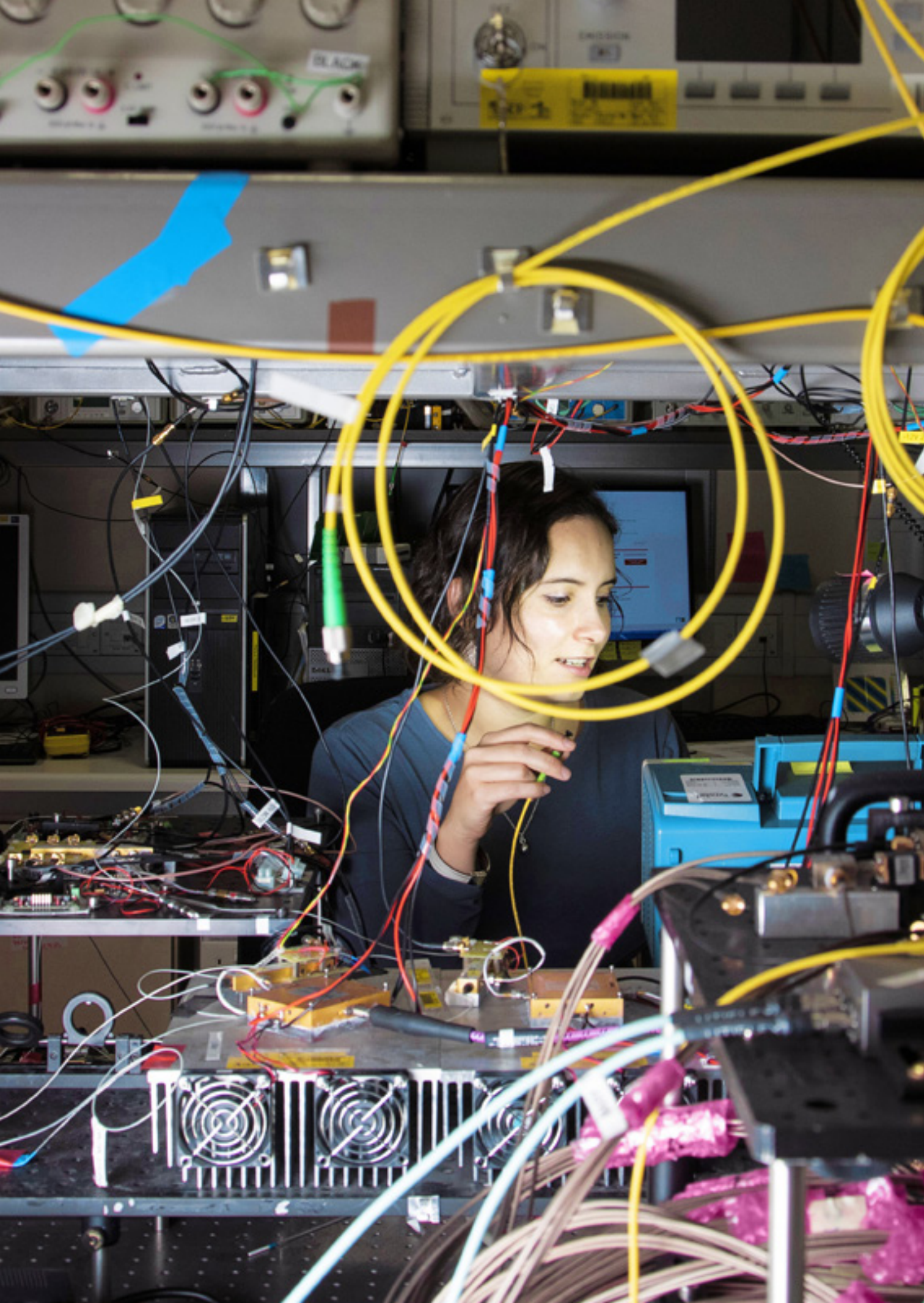
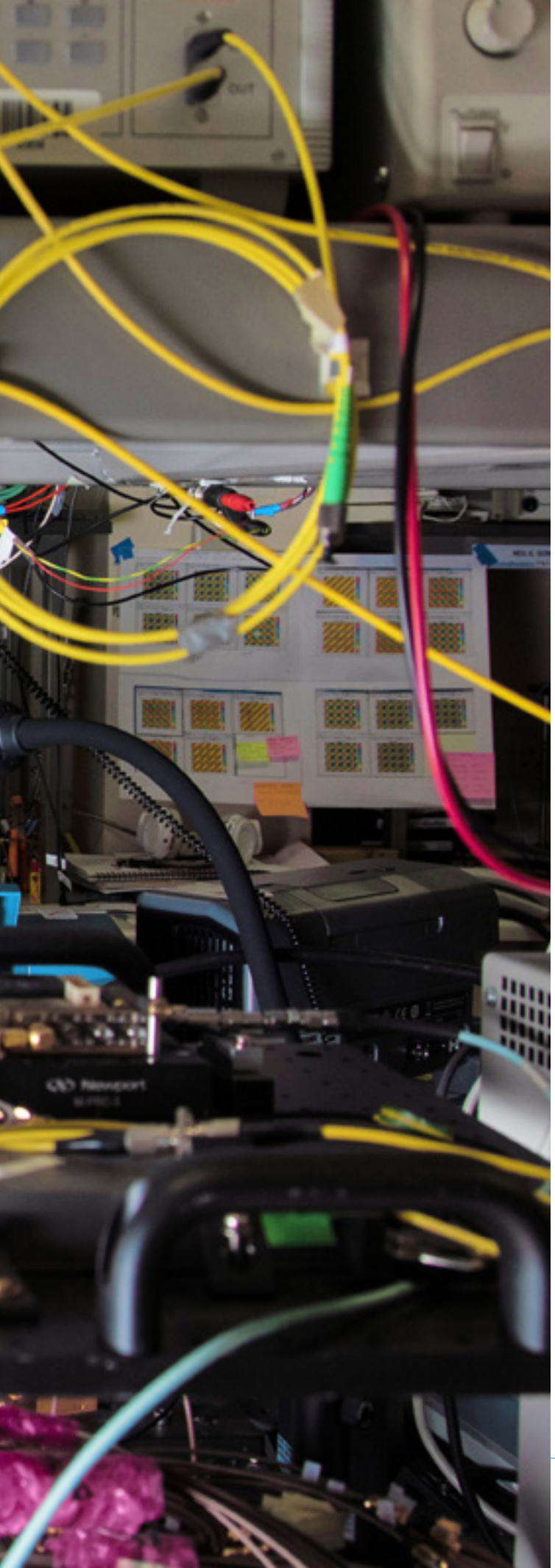
Impact from excellence

Tyndall
National Institute
Institiúid Náisiúnta

# 2019
## Annual report

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh





# Contents



*Natalia Cañas Estrada*
*PhD Student, Photonics*

# Chairman's message

Tyndall National Institute stands in a unique position as a partnership between University College Cork (UCC) and the Department of Business Enterprise and Innovation. This partnership fosters world class research and seeks to harness this research to build sustainable competitive advantage for companies located in Ireland. 2019 was a very productive year for Tyndall during which we saw an increase in our activity on all fronts and the consolidation of the role we play in the economic future of Ireland.

Tyndall drives innovation in information and communications technology (ICT) and its applications and supports the growth of this strategically important sector which employs over 37,000 people and generates €35bn in exports annually for Ireland. At Tyndall, we believe that effective industry-academia collaboration is the driver for the successful translation of research from the laboratory into innovative new products and services in the marketplace, ultimately leading to the creation and retention of high-quality sustainable jobs.

Tyndall is now embarking on an exciting new expansion plan. The growth of Tyndall is included as a priority in the Government's National Development Plan (NDP) and in the Government's strategic publication, 'Future Jobs Ireland 2019'. This expansion of Tyndall is a priority that will enhance Ireland's position as a leading international centre of scale in translational research, playing an important role in the further development of ICT-related innovation in Ireland.

In May 2019, the Minister for Business, Enterprise and Innovation Heather Humphreys visited Tyndall to see first-hand the Disruptive Technology Innovation Fund (DTIF) projects in which Tyndall has played a central role. The DTIF is one of the first funds of its type in the world, and it is the first scheme in Ireland to support company-to-company collaborations working with public research bodies.

In addition to the Ministerial visit, we hosted the Science Foundation Ireland (SFI) Board. During 2019, the Government announced an investment of €230m in six SFI Research Centres as part of Project Ireland 2040, which included the Irish Photonic Integration Centre (IPIC), at Tyndall National Institute.

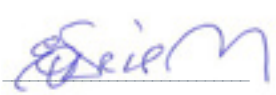
Our continued success is determined by our outstanding research talent. As we scale up in size, retaining and developing our staff remains a priority. In 2019, we worked hard to engage our staff, students and stakeholders in the formulation of our future strategy. Now with a well-defined strategy, clear goals and an excellent committed team we are confident that Tyndall can deliver the results in line with the confidence the Government expressed when Tyndall's expansion was included as a priority in the National Development Plan (NDP).

I would like to acknowledge the strong support we receive from UCC, its President, Professor Patrick O'Shea, and his management team. In addition, I would like to express our appreciation for the continued support and guidance we received from the Department of Business Enterprise and Innovation during the year.

I would like to acknowledge the retirement of Ian Quinn from our board during 2019, and I would like to thank him for his contribution to Tyndall over the past 10 years. I would also like to welcome Caroline Dowling and Bram Nauta as new members.

We currently face extraordinary societal challenges where much is being asked of individuals and organisations in response to the threats of the COVID-19 pandemic. Now more than ever our role as an institute of research excellence is central to securing deep-tech solutions to these challenges while continuing to contribute to Ireland's economic sustainability. Colleagues across Tyndall and its partners have successfully applied their expertise to deliver countermeasures and innovative technology that can have a rapid demonstrable impact on COVID-19.

We stand on the cusp of change, with urgent challenges and a stimulating future to embrace. Thanks to our world-class research and professional support teams we are ready to meet the challenges ahead.



**Eoin O'Driscoll**
Chairman

*Prof. William Scanlon, CEO Tyndall and Eoin O'Driscoll, Tyndall Chairman*


*UCC President, Professor Pat O'Shea presenting the UCC Staff leadership Award to Dr Giorgos Fagas*

# CEO's message

I am pleased to present to you Tyndall's 2019 Annual Report. The essence of Tyndall is that we combine multidisciplinary research leadership and state-of-the art infrastructure on-site. This is the perfect set-up to address the significant research challenges that society faces, and 2019 saw us continuing to develop our integrated world-class infrastructure to support our 'atoms to systems' research agenda.

During 2019, we worked collaboratively with a wide range of stakeholders, internally and externally, to develop our new strategic plan 'Tyndall 2025'. This is an ambitious plan which will see Tyndall double in size, become a more significant player on the international stage, and secure a global leadership position in deep-tech research.

We are building on a proud legacy of achievement over nearly 40 years here at Tyndall. The hard work and dedication of our staff and students and our unique innovation model has resulted in Tyndall becoming a research community of 600 people, including more than 140 graduate students and 80 industry researchers in residence.

Tyndall is the most successful research institute in Ireland, ranked eighth in the EU for ICT funding, and involved in 12% of the total Irish drawdown from the Horizon 2020 programme. We are a host and a major partner in national research centres such as IPIC, CONNECT, VistaMilk and CONFIRM and industry-led technology centres such as Microelectronic Circuits Centre Ireland (MCCI).

Our researchers, professional support staff and students deliver world-leading research that has relevance and impact globally, for our societies and economies. Our world-leading publication record is proof of this and our strong performance in 2019 resulted in 256 publications.

Our researchers and students were also recognised through several awards in 2019. Dr Fatima Gunning received the Science Foundation Ireland (SFI) Inaugural Mentorship Award and Dr Han Shao received the SFI Research Image of the Year Award.

For our research to be relevant we need to actively transfer to industry Tyndall's cutting-edge discoveries, knowledge, leadership and talent. During 2019, we delivered 36 invention disclosures; 18 licences, options and assignments; seven priority patent applications and an IP licence value in excess of €1m for platform technology research.

As Tyndall continues to scale, we will build on our performance and grow our long-term commercial partnerships. We support an ever-expanding cohort of Irish and international small and medium-sized enterprises (SMEs) who engage in research, make use of our fabrication and test facilities, and have a presence on-site. Tyndall already has a significant global commercial presence, with c.€6m in research income coming from companies with no research presence in Ireland over the past three years.

We also stimulate and create new businesses. Most notable in 2019 was the launch of high-potential spin-out, Varadis and the completion of the Harrier high-speed communications commercialisation activity.

2019 was another successful year for our EU programmes. To date 17 new projects were funded, with a success rate over three times the European average, bringing nearly €10m in funding to Tyndall.

I would personally like to thank all our talented staff and students for the commitment and hard work which delivered the successes of the past year. Our ability to continue to work and remain connected during COVID-19 is testament to our values of collaboration and integrity. Together as one Tyndall team we have made significant progress in critical areas. We are also grateful for the trust of our stakeholders and customers and the continued support of our funders.

**Prof. William Scanlon**
CEO

# Scorecard

## Research excellence

**36** invention disclosures; 18 licences, options and assignments; seven priority patent applications and an IP licence value in excess of €1m for platform technology research.

**256** published papers

**Dr Han Shao** received the SFI Research Image of the Year Award.

**€6m** in research income coming from companies with no research presence in Ireland over the past three years.

**Prof William Scanlon**, CEO, elected IEEE fellow

**Dr Fatima Gunning** received the Science Foundation Ireland (SFI) Inaugural Mentorship Award

## Impact

**Pixquanta**
High-potential SME leverages Tyndall infrastructure for product development.

**Varadis**
Launch of spin-out with early revenue in high-growth private space, worker safety and wearables markets.

**Alcass Health, ESA BIC** participant secures early client engagement at large corporates with their Habitus Posture product ( targeting the well-being of large cohorts of increasingly desk-bound employees. )

The total value of industrial research programmes in 2019 was €21m.

***More than 35 industry personnel concluded advanced photonics device and packaging training***

**35**

**ESA BIC** incubated **12 early-stage start-ups** and completed four technology transfers

SME sector accounted for 49% of all industry programmes during the year

## International Reach

***IPIC co-hosted the 2019 European Conference on Optical Communication (ECOC 2019)***

**EU Programmes**
17 new projects funded

**ASCENT**
delivering access to a €2bn research infrastructure

EU success rate over three times the European average brings €10m funding into Tyndall.

**PIXAPP**
50 companies and research organisations; completion of 28 industrial R&D projects

**SmartVista**
granted €4m in funding from the Horizon 2020 programme

## People and culture

**126** PhD students
**17** Master's students
**21** PhDs completed

***Two SFI science awards***

**5** UCC Staff awards

**37%** students are women

***4,800 school students engaged with Tyndall***

**121** Transition Year students

**8,000** participants at STEM-themed events

## Infrastructure

**>26k**
usage hours

>900 users.

ISO 9001, ISO 50001 and ISO 17025 accredited

Tyndall hosts **Innovation Access programmes** targeted at SMEs

Tyndall hosts European access programmes

Training opportunity for the next generation of researchers on state-of the art technologies.

# Research excellence

# From fundamental scientific investigations through to technologies with measurable economic and societal impact

Excellence in research underpins everything that Tyndall does and the impact that we deliver. We pride ourselves that our research goes from fundamental scientific investigations through to technologies with measurable economic and societal impact.

Our commitment to impact through excellence was recognised through funding received for several major research projects in 2019. These include the renewal of funding for the SFI Research Centre, IPIC, which Tyndall leads, and which kicked off in 2019, and CONNECT 2, where Tyndall is a major partner.

2019 saw the commencement of the first projects supported by the Disruptive Technology Innovation Fund (DTIF). These included:

- HOLISTICS - Holistic Human Sensing for Health, Aging and Wellness
- Photonics Manufacturing Pilot Line
- Cooperative Energy Trading System (CENTS)

This support for our key areas of research underpins the future development and exploitation of our deep-tech expertise in photonics and micro-nano systems.

Our commitment to research that ranges from atoms to systems is reflected in the following highlights, which include fundamental predictions relevant for future quantum technologies, novel materials for future data storage and display devices, and research related to wearable health monitoring systems and their application.


*Dr Fatima Gunning received the Science Foundation Ireland (SFI) Inaugural Mentorship Award; Dr Han Shao received the SFI Research Image of the Year Award*

# Exploring the potential of c-plane indium gallium nitride quantum dots for twin-photon emission

Quantum light sources are key building blocks for future photonic technologies. The design and control of non-classical states of light is strongly driven by applications in information processing or communication. Emission of non-classical light at elevated temperatures has to date presented a significant challenge.

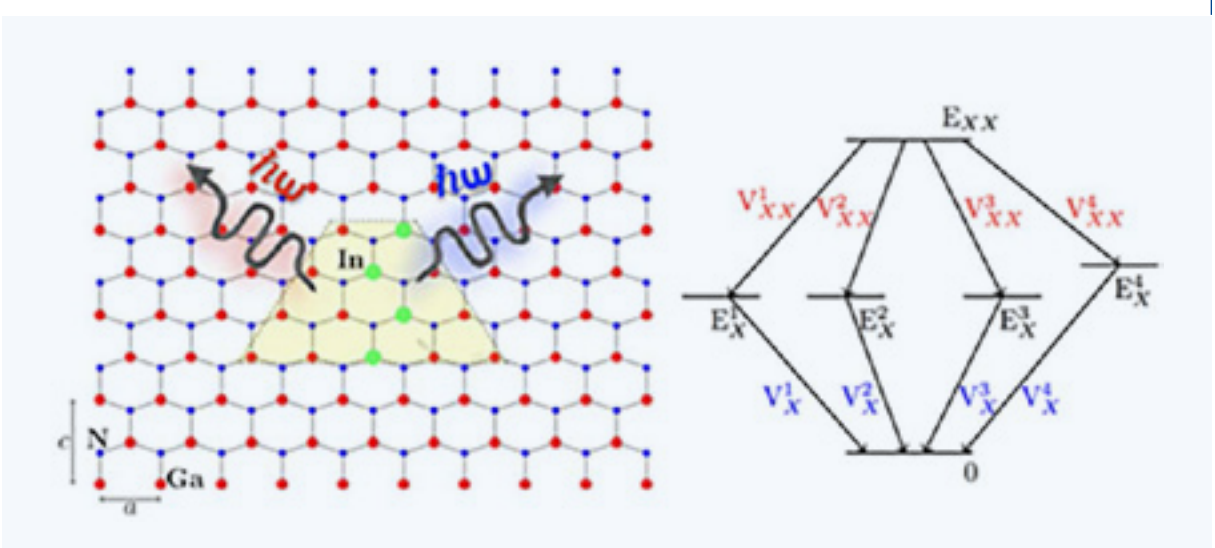
In a paper published in Nano Letters, Dr Saroj Kanta Patra and Dr Stefan Schulz investigated, in the framework of atomistic many-body theory, the potential of indium gallium nitride quantum dots for novel non-classical light emission via so-called twin photons.

In general, indium gallium nitride systems form the heart of current energy-efficient 'classical' light emitters, such as light-emitting diodes. Furthermore, thanks to their fundamental material properties, heterostructures based on indium gallium nitride and gallium nitride are highly attractive for efficient light emission at ambient temperatures. The teams' calculations showed and explained that key features, enabling non-classical light emission via twin-photons, are vastly different from arsenide-based quantum dots, so far used for such applications.

The investigations by Dr Patra and Dr Schulz highlighted the benefit of these distinctly different features of indium gallium nitride quantum dots for efficient twin photon emission near room temperature.

Nano Lett. 20, 234 (2020); https://doi.org/10.1021/acs.nanolett.9b03740

Saroj Kanta Patra and Stefan Schulz




*Schematic illustration of (left) alloy fluctuations in an InGaN quantum dot embedded in GaN and (right) the biexciton (XX) - exciton (X) cascade in this system, indicating that the emitted photons exhibit the same light polarization (Vxx and Vx).*

# Ferroelectric behavior in exfoliated 2d aurivillius oxide flakes of sub-unit cell thickness

As miniaturisation of electronic devices continues, a crucial requirement for materials in data storage applications is the enhancement of their functional properties at very small dimensions. This is challenging for ferroelectric materials because ferroelectricity is a collective phenomenon and spontaneous electrical polarisation is expected only to be sustained above a certain critical thickness, previously thought to be above 20 nm.

However, there has been significant progress in piezoresponse force microscopy (PFM) instrumentation over the past two decades that has provided experimental evidence for the persistence of ferroelectricity down to two-unit cell thicknesses.

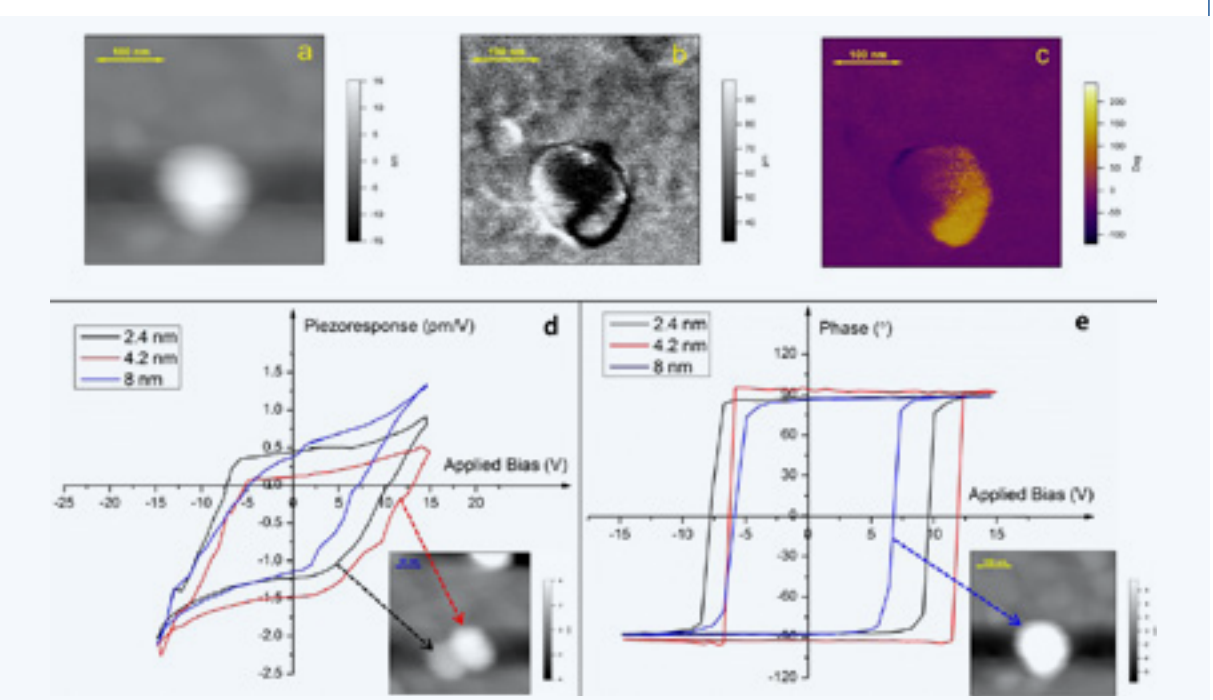
In this work, ceramics of an Aurivillius phase ferroelectric were ultrasonically exfoliated into thin (120 nm down to 2.4 nm) 2D flakes.

At Tyndall, we performed detailed PFM studies to overcome the challenges involved in measuring ferroelectric properties at such small dimensions. Measurements demonstrated that these very thin flakes exhibit piezoelectric effects. Furthermore, we have shown that ferroelectricity can exist and switch in flakes with thicknesses of only 2.4 nm, which equals one-half of the normal crystal unit cell. This work constitutes the first evidence for ferroelectricity in a 2D oxide material.

Adv. Electron. Mater. 6, 1901264 (2020); https://doi.org/10.1002/aelm.201901264

Lynette Keeney (Tyndall National Institute), Ronan J Smith (Trinity College Dublin), Meghdad Palizdar (University of Leeds), Michael Schmidt (Tyndall National Institute), Andrew J Bell (University of Leeds), Jonathan N Coleman (Trinity College Dublin) and Roger W Whatmore (Imperial College London)

*Representative a) topography, b) vertical DART-PFM amplitude, and c) vertical DART-PFM phase images of a single 15 nm high flake of exfoliated B5TFCO. Vertical DART-PFM switching spectroscopy d) piezoresponse and e) phase loops of exfoliated B5TFCO nanoflakes at room temperature after removal of an applied DC bias.*



# High power surface emitting InGaN superluminescent light-emitting diodes

Established photonic technologies such as lasers and light-emitting diodes can respectively provide high power in a beam and a broad emission spectrum, but not both. This has led to increasing interest in the super-luminescent light-emitting diode (SLED), which can, in principle, achieve both properties in a single device. However, current SLEDs are limited in the power that they can deliver, restricting their potential as light sources for pico-projection, optical coherence tomography, machine vision or LiDAR.

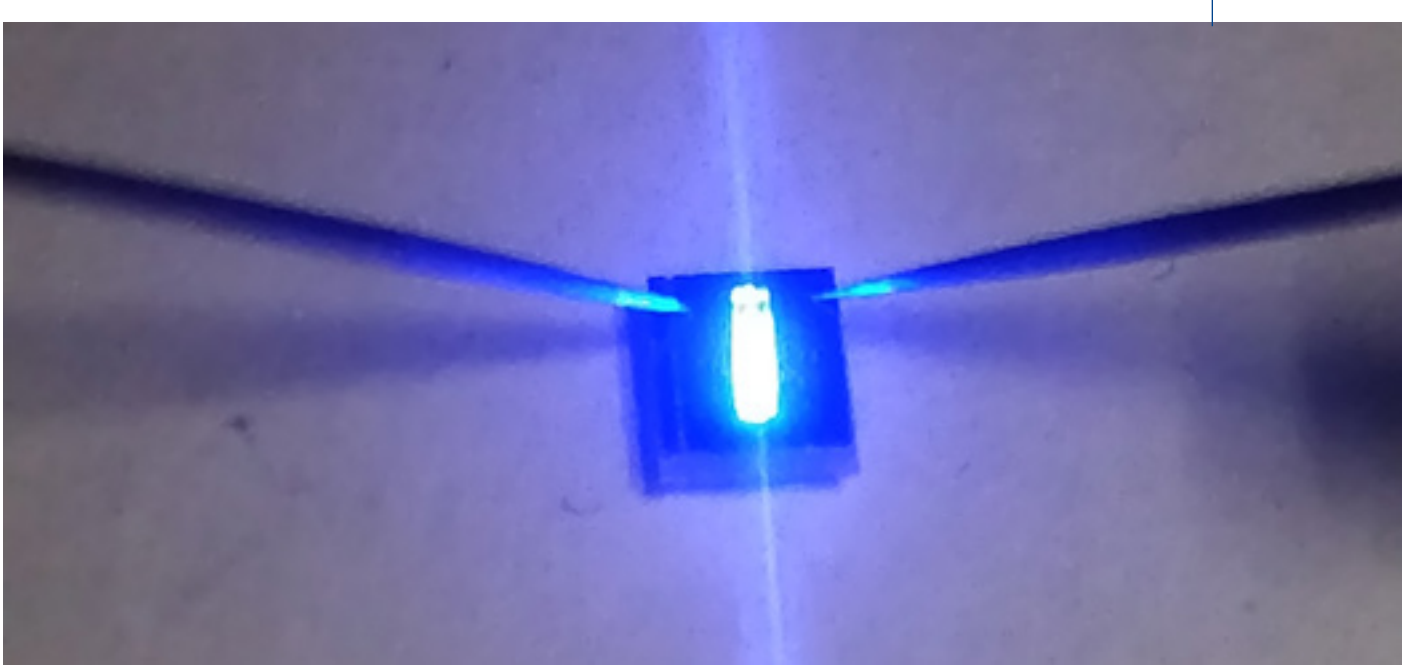
To address this issue, we developed our patented substrate-emitting arrangement using high-quality blue-emitting gallium nitride materials. Our approach uses a unique etching technology to create ultra-smooth angled facets that direct in-plane amplified light downwards and out through the transparent substrate.

In the work published in Applied Physics Letters, we demonstrate the world record optical power from a SLED (of any colour) while maintaining a broad emission spectrum. The experiments revealed the high levels of gain that can be achieved in these materials. The surface-emitting design reduces production costs by allowing for on-wafer testing, allows for integration of different functions and has the potential to be adapted for many applications in the future.

Appl. Phys. Lett. 115, 171102 (2019); https://doi.org/10.1063/1.5118953

Rory Cahill, Pleun Maaskant, Mahbub Akhter and Brian Corbett

*Below threshold emission from probed superluminescent LED*



# Using artificial neural networks and lower body kinematics to determine three-dimensional ground reaction forces in running

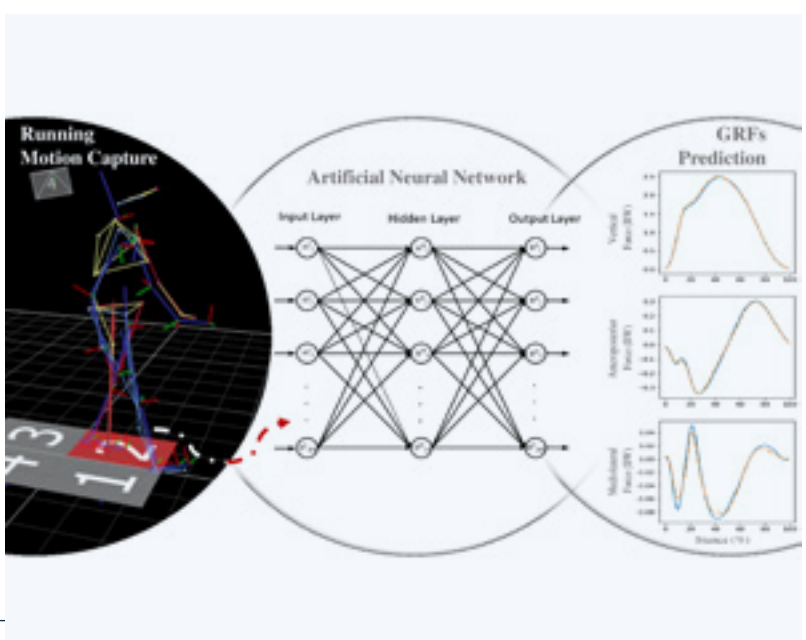
Monitoring the load placed on athletes in both training and competition is a key element of sports science. This project involves the development of a new prototype to quantify precisely the internal and external loads placed on athletes, and to enhance and predict athletes' performance and help protect them from injury and ill health.

Working in close collaboration with expert sports scientists at Setanta College, Ireland, the project provides a real-time ICT-oriented approach to monitoring athletes' training load. This is enabled by the use of state-of-the-art sensors, and proprietary technology and algorithms developed by the Wireless Sensor Network Group at Tyndall.

A key goal of the system is to monitor training load and the risk of micro traumas that may lead to serious injuries. The effects of repeated loads are related to the ground reaction forces and their summed-up measure. In work published in IEEE Access, we have shown that the ground reaction forces can be accurately estimated using artificial neural networks to analyse lower body kinematic data collected with wearable sensors. The system can enable continuous monitoring in unconstrained and open-field environments, providing real-time information on fatigue and training load to the athlete and their coaches.

IEEE Access 7, 156779 (2019); https://doi.org/10.1109/ACCESS.2019.2949699

Dimitrios-Sokratis Komaris, Eduardo Perez-Valero, Luke Jordan (Setanta College), John Barton, Liam Hennessy (Setanta College), Brendan O'Flynn and Salvatore Tedesco




*The three layers (Input, hidden and output) of the ANN used to predict GRFs from acceleration inputs*

# Impact

Tyndall's research spans fundamental research and industry-focused technology deployment. This is achieved through a common approach to impact delivery across all of our research centres and activities.

Our long-term success is founded on excellence in fundamental research which advances Ireland's impact in critical global development goals such as ICT adoption, agriculture and food security, energy and the life sciences.

Direct industry research engagement over successive generations of technology leads to fundamental shifts in technology adoption involving a rich network of SMEs, indigenous industry and multinational industry partners. In 2019 we saw immediate and strong industry participation in the most recent SFI Research Centres, VistaMilk and CONFIRM, which have significant activities at Tyndall.

Tyndall has also achieved significant global industrial impact through ongoing industrial deployment of platform technologies such as integrated magnetics, as demonstrated through the awarding of a joint patent with Apple Inc. in this important energy domain.

Other impacts include technology transfer in the form of licensing; industry training on advanced technology deployment and pilot line manufacturing; and new ventures in the form of spin-outs and spin-ins.

Working closely with the Tyndall Commercial Team, UCC Innovation (TTO) reports another successful year of technology transfer at Tyndall. In all, there were **36 invention disclosures; 18 licences**, options and assignments with industry partners; and **seven priority patent applications. IP licence income of over €1m for platform technology research** was achieved. A highlight was the launch of the start-up venture Varadis. Industrial partners collaborating with Tyndall and UCC Innovation range from global multi-nationals to local SMEs and new start-up companies, reflecting Tyndall's ability to engage with enterprises of all sizes and across a wide technology spectrum. The embedded model of TTO at Tyndall has also helped the research teams to build a high quality pipeline of opportunities for the future.

During 2019, industry commitment to new research programmes was almost €6m, with an additional in-kind contribution of in excess of €6m. **The total value of industrial research programmes in 2019 was €21m** (inclusive of in-kind).

In addition, 45 industry personnel participated in structured training on-site, attracting global talent from enterprises with no research presence in Ireland – an important indicator of our international industrial reach. Finally, the **ESA BIC**, a consortium of business incubators led by Tyndall, **incubated 12 early-stage start-ups and completed four technology transfers.**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*Dr Anthony Morrissey, Commercialisation Case Manager Tyndall, winner of the Knowledge Transfer Ireland (KTI) Achiever of the Year Award 2019 with Dr Alison Campbell, Director of KTI, and Dr Rich Ferrie, Director of Innovation UCC*

# Highlights

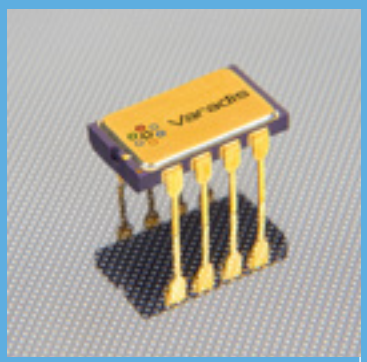
## New venture maximises radiation research impact

Throughout its history Tyndall has successfully commercialised its deep technology through spin-outs which go on to scale and deliver impact for our economy. These spin-outs are high-value, scaling enterprises which continue to collaborate and engage with the Institute through further research and SME services access.

Varadis, although only formed in 2019, is already on a path to early customer acquisition and scale. The company, led by CEO Brad Wrigley, and supported by Tyndall's radiation sensors (RADFETs) research team, was launched with the aim of maximising the impact of the Institute's radiation technology research. The new spin-out is riding the wave of investment in private and public space exploration markets.

In other global markets for radiation measurement devices, RADFETs can measure the amount of radiation that a tumour has absorbed in radiotherapy sessions, as well as having important applications in industrial power, disaster recovery, worker safety and wearables.

Varadis spun out with the benefit of an exclusive technology licence, access to the research talent of the RADFETs team and the advanced fabrication infrastructure at Tyndall. This ongoing access to Tyndall's world-class infrastructure, and the future support of UCC's Innovation and partner agencies in Enterprise Ireland and the European Space Agency, gives Varadis the ability to scale quickly and deliver high-impact return for all stakeholders.



*Varadis RADFET VT02*

*Eight Lead Ceramic Side Braze Package*

*Prof. William Scanlon, CEO Tyndall with Brad Wrigley, Varadis CEO*

# Delivering impact to industry partners

Tyndall supports industry partners through access to the very best research talent. In 2019, we continued to strengthen critical knowledge transfer activities with partners across the globe, including Intel and Seagate.

Bernie Capraro, Research Manager, Silicon Technology at Intel Ireland joined forces with the Tyndall Board to support Tyndall's 2019 Student Poster Competition, an event Mr Capraro commented on later: "As a global technology leader, Intel endeavours to maintain a strong research presence in the regions in which it operates, and therefore actively develops a strong technical pipeline to support our future operations and research interests. The domain expertise and enthusiasm of the collective talent we met on the day translates directly into advancing Intel's world-class technology."

During the year, we also had the pleasure of welcoming an increasing number of talented industrial researchers and engineers to participate in focused technology workshops and bespoke programmes aimed at commercialisation of advanced technologies for our industry partners. Marcus B Mooney, R&D Manager at Seagate Technology, says: "Tyndall provides us with a unique combination of world-class research talent in a state-of-the-art, live laboratory environment, which we can utilise to bridge the gap between excellent science and commercial deployment."

Outbound engagement programmes during the year included student placements at Applied Materials in the US under an Enterprise Ireland Innovation Partnership, and an SFI Fellowship placement at Analog Devices in Limerick.

IDA Ireland

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*Bernie Capraro, Research Manager, Intel Ireland with student poster winners and members of the Tyndall Board*

# Supporting Irish and international SMEs

Tyndall's extensive engagement with the SME community includes fostering spin-outs, start-ups and spin-ins. The latter cohort of indigenous SMEs now accounts for one-third of all industry researchers-in-residence who made Tyndall their home in 2019.

The SME sector accounted for 49% of all industry programmes during the year, a significant increase on 2018, and was responsible for 35% of total industry funds committed to Tyndall in 2019.

Three Irish SMEs joined DTIF consortia in 2019, creating strong industrial multinational connections across the value chain and winning €11m in funding for projects in areas ranging from health and well-being to photonics, energy and medical device research.

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*Prof. John O'Halloran, Deputy President and Registrar, UCC, Prof.William Scanlon, CEO Tyndall, Minister for Business Enterprise and Innovation Heather Humphreys TD, Eoin O'Driscoll, Tyndall Chairman*

*Dr Brendan O'Flynn, demonstrating the next generation wearable sensing technologies proposed under the DTIF funded project "Holistics" to Minister Humphreys TD during her visit*

# International reach

# International reach

Another highly successful year for our EU programmes has placed us in a great position as we set out to achieve our Tyndall 2025 goal of being the international research partner of choice. In 2019, 17 new projects were funded, bringing €10m in funding to Tyndall. That translated into a success rate more than three times the European average.

Funded projects ranged from making new discoveries and developing next-generation technologies to training early career talent, providing expertise and access to infrastructure to SMEs, and addressing global challenges in health, agri-food, the environment, and energy.

High-value wins included a photonics pilot line for medtech and a project on cryo-electronics for quantum computing. Tyndall also demonstrated leadership in four newly retained projects, including two by first-time coordinators and two Marie-Sklowdoska-Curie actions for the development of photonics research leaders and international exchange.

During 2019, we had six internal newcomers to EU research and innovation, while our thought leaders continued to contribute to research policy and industry roadmapping through our substantial stakeholder engagement in Europe and globally.

The new projects bring Tyndall's EU participations to a total of 88 since the launch of the Horizon 2020 programme. The total project value is close to €630m, with an investment in our activities at almost €50m and an equal amount of funding received by our Irish partners, including €18m to Irish SMEs.

In all, Tyndall has directly supported 19 SMEs and 13 large companies in EU programmes. That is more than three times the number of industrial partners supported on EU programmes by any other Irish research provider. Tyndall is also the main Irish beneficiary in EU ICT funding and the principal contributor to UCC's position in the top five ICT-funded universities Europe-wide.

*Prof. Martyn Pemble, Head of Advanced Materials, Jo Southernwood, Senior Research Engineer, International Energy Research Centre, Prof. William Scanlon, CEO, Dr Giorgos Fagas, Head of EU Programmes, Patrick Morrissey, Head of Photonics Operations, Dr Carlos Ochoa, Senior Researcher, International Energy Research Centre*

# Highlights

## ASCENT

### Delivering access to a €2bn research infrastructure

Led by Tyndall, the €5m EU ASCENT programme provided access to the world's most advanced nanoelectronics infrastructure and delivered 100 projects to researchers from 30 countries across the global research community over a four-year period.

ASCENT built a community of more than 400 researchers in nanoelectronics modelling and characterisation and provided free-of-charge access to unique research infrastructure and expertise.

The programme commenced in May 2015, when leading European nanoelectronics institutes, Tyndall in Ireland, CEA-Leti in France and imec in Belgium, entered into a collaborative open-access project to mobilise European research capabilities at a global scale.

The partners' facilities are truly world class, representing over €2bn of combined research infrastructure with unique credentials in advanced semiconductor processing, nanofabrication, heterogeneous and 3D integration, electrical characterisation, and atomistic and Technology computer-aided design (TCAD) modelling.

During the programme, ASCENT shared the best scientific and technological practices, formed a knowledge-innovation hub, trained new researchers in advanced methodologies, and established a unique research network of advanced technology designers, modellers and manufacturers in order to strengthen Europe's knowledge in the area of nanoelectronics research. A follow-up phase to expand the ASCENT offering, infrastructure network and community is planned.

ascent
European Nanoelectronics Access

*Julie Donnelly, ASCENT Programme Manager and Paul Roseingrave, ASCENT Access Coordinator at Tyndall are pictured with nanodevices fabricated on a 300mm silicon wafer at the announcement that 100 global research projects accessed the Tyndall-led ASCENT programme which delivered free access to €2 billion worth of state-of-the art facilities at Tyndall, imec and CEA-Leti*

# Achieving world firsts in photonics manufacturing

Managed by the Technology Gateway at Tyndall National Institute and directed by Dr Peter O'Brien, PIXAPP brings together a highly experienced consortium with an unmatched record of excellence in realising many world firsts in photonic integrated circuit (PIC) packaging and assembly.

With a budget of €16m, the PIXAPP network brings together EU foundries, assembly and packaging partners, and technology and equipment providers to develop a credible strategy for future volume manufacturing of photonic devices.

A major success of the PIXAPP Pilot Line to date has been its work with industrial users. Almost 150 companies and research organisations have interacted with the Gateway offices at Tyndall and this has led to the successful completion of 28 industrial R&D projects on scalable PIC packaging and assembly solutions. Key to these activities has been the development of packaging design rules and roadmaps, which create a framework for scalable and cost-effective packaging of photonic devices.

PIXAPP led the way in training and education by creating the world's first photonic packaging training programme in 2018. To date, over 40 engineers and researchers from across the world have attended the programme. With an emphasis on hands-on training, attendees develop the necessary skills to design, package and test photonic devices using state-of-the art equipment with advice from leaders in the field.

PIXAPP
Photonic Packaging
Pilot Line


*Noreen Nudds and Magaly Mora, Photonics Packaging Group*

# Leading the way in remote patient monitoring

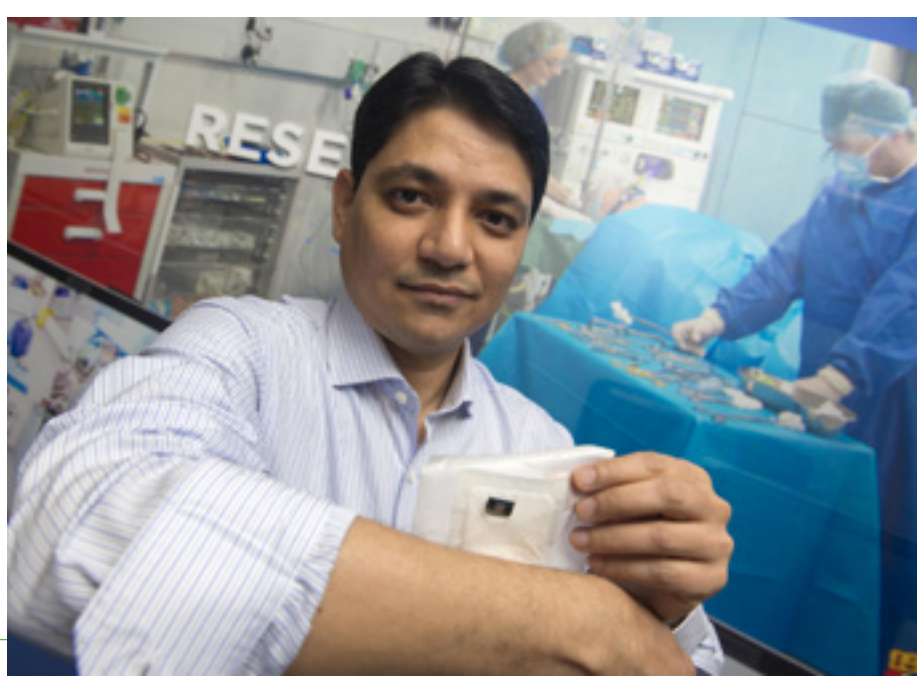
The importance of digital diagnostic and monitoring tools has become even more evident during the COVID 19 pandemic. In 2018, Tyndall had already proposed an idea to develop wearable biosensor technology for real-time wireless remote patient monitoring.

Building on a long-standing partnership with Fraunhofer EMFT in Germany and CNRS in France, a consortium was formed which also included UCC, Swedish SME Novosense, and Analog Devices.

Coordinated by Tyndall, the resulting project, SmartVista, was granted €4m in funding from the Horizon 2020 programme and commenced in January 2019. The SmartVista wearable biosensor will deliver a seamless feed of patient data, such as heart rhythm (electrocardiograph), respiration, temperature, and oxygen flow to enable remote patient monitoring.

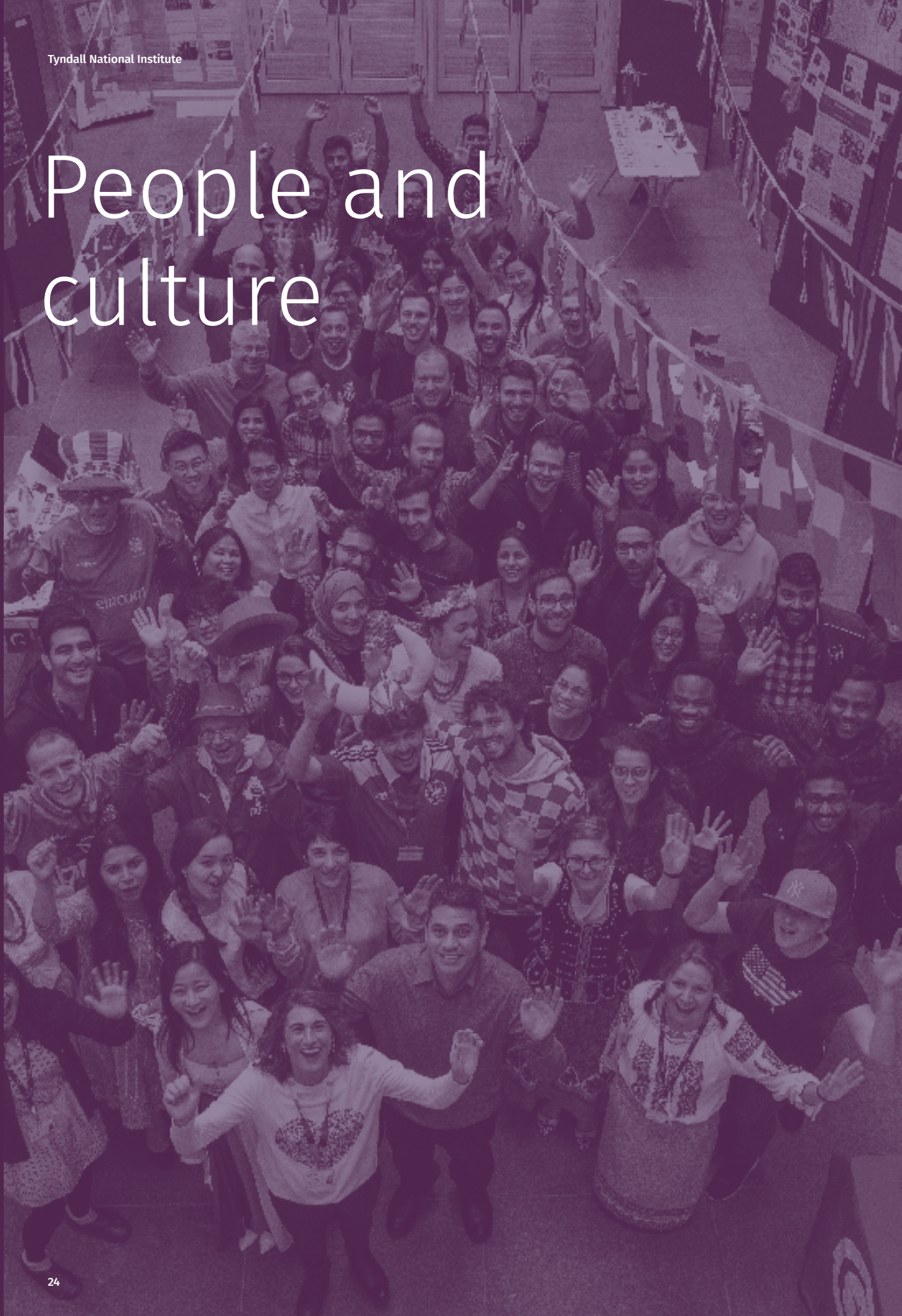
Of particular note is the thermoelectric harvesting platform developed jointly between Tyndall and Analog Devices as part of the SmartVista demonstrator which has the potential to be adapted for a wide range of patient monitoring technologies.

SmartVista is well positioned to be at the forefront of digital health and wearable biosensor technology for wireless monitoring of patients in hospitals and in remote settings. This technology is likely to form a key element of health authorities' future response to pandemics.



*Dr Kafil M. Razeeb, Senior Staff Researcher & Team Leader, with a mock-up of the SmartVista wearable biosensor which will be worn on a patient's chest.*

# People and culture



2019 brought about a step change in how we approach people and culture in Tyndall and this has given us an extremely strong foundation on which to build into the future and to aid in the delivery of our Tyndall 2025 ambitions.

Our approach during the year was informed by analysis of Tyndall's 2018 inaugural People Survey, which helped identify key projects for delivery. Projects were carried out under three main strands: attracting the best talent; career development; and integration and collaboration.

Key actions in the talent strand ranged from having a dedicated recruiter in Tyndall, to national and international recruitment campaigns. These were successful in raising awareness of Tyndall and resulted in securing several key appointments. We are continually streamlining our recruitment process and recent initiatives have moved us into a very proactive hiring mode to source top talent.

Regarding career development, much work took place in 2019 to deliver a strong training calendar and development programmes to nurture our people and enhance their knowledge and skillsets. We recognise the vibrancy of our talent pool at Tyndall and in 2019 more staff than in any preceding year advanced to new roles within Tyndall.

There were many excellent examples of integration and collaboration in 2019, ranging from our Equality, Diversity and Integration (EDI) events to the tremendous contributions of our staff and students to the Tyndall 2025 strategy and values process. Our annual Internal Conference moved away from departmental presentations and focused instead on our collaborative research and how it aligns with the United Nations Sustainable Development Goals (UNSDGs).

Maintaining smooth communications internally is key and in 2019 we launched our own internal communications platform and initiated a series of new, regular face-to-face meetings between staff and the leadership team.

## Graduate education 2019

We are very grateful to our generous industry sponsors who have supported our research excellence through annual awards for outstanding Tyndall students.

- The BOC Bursary by BOC Gases
- The Postgraduate Research Paper Award 2019 by Catalyst ADI
- The Student Poster Competition by Intel

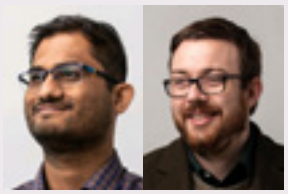
*Internal Kick-Off of the Tyndall 2025 Strategic Plan*

# Student achievements 2019

## Gioele Mirabelli

**Nano-electronic Materials and Devices Group**

won the BOC Bursary annual award for his research on two-dimensional semiconductor materials for future electronics.



## Saroj Kanta Patra

**Photonics Theory**

## Shane O'Mahony

**MNS Materials Theory**

were joint winners for the Postgraduate Research Paper award 2019 kindly sponsored by Catalyst ADI.

## Kankana Paul

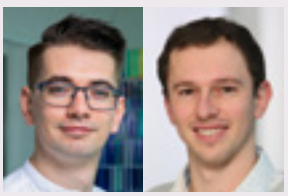
**Micropower Systems and Nanomagnetics Group**

received 1st prize General Category of the 2019 Intel Postgraduate Poster Competition. She also won 2 other awards in 2019: she was awarded Best Poster award at the Energy Harvesting NiPS International Summer School and won best Poster Award at the 3rd Annual International Society of Electrochemistry Student symposium.

## Vuslat Buk Juska

**MNS (Circuits and Systems) - LSI (Electronic Instrumentation Systems)**

was awarded a prize by ELSEVIER for her oral presentation in Biosensors & Biomedical Analysis Session at the 20th Euroanalysis Conference.



## Ehren Dixon

**Electrochemical Materials and Energy Group**

## Jean Souza Matia

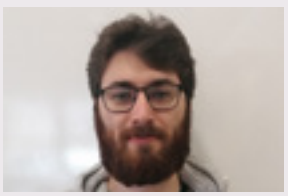
**Biophotonics**

received joint 1st early stage category prize for the Intel Postgraduate Poster Competition.

## Niamh Kavanagh

**Photonic Systems**

was selected as one of the Outstanding Scientists to attend the 69th Lindau Nobel Laureate Meeting.



## William Daly

**Advanced Materials and Surfaces**

was presented with the runner-up award recognizing his excellence as a Chemistry demonstrator.

## Luiza Wasiewska

**Nanotechnology**

## Andrea Pacheco

**Biophotonics**

were winners in the Cork heat of FameLab and finalists in the National Finals.

## Stephen Rhatigan

**Materials Modelling for Devices group**

was the winner of UCC's School of Chemistry 2019 Postgraduate prize.

## Stephen Murphy

**Photonic Systems**

won the College of SEFS Student Nominated Teaching Demonstrator Award in recognition of the high quality of his work, and dedication to, teaching physics to undergraduate students.

## Louise McGrath

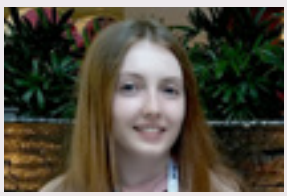
**Electrochemical Materials and Energy Group**

received the CONNECT Education and Public Engagement Award in recognition of the breadth and depth of Louise's EPE activities in CONNECT.

## Marco Cavaliere

**Electromagnetic and Electronics Systems**

won the Technology Award at the 31st International Society for Medical Innovation and Technology Conference



## Rita Mullins

**Materials Modelling for Devices**

won best Poster Presentation at the 19th International Conference on Atomic Layer Deposition.

## Brian Murray

**Photonic Systems**

was awarded an IEEE student travel bursary to attend the IEEE Photonics Conference 2019 in San Antonio, USA.

# PhD vivas 2019

## Abeer Alyami
Fabrication of plasmonic probes and composites for surface enhanced Raman scattering (SERS) investigation of commercial inks and food contaminants

## Reza Arkani
Modelling and analysis of hydrogenated and dilute nitride semiconductors

## Andrei Bakoz
Hybrid frequency modulated silicon photonic crystal laser

## Daniel Carey
Dynamically reconfigurable long-reach PONs for high capacity access

## Marco Dalla Santa
Next generation technologies for 100 Gb/s PON systems

## Mohamad Dernaika
Monolithically integrated coherent comb de-multiplexer using facetless semiconductor ring lasers

## Juan Morales
Optical properties of III-V nanowire/ nanopillar lasers grown on Si.

## Fabien Dubois
Mutually coupled lasers in photonic integrated circuits

## Shane Duggan
Regrowth-free monolithic vertical integration of passive and active waveguides

## Ekaterina Filatova
Area selective atomic layer deposition of Si-based materials

## Brian Hogan
Sub-wavelength gratings for long wavelength sensing

## How Yuan Hwang
Integrated silicon photonic packaging

## Niamh Kavanagh
Dense wavelength division multiplexing at 2 µm for future optical communications

## Ruggero Loi
Heterogeneous integration of InP etched facet lasers to silicon photonics by micro transfer printing

## Melissa McCarthy
Atomic layer deposition of photovoltaics

## Enrica Mura
MOVPE metamorphic lasers and nanostructures engineering at telecom wavelengths

## Ben O'Shaughnessy
Dynamics of swept source lasers

## Saroj Kanta Patra
Electronic and optical properties of III-nitride nanostructures

## Prasanna Ramaswamy
Monolithically integrated tuneable slotted Fabry-Pérot laser, wavelength monitor and modulator

## Yineng Wang
Development of a portable miniaturised capillary electrophoresis system for chemical nerve agents detection

## Mariusz Wilk
Data fusion for human motion tracking with multimodal sensing

# Education and public engagement

Engaging with the public is of increasing strategic importance for higher education, in order to strengthen relevance, responsiveness and accountability, and to build trust. During 2019, Tyndall engaged with over 800 primary school students and more than 4,000 secondary school students. In addition, 121 Transition Year (TY) students completed work experience programmes at Tyndall. We also interacted with over 8,000 members of the public through STEM-themed events.

Our aim is not only to encourage more students to do STEM subjects but to highlight the importance of physical sciences, their relevance to our everyday lives and the diverse career opportunities available in these fields. Our public engagement and outreach activities engage with tomorrow's scientists and the public in primary and secondary school classrooms, on-site for TY students, career fairs, open days, festivals and public venues.

During 2019, our 'Sensational STEM' project, led by senior engineer Catriona Kenny, competitively won over €40,000 in funding under the SFI Discover call to deliver the project in 2020. This unique and innovative project is aimed at students with an autism spectrum disorder (ASD) diagnosis who may otherwise find existing STEM programme settings distressing.

Another achievement during the year saw Tyndall PhD students Luiza Wasiewska and Andrea Pacheco come first and second in the Cork heat of FameLab. Held annually in over 30 countries across the globe, FameLab is the world's largest science communication competition.

Ireland hosted the prestigious European Conference in Optical Communications (ECOC) in September 2019. As part of this conference IPIC, SFI and ECOC joined to invite 750 post-primary students and teachers from across Ireland to see Professor Brian Cox present his "Exploring the Universe" lecture in the RDS. A key objective of the event was to attract young women into careers in physics and engineering, where there remains a gender deficit.

*Dr Caitriona Tyndall, Alida Zauers and young participant in the Tyndall Atrium during Culture Night 2019*

# Infrastructure

Tyndall is a recognised national asset sitting in a unique position at the mid-point between traditional higher education institution (HEI) research activities and the demanding industry interface. Tyndall is the only Irish research performing organisation to take an 'atoms to systems' approach and it serves as a model for marrying leading-edge research activities with strong industrial engagement, particularly with the Irish SME sector.

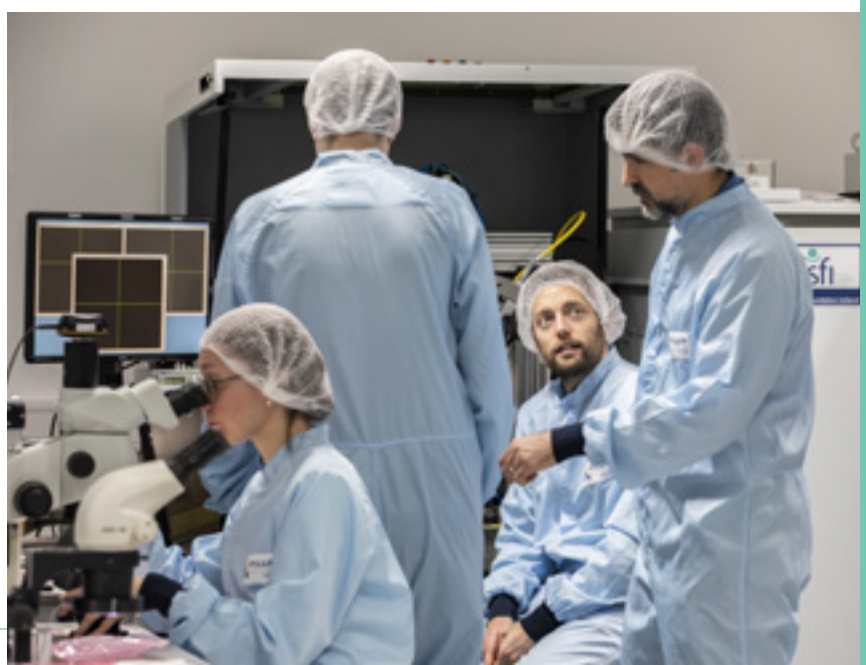
Tyndall is also ISO 9001, ISO 50001 and ISO 17025 accredited – key requirements when transferring research into production with industry and delivering economic impact.

The physical infrastructures supporting wafer fabrication, materials and device growth and analysis, integration and packaging and system testing, combined with the extensive and deep expertise of our staff, are key to the delivery of the solutions sought by our research and industry customers.

In 2017 and 2018, Tyndall was successful in securing the funding for a major upgrade and renewal of the cleanroom processing and associated metrology equipment. We are now almost one third of the way through this multi-year programme to transform our fabrication facilities to best in class in Ireland and one of only a handful in Europe with a full fabrication line for 200 mm wafers.

The new capabilities are critical in order to enable us to maintain our position at the leading edge of technology addressing new emerging technological challenges in quantum engineering, photonics, nanoelectronics, life sciences and energy that have been identified on national and international strategic roadmaps.

The tools that have been installed – and those in train – are already driving new research opportunities with industry partners, as well as enabling Tyndall to increase its competitiveness in Europe in winning EU and European Space Agency (ESA) funding. We have also strengthened our access programmes to make this state-of-the-art equipment available to internal and external academic and industry users nationally and internationally.



*Photonics Packaging Lab*

# Highlights

## Facilities and services

During 2019, we continued our substantial capital programme for infrastructure with the procurement of a number of strategically important pieces of capital equipment including:

Elionix e-beam – 6 nm on 200 mm wafers

Suss Labcluster tool for resist coating and developing

Evatec Clusterline 200II

Oxford PlasmaPro 100 etcher

SPTS Synapse etcher

MemsStar HF vapour etcher

# Access programmes at Tyndall

Tyndall is committed to providing external users with access to its state-of-the-art research infrastructure, expertise and pathways to innovation. Researchers and industry clients have direct access to Tyndall through collaborative research projects, partnerships in hosted research centres and through commercial contract research at Tyndall.

In addition to these traditional routes, Tyndall hosts a number of European access programmes that provide funded access to Tyndall's facilities and expertise. These access programmes are open to researchers in academia, SMEs and large industry and offer a unique opportunity to access Tyndall and leading facilities across Europe.

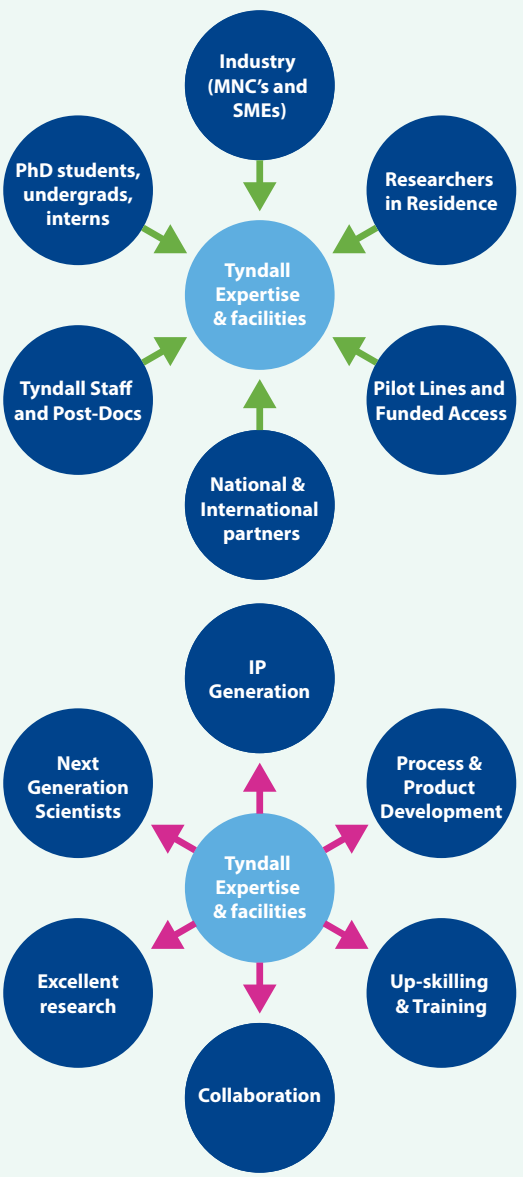
While some of the access programmes are limited to transnational users, Tyndall also helps Irish researchers access our partner sites across Europe.

The programmes are designed to be very user-focused, and they make it very easy for external researchers to access the latest technologies and experts at Tyndall. This helps researchers to advance their research outputs and it provides a significant training opportunity to the next generation of researchers on state-of the art technologies.

Tyndall also hosts several innovation access programmes targeted at SMEs, which provides them with a real opportunity to accelerate their product development and increase the commercial potential of their outputs through access to Tyndall's well-established innovation pathways.

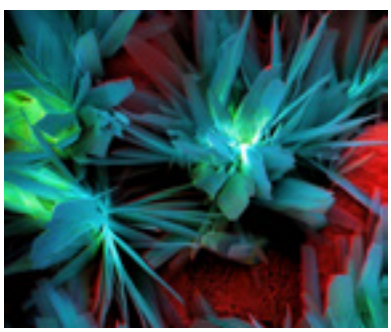
## User Access

Tyndall has streamlined access to its advanced facilities



# Scientific image competition winners

We would like to thank Elionix for their kind sponsorship of the Tyndall Scientific Images Competition where Tyndall researchers share images from the visually striking or informative to the technically excellent to compete for a prize.

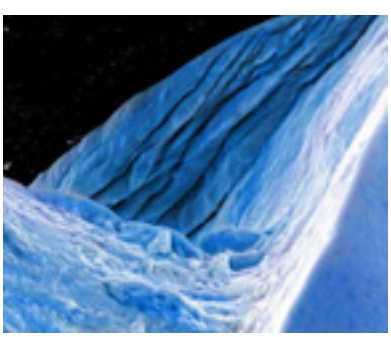


## EDX elemental mapping of cobalt phosphate micro/ nanoflowers on nickel foam

**Han Shao, Nanotechnology Group**
The image shows the distribution of different elements (red-Ni, purple-Co, blue-O, green-P). Cobalt phosphate nanoflake grown outward in different directions, forming a flower-like microstructure, which enhanced the energy storage performance to 43.2 Wh kg-1. With superior storage capacity and long life, the cobalt phosphate based device can be employed in next-generation artificial cardiac pacemakers as a rechargeable energy source that will last for more than 15 years.

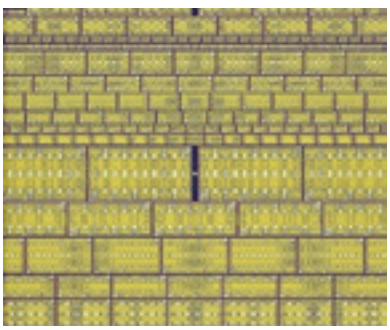
## Light for a better breath

**Andrea Liliana & Pacheco Tobo, Biophotonics**
The Biophotonics@Tyndall team is working on the clinical translation of Gas in Scattering Media Absorption Spectroscopy (GASMAS) technique for a noninvasive lung function assessment and diagnostics in neonates. Since studies and measurements in infants are limited to the essentials, we built the first multistructure optical phantoms with accurate anatomic geometry and tissue optical properties of human tissue.



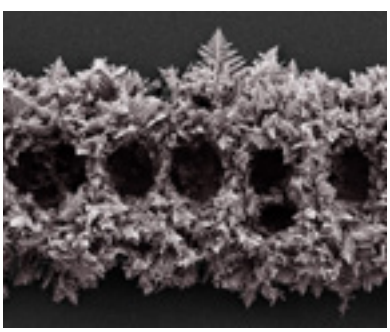
## Icy Comet Nucleus

**Daniel Smallwood, Electrochemical Materials and Energy**
SEM micrograph of an electroplated micro-wire. The wire's surface roughness creates the impression of a jagged icy slope with an undulating frozen backdrop. The frozen landscape is contrasted against a dark substrate in the background, which appears as the star-lit void of deep space. This research is part of the SFI Adept project.



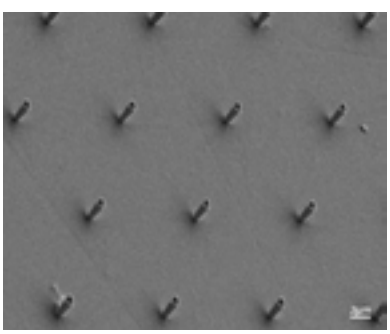
## Micro Circuit Metropolis

**Daniel Smallwood, Integrated Magnetics**
This is an image of a multi-tiered photomask design, where multiple devices are simultaneously fabricated on the same wafer. Vertical stacking and horizontal dicing lanes, when coupled with the complexity of the design, create the effect of a sprawling micro-metropolis. This research is part of the SFI Adept project.



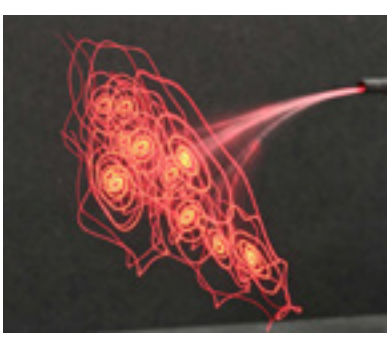
## Noble metal deposits onto a single micro-band electrode

**Vuslat Buk, LSI/ MNS**
Image represents a very elegant and controlled electrodeposition of copper dendrites onto a micro-band electrode. Prepared surface is used to develop electrochemical biosensors for SACCP project.



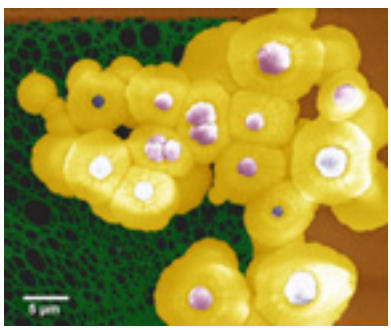
## Quantum-dot micropillars III

**Gediminas Juska, Simone Varo, Epitaxy and Physics of Nanostructures**
Microfabricated pillars contain a single semiconductor quantum dot precisely positioned at the central axis of the structure. Quantum dots are sources of non-classical light, such as single photons, entangled photon pairs, which can be used in quantum communication tasks. These practical applications require high brightness of such sources. To solve this problem, the pillar geometry is utilized to waveguide the emitted light.



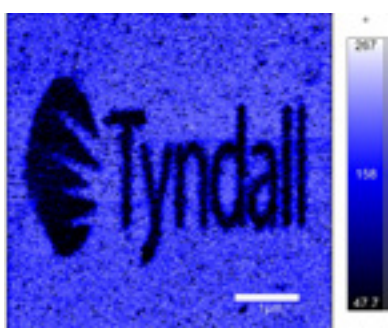
## Good Vibrations

**Lorenzo Niemitz, Biophotonics**
Image of an illuminated fibre bundle for micro camera illumination. The bundle was set in motion and the image captured using a long exposure time.



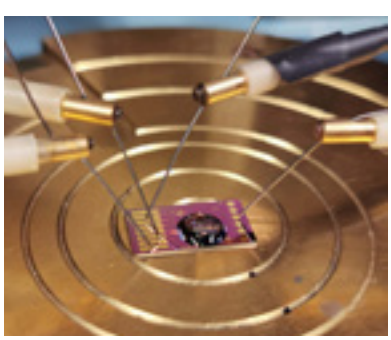
## Se-flowers

**Fionán Davitt, Materials Chemistry and Analysis Group**
This is a false coloured scanning electron microscopy (SEM) image of a carbon and selenium mixture, formed during the synthesis of selenium nanoparticles. These structures were imaged using the Zeiss Supra 40 SEM in Tyndall.



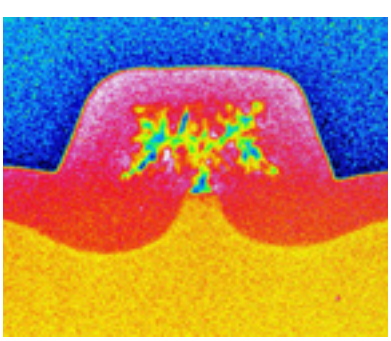

## Ferroelectric Lithography in Sub-10nm Film

**Lynette Keeney, Advanced Materials and Surfaces**
As miniaturisation of electronic devices continues, a crucial requirement for materials in data storage applications is the enhancement of their functional properties at very small dimensions. This is challenging for ferroelectrics as the spontaneous electrical polarisation is expected only to be sustained above some critical thickness. This image demonstrates the recent progress in the optimisation of Aurivillius phasematerials for potential data storage applications, where there is an ever increasing consumer demand.



## Smart Integrated Sensor Chip for Multiple Detections

**Han Shao, Advanced Energy Materials**
The image shows the smart integrated sensor chip for multiple detections. The chip has been used for multiple detections across agriculture, environment, and health care applications. Compare to the current lab approaches, the smart sensor has a rapid response time with low cost, and is user friendly.



## Vibrant Tree

**Margarita Georgieva, Photonics**
A cross-section of a nanowire that went through a strong oxidation/etch. This deformed the structure resulting into what is seen on the image (which through my eyes seems very similar to a tree).

# Agency-funded centres

Tyndall hosts a large number of research centres funded by our funding partners. They cover a broad range of technology and application areas, including space-related technologies, photonics, communications, energy, and agricultural technology.

IPIC
BRINGING PHOTONICS TO LIFE

IPIC is Ireland's centre of excellence for research, innovation and PhD training in photonics, and in 2019 the SFI Research Centre completed the transition from Phase 1 to Phase 2 funding, creating the platform to grow IPIC by 40% over the next three years.

During the year, IPIC strengthened many existing industry research partnerships, such as with Intel Corporation and Corning, and developed significant new research partnerships, including with QCoIr Quantum Computing and IBM. IPIC's European position continued to go from strength to strength, with over €5m secured in 2019.

The year also marked the start of the journey to strengthen IPIC's infrastructure in order to scale technology from the lab to commercial production, on the back of securing significant funding from the DTIF. The Photonics Manufacturing Pilot Line project involves a multi-SME collaboration with ficonTEC, Eblana, Sanmina, mBryonics, and FAZTech.

In addition, funding was secured to establish a Micro Transfer Printing Pilot Line in collaboration with X-Celeprint, Analog Devices, and Rockley Photonics.

Finally, IPIC co-hosted the 2019 European Conference on Optical Communication (ECOC 2019), a conference and trade show which showcases the latest advances in optical communication.

Science Foundation Ireland sfi For what's next


*IPIC researcher Andrea Pacheco receiving the 2019 Education & Pubic Engagement Award at our Annual Industry Day (photo includes Dr Yvonne Halpin, Scientific Programme Manager SFI and Dr Caitriona Tyndall, IPIC EPE Officer)*

MCCI
Microelectronic Circuits Centre Ireland

The Enterprise Ireland Technology Centre, MCCI, has established itself as a single point of contact in Ireland for access to high-calibre academic research in the field of microelectronics. The centre's vision is to be the number one microelectronic circuits research centre globally for industrial and academic collaboration by 2025.

MCCI's research is focused on the following four key pillars: High-speed Transceivers; Precision circuits; Power management; and Digital circuits.

In 2019, MCCI was recognised as the best performing centre in the Enterprise Ireland Technology Centre Programme, where for every €1 invested by Enterprise Ireland in MCCI, €20 was returned to the Irish economy. An external expert panel review also commended the strong operational team in place. The centre's growth plans are consistent with national strategies such as Innovation 2020, the National Development Plan 2018–2027 and Future Skills Needs 2017–2022.

During the year, 12 of MCCI's 16 publications in 2019 were presented at and published in Tier 1 conferences and journals; nine researchers transferred to industry, bringing the number of MCCI alumni to over 60, 75% of whom are based in Ireland; and the roll-out of a state-of-the-art collaboration platform enabled multi-site access to the centre's centralised infrastructure.

TECHNOLOGY CENTRE
SUPPORTED BY ENTERPRISE IRELAND


*Dr. Niamh Creedon, Technology Commercialisation Manager, MCCI, Aidan Murphy, PhD Student MCCI, Matthew Agnew, Masters Student, MCCI at the National Ploughing Championships 2019*

esa space solutions centre Ireland

The European Space Agency (ESA) Business Incubator Centre (BIC) programme led by Tyndall supports early-stage companies who wish to adopt space-related technologies for applications firmly rooted to solid earth. Our BIC clients target applications such as agriculture and food security, asset management, medical devices and communications and have joined a network of ESA Space Solutions Centres operating in 22 countries across Europe.

The BIC offers hands-on business support and advice, the technical expertise of ESA and the host institutes – Tyndall, MaREI, Maynooth University and Athlone IT –, access to the Europe-wide network of over 400 ESA BIC companies and events, and non-dilutive funding. By December 2019 there were a total of 18 companies in the BIC, of which seven were incubated at Tyndall.

As a joint venture between Enterprise Ireland, ESA and the Tyndall-led consortium of business incubators, Conor Sheehan, Programme Manager at Enterprise Ireland, sees the ESA BIC as an important programme under the National Space Strategy for Enterprise [2019–2025]. “The Irish space sector comprises more than 70 companies delivering exciting up-stream (space-bound) and down-stream (earth-bound) technologies,” he said. “Through the ESA BIC we are supporting a vibrant new cadre of entrepreneurs and start-ups, driving high-value employment across a surprising range of applications from agri-food to healthcare, Internet of Things (IoT) to advanced materials. We are excited to see these new ventures graduate from the programme and deliver economic impact for Ireland’s space sector.

ENTERPRISE IRELAND where innovation means business

## Highlights

### PixQuanta

PixQuanta is a disruptive deep-tech photonics company delivering a breakthrough in direct time-of-flight depth/3D sensor platforms to enable the next generation of pulse solid-state LiDAR solutions required for autonomous vehicles and a myriad of 3D spatial awareness applications. As an ESA BIC client the company has benefitted from extensive technology dialog with ESA to assist in commercial technology deployment and to identify opportunities in the space sector. Operating from Tyndall, Kevin O’Neill, CEO, said “as a small, pre-Seed/Series A enterprise, we have been able to access Tyndall’s world-class test and characterisation facilities and engineering expertise, bringing the company closer to market deployment and de-risking the venture for expected investment in 2020".

### Alcass Health

Alcass Health is a provider of innovative devices and software in the area of preventative and rehabilitative medicine and delivers evidence-based solutions in the areas of sports injury, chronic illness and occupational health. While on the ESA BIC programme in 2019, the company achieved early client engagement at large corporates with the Habitus Posture product, targeting the well-being of large cohorts of increasingly desk-bound employees. At first sight, the benefits of ESA BIC participation might not be obvious, but the company recognised the opportunity to tap into ESA’s astronaut programme’s experience in preparing astronauts for space flight, monitoring their activity in-flight (the impact of micro-gravity) and rehabilitation of the musculoskeletal system post flight. Breffni Allen, Co-founder of Alcass Health also believes the ESA BIC created “strong links with Tyndall and enabled a working relationship with the research teams which will advance the development of the precision smart sensor in our Habitus Posture product.”

IERC
International Energy Research Centre

The International Energy Research Centre (IERC) at Tyndall is an industry-focused collaborative research centre. The centre aims to deliver high-value energy solutions to the Irish economy and accomplishes this by bridging the gap between industry and research, translating industry innovation needs into well-defined and executable research objectives. The research outputs provide evidence of the performance and cost-effectiveness of novel technology options that can support enhanced delivery of energy policy.

IERC senior staff serve on 12 internationally recognised expert panels or working groups, including the United Nations Economic Commission for Europe Group of Experts on Energy Efficiency (UNECE GEEE) and the United Nations Framework Convention on Climate Change (UNFCCC).

The IERC experienced a busy and fruitful 2019, with several funding successes and an increased number of collaborations, including six industry-collaborative projects with a total value of over €5m. These included four Horizon 2020 programme projects and one DTIF project.

During the year, the IERC produced 13 publications, including nine papers to industry-relevant, internationally strategic technology conferences and four papers to high-impact journals. The IERC also helped deliver nearly €5m to Irish industry in the form of research outcomes and industry awards. At the UNFCCC 25th Conference of Parties (COP-25) in December 2019, the IERC project SPEEDIER was highlighted as an exemplar of innovation for energy efficiency and energy services to SMEs.

Roinn Cumarsáide, Gníomhaithe ar son na hAeráide & Comhshaoil
Department of Communications, Climate Action & Environment

*Prof Tony Day, Dr Piyush Verma, Dr Beth Massey, Dr Jo Southernwood, Dr Carlos Ocha of IERC*

CONNECT
Networks of the Future

Founded in 2015, CONNECT is the SFI Research Centre for future networks and communications led from Trinity College Dublin. CONNECT staff in Tyndall lead the centre's Low Energy Network theme, researching smart systems, smart sensors, energy generation and energy storage technology.

CONNECT had a successful four-year review in 2019, positioning Tyndall to lead research excellence in sustainable electronics for the 'one-trillion sensor' economy. Ongoing research includes electrochemical sensors for gas monitoring and liquid analysis, novel analogue-to-digital converter (ADC) designs for applications including low data-rate IoT applications and environmental sensor interfaces, new lithium-ion micro-batteries to power sensors for the Internet of things (IoT), and magnetic-based energy harvesting.

CONNECT's three Marie Skłodwaska-Curie 'EDGE' fellows are leading research in projects involving the development of piezoelectric films for use in Radio frequency (RF) filters and resonators for 5G communications; computational modelling and design of efficient thermoelectric nanocomposites; and the design and evaluation of a distributed system-of-systems consisting of IoT devices for precision agriculture.

The CONNECT 'Professor Tom Brazil Excellence in Research Award' was awarded to Professor Saibal Roy in recognition of his contribution to magnetic-based energy harvesting and power conversion, which have resulted in a global patent and international reach in high-impact journals.

CONNECT's future research will focus on the concept of sustainable IoT, encompassing themes such as biodegradable sensors and self-powered Energy Source in Package (eSiP).

Science Foundation Ireland sfi For what's next

*Prof Saibal Roy was awarded the CONNECT Tom Brazil 'Excellence in Research Award' 2019*

Confirm
Smart Manufacturing

CONFIRM is the leading SFI Research Centre for advanced manufacturing in Ireland, with a mission to "fundamentally transform industry to a smart manufacturing ecosystem". Tyndall is one of eight research organisations within CONFIRM and is developing some of its key technology platforms for industry in order to meet current and future smart manufacturing needs.

Through the CONFIRM programme, companies are collaborating directly with Tyndall to develop advanced manufacturing solutions.

In 2019, there were four separate research projects in the centre, with a combined budget of approximately €1m. International companies such as Johnson & Johnson, Analog Devices and Verdigris are pioneering new ways of advanced manufacturing and they are incorporating Tyndall technologies in the areas of predictive maintenance, wireless process monitoring, energy harvesting for IoT devices and intelligent plastic film manufacturing.

The CONFIRM projects give these advanced manufacturing companies a competitive advantage through working with the right research team to achieve business readiness for Industry 4.0.

CONFIRM's dynamic, collaborative, industry-focused approach is completely in line with Tyndall's vision of generating economic impact from deep-tech, and in order to support this further, Tyndall's Wireless Sensors Network (WSN) group has commissioned a new motion capture laboratory for human hand mapping Human–computer interaction (HCI) devices to be employed in the CONFIRM research programme.

Science Foundation Ireland sfi For what's next

*Developing future smart manufacturing technologies*

The SFI and Department of Agriculture, Food and the Marine VistaMilk Centre's mission is to be an agent of responsible and sustainable growth for the Irish dairy and agri-tech industries by being a world leader in fundamental and translational research for pasture-based dairying. Tyndall, tasked with developing smart sensor systems, is one of four research performing organisations in the centre, and through pooling research excellence across a range of areas and technologies is creating a truly unique collaboration to benefit the agri-tech and agri-food industries as we enter the fourth agricultural revolution.

In 2019, by attracting talent and developing internal talent, Tyndall began to establish an integrated, inclusive and collaborative research team to realise the VistaMilk research programme. In parallel, the state-of-the-art research infrastructure to enable advanced nano-sensor and systems development has been expanded.

This has enabled industry partners – both SMEs and multinational corporations (MNCs) – to work directly with VistaMilk researchers on the development of the advanced end-to-end platforms they require to address their current and future sensing needs. These novel deep-tech sensor systems will deliver significant impact by providing key enabling real-time decision support tools to industry partners which will assist in the development of innovative new products and solutions.

*VistaMilk: A world leading SFI Research Centre for innovative precision pasture-based dairying. Leading the Agri-Food technology sector through innovation and enhanced sustainability across the dairy supply chain Photo: Teagasc*

# Financial report

# Income and expenditure summary

| Income | 2019 €000s | 2018 €000s |
|---|---|---|
| **Government grant** | 7,000 | 4,500 |
| **Research** | 32,525 | 29,275 |
| **UCC contribution** | 2,084 | 2,241 |
| | **41,609** | **36,016** |

| Expenditure | 2019 €000s | 2018 €000s |
|---|---|---|
| **Remuneration costs** | 24,970 | 23,820 |
| **Equipment and infrastructure** | 3,175 | 1,860 |
| **Consumables and related costs** | 9,260 | 9,176 |
| **Other operating and deferred costs** | 4,204 | 1,160 |
| | **41,609** | **36,016** |

# Board members

## Eoin O'Driscoll
**Chairman**

## Marcus Breathnach
**Department of Business, Enterprise and Innovation**

## Caroline Dowling
**DCC Plc & IMI Plc**

## Dr. Ann Kelleher
**Intel Corporation**

## Prof. Anita Maguire
**University College Cork**

## John Mullins
**Amarenco Group**

## Prof. Bram Nauta
**University Of Twente**

## Sean O'Sullivan
**SOSV**

## Prof. Richard Penty
**University of Cambridge**

## Patricia Reilly
**European Commission**

## Prof. Steven Ringel
**The Ohio State University**

## Prof. William Scanlon
**CEO**

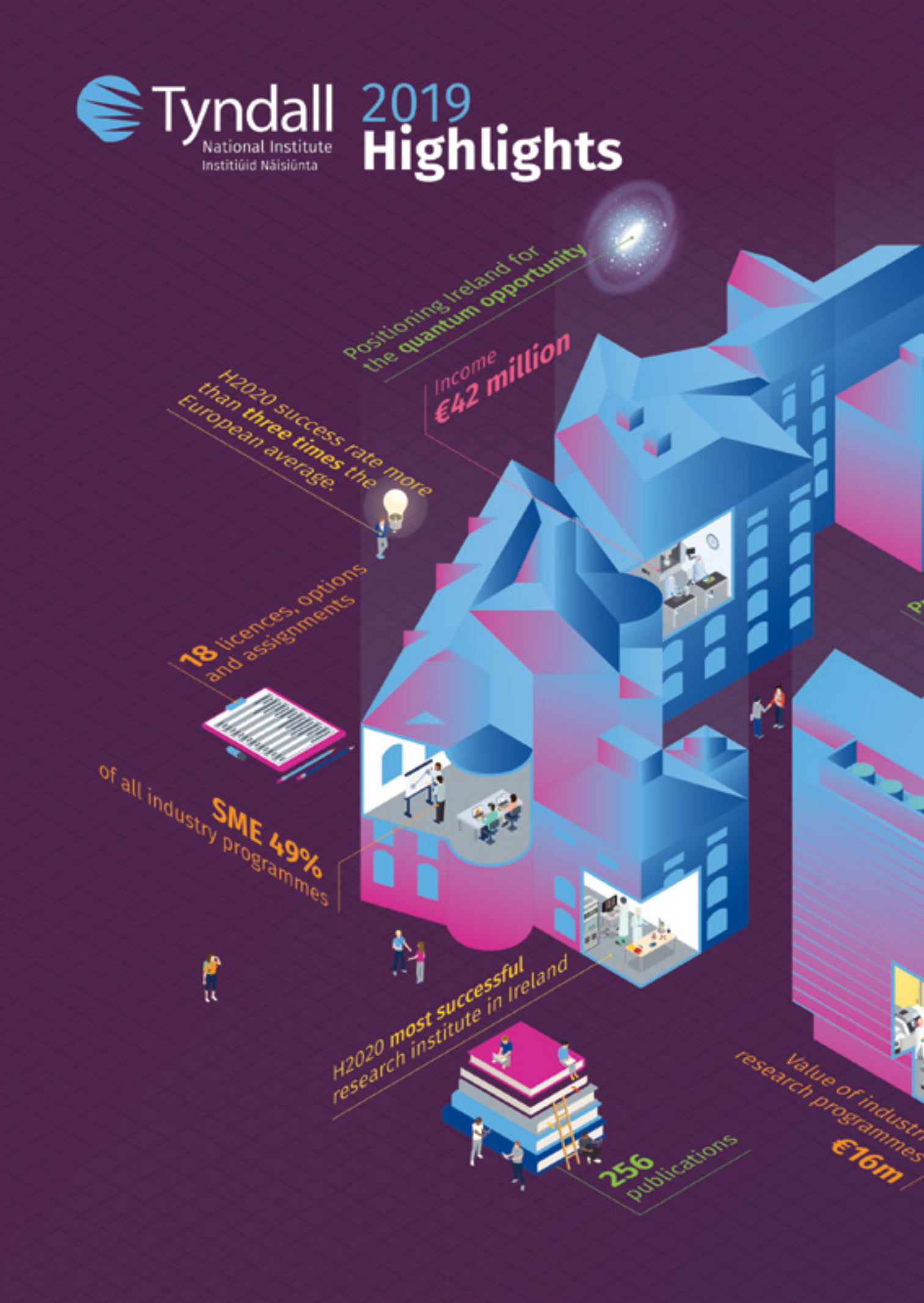
## Jane Williams
**Sia Partners**

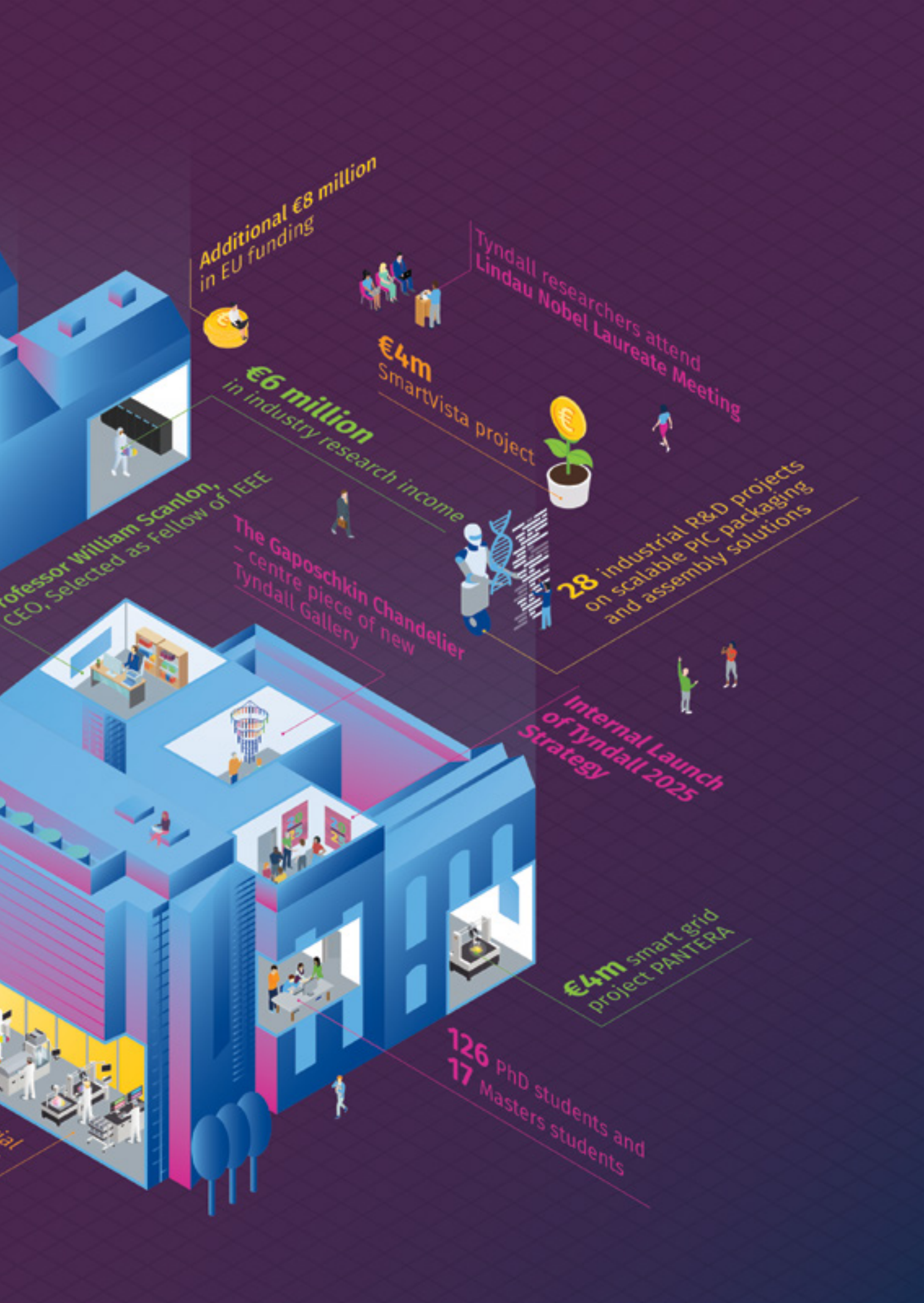
# 2019

## Highlights

Tyndall National Institute
Institiúid Náisiúnta

# 2019 Highlights




Additional €8 million
in EU funding
Tyndall researchers attend
Lindau Nobel Laureate Meeting
€4m
SmartVista project
€6 million
in industry research income
rofessor William Scanlon,
CEO, Selected as Fellow of IEEE
The Gaposchkin Chandelier
– centre piece of new
Tyndall Gallery
28 industrial R&D projects
on scalable PIC packaging
and assembly solutions
Internal Launch
of Tyndall 2025
Strategy
€4m smart grid
project PANTERA
126 PhD students and
17 Masters students

Rialtas na hÉireann
Government of Ireland

Tionscadal Éireann
Project Ireland 2040

Ireland's European Structural and Investment Funds Programmes 2014-2020
Co-funded by the Irish Government and the European Union

European Union
European Regional Development Fund

*Good Vibrations*

*Lorenzo Niemitz, Biophotonics*

*Image of an illuminated fibre bundle for micro camera illumination. The bundle was set in motion and the image captured using a long exposure time.*

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