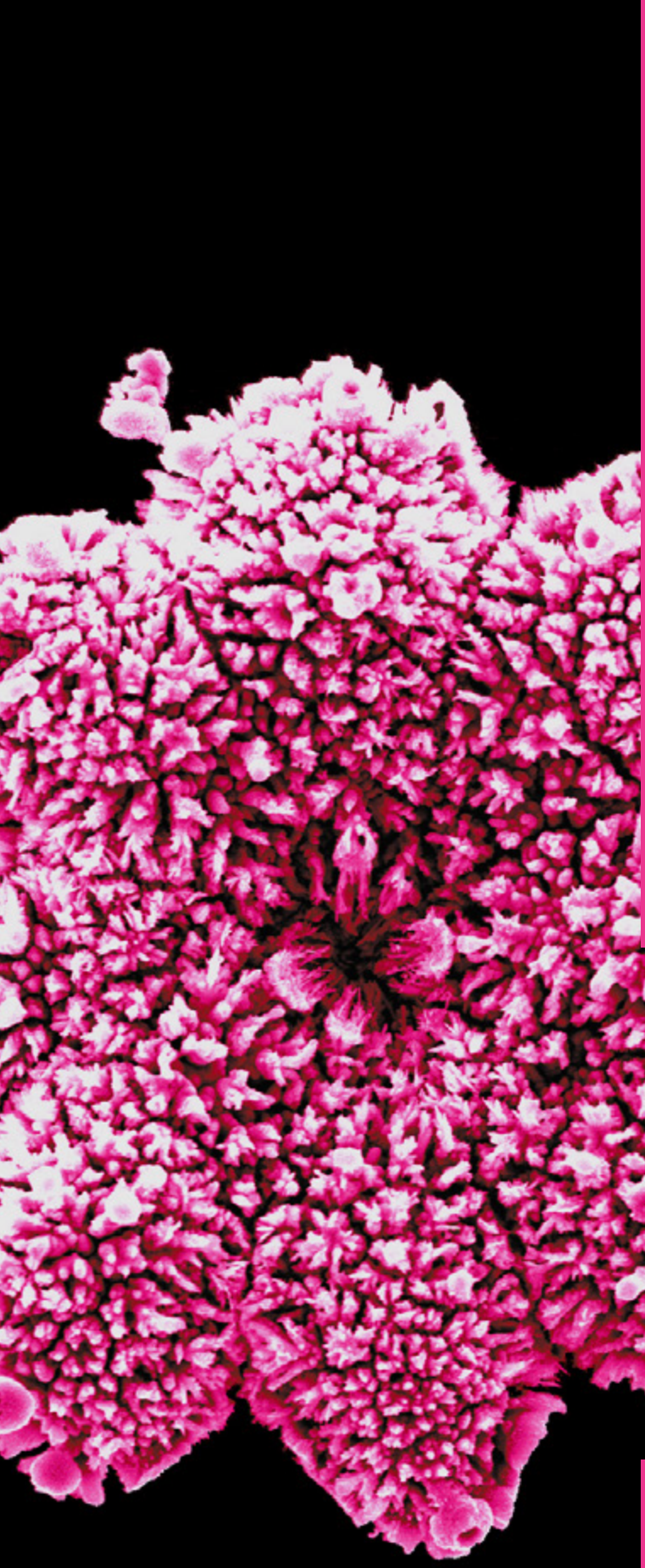


Impact from excellence

Tyndall
National Institute
Institiúid Náisiúnta

# 2021
## Annual report

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh


Tyndall

# Contents

# Chairperson's message

Tyndall's vision is to be a global leader in deep-tech innovation and impact, through excellence in research. Progress towards realising that vision was recognised during 2021 through a number of highly prestigious international awards.

Tyndall's leading research in magnetics on silicon and chip-level power received the 2021 EARTO (European Association of Research and Technology Organisations) award for impact expected and the research lead for this technology, Professor Cian Ó Mathúna received the inaugural IEEE (Institute of Electrical and Electronics Engineers) Power Electronics Society technical achievement award. This research has produced key enabling technology for the miniaturisation of electronics devices, which is now licensed to many of the world's leading consumer electronics companies.

Brian Corbett was awarded the 2021 Institute of Physics Katharine Burr Blodgett Medal and Prize. The gold medal was awarded for his identification and creation of breakthrough innovative photonic device technology solutions that have driven the development and growth of several start-ups as well as facilitating major innovations by multinational companies. As a result of this work, Tyndall and the Cork area are now attracting a growing cluster of photonics companies, as well as global leaders in augmented and virtual reality.

These achievements illustrate Tyndall's global leadership in generating impact from research excellence. They provide great examples of how multidisciplinary research teams, supported by world-class infrastructure, spanning the continuum from basic to applied research, can deliver significant commercial outcomes for industry.

Tyndall's role in the national innovation ecosystem was recognised as part of the National Development Plan (NDP) 2021-2040, which was launched in April 2021. The NDP and the Department of Further and Higher Education, Research, Innovation and Science's Budget 2022 budget will provide the funding to enable the continued upgrade and expansion of the Tyndall campus. The enhanced infrastructure will enable Tyndall to grow and to significantly increase its impact in the coming years.

That growth and impact will come through expansion of existing activities and a focus on areas such as energy, wireless networks, and quantum computing.

Research excellence ultimately depends on our ability to attract, retain and develop world-class talent. That is a major challenge at a time when there is a global shortage of science, engineering and technology talent. However, Tyndall's long track record of excellence in basic and applied research, spanning more than 40 years, places us in a strong position to continue to attract the very best researchers, both from within Ireland and internationally.

Nevertheless, it is an area that requires unrelenting focus, and we continue to collaborate with our colleagues in University College Cork (UCC) to maintain our strong position in that regard. We also continue to examine how we can improve gender diversity, particularly in senior positions.

As I step down from the Board, I would like to thank my fellow Board members and all the staff at Tyndall for their support over the past eight years. Their input and commitment have been an inspiration. I would also like to thank UCC and the Department of Further and Higher Education, Research, Innovation and Science and Minister Simon Harris TD (and his predecessors) for granting me the privilege of chairing the Tyndall Board. It has been both an honour and a pleasure.

I am pleased to say that Tyndall is in an immensely strong position as it embarks on the next exciting phase of its growth and development. I am confident that under the leadership of our CEO, Professor William Scanlon, and my successor Dr Denis Doyle, Tyndall will go on to achieve even greater success in the coming years.

**Eoin O'Driscoll**
Chairperson

*Eoin O'Driscoll,*
*Tyndall Chairperson*

*Professor John O'Halloran became the 16th President at University College Cork in September 2021*

# CEO's message

2021 was an exceptionally busy year for Tyndall during which we made significant progress on our expansion plan, opened our new Wireless Communications Laboratory in Dublin, and continued to expand our industry engagement, while our researchers were recognised internationally through highly prestigious awards.

Of significant note during the year was the commitment made by the Minister for Further and Higher Education, Research, Innovation and Science, Simon Harris TD, to significantly increase Tyndall's annual funding by 2024. We are tremendously grateful for that commitment, as it gives us a welcome degree of financial certainty as we plan further increases in our research activities over the coming years.

Last year also saw planning permission being sought for our new 16,000m$^2$ building on the North Mall in Cork City. When complete, this transformative new facility will see Tyndall double in size and accommodate 250 postgraduate students and 750 staff, and it will enable a substantial increase in our collaborative research activity with Irish and international industry partners.

As the majority of 2021 was spent under Covid-19 pandemic restrictions, we were therefore enormously grateful to receive funding of €2.4m from the Higher Education Authority (HEA) to support projects that were delayed or otherwise adversely affected by the Covid-19 pandemic.

As a result of this additional funding, as well as an increase in direct industry funding, Tyndall recorded an increase in total income during the year. This was a major achievement under the circumstances and has enabled us to continue to grow and expand.

Tyndall researchers were successful in winning a number of grants from the Disruptive Technologies Investment Fund (DTIF). This is a very important programme for bringing small, large and medium-sized enterprises (SMEs) and multinationals togewther with Tyndall and other research organisations to develop disruptive innovations.

Another highlight of 2021 was the launch of Ireland's first Quantum Computer Engineering Centre at Tyndall. This multi-million-euro investment will see 45 new jobs dedicated to quantum research and will place Tyndall at the forefront of the quantum revolution.

We are currently in the process of recruiting a Professor of Quantum Technology, a post funded by the Strategic Academic Leadership Initiative (SALI), established by the Government of Ireland to address gender imbalances in key academic disciplines.

Another milestone was achieved with the opening of our new Wireless Communications Laboratory in Dublin, a reflection of our growing status as a leading national and European research institution. The new laboratory will create 50 new research jobs over the next three years and will focus on future communication technologies for IoT, Wi-Fi, 6G, artificial intelligence, and quantum systems.

In photonics, industry partner Rockley has increased the value of its research collaboration with IPIC, the Science Foundation Ireland (SFI) Research Centre for Photonics based at Tyndall, by 60% through a substantial new healthcare applications project. The collaboration also won Knowledge Transfer Ireland's (KTI's) prestigious 2021 Industry Engagement Impact Award, a tremendous achievement for all involved.

Ireland's most valuable natural resource is its human and intellectual capital and another key aspect of Tyndall's work is talent development. We have seen strong growth in the number of PhD students at Tyndall in recent years and it is very pleasing to note that 38% of our graduate students are women.

We also run a summer internship programme to allow students experience what it is like to be a researcher and do a PhD. In 2021, we received more than 150 applications from across Ireland, with 40% from students who are women.

These are signs of the very real progress we are making on gender balance, as we strive towards achieving ever greater equality in the gender of our students and staff.

Ireland's future success as a society and an economy is dependent on continued investment in research and innovation, and Tyndall is well placed to play its role in addressing the challenges facing society and industry through its leading-edge research, as well as providing the pipeline of talent required to drive future waves of innovation.

I would like to express my thanks to UCC and the Tyndall board for their support and leadership throughout the year. I would also like to express my gratitude to all of the staff and students at Tyndall for their resilience and application during a most demanding year.

**Professor William Scanlon**
CEO

# Scorecard

## Research excellence

**Tyndall's Integrated Magnetics team's work on Magnetics on Silicon (MagIC) technology received:**

**2 international award wins**

- the EARTO Innovation Award in the Impact Expected category
- Professor Cian Ó Mathúna received the inaugural IEEE Power Electronic Society Award

**Professor Holger Claussen** was selected by the Institute of Electrical and Electronics Engineers to become an **IEEE Fellow**

**Brian Corbett** awarded the 2021 Institute of Physics Katharine Burr Blodgett Medal and Prize

**65** PUBLICATIONS WITH INTERNATIONAL COLLABORATORS IN TOP JOURNALS*

* TOP JOURNALS DEFINED AS THOSE WITH AN IMPACT FACTOR > 4.0

## Impact

TOTAL VALUE OF NEW INDUSTRY RESEARCH PROGRAMMES WAS

**€9m**

**130+** industry programmes

serving **60+** research partners

**€1.5m** SECURED IN COMMERCIALISATION FUNDING FOR THE NEW VENTURES SPIN-OUT PIPELINE

***Over 80 industry partner personnel with on-site access to research laboratories and trained on equipment infrastructure***

***Expanded ESA Space Solutions Centre Ireland Phase 2 launched***

SMEs accounting for **40%** of our new industry engagements and **42%** of our industry personnel resident on-site

## International reach

***LEAD IRISH CONSORTIUM IN ECSEL PROJECTS IMOCO4.E AND ENERGY-ECS***

### EU programmes (2014-2020) in numbers:

**€782m total project value | *€62m Tyndall grant value* | €53m to Irish partners | *€22m to industry based in Ireland* | Tyndall involved in 10% of the total drawdown in Ireland | *111 EU projects* | 48 projects in ICT | *19 projects coordinated by Tyndall***

Published perspective on ***Integrated Photonics for Quantum Technologies*** in Nature Reviews Physics

***Contributed to Packaging Chapter of IPSR-I Integrated Photonic Systems Roadmap, Photonics 21 Quantum PIC Position Paper and EPoSS White Paper 'AI at the Edge'***

12 ASCENT+ and 10 EnABLES Transnational Access projects extending respectively CMOS++ and 'Power the IoT' PIs network and international reach

**Awarded 2x**
Marie-Skodowska-Curie Fellowships, one global and one European

## People and culture

***204* volunteers**
***30,000* public reach**
***196* STEAM activities**

**Tyndall alumni 600+ members**

*A research community of over 600 people*

23 SUMMER RESEARCH INTERNS

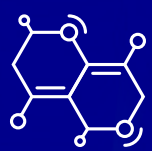
***Graduate Education***
- ***34 New PhD & Masters starts***
- ***140 PhDs, 13 Masters by research***
- ***20 Viva's***

## Infrastructure

**Successful in SFI capital bid**
- Lab to Fab integration from novel materials to devices using Atomic Layer Processing (Atomic Layer Deposition & Etch) valued at €3m
- Tera Lab for 6G wireless-Photonic Networking valued at nearly €3m

***Successful Completion of ESA funded project on the evaluation of automotive grade components for possible space use***

104
NEW USERS TO THE OPEN ACCESS LABS



292 people
trained in the operation of process or analysis tools

# Research excellence

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* TOP JOURNALS DEFINED AS THOSE WITH AN IMPACT FACTOR > 4.0

*Brian Corbett, IoP prize winner*

Research excellence with impact is a key goal of the Tyndall 2025 Research Strategy. 2021 saw major international recognition of Tyndall researchers. Brian Corbett was awarded the 2021 Institute of Physics Katharine Burr Blodgett Gold Medal for his identification and creation of breakthrough innovative photonic device technology solutions. Professor Cian Ó Mathúna received two international awards for his team's work on magnetics on silicon (MagIC) technology. In addition, new Tyndall Principal Investigator, Professor Holger Claussen was selected to become a Fellow of the Institute of Electrical and Electronics Engineers. Recognition was also given to the collaboration between Rockley Photonics and IPIC, which won Knowledge Transfer Ireland's (KTI's) 2021 Industry Engagement Impact Award.

Individual funding awards have historically underpinned much of the fundamental work that feeds into the research pipeline at Tyndall. A number of significant individual awards were approved in 2021. These included the award of an SFI Research Professorship to Professor Dimitra Psychogiou, School of Engineering and Architecture in UCC, as well as a Marie Skłodowska-Curie Individual Fellowship to Dr Chris Broderick to visit the University of California Santa Barbara, and a Marie Skłodowska-Curie Individual Fellowship for Dr Hassan Hamidi to visit Tyndall.

The research highlights that follow exemplify Tyndall's commitment to research excellence with impact. The selected highlights describe a theoretical analysis providing a route for continued use of copper for 2D interconnects in nanoelectronics, a novel approach to engineer transparency switching in photonic integrated circuits, an overview of the potential of micro-LED technologies, as well as a breakthrough in developing electrochemical sensors with reduced environmental footprints.


*Professor Cian Ó Mathúna's Integrated Magnetics team received the EARTO Innovation Award for their work on Magnetics on Silicon (MagIC) technology*

# Control of Cu morphology on Ru-passivated and Ru-doped TaN Surfaces

As semiconductor device dimensions continue to shrink and device structures become more complex, the key challenge and bottleneck lies in using copper as the level 1 and level 2 interconnects. At these nanoscale dimensions, copper has high resistivity, preventing it from functioning as a conducting wire, and it prefers to form non-conducting 3D islands. Furthermore, it requires two other materials, a barrier and liner, to prevent unwanted copper migration and ensure deposition of conducting films.

Given that changing to alternative metal interconnects is challenging, our SFI-NSF China partnership aims to develop single-phase materials that combine the properties of diffusion barriers and liners to reduce the volume used by this bilayer and to promote the coating of complex interconnect vias with conducting copper.

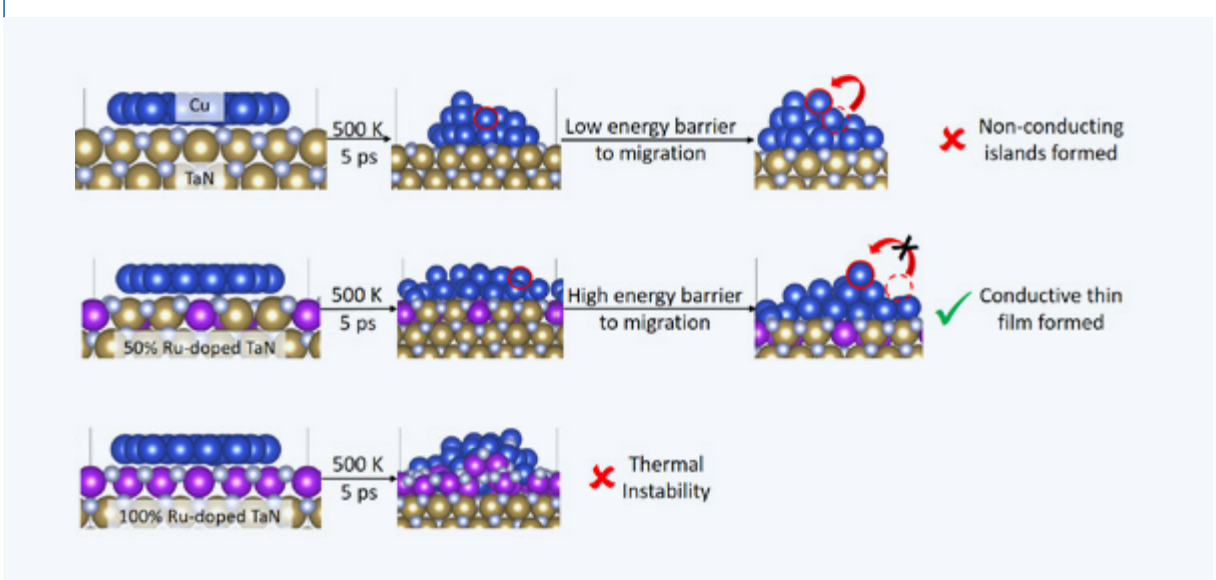
The researchers proposed and examined new combined barrier/liner materials, based on modifying the surface layer of the TaN barrier through Ru incorporation. They simulated copper on these surfaces with finite temperature dynamics simulations to demonstrate how the Ru content can promote deposition of conducting films through control of copper adhesion and stability. They showed that copper migration onto nucleating copper islands is inhibited by ruthenium, preventing the deposition of non-conducting copper islands. Deposition of these new materials is ongoing.

Chemical Science

https://doi.org/10.1039/D1SC04708F

Cara-Lena Nies; Suresh Kondati Natarajan; Michael Nolan

*Figure showing the effect of Ru-modification of TaN on copper morphology*



# Reagent-free silver ions detection in tap water using interdigitated electrodes

Silver nanoparticles have found a wide application in consumer products, ranging from electronic devices to textiles to cosmetics and home disinfectants, due to their antimicrobial properties. This has led, however, to their release into the environment, particularly into water. Silver ions are the most toxic form of silver and their rapid detection in water is important for its safety.

The researchers from Tyndall National Institute and Teagasc developed an on-chip electrochemical sensor for the detection of silver ions in tap water using in-situ pH control at interdigitated microelectrodes (IDEs). The pH is one of the crucial parameters in electrochemical detection and commonly needs to be lowered with strong acids for optimal detection. It is, however, not feasible to use such strong acids for point-of-care detection.

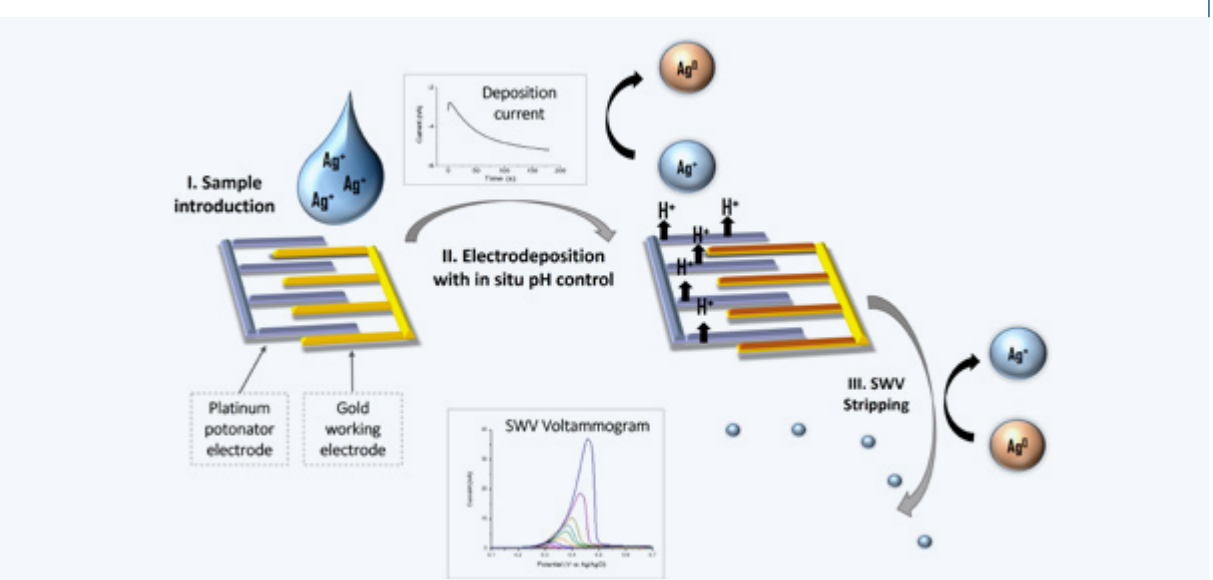
In this work, an electrochemical pH control was applied for the first time during silver ions detection in tap water. This means that there is no need to add acids, as protons produced during water electrolysis at one IDE were sufficient to tailor the pH at a second IDE and facilitate metal detection. The same technique can be used for the detection of other heavy metals and it can have a huge impact on water safety.

Sensors and Actuators B: Chemical

https://www.sciencedirect.com/science/article/pii/S092540052100099X

Luiza A.Wasiewska; Ian Seymour; Bernardo Patella; Rosalinda Inguanta; Catherine M.Burgess; Geraldine Duffy; Alan O'Riordan

*Scheme showing the silver detection process on an interdigitated microband electrode*



# Thermo-optically induced transparency on a photonic chip

This is a collaborative work between Munster Technological University, Tyndall National Institute and the University of Pavia that presents the first observation and accurate physical description of a novel non-linear optic effect, here called Thermo-optically Induced Transparency (TOIT), at room temperature on chip-integrated optical micro-resonators, i.e. very small engineered light traps obtained by fabricating periodic nanostructures on a silicon chip. This effect arises from the interference occurring between a laser signal that pumps an optical micro-resonator and the oscillating temperature field of the resonator, which in turn is generated by its absorption of the laser light.

This effect is able to slow light by orders of magnitude and is engineered to occur without the need to cool down the material, or without the presence of complex mechanical or atomic resonance, as opposed to other induced transparency phenomena.

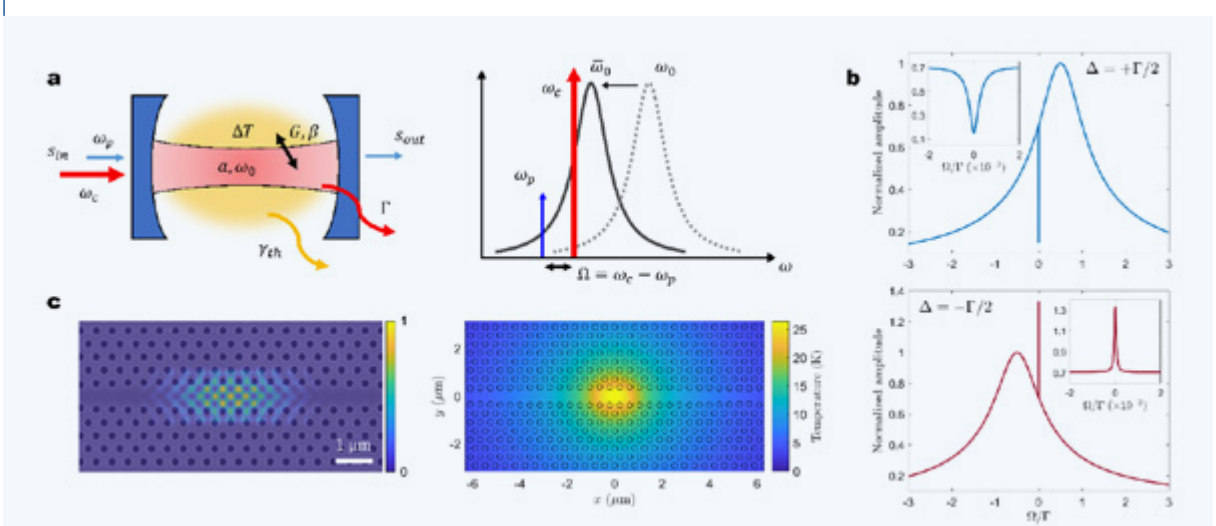
An analytical model was also developed to describe the underlying physics, accurately matching the experimental results, and was also able to predict the behaviour of different resonators before testing, thus becoming a powerful tool for the design of new systems to exploit this effect in delay lines and spectroscopy.

Nature, Light: Science & Applications

https://www.nature.com/articles/s41377-021-00678-4

Marco Clementi; Simone Iadanza; Sebastian A. Schulz; Giulia Urbinat;, Dario Gerace; Liam O'Faolain; Matteo Galli

*Figure shows a schematic of the optically pumped microcavity and the calculated response of the system under TOIT*



# Micro light-emitting diode: from chips to applications

Solid state light-emitting diodes (LEDs) based on non-toxic gallium nitride materials have revolutionised general lighting. These materials can now be miniaturised to micron-sized devices with ready applications in ultra-bright, high-efficiency displays, in augmented reality, in visible light communications, and for exciting new opportunities in the treatment of diseases though optogenetics. The technical challenges are in maintaining excellent device performance as the LED size decreases, and in combining optimised red, green and blue light-emitting pixels with high spatial density.

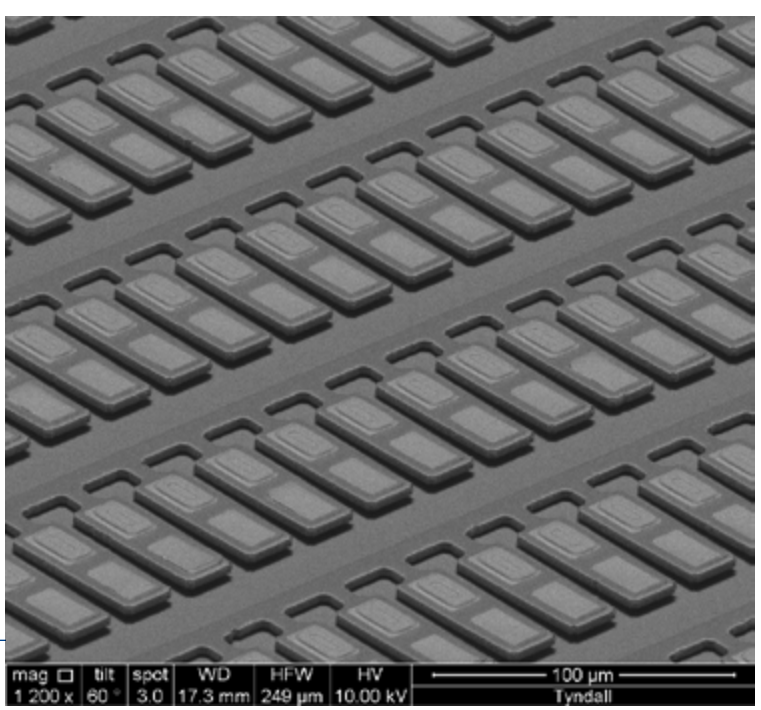
To address these issues, the loss of current at the exposed edges of the LED needs to be overcome through a combination of low damage etching, surface passivation, and protection. Alternatively, the junction can be buried using core-shell nanostructures created through clever epitaxy processes on structured templates.

The integration of the different colours coming from different wafers can be achieved through parallel mass transfer of RGB LEDs from their original substrates. This requires the creation of suspended arrays of LEDs together with a transfer printing process, followed by the integration with the drive electronics. Currently, red LEDs present the greatest challenge due to the use of a different material system. Research is therefore underway to make an efficient red LED from the nitride materials.

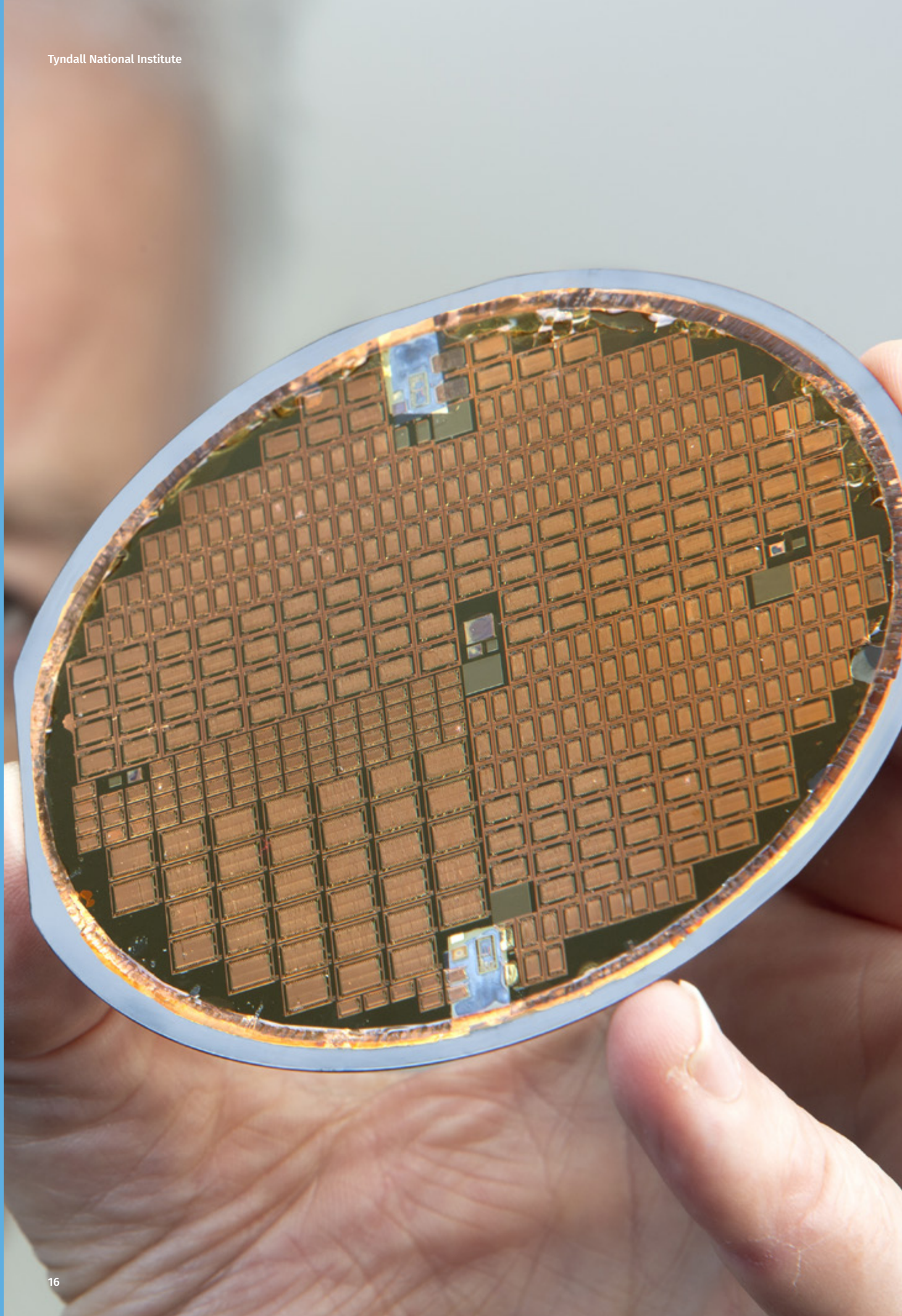
Laser & Photonics Reviews

https://onlinelibrary.wiley.com/doi/full/10.1002/lpor.202000133

Peter J Parbrook; Brian Corbett; Jung Han; Tae-Yeon Seong; Hiroshi Amano




*Array of released microLED ready for transfer*



# Impact

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**€9m**

**130+** industry programmes

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***Over 80 industry partner personnel with on-site access to research laboratories and trained on equipment infrastructure***

***Expanded ESA Space Solutions Centre Ireland Phase 2 launched***

SMEs accounting for **40%** of our new industry engagements and **42%** of our industry personnel resident on-site

*Wafer of world-leading magnetics-on-silicon fabricated in Tyndall's MEMS Fabrication facility*

In addition to the individual stories of impactful industry engagement outlined in this report, Tyndall's overall performance in industry research programmes remained consistently strong throughout the second year of the COVID-19 pandemic, delivering impactful research and managed access to critical infrastructure.

This was evident in Tyndall achieving 94% of its growth targets for industry engagement (as measured by industry funding). The year closed with a strong pipeline of new research engagements which will contribute to continued growth in 2022, with 40% of that pipeline coming from our SME community.

Overall, SME engagement was very strong in 2021, with 25 (54%) of industry partners in this category. SMEs were also deeply embedded with Tyndall's research teams, with 34 SME industry researchers-in-residence on-site (matching similar numbers from the multinational (MNC) sector).

Our international profile grew significantly in 2021, and we achieved 140% of target funding from industry partners with no research presence in Ireland. This brought 20 international industry partners into the Irish research landscape, representing 16% of all industry new programmes by value.

In total, Tyndall addressed the deep-tech research needs of more than 60 individual industry partners in 2021.

This included significant international funding for newly appointed Professor Dimitra Psychogiou's Advanced RF Technologies team and additional growth in engagements with SFI's CONNECT, AMBER and IPIC centres.

Industry personnel participated in a number of tailored training programmes, providing valuable financial return on infrastructure investments in key laboratories. We also took the first steps towards the establishment of a new Industrial Research Chair in semiconductor technologies with a leading international research partner.

During the year, Tyndall also received Ireland's first European Association of Research Providing Organisations (EARTO) Innovation Award for its MagIC integrated magnetics technology, further demonstrating an expanding international reputation and demonstrable commercialisation impact for its research.

# New Ventures

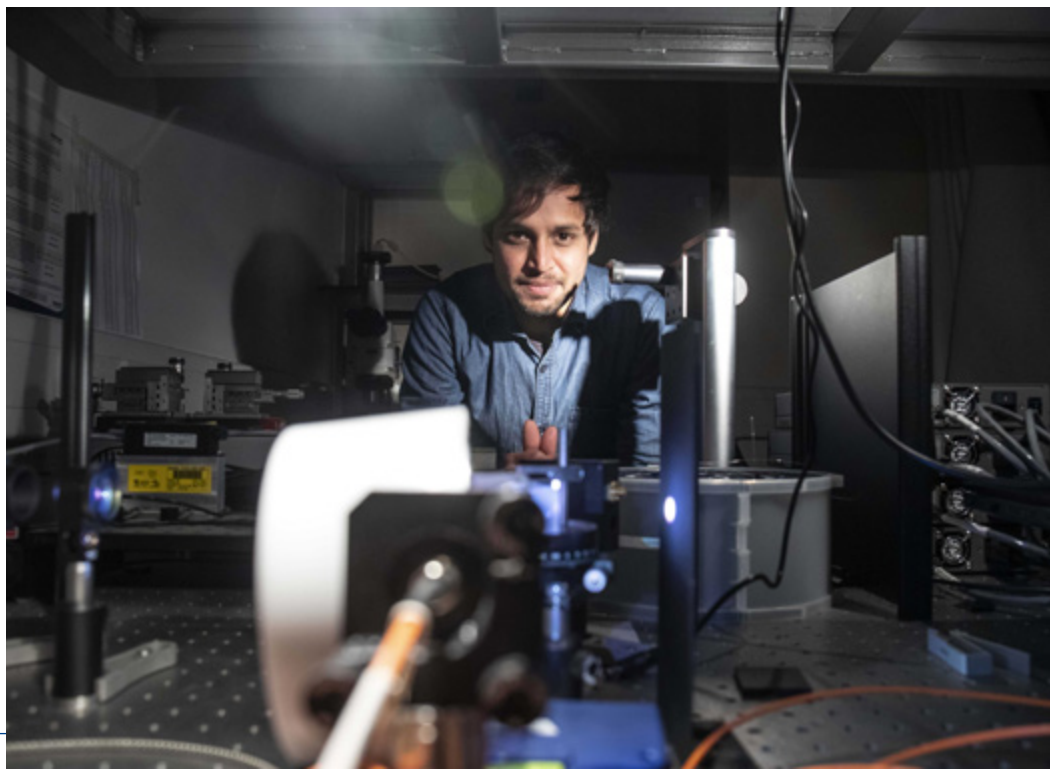
In recent years, Tyndall's innovation and new ventures activity has been rapidly expanding. In all, nine new ventures were launched during the year, with a pipeline of 18 projects carried forward into 2022, Tyndall's largest ever research commercialisation pipeline.

On the back of the success of the European Space Agency (ESA) Space Solutions Centre in previous years, Tyndall secured financing of €2.5 million to fund an additional four years of incubation and product demonstrator supports to SMEs from Enterprise Ireland and the European Space Agency (ESA), thus ensuring that Tyndall would continue to be a key contributor to the deep-tech innovation landscape in Ireland. The New Ventures team ran 20 events in support of a vibrant cohort of early-stage new ventures nationally.

We also secured €1.5 million in Enterprise Ireland commercialisation funding for the New Ventures spin-out pipeline.

ENTERPRISE IRELAND
where innovation means business

esa
space solutions
Ireland



*Dr Sanathana Konugolu Venkata Sekar, one of Optica's 12 Entrepreneurs to Watch*

# Adama Innovations

One of Tyndall's primary objectives is to leverage government investments in our unique infrastructure through the support of early-stage deep-tech companies – the next generation of indigenous, high-potential start-ups. Tyndall helps to reduce the cost of new product development and shorten time-to-market by providing access to high-value infrastructure combined with expert research and engineering supports.

Throughout 2021, Tyndall supported Adama Innovations with equipment and services to assist it with the design, development and manufacture of its probes for Atomic Force Microscopes (AFM). AFMs are 100 times more sensitive than the very best optical microscopes and are equivalent in sensitivity to electron microscopes.

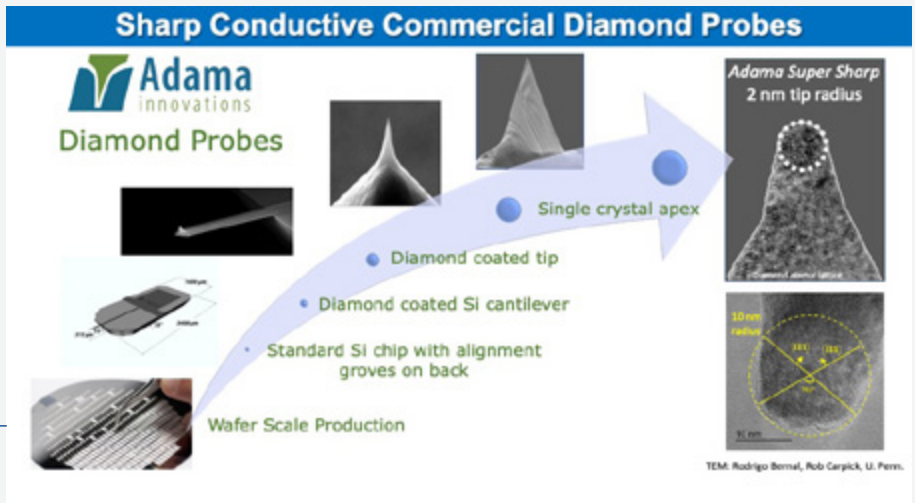
A spin-out of Trinity College Dublin, Adama Innovations now works with Tyndall on a number of critical manufacturing processes necessary for commercial production of the probes. Tyndall has also trained Adama Innovations staff to allow them to independently operate Tyndall's fabrication equipment – a key knowledge transfer step for an exciting indigenous venture.

Instead of using visible light or electrons, an AFM uses a probe – a micro-scaled stylus with an integrated atomically sharp tip, which is capable of probing at a nanometre scale. This allows the device to probe different characteristics such as electromagnetic fields and surface textures. It can also measure properties such as conductivity and resistance.

Every company in the sector is seeking to develop probes for new applications and Adama Innovations has proved particularly adept at this. The company's product range covers a variety of different applications, with slight changes to the tip geometry making it suitable for different uses. Adama Innovation's innovative and unique technology is a simple and efficient method to create bespoke micro- and nanoscale shapes and profiles in diamond and other hard carbon based materials. The repeatability and accuracy of the technique allows for precision engineering in desired locations.

Adama Innovation's main customers are the AFM manufacturers who distribute their probes to end customers. A new trend in the semiconductor industry is a desire on the part of companies to use multiple probes on the same instruments for parallel inspection of wafers and to increase throughput. Adama Innovations is therefore ideally placed to meet the needs of the semiconductor market.

Tyndall is able to offer companies like Adama Innovations access to high-value equipment that they could typically not afford to acquire when at an early stage in their growth.




*Adama diamond AFM probe products comprise macro, micro, and nano scale*

# Rockley Photonics collaboration takes top industry award

The collaboration between Rockley Photonics – a leading global supplier of integrated optical chips and modules – and IPIC, the SFI Research Centre for Photonics hosted at Tyndall, has won KTI's prestigious 2021 Industry Engagement Impact Award. KTI's Impact Awards recognise significant achievements in the commercialisation of publicly funded research.

The collaboration, active since 2017, between Tyndall and Rockley Photonics showcases how leading-edge research can be transitioned to market through industry partnerships, while also delivering value to the company and the community through job creation. It has resulted in 11 commercial licences and the establishment of Rockley Photonics Ireland in Cork, a venture which grew to 10 employees in 2021.

"Investment in research helps us address today's grand challenges, such as climate change and the health and well-being of citizens, while also creating opportunity for economic growth. Our partnership with Rockley is an example of this, where we are developing and deploying leading-edge technologies, and Ireland is at the centre of this technology revolution," commented IPIC Centre Manager, Dr Patrick Morrissey.

*Marc Frechette, Vice President of IP and Licensing at Rockley Photonics and Professor Frank Peters, Tyndall*

# International reach

***LEAD IRISH CONSORTIUM IN ECSEL PROJECTS IMOCO4.E AND ENERGY-ECS***

## EU programmes (2014-2020) in numbers:

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12 ASCENT+ and 10 EnABLES Transnational Access projects extending respectively CMOS++ and 'Power the IoT' PIs network and international reach

**Awarded 2x**

**Marie-Skodowska-Curie Fellowships, one global and one European**

*Tyndall researcher Dr. Chris Broderick was awarded a Marie Skłodowska-Curie Global Fellowship*

2021 was an exceptional year for Tyndall, despite COVID-19 pandemic-related travel restrictions and delays in the launch of the European Union's (EU's) programmes for science and innovation.

Our international reach activities on research policy and technology roadmapping, engagement with global technology leaders and the development and implementation of EU programmes continued. Our thought leaders had a major impact on new initiatives, highlighting why Tyndall is an international research partner of choice.

Tyndall researchers have been instrumental in the newly established Photonics 21 group on quantum photonic integrated circuits and in the development of their position paper through a series of consultations and workshops. Using this engagement as a springboard, our researchers have collaborated with colleagues globally to publish a perspective on 'the potential and global outlook of integrated photonics for quantum technologies' in Nature Reviews Physics.

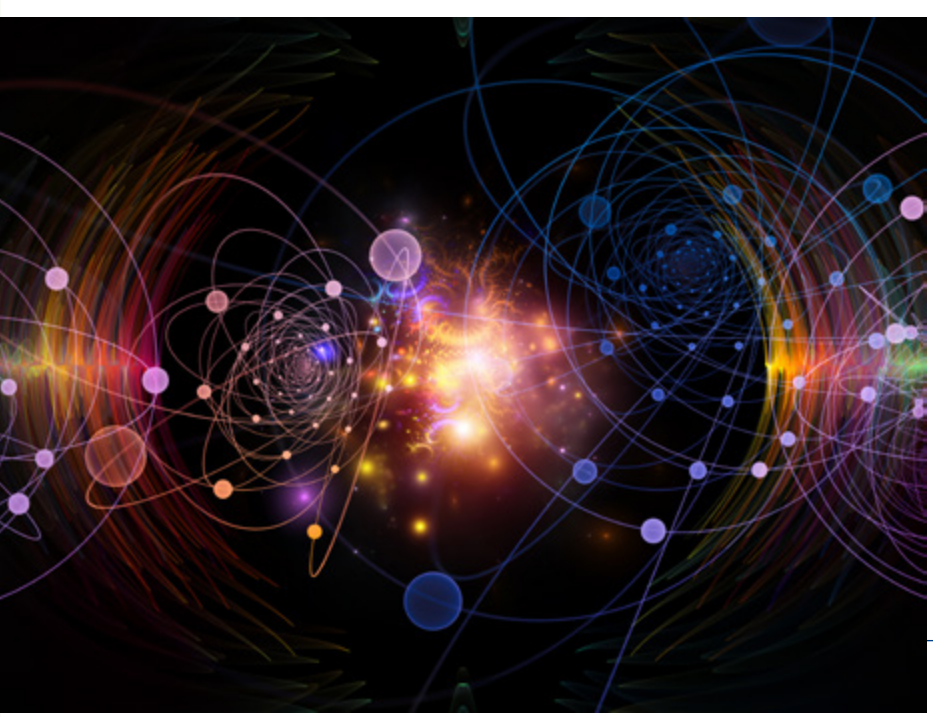
Tyndall researchers have also driven and made significant contributions to the White Paper titled 'AI at the edge' by the EPoSS (European Platform of Smart Systems) community of experts, presenting the state-of-the-art and future technology milestones in the Edge AI domain, and to the Packaging Chapter of the Integrated Photonic Systems Roadmap. The latter gives a detailed overview of the status, trends, expectations and key needs in the near future (0–5 years), intermediate future (5–10 years) and far future (10–20 years).

While the announcements of first results from Horizon Europe and other EU programmes were not available until early to mid-2022, we continued to enjoy success in the last topics of Horizon 2020. Successful projects included IMOCO4.E and ENERGY-ECS within Electronic Components and Systems for European Leadership (ECSEL), the precursor of the Key Digital Technologies Joint Undertaking, the first call of which will issue in 2022. Here, we partnered with Irish technology SMEs Emdalo and Net Feasa, and with Analog Devices. Another key success was the project SmartSPIN, led by the IERC at Tyndall, which aims to develop an innovative business model to unleash the energy efficiency and flexibility potential in commercial buildings.

We also celebrated the successes of Dr Chris Broderick and Dr Hassan Hamidi who have been awarded the prestigious and highly competitive Marie-Skłodowska-Curie Actions Postdoctoral Fellowship. These fellowships allow talented early career researchers to pursue their own independent research while acquiring new skills and knowledge in the host institution.

Our international activities offer expertise and access to infrastructure for SMEs while addressing global challenges in health, agri-food, the environment, and energy. As an example, 22 projects have commenced between Tyndall experts and partners from multiple countries through the ASCENT+ and EnABLES transnational access programmes. Both ASCENT+ EnABLES are funded by the EU to make available key research infrastructures across Europe and both programmes are led by Tyndall.


*Mike Fitzgerald, Chairman of Net Feasa and Mike Hayes, Head of ICT for Energy Efficiency at Tyndall, are joining forces to make 25 million steel cargo containers smarter and more energy efficient*



*A roadmap published in Nature Reviews Physics highlights the value of integrated photonics to quantum technologies and applications for the future*

# People and culture

***204*** *volunteers*
***30,000*** *public reach*
***196*** *STEAM activities*

23
SUMMER RESEARCH INTERNS

***A research community of over 600 people***

Tyndall alumni
**600+**
**members**

***Graduate Education***
***→ 34 New PhD & Masters starts***
***→ 140 PhDs, 13 Masters by research***
***→ 20 Viva's***

In 2021 we were still in the throes of the Covid-19 pandemic, which curtailed our ability to meet in person. This was challenging, as one of our key objectives is integration and collaboration between functions and disciplines. However, we maintained our connections and collaborations with one another through an extensive series of webinars and talks, Tyndall Talks, hosted online. It gave our talented researchers the opportunity to share their research and continue to connect with our research community of over 600 staff, students and Researchers in Residence.

Professor Dimitra Psychogiou, a global expert in radio frequency front-end technologies, joined Tyndall as Head of Advanced RF Technologies Research and Professor of RF Microwave Communications in UCC's School of Engineering and Architecture. Our new Wireless Communications Laboratory in Dublin also opened in 2021, with another drive to create 50 new research jobs by 2024. The launch of Ireland's first Quantum Computer Engineering Centre at Tyndall resulted in a major recruitment drive, which is now underway in earnest.

Overall, we recruited more than 140 staff and students in 2021. Nurturing our talent is another key driver for people and culture and we were delighted to announce that Dr Chris Broderick, newly appointed Senior Researcher, was awarded a Marie Skłodowska-Curie Global Fellowship and will be spending the two-year outgoing phase of the three-year Fellowship at the University of California.

2021 also saw the first full year of the operation of our Tyndall Research Leaders Career Structure which provides clear guidance on next career steps and the important skills and competencies to be developed for long term research career progression. We were delighted to see a significant increase in the number of internal career progressions and we look forward to the Research Leader Career Structure being a very important tool for researchers and their leaders throughout their careers at Tyndall.

# Education and public engagement

Creating awareness of the fundamental role science plays in our local communities and in our world is pivotal to Tyndall's education and public engagement activities, inspiring a new generation to consider science-related careers. In 2021, we engaged with 344 secondary school students through career talks and virtual laboratory tours, in addition to engaging with 152 primary school pupils through four workshops delivered remotely.

Among the highlights of the year was the 'Science of Walking'. This is an activity designed for primary school children by PhD student Liudmila Khoklova. It introduces students to basic concepts of biomechanics through card cut-outs and motion assemblies. It was developed and trialled virtually with 30 children at our Culture Night event 'Tyndall-rrific Virtual STEAM workshops' and was also showcased at Science Week in November.

Another highlight comes from our Biophotonics researchers who co-created with teachers a new IPIC Biophotonics course for transition year students, facilitating an understanding of light-based technologies in other STEM disciplines such as medicine and health. The course has been trialled in three schools in Cork with the aim of establishing long-term interactions with teachers, providing resources that can be used in other classes throughout the academic year.

At third level, applications for the Tyndall and IPIC Internship Programme doubled in 2021 in comparison to 2020. This programme aims to attract undergraduate students in all STEM fields across Ireland experiencing cutting-edge research for the first time. In 2021, nearly 40% of our intern cohort were women studying STEM disciplines, with projects in quantum physics, biomedical and environmental sensing, electronic and photonic devices, and communications with light, among many others.


*Post graduate students Fernando Diaz and Alida Russo, participants at the FameLab Cork Heat*

# PhD vivas 2021

**Hasan Baghbaderani**
Amorphous and nanocrystalline soft magnetic materials: from design to application

**Rory Cahill**
High power superluminescent light-emitting diodes

**Djordje Danjic**
Thermal properties of germanium telluride close to the ferroelectric phase transition

**Michael Dillane**
Optically injected dual state quantum dot lasers

**Shumithira Gandan**
Photoluminescence properties of novel III-V semiconductor systems

**Jennifer Halpin**
Synthesis and characterisation of aurivillius phase materials

**Declan Jordan**
Integrated thin film magnetics in advanced organic substrates

**Amy Kirwan**
Fundamental properties of novel group IV alloys: A density functional theory study

**Christian Konig**
Design of semimetal electronics relying on the quantum confinement effect

**Sanjeev Kumar**
Bandwidth enhanced sub-GHz wristwatch antennas for wireless body sensor network applications

**Swatchith Lal**
Development of thermoelectric materials and micro-devices for cooling and power generation

**Louise McGrath**
Nanomaterial-based devices for advanced energy storage and delivery

**Marcelo Saito Nogueira**
Optical spectroscopy for biological and biomedical applications: potentially impacting future of healthcare with research, clinical translation and education

**Conor O'Donnell**
Germanium tin for use in semimetal electronics

**Carlos Reyes**
Design and development of an endoscopic optical coherence tomography (Oct) imaging system

**Stephen Rhatigan**
Design of material for solar fuel production

**Daniel Smallwood**
Electrochemical materials for integrated magnetics

**Salvatore Tedesco**
Smart ageing systems for health and wellness in sports, ageing, and rehabilitation

**Simone Varo**
Advanced processing strategies for site-controlled pyramidal quantum dots

**Luca Zagalia**
Optimised grating coupler designs for integrated photonics

Tyndall National Institute

# Infrastructure

**Successful in SFI capital bid**

- Lab to Fab integration from novel materials to devices using Atomic Layer Processing (Atomic Layer Deposition & Etch) valued at €3m
- Tera Lab for 6G wireless-Photonic Networking valued at nearly €3m

**104 NEW USERS TO THE OPEN ACCESS LABS**

292 people

trained in the operation of process or analysis tools

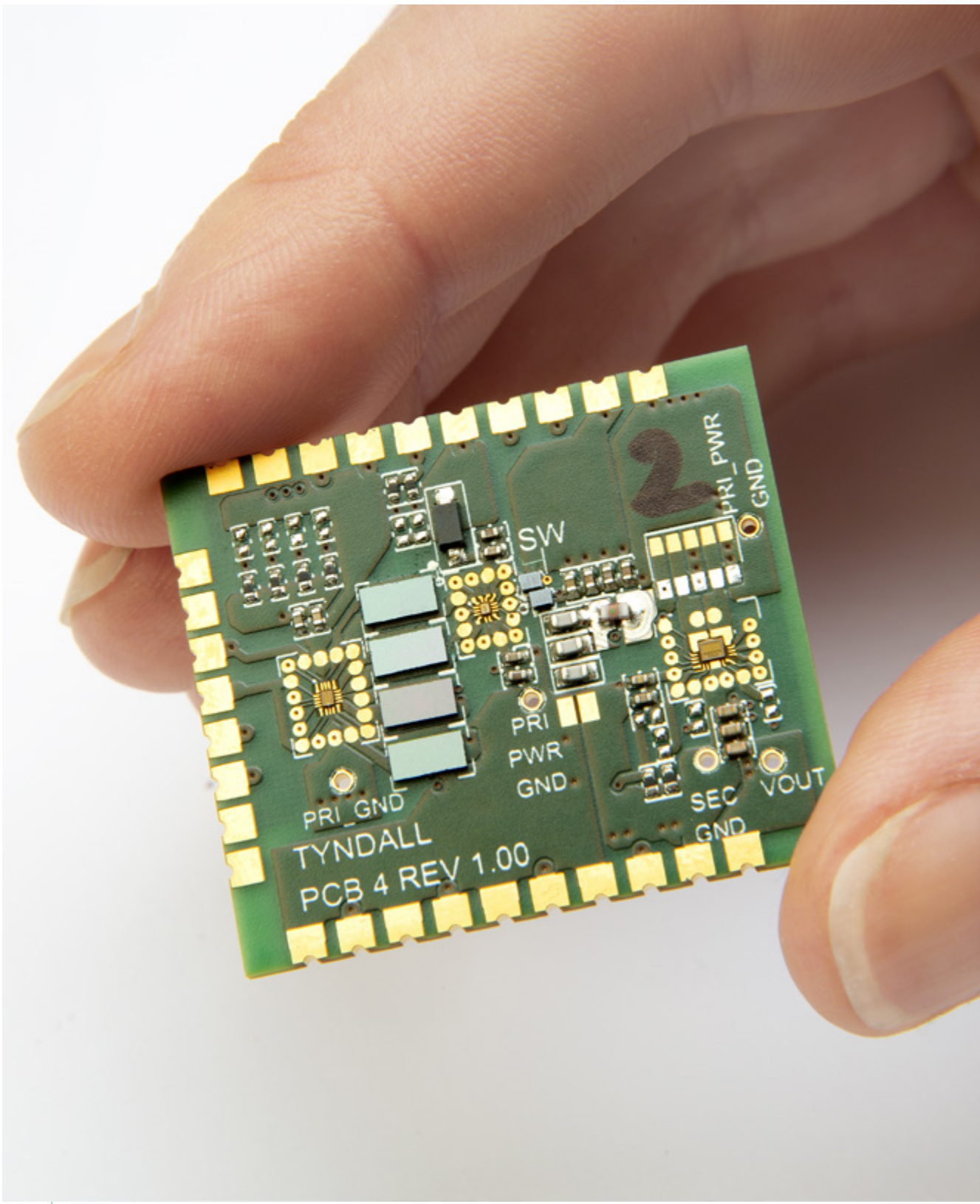
***Successful Completion of ESA funded project on the evaluation of automotive grade components for possible space use***

Tyndall continued to develop and upgrade its state-of-the-art infrastructure during 2021. Among our main areas of focus has been the ongoing equipment refresh programme, which ensures that we continue to provide leading-edge services and supports to Tyndall researchers, our external partners in industry and other research-performing organisations. We also completed the moves to our new Open Access Characterisation Facility (OACF) and Reliability Laboratories in July and August, respectively.

Our role in Specialty Products and Services (SP&S) spans the complete research process from the back end, where we assist researchers and external partners with the development and construction of prototypes, through to the front end where we deploy our forensic analysis capabilities to establish precisely why a product or prototype does or does not work.

Among our more significant external partners in this respect is the European Space Agency (ESA), and 2021 saw the completion of a project to evaluate automotive grade components for possible space use. This project has significant cost-reducing potential as it will enable components designed and manufactured for terrestrial use to be used in the space environment.

Our forensic analysis capabilities were further enhanced with the addition of a xenon-focused ion beam milling instrument. Tyndall researchers work with materials and components that are hundreds or even tens of atoms thick. Using a focused beam of ions, which is of the order of one-hundredth of the scale of a beam of light, we can cut into surfaces very precisely to examine a cross-section of the material or take away material for further analysis. This new instrument hugely enhances our ability to perform analysis at such small scales.



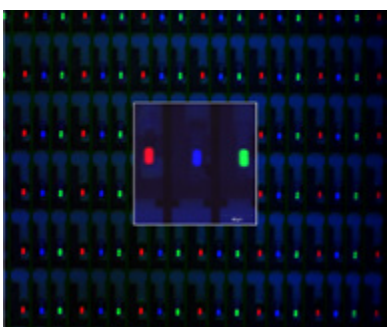

*Four Tyndall magnetics-on-silicon chips (silver/grey) in power supply test circuit*

# Scientific image competition winners

## Winter

**Vitaly Zubialevich, III-Nitride Materials**

This is a Scanning Electron Microscopy (SEM) image of a two dimensional pattern sometimes naturally occurring when silica nanospheres are scooped from the water surface to a hydrophobic sample. The fractal-like darker regions are regions where the surface tension force acting against the so-called 'capillary pump' force managed to push away spheres from the hydrophobic substrate surface.



## RGB micro-LEDs displays enabled by transfer printing technologies

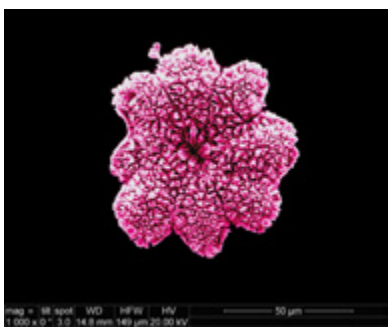
**Zhi Li, III-V Materials and Devices**

Colour displays using micro-LEDs need the heterogeneous integration of red, green and blue devices from different materials. By developing advanced device releasing techniques, 20um-sized LEDs emitting three colours are separated from their native substrates, then extensively transfer printed on a glass substrate for displays application. The image shows the details of lit-up pixels (with metal connections) from a bigger display.

## Codicology and multispectral imaging

**Veronica Biolcati, Nanotechnology**

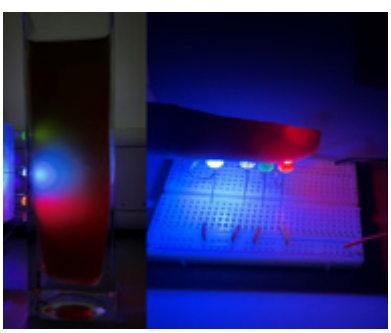
This infrared false-colour image (IRFC) captures the different inks used in the Irish manuscript the Book of Uí Mhaine (AD 1394). The interaction of inks with infrared illumination is strictly related to their chemical composition. This property is used for the typological classification of inks as part of the Ink and Skin project. This IRFC image was created by combining a visible and an infrared image at 940 nm and it shows that both an iron gall ink (red in IRFC) and a carbon-based ink (black in IRFC) were employed as writing material.



## Platinum bloom

**Ehren Dixon, Electrochemical Materials & Energy**

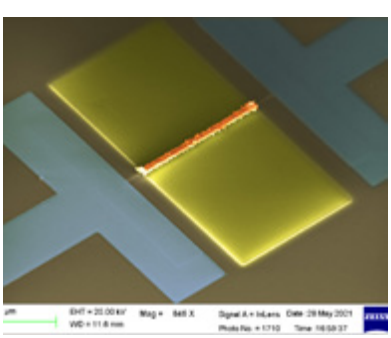
Producing nanoporous platinum can sometimes create interesting platinum deposits. This can result in the fascinating formation of flowers 'blooming' from the initial electrode surface into a 'blossom-like structure'. Dixon's research in the VistaMilk SFI Research Centre project is aimed at creating improvements in electrochemical sensors, which can then be used for next-generation gas/liquid sensors for the Irish agri-sector.



## Light lost in coffee

**Siddra Maryam, Biophotonics**

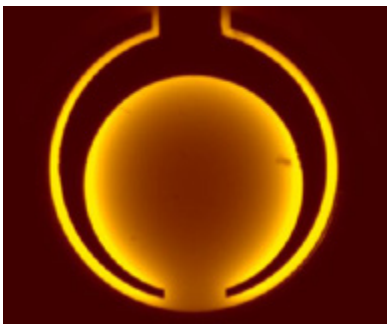
All materials respond differently to different wavelengths of light, and their response to every wavelength determines their colour. This image represents attenuation of light in coffee and human tissue. Different wavelengths of light can travel varied distances in coffee. The green light is the most absorbed and red light is the most scattered. But in the end, all seven wavelengths of white light are lost in coffee, which is why it appears black to us.



## NanoCuRocks-on-a-chip

**Vuslat Juska, Nanotechnology**

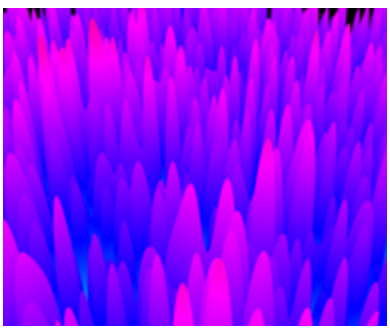
In the Advanced Nanosensors and Systems research group, the team successfully implemented silicon micro and nanotechnologies with surface chemistry, biology and electrochemistry. They designed, fabricated and characterised silicon-based multiplexed sensing devices to be used as a tool for the detection of several biomarkers in the same sample. The device fabrication is based on several lithography steps, metals depositions, lift-off, and etching.



## Current crowding

**Antoine Lemaire, III-V Materials and Devices**

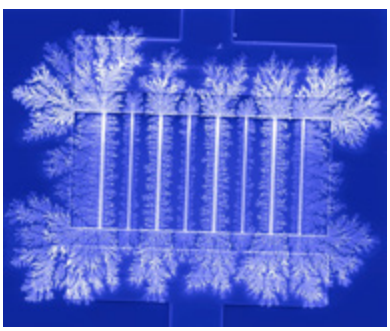
This image comes from electroluminescence (EL) measurement under high injection. It highlights the current crowding effect on a mesa structure. The image was captured on a photonic GaAs-based device. The current crowding shows how much the lateral flow of carriers is affected by the device resistance. The current spreading length (LCS) is a good value to measure such an effect. When LCS is much greater than the lateral length of the device (LD), then the carriers flow is homogenously laterally distributed.



## Stone forest of invisible radio

**Xing Ouyang, Photonics**

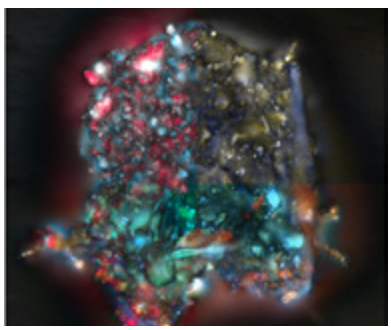
Today, we are connected everywhere through invisible wireless signals. However, have you ever wondered why you sometimes lose your signal even if you move your smartphone by a fraction of a metre? This image is the graphic rendering of a wireless channel in 2-D space, which looks like an astonishing stone forest with sculpted pinnacle columns, a typical geographic landscape called 'karst hills'. The height of the hills indicates the strength of the signal. The formation of the radio karst hills is due to the rich scattering environment without a direct line of sight from the signal tower.



## Merry Christmas

**Han Shao, Nanotechnology**

Free chlorine is a strong oxidising agent widely used in the treatment of drinking water, wastewater, as well as the paper and food industries. However, an excess of free chlorine may cause some serious problems such as breathing difficulties and irritation, and may lead to cancer. A fast, cheap and sensitive testing method is crucial therefore in order to monitor the free chlorine in drinking water. This image shows a thin layer of Ag nanostructure deposited on a platinum electrode using an electroplating method.



## Micro to Macro

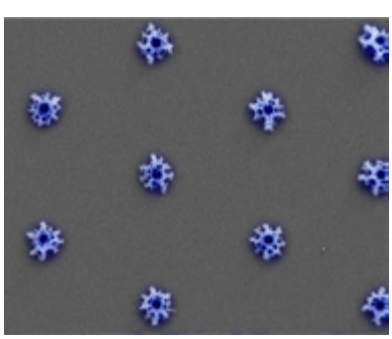
**Veronica Biolcati, Nanotechnology**

The purpose of this image is both to raise awareness of colour blindness and to pay tribute to the launch of the James Webb Space Telescope on 25 December 2021. This cosmic-like image resembles the telescope images one sees of galaxies and nebulae. The mosaic image represents a micrograph of a pigment fragment from a 500-year-old medieval Irish manuscript known as the Book of Uí Mhaine (AD 1394), which is preserved at the Royal Irish Academy in Dublin. This is a joint project with UCC (Modern Irish) and Tyndall (Nanotechnology Group) called Ink & Skin.

## Nano Forest

**Vuslat Juska, Advanced Sensors**

In nanotechnology, there is a focus on micro and nanoelectrochemistry for sensing systems development. This image represents one of the surfaces developed for this purpose. Here, deposition protocol is studied on single band electrodes with 1 micron width. The resulting dendritic structure of deposited metal is used as a matrix for immobilisation of biomolecules in the presence of a functional layer. These gold deposits are studied in order to create a surface that provides a solution for electrochemical applications and the 3D environment.

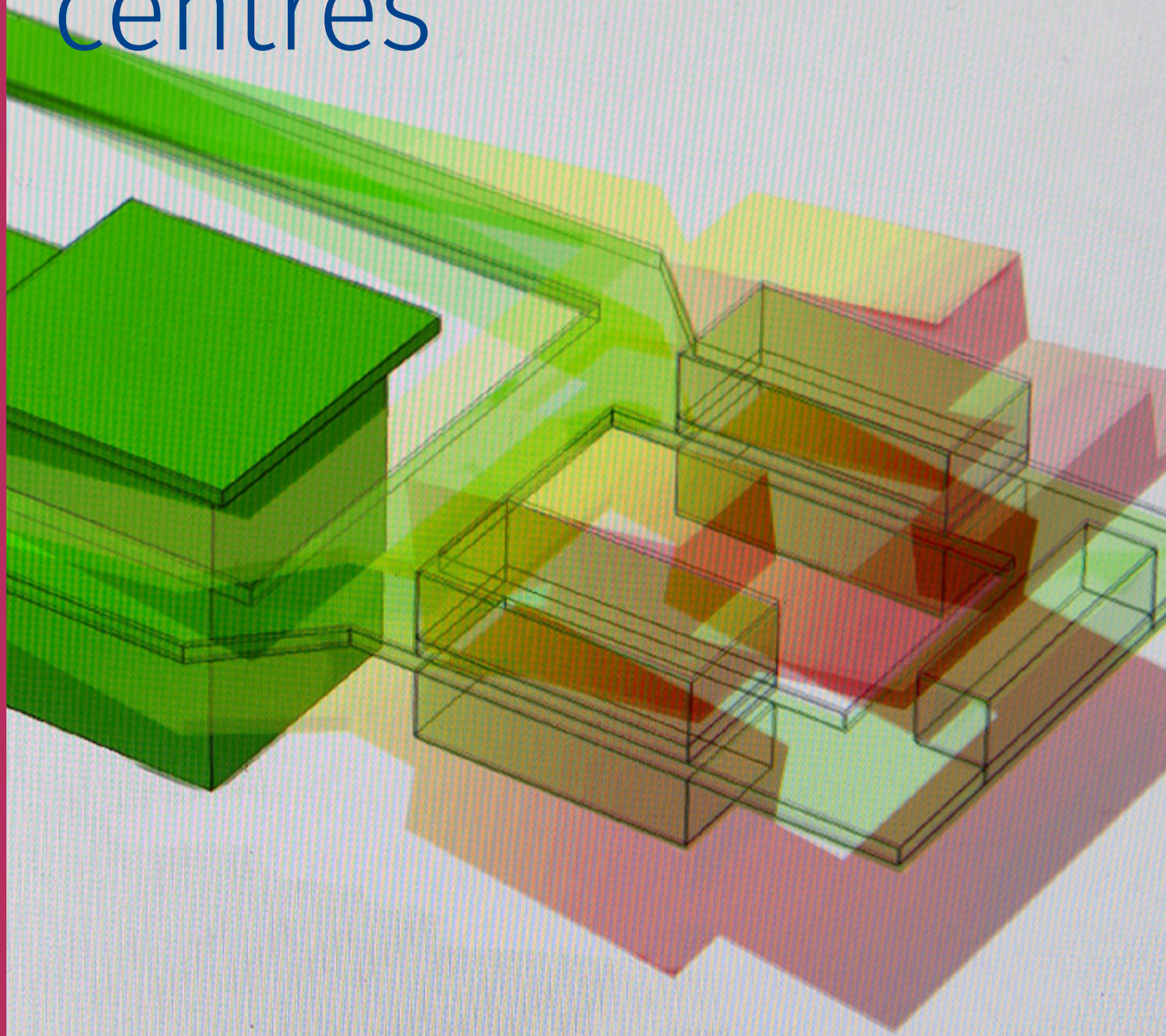


## NanoCatalyst

**Vuslat Juska, Advanced Sensors**

This NanoCatalyst is one of the outcomes of a recent Catalyst project called Label-free micro immunosensor development for multiple sclerosis detection (MISMS). The Catalyst programme was launched in partnership with the Institute for Materials Research (IMR) at The Ohio State University, to immediately advance international research projects and lay the groundwork for increasing research collaborations.

# Agency-funded centres



IPIC
BRINGING PHOTONICS TO LIFE

The Irish Photonic Integration Centre, IPIC, is the SFI Research Centre for Photonics. IPIC's research spans from 'atoms to systems', with the core research programme focused on four themes: monolithic and heterogeneous integration; packaging and hybrid integration; optical communications; and biomedical. These combine the expertise and knowledge of 17 research groups, bringing cohesion and coordination across the centre's activities.

The centre underwent a major international panel review in December 2021 and received extremely positive feedback, including that the "impact of IPIC for Ireland is outstanding".

IPIC operates a successful industry engagement programme that leads to a regular flow of projects worth approximately €2 million in income per year, with around 75% coming from repeat business. The centre won the KTI 2021 Industry Engagement Award for its work on silicon photonics devices, such as high-speed electro-absorption modulators for data centre interconnects. In addition, 60% of IPIC trainees who departed transferred directly to industry.

In 2021, industry partner Rockley Photonics strengthened its collaboration with IPIC through a new three-year project valued at over €3 million. The research partnership also includes the Biophotonics team, focusing on healthcare applications.

The year also saw the centre build on the success of the Explorer Deep Tech Pre-Accelerator Programme, which supports the development of deep-tech start-ups in Ireland. Teams on the programme are currently working on a wide range of ideas, including a technique to identify brain tumour boundaries and a transparent antenna to improve mobile signals in buildings.

IPIC also benefits from more than 50 active academic collaborations with some of the best universities and research institutes in the world and a phenomenal 67% of the centre's publications involve international co-authors.

Science Foundation Ireland sfi For what's next

*CAD screen output from finite element simulation of patented MEMS electromagnetic vibration energy harvester*

*Dr David McGovern, Senior Business Development Manager, IPIC holding a non-scattering anatomically correct 3D mock-up SiliGlass phantom developed using CT scans of a newborn infant*

CONNECT
Networks of the Future

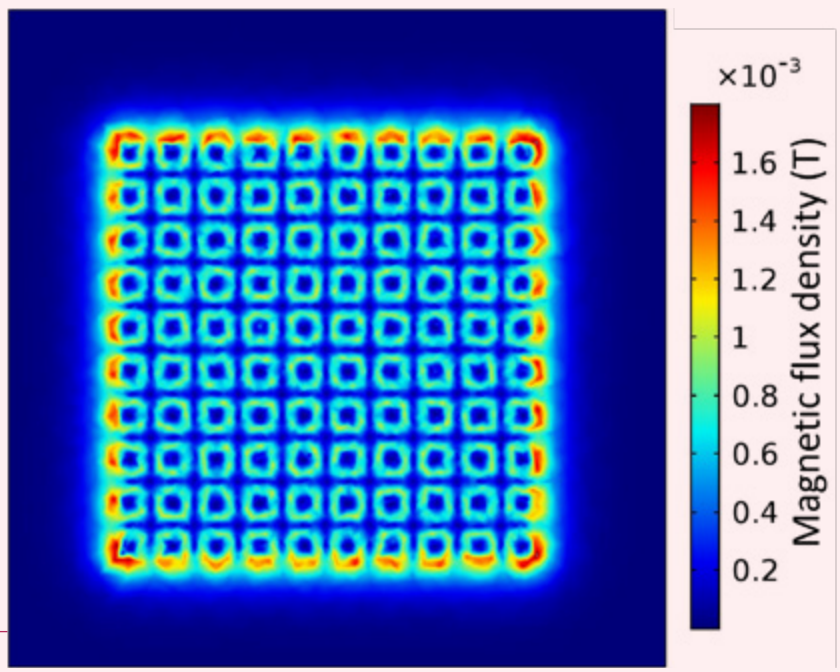
CONNECT is the SFI Research Centre for Future Networks and Communications. CONNECT is funded under the SFI Research Centres programme, which has established a network of Research Centres focusing on key research areas in Ireland. CONNECT brings together research expertise from 10 academic institutions with a unified purpose and mission: "We envision a future of sustainably deployed dependable networks that foster innovation in services and customer experience, empower citizens, and improve quality of life."

2021 was an exciting year for CONNECT as it entered its seventh year of operation with an enhanced mandate for growth in scaling industry interaction and collaboration. Research within the CONNECT centre is divided into the following themes: Dependable networks; Sustainable Internet of Things; Link performance; Customised networks; Data-driven optimisation and management; Network ecologies; Smart cities; Connected autonomous vehicles; Cybersecurity; Quantum; and Satellite.

During the year, Tyndall researchers expanded on their leading role in the CONNECT centre's Sustainable Internet of Things research theme in addition to increasing contributions to the CONNECT centre's Dependable networks, and Link Performance research themes. Tyndall researchers led nine platform research projects covering research areas including energy storage, energy harvesting, and wireless communications.

In a significant development during the year, three additional Tyndall principal researchers were appointed to the CONNECT leadership team.

Science Foundation Ireland sfi For what's next




*Simulation result showing the magnetic flux density distribution on patterned micromagnets*

# Confirm
## Smart Manufacturing

CONFIRM is the SFI research centre for Smart Manufacturing. A key highlight of 2021 was the licensing of innovative technology to an industry partner developed by CONFIRM PI, Dr Michael Walsh and CONFIRM researcher Dr Javier Torres, members of the Human Centric Systems Cluster. This technology innovation (5GT Smart Pallet) was applied via the development of smart self-powered wireless sensors for use in the linear motor vehicles of the Johnson & Johnson VisionCare contact lens production line.

The goal of this research was to develop an edge processing device to enable close to real-time detection of faults in the high-volume manufacturing sector. A number of key innovations were integrated into the research project.

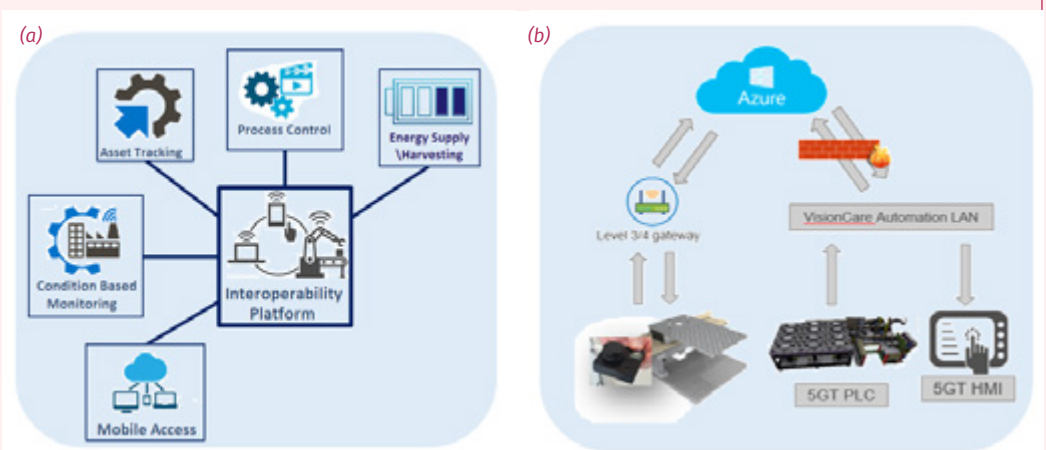
First, an energy recovery methodology was formulated to harvest energy directly from the linear synchronous motor-based propulsion system used to move the vehicles or pallets carrying the product throughout the manufacturing process. For example, embedded edge processing was employed to enable condition-based monitoring to detect deterioration in bearings, wheels and tracks; monitor and provide feedback on processing conditions; and detect equipment misalignments.

Second, on-board intelligence tracks the position of the vehicle as it traverses the stages of production, thus isolating where in the process faults are occurring. The system was designed to be made compatible with pre-existing equipment and requires minimal adjustment of same, which is advantageous as it can enable existing capital equipment to become more digitalised and smart.

The technology therefore serves as an interoperability platform with several beneficial features (e.g. mobile access capabilities; its own energy supply/harvesting) and applications within manufacturing environments (e.g. fault detection, condition-based monitoring; asset tracking; and process control). It is envisaged that diagnostics based on the information recorded could result in measurable and significant improvements in yield for the application under study. This was CONFIRM's first licensed technology and it serves as a useful industry use case to demonstrate how existing production infrastructure can be sensorised and augmented with intelligence, leading to smarter process, machines and systems.

Science Foundation Ireland sfi For what's next

*(a) Interoperability platform;*
*(b) 5GT Smart pallet technology integration schematic.*



VistaMilk

Funded by SFI and the Department of Agriculture, Food and the Marine, VistaMilk's aim is to become a world-leading research centre for innovative precision pasture-based dairying.

As part of Tyndall's contribution, we continued to grow our industry collaborations during the year with new projects, starting with Pepsi-Cola, animal feed supplements specialist Terra NutriTECH, and Zoetis, the world's largest animal health company.

In the case of Terra NutriTECH, VistaMilk is collaborating on research into the measurement of minerals in animal diets, while the focus of the research with Zoetis is on disease detection to ensure that animals are not receiving unnecessary treatment.

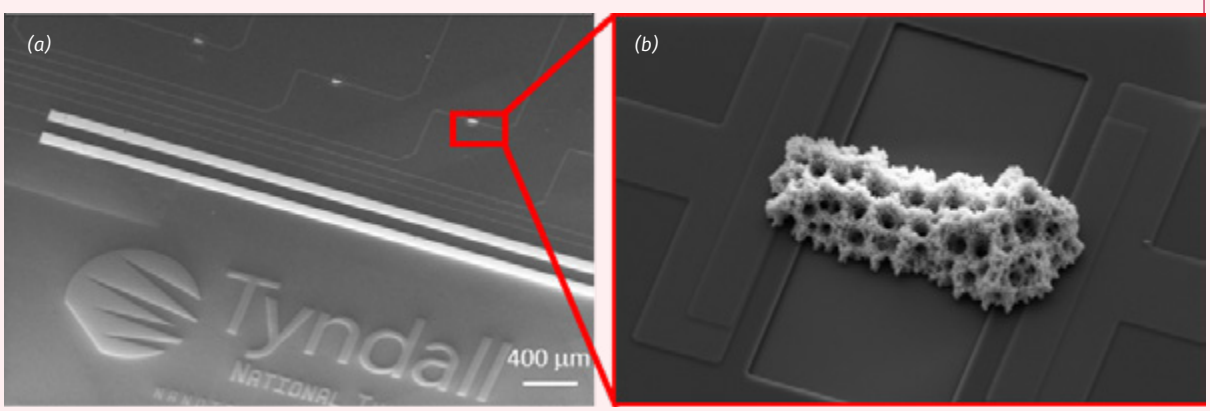
2021 also saw VistaMilk continuing to recruit high-quality researchers and PhD candidates despite the constraints imposed by COVID-19 public health measures. We also continued to grow our international reputation, with an increasing number of citations and references for our peer-reviewed publications.

A major achievement during 2021 was the development of a nanoelectrode, which can adjust the pH of a sample under analysis. This is useful for a wide variety of applications, as many analysis processes are sensitive to pH and require interventions to adjust it, such as the addition of acids or bases to the sample. These interventions can interfere with results and often present difficulties with disposal.

Nanoelectrode technology has already been used for measurement of nitrates in soil and water, as well as for the detection of heavy metals in rivers. We are now working on adapting the technology for use in the measurement of calcium in milk and the detection of diseases.

Science Foundation Ireland sfi For what's next

*(a) Scanning electron micrograph (SEM) of a portion of an electrochemical sensor chip showing three working sensors as well as counter and reference electrodes (white stripes). (b) High resolution SEM image showing a gold foam modified sensor for highly sensitive detection of bovine disease biomarkers.*



IERC
International Energy Research

The International Energy Research Centre (IERC) at Tyndall conducts research in energy efficiency in residential and industrial sectors, renewable energy generation and storage technologies, innovative business models to enable decarbonisation, and energy policy and regulation.

During the year, IERC received funding from Enterprise Ireland's Disruptive Technologies Innovation Fund (DTIF) for TRIDENT, a grid-ready, sustainable sodium-ion smart battery for stationary storage.

Funding under Horizon 2020 was received for SmartSPIN, a project to enable the next generation of smart energy services valorising energy efficiency and flexibility at the demand-side. IERC also received funding from the Velux Stiftung foundation in Switzerland in the area of luminescent spectral shifting with light propagation.

The objective of this research is to provide visual and circadian luminance under low daylight and in poorly daylit locations in buildings.

In another 2021 research highlight, Professor Brian Norton received the Best Paper Award in the Energy and Buildings category at the 2021 International Sustainable Ecological Engineering Design for Society (SEEDS) Conference.

A paper titled 'An Innovative Smart Grid Framework for Integration and Trading' by Dr Fabio Silva and Dr Brian O'Regan received Best Presentation at the Sixth International Conference on Sustainable and Renewable Energy Engineering held in Strasbourg.

2021 also saw IERC and Dr Pádraig Lyons appointed as Ireland's representative on the International Energy Agency Technology Collaboration Programme on Energy in Buildings and Communities/Annex 83 Energy Positive Districts.

The year concluded with Dr Fabio Silva presenting a paper titled 'Energy Transition X Energy Inclusion: A Community Energy Concept for Developing Countries' at the IEEE International Humanitarian Technology Conference in December.

Finally, in 2021 IERC constituted and held the first meeting of its International Advisory Board, formed from a diverse group representing industry, non-governmental organisations (NGOs), and research. This group is providing robust advice and support on IERC's long-term strategy as well as providing feedback on IERC's existing and forthcoming research projects.

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

*Ruchi Agrawal, Integrated Energy System Researcher and Dr Pádraig Lyons, Head of Group, IERC*

MCCI
SOLVE THE IMPOSSIBLE

Microelectronic Circuits Centre Ireland (MCCI) is a large scale microelectronics technology centre, focused on delivering high impact microelectronic research, and trained skilled engineers, driven by global industry application needs. The centre collaborates with global semiconductor companies to enhance their microelectronics technology research for advanced product applications. The centre has a large number of industry projects underway and is actively engaged with new and established international companies to work on new research projects.

The MCCI research strategy focuses on analog, mixed-signal, RF circuit, IC architecture and design, including the development of system-level research demonstrator prototypes.

Founded in 2010, MCCI is in its third phase of research funding as an Enterprise Ireland technology centre. This continued support is a strong endorsement of the research and talent produced for the microelectronics sector by MCCI.

This sector is of key importance for Ireland, with over 13,000 jobs and exports worth almost €10 billion generated. MCCI has become a conduit for IDA clients entering the Irish microelectronics system, and this is borne out by the number of semiconductor companies establishing or expanding their circuit design research and development (R&D) operations in Ireland over the last 15 years and more.

MCCI also supports the industry by providing skilled talent, with many PhD student researchers coming through the centre being in high demand within the microelectronics sector. MCCI also has an excellent track record in producing leading IEEE publications in journals and conferences, with 44 Tier 1 publications in 2021 alone.

TECHNOLOGY CENTRE
SUPPORTED BY ENTERPRISE IRELAND

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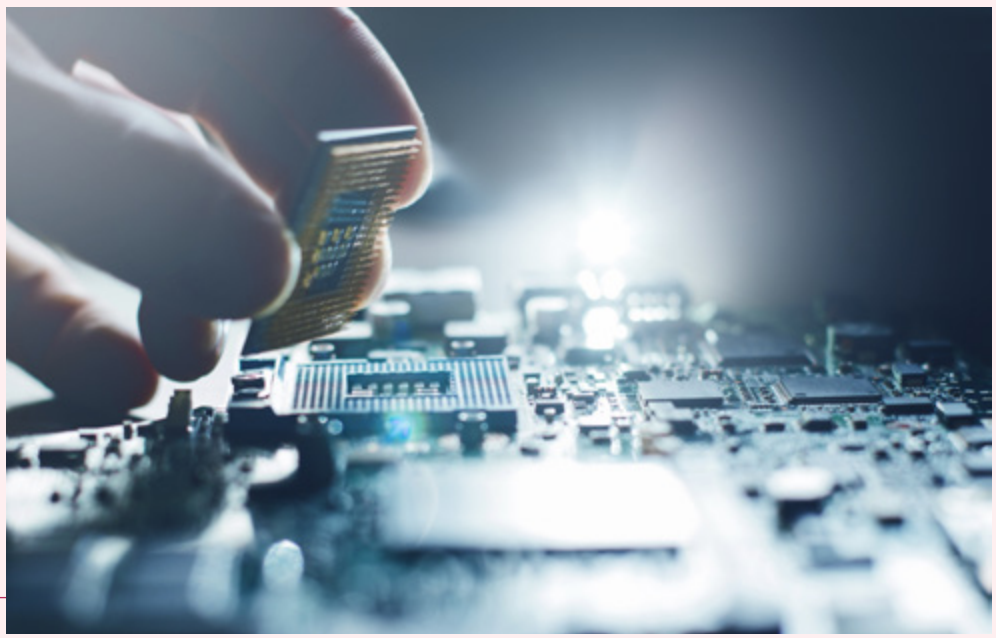

*Invisible power-zero sensory and digitization technology*

esa space solutions Ireland

Established in 2016, the European Space Agency (ESA) Space Solutions Centre Ireland is made up of five consortium partners – lead partner Tyndall National Institute; UCC/MaREI; Maynooth University; Technological University of the Shannon; and University College Dublin. Funding support is provided by Enterprise Ireland.

In 2021, three ESA BIC Ireland companies were approved for incubation support (Raceix, Cortex Labs and PlantQuest), while a total of six ESA Technology Transfer Demonstrator (TTD) projects (ATG Innovation, Composites Testing Laboratory, Eblana Photonics, ÉireComposites, O.C.E. Technology, Simplex-Fidum) were approved.

In addition, the centre hosted 10 Lunch and Learn Webinars, and a Founders Funding Network was also established. ESA BIC Ireland companies also participated in three financial training workshops.

A four-year funding extension of the centre was approved by the ESA during the year. Over the four-year period, a total of 30 Irish companies will be supported by ESA BIC Ireland, which represents a 50% increase on the first funding cycle. A new feature of ESA BIC Ireland is a dual incubation model, physical or remote, which is now operational.

A new technology transfer funding mechanism known as ESA Spark Funding will replace the previous ESA TTD funding mechanism. ESA Spark Funding will support eight established companies during the four-year period.

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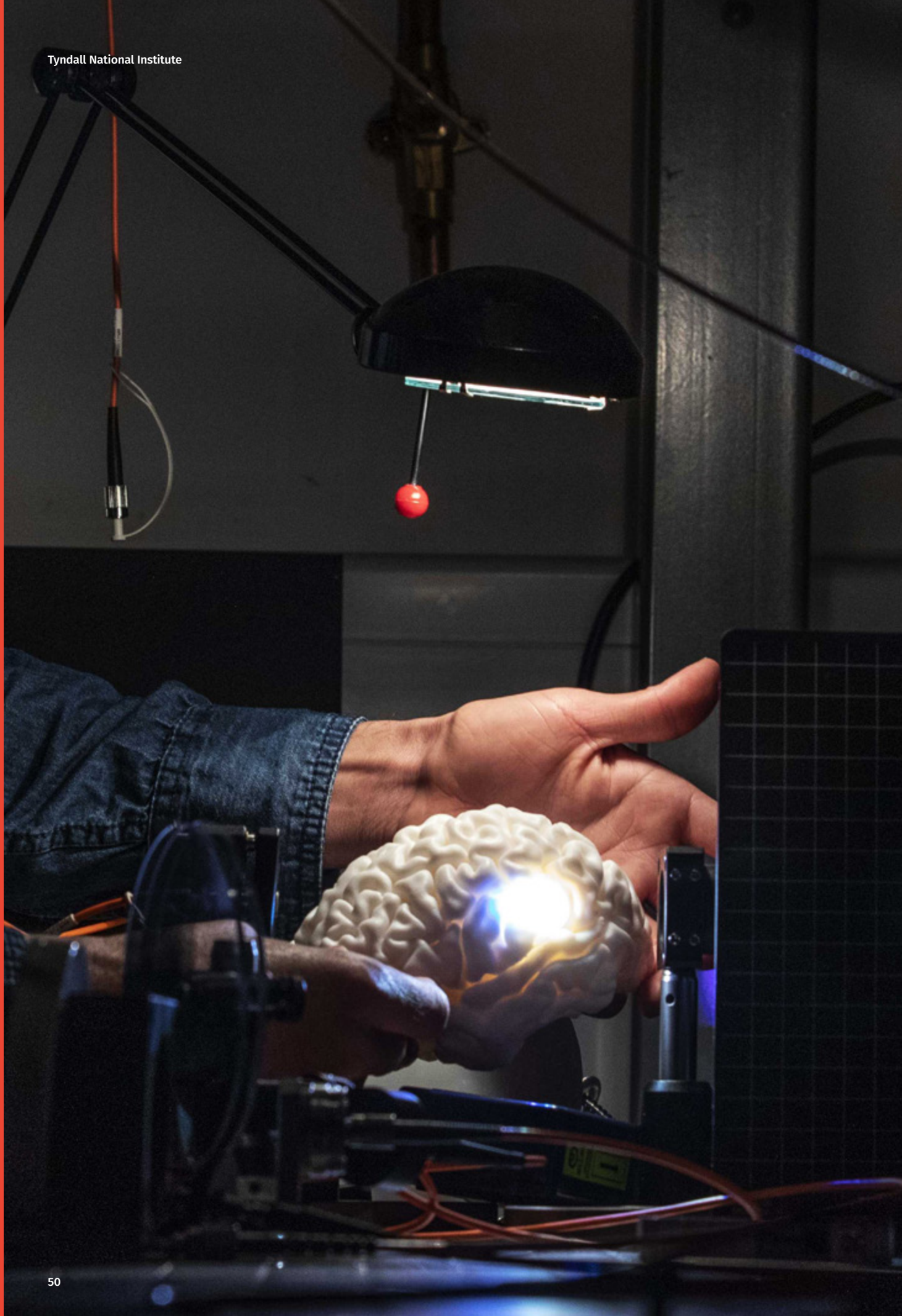
*Jens Köpke, Founder & CEO of Motoklik, an ESA BIC Ireland supported company, showcasing his company's suspension measurement and lap-timing system, which is used with off-road motorcycles*

# Financial report

# Income and expenditure summary

| Income | 2021 €000s | 2020 €000s |
|---|---|---|
| **Government grant** | 7,000 | 9,000 |
| **Research** | 36,209 | 33,036 |
| **Exceptional Infrastructure** | 1,733 | 967 |
| **UCC contribution** | 2,221 | 2,278 |
| | **47,163** | **45,281** |

| Expenditure | 2021 €000s | 2020 €000s |
|---|---|---|
| **Remuneration costs** | 26,465 | 26,660 |
| **Equipment and infrastructure** | 2,632 | 2,898 |
| **Consumables and related costs** | 9,531 | 10,025 |
| **Other operating and deferred costs** | 8,534 | 5,698 |
| | **47,163** | **45,281** |



Tyndall National Institute

# Board members

## Eoin O'Driscoll
**Chairperson**

## Caroline Dowling
**Non-executive director (various)**

## Dr Ann Kelleher
**Intel Corporation**

## Prof. John Cryan
**University College Cork**

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

## Sean O'Sullivan
**SOSV**

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

## Patricia Reilly
**Department of Agriculture, Food and the Marine**

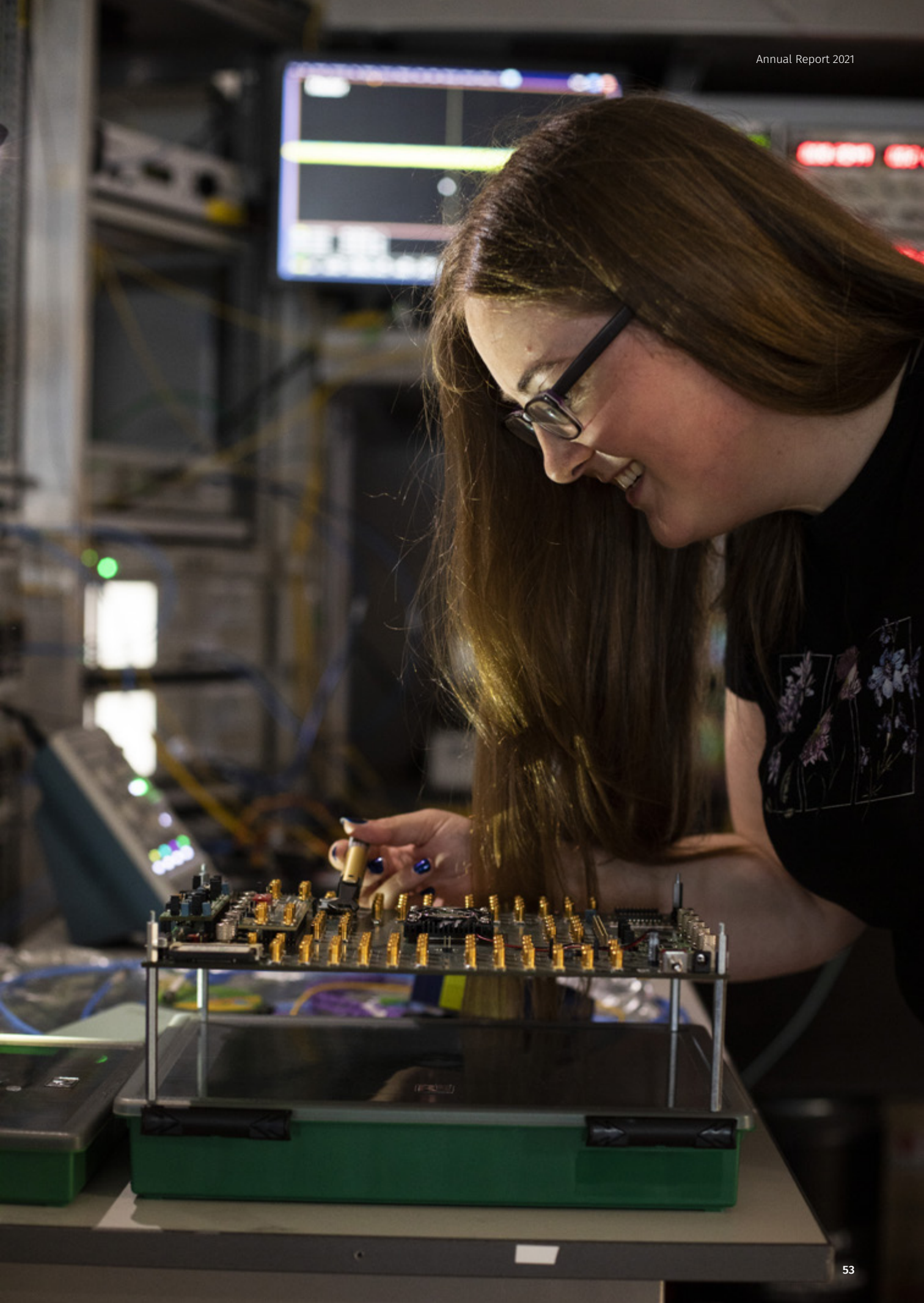
## Prof. Steven Ringel
**The Ohio State University**

## Prof. William Scanlon
**CEO**

## Jane Williams
**Sia Partners**

*Infant brain tissue simulating phantom illuminated with supercontinuum white light, standardization protocol carried out in biophotonics lab in collaboration with spinout company BioPixS*

# Notes



Rialtas na hÉireann
Government of Ireland

Tionscadal Éireann
Project Ireland 2040

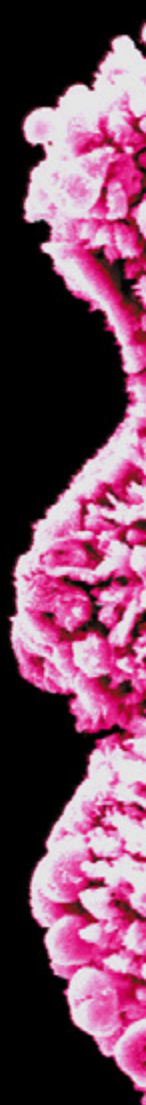
Ireland's European Structural and Investment Funds Programmes 2014-2020
Co-funded by the Irish Government and the European Union

European Union
European Regional Development Fund

*Platinum Bloom*

*Ehren Dixon, Electrochemical Materials & Energy Research Group*

*Producing nano-porous platinum can sometimes create interesting platinum deposits. This can result in the fascinating formation of flowers 'blooming' from the initial electrode surface*



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