Tyndall
National Institute
Institiúid Náisiúnta

ANNUAL REPORT



2015

Impact from Excellence

Contents

Message from our Chairman

Tyndall National Institute's uniqueness and flexibility continued to enhance its impact in 2015 as a national and global leader in impact from ICT research excellence. Tyndall's unique relationship with University College Cork (UCC) and the Department of Jobs, Enterprise and Innovation (DJEI) allows the institute to operate with a degree of autonomy that offers the agility necessary to work with industry, without sacrificing governance or the standards of world-class scientific research.

As a small open economy Ireland is particularly impacted by the ever increasing pace of globalisation. Ireland is a relatively high cost economy and therefore cannot compete on cost alone. Irish products and services must offer unique value propositions in the marketplace. ICT has the ability to create value in several domains including agriculture, energy, communications and health. During 2015, Tyndall continued to work closely with industry in these areas to enhance product and service offerings by delivering on its mission of creating impact through scientific excellence.

Tyndall's contribution to Ireland's long-term competitiveness lies in its focus on market-ready research and its relationship with industry. Partnerships with multinationals and indigenous companies continue to increase with over 200 industry partnerships generating in excess of €5m industry revenue in 2015. Partnerships with Teagasc and the Telecommunications Software and Systems Group (TSSG) continue to flourish with the potential to create products and services in precision agriculture that can enhance the growth and competitiveness of Ireland's agri-food industry.

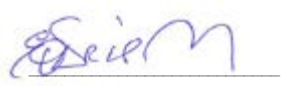
Research excellence continues to be the basis for Tyndall's success and in 2015 there were over 200 peer reviewed publications, 106 PhD students, 19 student awards and 26 EU Horizon 2020 projects. Tyndall's leading role in the SFI Connect centre, launched in 2014, demonstrates the centrality of Tyndall's research in the pervasive and growing field of the Internet of Things (IoT). The launch of the EU ASCENT Project in conjunction with CEA-Leti (France) and imec (Belgium) recognises Tyndall's expertise in advanced semiconductor fabrication infrastructure. Tyndall continues to support Ireland's vision to become a global innovation leader by expanding its international engagement in research organisations and in Horizon 2020 projects.

Recent reviews of research in Ireland by the Organisation for Economic Co-operation and Development (OECD), the Technopolis Group and the DJEI identify the need to "strengthen Ireland's market–focused research centre landscape". Tyndall, as an organisation with both strong university links and expanding commercial relationships with industry is well positioned to evolve to be a national ICT Research Technology Organisation (RTO) thereby strengthening Ireland's market-focused research.

Ultimately, Tyndall's people are the key to its success, and Tyndall must continue to attract, retain and develop talent. The ongoing support of UCC and Science Foundation Ireland (SFI) to create research professorships is important to the institute's success and allows them to attract and retain leading talent. This support enabled the Irish Photonic Integration Centre (IPIC) at Tyndall to attract Professor Stefan Andersson-Engels to the newly created position of Professor of Biophotonics.

Tyndall alumni are at the heart of the microelectronics and photonics industry activity in Ireland and with over 100 PhD students, the institute continues to support the Governement's ambition of creating competitive advantage through the quality of the people available to industry, research and academia.

I would like to thank outgoing board members Martin Cronin and Professor Jim Merz for years of invaluable service, the standards they set all of us on the board and their positive challenge to the executive, staff and fellow board members.



Eoin O'Driscoll
Chairman

Message from our CEO

As we move toward the midpoint of our five-year strategic plan, this is an appropriate time to review our achievements, examine our progress, and make necessary adjustments in response to a changing environment. Since the plan was launched in 2013, we have recorded outstanding successes in terms of research results, industry partnerships, funding, and exciting new initiatives that apply and maximise the impact of our work worldwide. As we ask ourselves how we can further build on our achievements, we are not just looking to the second half of this strategic plan, but to the opportunities to 2025 and beyond and our vision of global leadership in the field of ICT research.

We delivered substantial research output in 2015 including over 220 publications in prestigious high-citation journals such as Nature Communications, Scientific Reports, Physical Review Letters and Advanced Functional Materials. Tyndall's SFI centre IPIC (Irish Photonic Integration Centre) had a very successful year in terms of technical achievements, national coordination activities, expansion of international reach and major funding wins.

In academic and commercial terms, we have made significant strides this year in the field of integrated power. Our presentation at the Applied Power Electronics Conference (APEC) and our focus on power management and the Internet of Things (IoT) has brought new collaborations with global industry players to our door, resulting in several large-scale commercial projects.

Continuing our commitment to attract new talent and develop our staff, we are delighted to welcome Professor Stefan Andersson-Engels on board in the newly-created position of Professor of Biophotonics, heralding the planned development of a large research concentration in the biophotonics space, as part of the IPIC development plan. Our female staff are, for the second year, participating successfully in a targeted Leadership Foundation Aurora programme, which is an important instrument for us to champion gender equality in research and higher education.

In 2015, our income from direct industry partnerships increased by 65%. Companies increasingly partner with us directly through a challenge they need to solve, while leveraged participation and industry interaction through our agency-funded centres is also growing. Traditionally, the relatively large microelectronics sector has been our natural industry partner in Ireland. However, as devices become smarter and more connected, we now see microelectronics migrating into areas such as medical device technology and photonics. This has created an exciting opportunity to grow activities in the MedTech space, which is now materialising in the outputs of our institute. As ICT becomes pervasive, we are reaching into other sectors as varied as AgriTech and the marine. Smart, connected technology increases the value of products developed and made in Ireland.

As well as IPIC, the other agency-funded centres hosted at Tyndall continue to successfully grow their activities. The Microelectronic Circuits Centre Ireland (MCCI) is expanding as new companies outside its core electronics focus are attracted to their work. The International Energy Research Centre (IERC) also continues to perform well, developing its vision to realise deployable innovations in integrated, secure, affordable and sustainable energy solutions. The SFI centre Connect, which was launched last year is making exciting progress in the future networks and communications arena.

Our excellent research and ability to cover a broad range of Technology Readiness Levels (TRLs) continues to make a significant impact in supporting industry and the national economy. Our work with multinational companies and SMEs, allows us to conduct globally competitive advanced research that has an impact on multiple sectors of the economy. Our vision as we move forward is to make these industry partnerships even more effective and help to improve the competitiveness of our industry partners, with the valuable input of the Department of Jobs, Enterprise and Innovation, SFI, IDA Ireland, and Enterprise Ireland.

We are performing well in the EU Horizon 2020 programme with related income of €5m for 2015. Our retention rate is ahead of both national and EU averages and we are competing hard to win projects on key H2020 pilot lines such as device packaging and AgriTech. The launch of the ASCENT project in conjunction with CEA-Leti (France) and imec (Belgium) represents another important milestone. We coordinate ASCENT, making us the portal through which researchers can access Europe's most advanced semiconductor fabrication infrastructures.

Our strategic partnerships with Teagasc and the Telecommunications Software and Systems Group (TSSG) also gathered further impetus during the year. Together our teams actively contributed to a technology foresight initiative with a focus on how ICT can play a part transforming the agri-food and bioeconomy. We have also entered into partnerships this year with Delft University of Technology in The Netherlands and the Fraunhofer Research Institute in Munich, Germany.

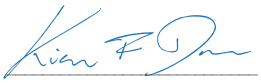
Our intense focus on generating impact from excellence reflects our position as a national institute that delivers an advanced standard of applied, translated research for maximum economic impact.

The Tyndall Founder Programme was launched in 2015 in partnership with Enterprise Ireland's Business Partner Programme. It seeks to match our portfolio of emerging technologies with experienced entrepreneurs who will help establish new companies and lead these spin-outs to the marketplace. Building on our track record of 10 spin-outs over the last decade, the essence of our Tyndall Founder Programme is to identify people who have the skillset to enter a research environment and incubate a high-potential technology into a commercial offering in their role as CEO. With the additional appointment of an Entrepreneur-in-Residence, we have reinforced our position as an innovation-focused institute.

Our graduate education programme continues to play a crucial role at the heart of Tyndall's research activities, with 19 PhD students graduating in 2015. Our 1,400 alumni continue to grow and help talent nurtured here to fill roles in industry and become academic leaders around the world.

I would like to thank the Department of Jobs, Enterprise and Innovation, for their critical support and valuable partnership. I would further like to thank President Michael Murphy and his management team for their valued ongoing support. I would like to thank our chairman Eoin O'Driscoll who in his second year in the role has continued to make a strong contribution to the development of the institute.

Finally, I would like to thank our staff and students for their dedication to excellence, hard work and commitment. You continue to drive Tyndall's many achievements, and have made 2015 a truly successful year.



Kieran F. Drain, Ph.D.
CEO

Scorecard:

People

- 106 PhD and 16 Masters students pursued their studies
- 19 students completed their PhDs
- SFI fund new professorship in biophotonics
- Multiple initiatives to support entrepreneurs (Entrepreneur-in-Residence, Makerspace, IPIC Bootcamp, CorkBIC)

Industry Engagement

- Total industry contribution increased by 65% vs 2014
- Intel three-year contract renewed for a third time
- Multiple large-scale contracts and licenses in integrated micropower with global players
- Photonics Ireland National Technology Platform launched

Research Excellence

- Dr Lynette Keeney awarded one of the first Royal Society-Science Foundation Ireland University Research Fellowships
- More than 220 peer reviewed publications in 2015
- Highest ranking achieved in UCC's five-year research quality review
- Hosted Photonics Ireland Conference

Infrastructure Access

- Gateone launched to facilitate EU-wide SMEs access to our product-ready technologies
- ASCENT was established to provide the research community with access to Europe's leading nanofabrication research facilities at Tyndall, imec and CEA-Leti
- Addition of new rapid prototyping suite which can add electrical functionality to 3D printed objects

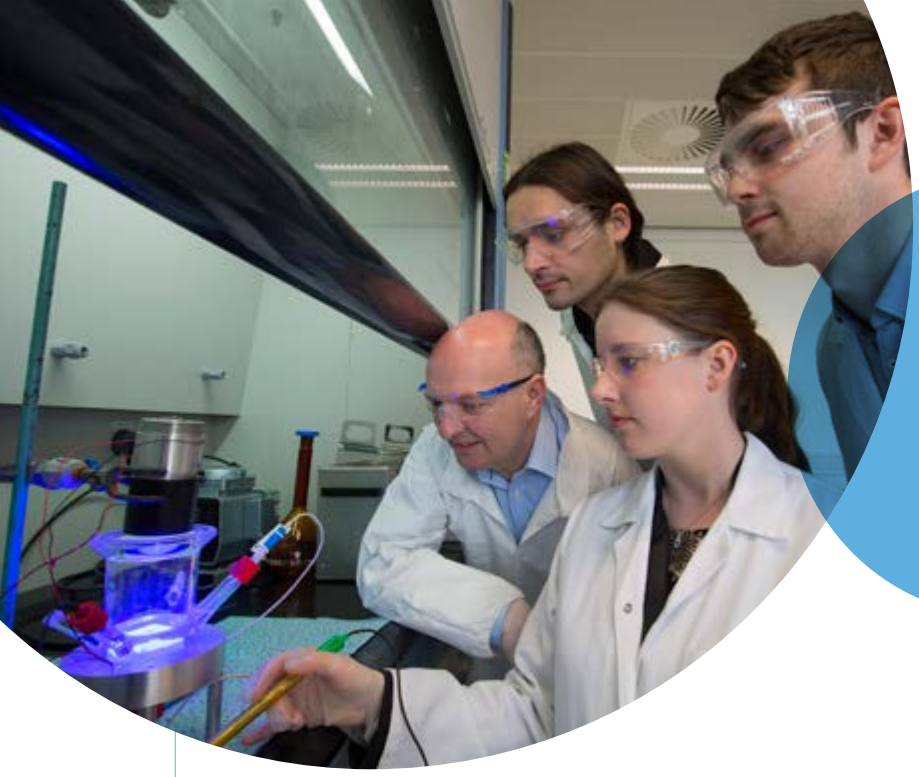
Funding

- EU income received over €5m
- We participate in 26 H2020 projects worth over €140m
- 16% success rate in H2020 calls
- 222 proposals submitted, valued at €122m

Global Reach

- IPIC secure first SFI US-Ireland centre-to-centre R&D partnership programme
- International IEEE Nano conference 2018 secured for Cork
- ECOC 2019 secured for Dublin

Research highlights



Dr Paul Hurley and postgraduate students Jan Kegel, Jennifer Halpin and Adrian Walsh with the water splitting photo-electrochemical cell developed in Tyndall.

Electronics

Breakthrough in use of solar energy to split water molecules and produce fuels

The development of clean fuels from a renewable source represents one of the main challenges for science and society in the 21st century. Researchers in our Nanoelectronic Materials and Devices group, working in collaboration with colleagues in Stanford University USA and Queens University Belfast, have made a significant development in the design of solar cells that can be submerged in water to produce clean, renewable fuel from 'water-splitting' chemical reactions driven by sunlight.

To protect the solar cell's surface from water corrosion, a breakthrough was achieved by Professor Paul McIntyre and colleagues at Stanford University in 2011, by applying an extremely thin layer of titanium dioxide to the anode part of the solar cell. However, this presented a problem: the thicker the protective layer, the lower the voltage generated by the silicon-based cell beneath. Tyndall Principal Investigator, Dr Paul Hurley, developed an innovative solution to boost the voltage, following which a prototype was fabricated at Tyndall and sent to Stanford for testing, where the voltage-producing capacities of the new solar anode design exceeded all expectations.

The new design of the photo-anode produced a record-breaking voltage, suggesting that it will be possible to generate the electricity needed to split water molecules into fuel components solely from sunlight. With sunlight as a sole source of energy, water-splitting reactors could provide a renewable source of hydrogen, methane and methanol, and potentially funnel CO_2 into reactors for transformation into fuel instead of releasing it into the atmosphere, reducing its harmful effects on the global climate. The impact of this innovation was recognised by the journal "Nature", which published the collaborative research paper online in Nature Materials in October 2015 and in the print edition in January 2016.

This research has been undertaken as part of the US Ireland R&D Partnership programme under the RENEW project (Research into Emerging Nanostructured Electrodes for the Splitting of Water), and is funded by SFI, Invest Northern Ireland, and the US National Science Foundation.

Prof. Mark Ferguson, Director General, Science Foundation Ireland and Dr Lynette Keeney, Tyndall.

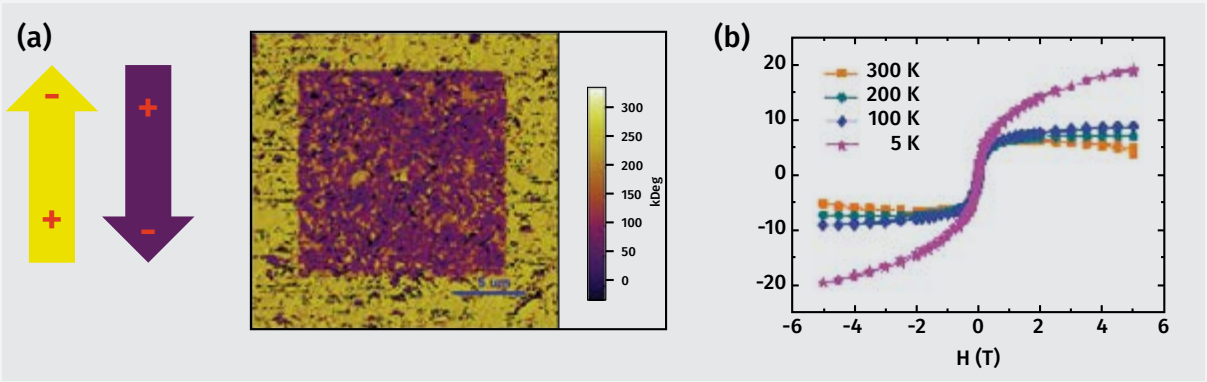
Memories are made of this: multiferroics research for future generation memories

Dr Lynette Keeney was awarded the prestigious Royal Society-Science Foundation Ireland University Research Fellowship in 2015 for her groundbreaking work on a newly-discovered multiferroic (containing both electric and magnetic memory states) material.

High data-density, energy-efficient memory devices based on single-phase multiferroic materials have been road-mapped as promising architectures for memory scaling beyond current technologies. Until recently, no materials showed genuine multiferroic effects at room temperature, therefore no such devices exist.

The research fellowship is working to optimise the newly-discovered multiferroic material and address the intriguing research challenges that this discovery presents. For instance, the origin of magnetism in these materials is not known, nor is it understood how the magnetic and electronic polarisation components interact. Understanding these matters will advance the development of this unique material and progress the rapid development of new room temperature single-phase multiferroic materials.

The advantage of these advanced materials is that not only could they find application in low-power memory devices that can be electrically written and magnetically read, but they also promise a technology that takes advantage of simultaneous electric and magnetic memory states allowing for multiple bits per memory element.



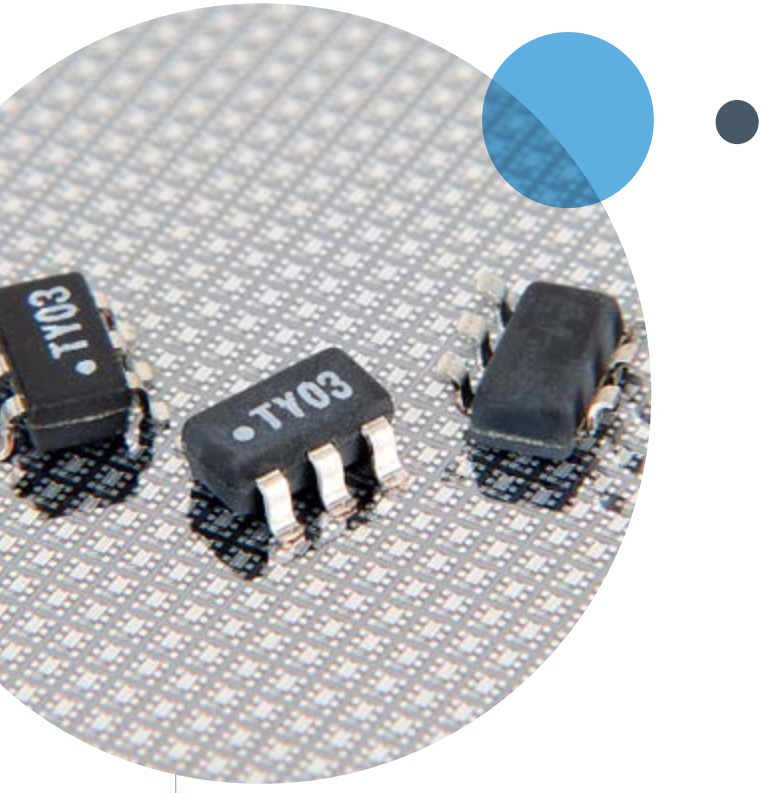
(a) Representative piezoresponse phase image demonstrating ferroelectric properties and (b) Superconducting quantum interference device magnetometry data demonstrating ferromagnetic properties of the Bi6TixFeyMnzO18 Aurivillius phase thin films.

EuCPAD radiation detector deployed in space

In the harsh environment of space, astronauts are exposed to harmful radiation. Through the European Space Agency (ESA) funded EuCPAD project, our researchers co-developed a novel, active and wearable device that can measure radiation in real time and instantly warn astronauts of increased radiation levels.

This personal radiation dosimeter system is made up of a phone-sized mobile unit, worn in a pouch on the astronaut's body, and a docking station to recharge the unit, download the data and transmit it back to Earth.

At Tyndall, we developed, fabricated and supplied three of the four radiation detectors that make up the mobile unit, a RADFET and two types of highly customised PIN diodes. Each detector covers a different region of the electromagnetic spectrum to give a comprehensive picture of the radiation environment in space. The device will be permanently installed at ESA's Columbus module of the International Space Station in the second half of 2016.



RADFETs in miniature plastic packages developed for the European Space Agency.

Surface chemistry paves the way for radically new doping processes

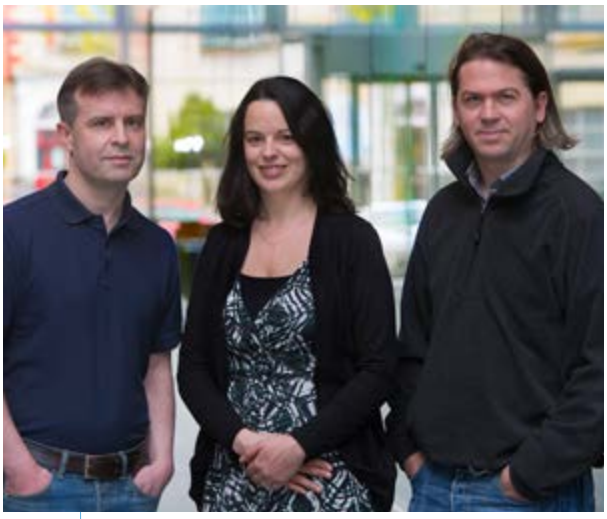
To maintain transistor device scaling, industry will be forced to move from planar to non-planar device architectures. This has created the need to develop a radically new, conformal method for doping, which alters the electrical properties of a semiconductor, related to the access resistance.

Low-access resistance is required for transistor device technology to be high performing with reduced power but this resistance exponentially increases once the semiconductor device body is thinned. As a result of this, current drops.

In these device designs, surfaces dominate as there are proportionately more and more atoms bound-to or located close to the surface. Since it is highly likely that future FET devices will consist of these architectures, it is imminent that surface science and chemistry-based studies of these systems will rapidly emerge as the key enabling technology in terms of device optimisation.

Researchers in our fabrication team, in conjunction with the UCC Department of Chemistry, are using surface chemistry to introduce dopant atoms into thin-body devices, fabricated in-house, down to sub 10 nm dimensions. This is the first time this research has been undertaken at sub 10 nm which is the scale required for application in nanowire devices.

Under an Enterprise Ireland Innovation Partnership project, we are comparing doping process technologies to understand geometry effects for beam line ion implant, plasma doping and molecular monolayer doping and for small geometry fins or gate-all-around devices.



Dr James Connolly, Researcher-in-Residence, Applied Materials; Dr Brenda Long, Chemistry Department, UCC; and Dr Ray Duffy, Tyndall.

Integrated Magnetics team shaping the power electronics landscape

Established by Prof. Cian Ó Mathúna and now led by Dr Paul McCloskey, our Integrated Magnetics team is widely recognised as world leaders in the area of integrated magnetic passives for Power Supply-in-Package (PwrSiP). With over 100 person years of research in this field completed, the team has demonstrated a multi-disciplinary skill set for power magnetics research which makes Tyndall unique within the European power electronics landscape.

Over the years, we have demonstrated world beating results in the area of integrated magnetics for Printed Circuit Board (PCB) and on-silicon applications. We were the first to develop an optimisation Computer Aided Design (CAD) tool for design of magnetic passive components on silicon, to establish a magnetics processing platform for prototyping on-silicon magnetics and to develop best-in class magnetic materials. To date, we have demonstrated the highest efficiency for a micro-inductor (93%), highest efficiency micro-transformer (80%) and ultra-low loss high flux density soft magnetic materials (less than half ferrite power loss density).

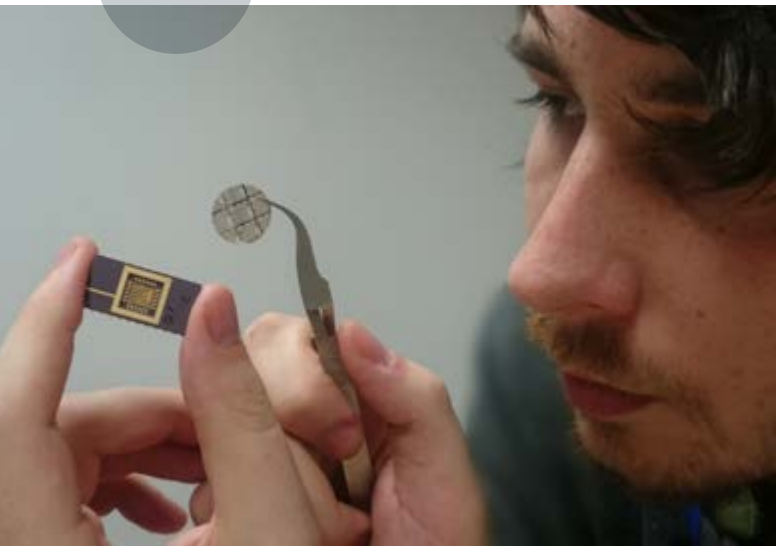
This technology is now a key enabler to meet the emerging needs for multiple voltage rails, higher power efficiency, smaller form factor and proximity to the Point-of-Load (PoL) in the power management of devices around the IoT. Our team balances the needs of industry engagements while forging ahead with future generations of the technology in the area of PwrSiP.

We are currently co-ordinating the first EU-funded FP7 project on development of Power Supply-on-Chip technology (PowerSwipe) and are leading the Power Supply development work package in the IBM-led FP7 project, Carricool.

These achievements were recognised in 2015 when the Integrated Magnetics team was awarded the 2015 UCC Research Team of the Year.

Members of the Integrated Magnetics team, winners of the UCC Research Team of the Year 2015.

Tyndall winners honoured at the UCC Staff Recognition Awards 2015. Pictured (l-r): Lynette Keeney, Tyndall; Orla Lynch, UCC; Jill Haynes, UCC; Samantha Dockray, UCC; David Cadogan, Gilead Sciences Ireland Uc, David McGovern, Tyndall; Anita Maguire, UCC; Catherine Walsh, Tyndall; Emily Maria Power, UCC and Cian Ó Mathúna, Tyndall.



Dr Matthew Smith exhibits some of the GaN transistors that were grown, fabricated and tested at Tyndall.

GaN power devices used in space

Researchers in our Nitride Materials group worked with the European Space Agency (ESA) to develop transistors that can withstand high doses of radiation in space. “Radiation-hard” transistors make it easier for space missions to avoid electronic system failures caused by radiation damage, so they can function and collect data more reliably.

Conventional silicon-based transistors used on previous space missions tend to fail when exposed to excessive levels of radiation. The project requires us to investigate and develop a gallium nitride-based (GaN-based) device which would be stable enough to withstand the radiation present in space. Dr Matthew Smith, working with Prof. Peter Parbrook, took on the challenge of designing, manufacturing, and analysing the performance of the new device, which has been successfully tested for its radiation stability in a purpose built test facility located in the Netherlands during the 2015.

The first application of the new transistor is likely to be ESA’s Jupiter Icy Moon Explorer (JUICE) mission, planned for launch in 2022. The research is funded by the ESA Networking/Partnership Initiative (NPI) and the Irish Research Council INSPIRE program.

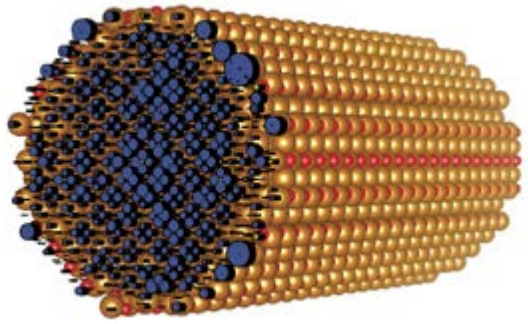
Finding a solution to the wiring problem

Reducing power is a key requirement in electronic applications to extend battery life and reduce costs while being environmentally friendly.

Modern electronics is enabled by integrated circuits, invented by Jack Kilby in 1958 at Texas Instruments, to avoid the wiring problem as electronics became more complicated and connecting parts became too bulky and complex. The most advanced circuits today consist of billions of transistors wired together to achieve the ever more complex functions driving consumer and industrial electronics. To pack so many transistors together with so many wires onto a single circuit has required an incredible level of miniaturisation, reaching the point that individual transistors and the wires connecting them are now being manufactured at atomic length scales. At these sizes, the interconnect begins to dominate power consumption as the electrical resistance increases dramatically with reducing nanowire diameter.

Researchers, Prof. Jim Greer and PhD student Alfonso Sanchez Soares, funded under the Intel-Tyndall collaboration agreement and an Irish Research Council PhD Fellowship, are working with a team in Intel’s Components Research lab in Portland to develop advanced simulations designed to understand how electricity flows in copper nanowires that are only tens of atoms in diameter.

The figure below depicts a three nanometre nanowire. Projected onto the cross section is a map of how electrons flow and scatter in the wire as predicted by advanced quantum mechanical simulations performed on our high performance computing facility. Scattering within the wires is the cause for the resistances that increase power consumption and heating. Findings by the team on resistances in copper nanowires have been reported in Physical Review B revealing the enormous influence of surface scattering in these tiny wires.



Projected onto the cross section is a map of how electrons flow and scatter in a copper nanowire of 3 nm diameter (metal atoms coloured copper, oxygen atoms at the surface of the wire are shown in red). The size of the blue circles represents the ease with which electrons flow through the wire.

Tyndall Connect with Rambus

Connect, the SFI research centre for future networks and communications, launched in 2014 with a view to researching, developing and innovating next generation technologies for autonomous sensors, the Internet of Things (IoT) and 5G cellular communications. Connect is a collaboration between Tyndall and nine other Irish academic institutions, and at Tyndall we lead the 'Responsive Things' research stream.

Within Connect, the Tyndall team is currently working with a team at Rambus Incorporated to develop the next generation of optical sensing systems, focusing on the potential to use the technology in wearable microsystems for gesture recognition and Human Computer Interfacing. As seen by the recent development of VR systems such as OCULUS and Hololens, there is a significant drive for users to be able to interact with the augmented "smart world".

Lensless CMOS-based sensing systems are seen as a key enabler for low power consumption wearable sensing systems for the IoT. One of the key components in the interfacing of the users of smart infrastructural systems is a bi-directional communications infrastructure that can gather data, present data for decision making and provide feedback to the end user. These wearable sensors are capable of contextualising a variety of data streams including location and context of a number of environmental and physical sensors such as light, temperature, humidity, environmental parameters, motion artifact and physiological sensor streams.

The Tyndall Connect team is developing the data analytics and algorithms for both data acquisition and point of tracking based on the next generation of lensless optical sensors being developed by Rambus which will enable low power consumption location aware tracking systems.

Andrea Urru and Mariusz Wilk displaying the optical sensing system.

Dr Devendraprakash Gautam and Dr Kafil M. Razeeb working with the thermoelectric materials deposited on Si.

Thermoelectric generator: scavenging electrical energy from heat

Researchers in our Nano-Interconnection team are developing highly efficient materials and devices to scavenge electric energy from waste heat. Led by Dr Kafil M. Razeeb, the team is developing novel thermoelectric materials on silicon using CMOS compatible processes.

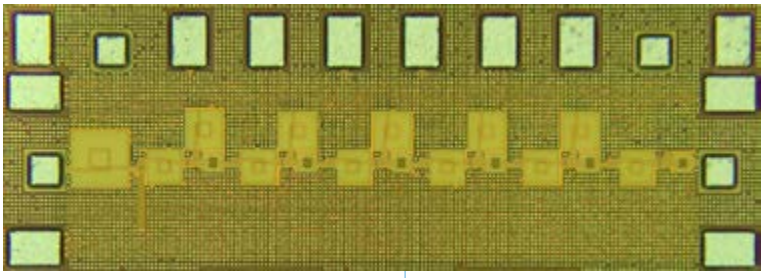
There is huge demand for energy harvesting or scavenging devices to replace batteries in applications such as wireless sensors in order to eliminate the battery replacement maintenance cycle. It requires micro-thermoelectric generators (μ-TEG) which are cost effective, scalable and compatible with CMOS technology.

Jointly funded by Enterprise Ireland and Analog Devices under the Innovation Partnership Programme and in collaboration with Analog Devices, the research has already developed p-type $(Sb_{1-x}Bi_x)_2Te_3$ and n-type BixTey materials using electrochemical deposition at room temperature.

The Tyndall team has developed a novel process which is environmentally friendly with a reduced annealing time from 60 hours to one hour, while retaining the state-of-the-art Seebeck coefficient for these electroplated materials. This newly developed μ-TEG module is fabricated using standard photolithography processes.

The team has also filed a US patent application for this work.

High-gain 90 GHz CMOS low noise amplifier could replace x-rays



Chip micrograph - area: 855 µm × 324 µm.

Passive imaging consists of forming images by detecting the electro-magnetic radiation emitted spontaneously by bodies above the absolute zero temperature. Being non-invasive by nature, passive imagers have the potential to replace X-rays in a number of applications, such as security scanning in airports and medical scanning.

The effective implementation of passive imagers requires high-gain low-noise amplifiers. Dr Domenico Pepe and Dr Domenico Zito, researchers in our Radio-Frequency System-on-Chip (RF SoC) group, designed and characterised experimentally a high-gain low noise amplifier in 28 nm bulk CMOS technology for passive body imagers operating in the W-band (75-110 GHz).

The amplifier consists of six cascode stages with input, output and interstage conjugate impedance matching for maximum power transfer. Measurement results show a peak gain of 32 dB and a noise figure of 5.3 dB at 91 GHz, corresponding to improvements of about 5 and 1 dB respectively, when compared to current state-of-the-art designs, so enabling the silicon implementation of miniaturised high-resolution imagers.

This work was supported by MCCI, Analog Devices, M/A-COM Technology Solutions, Silansys, SFI and Keysight Technologies.

Energy harvesting simulation tools

Jeff Smith, Bilfinger; Marie Donnelly, European Commission and Mike Hayes, Tyndall with technology from ROWBUST at the IERC 2015 conference.

Simulation tools to help system developers and users assess the feasibility of energy harvesting for powering IoT devices such as wireless sensor network nodes have been developed by researchers at Tyndall in collaboration with Cork Institute of Technology.

Known as ROWBUST, this new system removes the uncertainty of whether energy harvesting will work reliably when deployed in real-life operating conditions such as sensor selection, duty cycle and ambient energies.

Funded by the International Energy Research Centre (IERC), the tool was developed based on guidance from industry partners United Technologies Research Centre, Endeco, Bilfinger, Alcatel-Lucent and Bord Gáis, and used to develop an energy harvesting kit that was deployed by Bilfinger in a local school, demonstrating a self-powered smart radiator thermostat.

SAFESENS location tracking and first responder monitoring

A team from our Wireless Sensor Networks group has collaborated with researchers in United Technologies Research Centre, Cork and EU partners to develop a state-of-the-art wireless indoor location tracking systems for first responders such as fire fighters.

Integrating multiple gas sensors and presence detection technologies into building safety sensors and personal monitors has resulted in more accurate and reliable fire and occupancy detection information.

A demonstration system developed by the Irish team under EU FP7 funding was capable of tracking occupancy levels in a built-up environment as well as the specific location of fire fighters within those buildings, using a multi-sensor hybrid tracking system.

This ultra-wideband indoor tracking system, developed using Irish company Decawave's radio front end, is the first of its kind to provide indoor localisation capability to sub meter accuracies with combined Bluetooth low energy capability for low power communications and additional inertial, temperature and pressure sensors. This facilitates increased precision in accuracy detection through data fusion, as well as the capability to communicate directly with smartphones and the cloud, without the need for additional gateway support.

A SAFESENS demonstrator is currently deployed in Tyndall and is providing real time occupancy levels while tracking tags and tokens using the ultra-wideband system developed here. This living laboratory will be the demonstrator site for SAFESENS until the conclusion of the project.

The SAFESENS first responder activity and location tracker.

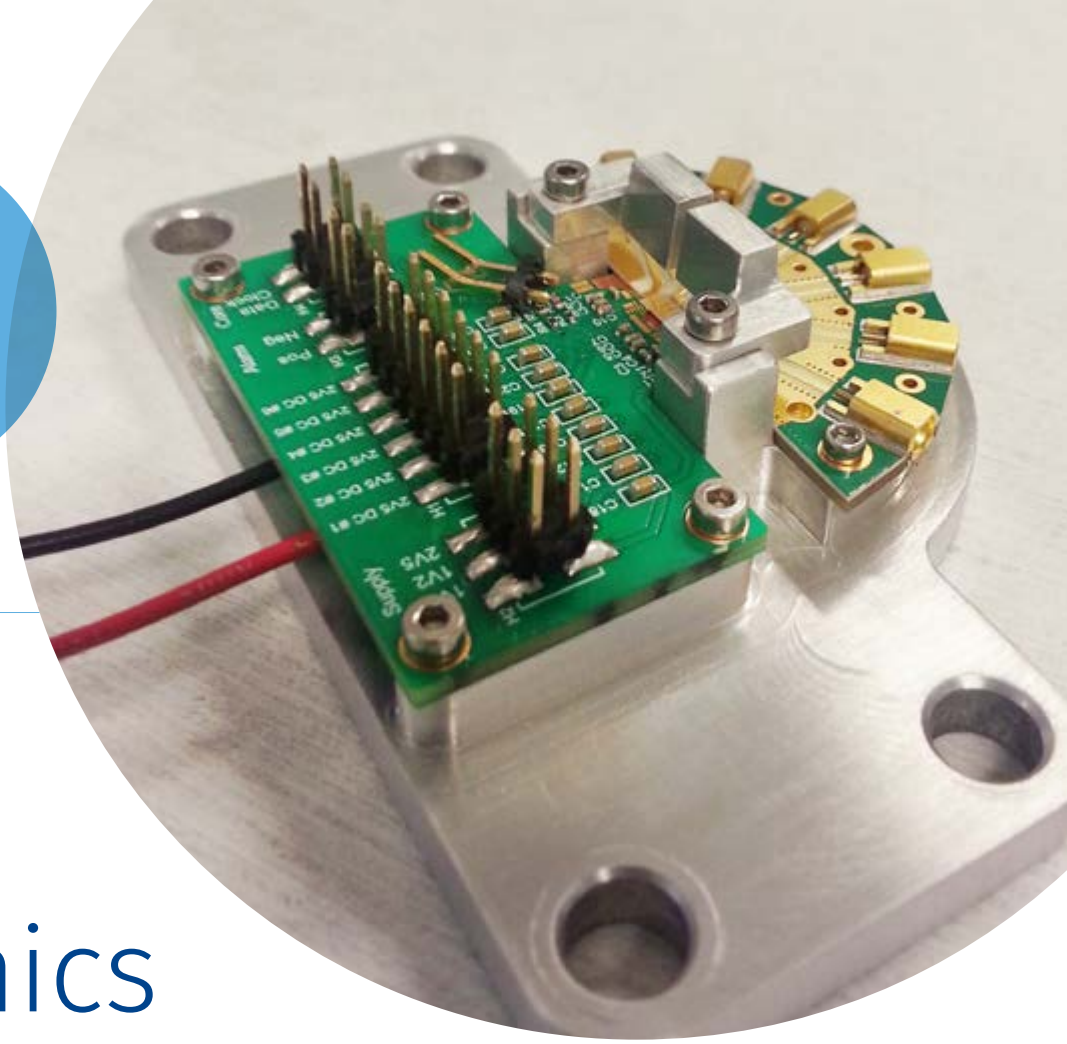
Professor Peter Kennedy elected to Academia Europaea

Academia Europaea is a European academy of humanities, letters and sciences. Membership to this prestigious academy is by invitation only and involves scrutiny and confirmation of the scholarship and eminence of the individual in their chosen domain. Peter's career achievements in the field of engineering including pioneering contributions to neural networks, chaos communications and frequency synthesis, led to his election to the academy.

Peter joins an impressive collection of scientists and scholars, including 52 Nobel Laureates, who collectively aim to promote learning, education and research, and is the first member of the Physical & Engineering Sciences section of the academy from UCC and Tyndall.

Peter joined UCC as Chair of the Department of Microelectronic Engineering in 2000 and served as Dean of the Faculty of Engineering from 2003 through 2005 and as UCC's Vice-President for Research from 2005 to 2011.

He was made a Fellow of the Institute of Electrical and Electronic Engineers (IEEE) in 1998 "for contributions to the theory of neural networks and nonlinear dynamics and for leadership in nonlinear circuits research and education." Peter was a founding Director of the Microelectronics Industry Design Association (MIDAS Ireland) and the Microelectronic Circuits Centre Ireland (MCCI).



PAM-4 driver assembly

Photonics

Growing the green cloud

Data centres are playing an ever increasing role in ICT infrastructures, storing data from our mobile devices and making information, photos and videos available 24/7. There is significant market and end-user demand to store more and more data and to have it available faster. This requires optical transceivers in the network that communicate faster and at a lower energy per bit.

Conventional transceivers use on-off keying to transmit ones and zeros, however a team of Tyndall researchers led by Dr Peter Ossieur, and funded by SFI is exploring the application of a modulation technique known as PAM-4. This uses the amplitude of each pulse (4 levels) to enable the communication of the following options, 00, 01, 11, and 10 per pulse, thus transmitting 2 bits in parallel, doubling the data rate.

In recent developments, a push-pull Silicon Photonic Mach-Zehnder Modulator (MZM) driver chip was fabricated, tested and shown to operate up to 36Gb/s (18Gbaud). The switched capacitor approach drives the MZM with reduced power consumption compared to the conventional approaches which is critical for next generation short-reach link standards such as 400Gb/s 802.3 ethernet.

The driver chip has a core area of 0.11mm^2 and delivers an energy efficiency of 6.55pJ/bit.

Dr Peter Ossieur.

Breaking atomic forces in photoexcited bismuth

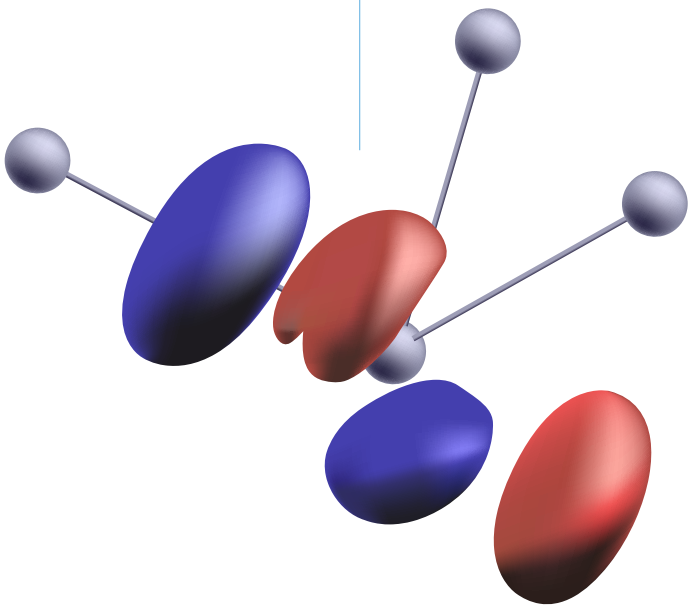
Researchers in our Materials Theory group, led by Prof. Stephen Fahy have studied the forces on atoms in the first picosecond (a billionth of a billionth of a second) following the absorption of intense light pulses using quantum mechanical simulations.

The team calculated how the charge around the atoms is altered by absorption of light, how the forces on the atoms change and how the atoms move in response to those forces. These studies are of fundamental importance in understanding how light can be used to drive chemical reactions and other processes in materials. Such processes determine the efficiency and speed of natural processes such as photosynthesis, as well as photocatalytic processes that occur in solar cells.

Under funding from SFI and the EU Marie Skłodowska-Curie Fellowship and in partnership with leading experimental groups in Switzerland and USA, we used free-electron-laser facilities to verify the predictions of our theories. Shown in the figure below is a picture of the change of charge around an atom in photoexcited bismuth, driving the bismuth atoms away from the normal equilibrium positions. This change of charge lasts for about 0.01 picoseconds after photoexcitation.

For the first time, we now understand why atoms move when light is absorbed and why motion in one direction (vertical in the figure shown) is much larger than motion in the perpendicular direction.

This is important in developing new ways of manipulating materials and driving chemical reactions with very short pulses of light.



Change in electron density in solid bismuth induced by the absorption of a sudden pulse of radiation, which drives the atoms away from their normal positions and changes the structure of the material. Red indicates regions of increased electron density and blue indicates reduced density.

DISCUS consortium view the demonstrator at Tyndall's photonics systems lab.

Demonstrating the future internet

A team of our researchers along with partners from Trinity College Dublin (TCD) demonstrated an advanced 'long reach' Fibre To The Home (FTTH) network at one of the world's leading optical communications conferences, ECOC 2015. This demonstration is part of the €8.1m EU funded project DISCUS, which aims to revolutionise broadband provision across Ireland and Europe.

The demonstrator showcased for the first time how FTTH networks can grow from approximately 10km span today up to 100km in the future. This will enable a significant (factor of 50) reduction in the number of electronic switches and exchange buildings which are typical in today's networks, thus greatly reducing network power consumption and costs. The system included key enabling components such as the Tyndall patented linear burst mode receiver technology.

The project is coordinated by TCD, with Tyndall researchers leading the development of the final physical layer system and includes industry and academic partners Alcatel Lucent, Coriant, Telefónica I+D, Telecom Italia, Aston University, imec, III-V lab, Polatis, Atesio and KTH.

Shining light in healthcare

The application of photonics technology in the healthcare industry has the potential to deliver smarter technologies to detect and treat illness. At Tyndall, our photonics researchers are applying technologies originally developed for the internet to fabricate highly-compact and miniaturised devices for smart medical instruments.

At the annual SFI St Patrick's Day festival in Washington DC, the Taoiseach, Mr Enda Kenny, T.D. announced a new research partnership between Stryker and IPIC. The partnership brings together Stryker R&D scientists and engineers from its global headquarters in Kalamazoo, Michigan, USA with Stryker R&D design and development experts in Cork to collaborate with IPIC researchers at Tyndall.

This inter-disciplinary team is applying photonics technologies to develop next-generation smart surgical tools that enable faster, simpler, and novel procedures to improve patient outcomes. The collaboration also enhances the expertise and competencies of each organisation and builds a long-term alliance. The inaugural project will run for four years, expanding IPIC's biophotonics research programme funded by SFI.

Members of IPIC, Tyndall and Stryker meeting Taoiseach, Mr Enda Kenny, T.D. and Prof. Mark Ferguson, Director General SFI at the annual SFI St Patrick's Day festival in Washington to announce a new research partnership between Stryker and IPIC.

Unlocking the potential of micro-transfer printing

TOPHIT, a European consortium funded through Horizon 2020, will develop and validate a novel technology to address the challenge of integrating electronics and photonics components fabricated from different materials in large volumes, initially targeting its application in the data storage and communications industries.

Led by Brian Corbett, the TOPHIT consortium will investigate micro-transfer printing (µTP). This technology allows a set of devices, with thicknesses of a few microns, to be taken out of one semiconductor wafer and printed sparsely onto another wafer with micron-scale placement accuracy, transferring potentially many thousands of devices in each single transfer operation. By combining diverse optical, electronic and other functional materials, this transfer print process opens up an enormous range of possibilities for new devices with embedded functionality. This will lead to more compact chips and systems for a variety of applications, such as telecommunications, smart sensing, biomedical sensing and data storage.

With a budget of over €5m, the TOPHIT consortium includes Tyndall (Ireland), X-Celeprint (Ireland), imec (Belgium), Caliopa Huawei (Belgium), Centre for Integrated Photonics (CIP, a wholly owned subsidiary of HUAWEI, United Kingdom), X-Fab (Germany) and Seagate (Ireland).

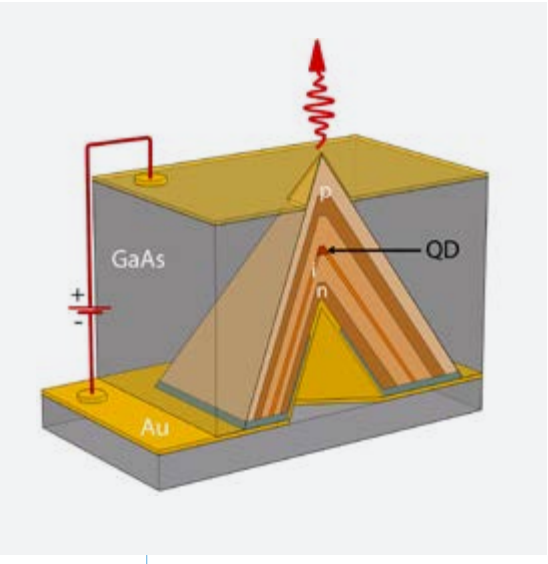
TOPHIT project team.

Quantum entanglement takes a step closer to reality

Interest in quantum technologies is increasing because of their potential impact on our future through the ability to create quantum computers that can hold and process more data faster than current computers and to develop secure communication networks.

At Tyndall, a team led by Dr Emanuele Pelucchi has explored novel quantum sources of light. The team's effort has concentrated on single site-controlled quantum dots, i.e. artificial atom-like structures made of a few thousand atoms of semiconductor material, which are deterministically positioned inside a semiconductor matrix and device.

In 2015, the team demonstrated the first entangled photon emission from these novel sources, both in optically pumped and electrically pumped devices. The devices can emit individual units of light (photons), which are linked together by a specific rule defining their state, even though they may be physically separated. As a result, if one of these photons interacts with a device then the other also reacts, as it also carries fundamental information relating to the first photon. One potential application is secure communications where, if information is transmitted using an entangled photon and an unknown party looks at the information, the other photon reacts thus indicating that someone has tried to intercept the information.



Schematic of a single quantum dot device emitting entangled photons with the dot position determined within a few nanometres. The overall pyramidal "shape" is necessary for obtaining a single dot with correct "quantum" characteristics and position.

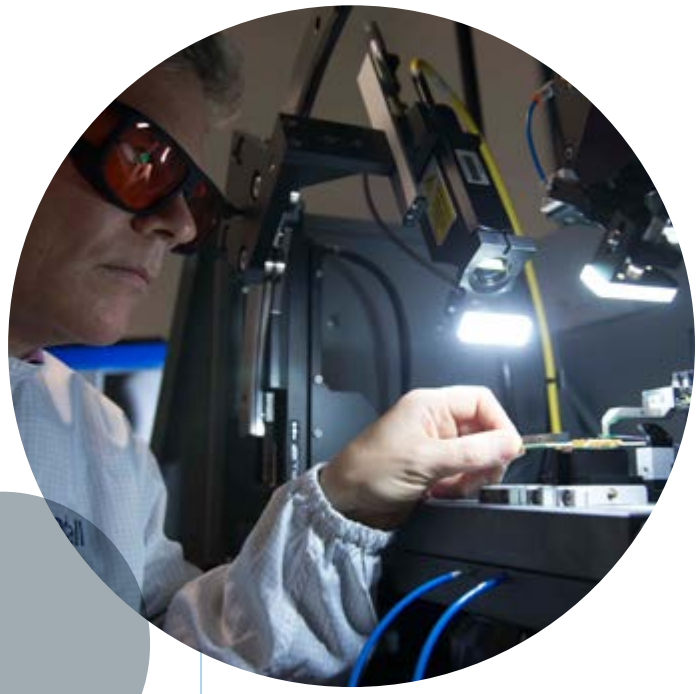
World renowned biophotonics researcher joins Tyndall

In 2015, we were delighted to announce that Professor Stefan Andersson-Engels will join Tyndall and UCC as Professor of Biophotonics at UCC and Head of the newly established Biophotonics group within IPIC at Tyndall. In 2016, Stefan will set-up an internationally leading biophotonics research team to increase Ireland's medical device and diagnostics research capability. The development is enabled through a prestigious €6m SFI Professor Award.

Stefan has received several international prizes for his research achievements and his impressive track record in the development and commercialisation of technology has been critical to ensuring that patients will benefit from results of scientific research. His pioneering work in the area of of ALA-PDT (Amino Leuvulinic Acid-Photodynamic Therapy) for the treatment of non–melanoma skin cancer is currently one of the first lines of treatment at most skin cancer clinics around the world.

The research will form an integral part of IPIC and the team will collaborate with sister SFI centres (APC Microbiome Institute and INFANT) and a range of industry partners to leverage photonic device integration technology to develop and deploy more accurate, less invasive diagnostic treatment methods for cancer and other diseases.

SFI Research Professor Stefan Andersson-Engels



Dr Peter O'Brien using a laser welding machine in Tyndall's photonics packaging lab to actively align an optical fibre with photonic integrated circuits under sub-micrometre tolerance.

Delivering miniaturised ultrasound sensors for 3D medical imaging

Next generation 3D medical imaging requires arrays of small sensor elements to selectively record the sound waves coming from a particular direction. Dr Peter O'Brien and his team, in collaboration with Delft University of Technology, demonstrated the application of a novel silicon photonic sensor, which enables an extremely small device footprint, a key requirement for the application.

The team presented a proof of concept of the optical micro-machined ultrasound sensor fabricated with a CMOS fabrication line. These first fully packaged demonstrators displayed the ability to detect pressures of 0.4 Pa, which matches the performance of state-of-the-art piezo-electric transducers, while having a footprint that is 60 times smaller. Details of the development were published on Nature.com.

The highly integrated photonic sensor is compatible with Magnetic Resonance Imaging (MRI) systems, due to the absence of integrated electrical components, and has the capability to sense an array of elements, enabling high resolution imaging. It is expected that the technology will find use in applications such as smart catheters, facilitating minimally invasive high resolution ultrasonic imaging during clinical procedures.

The National Technology Platform and Photonics Ireland 2015

The Photonics Ireland National Technology Platform (NTP), led by IPIC, was established to bring together Ireland's photonics community to give it a single voice, to increase its international visibility and to become more effective at delivering economic impact.

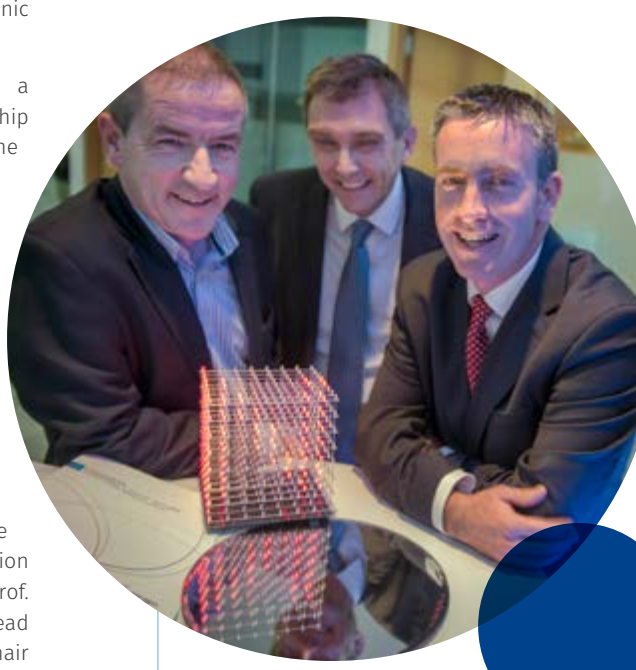
The NTP aims to deliver a suite of research and innovation actions focused on the areas of technology, incubation and training – all of which will deliver greater investment to photonic start-ups and SMEs and access to world-leading research and technology, while also meeting the ever growing photonics skills needs of Ireland's high-tech sectors through a number of training and outreach activities. It will also create a vehicle to engage with similar platforms across Europe and to assist Irish companies to develop partnerships with Europe's leading photonics companies and universities.

The NTP was launched at Photonics Ireland 2015, Ireland's premier photonics conference. Tyndall and IPIC were proud to host the event which brought together national and international photonics experts from industry and academia with policy makers who have a shared interest in putting Ireland at the forefront of the global photonics market. The event showcased the latest photonics research including biophotonics and optical sensing, imaging, optical communications and networks, photonic integration, packaging, and photonic devices.

The conference also hosted a successful session on entrepreneurship where attendees learned from the experiences of successful technology start-ups, as well as from Dr Peter Chang, Components Research, Intel. The three day conference was attended by over 250 attendees and included 9 high profile international speakers, 50 talks and more than 100 posters.

Ireland's standing on the global photonics landscape was further enhanced by the announcement that the 2019 European Conference & Exhibition on Optical Communication (ECOC) will be held in Dublin. Prof. Paul Townsend, IPIC Director and Head of Photonics at Tyndall will co-chair the conference with Prof. Liam Barry, IPIC. The conference will attract 5,000 overseas delegates and is the largest conference on optical communication in Europe, and one of the most prestigious and long-standing events in this field worldwide.

Dr Peter Chang of Intel speaking at the Photonics Ireland conference, 03 September 2015



NTP launched by Mr Damien English, Minister of State for Skills, Research and Innovation; Professor Paul Townsend, Centre Director IPIC and Declan O'Mahoney, CEO HeartSine Technologies.

Prof. Paul Townsend, IPIC with Ben Hurley, CEO NDRC.

IPIC Bootcamp – advancing entrepreneurs

IPIC Bootcamp, an exciting new initiative designed to develop the technology commercialisation and business start-up skills of Irish photonics researchers launched in 2015. Participants in the programme are mentored to enhance their skillset for future industry careers and obtain a valuable toolkit to enable exploration of possible start-up opportunities.

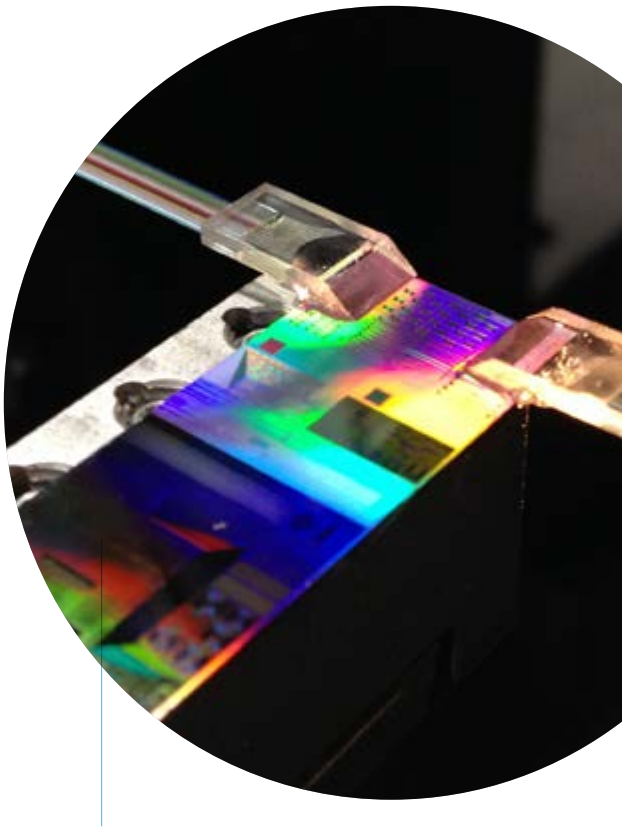
The programme is run in partnership with the NDRC, who were ranked by UBI Global as the number two university business accelerator in the world for 2015. NDRC introduce participants to their lean start-up programme and develop six potential start-up ideas to be presented to a panel of experts at the end of the programme. The IPIC Bootcamp will open the opportunity for investment in one or more of the ideas to advance them towards commercialisation. This programme is part of the Photonics Ireland NTP and is open to individuals from industry and academia. The initiative is supported by SFI.

US - Ireland project to research ways of delivering faster internet speeds

A new collaborative partnership will develop optical integrated chip technology for use in data centres with the aim to improve the agility of high-bandwidth optical connections that support high-capacity cloud applications, delivering faster internet speed while also reducing the energy consumption and cost. The project launched in 2015 and will build close collaborative links with leading US universities, offer PhD students hands-on training opportunities across the partners and open the prospect for trans-Atlantic industrial collaborations.

The project is enabled through a collaborative investment of $3m by Science Foundation Ireland, the National Science Foundation USA (NSF) and the Department for Employment and Learning in Northern Ireland. It creates a unique partnership across the Atlantic bringing together the US NSF funded Centre for Integrated Access Networks with the Irish Photonic Integration Centre, Connect, the centre for Future Networks and Communications and the Computer Science Research Institute.

This exciting development includes researchers from University of Arizona, Columbia University, University of California San Diego, University of California Berkeley, University of Southern California, Dublin City University, Tyndall National Institute, University College Cork, Trinity College Dublin and University of Ulster Coleraine.



Planar fiber coupling to a silicon photonic sensor.

EU Programmes at Tyndall

Wafer fabrication facility at Tyndall.

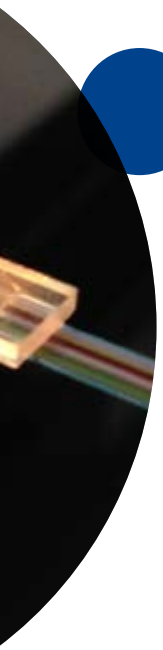
Transforming research into innovation with impact

The objective of our EU Programmes team is to enhance and add value to our EU collaborative research across the whole innovation chain to achieve industry growth and benefit society at large.

Our extensive network builds on partnerships with over 400 international organisations to deliver value across several European programmes including Horizon 2020, Public-Private-Partnerships and the European Regional Development Fund.

Since the launch of Horizon 2020 in 2014, we have participated in 26 projects to date with total value of €140m from which the European Commission contributes 70% and the rest largely matched by the industrial partners. The investment in our activities from these projects is €13m with an additional €13m going to our Irish partners, including €8.5m to industry partners (translating to ca. 40 jobs p.a.).

In 2015, three major initiatives were launched that link new scientific knowledge with application-driven research to create high-impact innovations. One is a globally leading partnership of Research and Technology Organisations and the other two projects are funded under the Smart Anything Everywhere initiative, supporting product and service innovation through digital technologies:



ascent
European Nanoelectronics Access

ASCENT provides access to the world's most advanced 14 nm and beyond-CMOS nanoelectronics data and test structures in Europe's leading nanofabrication research institutes. Led by Tyndall, in partnership with CEA-Leti (FR) and imec (BE), the three institutes offer:

- Extensive advanced semiconductor processing fabrication facilities
- Flexible nanofabrication facilities
- Advanced electrical characterisation equipment
- Expertise in design and modeling

This is the first time that access to these state-of-the-art devices and test structures is available anywhere in the world. The impact of this access, and the resulting advances that will be made, will contribute significantly to competitiveness and growth capacity in Europe's nanoelectronics industry.

Gateone facilitates European SMEs to access product-ready technologies and an average of €50,000 in funding to help them bridge the gap from R&D to market-ready products.

Aimed at accelerating smart systems adoption in the SME sector, Gateone endeavors to expose these companies to new business opportunities by demonstrating over 200 new product concepts, which are applicable across a broad range of industries.

Specifically, we are presenting our unique capabilities and offerings in wearable technologies, microneedle applications, energy management systems and radiation sensing. These product concepts are the result of the research-led business development undertaken by our researchers.

Gateone will provide funding to allow SMEs develop demonstrator products based on these technologies. Researchers will work directly with the SME community to define their technology needs and deliver demonstrators that accelerate the innovation cycle.

Gateone is an EU funded project led by recognised experts in innovation, marketing and financing through Yole Développement in collaboration with leading European research and technology organisations.

Smarter-SI is a Europe-wide collaboration to provide SMEs with easier access to state-of-the-art technology in the area of advanced smart systems integration. The project provides SMEs with solutions based on technology in the area of photonics, electronics, microfluidics and mechanic sensors which are ready to be integrated into a system and function as a product. Participants also receive up to €70,000 in funding to cover costs including validation studies and market testing.

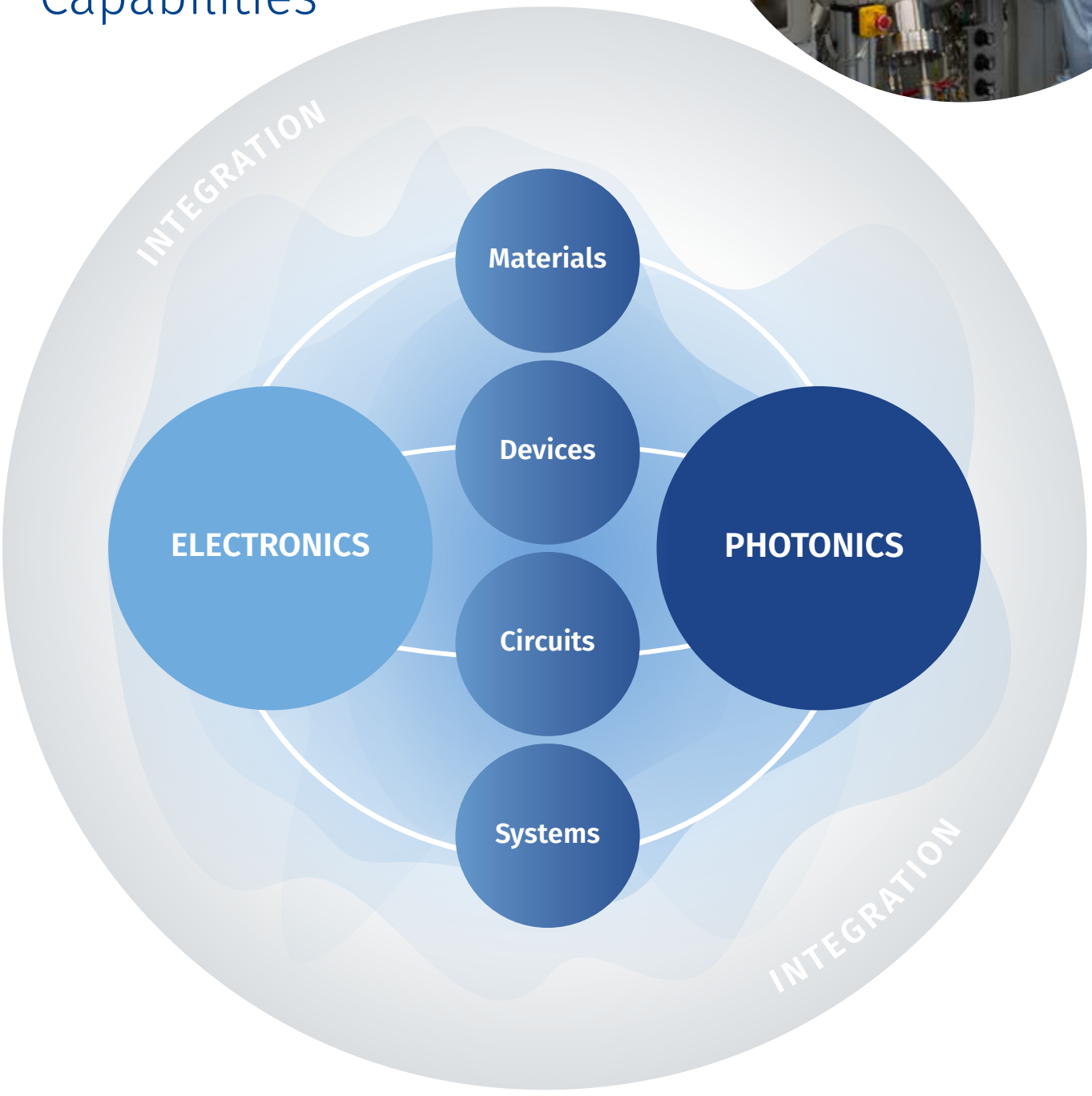
During the first year of the project, the consortia of research institutes (Tyndall, CiS, CSEM, Hahn-Schickard, Ik4-IKERLAN, Swerea IVF) have integrated their technology in four systems:

- Portable device to test water contamination
- CO_2 sensor for building automation
- Energy autonomous dew-point measurement for freeze-drying processes
- Point-of-care device for food quality control

The project is beginning its second phase where these four SMEs will be assisted in developing a commercialisation plan for their solutions. Seven new applications will also be developed in areas such as drug detection, automotives and environmental control.

Tyndall EU Programmes team – Martin O'Connell, Giorgos Fagas and Aoife O'Brien.

Capabilities



Agri-Food Communications Energy

Environment Health

Industry engagement

Tyndall had an excellent year of industry engagement during 2015. Across multiple industry sectors, we delivered cutting edge solutions and new market opportunities to help our Irish and international clients secure a long-term competitive advantage.

Mark Fleming, CEO, Fleming Medical and Dr Paul Galvin, Head of ICT for Health, Tyndall National Institute at the "Smart Dressing" project launch.

Tyndall had an excellent year of industry engagement during 2015. Across multiple industry sectors, we delivered cutting edge solutions and new market opportunities to help our Irish and international clients secure a long-term competitive advantage. Total funding increased to €8m, an impressive increase by 65% on the previous year, building on existing industry relationships and working internationally with a number of new sector leaders.

Our outstanding reputation for excellence in fundamental research provides a strong foundation for some of the most advanced proprietary research for leading global brands. Our deep domain expertise in electronics and photonics enables our industry partners to identify those research paths which can deliver the greatest return from direct-funded, focussed commercial research.

We continue to drive new business opportunities through our strategic programmes which align with Ireland's economic drivers such as Internet of Things, life sciences, AgriTech, communications, energy, and the environment. Our close engagement with industry ensures we remain focused on delivering results aligned to client needs and that we provide them with a pipeline of relevant and highly skilled PhD and Masters graduates. This world class talent developed at Tyndall alongside an industry-facing approach to commercialisation of research are key instruments for IDA Ireland to help make the country more attractive for foreign direct investment.

We work closely with five of the world's top 15 medical device companies, which is a strong validation of the importance of our research in the area of ICT for Health. We have built strong working relationships with the corporate R&D headquarters of these organisations with a strategic objective to help grow their related footprint in Ireland, leveraging Tyndall's unique ICT infrastructure and expertise. We continue to expand our reach globally with over 200 industry partners and customers worldwide, from local SMEs to global corporations.

In collaboration with Enterprise Ireland, we are improving our processes to create the next Tyndall spin-outs through the Tyndall Founder Programme. Our aim is to secure successful business executives to partner with us and transform our portfolio of applied research projects and capabilities into successful commercial ventures.

Throughout 2015 we also expanded our national footprint with the opening of our Dublin office, bringing us closer to the many technology companies based in the region, further deepening our relationships with the national research community and being an accessible resource to state agencies.

In November 2015 we welcomed over 250 delegates to our annual Tyndall Technology Days event. The theme of the event was Shaping the Industrial Internet with a focus on ICT, healthcare and agri-food. Attendees cited the high-calibre speakers and excellent networking opportunities as the main highlights of the event. We look forward to bringing this event to Dublin in 2016.

Technology licencing continues to be an important part of our industry engagement. We executed three licences in 2015 including one to Dublin Design Studios to develop the circuitry for an exciting new Irish start-up Scriba, helping create its new product, an ergonomic stylus for mobile devices.

Patents

The following four patents were issued:

Linear Burst Mode Receiver

US patent 9,059,807

Inventors: Peter Ossieur, Paul Townsend

Patent received on a receiver for passive optical networks that can process data at rates in excess of 10Gb/s. This technology has already been utilised as part of the European project DISCUS, which has demonstrated an advanced 'long reach' Fibre To The Home (FTTH) network.

Light Source

US patent 8,950,894

Inventor: Peter O'Brien

This patent embodies our world-leading expertise in LED light source technology. The invention provides a wide spectrum light source designed as a replacement product for specialty lamps used in analysis applications. The LED lamp is designed to emit a broad spectrum from a narrow aperture. The design of the light source enables it to be used for spectroscopy applications. In addition, its unique features of small size, high efficiency and low power consumption, make the light source attractive for emergent applications in portable analysis systems, such as point-of-care diagnostics, instrumentation, blood analysis and chemical analysis.

Dual-Axis Anisotropic Magnetoresistive Sensors

US patent 8,947,082

Inventor: Jan Kubik

Patent granted for a 2-axis Anisotropic Magneto-Resistive (AMR) sensor developing and integrating a ferromagnetic thin-film resistor on Si substrate. The proprietary new sensor layout has allowed measurement of strength and polarity of low intensity magnetic field in two perpendicular axes. This IP was licensed to Analog Devices in 2011.

Nanowire Electrode Sensor

European patent 2735868

Inventors: Alan O'Riordan, Karen Dawson, Amelie Wahl

The Nanotechnology group has developed the world's first fully integrated nanoelectrochemical multiplexed silicon chips for electroanalysis employing arrays of discrete gold nanowires as sensors. Using microelectronics fabrication approaches, highly reproducible nanoelectrode structures with excellent electrochemical performance are readily achievable. These discrete nanowire devices exhibit a 1,000 fold increase in sensitivity and can undertake analysis 500 times faster compared to commercial state-of-the-art electrodes. The technology has been applied to detection of a variety of key important analytes in health, security and environmental sectors.

Case studies

At Tyndall, our success stems from a 360° approach involving researchers, businesses and end users to deliver smart solutions for identified needs. The case studies over the coming pages highlight a sample of the value we bring to companies in this way.

PMD to commercialise new respiratory device

2015 was a stellar year for long-time Tyndall partner, Cork-based PMD Solutions, who secured over €4m in funding from the EU Horizon 2020 SME Instrument.

PMD Solutions was one of only three innovative SMEs from across Europe selected in the health sector of the SME Instrument. The funding will be used to commercialise its new respiratory monitoring device 'RespiraSense'.

Heart rate, temperature, blood pressure, pulse oximetry and respiratory rate, all need to be monitored to provide an overall picture of a patient's health. Up to now, respiratory rate has been known as the 'Lost Vital' due to the lack of a comprehensive monitoring apparatus. However, PMD's 'RespiraSense' solves that problem and in doing so, is set to become the industry standard in respiratory rate monitoring, a market valued at over €2.2bn.

'RespiraSense' is a discreet wireless sensor, placed on the patient's chest at admission and worn continuously until discharge. It measures the chest and gut movement during breathing to deliver highly accurate measurements.

Myles Murray, PMD Solutions' founder, explained that 'RespiraSense' is explicitly designed to support nurses and enhance routine vital sign observations. "Respiratory rate is a key indicator of a patient's general well-being, so changes in this vital sign can be indications of respiratory compromise, increasing severity of sepsis, worsening pneumonia, and oncoming heart attacks."

PMD Solutions has enjoyed a close, symbiotic relationship with Tyndall since its inception, and Tyndall has had crucial input into the development of 'RespiraSense'.

Murray is fulsome in his praise, saying, "An institution like Tyndall is an essential asset for start-ups such as ours. They fill the knowledge gap that we, as a start-up, simply can't afford."

"Tyndall provided expert input in areas such as electronics and miniaturisation, and they gave us the benefit of their state-of-the-art know how. But that's just one part of the relationship, as PMD Solutions started to mature, Tyndall engaged with us on how to structure and develop the company around a core product, in our case around our wireless 'RespiraSense' invention."

Philips and Tyndall partner in InForMed

Dutch electronics giant Philips and Tyndall have worked together for almost three decades in a partnership that has evolved over the years. Today, the focus of that relationship is firmly on MedTech and ICT industries.

The thrust of Philip's focus on research and development in medical devices is carried out as part of the EU-driven InForMed project, funded by the ECSEL program.

As Ronald Dekker, Principal Scientist, Philips Research outlined, "There are a lot of potential inventions brewing in the MedTech space, but to bring them to production you need an environment that is specifically targeted and equipped to bridge the gap between concept creation and full-scale production. Philips hosts a pilot line facility for medical devices that provides exactly that environment."

39 Partners from 10 countries participate in the InforMed project, including Tyndall. The aim of the project is to form manufacturing networks and an eco-system where new medical devices can be seeded and nurtured to grow into new business opportunities for Europe, at a time when there is a paradigm shift from large expensive diagnostic equipment towards small, disposable, minimal invasive and un-obtrusive diagnostic and therapeutic instruments and tools.

Dekker said, "We have had intense co-operation with Tyndall over the past four to five years on a number of projects. We enjoy working with Tyndall because they have an interesting health programme, but importantly, they also have a real feel for what companies need."

From a Tyndall perspective, its capabilities, technology platforms and health strategy are aligned with those of Philips, but the institute sees as key its ability to provide a gateway for Philips to SMEs and MNCs in the Irish MedTech and ICT Industry.

Dekker acknowledged that Tyndall is a gateway to the extensive MedTech industry in Ireland and also to the US parents of many of those companies, which he sees as an important advantage.

Through Tyndall, Philips is already engaging with three Irish companies and all three projects involve highly innovative smart MedTech solutions to healthcare challenges.

Endeco Technologies - from start-up to industry leader

Endeco Technologies, a leader in smart grid optimisation has partnered with Tyndall since the company was established in 2007, and although the business now has offices in London and Dublin, it retains its 'Smart Grid Lab' at Tyndall.

Michael Phelan, founder and CEO said, "A previous company I worked for had a relationship with Tyndall, so I knew what Tyndall and its team were capable of, and in particular I knew they were conducting very interesting research in wireless technology, an important building block in the creation of Endeco's energy management solutions."

Endeco Technologies worked in partnership with Tyndall to create the original technology. Michael Phelan described the initial support as being invaluable. "Start-ups don't have the resources in-house to develop the breadth of expertise available at Tyndall. We set up an office in the Tyndall incubation centre to allow us maximise the benefits of our working relationship."

This relationship with Tyndall was instrumental in its ability to attract venture capital as it gave Endeco Technologies the opportunity to sell a product rather than a concept. During the intervening years the company has grown to a position of leadership in its field both in Ireland and in the UK, using IoT to reduce energy consumption for large businesses.

The strength of its offer was recently underpinned with a €3.3m investment by 'ESB NovusModus' the ESB Clean Tech Fund.

As Phelan explained, "Our clients are large power users within different industries. We manage their participation to the National Grid Scheme with respect of their processes and without disrupting their operations and production."

Reflecting on his relationship with Tyndall, Phelan said what impresses him apart from the cutting edge technology generated on campus, is the fact that the people at Tyndall are commercially astute. "They understand industry and they understand the importance of delivering within a meaningful timeline. When Mike Hayes and his ICT for Energy Efficiency team say they will do something and will deliver at a certain time, they do, and that's not always the case when interacting with research institutes."

An ideal collaboration model

2015 was a milestone year for Powervation (PV) - an Irish spin-out company that develops Digital Power Management system-on-chip solutions - which was recently sold to ROHM Semiconductor (Japan), for approximately $70m.

Established as a University of Limerick spin-out in 2007, PV headquartered in Cork and quickly became a leading innovator in digital power controllers serving high performance computing, cloud and communications infrastructure markets.

During its nine-year journey from start-up to acquisition, ROHM Powervation (RPV) interacted with Tyndall on a collaborative research project through MCCI (Microelectronic Circuits Centre Ireland).

Apart from Tyndall's compatible capabilities, there was a strong personal connection between PV and the institute. John Ryan, VP Engineering with RPV was a student at Tyndall's precursor, the National Microelectronics Research Centre (NMRC), in the early 1980's. The connection remains alive, as he currently serves as a member of the MCCI steering committee.

Ryan outlined the project, "It involved the design of a 12-bit ADC (analog to digital converter) which is optimised for use in the type of products that PV and latterly RPV produce. Our designers were at that time fully immersed in another project but we knew that this new ADC would be needed for 2016/2017, and therefore getting it started earlier through Tyndall made a lot of sense."

When the collaboration with Tyndall commenced it was with PV, at that time a venture funded start-up with limited cash. Ryan said, "The Innovation Partnership mechanism was a good way of getting engaged with Tyndall as it is subsidised by Enterprise Ireland. An additional advantage was the benefit of the MCCI 'Visiting Professor' programme where world-class experts reviewed the project with a view to suggesting improvements or spotting problems."

Assessing the benefits of engagement with Tyndall, Ryan said, "A key benefit for us was access to engineering resources that we did not have in our company, as well as access to expert project review and mentoring by visiting professors."

The collaboration enabled PV to make progress on future projects without diverting internal staff from current projects. Ryan also highlighted the beneficial funding model with support from Enterprise Ireland. "While it may not be the shortest path to acquiring a new IP, we would recommend this model to other start-ups."

Irish SME transforming to global innovator

In existence for over 25 years, Fleming Medical has historically been a distributor of wound care products and had not previously interacted with a third level institute on R&D, and never collaborated with one to develop advanced device technologies. But, suitably intrigued after receiving an invitation from Tyndall to discuss research into next-generation wearable sensors with the potential to make a significant impact on his business, company CEO Mark Fleming responded immediately.

After initial interactions with the Tyndall team, a third partner, the Holst Centre/TNO (Eindhoven, Netherlands) was introduced and together, they are developing the world's first commercially -available "smart dressing", provisionally branded as 'DermaTrax' and intended to form part of a wider suite of healthcare products that interact with the patient and clinician in real time, providing valuable information that will result in improved patient wellbeing and reduced healthcare costs.

Just three years later, Fleming Medical is globally recognised as a cutting edge R&D business thanks to 'DermaTrax' and the collaborations that made it possible.

Dr Paul Galvin, Head of ICT for Health at Tyndall, said, "DermaTrax is not only a significant addition to Fleming Medical's product portfolio – it will also help increase Ireland's standing as an international hub for medical device research and development. The success of this and other innovative products underpins the ongoing expansion of health-related technology projects here at Tyndall, projected to be worth over €10m by 2018."

Mark Fleming said, "DermaTrax" contains sensors that monitor the condition of a patient's wound, and of the dressing itself, relaying information to clinical personnel or a nurses' station via a wireless link. Medical staff can be alerted to the possible presence of infection and other healing issues without the need to remove the dressing, which can disturb the patient and disrupt the conditions needed for optimal healing.

"Manual removal of patient dressings to visually inspect chronic wounds is an invasive and costly healthcare issue, particularly in countries with ageing populations, and that's part of the reason why "DermaTrax" is such an exciting invention."

He added, "DermaTrax has opened a whole new space for Fleming Medical but the invention process also opened us to new ideas and technologies and collaborations that we would not have thought possible.

"Our association with Tyndall gives us credibility, but the Tyndall team also connected us to people and helped plug us into funding, specifically by introducing us to Philips (Netherlands) who lead the 'InForMed' European Horizon 2020 project through which the research is coordinated . This activity is co-funded by Enterprise Ireland, which recognises and encourages the value added by institute-industry collaborations."

The outward looking engagement facilitated by Tyndall will help to further build the export business of Fleming Medical, which now stands at 30 percent. Current export markets include the UK, Middle East, Africa, the Caribbean and India.

Würth Elektronik partner with Tyndall on wafer-level magnetics

Würth Elektronik eiSos GmbH & Co. is a manufacturer of electronic and electromechanical components for the electronics industry and is part of the Würth Group, the global market leader in fastener technology. The company employs 6,100 people and generated sales of €475m in 2015.

The Würth Elektronik eiSos product range covers EMC components, capacitors, inductors, RF inductors and LTCC components, transformers, components for circuit protection, power modules, LEDs, connectors, switches, power elements in press-fit technology and assembly technique.

The team at Würth Elektronik eiSos was aware of Tyndall, having attended the International Workshop on Power Supply on Chip, hosted by Tyndall in Cork in 2010. However, it wasn't until 2014 that Würth Elektronik first collaborated with Tyndall with the commencement of a joint research project in the area of wafer-level magnetics.

As Martin Haug, Division Manager MagI³C R&D said, "In recent years Würth Elektronik eiSos has started to investigate wafer-level magnetics. Through co-operation with Tyndall we intend to accelerate and extend our program."

Tyndall makes devices, based on its proprietary technology, for Würth Elektronik to evaluate in a number of future Würth products. These are fully packaged devices, in line with Tyndall's ability to act as a one-stop-shop in terms of modelling, designing, fabricating, testing/characterising and finally packaging the devices.

Martin Haug reported, "Our joint project is still in progress and we are excited by the prospect of receiving our first samples soon. We have had very interesting and fruitful discussions during project meetings and reviews which helped us to enhance our designs."

Tyndall's long history in the field of wafer-level magnetics and world class facilities at their labs in Cork were the key factors that attracted Würth Elektronik, but the experience of working with Tyndall has highlighted how connected the people at Tyndall are with the industry and research communities worldwide.

"On top of their excellent research capabilities, the team at Tyndall bring a good understanding of the latest technology and market trends," said Martin Haug.

Agency-funded centres

Prof. Paul Townsend, Director of IPIC, Head of Photonics Centre, Tyndall

What is your centre's mission?

IPIC's mission is to deliver excellence in photonics research and advance and miniaturise photonics integration science in order to develop leading edge technologies and products.

Why is it important/who will benefit?

Our work focuses on:

- Revolutionising the speed of data transfer for the continued growth of the internet
- Delivering new smart medical devices for improved patient outcomes
- Developing highly compact instrumentation for point-of-care diagnostics and wearable devices
- Developing systems for food, beverage and environmental monitoring

How has your mission progressed in 2015?

At the end of 2015, IPIC's second full year of operation, the centre's research programmes are delivering IPIC's three target outputs of scientific excellence, the development of highly skilled trainees and economic impact, with 160 publications generated by the platform research programme and over 20 targeted and commercial projects.

What was your key highlight?

We established and launched the Photonics Ireland National Technology Platform (NTP), which brings together Ireland's photonics community to give it a single voice, to increase its international visibility and to become more effective at delivering economic impact.

What are you excited about for 2016?

2016 will see the addition of internationally renowned biophotonics professor, Stefan Andersson-Engels, to the IPIC team. Prof. Andersson-Engels will enhance Ireland's scientific excellence in the biophotonics field and enhance IPIC's capability to engage with and support Ireland's medical industry.

Mr Donnacha O'Riordan, Director of MCCI

What is your centre's mission?

Our mission is to increase jobs and exports in semiconductor, and semiconductor related companies. We will achieve this by becoming a world leading, industry-led, analog-mixed signal circuits research centre by 2020.

Why is it important/who will benefit?

Microelectronics is an enabling technology. The circuits we research connect the digital world and the tools we use to the real or physical world comprising biology, chemistry, light, or sound. Our research detects, interprets, conditions and converts the physical world to 1's & 0's. In that respect the entire economy benefits.

How has your mission progressed in 2015?

Now in our second funding phase, we have significantly grown the core team of researchers to 23, and with a wider community of 45 circuits researchers, we have positioned MCCI as a single point of contact for industry to access microelectronics circuits research. At the end of 2015 we had 28 industry member companies, with 17 research projects running. In addition we continue to deliver to industry on one of our core tenants, producing skilled and industry ready researchers, transferring 11 further researchers to member companies, and growing the MCCI alumni to 21.

What was your key highlight?

In 2015 our highlight was a successful centre review of a business plan which secured additional funding to enable a five-year roadmap of research to 2020. The centre's core funding has increased from €5m in the first 5 years (2010-2015) to €6.8m for the second 5 years through 2020, which enables a significant body of research work to be undertaken

What are you excited about for 2016?

The next phase for MCCI will be characterised by growth. The successful centre review in 2015 validated the engagement model between academia and industry, and the challenge now is to scale that model up. That means greater investment and higher engagement from industry and greater outcomes in terms of people and IP from the centre.

Dr Alan Mathewson, Assistant Director & PI, CONNECT Centre

What is your centre's mission?

Connect is the SFI research centre for future networks and communications. The 'networks' refers to the end-to-end system (including responsive things), and also refers to that portion of the chain dealing with wireless and optical connectivity.

Why is it important/who will benefit?

Communications networks are now a vital part of society's critical infrastructure. Connect researchers, in collaboration with over 30 industry partners, are investigating ways of providing faster internet speeds, improved device battery performance and more reliable mobile phone connectivity, as well as exploring IoT technology, which will benefit billions of users worldwide.

How has your mission progressed in 2015?

The Tyndall Connect team successfully negotiated projects with several industry partners which will begin work in 2016, and is leading the 'responsive things' strand of Connect, developing platform research ideas. Through this leadership, synergetic research from different fields in ten HEI's is being combined to deliver results which would be impossible without the diverse range of expertise.

What was your key highlight?

A team of experts in various areas, all related to 'responsive things', was assembled during 2015. Their success in developing industry projects and planning research for the coming years puts Tyndall on target to deliver excellent results as the Connect centre matures.

What are you excited about for 2016?

Executing on the industry and platform research, as well as expanding to fund new innovations will make 2016 a great year for the centre.

Prof. Tony Day, Director of IERC

What is your centre's mission?

We are an international research centre working with our members to realise deployable innovations in integrated, secure, affordable and sustainable energy systems.

Why is it important/who will benefit?

The Irish economy in general relies on secure, affordable energy, and low carbon supplies will be essential to avoid penalties and the impacts of climate change. Our partner industries will benefit from being at the leading edge of innovations in this critical sector as new global market opportunities start to be realised.

How has your mission progressed in 2015?

We increased the number of companies we work with to develop new collaborative research projects from two to six. We established new ways of working with our partners to translate business needs into high impact research objectives. In addition we consulted widely across the energy sector in Ireland and internationally about the most pressing needs for the economy, and the longer term innovation needs for transforming the energy system to one fit for the 21st century. We added some key new skills to the team to ensure we could deliver our complex mission effectively.

What was your key highlight?

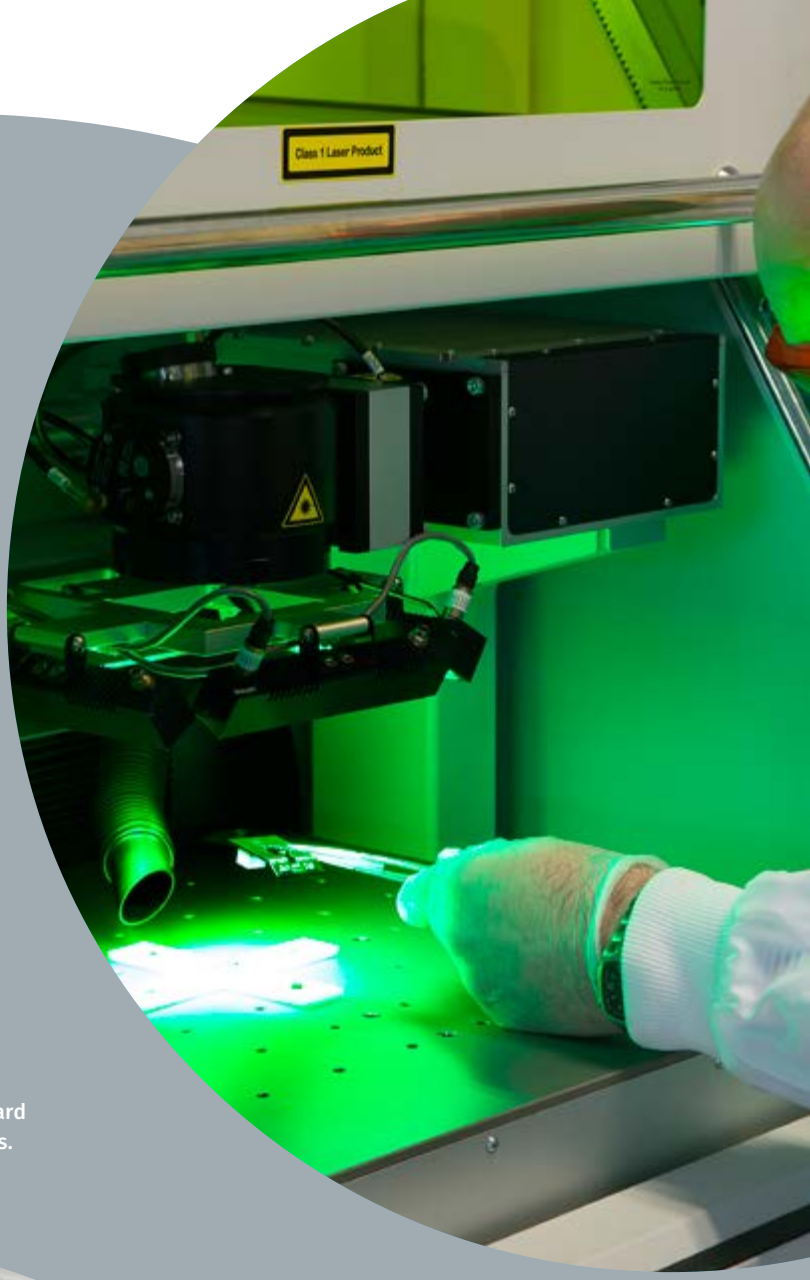
The IERC conference in May 2015 was our best event to date. It was opened by Minister Alex White TD, and Marie Donnelly, Director of New and Renewable Energy Sources at the European Commission, gave an inspiring keynote address on the future challenges to the energy system. With over 170 delegates attending the IERC has been shown to have an important voice in demonstrating the needs and opportunities for new innovations across the whole of the energy sector, and has built a solid reputation for thought leadership in the field.

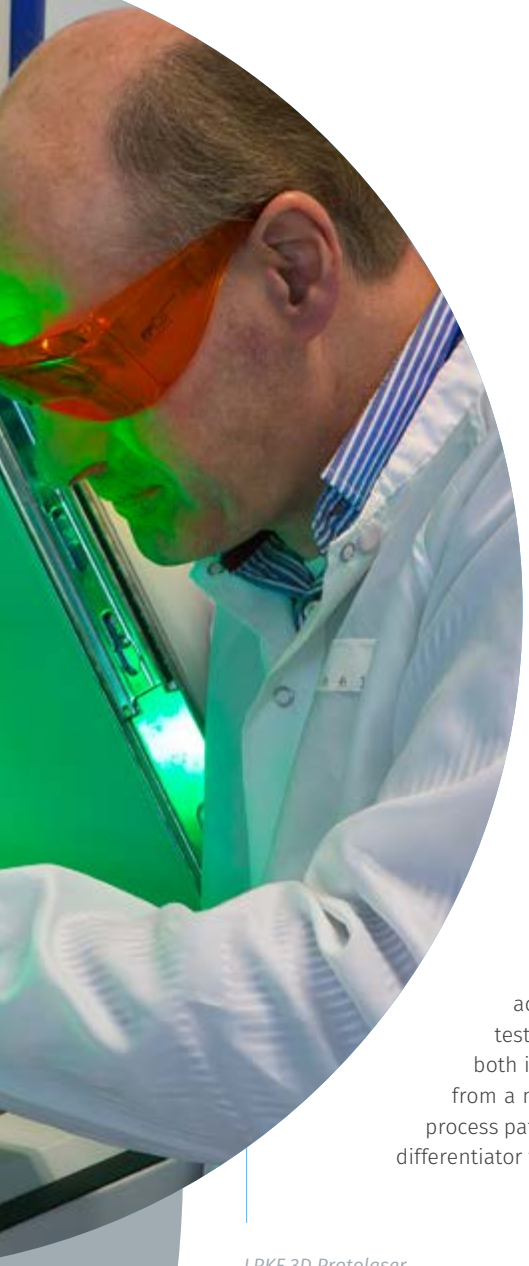
What are you excited about for 2016?

The IERC has started work on a new strategic plan, which will further enhance the mission, and allow us to work more closely with the best energy research teams in Ireland.

Services

2015 has seen significant growth in commercial activity in the fabrication arena at Tyndall, driven primarily by contracts in the area of Magnetics-on-Silicon. Our Process and Product Development group has been heavily involved in custom fabrication for customers, as well as training staff in the fabrication process, effectively facilitating technology transfer. Our close ongoing relationship with industry partners demonstrates our capability to deliver devices to a standard that meets the needs of our large multinational customers.





The Design and Technology Evaluation (DTE) group, led by Ted O'Shea, successfully renegotiated the renewal of a three-year commercial contract with Analog Devices. The contract continues the excellent working relationship between Tyndall and Analog Devices, focusing on mixed signal IC device characterisation and process technology analysis.

In 2015, the DTE group also began working closely with a US-based intellectual property licensing company in the field of device re-engineering for patent analysis. This involves the forensic examination of analogue and mixed signal ICs in order to compare their design and performance with claims that are in patent to detect infringements.

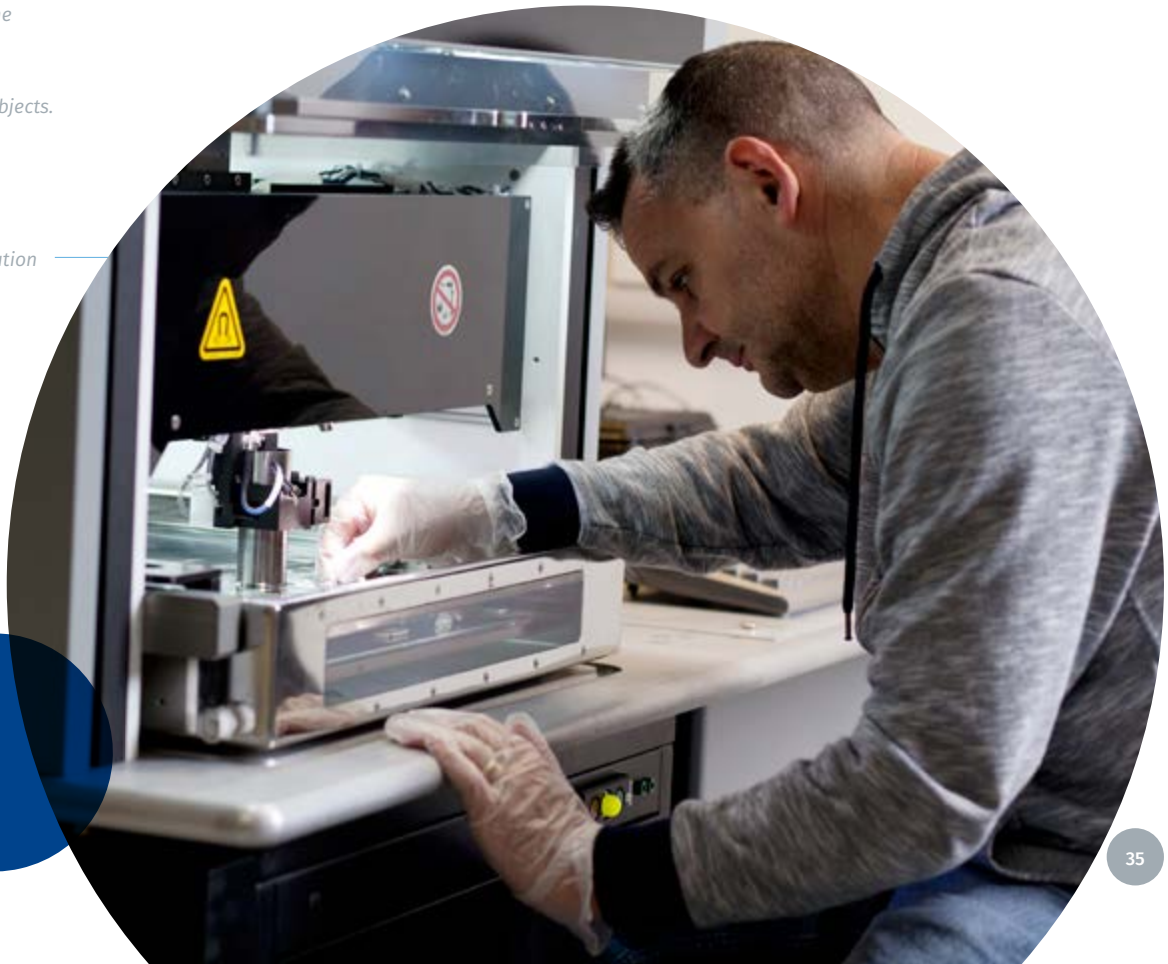
The Electronics Packaging and Reliability Services group added a new rapid prototyping suite that can add electrical functionality to 3D-printed objects. The tool allows the user to post-process a 3D-printed plastic object in order to integrate conducting tracks, opening up the possibilities of integrated electronic functions for 3D-printed objects for functionalised housings and prototype products containing Tyndall sensor chips inside.

The maintenance and facilities teams have recorded significant success this year in maintaining uptimes with 98.1% uptime in our newest cleanroom. They have also succeeded in further reducing energy use by 5% for the entire silicon fabrication cleanroom.

As we add ISO 17025 accreditation to our existing ISO9001:2008, which is set to be achieved in late-2016, the ability to carry out high-quality, reliable and auditable testing on behalf of partners such as ESA will enhance our position as a partner for both industry and academia. Customers increasingly seek flexibility in processing, both from a materials and a device geometry point of view. Our flexibility in terms of building process pathways and what we can achieve with material integration continues to be a strong differentiator for Tyndall.

LPKF 3D Protolaser system for the definition of circuits on 3D-printed objects.

A high resolution Scanning Acoustic Microscope (SAM).



Tyndall research out of this world

Tyndall and the European Space Agency

Tyndall has a long history of working with the European Space Agency (ESA), from the first contract between ESA and Tyndall in 1988. Since then, we have worked with ESA on a core contract as a Microelectronics Technology Support Laboratory (MTSL) to ESA's test centre in the Netherlands (ESTEC) which allows ESA to access a range of our capabilities, including component analysis and rigorous testing of technology intended for use in space.

Component analysis

Researchers in our Specialty Products and Services centre work with ESA to analyse components that are manufactured by leading European space technology manufacturers, disassembling them in a structured manner to examine the quality of materials used, compliance with space standards and fitness for deployment in the harsh environment of space. ESA expects components to have excellent reliability and longevity, with the ability to withstand hazards such as extremes of temperature and radiation, as well as the physical shock and vibrations of the launch process.

While much of the testing implemented on behalf of ESA focusses on confirming the reliability of established technologies, we also analyse and test new devices that have emerged from the commercial or consumer environment. Our researchers examine components with potential space applications for their ability to resist the rigours of space, investigating aspects of their construction including materials, adhesives, assembly techniques such as flip chip, and component encapsulation. ESA also relies on our expertise to help develop appropriate test methodologies and testing procedures for new technologies.

Radiation dosimeter

In 2015, we announced the exciting results of work on the collaborative ESA-funded EuCPAD (European Crew Personal Active Dosimeters) project, which involved the development of a real-time, active and wearable radiation monitor that can instantly warn astronauts of dangerous radiation levels. Although we were initially asked to produce just one part of the device (RADFETs, or Radiation Sensing Field Effect Transistors), a lack of suitable sensors on the market meant that our researchers were subsequently asked to develop and produce two additional parts of the unit - the thin diode and thick diode detectors. Having undergone systematic testing, the device is set to be permanently fixed on the International Space Station in the second half of 2016.

With contributions from Tyndall, the German Aerospace Centre (DLR), the Austrian Institute of Technology (AIT), RADOS/Mirion of Finland and PTB of Germany, the project has resulted in the development of an active dosimeter that detects and measures astronauts' radiation exposure in real time.

Our RADFET dosimeters are also commercially available and have attracted attention in recent years from the medical community, with interest in applications in quality assurance of cancer treatment and medical devices such as catheters. CERN have recently purchased 2,000 of our RADFETs for radiation monitoring in the 27km long Large Hadron Colider (LHC) accelerator ring.

ESA BIC

Space Solutions Centre Ireland

We have recently been chosen to lead Ireland's ESA BIC (European Space Agency Business Incubation Centre) – the newly created Space Solutions Centre Ireland. Working in partnership with Athlone Institute of Technology, National University of Ireland Maynooth, and the Irish Maritime and Energy Resource Cluster, Tyndall will be responsible for managing the operations of the national centre across its four locations. The objective of Space Solutions Centre Ireland, which is jointly funded by ESA and Enterprise Ireland, is to foster the development of Irish enterprises operating in the arena of space-related technology that can be applied in either terrestrial or space exploration contexts. With responsibility for administering a seed fund to support entrepreneurial ventures in space-related fields, Tyndall's leadership role is reflective of the confidence that ESA and the national agencies place in Tyndall.

Transistor for use in space

2015 also saw the conclusion of a series of tests on a gallium nitride-based transistor for use in space, which successfully outperformed devices made from conventional semiconductors such as silicon. ESA approached us to investigate and develop a GaN-based device that would be stable enough to withstand the radiation present in space. We took on the challenge of designing, manufacturing, and analysing the performance of the new device, which was successfully tested during 2015 in ESTEC for its stability in the face of radiation.

The project was led by Prof. Peter Parbrook of Tyndall and Dr Andrew Barnes of ESA, and was supported and funded by the Irish Research Council (IRC) and ESA. Dr Matthew Smith, who was recruited to carry out the research and was awarded his doctorate for his work on the project, published a paper on the results of the radiation testing in Semiconductor Science and Technology. One possible application of the new transistor is on ESA's Jupiter Icy Moon Explorer (JUICE) mission to Jupiter, planned for launch in 2022.

Evaluating microsystems technologies for space

We continue to work with companies that are developing technology for use by ESA, applying the expertise of Tyndall researchers in the areas of component analysis and testing. In 2015, we carried out a rigorous testing campaign on a batch of System in Package demonstrator devices made up of MEMS, ASICs and passives which were developed by a consortium led by the Portuguese company Lusospace, in partnership with Optocap (UK) and ESS (GR). The testing programme included exposure to stresses such as thermal shock, varying temperatures, and humidity changes, with component characterisation ongoing throughout the test programme. The programme concluded with a comprehensive construction analysis of the devices.

Accreditation and ISO-17025

In 2015, the Specialty Products and Services centre began the process of attaining the high-level ISO 17025 quality standard for its space-related laboratory testing activities, and we are on track for its successful achievement in 2016. As ESA continues to increase the volume of component analysis work outsourced from the ESTEC laboratories in the Netherlands, ISO 17025 accreditation by the Irish National Accreditation Board (INAB) will further improve our status as a preferred partner lab for ESA and a leader in the field of component analysis for space-related devices. This accreditation will give us the unique distinction of having the only space analytical lab in Europe that is accredited under the ISO 17025 quality system.

NAP celebrating 11 years of success as programme concludes

The National Access Programme (NAP) enabled access to the state-of-the-art facilities and expertise at Tyndall to all researchers in Ireland. The 11 year programme, which ended in December 2015, was extremely successful, exceeding its objectives. Some of their main achievements include:

- 350 projects funded with a value of over €7m
- 40 items of capital equipment funded to over €3m
- 296 NAP-specific promotion events with over 2,100 attendees
- 9 annual scientific workshops with over 500 attendees
- 205 journals, 322 conference papers, 187 posters, 62 workshop papers

Following the success of NAP, the remit of the team has expanded to serve a wider national and international community through the two new European H2020 projects, ASCENT and Gateone.

Postgraduate studies

Skilled graduates

At Tyndall, we provide students with the opportunity to work on leading edge research, within multi-disciplinary teams of experts while availing of our state-of–the-art R&D infrastructure.

At the end of 2015, there were 106 PhD and 16 Masters students pursuing their degrees at Tyndall and 19 students successfully completed PhD viva examinations in 2015.

The Tyndall led PhD Engineering Science programme continued to grow steadily in 2015. This novel structured PhD programme provides students with access to taught modules designed to complement their research and equip them with a wide range of skills. Alongside technical training, the programme offers access to innovation, commercialisation and entrepreneurship modules. At the end of 2015, 24 students are registered on the programme and the first two students had successfully completed the PhD Engineering Science degree.

INSPIRE national graduate education programme in nanoscience & nanotechnology

We continue to lead the INSPIRE graduate research education programme which is now in its penultimate year. The project has established a national framework for structured PhD programmes in nanoscience and nanotechnology by developing and sharing a curriculum comprising taught modules and hands-on training across Ireland.

INSPIRE partners offer courses at their own institutes as well as nationally via an online portal. In addition to the core technical components, the INSPIRE graduate education programme includes generic and transferable skills modules for science and engineering postgraduates, all of which are offered via Flexilearn. During the 2014-15 academic year, INSPIRE offered 20 graduate modules across its partner institutes with over 130 graduate students enrolling via Flexilearn.

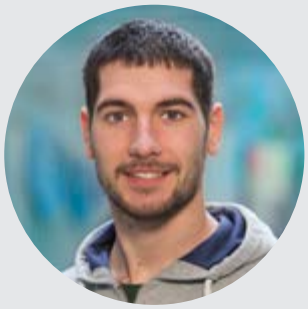
The INSPIRE mobility fund enables students to attend courses and/or access infrastructure nationally. In 2015, over 60 students accessed this funding to attend courses and conferences within Ireland, while 6 students availed of the research placement funding internationally.

INSPIRE is funded under the framework of the Irish Government Programme for Research in Third Level Institutions Cycle 5, National Development Plan 2007-2013 with assistance of the European Regional Development Fund.

Makerspace

Tyndall's Makerspace officially opened in July 2015. The space facilitates the development of a 'maker community' among postgraduate students and staff and provides a laboratory environment for graduate training focused at the interface between technology development and product design. The space enables us to develop a module around design and 'making' for engineers and scientists to facilitate ideation, collaboration, problem solving, prototyping and related topics. The module development will be funded by INSPIRE in collaboration with National College of Art and Design (NCAD).

Here's what our students think



Stefano Facchin

PhD student, Photonics centre

"There is a friendly environment in Tyndall. The people here are passionate about their work and I have a lot of freedom in my research. I would advise students not to underestimate the impact that a small, "cozy" city like Cork can have on your daily PhD routines! Tyndall's Makerspace is great because it allows me to combine hard work and fun activities"

PhD research: PAM-4 56-Gb/s CMOS receiver for short reach optical interconnects

Undergraduate degree: Biomedical Engineering from Politecnico di Milano, Joint MSc between Politecnico di Torino, INPGrenoble and EPFLausanne

Jan Kegel

PhD Eng Sc student, Micro & Nanosystems centre

"I wanted to do research in photovoltaics and related fields in an English speaking country, so when I saw a PhD position on the RENEW project advertised on the Tyndall webpages I decided to apply for it. Tyndall has a great range of fabrication and characterisation tools and the working environment is really good thanks to the friendly people working here".

PhD research: Development of novel photo-electrodes for solar water splitting

Undergraduate degree: B.Sc. and M.Sc. Environmental Engineering/ Regenerative Energies; Hochschule für Technik und Wirtschaft, Berlin

Catherine Ryan

PhD student, Micro & Nano Systems centre

"I started in Tyndall as an undergraduate student and really liked the place and the people so I was delighted to be offered a PhD position. I have gained experience in cutting-edge scientific research and teaching and also got the opportunity to travel internationally as far as Brazil and Japan. There is a wide array of research groups so it is great to learn about different topics and methods"

PhD research: Chitosan based interpenetrating polymer networks: synthesis, characterization and applications

Undergraduate degree: B.Sc Chemistry, UCC

Joveria Baig

PhD student, Photonics centre

"I was aware of the state-of-the-art facilities at Tyndall showcased at various conferences that I attended during my Master studies. A major reason for pursuing a PhD in Tyndall was the cultural diversity among researchers working here. Researchers from a wide variety of expertise and their willingness to share their knowledge with their peers is something I find unique about Tyndall."

PhD research: Integrated tunable lasers for burst mode transmitters

Undergraduate degree: Erasmus Mundus Double Masters: MSc Applied Physics from TU Delft, Netherlands. MSc Laser, Plasma and Matter from Institut d'Optique Graduate School, France and University of Oxford, UK. BS Electrical Engineering from Lahore University of Management Sciences, Pakistan

Student awards and prizes 2015

Ricky Anthony, PhD student with the Electrochemical Materials and Energy group, was selected by Enterprise Ireland as an International Student Ambassador. He was awarded for his services in promoting education in Ireland by Minister for Education and Skills, Jan O' Sullivan T.D. in the presence of the Indian Ambassador to Ireland HE Mrs Radhika Lal Lokesh at Farmleigh, Dublin, in April 2015.

Joveria Baig, PhD student in the III–V Materials and Devices Photonics group, is undertaking research in InP Based Devices for Communications and Sensing. She was awarded a SPIE Travel Scholarship for her potential contributions to the field of optics and photonics. She was also awarded an IEEE Women in Engineering International Leadership Conference Travel Grant.

Abulaiti Hairisha, PhD Eng Sc student with the Materials Modelling for Devices group, was awarded a scholarship for outstanding Xinjiang students studying abroad. This scholarship is awarded for outstanding Xinjiang students studying outside China to recognise their current achievements and to encourage them to achieve even better academic results and excel in their future career.

Lisa Helen, PhD student with the Life Science Interface group. She won the Best Poster Presentation in Smart Health at Evolve Biomed 2015 for her poster entitled "Characterisation of a prototype smart needle". She was awarded Best Presentation at South of Ireland Association of Anaesthetists Autumn Scientific Meeting 2015 for her presentation on "A 'Smart' Needle for Objective Nerve Localisation during Ultrasound Guided Peripheral Nerve Block". At the SFI Technology Innovation Development Award (TIDA), Lisa was awarded pitch-off winner 2015.

Niamh Kavanagh, PhD student with the Photonic Systems group. At Tyndall's internal conference she was awarded 2nd place for her Elevator Pitch on "Photonic communications In the 2μm wavelength band". She was a Grand Plan Finalist at the UCC Doctoral Showcase and presented on: "The Internet is not Limitless". In November, she presented "A new Suitcase for Travelling Light" at the Thesis in 3: Elevator Pitch for A PhD National Competition and won 2nd prize.

Anne Marie Mc Garrigle, PhD student with the Heterogeneous Integration group, won the Best Poster award at the 6th Annual Scientific Meeting of the Irish Association of Physicists in Medicine for the work on "Characterisation of Radfet Devices at the Diagnostic Energy Range".

Gioele Mirabelli, PhD student with the Nanoelectronic Materials and Devices group, undertaking research on Electrical and Material characterization of 2D materials as replacement for Silicon in future electronics. He was awarded an Irish Research Council – Enterprise Postgraduate Scholarship award, with Intel Ireland as the enterprise partner.

Shane O'Mahony, PhD student with the Materials Theory group, was awarded an Irish Research Council Government of Ireland Postgraduate Scholarship to pursue a PhD investigating the Relaxation of Electronic Distributions and Atomic Forces in Materials following Illumination by a Short, Intense Burst of Light.

Carola Schopf, PhD student with the Nanotechnology group, won best young scientist award at the NanoSMA conference in Japan in July 2015 for her research on "Single Gold Nanorods for Mercury Detection."

Ian Seymour, PhD Eng Sc student with the Electrochemical Materials and Energy group, was awarded Best Presentation for his work on "The use of Gold Micro-Electrode Arrays for Sensing Applications and Subsequent Enhancement of Sensing Capabilities by Modification of Electrodes with Nanostructures" at the 2nd Annual George Guilbault Symposium held in Tyndall.

Left to right – Niamh Creedon, Ian Seymour and Niamh Kavanagh.

The annual Tyndall postgraduate poster competition is organised by the Postgraduate Student Committee and was judged by a panel consisting of: Kieran Drain, Tyndall CEO; Bernie Di Capraro, Intel Ireland Research; John Power, Engineers Ireland and Paul Ross, UCC College of SEFS. First prize was awarded to Niamh Kavanagh, a PhD student with the Photonics Systems group for her poster entitled "Dense Wavelength Division Multiplexing at 2um". Niamh Creedon received second prize for her poster entitled "Novel Single Gold Nanowire–based Electrochemical Immunosensor for Rapid Detection of Bovine Viral Diarrhoea Antibodies in Serum". Ian Seymour was awarded third prize for his poster on "Detection of Active Pharmaceutical Ingredients in Drug Formulations at Flat Gold Microdisc Electrode Arrays vs Nanaporous Gold Modified Microdisc Electrode Arrays."

Tyndall PhD Students Jan Kegel, Prasanna Ramaswamy and Ruggero Loi and Conor O'Shea (Electrical and Electronic Engineering, UCC) were presented with the award for Most Technologically Innovative Idea at the UCC Entrepreneur of the Year Awards 2015.

Left to right – Jan Kegel, Conor O'Shea, Prasanna Ramaswamy and Ruggero Loi.

PhD theses 2015

Hadi Arefi
A microscopic study of structural and electronic properties of functionalised silicon surfaces based on first-principles

Christopher Broderick
Theory of the electronic and optical properties of dilute bismide alloys

Darragh Carolan
Synthesis, functionalisation and characterisation of germanium nanocrystals and their applications

Michele Conroy
Preparation and characterisation of III-N nanorods

Conor Coughlan
A tight-binding analysis of the electronic properties of III-nitride semiconductors

Anushka Gangnaik
Electron beam lithography assisted high-resolution pattern generation

Patrick Harnedy
Experimental analysis of novel telecom source materials and devices

Nazmul Hossain
Design, fabrication and characterisation of resonant waveguide grating based optical biosensors

Daniel Jones
Nanofabrication towards biophotonics

John Kinsella
Langmuir-Blodgett assembly of colloidal photonic crystals combined with controlled infiltration of conducting metal oxides

Merid Legesse
First principles simulation of amorphous silicon bulk, interfaces, and nanowires for photovoltaics

Haoning Li
AlGaN materials growth for UV devices

Yasheng Maimaiti
Computational study of the growth of copper thin films by atomic layer deposition

Tuhin Maity
Manipulation of magnetic anisotropy in nanostructures

Rosemary O'Keeffe
Piezoelectric energy harvesting using blood-flow-like excitation for implantable devices

Michael Schmidt
Beyond simple imaging in electron microscopy

Carola Schopf
Plasmonic gold nanostructures: optical properties and application in mercury detection

Matthew Smith
Development of InAlN/GaN high electron mobility transistors for space applications

Tingcong Ye
The development of a bilateral transmitter output power control algorithm and a fully-coupled architecture for hybrid IEEE 802.15.4-2011 UWB and IMU positioning

Royal Society's Head Librarian, Keith Moore showing Dr Emanuele Pelucchi, Tyndall, and Prof. Patrick Fitzpatrick, UCC, George Boole's original handwritten copy of The Laws of Thought.

International reach

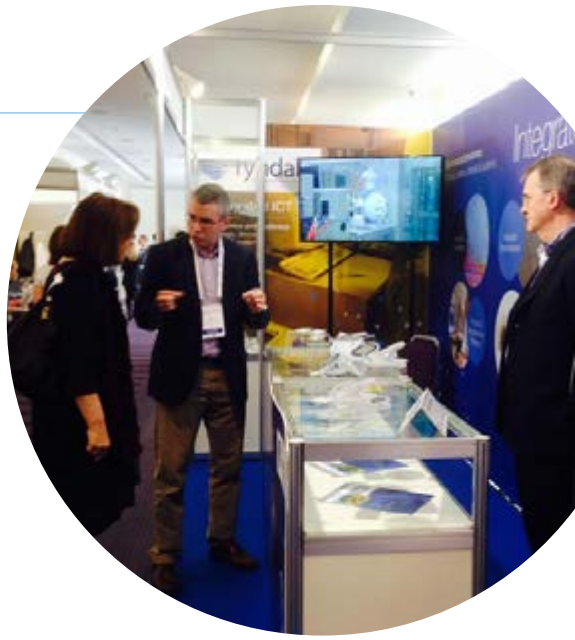
A Memorandum of Understanding between Tyndall and TU Delft, one of the top engineering universities in Europe, was signed in 2015. This partnership extends our fabrication capabilities and we will seek opportunities to collaborate in H2020 calls.

US Ambassador to Ireland, Mr Kevin F. O'Malley, seeing firsthand the support Tyndall provides to American companies during a recent visit to the institute.

We welcomed a business development mission from Newfoundland and Labrador to learn about our activity in environmental and marine monitoring analysis. The group led by Allison Dancey, International Business Development, Gov. NL, included Darin King, Minister Business, Tourism, Culture and Rural Development, Gov NL, and business and research members of the OceansAdvance Ocean Cluster, NL.

A team of Tyndall and IPIC researchers, along with partners from Trinity College Dublin, demonstrated an advanced 'long reach' Fibre To The Home (FTTH) at one of the world's leading optical communications conferences, ECOC 2015.

Mr Simon Coveney, Minister for Agriculture, Food and the Marine.



Exhibiting our integrated ICT expertise to 1,200 delegates attending the 7th Euro Nano Forum in Riga, Latvia.

Left to right: Graeme Maxwell, Tyndall; Kieran Drain, Tyndall; Mr Simon Coveney, Minister for Agriculture, Food and the Marine and Aleksandar Jaksic, Tyndall.

Vietnamese Minister of Planning and Investment Bui Quang Vinh and his delegation visited UCC, Tyndall and other partners for smart agriculture. The Irish Ambassador Cait Moran, second right, introduced the best partners in agriculture management, business and technology for Vietnam to upscale its agriculture to higher added value production.

Tyndall launches alumni network

With over 1,400 alumni spread around the world we have created a portal for you to reconnect with former colleagues and students. Sign up at ***tyndall.konnectagain.com****.*

Dr Ann Kelleher, Corporate Vice president in Intel's Technology and Manufacturing Group and General Manager of the Semiconductor Manufacturing organization at Intel Corporation was honoured at the 2015 UCC Alumni Achievement Awards. Pictured with Dr Michael Murphy, UCC President, Ann Kelleher was the first female scientist to receive a PhD from the National Microelectronics Research Centre (NMRC), now part of Tyndall National Institute at UCC.

Outreach

Launch of Tyndall Makerspace

"Beyond the Bulb" photo exhibition travelled Cork

400 primary school students engaged

360 secondary school students engaged

3,000 members of the general public engaged

Media coverage by RTÉ, Irish Times, Irish Examiner, Silicon Republic and more...

Over €65k in funding competitively won

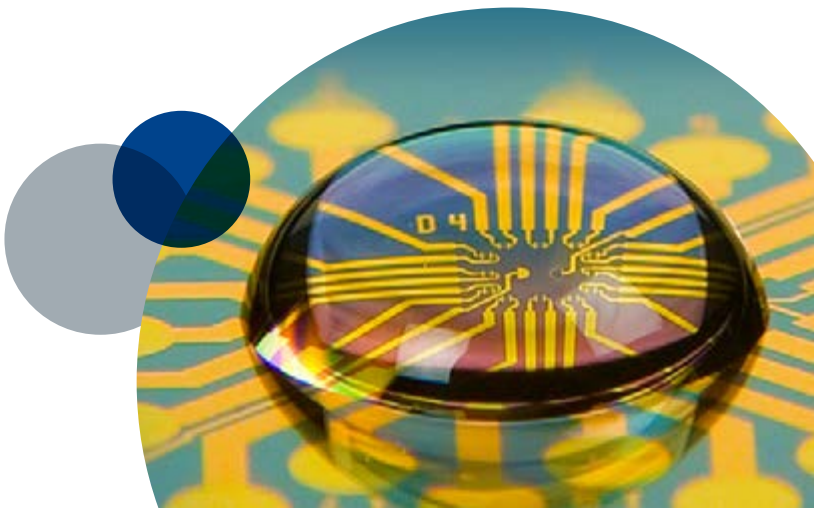
Links with Blackrock Castle Observatory, UCC & local libraries

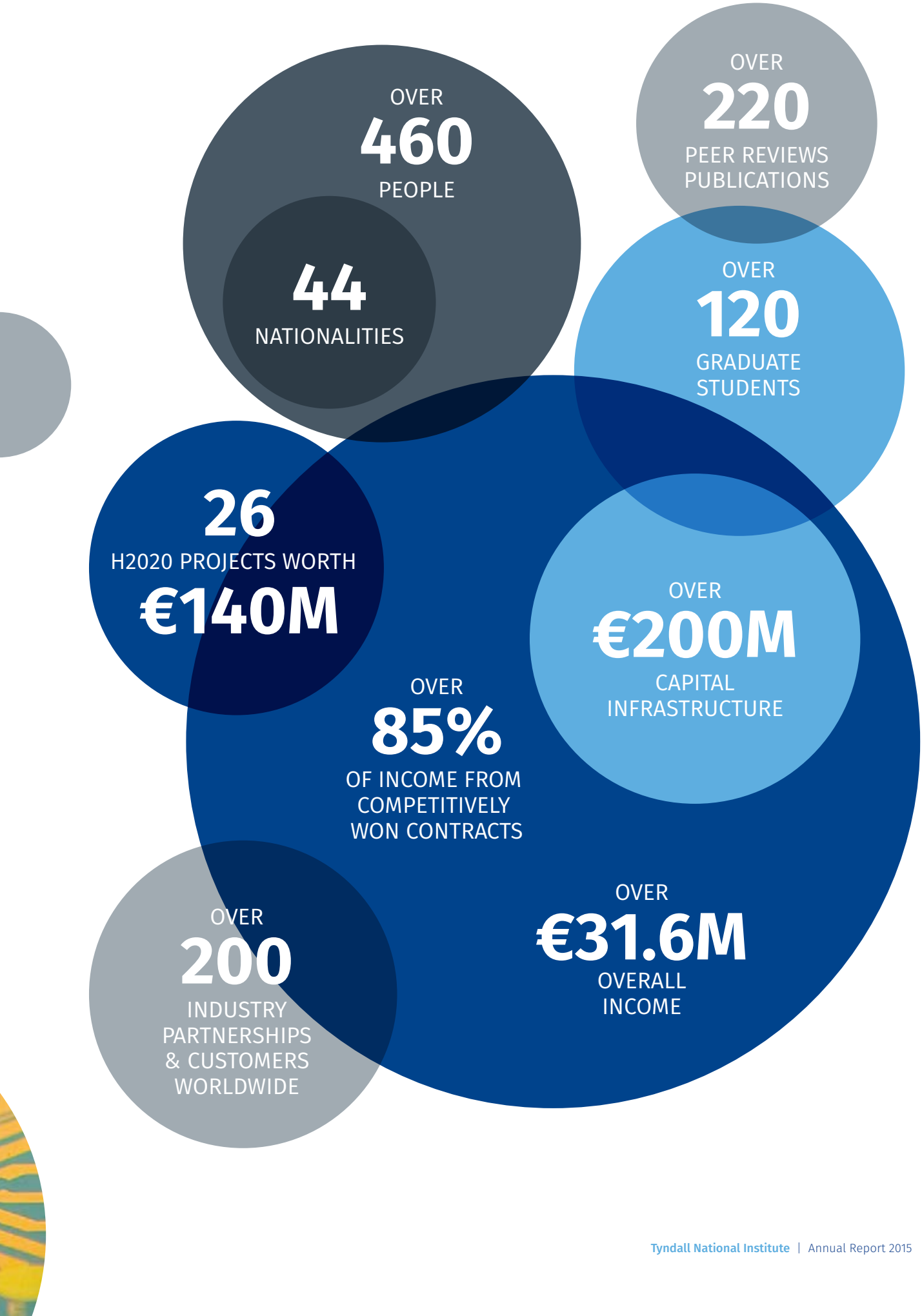
Financial report

Income and expenditure summary 2015

Income	2015	2014
	€1000s	€1000s
Government grant	3,400	2,900
Research	26,066	26,687
UCC contribution	2,151	2,287
	31,617	**31,874**

Expenditure	2015	2014
	€1000s	€1000s
Remuneration costs	20,185	18,650
Equipment and infrastructure	2,509	2,654
Consumables and related costs	8,446	8,662
Other operating and deferred costs	477	1,908
	31,617	**31,874**




OVER
460
PEOPLE
44
NATIONALITIES
OVER
220
PEER REVIEWS
PUBLICATIONS
OVER
120
GRADUATE
STUDENTS
26
H2020 PROJECTS WORTH
€140M
OVER
€200M
CAPITAL
INFRASTRUCTURE
OVER
85%
OF INCOME FROM
COMPETITIVELY
WON CONTRACTS
OVER
€31.6M
OVERALL
INCOME
OVER
200
INDUSTRY
PARTNERSHIPS
& CUSTOMERS
WORLDWIDE

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Forfás

Prof. Em. Willy Sansen
KU Leuven

Dr Ann Kelleher
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European Union
European Regional Development Fund