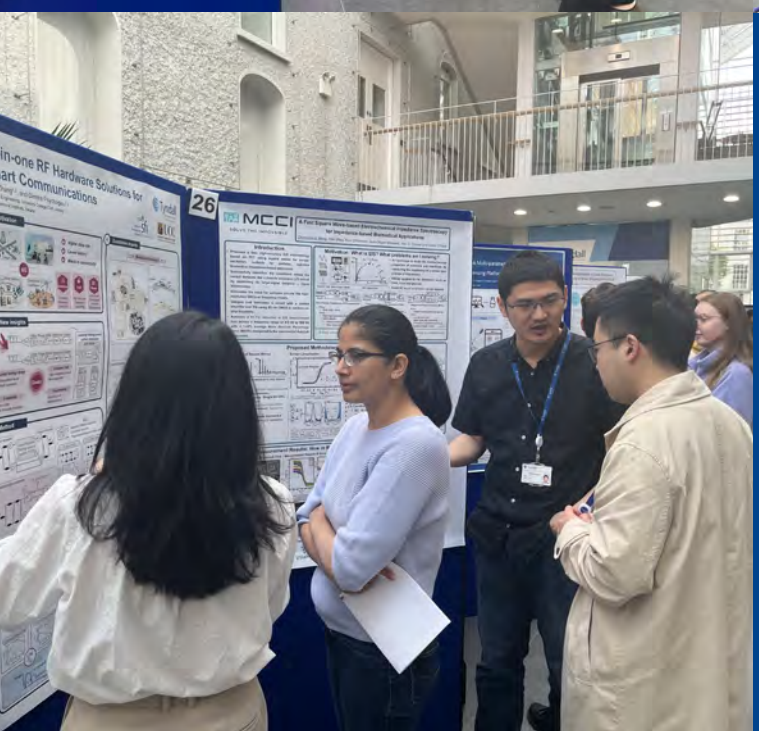
Optical emission study of ion-implanted NV fluorescent centres in diamonds and their biosensing applications

Spyros Kalogiros

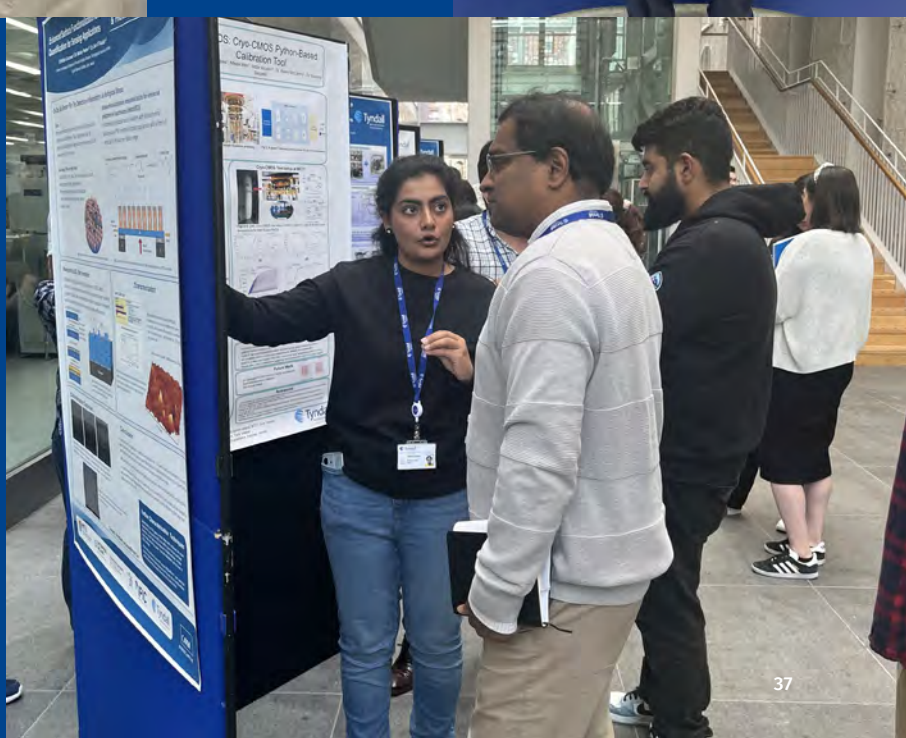
Design techniques for power-efficient delta-sigma analogue-to-digital converters


Tyndall
Research Objectives
Results
Conclusion & Future Work




26
MCCI


Tyndall
National Institute
TyndallLie


Cryo-CMOS Python-Based
Calibration Tool

Student awards

2023 Postgraduate Publication of the Year

Sponsored by:

Qualcomm

Winner:

Hemalatha Muthuganesan

'100 Gbps PAM4 ultra-thin photodetectors integrated on SOI platform by micro transfer printing'

https://doi.org/10.1364/OE.502285

Runners-up:

Nadeem Rather

'Deep-learning-assisted robust detection techniques for a chipless RFID sensor tag'

https://ieeexplore.ieee.org/document/10330726

Cónal Murphy

'Theory and optimisation of radiative recombination in broken-gap InAs/GaSb superlattices'

https://iopscience.iop.org/article/10.1088/1361-6463/ad015d

Arindam Samanta

'Spin waves in exchange spring nanoheterostructured amorphous/nanocrystalline films'

https://journals.aps.org/prb/abstract/10.1103/PhysRevB.107.214449

Rising star:

Zixiao Zhang

'Incorporating directionality in transversal-resonator-based bandpass filters with tunable transfer function characteristics'

https://ieeexplore.ieee.org/document/10288484

Wrixon Research Excellence Bursaries

Patricia O'Sullivan

Workforce fatigue prediction via wearable sensor data analytics

Patricia's research aims to prevent work-related musculoskeletal disorders among smart factory workers by developing a fatigue forecasting system that uses wearable sensor data analytics. This system, which consists of a mobile application and sensors, monitors user movements and task loads to predict physical fatigue in real time in an individualised and task-generalisable manner using biomechanical modelling and machine learning.

Ana Claudia Ferreira

Development of a smart bolus system for multi parameter monitoring of bovine welfare

The global demand for animal-derived products requires innovative systems for effective livestock monitoring to enhance dairy industry efficiency, ensure animal wellbeing, and reduce costs. Claudia's PhD focused on the design, fabrication, integration and validation of a fast portable multi-parametric electrochemical platform for bovine health monitoring, called PULSE. Her work also demonstrated the possibility to deploy sensors for pH, temperature, nitrate, nitrite, potassium, and sodium in the rumen for health monitoring.

Steven Cheng

RF co-design and complex-load synthesis techniques for multi-functional and tunable LNAs

Wireless communications have become a necessity for human society. As the need for more connectivity grows, communication technologies advance from the current 5G infrastructure to the future of 5G+ and 6G communication systems. Specifically, due to the envisioned highly interconnected future wherein everything on the planet becomes wirelessly connected, higher data rates, lower latency, and better efficiency are key requirements that need to be satisfied. To adapt to these demands, conventional methods of designing the communication hardware become too bulky due to the increased number of components. In particular, each component of the radio frequency (RF) hardware such as switches, low noise amplifiers (LNAs), power amplifiers (PAs), filters, and phase shifters grows proportionally with the required number of frequency bands, standards, and applications. Steven's research investigates novel integration methodologies for tunable RF co-designed passive/active RF front-end (RFFE) components that dramatically reduce the size of RF transceivers and improve the system's overall signal to noise ratio (SNR), thus addressing the challenges of emerging communication systems.

Nadeem Rather

AI-enabled chipless RFID sensing system for reliable IoT applications

Nadeem's research advances radar-based chipless RFID (CRFID) for IoT applications, introducing a novel concentric ring-based, polarisation-insensitive sensing tag. By using exponential ring spacing, the design increases binary data encoding capacity by 88.2%. The innermost ring enables capacitive sensing, while Radar Cross Section (RCS) nulls improve detection accuracy. AI is integrated into the radar, leveraging machine learning (ML) and deep learning (DL) for robust CRFID data detection. A robotic system is demonstrated to automate large-scale RCS data acquisition to train ML/DL models. This study demonstrates that 1D-CNN models outperform traditional ML in tag identification. Additionally, a 3-bit depolarising CRFID tag is demonstrated to enhance surface robustness, with Bi-LSTM and attention mechanisms utilised for improved accuracy, achieving a low RMSE of 0.029 (0.48%). These innovations contribute to more reliable, AI-enabled CRFID systems for real-world IoT applications.

Andrea Bocchino

A Multifunctional Platform for the Rapid Prototyping of Polymeric Microneedle-based Devices and Systems

Microneedle (MN)–based technologies have the potential to underpin the next wave of transdermal delivery, continuous monitoring and biopotential capturing wearables. Their ability to painlessly interface with the outermost skin layers, coupled with their microscopic form factor, avoids needle phobia and makes them extremely appealing for healthcare and lifestyle applications. Andrea's research focuses on the development of a manufacturing platform for the rapid prototyping of polymeric microneedle wafers, allowing the production of customisable MN arrays for use in a wide range of delivery and diagnostic use cases. This platform has the potential to dramatically speed up microneedle research, facilitating the rapid development and iteration of complex MN arrays, and expediting the creation of these next-generation devices.

Wrixon Research Excellence Travel Bursaries:

Hasti Yavari

Hasti's award is for a 6-month project at the Princess Margaret Cancer Centre, affiliated with the University of Toronto in Toronto, Canada. Her project focuses on developing a non-invasive diagnostic and characterisation method for uveal melanoma.

Owen Moynihan

Owen travelled to the University of British Columbia in Vancouver, BC Canada, where he is working on heterogeneous photonics integration, specialising in coupling methods for III-V laser devices to silicon photonics circuits for integrated tunable laser sources.

BOC Gases Postgraduate Bursary

Arindam Samanta

Nanostructured magnetic materials for integrated magnonic devices

Professor Gerry Wrixon with winners of the Wrixon Research Excellence and Travel Bursaries

Student Poster Competition

Early Student Category

Winner:

Aashi Gupta

Pulsed laser annealing of 2D materials for BEOL application

Runner-up:

Mauricio Montanares

IceMOS: Cryo-CMOS python-based calibration tool

2nd year and higher

Winner:

Mintesinot Tamiru

Sustainable chemi-resistive sensors for room temperature detection of ammonia using chitosan and laser-induced graphene

Runner-up:

Kevin Martin

Enhanced in-band self-interference suppression by combining bandpass filter-based RF cancellers and dual-polarised

Caroline Peres da Silva

Predicting the migraine cycle using EEG and wearable devices cancellers and dual-polarised

Notable Student Awards

Cian O'Donnell

- Analog Devices Outstanding student IC designer, European Region. Research: Wirelessly powering a mm3 implant for image-guided surgery

Debismita Dutta

- Selected by UCC to represent the university at the Annual Lindau Nobel Laureate Meeting in Lindau, Germany

Julie Raulin

- Corning Women in Optical Communications Scholarship. Research: Software-defined networking for packet and optical networks

Kevin Martin

- Tom Brazil Early-Career Researcher Award from CONNECT
- 3MT John Bandler Memorial Award at International Microwave Symposium (IMS) 2024. Conference paper: Enhanced in-band self-interference suppression by combining bandpass filter-based RF cancellers and dual-polarised antennas

Olivia Shortall

- Best student poster presentation at UK Nitrides Consortium Annual Winter Conference. Title: Photoluminescence properties of BAlGaN/AlGaN quantum well heterostructures as a function of temperature

Rupa Ranajani Palanisamy

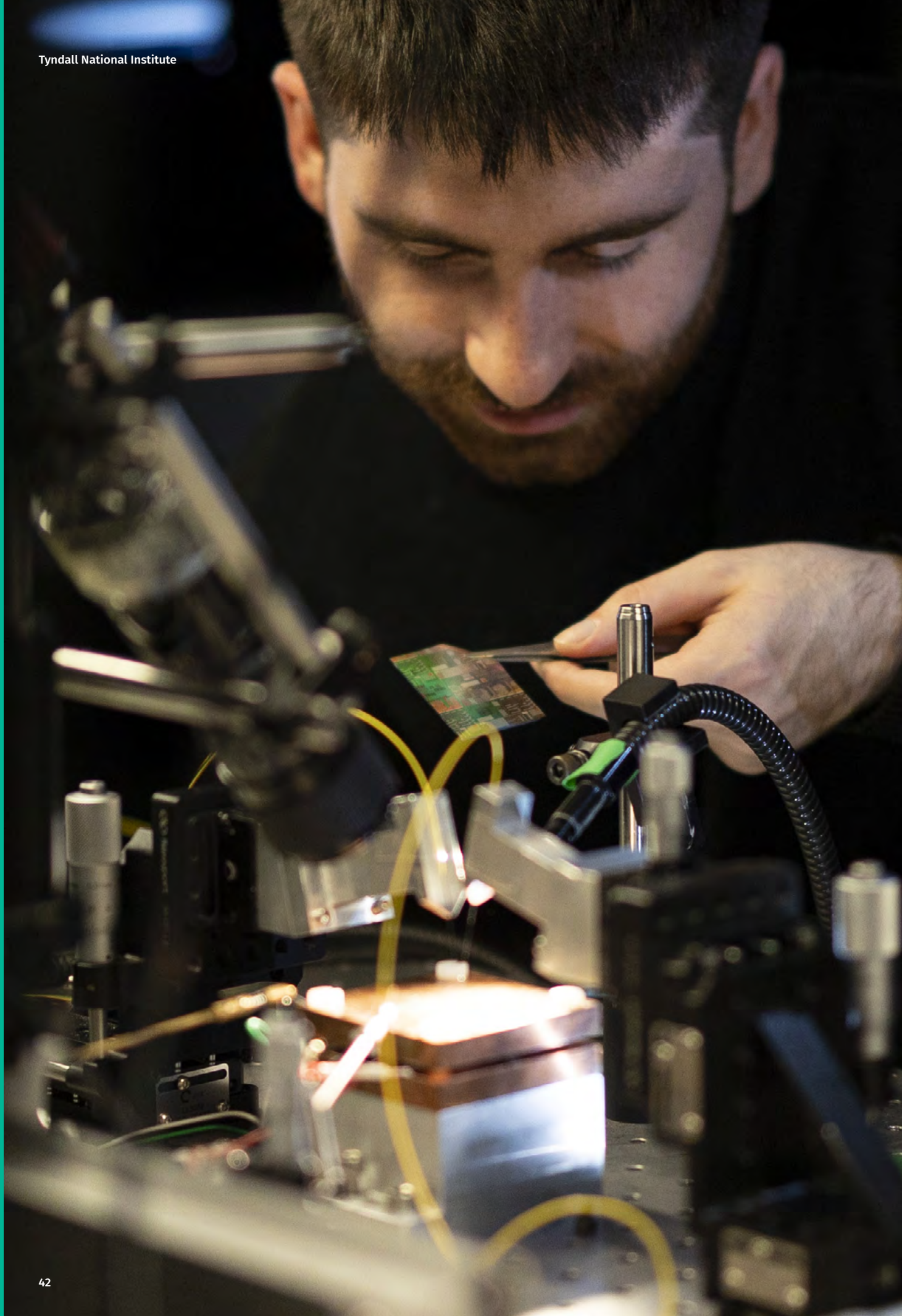
- Best poster presentation award in the European Materials Research Society (E-MRS) conference. Title: Redox electrodes for electrochemical energy storage and thermal energy conversion

Steven Cheng

- First place in the Student Paper Award at 2024 IEEE International Microwave Filter Workshop
- First prize, Tom Brazil Fellowship award Student Essay Competition at 2024 European Microwave Integrated Circuits Conference (European Microwave Week)

Zhongzheng Wang

- IEEE SSCS Student Travel Grant Award for BioCAS 2024



Tyndall National Institute

Infrastructure

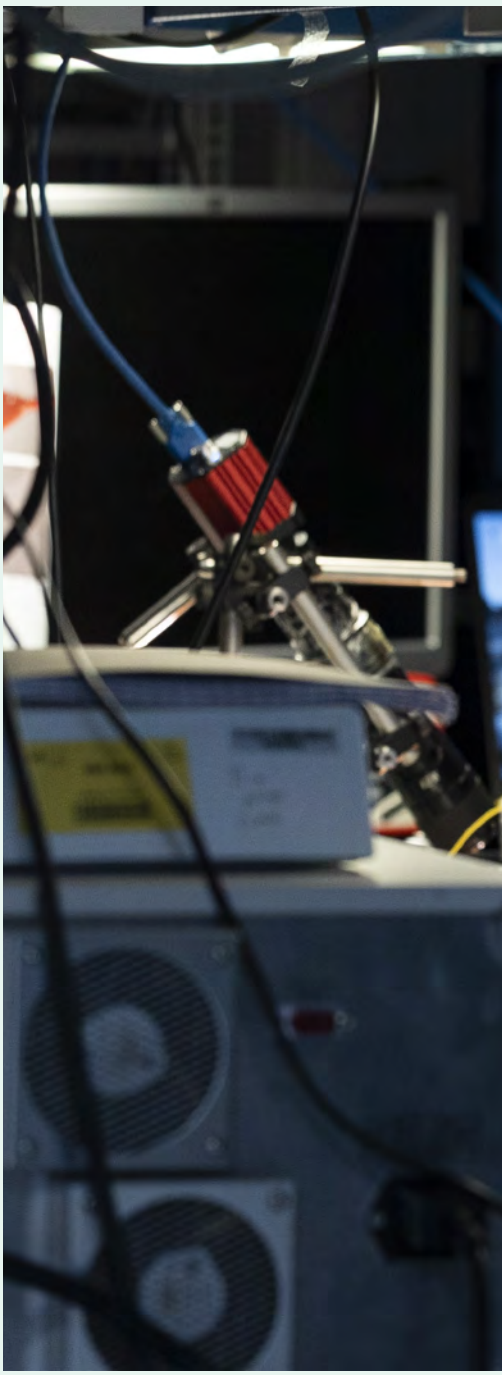
327
users trained in the operation of process and analysis tools

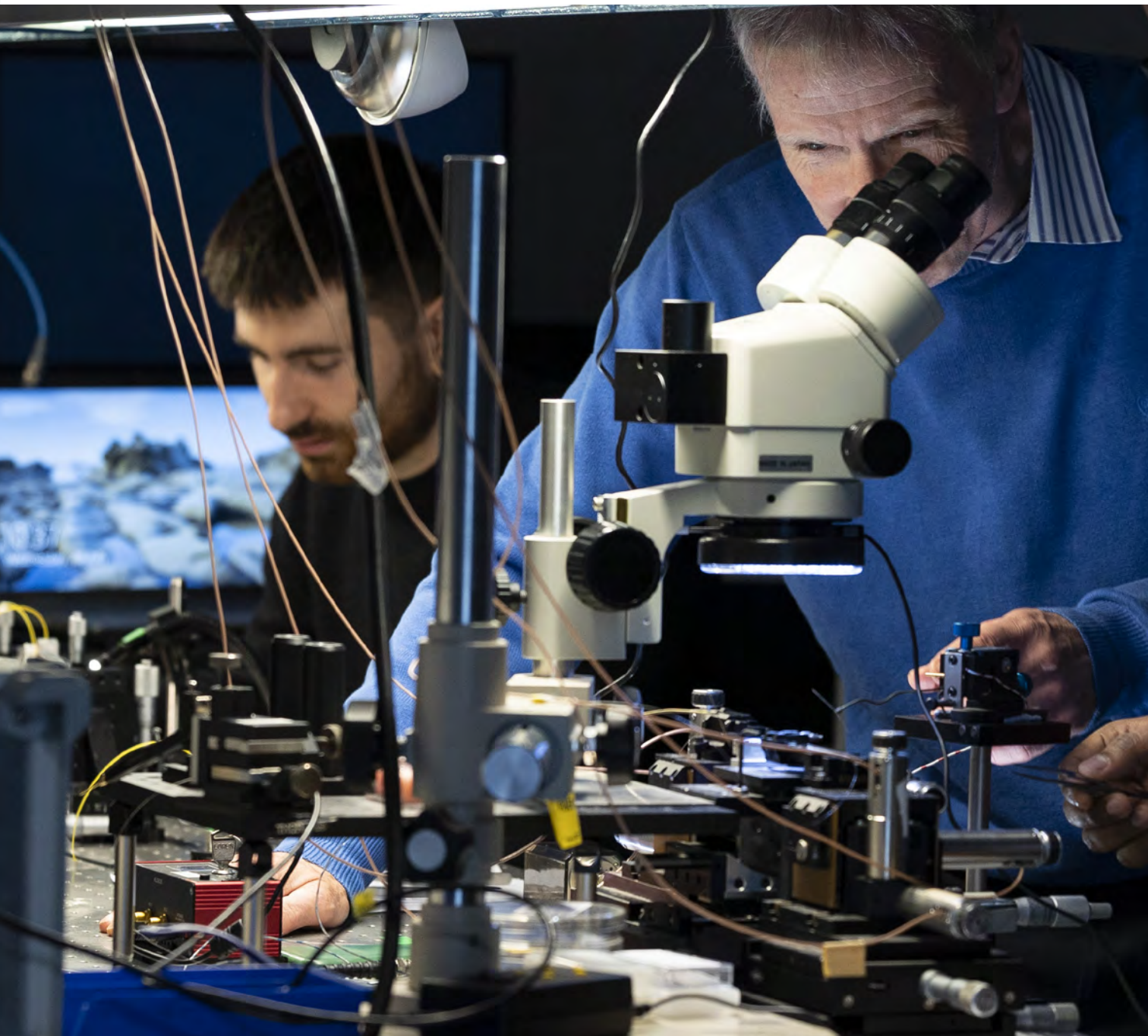
377
users to the open access laboratories and cleanrooms

Owen Moynihan, PhD student

In 2024, Tyndall continued its strategic investment in infrastructure, reinforcing our position at the forefront of scientific and technological innovation. Through upgrades, facility expansions, and the integration of next-generation equipment, we are empowering our researchers and collaborators to push the boundaries of discovery.

These developments reflect not only our ambition to lead in emerging fields such as quantum technologies and next-generation node technologies for transistor fabrication, but also our commitment to supporting a vibrant, future-ready research ecosystem.





Brian Corbett

Training fabrication facility

In 2024, Tyndall completed the relocation and commissioning of its dedicated training fabrication (fab) facility, marking a significant step forward in hands-on skills development for the next generation of researchers. This facility plays a central role in our training programmes, offering PhD students and postdoctoral researchers the opportunity to gain practical experience in semiconductor device fabrication.

The training fab provides a structured, 1-week immersive course during which participants are guided through the fabrication of a visible light-emitting diode (LED) using semiconductor wafer processing equipment. This hands-on experience is designed to complement theoretical knowledge with real-world technical skills, enhancing participants' understanding of cleanroom processes, fabrication workflows, and the operational intricacies of advanced micro- and nano-fabrication tools.

The relocation of the training fab to a newly refurbished facility ensures improved workflow, upgraded infrastructure, and a more streamlined learning environment. With the new space now fully operational, we are ready to welcome the next cohort of students and continue our mission to build strong, industry-relevant competencies within Ireland's research talent pipeline. This initiative reflects Tyndall's broader commitment to fostering technical excellence and preparing researchers to contribute effectively to both academic and industrial innovation ecosystems.

Plasma deposition system in new training facility

IQ – The Irish Quantum Technology Facility for Advanced Qubit Manipulation (IQ Facility)

In 2024, several key investments were made to enhance our capabilities at the IQ Facility. A number of equipment tenders were issued, with some successfully finalised by the end of the year.

1. **New superconducting detectors for quantum light**
   We acquired four advanced detectors designed to work at telecom wavelengths, along with an additional detector optimised for light at 2 microns. These detectors were integrated into our existing cryogenic system. This upgrade allows researchers to detect individual photons with exceptional precision and very low noise. The new system also supports photon correlation studies, which are important for understanding how quantum light behaves. These types of light sources are commonly used in secure quantum communication and in cutting-edge silicon-based photonic circuits.

2. **Imaging spectrometer for telecom wavelengths**
   To support detailed analysis of light from single quantum emitters, we are adding a specialised imaging spectrometer tailored for telecom wavelengths. This system will be equipped with a new infrared-sensitive camera (InGaAs array), which is expected to arrive soon. Currently, a Charge Coupled Device (CCD) camera is in use, providing near-infrared spectroscopic capabilities that already represent a valuable enhancement to the IQ Facility's research tools.

Dr Emanuele Pelucchi

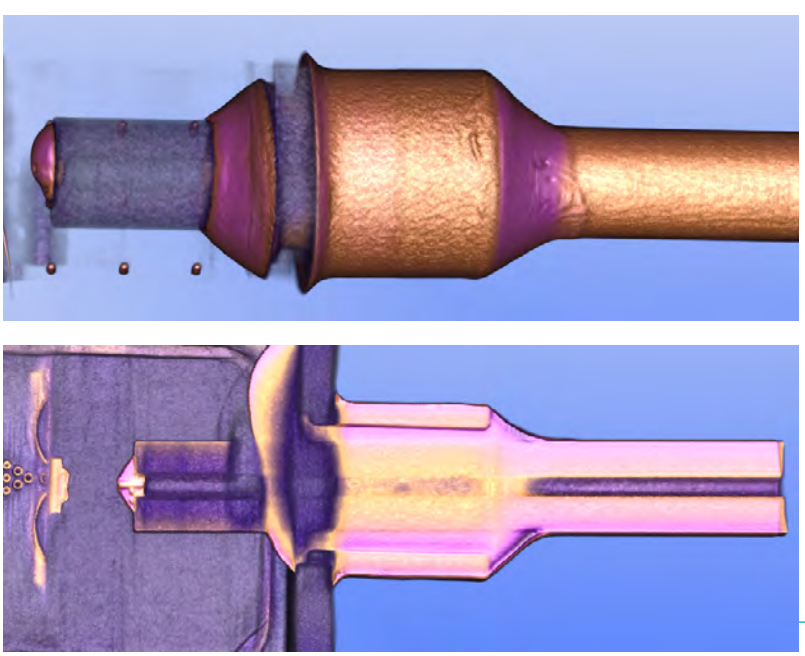
Reliability Testing for European Space Agency LISA program

During 2024, the Tyndall reliability and component analysis team successfully advanced its work on a European Space Agency (ESA) contract titled Photonic Component Analysis in Support of the LISA Laser System Development.

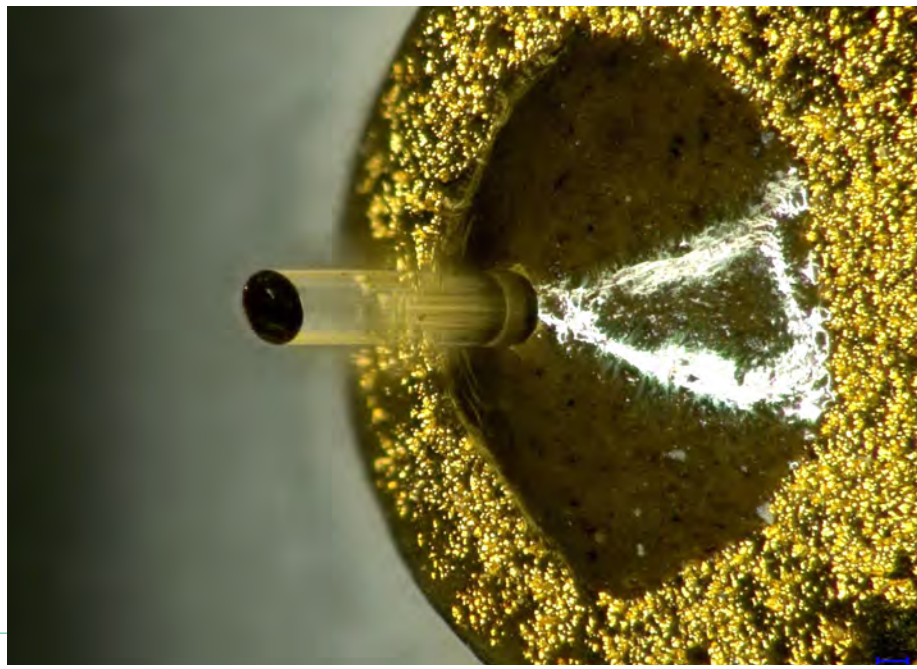
The ESA Laser Interferometer Space Antenna (LISA) will be the first space-based observatory dedicated to the study of gravitational waves – i.e. ripples in the fabric of space-time emitted during the most powerful events in the Universe, for example when pairs of black holes come together and merge.

The multi-year contract, which is now nearing conclusion, is concerned with the physical, quality and reliability evaluation of a wide range of commercially available active and passive photonics components to assess their suitability for possible use in the LISA laser system.

The LISA mission, planned for launch in 2035, will consist of three spacecraft flying in formation, creating an equilateral triangle connected by laser beams. The formation will trail the Earth during its orbit around the Sun. Each spacecraft will have two free-floating gold cubes (test masses) inside it. Gravitational waves cause distances between objects to contract and expand. Hence, by measuring the distances travelled by the laser beams and the test masses in each spacecraft, LISA will be able to detect the waves and determine their origin.



Computerised Tomography X-ray images showing fibre feed-through of a photodiode component



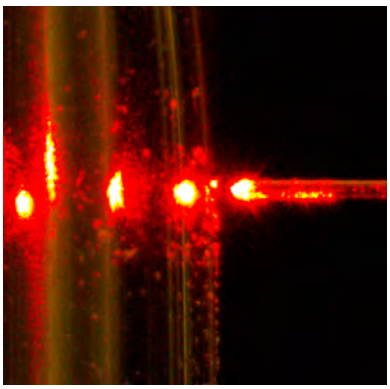
High magnification optical image showing optical fibre tip in hermetically sealed feed-through

Tyndall's role was to evaluate the suitability of a range of commercial photonics components for possible use in the laser system. The use of such components in the harsh space environment can be challenging. During manufacture, parts of many photonics components are assembled using adhesives and other organic materials. Under conditions of high vacuum, these materials are at risk of outgassing, leading to potential contamination of internal optical surfaces with resultant performance degradation. Such components also use precisely aligned structures which may not be resilient to the effects of the mechanical shock and vibration they would experience during launch.

Tyndall conducted a series of long-term reliability tests and detailed construction analysis on components such as: pump laser diodes: photodiodes; ultra-violet light-emitting diodes; electro-optical modulators; optical switches; isolators; couplers; pump-signal combiners; mode strippers; mode field adapters and other devices.

The outcome of the work was a comprehensive assessment of each component against the requirements of the mission and the relevant space test standards, and identifying a risk level with their use in the mission environment.

Scientific image competition winners



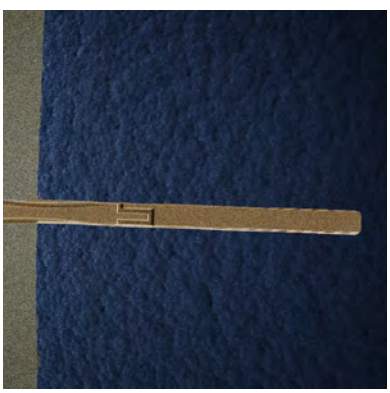
Fireball

Nadia Anam, *Photonic Systems Group*

This scientific image is part of a research project that focuses on light-gas interaction to detect greenhouse gases such as methane. It is expected that an optical system that uses laser to detect gases would be very efficient in tracing small portions of hazardous gases. This would hopefully then pave the way for future commercial photonic sensors that are miniaturised, cost-effective and reliable.

The microscopic image was captured in IPIC at Tyndall when red laser light hit a highly reflective glass tube.

The research is being carried out in the Photonic Systems Group at IPIC in Tyndall in collaboration with Queen's University Belfast.



Nano Dock

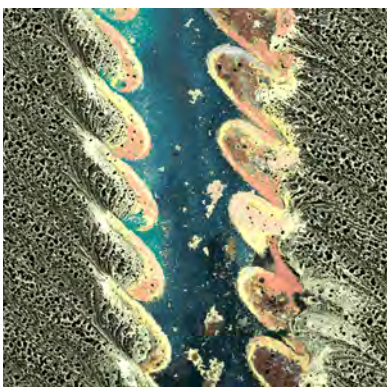
Savda Sam, Artem Vorobev and William Whelan Curtin, *Photonics: CAPPA Group*

A cantilever featuring an embedded nanophotonic resonator was fabricated at Tyndall on a silicon nitride platform.

The nanophotonic structure was patterned using the Elionix electron beam lithography system, while the cantilever window was patterned using photolithography.

The cantilever was then released through dry isotropic etching of silicon with the XeF2 etcher.

The purpose of this cantilever is for chemical sensing applications, specifically in conjunction with a photoacoustic spectroscopy system for gas sensing.



Cliffs of LIG

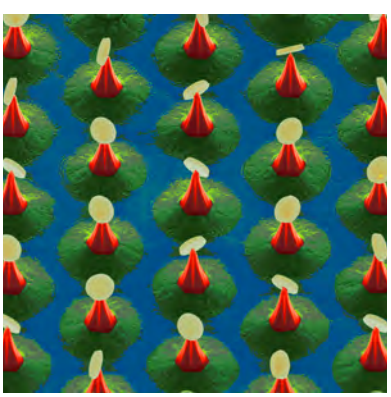
Alida Russo and Richard Murray,
Nanotechnology Group

This scientific image was inspired by the breathtaking panorama of Ireland's coastal scenery.

The image is a false-coloured scanning electron micrograph of LIG (laser-induced graphene), which is a 3D porous, conductive, carbon structure with a high surface area that can be constructed via laser-irradiation of a target substrate, such as polyimide. The properties of the material can be tuned by altering the fabrication process to suit the desired application; this could be related to the use of diverse substrates, laser systems/parameters, and surface modification.

In this group at Tyndall, LIG has been fabricated on polyimide but also on sustainable substrates, such as chitosan or cork. Different applications have been trialled, ranging from volatile organic compound (VOC) detection and electrochemical sensors to supercapacitors.

In this case, the use of different nanoparticles, such as gold nanoparticles, has been explored to modify the surface of the material and the gaps between different 'cliffs'.



Ladies in Red

Vitaly Zubialevich,
III-Nitride Materials Group

This scientific image shows SiN disks GaN capped with nanorods after an excessive thermal annealing. Exposure of GaN to high temperatures in ambient ammonia and nitrogen is used as subtractive annealing for controlled thermal etching. Too high a temperature and/or too long duration of the annealing results in too much of the nanorod body material decomposing and subliming.

In this image, the exact moment (a lucky combination of temperature and time) is captured when the diameter of the nanorods decreases down to zero. This occurs because the SiN caps cannot preserve their original orientation (parallel to the 'ground') but (being still held by van der-Waals forces) tilt at random angles.

The residual shapes of GaN nanorods after the fake colourisation bear some resemblance to people in long red cloaks.

Scientific image competition winners

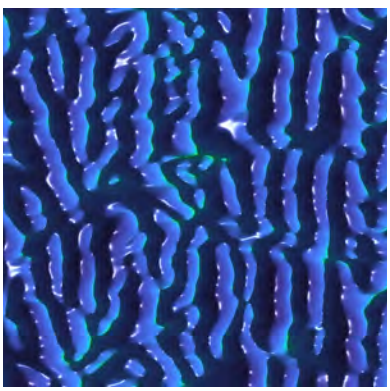
Gold Leafy Cobaltets

Padman Narayanasamy and Irish Rohra, *Nanotechnology Group*

This image is of a scanning electron micrograph (SEM) portrayal of cobalt nanoarchitecture on a gold micro-electrode.

This image was developed for the purpose of glucose sensing.

Within the framework of the Summer Fellowship Programme and project 'Hierarchical hetero-nanostructured catalyst for non-enzymatic glucose sensing', the goal is to create a nanostructured catalyst to facilitate non-enzymatic glucose sensing for the purpose of commercial food product analysis.



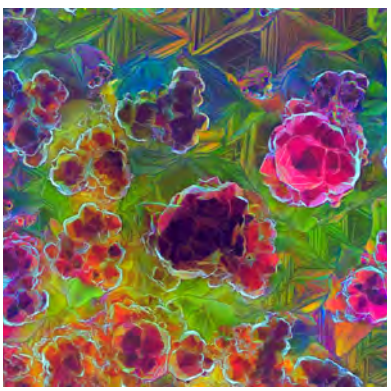
Information Waves

Xing Ouyang, *Photonic Systems Group*

This image illustrates the so-called fading effect in wireless communication systems which usually happens in an outdoor environment surrounded by dense buildings.

The fading effect looks like the endless waves of the Atlantic Ocean, and the fluctuation of these waves indicates the strength of the radio frequency signals. This is due to the fading effect over time (horizontal) and frequency (vertical) dimensions. That is why they are called information waves.

This fading effect is caused by both the small-scale scattering effect of a single RF signal path, created by surrounding buildings/objects and the multiple delayed transmission signal paths due to large-scale reflections. The construction and destruction of the combined scattered and reflected signal paths lead to the up and down pattern of the signal strength received by cell phones.



Flowerbed of GaAs Roses

Luca Colavecchi, *Epitaxy and Physics of Nanostructures (EPN) Group*

This scientific image is an SEM picture of a 111B Gallium Arsenide surface after epitaxial growth has been left for too long.

Normally, decomposition of precursors on GaAs 111B is minimal and deposition of new crystal doesn't occur.

The EPN group exploited this characteristic behaviour of the 111B by patterning onto it an array of tetrahedral recesses, over which slanted 111A surfaces, decomposition and deposition of new crystal occurs, allowing for the design of the pyramidal quantum dots. However, the thicker the growth, the steeper the angle of the sidewalls becomes, until recesses close completely. From that moment onwards, precursors kept decomposing on surfaces vicinal to the 111B and ad-atoms wander on the flat surface, eventually finding favourable bonds where they stick and form these beautiful (though useless) clusters.

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Stairway to Quantum Heaven

Sheshank Biradar, Nikolay Petkov, Giorgos Fagas and Ray Duffy, *Quantum Electronic Devices (QED) Group*

This image illustrates the germanium-tin (GeSn) nanowires of different lengths suspended across the structure.

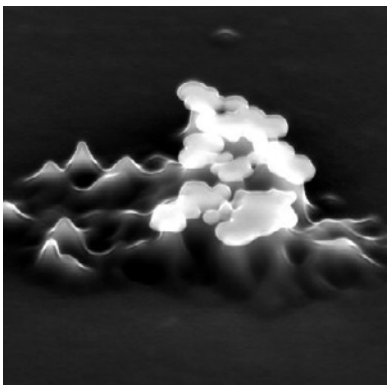
The image was developed for the optimisation of etch recipes and the length of the nanowires for fabrication of quantum devices.

An alloy of GeSn exhibits properties that can act as a qubit.

These GeSn nanowires of different length are obtained after lithography and isotropic etching to etch away the underlying germanium.

This results in the suspended GeSn bridge, hence making way for further quantum device exploration.

Scientific image competition winners



Mist on nano-Alps

Sheshank Biradar, Nikolay Petkov, Giorgos Fagas and Ray Duffy, *Quantum Electronic Devices (QED) Group*

This image shows the effect of wet chemical mixture on a partially cleaned GeSn wafer.

Wet chemical cleaning is widely used for processing wafers to remove organic or inorganic contaminants prior to nanofabrication. This cleaning is carried out using several chemical compounds that include acids, bases, DI water or mixture of these solutions with varying compositions.

At elevated temperatures, these solutions can become unstable due to the faster decomposition of the cleaning agent. This change can occasionally lead to higher etching, increase in surface roughness and insufficient particle removal, resulting in this image.

Nickel Web

Rupa Ranjani Palanisamy, *Advanced Energy Materials Group*

This SEM image showcases the intricate structure of a nickel foam substrate, captured at a microscopic level.

The interconnected design reminds one of a spider's web, exemplifying the fascinating patterns created during fabrication. This work of fabricating electrodes is part of the TRANSLATE project, which focuses on the innovative conversion of waste heat to electricity.

Using a hydrothermal method, the metal chalcogenides are grown directly onto the Ni foam substrate. This distinctive architecture allows for strong adhesion of the materials to the substrate, akin to how a spider's web secures prey. Such robust integration significantly enhances overall electrochemical performance, making this electrode highly suitable for both supercapacitor applications and heat-to-electricity conversion. The 'Nickel Web' prototype is a promising candidate for advanced energy storage solutions, paving the way for more sustainable technologies.

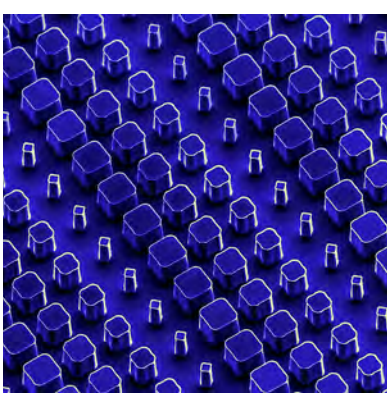
Sahara's Lake

Ehren Dixon, *Electrochemical Materials & Energy Group*

During electroplating at Tyndall, the deposition process may occasionally go off track, but the outcomes can still be intriguing.

Electroplated layers have internal stress, with the layer's atoms pushing and pulling at each other. Too much stress and the layer will crack. It is never nice to find these cracks in deposits, but sometimes these micro-fractures lead to some interesting design and patterns in the deposit.

Coloured in a red hue, this cracked deposit looks similar to the dry lake beds in the Sahara Desert.



Night in Metacity

Jesus Hernan Mendoza-Casto, Tomasz Piwonski and Artem Vorobev, *Photonics: CAPPA Group*

A rectangular-pillar-based metadeflector was fabricated on a geranium platform at Tyndall.

The nanostructures were optimised for compatibility with mass production via photolithographic techniques.

The device was designed to demonstrate beam-steering capabilities to enable efficient control of mid-infrared wavelength light for spectroscopy applications. Obtained metastructures will be used in the Enhanced Selectivity VOC Detection Using Novel GC-QEPAS, (EVOQUE) project funded by the EU's Horizon Europe research and innovation programme.

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 SFI RESEARCH CENTRE FOR DATA ANALYTICS

ICHEC Irish Centre for High-End Computing

ADVANCECRT

IPIC
BRINGING PHOTONICS TO LIFE

The Irish Photonics Integration Centre, IPIC, transitioned from SFI to become the Research Ireland Centre for photonics in 2024, following the establishment of the new national research and innovation funding agency. IPIC remains Ireland's centre of excellence for research, innovation and PhD training in photonics and 2024 saw continued progress towards market deployment for its breakthrough research programme.

An additional milestone saw the percentage of IPIC PhDs who have transitioned to industry exceed 70% for the first time. This reflects high demand for IPIC PhDs, with students joining both AMD and Meta in 2024.

As the centre will come to its natural end in 2026, the core IPIC team prepared a submission to Research Ireland for a new national research centre in heterogeneous semiconductor system technology – the Irish Centre for Heterogeneous Integration and Packaged Systems Research (iCHIPS). The proposal has been accepted by Research Ireland for the next stage of the selection process.

Taighde Éireann
Research Ireland

IPIC's Photonic Packaging Group

CONNECT
Networks of the Future

CONNECT is the Research Ireland Centre for Future Networks and Communications. The Centre, hosted in Trinity College Dublin, brings together research expertise from 12 Irish academic institutions, including Tyndall, to create a one-stop shop for telecommunications research, development and innovation. Now on its ninth year, CONNECT has engaged with over 40 companies, including large multinationals, SMEs and start-ups, in pioneering networks research and advancing fields like 6G, IoT, and network security. CONNECT's research translates into real-world solutions, creating economic value, supporting sustainability, and empowering industries.

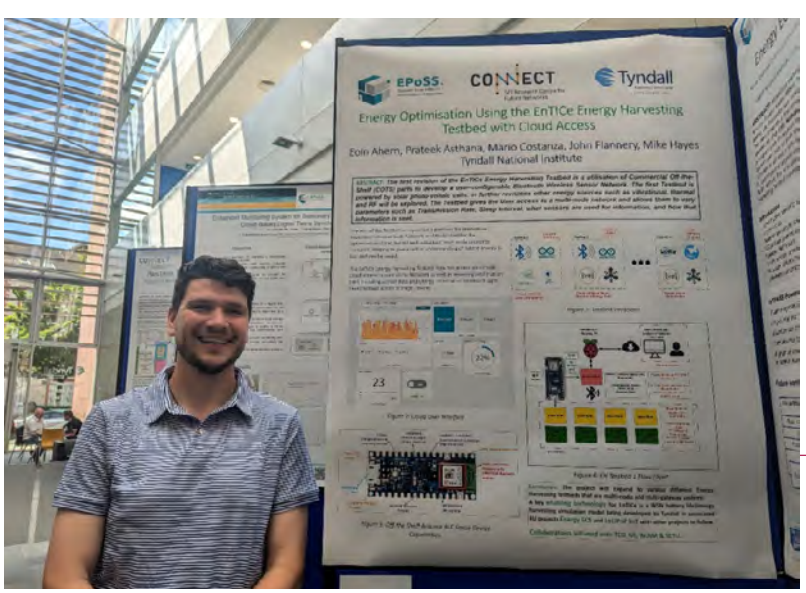
Tyndall researchers play leading roles within CONNECT, contributing their expertise in energy harvesting, energy storage, sustainable electronics, advanced RF and wireless communications to the sustainable IoT, dependable networks, link performance and quantum themes.

In 2024, CONNECT provided sponsorship for two international events: EnerHarv 2024, Perugia, Italy and the EPoSS Annual Forum 2024 'Sensing the future of Smart Systems: Bridging Minds and Microelectronics', hosted in Tyndall. CONNECT's Tyndall-based researchers chaired sessions at EnerHarv and presented at both events.

EnTICe, an Energy Harvesting Testbed funded by CONNECT was promoted at those events as well as at the Applied Power Electronics Conference (APEC) 2024.

PhD student Kevin Martin received the Tom Brazil Early-Career Researcher Award at this year's CONNECT Plenary Meeting. Tom also received the 3MT John Bandler Memorial Award at the International Microwave Symposium (IMS) 2024.

CONNECT researchers from the Wireless Communications Laboratory at Tyndall established HyperPath, a spin-out company during the year. The SFI Defence Forces challenge prize-winning project MISTRAL – Improving Communications Capabilities of the Irish Defence Forces, was completed in 2024.



Eoin Ahern presenting his poster on EnTiCE at the EPoSS Annual Forum 2024, Tyndall

Taighde Éireann
Research Ireland

VistaMilk

VistaMilk Research Ireland Centre is focused on digitalising the dairy industry and it operates in collaboration with leading Irish and multinational food and ICT companies. Funded by both Research Ireland and the Department of Agriculture, Food and the Marine, VistaMilk aims to revolutionise the dairy industry through increased innovation and sustainability across the entire dairy process 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 the development of novel chemical and biochemical sensors and wearables in collaboration with other researchers and industry. Significant intellectual property has been developed, resulting in multiple invention disclosure forms and patents being submitted, and with over 60% of the associated scientific papers published in top 10% of all journals.

In Phase II of VistaMilk (2024–2030), Tyndall has expanded its focus to include energy management and theoretical modelling. VistaMilk's mission extends beyond technological advancements. It aims to develop innovative new technologies and 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, thus ensuring a sustainable and efficient future for the dairy industry.

Taighde Éireann
Research Ireland

Dr Han Shao with EU Commissioner Mairéad McGuinness

MCCI

SOLVE THE IMPOSSIBLE

MCCI (Microelectronic Circuits Centre Ireland) is an established technology centre of excellence in microelectronics research, with expertise in RF, power systems, multi-sensor systems, data converters, and cryogenic CMOS. These technologies are essential enablers across a wide range of industry applications. The centre's research is application-driven and is strategically aligned with key industry challenges. Key focus areas include industry, IoT, healthcare, telecommunications and aerospace.

In 2024, MCCI made two key strategic appointments. Dr Vishal Jagtap joined as Head of Group, from the Institute for High-Frequency and Communication Technology at the University of Wuppertal, Germany. His extensive research expertise and leadership will strengthen MCCI's strategic direction, providing valuable insights and a fresh perspective for the research team. Dr Jagtap will lead MCCI's new research on silicon-integrated THz transceivers for imaging applications. Dr Hugo Cruz joined as a Principal Investigator in the Integrated Power Systems Group. His research on low-power Energy Harvesting Power Management Integrated Circuits (PMICs) and granular Point-of-Load (PoL) Integrated Voltage Regulators (iVR) enhances MCCI's expertise in advanced power management solutions. These innovations present a key opportunity for industry collaboration, driving the development of next-generation energy-efficient systems for a wide range of applications.

MCCI Masters Research Student Yevhenii Mormul was awarded the Analog Devices (ADI) Outstanding Student IC Designer Award for 2024 in the EU region. This prestigious award recognises his exceptional talent and research contributions, specifically his work on a Time-to-Digital Converter (TDC) for cryogenic applications on 28nm CMOS.

MCCI's IEEE Distinguished Lecturer Series continued in 2024 with an outstanding lineup of speakers, including Dr Alvin Loke (Intel, USA); Professor Makoto Nagata (Kobe University, Japan); and Professor Makoto Ikeda (The University of Tokyo, Japan). Hosting such distinguished experts at Tyndall provided a valuable opportunity for researchers and industry professionals to gain insights from global leaders in microelectronics, thus reinforcing MCCI's commitment to knowledge exchange and innovation.

2024 was a very successful year for Tier1 IEEE publications, with 29 papers published. Highlights included Professor Peter Kennedy's presentation at IEEE ISSCC'24 (USA) winning the Outstanding Forum Presenter award; Dr Danny O'Hare at IEEE BIOCAS (Xi'an, China), and Dr Gerardo Salgado at IEEE ISCAS (Singapore).

MCCI in partnership with Tyndall, MIDAS Ireland, and UCD/NOVA had its proposal to the EU (Chips JU) for the foundation of the I-C3 Irish Competence Centre approved for funding by the EU and the Department of Enterprise, Trade and Employment (DETE), and will be established in 2025.

A standout event in 2024 was MCCI's Technical Conference (MTC), which continues to grow as a key platform for fostering collaboration and strengthening connections between researchers and industry leaders in the microelectronics community. Over 90 industry guests gathered at Tyndall to explore cutting-edge advancements across several critical areas: Analog to Digital Converters (ADCs); ADCs and power; biomedical; Radio Frequency (RF); modelling and Cryogenics (Cryo); RF, and optical.

Enterprise Ireland

John Morrissey MCCI; Professor Bogdan Staszewski UCD; Yevhenii Mormul UCD; Philip Quinlan, Analog Devices; and Dr Viet Nguyen, UCD.

esa space solutions Ireland

ESA Space Solutions Centre Ireland (SSCI), funded by the Department of Enterprise Trade and Employment through Ireland's membership of ESA, and Enterprise Ireland, now comprises seven Consortium Partners: Tyndall National Institute (Lead Partner); Atlantic Technological University (ATU); Dublin City University (DCU); Maynooth University (MU); Munster Technological University (MTU); Technological University of the Shannon (TUS); and University College Dublin (UCD). ATU and MTU joined the Consortium in 2024.

The Centre supports Irish companies through the ESA BIC (Business Incubation Centre) Ireland initiative and the ESA Spark Funding mechanism.

ESA BIC Ireland is a 2-year initiative supporting high potential start-up companies in the areas of agritech, medical device, health and wellness, materials science, semiconductor, cybersecurity, disability support, carbon capture, sports performance, and micromobility.

ESA BIC Ireland offers technical, business and financial supports, as well as national and international networking opportunities, to start-ups focused on space-related upstream or downstream applications. Incubation space is also available at each of the Consortium Partner locations, thus creating an immersive and experiential environment for founders. In 2024, when ATU and MTU joined the Consortium, this increased the number of incubation locations from 5 to 10.

Support is delivered through a dual-incubation model offering physical or remote incubation, financial aid (up to €50,000), and technical support through ESA and the Consortium Partners.

ESA SSCI also offers ESA Spark Funding, a technology transfer funding mechanism which is designed to accelerate product development in companies that are integrating space technology with a view to developing a new market application. ESA Spark Funding provides €40,000 to companies for eligible projects that have a maximum duration of 12 months.

ESA BIC Ireland incubation contracts were executed with three start-up companies during the year - Biota Mrv, PicoGlaze and Tao Climate. An additional six companies were selected for ESA BIC Ireland during 2024.

In 2024, ESA BIC Ireland hosted two well-attended national networking events. These events included a number of speakers from ESA.

Enterprise Ireland

ESA SSCI company participants at the National Networking Day

Financial report

Income and expenditure summary

Income	2024 €'m	2023 €'m
Government grant	10.0	7.0
Research	41.7	41.0
UCC contribution	2.4	2.4
	54.1	**50.4**

Expenditure	2024 €'m	2023 €'m
Remuneration costs	31.7	29.6
Equipment and infrastructure	2.8	2.7
Consumables and related costs	15.0	14.2
Other operating and deferred costs	4.6	3.9
	54.1	**50.4**

Tyndall National Institute

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Chairperson

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CEO

Prof. John F. Cryan
University College Cork

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Aalborg University

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National Center for the Advancement of Semiconductor Technology (Natcast)

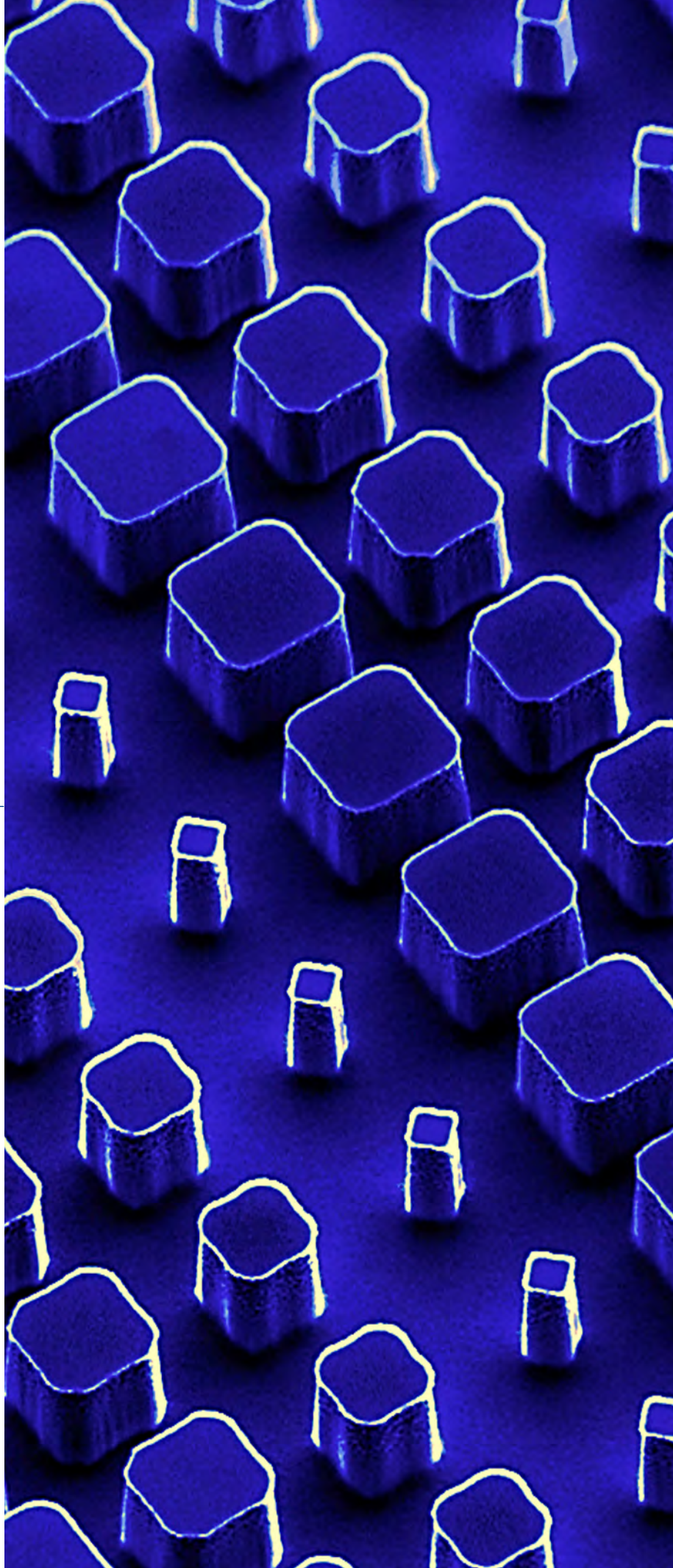
Bob Savage
Dell Technologies

Rialtas na hÉireann
Government of Ireland

Tionscadal Éireann
Project Ireland
2040

European Union
European Regional
Development Fund

A rectangular-pillar-based meta deflector was fabricated on a geranium platform at Tyndall. The nanostructures were optimised for compatibility with mass production via photolithographic techniques. The device was designed to demonstrate beam-steering capabilities to enable efficient control of mid-infrared wavelength light for spectroscopy applications. Obtained metastructures will be used in the Enhanced Selectivity VOC Detection Using Novel GC-QEPAS, (EVOQUE) project funded by the EU's Horizon Europe research and innovation programme.



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