Tyndall
National Institute
Institiúid Náisiúnta

ANNUAL REPORT 2014

Impact from Excellence

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National Institute

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Contents

Message from the **Chairman**

On joining the board of Tyndall National Institute in October 2014, I was impressed by the clarity and the boldness of the Tyndall vision to **'be the premier Information and Communication Technology research Institute worldwide in generating economic impact through excellence in research'.**

Tyndall's strategic plan to 2018 sets out an ambitious roadmap to realise this vision. The plan is underpinned by the high calibre of the research staff, the impressive track record of scientific excellence, the quality of the industry collaborations, and the important contributions Tyndall has already made to national economic growth and job creation.

Tyndall operates through world class teams performing ground breaking research on new materials, devices and systems with a 'from atoms to systems' philosophy. The impressive achievements in 2014 are built on the strategic government investment in science, technology and innovation over the past 15 years. This investment has enabled us to develop into a leading European research institute in ICT. Tyndall is renowned for its scientific excellence, global expertise and substantial outputs from its state-of-the-art infrastructure.

While continuing to explore new research areas, the Institute is increasing economic impact from areas of existing research strength. Tyndall is focussing its efforts on appropriate opportunities in the global marketplace that are most likely to deliver economic impact and jobs in Ireland. 2014 concluded with significant agreements with world leading high-tech companies.

Tyndall continues to develop opportunities in ICT for Communications, Health, Energy and Agriculture, Food & the Environment. These opportunities are informed by a broad range of strategic partnerships; the engagment of over 200 industry partners; the presence of a substantial number of Industry Researchers-in-Residence and the provision of access to a substantial national research infrastructure, including wafer fabrication.

Tyndall engaged over 400 collaborators worldwide and continues to develop strategic international relationships with other like-minded organisations.

With over 1400 Tyndall alumni around the world, Tyndall acts as a key source of highly skilled relevant graduates to industry. At the end of 2014 there were almost 130 postgraduate candidates undertaking research based theses at Tyndall.

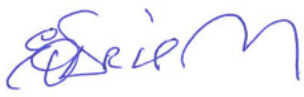
As Ireland's ICT research Institute, Tyndall was established under a formal agreement between the Minister for Jobs, Enterprise and Innovation and University College Cork, creating a model that is unique in the Irish research and innovation landscape. The flexibility and agility inherent in that model allows Tyndall to lead nationally and internationally in creating the collaborations that harness research excellence in pursuit of economic impact.

It is our ambition to further enhance this successful formula and unique culture at Tyndall for the benefit of both primary stakeholders, and to achieve significant economic impact by building strong technology differentiated Irish companies and attracting foreign direct investment from international technology innovators.

To enable this ambition we will pursue significant new commercial and international funding to complement the funds available from the Irish exchequer. Under the previous European Framework 7 programme €48m was won by Tyndall and industry funding continues to grow. Recognising the need to further grow and diversify funding the Institute established a dedicated EU programme support team in 2014, and also added key resources in the area of business development.

2014 was a year in which Tyndall continued to cement its position as a leading European Research and Technology Organisation (RTO) in ICT. We are pursuing a clear strategic vision and delivering high research quality and related output levels in a highly competitive international research environment. I am very encouraged by the talent and tenacity of the staff and students at Tyndall. I am personally excited by the prospect of playing an active role in supporting the continuing development of this national asset.

Finally, I would like to thank President Michael Murphy and his team at UCC, and the Department of Jobs, Enterprise and Innovation for their support.



Eoin O'Driscoll
Chairman

Message from the **CEO**

2014 marked the first full year of implementation of the Tyndall National Institute 5-year strategic plan, with success recorded against all key performance indicators. The outstanding scientific results, significant project wins, new strategic partnerships and funding awarded gives us great confidence for further growth in 2015. The year's results bring us a step closer in realising our vision to become the premier ICT research institute worldwide in generating economic impact through excellence in research.

Tyndall is at the forefront of developing technologies that join the physical and digital world. Industry partners need technology solutions that will provide them with a competitive edge in global markets. With over 200 industry partners, from the health, communications, energy, agri-food and the environment sectors, Tyndall continues to deliver market relevant innovative technologies.

Industry engagement intensified in 2014 with innovation partnership programmes, commercial license agreements, invention disclosures made, and patents filed during the year. We have now established an excellent pipeline of industry opportunities to generate further growth throughout the strategic plan period.

The Institute enjoyed an excellent start to the EU Horizon 2020 programme, with success to an estimated retained value of €7m in the initial ICT calls. Total EU income received for the year was €5.07m. Tyndall's success rate in year one H2020 calls at 18% was close to our ambitious goal and significantly exceeded both the national and EU averages. Within this programme, Tyndall has won large scale projects of strategic value to Ireland.

In recognition of the importance of EU funding to achieve both our own strategic plan and the national Horizon 2020 targets, we have established a dedicated EU Programme Team, with four experienced staff across Tyndall and its centres IERC, CCAN and IPIC.

€31.8m OVERALL INCOME

200 INDUSTRY PARTNERS

5 INNOVATION INDUSTRY PARTNERSHIP PROGRAMMES FUNDED

46 INVENTION DISCLOSURES MADE

5 PATENTS FILED

12 COMMERCIAL LICENCES CONCLUDED

> We have intensified our focus on **impact from excellence**.

We have intensified our focus on impact from excellence which reflects our responsibility as a national Institute to deliver economic impact through excellence in research and, as Ireland's ICT research institute, we play a leading and proactive role in the national innovation ecosystem.

The successful first year of the SFI-funded Irish Photonics Integration Centre (IPIC) and the launch of the new SFI Internet-of-Things-focused centre 'CONNECT' are highlights of the year that form core platforms for future impact and growth.

Dr Michael Murphy, UCC; Dr Kieran Drain, Tyndall; Mr Sean Sherlock, TD; Prof. Anita Maguire, UCC; Dr Niall Smith, CIT and Dr Brendan Murphy, CIT pictured at the ceremony marking the expansion of the CIT-Tyndall MOU.

> The centres, with support from **Enterprise Ireland** and **IDA,** play an important role in knowledge transfer (including personnel) to industry.

Of particular note was Tyndall's appointment to the role of leader of the "Physical Layer" in the new CONNECT centre under Professor Cian O'Mathuna.

Important organisational developments took place in 2014, with the alignment of all Institute technical services into a complete supply chain within the 'Specialty Products and Services' centre, new leadership both in this centre and human resources has contributed significantly to Institute performance. Professor Eoin O'Reilly was appointed as Tyndall's Chief Scientific Officer (CSO), and has the development of research staff and the challenge of talent acquisition among his priorities. Professor Cian O'Mathuna was appointed to the new position of Head of Strategic Programmes, to develop technology commercialisation programmes in strategic market sectors.

Over the last 15 years Ireland has developed a world-class research infrastructure, making it an attractive location for international research active organisations to engage with. In an effort to try and exploit this further, a number of key strategic partnerships were executed to help maximise and broaden our economic impact. The MOU with Cork Institute of Technology was expanded to foster collaboration beyond our very successful photonics partnership. In addition, and recognising the opportunity and need to support companies with a suite of ICT hardware, software and industrial design capabilities, MOUs were signed with the Telecommunications Software Systems Group (TSSG) part of Waterford Institute of Technology and the National College of Art and Design (NCAD). Supporting our sector strategy of ICT for Sustainable Agriculture, Food and the Environment (SAFE) Tyndall also signed an MOU with Teagasc, the agriculture and food development authority in Ireland. This report features some of the early collaborations based on these agreements that have commenced.

The primary driver of our overall impact remains excellence in research. Among the many highlights summarised in this report is Tyndall's feature in Nature Scientific Reports on "Absence of Evidence ≠ Evidence of Absence: Statistical Analysis of Inclusions in Multiferroic Thin Films". This research reacted to the growth in the creation of digital data continuing to outpace the growth of storage capacity.

The Tyndall-hosted and Enterprise Ireland-funded technology centres MCCI (Microelectronics) and CCAN (Applied Nanotechnology), and the multi-agency funded IERC (Energy Efficiency) continue to play an important national role in the delivery of technology and knowledge transfer to industry. Industry membership increased across all centres and targets were exceeded.

The centres, with support from Enterprise Ireland and IDA, play an important role in knowledge transfer (including personnel) to industry and complement the research platforms of the SFI centres.

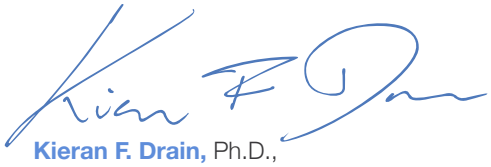
As part of our enterprise objectives, a new Tyndall spin-out company, GRASP Wearable Technologies, was launched during the year. GRASP is focused in the wireless inertial measurement space, with particular emphasis on motion analytics for sports applications. With an increasing focus on entrepreneurship, the institute's current start-up pipeline includes opportunities in integrated magnetics, photonics packaging and technology computer-aided design.

As part of our impact objectives, graduate education continues to play an important role. We were very pleased to have graduated 27 new PhDs in 2014, with many transferring to industry.

I would like to thank our outgoing chairman Alastair Glass and the board for their leadership and valuable advice during the year. Dr Glass completed 10-years as chair (including two periods as interim CEO) during which time he made a significant contribution to the development of Tyndall and the Irish research system.

We welcome and look forward to working with our new chairman Eoin O'Driscoll, as we strive to achieve our challenging objectives to 2018 and beyond. I would further like to thank President Michael Murphy of UCC and the Department of Jobs Enterprise and Innovation for their encouragement and support.

Finally, I would like to thank our staff and students whose hard work, dedication and consistently outstanding achievements, as summarised in this report, made 2014 another successful year.



Kieran F. Drain, Ph.D.,
CEO

2014 Highlights

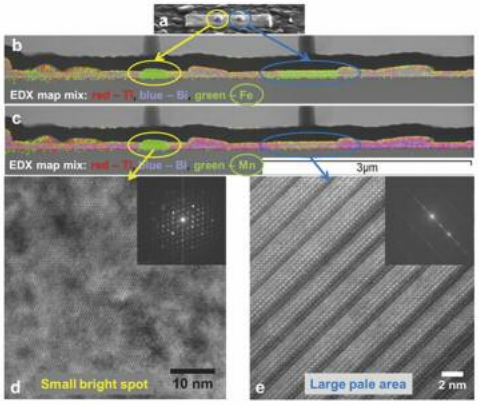
Tyndall Researchers Developing Next Generation Memory Storage

A team of researchers at Tyndall have been looking at solutions to meet the exponential growth of digital data that continues to outpace the growth of storage capacity. Led by former Tyndall CEO, Roger Whatmore, the research team validated that the absence of evidence is not equal to the evidence of absence, through a statistical analysis of inclusions in multiferroic thin films, in a paper published in Nature Scientific Reports.

High data-density, energy-efficient memory devices based on single-phase multiferroic materials (where memory can be electrically written and magnetically read) have been road-mapped as the future of memory storage. Until very recently, there were no materials showing genuine multiferroic effects at room temperature, therefore no such devices exist.

The paper demonstrates that the unique properties of newly discovered room temperature multiferroic material were intrinsic to the material in question and not due to the presence of uwanted impurity phases. The development of a logic device based on these unique materials would have substantial commercial potential.

The work has received additional support in 2014 through an SFI TIDA award for Lynette Keeney, supported by Intel.



Some of the data presented in the paper published in Scientific Reports. The images depict the various points at which careful elemental analysis reveals the accumulation of some elements in specific regions of the deposited layer, together with evidence for the crystallinity and layer structure inherent to these materials.

New Tyndall Spin-Out GRASP Wearable Technologies

GRASP Wearable Technologies, launched in October 2014, is Tyndall's latest spin-out company. The new company is gearing up for the release of their first market-ready offering to measure running biomechanics. The world-leading product builds on almost 10 years of research by scientists at Tyndall, under the technical leadership of Michael Walsh, who has taken up the position of GRASP's Chief Technology Officer.

Using sophisticated algorithms, GRASP will provide an instantaneous three dimensional profile about a user's stride length, vertical lift and impact. This information can be used to draw informed conclusions about a user's performance and efficiency, and can be applied to improving an athlete's running technique and helping avoid injury along with analysing real-time player and team position and movement patterns in team sports.

Capitalising on the growing consumer demand for wearable technologies, GRASP is creating innovative and disruptive technologies with applications in sport, health, fitness and rehabilitation.

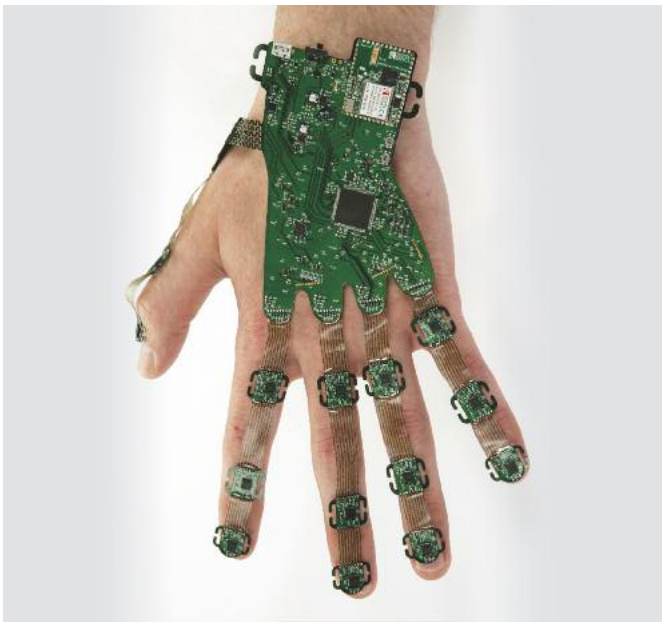
Damien English TD, Minister of State for Skills, Research & Innovation; Ken Byrne CEO, Grasp Wearable Technologies; Dr Michael Walsh, Chief Technology Officer, Grasp Wearable Technologies and Dr Kieran Drain, CEO, Tyndall.

CONNECT - Responsive & Flexible Networks

CONNECT, the centre for future networks and communications, was one of five new SFI centres established in 2014. The centre received €24m in funding from SFI and €12m from industry partners. Tyndall's Cian O'Mathuna is a Principal Investigator and Deputy Director of the centre, leading CONNECT's research on 'Responsive Things'.

CONNECT will address key challenges that face society via new and varied forms of networked services including mobile internet, connected health, smart agriculture, smart grids and metering, and environmental monitoring services.

The centre focuses on future broadband, cellular and Internet-of-Things networks on which all of these services will be enabled. **CONNECT** is a national consortium of 10 academic institutions and 37 companies and is the most inclusive and comprehensive research centre of its kind. The academics are leaders in their fields and the industry partners come from a range of key companies from across the value-chain in the all-important ICT sector in Ireland.



Wearable technologies developed at Tyndall will be a key research focus within the CONNECT Centre.

Tyndall Leading in Horizon 2020 Success

The Horizon 2020 EU research and innovation programme, with almost €80 billion dedicated to fund scientific and technological breakthroughs, funded its first calls for proposals during 2014. Tyndall has had an encouraging start to the programme with the following successes:

- **12 projects funded** with a value of almost **€7 million** to Tyndall, exceeding targets for the first year.
- **€2.3 million** delivered to Irish research partners including **€1.6 million** to industry.
- **35 jobs** directly attributed to Horizon 2020 projects.
- **18% success rate** - exceeding both the national average of 16% and the EU average of 14.5%.
- **5** of **12 successful proposals** in Tyndall's core area of Information and Communications Technology.
- **Coordinating 4** of the 12 projects funded.
- **Tyndall coordinate the ASCENT project and participate in Gateone**. These projects facilitate Small & Medium Enterprise (SME) and Multi-National Corporation (MNC) access to the cutting-edge technologies and research infrastructure of Tyndall and key European research organisations.

Tyndall's Horizon 2020 success follows an excellent performance in FP7, Europe's previous research investment programme (2007-2013).

Tyndall EU Programmes Team - Martin O'Connell, Giorgos Fagas & Aoife O'Brien.

Partnering with over 420 organisations in 40 countries to deliver scientific and industrial outputs worth €300 million, Tyndall led 27 out of 90 projects, bringing almost €50 million in investment to Ireland.

In 2014, Tyndall established an EU Programmes Team, led by Giorgos Fagas, dedicated to maximising participation in Horizon 2020, increasing the impact of EU project outputs, promoting Ireland's industrial base and R&D infrastructure, and doubling Europe's research investment in Ireland.

Eoin O'Reilly Awarded 2014 Rank Prize

Eoin O'Reilly, Chief Scientist at Tyndall was awarded the prestigious 2014 Rank Prize for Optoelectronics. Eoin received the award for his pioneering work on strained-layer laser structures, which today underpin all optical fibre communication.

He was honoured as one of four luminary scientists who challenged the widely accepted orthodoxy of the 1980s that semiconductor lasers should be strain-free. The innovation reduced threshold currents and increased efficiency and output power. It also maximised operating frequency while decreasing linewidth and frequency chirp, and enabled a wide range of laser wavelengths to be accessed that would not otherwise be possible.

This has led to the dominant role that strained lasers now play in a wide range of optoelectronic applications, from DVD and blu-ray storage to printers and sensing and pollution monitoring at longer wavelengths.

Eoin's current work is focused on extrapolating the energy efficiencies further, with projects seeking to double the efficiency of LEDs with the likelihood that this will be the preferred form of lighting in future.

Prof. Eoin O'Reilly, Tyndall.

X-Celeprint Establishes its Headquarters in Tyndall

X-Celeprint Ltd. develops and licenses patented Micro-Transfer-Printing (µTP) technology. Micro-Transfer-Printing is a cost-effective and scalable manufacturing platform for integrating microscale devices such as lasers, LEDs or integrated circuits onto non-native substrates.

It opens new opportunities for high-volume, high-performance applications such as optoelectronics and next-generation data storage. X-Celeprint is an industry partner of the Irish Photonics Integration Centre (IPIC), and is headquartered at Tyndall.

Commenting on X-Celeprint's partnership with Tyndall and location within the facility, Kyle Benkendorfer, CEO said, **"We are headquartered in Ireland because of Tyndall's synergistic work environment, and the unique research and commercialisation opportunities it offers through its relationships with renowned international technology companies."**

X-Celeprint is confident that it will create up to 20 technical and licensing jobs in Ireland during the next two to three years. The combination of their enabling technology and the development capabilities at Tyndall has the ability to entice other companies into Cork.

Kyle Benkendorfer, CEO X-Celeprint Ltd announcing its establishment at Tyndall.

CitySense - Keeping a Health Check on Our Cities

Internationally recognised Irish research and industry partners created a proof of concept project to use sensor technology to measure how everyday atmospheric conditions impact on people.

The **CitySense** study was supported by PCH, Tyndall, TSSG, NCAD and Vodafone Ireland. The multidisciplinary team developed a digital tracking device from initial concept to fully functional product in only three months. Tyndall and PCH provided the sensor technology to gather the atmospheric data while NCAD designed the usable sensor system. The Vodafone Ireland network and machine-to-machine technology experience enabled the transmission of the data collected which was then collated, analysed and presented by TSSG.

The environmental sensor and GPS equipment was mounted on 20 Cyclone Courier bikes along with volunteers from the Dublin Cycling Campaign to measure carbon dioxide, carbon monoxide, smoke and particulates, and temperature levels around Dublin city. The results allowed researchers to map information critical to the everyday functioning of the city and its inhabitants such as environmental pollution, traffic congestion, urban planning and policy development. The project was demonstrated successfully and the results revealed at the Dublin Web Summit in November 2014.

Minister for Skills, Research & Innovation, Damien English, TD, at the launch of the CitySense Project.

Tyndall Partner with Teagasc & TSSG

Tyndall signed new Memoranda Of Understanding (MOU) with both Teagasc and Waterford Institute of Technology's Telecommunications Software & Systems Group (TSSG), further developing collaborations in the agriculture and software space.

Tyndall's partnership with Teagasc will create smart agriculture technologies to increase Irish competitiveness in the agri-food sector. The MOU will provide the foundation for a series of projects aimed at making agriculture smarter and more efficient and it formalises an already fruitful partnership with a number of successful projects already completed.

One such project, IBR-Nano, enables the early detection of the harmful, and highly virulent, Infectious Bovine Rhinotracheitis (IBR) herpes virus. Novel nanosensor technology will enable rapid detection of the infected members of a herd while previously lab tests took up to 7 days to give results.

Tyndall's MOU with TSSG will help exploit the market potential of the Internet of Things (IoT). The partnership combines the industry leading expertise of both parties in hardware and software development, to create a full end-to-end offering in the IoT space. Tyndall and TSSG are currently collaborating on several projects to develop innovative technologies across the energy, agriculture, environment and health sectors. One project already underway will have transformative effects for the healthcare community by enabling tailored rehabilitation programmes.

Prof. Gerry Boyle, Teagasc; Simon Coveney TD, Minister for Agriculture, Food, the Marine and Defence; and Dr Kieran Drain, Tyndall, pictured at the signing of the MOU.

Dr Kieran Drain, Tyndall; Damien English TD, Minister for Skills, Research and Innovation; and Willie Donnelly, President of Waterford Institute of Technology, Chairman of TSSG, pictured at the signing of the MOU.

US Ireland - Pushing Out the Boundaries of ICT

Tyndall has been awarded funding for three projects under the US Ireland Research & Development Partnership. This partnership coordinates key funding agencies across the Republic of Ireland, Northern Ireland and USA to fund projects under a 'single proposal, single review mechanism' exploiting the synergies between the participants.

SuSChem aims to design and develop a new material, powered only by sunlight, to be deployed in power stations and turn the CO_2 waste products into liquid fuels.

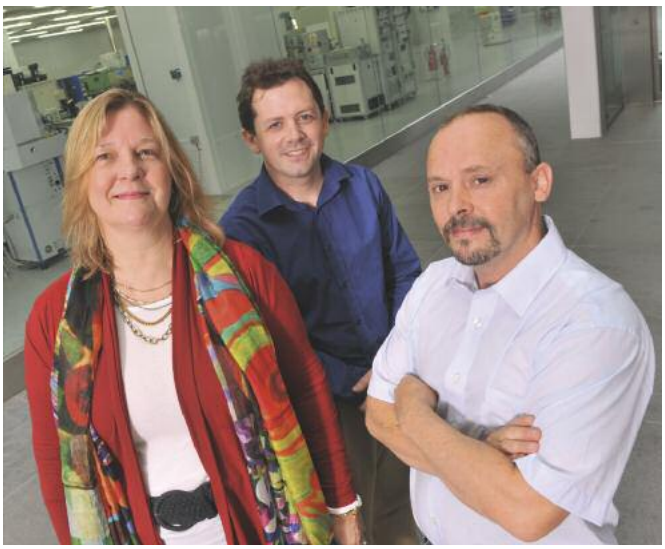
A successful outcome would have transformative effects on society's energy usage. The project has the dual benefit of reducing our harmful CO_2 emissions while also decreasing the global reliance on traditional fossil fuels.

The **UNITE** project is exploring new semiconducting materials in the miniaturisation of transistors. Researchers will create and test the properties of atomically-thin, 2-dimensional layers of semiconductors called Transition Metal Dichalcogenides which are 100,000 times smaller than the smallest thing the human eye can see.

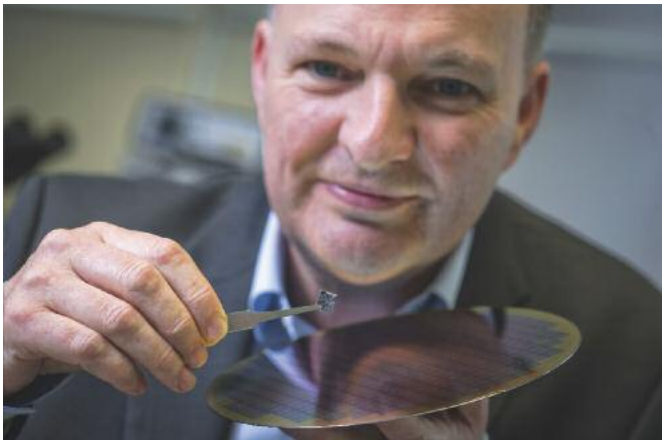
The properties these materials have displayed suggest that they could facilitate extremely efficient power usage and high performance computing. The application of these materials in transistors could prolong battery charge life as well as having applications in larger more power-intensive operations like data storage and server centres.

The **Nano-GaN Power Electronic Devices** project will seek to improve the efficiency of converting electrical power by up to 25%. Working with a substance called Gallium Nitride, researchers will look to stabilise the material so it can be used to convert high voltages to more manageable levels, without the current high energy losses.

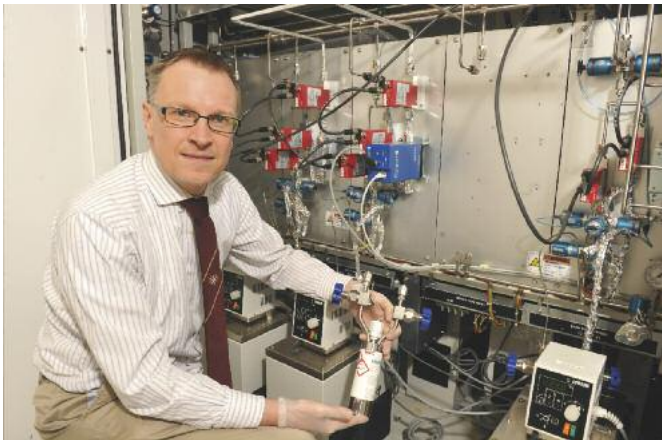
This will be the first time nanostructures using Gallium Nitride will be used for power electronics. The team will attempt to bend out material defects, making it more stable and hence more reliable in the conversion process. It has the potential to produce significant energy saving efficiencies that will be benefit people in the home and at work.



Prof. Kimberly Gray, Northwestern; Dr Michael Nolan, Tyndall; Prof. Tony Byrne, University of Ulster. Lead PIs on the SusChem project.



Dr Paul Hurley, Tyndall lead researcher on the UNITE project.



Prof. Peter Parbrook, Tyndall lead researcher on the Nano-GaN Electronic Devices project.

Tyndall Scorecard

People

- 113 PhD and 14 masters students pursued their studies.
- 27 students completed their PhDs.
- New talent hired to strengthen the organisation for delivery on our strategic objectives.
- Expansion of our EU support team.

Research Excellence

- SFI CONNECT Centre - Tyndall to lead the research into 'Making smart things for the Internet of Everything'.
- Dr Saibal Roy awarded Chair Professorship in Engineering by the Indian National Science Academy.
- More than 230 peer reviewed publications in 2014.
- Key research results in: ultrafast material restructuring with light, opening a new two micron wavelength band for optical communications and smart radio systems for wearable sensing.

Funding

- SFI centre CONNECT to contribute €7.5m over 6 years.
- Total EU income received was over €7m.
- 18% success rate in H2020 calls.
- Total industry contribution €5.3m.

Industry Engagement

- Tyndall recognised by IEEE Power Electronics Society as thought leader in Power-Supply-on-Chip development.
- Research contracts secured with two global top ten medtech companies.
- Over 80 SME and over 100 FDI company visits to Tyndall.
- X-Celeprint established its European headquarters at Tyndall.

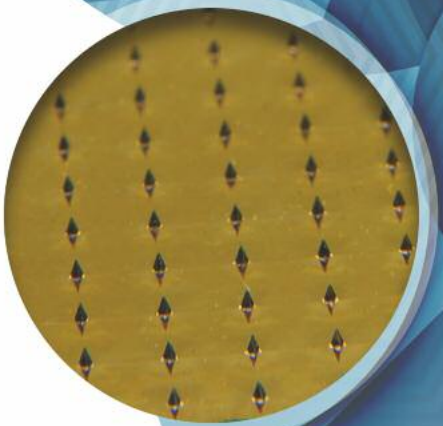
Infrastructure Access

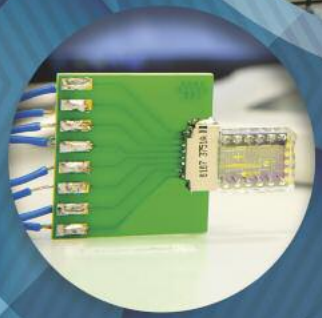
- Irish SME InfiniLED expanded access to our facilities in testing and packaging.
- Tyndall to co-ordinate EU project ASCENT with IMEC and CEA-LETI providing access to European nanoelectronics infrastructure.
- EU Gateone project commenced providing European SMEs access to research, technology and support services.
- Testing capabilities enhanced with addition of new advanced imaging systems.

Global Reach

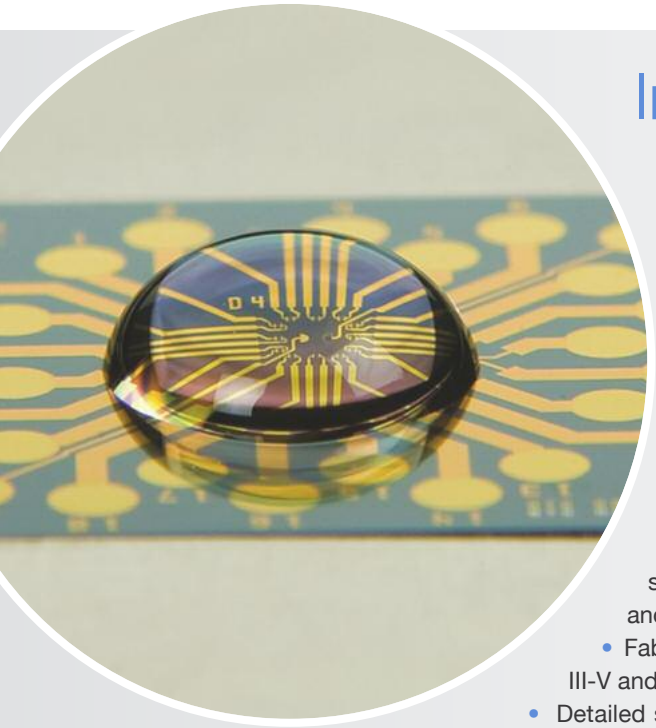
- International recognition award: Rank Prize for Optoelectronics - Eoin O'Reilly.
- Won 3 US-Ireland R&D Partnership Programme projects.
- Increased our reach in social media by 25%.
- Hosted 3 international conferences: Workshop on Bismuth, WODIM 2014, 3DIC.
- 44 nationalities working and studying at Tyndall.
- Partnering with over 400 organisations.

Research





Micro/Nanoelectronics



Introduction

Advances in the areas of electronics, data storage, sensing and renewable energy require new materials and devices to be developed to facilitate the need for further miniaturisation - following Moore's Law.

The Micro/Nanoelectronics Centre at Tyndall is active in the development of both materials and devices, exploiting the novel and often surprising properties that materials possess when prepared on the nanoscale.

Working closely with many industry and academic partners, researchers study the following key topics, which are directly aligned to the priority areas defined by Horizon 2020:

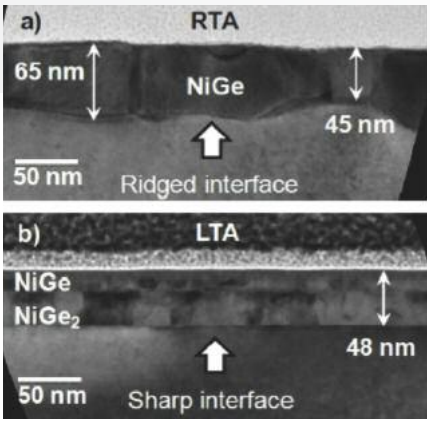
- Design and synthesis of novel nanoscale materials for use in areas such as transistor fabrication, fabrication of metal-insulator-metal capacitor structures, advanced lithographic structure delineation, novel sensor platforms and renewable energy (photovoltaic) applications.
- Fabrication and characterisation of novel nanoscale device structures on silicon, III-V and other substrates, including graphene and its derivatives.
- Detailed studies of the electrical and optical properties of these devices, including studies of doping and contact formation.

2014 was a very successful year for the centre; funding was awarded for several new projects with a combined value of up to €2 million, 4 notable papers were published in high-quality journals and 3 centre members received prestigious awards. Researchers were recognised for their extensive and highly productive engagement with industry partners, including Intel, Applied Materials, Philips Research, Boston Scientific, BD Medical and Teagasc. Further partnerships were developed with academics across the globe. Notably, researchers from Brazil travelled to Ireland to collaborate with Tyndall in the area of Advanced Materials and Nanotechnology, in a programme funded by the SFI International Strategic Cooperation Award.

Patent Granted for Improved Low Resistance Contacts for Semiconductor Devices

There are almost 7 billion mobile electronic devices in the world. The increased accessibility to technology we all enjoy is a direct result of making the component parts (transistors) increasingly smaller and therefore cheaper.

Transistor fabrication involves many processes, one of which is forming metal contacts to the semiconductor substrate. This process has become more challenging as transistor size and design has evolved. The work patented by Ray Duffy and Maryam Shayesteh of the Micro/Nano-electronics Centre, used state-of-the-art Laser Thermal Annealing (LTA) to form germanide (i.e. metal-germanium alloy) contacts on n-type doped germanium.



Representative Cross-Sectional Transmission Electron Microscopy Images of Nige Layers Formed By **(a)** 350°C Rapid Thermal Anneal (RTA) and **(b)** Laser Thermal Anneal (LTA) With Energy Density of 0.45 J/CM^2.

The industry standard approach is to use Rapid Thermal Annealing (RTA) for germanide formation, but this results in an uneven and poorly defined interface with the substrate. Through using LTA, the germanide-substrate interface was extremely sharp without any detectable interfacial region or transition zone. The electrical performance yielded one of the best contact resistivity values obtained world-wide for this material system.

UCC President's Award for Research Impact

Tyndall Associate Researcher and UCC Lecturer in Physical Chemistry, Colm O'Dwyer received the President of UCC Impact Award for Research. Colm, who works in Applied Nanoscience, was honoured for his outstanding achievements in creativity and innovation, building collaborations, identifying and developing strategic opportunities and his self-starter capability.

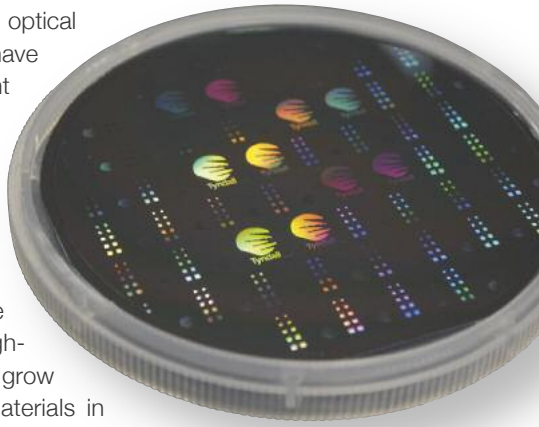
The Selection Committee was particularly impressed by his role in developing a wide range of high-level research collaborations, both nationally and internationally, leading to significant research funding and industry collaborations; his role in pioneering a number of innovative scientific and commercial discoveries; his contribution to research-led teaching; and his role in promoting science to the wider community via scientific and other media.

Dr Colm O'Dwyer received UCC Impact Award for Research.

Colm is currently working on the development of advanced Li-ion battery materials and diffractive optics in order to elucidate charging and discharging mechanisms and improve overall functionality. Li-ion batteries that are safe, stable with long lifetimes and short charge times are important both for consumer electronic devices and charge storage for solar cell technologies.

High Aspect Ratio Iridescent Three-Dimensional Metal-Insulator-Metal Capacitors using Atomic Layer Deposition

In a world first, Micheal Burke and colleagues demonstrated the power of Atomic Layer Deposition (ALD) for the production of hybrid capacitor devices which combine unique electrical and optical signatures. The devices also have a significantly reduced footprint on chip – some ten times smaller than that occupied by conventional on-chip capacitors.



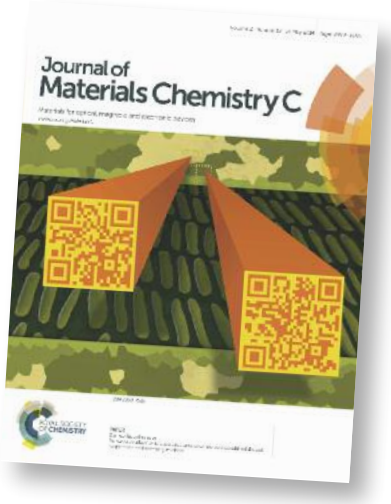
Iridescent capacitors grown by ALD on patterned trenches and vias.

This research, published in the Journal of Vacuum Science & Technology A (JVST A), highlighted the power of ALD to grow highly conformal layers of materials in very high aspect ratio structures. The structures produced form an array which is periodic on a scale that is comparable to the wavelength of visible light. As a result the structures display pleasing iridescence similar to the kind of structural colour observed from opal gemstones and the wings of certain butterflies. These findings could be used together with the electrical response in anti-counterfeiting security tags.

Spotlight on Arrays of Gold Nanorods

Ground breaking research on the production of oriented arrays of gold nanorods, by Daniela Iacopino and colleagues, was selected as the cover feature for the highly-rated Journal of Materials Chemistry C.

The dimensional anisotropy of gold nanorods results in strong polarisation-dependent surface-plasmon-based optical properties. Therefore, gold nanorod assemblies are ideal candidates for the preparation of optically anisotropic superstructures that allow manipulation of light at the nanoscale.



Arrays of nanorods help to improve the sensitivity of spectroscopic sensors that can be used to detect individual molecules and are finding application in areas such as medicine, health and security.

Microsystems

Introduction

Over the next decade, the Internet of Things (IoT) will grow into an interconnected web of billions of embedded smart sensors which will transform how we live our lives, how we interact with our environment and how we manage our natural resources.

The Microsystems Centre at Tyndall is developing microelectronics and microsystems technologies for the next generation of 'deploy and forget' smart sensors. These sensors will be tiny, low cost and have an indefinite lifetime. In effect, Tyndall is making the smart things for the future 'Internet of Everything'.

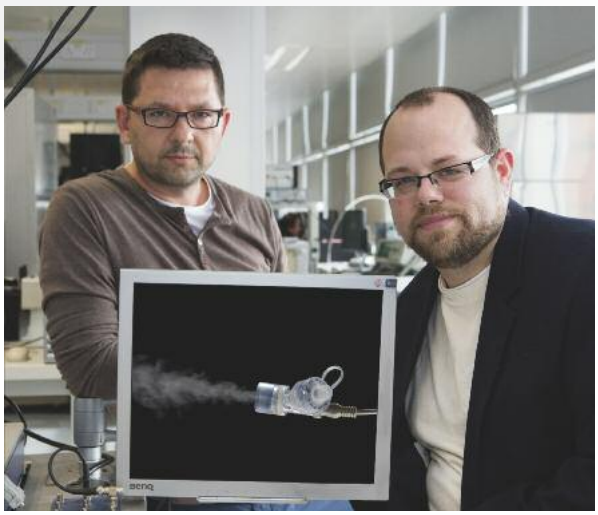
2014 highlights include:

- The funding of the €40m Science Foundation Ireland CONNECT Centre to undertake industry-relevant research into future broadband, cellular and Internet-of-Things networks. Tyndall is leading research into the "Smart things for the Internet of Everything".
- Technology licensed to Analog Devices and Brockley.
- The launch of GRASP Wearable Technologies, a new company in smart wearable sensors for sports and fitness.
- UCC Staff Recognition Award to Brendan O'Flynn, whose Wireless Sensor Networks team have delivered 15% of all UCC licenses over the last 5 years.
- Development of the "CitySense" demonstrator at the Web Summit, an 'urban nervous system' using sensor technology on bicycles around Dublin. Collaborators included TSSG Waterford, the National College of Art & Design, PCH and Vodafone Ireland.
- The kick off of EU FP7 project, MANPOWER, and the funding of the H2020 TIPS project, both coordinated by the Heterogeneous Systems Integration Group.

Next Generation MEMS-Based Nebuliser for Aerosol Therapy

Nebulisers are medical devices that convert liquids into aerosol droplets to help deliver drugs directly to the lungs and are commonly used for the treatment of diseases such as asthma. The **INHALE** project, led by Tyndall in collaboration with Aerogen and Analog Devices, aims to develop next generation nebulisers by integrating piezo-MEMS capabilities from Tyndall into the market-leading nebulisers from Aerogen.

The first stage of the project successfully developed a MEMS-based version of the core element of the nebuliser namely, Aperture Plate (AP). The Tyndall version of the AP is fabricated in their CMOS Fab and provides potential for lower cost and more sophisticated aerosol generators.



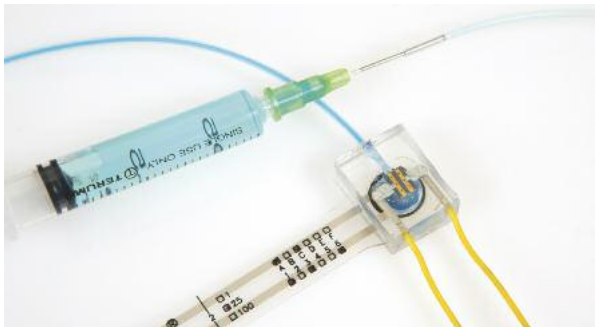
Dr Zbigniew Olszewski (Oskar) and Dr Nathan Jackson, Tyndall researchers on the INHALE project.

The first versions of Tyndall's AP were integrated with the nebulisers from Aerogen and were proven to generate the aerosol.

Microneedle Technology for Next Generation Wearable Health Monitoring

Tyndall has an established track record in the development of microneedle technologies for diagnostics and therapeutics applications. In collaboration with leading pharmaceutical companies, these microneedles have been extensively evaluated, through mechanical and preclinical tests, to verify their suitability as wearable transdermal devices.

Originally targeting drug delivery, Tyndall continues to develop this platform technology for the next generation of wearable health monitoring. Ongoing research includes developing solutions for real-time analysis and continuous monitoring of biomarkers in interstitial fluids, as well as providing dry electrodes for electrophysiological monitoring through EEG, ECG and EMG.



Prototype 'smart' microneedle patch featuring integrated pressure and impedance sensors for real-time delivery system performance monitoring and control.

These technologies and capabilities are now being combined into integrated smart patch wearable theranostic healthcare solutions, which will combine diagnostic and therapeutic capabilities into wearable smart systems. These will allow for the controlled release of therapeutics activated through embedded software or through remote activation using wireless telemedicine links to the clinical expert. This breakthrough research is being funded by Science Foundation Ireland, Enterprise Ireland and industry partners.

Smart Radio Systems for Wearable Sensing

Small, power efficient and lightweight smart sensors are key for unobtrusive, wearable monitoring systems for healthcare, fitness monitoring and the provision of assistive technologies for elderly-care in the home.

A major challenge is the adverse effect of antenna detuning due to the human body, as it leads to reduced wireless performance and increased power consumption because of the reflection of electromagnetic energy from the antenna.

The Wireless Sensor Networks Group at Tyndall is developing smart radio front ends to optimise the size and efficiency of ISM band wireless systems for body area networks designed to optimise data throughput from such systems with maximum power efficiency.

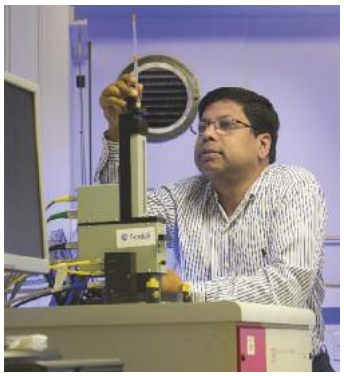
Smart antenna technology for future wearable devices.

In a recent publication in Electronic Letters, the group reported on the development of a new type of planar antenna that operates in the medical ISM band of 433 MHz. The antenna is compact in size and is fabricated on low-cost, FR4 material.

A 'Smart Antenna' based on this topology has now been developed. This antenna, unlike existing solutions, has intelligence with the ability to tune itself, regardless of its placement and proximity to the user, thereby minimising energy dissipation due to antenna reflections. This results in improved wireless performance, tolerance of fabrication variations, reduced power dissipation and increased battery lifetime and has important consequences for implementing future smart sensors for the Internet of Things.

Novel Magnetic Phenomenon – Basis of Future Memory Devices

Saibal Roy along with his PhD student Tuhin Maity reported the first demonstration of a nano-chain of $BiFeO_3$ showing a huge asymmetric exchange bias.



Dr Roy taking measurements in a SQUID Magnetometer.

The researchers have shown for the first time that the exchange bias, which refers to a big lateral shift of the magnetic hysteresis loop due to coupling between a ferromagnetic and an antiferromagnetic phase, is tunable depending on the nature of the magnetic field applied to a particular nanocomposite phase. The findings were published in the Physical Review Letters.

This core capability yields new and complex magnetic properties which have possible use in advanced sensors and magnetic memory for digital data storage. The findings enable Tyndall to develop new and advanced sensors to detect subtle changes in the electromagnetic spectrum from physical phenomena, or to investigate novel magnetic memory devices.

The research has been undertaken in collaboration with a team from a premier Indian research institution, Central Glass and Ceramic Research Institute (CGCRI) and was performed under an Indo-Ireland research programme supported both by Irish and Indian government funding.

Photonics

Introduction

The Photonics Centre at Tyndall is driving new advances in photonic science including the fundamentals of light emission and detection processes in nano- and micro-photonic materials and devices. These innovations are being harnessed to provide application solutions in partnership with industry.

The research and commercialisation activities span the following areas:

- Semiconductor materials and devices
- Microelectronics
- Photonic integration and packaging
- Advanced photonic systems for information transport, storage and display
- Environmental sensing
- Medical device applications

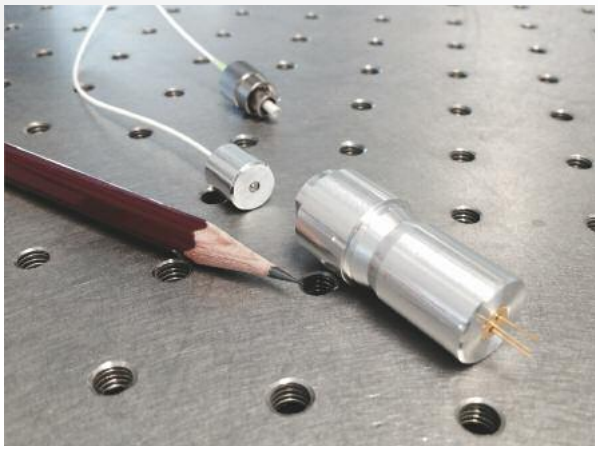
Photonic integration is one of the key research themes for the centre. Similar to the development of electronic integrated circuits some fifty years ago, the aim is to enable much higher levels of functionality whilst simultaneously reducing the cost and size of devices. The main vehicle for this programme is the Science Foundation Ireland (SFI) funded Irish Photonic Integration Centre (IPIC), in partnership with Cork Institute of Technology (CIT), Dublin City University (DCU) and University College Cork (UCC). IPIC brings together Irish research expertise in photonics and biomedical science along with 20 industrial partners to develop technological solutions via photonic integration.

The research will use photonics to enhance point-of-care medical diagnostics, minimally invasive patient monitoring, screening and surgical procedures, and to enable continued growth of communication systems and the internet. IPIC represents a combined SFI and industry investment of some €24m in Irish photonics research over the period 2013-2019.

Licensing Agreement with ProPhotonix

ProPhotonix Limited, a designer and manufacturer of LED illumination systems and laser diode modules with operations in Cork and the UK, entered into an exclusive worldwide licensing agreement with Tyndall and CIT. The license agreement covers high power fiber-coupled laser module technology, developed through an Enterprise Ireland Innovation Partnership Programme, in collaboration with CIT CAPPA and the Photonics Packaging Group at Tyndall.

Simon Stanley, Managing Director, ProPhotonix Ireland, stated "We are delighted with the success of our collaboration with Tyndall and CAPPA and look forward to working together in the future to expand photonics technologies. These new capabilities provide a platform to develop a range of innovative product solutions for our customers in the industrial, security and medical markets, for a diverse range of applications including food and pharmaceutical product sorting and semiconductor and biomedical inspection systems. The technology was developed to be "production ready" and ProPhotonix launched this new capability at Photonics West, in San Francisco".

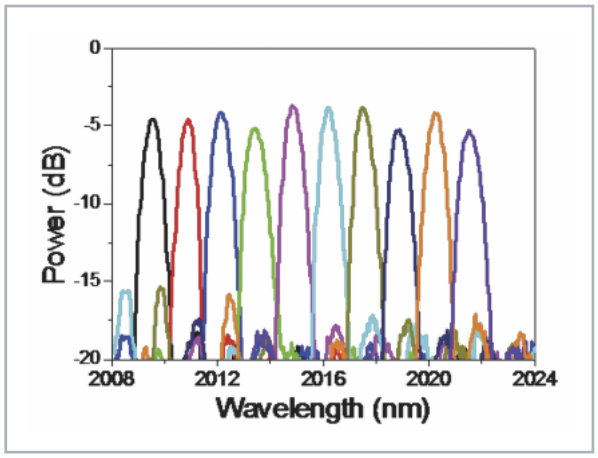


High power fiber-coupled laser module.

Opening a New Two Micron Wavelength Band for Optical Communications

Researchers at Tyndall, led by Brian Corbett, developed a suite of state-of-the-art high bandwidth (10 GHz) optical components operating at a wavelength of two microns.

In particular, the team demonstrated the first InP based Mach-Zehnder modulators, which in combination with arrayed waveguide grating multiplexers with 100 GHz channel spacing and 10 GHz photodiodes, allowed the first Dense Wavelength Division Multiplexing optical communication experiments at this wavelength band. These components will prove very valuable in a range of additional applications especially in sensing CO_2.



Two micron wavelength optoelectronic device results.

The work was carried out under the EU FP7 MODEGAP project with external partners and significant cross-centre internal collaboration, with growth, design, fabrication, packaging and systems test all performed at Tyndall.

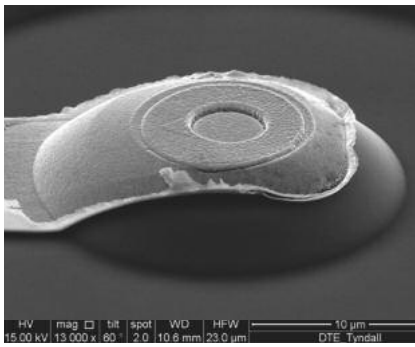
The results were presented at an invited talk at the leading European Conference on Optical Communications (ECOC 2014) in Cannes, France.

First Ever Fabrication of Deep Ultraviolet Micro LEDs

In a project funded by the European Space Agency, Peter Parbrook and the III-Nitride development team achieved the first ever fabrication of deep ultraviolet micro LEDs.

The devices emit at 250nm and can be used to discharge gold-platinum test masses by photoelectron emission. Their key application will be compact, lightweight and low power replacements for mercury lamps in space-borne gravitational wave detectors, where electrostatic attraction due to charging of the test masses can otherwise swamp the microscopic displacements caused by weak gravitational effects.

The team has achieved its first devices with a multiple quantum well AlGaN based epitaxial structure that was developed at Tyndall. Through controlled etching of the wafer, quasi-parabolically shaped microLED structures were used to enhance the light extraction through the sapphire substrate. A fibre coupled package for these LEDs was also developed.

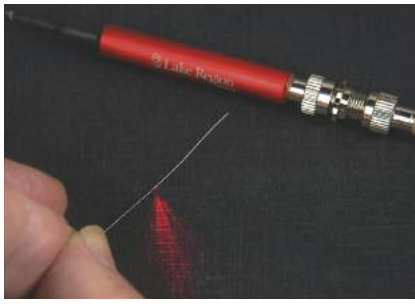


A single 16µm diameter DUV microLED.

Photonic Sensors on Arterial Guidewires

The Photonics Packaging Groups at Tyndall and the CIT CAPPA group within IPIC, delivered twenty demonstration prototypes of a minimally-invasive surgical device (sensor on guidewire) to partner, Lake Region Medical. The company demonstrated the technology to potential customers at the Transcatheter Cardiovascular Therapeutics Conference in Washington DC.

Tyndall continues to work with the company to develop a highly miniaturised optical fibre connector (<350µm diameter) and to evaluate the prototypes under full clinical trials.



Photonic sensor technology in medical guidewire.

New Lasers for Optical Coherence Tomography (OCT)

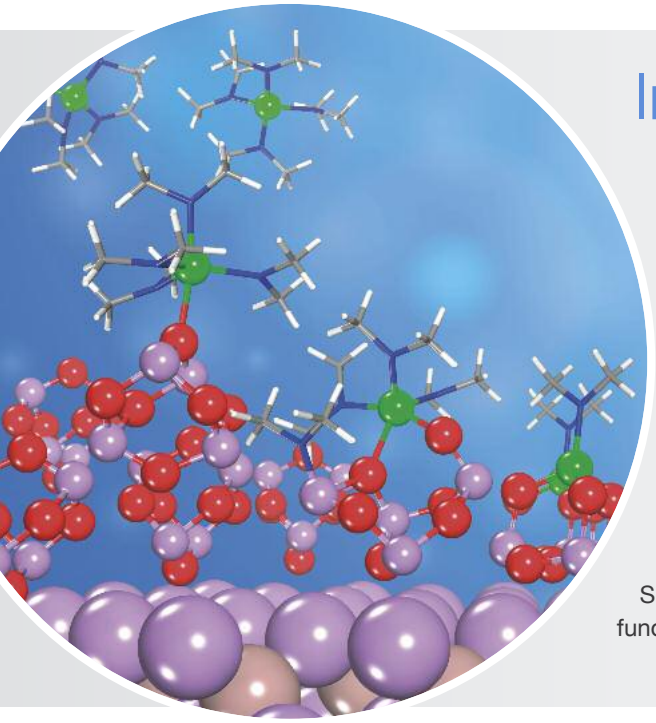
The work of a team of CAPPA researchers, led by Svetlana Slepneva, on the dynamics of a short cavity swept source OCT laser has been promoted by OCTNews.org, a high-profile resource for the OCT community.

Fast, frequency swept lasers are required for Optical Coherence Tomography (OCT) tissue analysis, for example, where a wide frequency range translates to higher depth resolution and high sweeping speed enables fast 3D image construction.

The article describes the group's work on experimental characterisation and numerical modelling of a fast frequency swept laser source used in OCT. It details the various lasing regimes (mode hopping, sliding frequency mode locking and chaos), explains their origin and uses the model to provide guidelines for further laser OCT performance optimisation.

Dr Guillaume Huyet, Dr Svetlana Slepneva and Ben O'Shaughnessy.

Theory Modelling & Design



Introduction

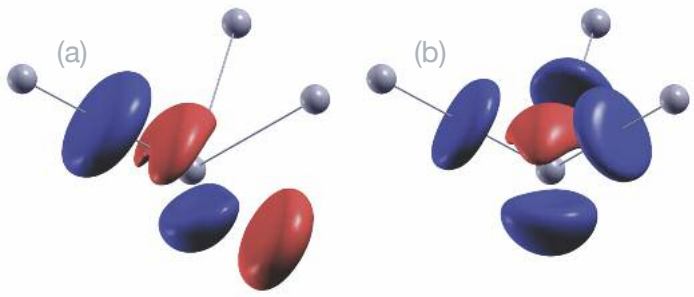
The Theory Centre at Tyndall researches fundamental materials analysis and physics investigation through to circuits and systems design.

The centre is built upon a strong cohort of researchers, who make a major contribution to Tyndall's overall reputation and impact. 2014 highlights include Peter Kennedy's election as a Fellow of the Irish Academy of Engineering and Eoin O'Reilly winning the prestigious 2014 Rank Prize for Optoelectronics. Eoin received the award for his pioneering work on strained-layer laser structures, which today underpin all optical fibre communication, from long-haul to local area networks, and act as power sources for optical amplifiers – making undersea networks possible.

2014 was a very successful year for centre funding, including several individual SFI awards (Kennedy, Greer & Fagas, Schulz) as well as new EU and industry-funded projects and centre awards.

Ultrafast Material Restructuring with Light

Light pulses which last for much less than a picosecond (a millionth of a millionth of a second) are capable in principle of driving permanent transformations of certain materials.



Changes in electron density induced by optical excitation in bismuth for two different directions of light polarization. By choosing the light polarization, different types of atomic motion can be induced.

The Materials Theory Group are collaborating with colleagues in the USA and Germany, to investigate how such "ultrafast" light pulses alter the forces between atoms and might be used to drive rapid changes in the arrangement of atoms in materials.

These physical processes have applications in artificial photosynthesis, photocatalysis and ultrafast all-optical memory devices.

Éamonn Murray and Stephen Fahy have recently developed advanced quantum simulation methods to predict such forces, calculating optically-induced atomic motion in bismuth, which has been studied experimentally by their collaborators. Their calculations, recently published in Physical Review Letters, demonstrate how absorbed light alters the distribution of electrons in the material and drives atoms away from their normal equilibrium positions.

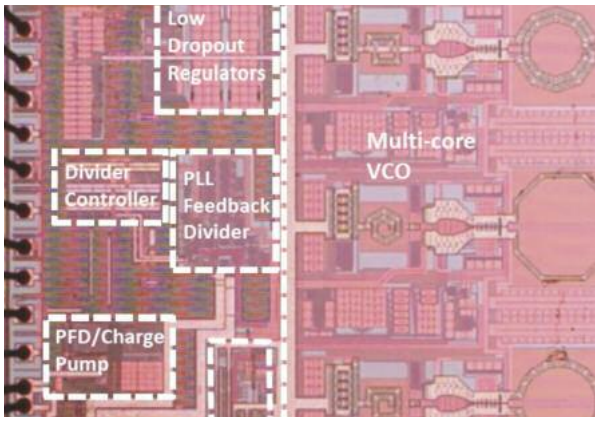
High-Performance Fractional-N Frequency Synthesiser

Fractional-N frequency synthesisers are used to generate carrier signals in almost all wireless communication links. Conventional synthesisers approximate rational numbers using an integer numerator and a denominator that is a power of two; this fundamentally limits their accuracy.

For example, with a network reference frequency of 122.88 MHz, a classical power-of-two synthesiser in a cellular base station produces 4 GHz with an error of approximately 2.44 Hz. To the system, this frequency error is like an off-tune radio.

By removing the requirement to use a power of two, Peter Kennedy and his group developed a mixed-radix architecture which advances the state of the art in terms of frequency accuracy.

The resulting synthesiser can produce exactly 4 GHz. With exact tuning, digital information can be transmitted with fewer errors, reducing the need to retransmit messages. This, in turn, makes the communication links more energy-efficient. The underlying concept, a nested digital delta-sigma modulator, was granted a US patent in 2014.



Micrograph of prototype synthesiser. The patented circuitry is labeled "Divider Controller".

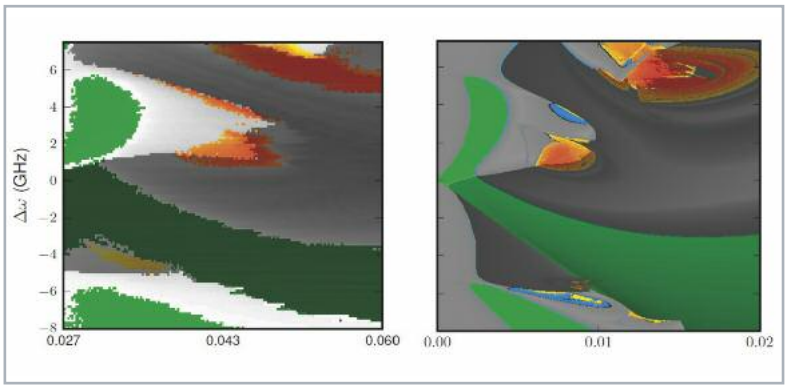
To prove the concept, a prototype fractional-N synthesiser with a nested mixed-radix modulator was implemented in 0.18 µm SiGe BiCMOS in collaboration with Analog Devices. The silicon chip which validates the idea was described in an invited paper in the IEEE Journal of Solid-State Circuits. The figure above shows a micrograph of the prototype mixed-radix synthesiser; the die size is 2.6 x 2.6 mm^2.

Prediction and Control of Complex Response of Two-Colour Lasers

Semiconductor lasers display a very complex response to external perturbations, such as light injection from another laser or light source. This response becomes even more complex in two-mode lasers, where two colours are emitted at the same time.

Tyndall researchers have demonstrated how these two-mode lasers can be used to design memory elements which can be switched by purely optical means. The theoretical and experimental characterisation of the lasers poses a significant challenge – however Tyndall PhD student David O'Shea, supervised by Andreas Amann, has made significant progress.

In the left panel of the figure (top right of this page), the experimental response of the laser to an external light input is shown, where the injection strength and frequency of the input light are on the x and y axes, respectively. Different colours indicate different dynamical regimes.

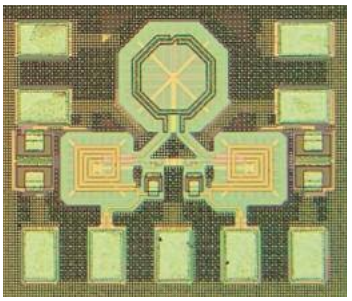


Surprisingly, this complex dependence is well reproduced by a relatively simple theoretical model as shown in the right panel. These results provide an important benchmark for the correctness of the theoretical description and its application to laser design and further analysis.

High-Frequency CMOS Active Inductors

Inductors are used to generate carrier signals for wireless communications. Classical inductors comprise multiple turns of wire while in integrated circuits, the coil is usually a single turn of metal. Such passive inductors are of poor quality compared to their wirewound counterparts.

A potential way to emulate a high quality inductor on an integrated circuit is to supplement a poor inductor with transistors. This is called an active inductor. The full potential of active inductors has not yet been achieved because of a lack of accurate design methodologies and limitations due to inherent noise sources.



Chip photograph. The total area is 0.21 mm^2 (Pads inclusive).

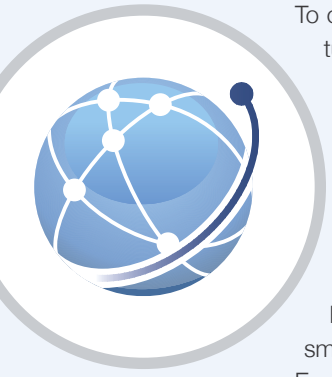
Domenico Pepe and Domenico Zito addressed these two open issues for a high-frequency (>10 GHz) CMOS active inductor characterized by high-quality factor, low-power consumption, and low noise. Firstly, they showed an effective and reliable design methodology in modern nanoscale CMOS technologies. The experimental results showed equivalent inductance of a few nanohenry with associated quality factor in excess of 200. Secondly, they demonstrated the very low noise contributions, resulting in a noise power spectral density lower than -150 dBm/Hz.

These results enable the application of such inductors for the implementation of a high-quality factor low-noise LC tank in high-frequency building blocks of radio frequency front-ends.

Tyndall Solutions

Communications & Electronics

Electronics and photonics underpin the information systems that impact every facet of human endeavor today. Access to information anytime, anywhere wouldn't be possible without the intelligence, visual interfaces and communication technologies that underpin our smart phones, computers and indeed the global internet that connects us all together. These technologies depend on the availability of low power, low cost electronics and photonics for their operation.

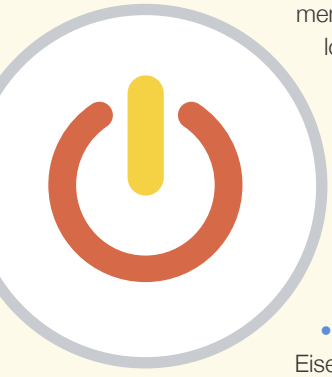


To continue this data revolution, we are exploring new approaches to electronic and photonic materials, manufacturing, components and systems including:

- The exploration of alternative semiconductor materials to replace traditional silicon transistors for technology being envisioned for the next 5 to 10 years.
- Design of manufacturing techniques that grow materials atomic layer by atomic layer, allowing for the material thickness control needed for the realisation of nanoscale electronic devices and coatings and light emitting LEDs and lasers with wavelengths spanning from the UV to the infrared for applications in displays, sensing and optical fibre communications.
- The development and integration of novel devices into circuits that can sense chemicals and gases, measure heat and radiation, micro- and nano-mechanical systems energy harvesting as required by new embedded in smart system applications.
- Exploiting material properties due to novel effects arising on nanometer length scales for new, lower cost, lower power, increased functionality switches and wires to enable increased mobility and connectedness for products that form the physical layer for the Internet of Things.
- New systems that allow optical data to be transmitted directly to the consumer ("Fibre-to-the-home") in highly energy-efficient ways and new techniques to increase the capacity in the core of the internet by using multiple colours of light together with novel data modulation and digital signal processing schemes to send information over a single optical fibre with minimal interference.

Energy

Integrating ICT into the systems and equipment in our home, workplace and outdoor environment offers an enormous opportunity to reduce energy consumption and deliver smarter and greener solutions.



Energy harvesting technology enables us to deploy self-powered wireless sensors without the need for battery replacement. These sensors are used to optimise energy usage in buildings and to interact with the smart grid to minimise load peaks and maximise renewable energy usage.

Wireless sensors are also used for conditional monitoring of equipment to determine when operating anomalies occur, thereby ensuring efficient and reliable operation.

Miniaturisation technologies such as power supply on chip and thin film magnetics on silicon enable us to design smaller and more efficient high frequency power supplies for a broad range of applications, from smart phones and tablets to microprocessors in servers and radio base stations.

Key research activities in 2014 included:

- Discrete soft magnetic thin film cores for offline power applications for commercial validation. Sponsored by Eisergy Nuvotem Talema and Excelsys Ltd. and Bourns Electronics.
- Novel integrated magnetic thin films for digital isolation applications. Sponsored by Analog Devices Ireland and TEL Magnetic Solutions.
- 3D power electronic packaging based on PCB embedded magnetics.
- Wireless Sensor Network energy micro-generation and storage platform for the smart grid.
- Simulation tools to assess the feasibility of energy harvesting in powering WSN nodes in commercial buildings.

Healthcare

Tyndall is shaping the future of precision medicine through researching and developing a new generation of smart medical devices. The unique ABC (Academic, Business, Clinician) ecosystem sees researchers working closely with academic partners, global leaders in medtech and pharma industries, and in collaboration with clinical experts to ensure that Tyndall solutions have both clinical utility and commercial opportunity.

Tyndall's core capabilities in this area include micro and nanotechnologies, photonics, electronics and smart systems. Through these leading capabilities, we deliver novel solutions including:

- Diagnostic devices based on optical and electrochemical platforms for point of care testing of nucleic acid, protein and cell biomarkers. A novel x-ray system is being enabled through the development of a solid state x-ray emission device.
- Connected Health solutions through integrating sensors for continuous measurement of inertial, electro-physiological and biochemical parameters on wearable and non-contact systems. These include proprietary algorithms within embedded software to extract the clinically relevant events through data fusion.
- Drug delivery systems to enable painless transdermal therapeutic delivery through a smart patch. Our smart needle system enables a safe delivery of anaesthesia for a peripheral nerve block.
- Neuromodulation devices to treat urinary incontinence and novel electronic components for cardio rhythm management including an energy harvesting system to power next generation pacemakers.
- Sensorised surgical tools, including guidewires and catheters to enable real time intraoperative measurements of tissue parameters to facilitate better clinical outcomes especially in cardiology, orthopaedics and anaesthetics.

ICT for SAFE

(Sustainable Agriculture, Food and the Environment)

The future growth of Ireland's agri-food and marine industry, our largest indigenous industry, is based on a strategy of ensuring the highest possible returns are secured for the high-quality food produced through traceable, sustainable and information-driven production practices.

Meanwhile, the Internet of Things (IoT), through new, smart, connected products and systems with embedded IoT sensors, are creating new manufacturing efficiencies, products and services that redefine the customer value proposition.

The interface between ICT and agri-food represents an ideal opportunity for Ireland to achieve the ambitious goals set forth under the innovation agenda in Ireland's Harvest 2020 strategy.

During the Tyndall Technology Days in November 2014, Tyndall formally launched a strategic programme in the area of ICT for Sustainable Agriculture, Food and the Environment (SAFE). It brings together 10 research teams across the institute who have been working in this space for more than a decade.

Key areas of research include:

- Microsystem technology for food and beverage.
- Nano-chemical sensors for in-the-field animal health diagnostics.
- Chemical instrumentation for water quality monitoring in harbours.
- Environmental sensors.
- Photonic sensors for water quality monitoring in fishery and fish production.

Industry

Total industry contribution amounted to ***€5.3m*** *in 2014.*

Tyndall's core goal is to deliver economic impact through research excellence. Our close engagement with industry ensures that we remain focused on delivering results aligned to its needs.

In the 33 years since Tyndall and its forerunner, the National Microelectronics Research Centre, were founded, Tyndall has developed and maintained strong links with industry, both indigenous SMEs and large multinational companies. In the early years, this was primarily with companies in the computer, electronic component and communications sectors, but with a strategically focused effort over the last 5 years this has expanded due to increased competence in healthcare applications, with energy, food production and the environment targeted for future growth.

The development of the Industrial Internet means that our core expertise in ICT hardware and systems can provide solutions to the challenges facing a growing number of industries that traditionally would not have looked on ICT as a key enabling technology.

Industry engagement takes place through:

- Collaborative research projects.
- Industry Researchers-in-Residence.
- Access to facilities such as wafer fabrication (including compound semiconductor, silicon CMOS and MEMS), device forensics (including electron microscopy analysis facility, design technology evaluation and packaging and reliability) and contract research.
- Licensing of existing technologies.
- Start-up incubation.
- Spin-out and spin-in of new technology companies.

During 2014, Tyndall engaged with 97 industry partners, 63 of which were Irish based and 34 were based internationally. Total industry contribution amounted to €5.3m in 2014.

Some examples of these collaborations include:

- Development and manufacture of demonstrator product (high power UV laser modules) for Irish high potential start-up ProPhotonix and an exclusive worldwide license agreement around the high power fibre laser module technology.
- Development of micromachinable components for nebulisers for Irish healthcare SME Aerogen.
- Development of wireless sensor system for Irish chemicals SME Brockley Group.
- Hosting US/Irish high potential start-up operations of Advanced Micro-Transfer-Printing Technology Solutions provider X-Celeprint.

Many of these engagements are enabled by Enterprise Ireland grant funding, such as Innovation Partnerships, Commercialisation Funds and Feasibility Studies. The 51 projects submitted during 2014 and supported by Enterprise Ireland amounted to €5.4 million. To date, Tyndall has won 12 projects under the 2014 Horizon 2020 calls and is a coordinator of four of them. These successes are worth almost €7m for Tyndall with an additional €2.3m going to other Irish participants of which €1.6m went to industry partners.

Technology licensing is an important part of our industry engagement. Development of technology to the point where it can be licensed to industry or form the basis for a new start-up enterprise is frequently enabled by Enterprise Ireland's Commercialisation Fund support.

Two particular areas of technology developed over the past 10 years, which are leading to significant licensing and start-up opportunities, are:

- MicroLED's for display technology
- Integrated Magnetics on Silicon – enabling a Power Supply on-chip (PwrSoC) through the integration of the passive components

Brendan O'Flynn receiving a UCC award from President Michael Murphy in recognition of his team delivering 15% of all UCC licenses over the last 5 years.

University College Cork's Technology Transfer Office finalised 11 contracts which license Tyndall developed technology during 2014. Companies licensing Tyndall technology range from foreign owned multinationals with important Irish facilities, such as semiconductor manufacturer Analog Devices and medical devices company Stryker to Irish SME's Eblana Photonics and Pilot Photonix.

Tyndall continues to be an important source of world class graduates for industry. The supply of highly skilled graduates, world class research activity and the national commitment to research and innovation implicit in the Government's investment in Tyndall continues to be a persuasive instrument for the Industrial Development Authority (IDA) in attracting new Foreign Direct Investment (FDI). During 2014, over 100 potential FDI IDA clients visited Tyndall.

Tyndall held its second Technology Days event in November 2014. The unique format of this event brought together industry leaders, technology experts and end-users to give a 360° view of how world leading ICT can deliver growth for the Health, Agriculture, Food and Environment sectors. The three-day event was attended by 300 people, half of which were from industry.

In order to achieve the ambitious industry targets set out in Tyndall's strategic plan, the business development team has expanded with the appointment of Commercial Director, Ultan O'Raghallaigh and Head of Business Development, Hugh Smiddy. Their valuable commercial expertise will help to enhance Tyndall's business engagement and grow industry funding.

Company	Licenced Technology
United Technologies Research Center	Demonstration of a MEMS-Based Ionization Source
Radisens Diagnostics Ltd.	Compact Multichannel Fluorescence Detection Sub-System
Casperdaisy Ltd.	Miniaturised System for Detecting Shower Usage and Alerting
Magnomics	Apparatus & Methods for Frequency Modulated Biomolecular Recognition Detection & Manipulation on a Biochip
Grasp Wearable Technologies	WIMU Platform for Motion Analysis
Stryker Corporation	Smart Surgical Instruments
Analog Devices	Non-poled d33 Operated Piezoelectric Materials and Device Concepts
ProPhotonix (IRL) Limited	Opto-mechanical Design of Fibre Coupled UV Laser Module
Eblana Photonics Limited	Design of Photonic Integrated Circuits Software Package
Pilot Photonics	Design of Photonic Integrated Circuits Software Package
Pilot Photonics	Four-channel Demultiplexer Using Injection Locked Slotted Fabry-Perot Lenses

Case Studies

> My experience with Tyndall researchers thus far is that they are amongst the most productive and "industry savvy".

Aerogen®

Founded in Galway in 1997, Aerogen specialises in the design, manufacture and marketing of aerosol drug delivery systems aimed at the critical care respiratory market. Its products are used to treat patients on life-support ventilation in over 65 countries worldwide.

Aerogen invests heavily in its R&D in order to evolve and extend its product range. To this end it built strategic alliances with Tyndall, to enable it to leverage home grown scientific excellence to facilitate its rapid growth.

The joint INHALE proposal received CCAN (Collaborative Centre for Applied Nanotechnology) funding for 2014 - 2015 and the project has progressed from there.

Dr. Ronan MacLoughlin, Senior Scientist with Aerogen, is as fulsome in his praise of the research carried out at Tyndall as he is for the manner in which the client relationship is handled.

MEMS-based version of Aperture Plate integrated into Nebuliser.

During 2014, Aerogen collaborated with Tyndall on a research project known as 'INHALE'. The PiezoMEMS team at Tyndall, which focuses on development of MEMS (Micro Electro Mechanical System) devices and development of novel Piezoelectric materials, realised that there was great synergy and therefore an opportunity for both parties to collaborate.

Knowing the industry need for new technology to enhance the efficiency of drug delivery, reduce costs and increase functionality, Nathan Jackson, lead Principal Investigator (PI), successfully pitched the research idea to Aerogen. It centres on bringing MEMS fabrication techniques and thin film piezoelectrics to the nebuliser market.

"My experience with Tyndall researchers thus far is that they are amongst the most productive and "industry savvy" I have ever come across in all my interactions with academic institutions from around the world. The researchers appreciate my approach and understand the requirement for rapid progress, and the reporting of same. They are exceptionally knowledgeable in their respective fields and have the capacity to apply that knowledge in other applications. This is not a common thing."

Aerogen is currently working with Tyndall on new projects.

Intel has enjoyed a long-standing relationship with Tyndall since it first set up a manufacturing site in Ireland in 1989. The relationship has matured over time and is now firmly built on collaboration and productive partnership.

In 2010, Intel commenced a major research programme with Tyndall, which was renewed in 2012 when Intel announced a further commitment to invest $1.5 million in research to be carried out at Tyndall over a three-year term. The initial programme produced some very useful outcomes for Intel across a range of challenging topics in areas such as photonics, device modelling and new material development.

The current agreement to run from 2013 - 2015 again provides Intel with a commercial exploitation license to technology created through the collaboration with Tyndall.

Leonard Hobbs, Director of Public Affairs, Intel Ireland said, **"The fact that we renewed the programme is a great testament to the quality of the research carried out by Tyndall. Intel can spend anywhere in the world, and we typically spend where the work is leading edge. We have found the work to be of an excellent standard at Tyndall."**

Intel also has two Researchers-in-Residence at Tyndall and believes that level of constant contact and knowledge transfer is integral to the success of its partnership to date.

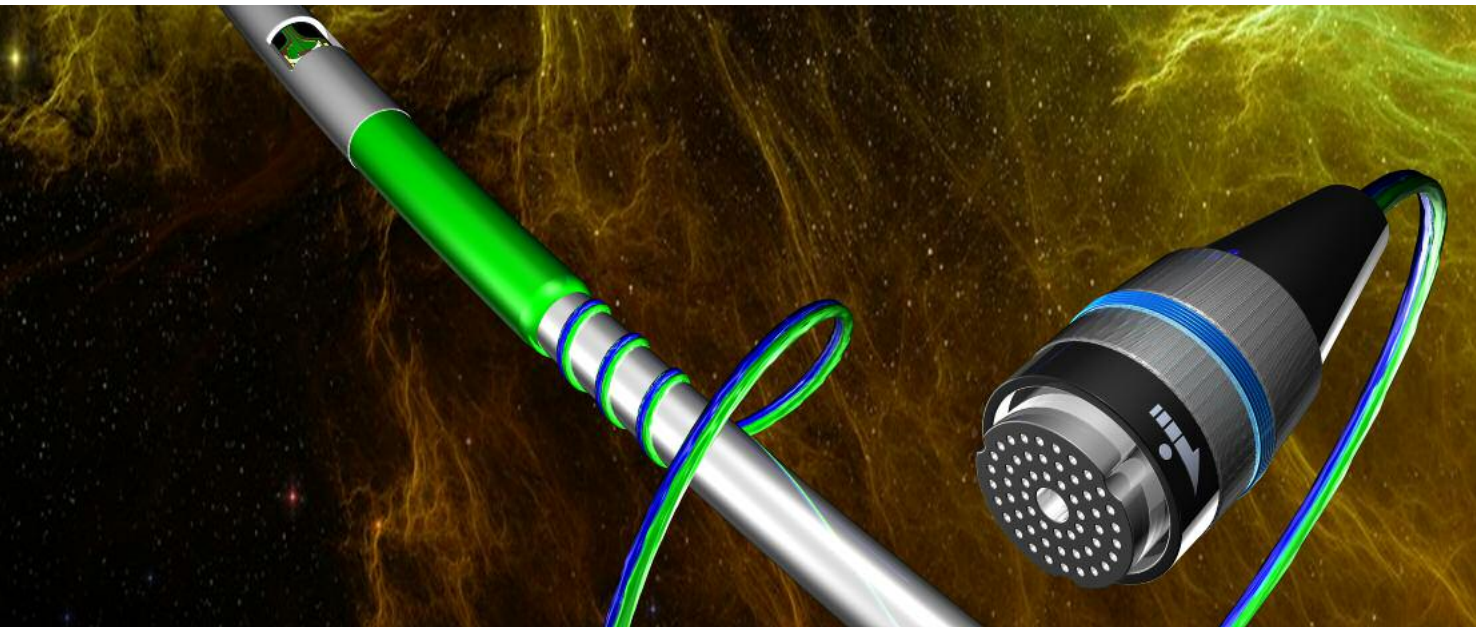
Hobbs confirmed that under its current programme, Intel has a number of different projects in research. **"We refresh the programme every year and that's part of its success and also a reflection of just how flexible Tyndall is in its approach and willingness to quickly transition into new areas."**

A key project underway looks at new ways of making transistors, which are essential to Intel's business. During 2014, the team investigated ways to integrate photonics with silicon with some useful outputs.

Also in focus is research to explore the limits of copper which is the current choice of metal for making chips. **"Tyndall can model devices to a nanometer level of scale and that gives lots of information to help us to explore future possibilities for Moore's Law, a law that drives the entire industry."** said Hobbs.

> Tyndall can model devices to a nanometer level of scale and that gives lots of information to help us to explore future possibilities for Moore's Law, a law that drives the entire industry.

Leonard Hobbs, Director of Public Affairs, Intel Ireland.



Lake Region Medical in partnership with Tyndall is exploring the potential use of photonic sensor technologies in medical guidewires and catheters.

The convergence of ICT into the medical device market has gained considerable momentum and Tyndall is already exploiting opportunities presented by this trend to undertake RD&I in conjunction with medical device companies, including Lake Region Medical.

Lake Region Medical International Research and Development Centre is the Galway-based Irish subsidiary of Massachusetts-based Lake Region Medical, the world's largest manufacturer of medical guidewires for the cardio and vascular and advanced surgical markets.

The partnership between Lake Region Medical and Tyndall commenced in 2012. They knew their customers, including major medical device companies, were looking for products and solutions capable of capturing vital patient information.

Lake Region Medical chose to partner with the Irish Photonic Integration Centre (IPIC) and Tyndall, because of its reputation for research in the field of photonics, sensors, nanotechnology and miniaturisation.The partnership will run until at least 2016, with successful commercialisation leading to the creation of additional jobs in a rapidly growing medical device market segment worth almost €2 billion annually.

In 2012, soon after the partnership commenced, Dr John Hayes, a former researcher on sensor devices within Tyndall became Lake Region Medical's Researcher-in-Residence. The Researcher-in-Residence route guarantees Lake Region Medical knowledge transfer of the highest quality and provides Tyndall with invaluable first-hand industry insight into the demands of the medical devices sector and ensures practical, cost-effective ICT solutions.

> ...Tyndall had the potential to be the most effective Institute in Europe...

The current research project is run through Dr. Peter O'Brien's Photonics Packaging Group and the Irish Photonic Integration Centre (IPIC) based at Tyndall. This project is focused on exploring the potential use of photonic sensor technologies in medical guidewires, to create and relay real-time information to physicians during diagnostic angiography and other interventional procedures. This information, including blood pressure and blood-flow characteristics, can be used to assess the severity of diseased arteries thereby providing valuable diagnostic information on how to best manage surgery or post-operative treatment.

In 2014, Lake Region Medical successfully displayed prototypes representing the project to date at the TCT international Conference organised by the Cardiovascular Research Foundation of America, held in Washington DC. Dr John Hayes said, **"The output from our first project at Tyndall is very encouraging and Lake Region Medical is looking forward to a long and fruitful relationship with Tyndall."**

Teagasc, the leading organisation in agriculture and food research in Ireland, has worked in partnership with Tyndall for a number of years on ICT solutions for the agricultural sector.

In 2014, the relationship was placed on a more formal footing with the signing of a Memorandum of Understanding (MOU), to explore ways to adapt sensor technologies to the agricultural environment. The MOU also includes co-supervising PhD students and the placement of full-time Teagasc researchers in Tyndall.

The MOU is seen as a milestone in a long-term partnership, opening possibilities for Teagasc and Tyndall to collaborate on projects into the future.

The research thus far has resulted in the development of a series of on-farm diagnostic sensor devices, for early diagnosis of Liver Fluke and the respiratory condition IBR, both of which can have devastating consequences.

Professor Gerry Boyle, Director, Teagasc is excited by the progression and future potential of the collaborative research. **"Precision agriculture is the buzz phrase of the moment. Internationally the attention is on optimal cereal management, but at Teagasc we see huge potential to apply the principles of precision agriculture, with Tyndall as our partner, to our unique pasture based niche. Such pioneering work would complement Ireland's already strong reputation in the marketplace for sustainability and quality."**

Diagnostic tools are hugely important in the area of animal health. They are critical not only to the welfare of animals, but also to the realisation of the economic potential of Ireland's livestock sector.

Rapid, easy, on-farm detection is what is needed by the agricultural sector and the feedback from early trials of the sensor devices created at Tyndall has been extremely positive.

"With milk quotas abolished, and significant expansion underway in the dairy sector, the quality of the milk leaving Ireland has to be beyond question. Of critical importance is the need to ensure that there are no undesirable residues present in the milk. Within this context the devices developed by Tyndall scientists are invaluable," said Boyle.

> Internationally the attention is on optimal cereal management, but at Teagasc we see huge potential to apply the principles of precision agriculture, with Tyndall as our partner, to our unique pasture based niche.

Dr Alan O'Riordan, Tyndall; Dr Riona Sayers, Teagasc and Dr Kieran Drain, Tyndall CEO at the launch of AgriSense in Cork.

Nicky Holmes, Brockley Group; Richard Bruton, TD, Minister for Jobs, Enterprise and Innovation; John Barton, Tyndall; Jim Greer, Tyndall at the opening of Brockley Group's innovative Cleantech BlueCat facility.

BROCKLEY group

> Working with Tyndall gave us the opportunity to helicopter above our normal world to see a far bigger horizon.

Brockley Group, headquartered in Dublin, is an indigenous SME that supplies major manufacturers from around the world with both commodity and specialised chemicals and environmental fluid BlueCat AdBlue®

At an Enterprise Ireland Big Ideas forum held in 2011, Nicky Holmes, director with the Brockley Group met Tyndall representative Patrick Morrissey, then head of the Technology Transfer Office (TTO) at Tyndall. Holmes went to the event armed with an idea for a product to meet a specific needs gap. It required telemetry expertise, something Tyndall has in abundance. The initial chat led to some meetings, an EI funded feasibility study and later an innovation partnership.

Brockley Group is in the business of delivering the high volume low value environmental solutions BlueCat AdBlue® which are stored in tanks on clients premises.

The gap identified by Holmes was for an accurate, low-cost, measuring device to help better manage tank content via remote monitoring.

The research was entrusted to the Wireless Sensor Networks Group at Tyndall. The end product uses ultrasound to determine the level of the liquid contained inside a tank. The unit connects once per day to the Brockley server via GPRS to upload all the stored sensor readings. Only if critical trigger values (user-defined) are crossed will the unit establish multiple connections per day. No cabling is required as the unit is battery powered.

Brockley Group looks forward to the international launch of this new product in 2016.

Brockley's relationship with Tyndall marked a new departure for the Group in more ways that one. It will result in the launch of a smart product to complement its core business – the supply of chemical solutions - but it also represented the first time it worked with a research institute.

Nicky Holmes said, **"As an SME we tended to do what other traditional SMEs do, keep our heads down and run our business. We trundled along for years with little resources. We never looked up to investigate what other markets we could compete in, and with what products. Working with Tyndall gave us the opportunity to helicopter above our normal world to see a far bigger horizon."**

There's a knowledge gap for SME's like ours, and it's difficult to bridge, but the experience with Tyndall was so positive that it has given us the confidence to approach other research institutions on other R&D projects. We now have research students working with us, who bring with them new thinking, fresh ideas and knowledge.

United Technologies Research Center

United Technologies Research Centre (UTRC) established in Cork in 2010 as the European corporate research hub for United Technologies Corp. (UTC), a $65 billion US-headquartered multinational corporation, providing high-technology systems and services to the building and aerospace industries.

The research output from its Cork base is focused on driving improvements in the energy use of buildings. The aim is to harness emerging technologies on a scale ranging from individual buildings to district-wide applications, to the point where these technologies can be incorporated with confidence into UTC products.

One of the key factors that attracted UTRC-Ireland to Cork was its proximity to leading research institutes, including Tyndall National Institute with its high-quality researchers, facilities and graduates.

UTC management was particularly impressed by Tyndall's model for engagement and its industry focus as well as its track record for executing significant funded research projects, and hosting Industry Researchers-in-Residence. Also very appealing was Tyndall's extensive network of contacts and its track record in gaining EU funding.

Having initially based itself on-site at Tyndall, today UTRC-Ireland employs 49 people at its new premises in Cork.

To date, the relationship between UTRC-Ireland and Tyndall has been primarily focused on wireless sensor network and energy harvesting technologies, where UTRC-Ireland has been able to draw on the high quality researchers and facilities available on its doorstep at Tyndall.

Tyndall and UTRC-Ireland worked jointly to establish the International Energy Research Centre (IERC), supported by the Department of Jobs, Enterprise and Innovation and the Department of Communications, Energy, and Natural Resources. Through the IERC-supported AUTHENTIC and ROWBUST projects, Tyndall, UTRC-Ireland, and other partners have been evaluating wireless technologies for home automation and modelling tools for improving the reliability and lifetime of battery-powered wireless networks.

In 2014, UTRC-Ireland successfully partnered with Tyndall as the Irish consortium within the EU-funded project SAFE-SENS, where together they are developing next-generation fire safety and building evacuation technology.

Dr. Phil Harris, Group Leader, Networks & Embedded Systems, UTRC-Ireland, acknowledged, **"Based on this experience, we are continually looking for additional opportunities to partner with Tyndall to support our internal research agenda and to address large-scale European research opportunities, and we expect this partnership to continue growing over the long term."**

> UTRC-Ireland has been able to draw on the high quality researchers and facilities available on its doorstep at Tyndall.

Dr Phil Harris, Group Leader, Networks & Embedded Systems, UTRC-Ireland.

Host to Industry Aligned Research Centers

MCCI
Microelectronic Circuits Centre Ireland

The vision of MCCI (Microelectronic Circuits Centre Ireland) is to be the world's number one industry-led analogue and mixed-signal research centre by 2020. After 5 years in existence, MCCI is well on its way towards this goal with 26 industry members and 17 projects spanning applications from high-end computing to medical devices and agri-food. To date MCCI has executed six IP licenses to Irish based companies and has IP already running in high volume products. MCCI has helped member companies to create over 1000 new jobs in Ireland, 200 of which have been attributed to the centre. It is also helping to fill those positions with over 90% of staff who leave MCCI, joining these companies.

"One of the attractions for Qualcomm to Cork was its legacy in terms of chip design. We found lots of research in universities in Ireland that would be of interest to us, particularly at UCC and the Tyndall Institute." – Kevork Kechichian, VP Qualcomm, San Diego.

Prof. Franco Maloberti (University of Pavia) at the MCCI Research Forum 2014.

In 2014 MCCI had its centre funding extended to 2020 following review by EI/IDA. All MCCI projects are with industry partners. 2014 saw the start of six new one-to-one projects with companies including development of a DNA detection chip for food traceability with Irish start-up Altratech, a project with Irish low light detection company SensL and multiple data-converter projects with Analog Devices.

In the ICT space, MCCI will partner with 5 companies within CONNECT, a new large scale SFI research centre announced in 2014 with a focus on circuits for the Internet of Things.

In 2014, MCCI has also started to work in the medtech space where companies wish to add electrical, RF and light based medical sensors and stimulation to everything from surgical tools to smart bandages.

Funding from industry and public sources will reach €4.5M PA in 2015 which will fund over 40 mixed-signal and RF designers undertaking world-class microelectronics circuits research.

"MCCI has built up the scale and critical mass of microelectronic circuit research activity in Ireland. Creating a world class research team and infrastructure at a sufficient scale has given credibility to Irish publically funded research in terms of competing internationally." - Brendan Farley, Director of Engineering, Xilinx.

CCAN
Collaborative Centre for Applied Nanotechnology

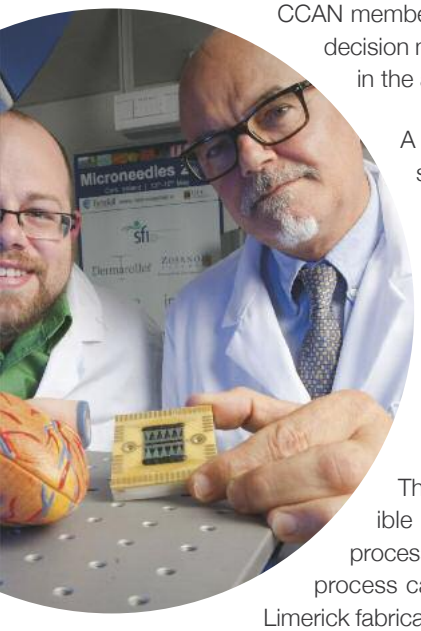
2014 saw CCAN (Collaborative Centre for Applied Nanotechnology) increase industry membership to 21 companies (40% above target), execute 3 commercial technology licenses to CCAN member companies and lead the Technology Centre programme in industry cash contributed into our core projects. New members in 2014 included Tokyo Electron, Randox Laboratories, Eisergy and Nuvotem Talema.

Over the past 4 years CCAN projects have enabled new products, new jobs, equity investments and increased R&D capabilities within our member companies. In addition, the extremely effective CCAN supply chain collaboration model has enabled new business partnerships to form between our small and medium enterprises (SMEs)

and our large company members. The model has also seen CCAN invited to represent Ireland on the steering committee for EU materials platform EuMAT & the EU commission High Level Group on Advanced Materials.

CCAN's model of building projects from the national resource pool using companies who are partners in the end products value chain has been recognised internationally as best in class for materials-driven innovation.

In September CCAN was invited onto the steering committee of the EU Commission's High-level Group for nanotechnologies. This gives Tyndall and other CCAN members direct access to key EU decision makers and H2020 partners in the advanced materials space.



A highlight of 2014 was the signing of a CCAN commercial license with Analog Devices (ADI) for Tyndall's piezoelectric technology.

Dr. Nathan Jackson and Dr. Alan Mathewson, Tyndall.

The licensed CMOS-compatible piezoelectric materials and process technology enables a new process capability in Analog Devices Limerick fabrication facility and allows ADI's development engineers and sensor designers to experiment with new product concepts aimed at delivering power and sensing capability to the growing Internet of Things market.

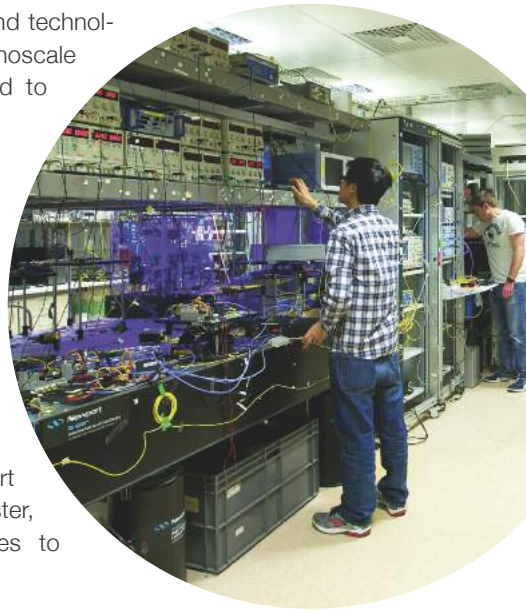
Bill Lane, Process Development Director at Analog Devices stated **"A key part of ADI's strategy for the Limerick site is working on new technology and materials such as non-transistor type processes at the wafer level. The CCAN model makes it so easy for us to engage with both researchers and supply chain partner companies to de-risk such early stage technologies. This technology development and our subsequent investment would not have been possible for Analog Devices without the presence in Ireland of both the outstanding CCAN Technology Centre model and the prototyping capabilities at Tyndall. It gives us a real competitive advantage internationally. This licensed technology will eventually support a wide range of product lines serving the growing Internet of Things market."**

IPIC
BRINGING PHOTONICS TO LIFE

The Irish Photonic Integration Centre (IPIC) is one of Science Foundation Ireland's twelve world-leading large-scale research centres, established to provide major economic impact for Ireland. Its mission is to deliver excellence in photonics research and leadership in its application to develop leading edge products.

As a recently emerged Key Enabling Technology (KET), the integration of Photonics technology into products from communications networks to medical devices has the potential to lead to significant economic benefits, with the global photonics market expected to grow to €650 billion by 2020.

IPIC's focus is to advance and miniaturise photonic integration science and technology to produce micro- and nanoscale optoelectronic systems tailored to the needs of industry partners.



2014 was IPIC's first full year in operation and in this period it completed the establishment of the centre and the initiation of projects with 20 industry partners, 9 MNCs and 11 SMEs. This includes the addition of two new partners, such as Stryker where the focus is to develop next-generation smart surgical tools that enable faster, simpler, and novel procedures to improve patient outcome.

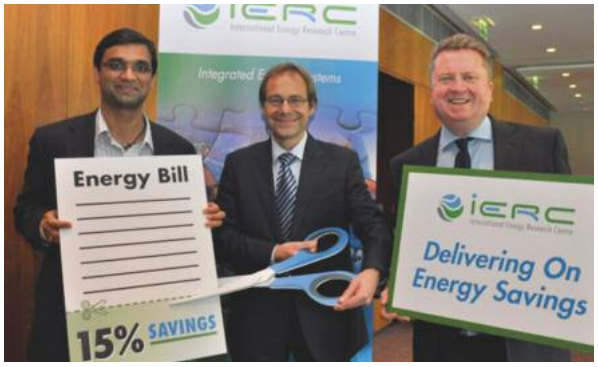
Initial feedback is positive, with 50% of industry partners expecting that the work will deliver improved performance or functionality of existing products, and 18% expecting new project launches. This is reinforced by Lake Region's demonstration of their IPIC – developed technology at Transcatheter Cardiovascular Therapeutics in Washington, DC. IPIC partners include Cork Institute of Technology, Dublin City University and University College Cork.

IERC Vision and Mission

The vision for the International Energy Research Centre (IERC) is to work with its members to realise deployable innovations in integrated, secure, affordable and sustainable energy systems. The mission for the IERC is to facilitate the delivery of insights and knowledge to our industry and research partners accelerating the development of innovative energy products and services through research excellence.

The IERC will:

- Foster success through collaborative working with leading companies and researchers.
- Enable the Irish economy to capitalise on global energy services opportunities.
- Extend and deepen the research expertise and capability in integrated demand-side energy systems.
- Inform energy policy through innovation needs analysis.



Ankit Tiwari, UTRC, Dirk Pesch, CIT and Jeff Smith, Bilfinger Ireland demonstrating the success of the IERC EMWINS project at the IERC Conference, May 2014.

Research Strategy and Outputs

In 2014 the IERC launched 4 new strategic themes under the following areas; Smart and Sustainable Communities, Low Carbon Heating and Cooling, Energy Measurement Monitoring and Analysis and Embedded and Micro Generation Systems. The team have been focused on working with existing and new industry partners to develop a pipeline of new research projects under these strategic themes. New hires to the core team have increased the Centre's capacity to deliver new research activity in conjunction with industry partners.

To date the IERC has funded a research portfolio of approximately €5.2M. The IERC Phase Change Material Project concluded in 2014. The collaborative project including partners from Dublin Institute of Technology, Cork Institute of Technology and a number of industry partners developed and successfully demonstrated a full scale thermal energy storage heat exchanger. The use of a PCM tank has resulted in the Combined Heat and Power (CHP) plant operating in a more continuous way (run times increased from 20 to 210 minutes) enabling greater system efficiency, improved system reliability and improved return on investment. At temperatures above 60°C, the PCM tank stored 6.5 times more energy than an equivalent sized water tank.

Commercial Impact of IERC Research Portfolio

- The IERC has worked closely with 9 companies (7 Multi-National Companies (MNC's) and 2 Small to Medium Enterprises (SME's) as collaborating initial research partners.
- 3 MNC's signed the CIPA as members of the IERC.
- IERC 3rd Annual Conference held on May 1st 2014 had approximately 120 participants with 60 industry representatives in attendance.
- 4 Invention Disclosures were filed and a similar number are in preparation.
- A patent application is pending based on the outcome of the Phase Change Material Project.

Capacity Build

At the end of 2014, the IERC had 58 individuals from across the industry, research and core team associated with the delivery and support of the current research portfolio. The IERC had 4 peer reviewed papers and 2 posters at CIBSE ASHRAE Technical Symposium on 3rd-4th April 2014 in Dublin. 4 submissions were made to European Funding Programmes leveraging the outcomes of the IERC research portfolio including applications under Factories of the Future, Energy Efficient Buildings programmes. TEMPO Principal Investigator John Cosgrove also won an award for best pitch of the research outcomes at KIC InnoEnergy Event, Berlin. Competencies further developed in Ireland as a result of the IERC research portfolio to-date include the areas of software development, hardware design and prototyping, data analysis, techno-economic modelling, business models, systems level installation, maintenance and deployment at demonstration sites, social sciences and psychology, project and research management and research dissemination.

Specialty Products & Services

2014 saw the expansion of activity in the Specialty Products & Services Centre; both within the front-end activities encompassing the cleanroom fabrication and training facilities; and the back-end Device Forensics activities encompassing analysis, test, reverse engineering, packaging and reliability.

The emerging Internet of Things (IoT) market has created a need to closely integrate analogue sensors with simple CMOS circuitry to digitally 'polish' the signals. Tyndall's flexible fabrication offering, Flexifab, is in a unique position to allow for greater material exchange between the fabrication areas, whilst maintaining protocols to avoid cross contamination.

Magnetics-on-Silicon has seen a significant increase in commercial interest and activity. This exciting area will deliver devices that significantly enhance power management (and hence battery life) in portable electronic devices. Tyndall's offering has been enhanced in this area with the purchase of new capabilities for magnetic layer deposition.

Main photo: Finbarr Waldron operating the new Nordson Dage Diamond XD7600 NT high-resolution X-ray system.

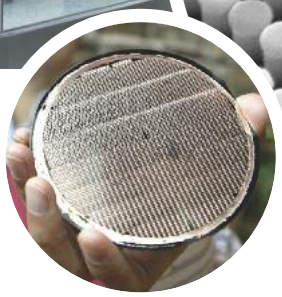
Tyndall is one of the premier sites in Ireland for Device Forensics of packaged devices and bare chips due to our existing capabilities in electron microscopy - SEM, TEM, FIB combined with the purchase of new tooling. The new suite of tools provide state-of-the-art CT scanning X-ray analysis, a high resolution Scanning Acoustic Microscope (SAM), and a 3D optical microscope.

2014 saw our successful ISO9001:2008 re-accreditation validating the efficacy of our Tyndall wide Quality Management System (QMS). Additionally, work is well underway to have the Device Forensics activities accredited to ISO17025 levels, in collaboration with the European Space Agency. This accreditation is planned to be completed in 2015.

Quality

In order to scale our ambitions of rolling out further quality improvements and risk management for both our research and commercial engagements, we have undertaken a significant review of our QMS and have selected, and are in the process of implementing, an electronic tool which will further streamline and simplify the system.

Tony Compagno working on the new Scanning Acoustic Microscope (SAM).



A wafer demonstrating integration of magnetic materials on silicon.

Nano structure arrays for bio-sensing using imprint lithography.

Process & Product Development

Tyndall's extensive fabrication facilities cover:

- Silicon MOS Fabrication
- MEMS Fabrication
- Compound Semiconductor Fabrication
- Training Facility
- E-Beam Lithography
- Flexifab

There is a flexible exchange of materials and devices across the functional areas of CMOS, MEMs and Compound Semiconductor (Flexifab) which is unique in industrially accessible fabrication facilities. This enables the type of material integration which is essential for the More than Moore and IoT domains where advanced sensors are made network aware.

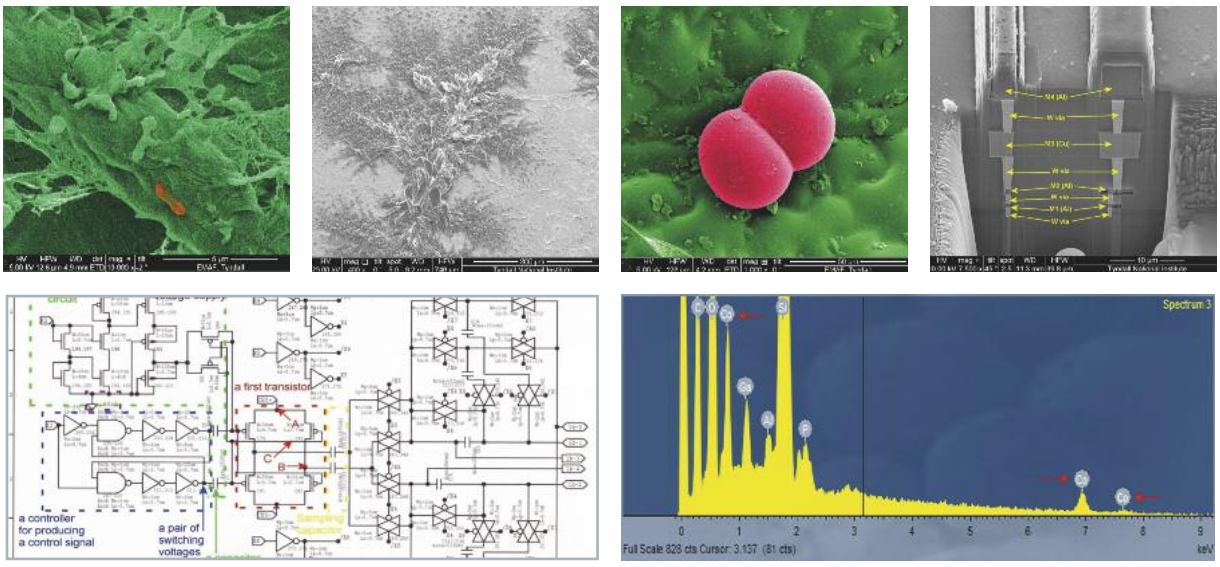
The resulting functionalised devices are transferred into the Device Forensics area for packaging, analysis, reliability and test.

Device Forensics

Complementing the 'front-end' fabrication capabilities, Tyndall has extensive 'back-end' facilities and expertise to be able to take the functionalised devices and package them in a form that enables the customer to use them in their real world systems. Married with this are capabilities in reliability testing, reverse engineering, electron microscopy and analysis which together provide the diagnostic tools that allow for the forensic analysis of materials and devices.

The particular capabilities cover the areas of:

- Electronic Packaging & Reliability analysis – wire/die bond, PCB assembly, µBGA. Environmental testing, package & failure analysis, burn-in, shock & drop, X-ray analysis.



Range of capabilities covered in device forensics: material and device analysis and circuit reverse engineering.

- Electron Microscopy Analysis Facility (EMAF) – SEM, TEM, FIB, EDAX analysis, cryo-stage enabled SEM for biological sample analysis.
- DTE – IC re-engineering, patent infringement, circuit design analysis, analogue, digital & mixed signal diagnostic measurements.

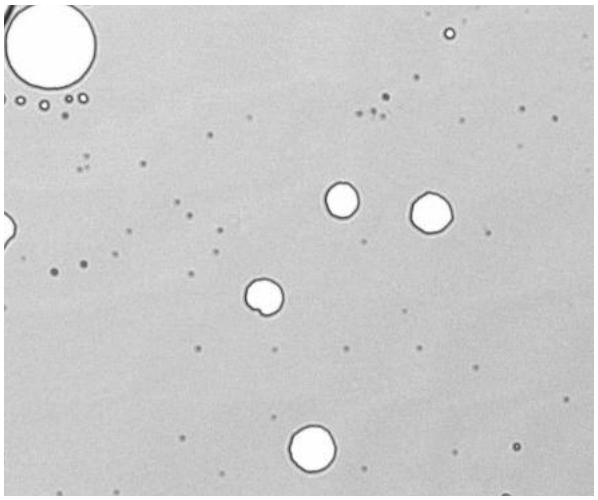
More details of the capabilities, processes and case studies in these areas can be found at

www.tyndall.ie/content/services

New Advanced Imaging Capabilities

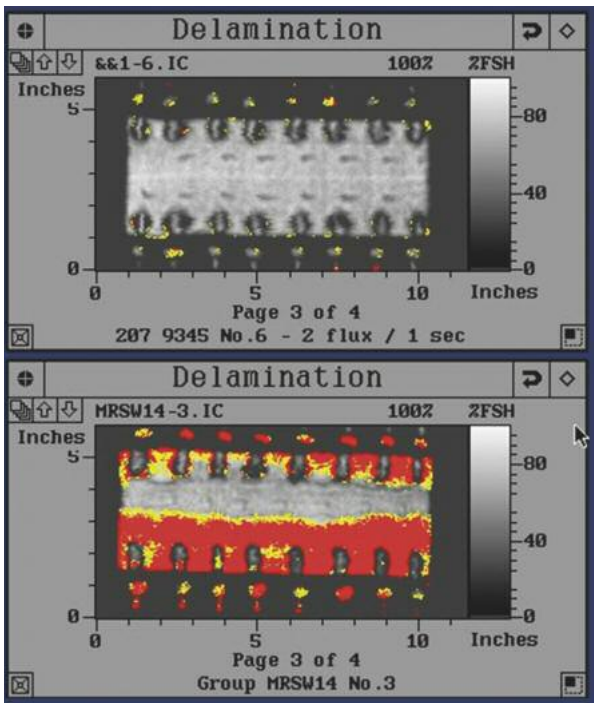
During 2014, the packaging group at Tyndall installed two new advanced imaging systems for component analysis, a Nordson Dage Diamond XD7600 NT high-resolution x-ray system equipped with both "x-plane" and "µCT" (micro Computerised Tomography) capabilities and a Sonoscan D9600 Scanning Acoustic Microscope. These new tools complement other imaging capabilities already available at Tyndall (e.g. 3D optical microscopy, SEM & TEM) and are particularly useful for the analysis of packaged devices and bonded structures.

The new Nordson Dage X-ray system is capable of handling a large range of sample sizes (from small individual semiconductor ICs to large Printed Circuit Board assemblies) and is particularly effective in identifying interconnect defects in wire-bonds, surface-mount solder joints, Ball-Grid Array (BGA) joints and flip-chip assemblies. The "X-plane" feature of the Tyndall system also allows a layer-by-layer investigation of a product to be performed – a feature which is particularly useful for the identification of defects within multi-layered substrates. The µCT allows a full three dimensional image of a sample to be obtained and effectively allows non-destructive cross-sectioning of a component to be rapidly carried out.



Acoustic image of bonded Si-to-Si wafer structure showing voided areas.

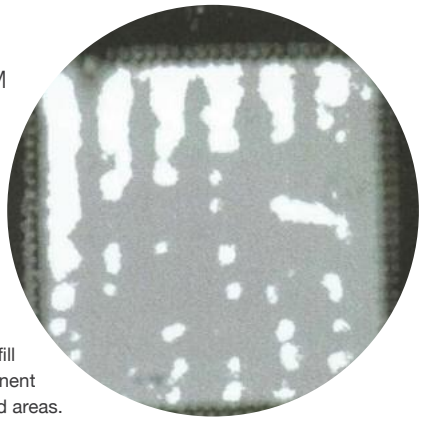
The Scanning Acoustic Microscope (SAM) complements the x-ray system. The SAM produces an image by means of the transmission and reflection of a focussed sound beam within the sample. The system is especially effective in analysing the quality of adhesion between layers (e.g. plastic encapsulant to an IC) and is extensively used for the identification of failures such as cracking, voiding and delamination in plastic-encapsulated electronic components.



Acoustic images of two plastic packaged integrated circuits. The lower image shows large areas of delamination where the plastic encapsulant has detached from the lead-frame/die paddle.

The SAM is also highly effective in the evaluation of the quality of bonded structures and has been used as a quality assessment tool for the evaluation of bonded wafer structures at Tyndall. Like X-ray, SAM is a non-destructive analytical technique. The Tyndall system is equipped with a wide range of ultrasonic transducers (ranging from 15MHz to 100 MHz) to cater for a wide variety of sample types.

Both the X-ray and the SAM systems are also equipped with advanced measurement capabilities which allow key features and dimensions of devices under evaluation to be measured easily & quickly.



Acoustic image of under-fill quality in flip-chip component showing large voided areas.

National Access Programme

The National Access Programme (NAP) is a Science Foundation Ireland (SFI) programme that enables access to Tyndall National Institute's state-of-the-art facilities and expertise to all researchers in Ireland. Over the past 10 years 347 collaborative projects have been funded and NAP has delivered strong impacts across all Tyndall's technology areas.

NAP is governed by an independent access committee of 14 senior academics representing all of the Universities and large Institutes of Technology, chaired by Greg Hughes of Dublin City University.

In 2014 SFI changed the funding model and researchers now pay for NAP project costs from their own grants. This resulted in an expected sharp decrease in the number of direct projects undertaken through NAP, as external researchers prefer to collaborate with Tyndall as a partner rather than paying for direct access through NAP. However, the NAP team has expanded to serve a wider national and international community and was successful in securing funding in 2 European H2020 projects:

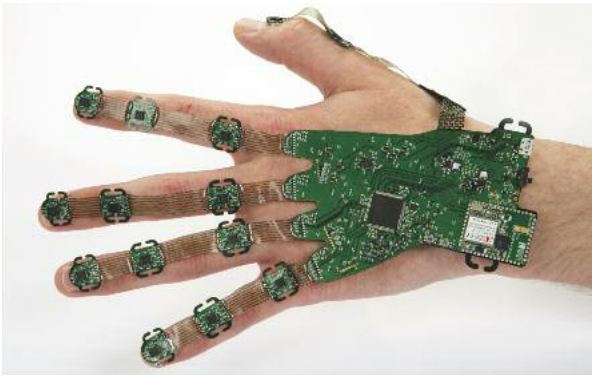
- Gateone provides SMEs with fully-funded access to demonstrators based on Tyndall's Smart Systems technologies and also funds access to similar technologies in 9 other leading research Institutes across Europe.
- ASCENT is a transnational access programme enabling access to world-leading state-of-the-art 10nm CMOS processes in IMEC, Belgium and Leti, France and will provide fully-funded access to Tyndall's advanced characterisation tools to researchers in Europe.

NAP Highlights:

- **670 researchers** have been funded from all 9 Universities including Queens University Belfast (QUB) and University of Ulster (UU); 10 Institutes of Technology; 2 Research Institutes, RCSI and Teagasc; and 1 international University, University of St. Andrews.
- **2,100 researchers** have attended NAP talks and Open Days.
- **320 researchers** have spent over 680 access days at Tyndall.
- **718 publications** have resulted from NAP projects to date, including 176 Journal publications.
- **30% of participants** have been postgraduate students. 86 students who have completed PhD & Masters Theses have acknowledged NAP.
- **NAP projects have seeded collaborations** which have led to significant follow-on SFI, EI and EU funding.
- **9 patent applications** have been reported resulting directly from NAP projects.

Precise Finger Measurement Device for Patients with Hand Trauma

Joan Condell (University of Ulster)



Wireless sensing glove enabling accurate measurements of hand and finger joint movement.

Arthritis is a disabling and painful disease and accurate measurement of the arthritis patient's movement is the key to effective rehabilitation. Researchers in University of Ulster are replacing traditional measurement methods that use very basic measurement tools and exhaustive physical examination with a highly accurate wireless glove sensing system.

In this project the wireless team at Tyndall developed an extremely flexible glove with a range of sensors strategically placed to allow highly accurate measurement of the movement in each part of the finger and hand. The high accuracy results allow detailed analysis and monitoring of hand movement and graphically displays the moving 'hand' on the screen.

This highly accurate wireless data system will not only improve diagnosis and rehabilitation treatment for patients in the clinic but will also allow the patient to be monitored remotely at home.

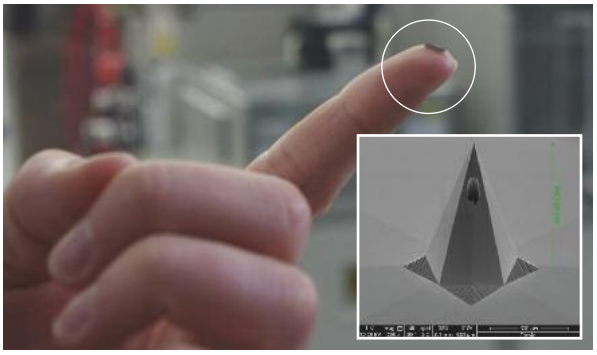
Application of Microneedles in Dental Procedures for Local Anaesthetic Delivery

Darius Sagheri (Trinity College Dublin)

Local anaesthesia is required for painless dental care but fear and anxiety associated with normal needle delivery can be a major impediment for patients and cause them to either delay or avoid vital treatment. There is also a problem with needle-stick injuries for health care workers. The use of microneedles rather than conventional needles can overcome both these issues.

Researchers in the School of Dental Science in TCD are investigating whether microneedles that have been developed for drug delivery in external skin can be effective in delivering drugs through the skin in the mouth which have quite different properties.

In this project the MEMS team at Tyndall developed a silicon hollow microneedle that was customised specifically for this application. The key design parameters including microneedle height, array size and the reservoir size were designed to match the volume of anaesthetic to be delivered. This complex project delivered microneedles that are only 500µm high and have a bore size less than 50µm wide.



Hollow microneedles customised to deliver local anaesthetic during dental procedures.

Fabrication of Microfluidic Chips for Enhancement of Fine Chemicals Synthesis

Evgeny Rebrov and Taifur Rahman
(Queens University Belfast)

Over the past 2 decades chemical reactors have been miniaturised to the micron-scale (micro-reactors) in order to finely control the reactor dimensions and thereby improve the control of the chemical reactions themselves. Even though the volume of chemicals is low in micro-reactors the flow process is continuous which means they can be used in large-scale chemical and pharmaceutical industries.

Two of the main drawbacks with micro-reactors are that the channels can become blocked or the flow can be too slow for production. Researchers in Queens University Belfast have developed a novel solution to ensure a highly efficient and economically viable process. They have designed a novel platform that incorporates the chemical onto magnetic microparticles and then they use an external magnetic field to move the chemicals through the micro-channels in a well-controlled manner.

Tyndall researchers in the MEMS Fabrication facility have fabricated high precision micro-reactors in different materials and with different geometries in order to allow this novel technique to be realised by the QUB researchers.

Microfluidic devices enabling accurate control of flow in chemical micro-reactors.

Skilled Graduates

Graduate Studies at Tyndall pursues innovative and quality education for excellence in graduate training, that leads to innovative and disruptive ICT solutions and highly trained people to ensure future advances in communications, energy, health and the environment.

A key strategic target for Tyndall is to act as a primary source of relevant graduates to industry. At the end of 2014, there were 113 PhD and 14 Masters candidates pursuing their degrees at Tyndall and during the year 27 PhD viva examinations were completed.

Of these recent graduates:

- **15%** are now working in Irish industry.
- **7%** are working in EU based industry.
- **78%** are pursuing advanced specialised training through postdoctoral positions.

PhD Engineering Science

The PhD (Engineering Science) concluded its 4th year leading to 18 doctoral candidates registered on this novel progamme introduced by the Tyndall Graduate Studies Committee. The structured PhD programme at UCC was the first such programme to explore how to exchange graduate modules between Irish Universities and Institutes of Technology.

The flexibility of the PhD (Engineering Science) curriculum allows PhD candidates to obtain the skills needed to support their research projects with the interdisciplinarity that is a characteristic feature of many of Tyndall's PhD and Master thesis topics, while also affording the students the opportunity to acquire business and innovation skills.

In 2014, Cormac Ryan became the first student to successfully complete the new Graduate Certificate in Innovation, Commercialisation and Entrepreneurship (ICE). This certificate is a novel and flexible embedded award that is offered by UCC's College of Business & Law to PhD (Engineering Science) candidates. The training serves to instill an entrepreneurial culture within our graduate community, enabling students to place their technical knowledge within a commercial context.

INSPIRE National Graduate Education Programme in Nanoscience & Nanotechnology

Tyndall continues to lead INSPIRE, the national graduate education initiative to enhance Nanoscience and Nanotechnology. INSPIRE enables sharing of a national curriculum in nano -science and -engineering between our academic partners which includes Cork Institute of Technology, Dublin City University, Dublin Institute of Technology, NUI Galway, Trinity College Dublin, University College Cork, University College Dublin and the University of Limerick. The curriculum relies on the combined strengths of the partner institutions and pools the scientific and pedagogical expertise of each contributor into a single offering to students via the portal www.flexilearn.ie and the virtual learning environment provided through Flexilearn.

The structured training covers graduate courses in technical topics and transferable skills offered via a range of options from block on-site delivery to remote delivery via on-line streaming, or as pre-recorded lecture podcasts.

INSPIRE enabled the delivery of 25 graduate modules offered inter-institutionally during the 2013-2014 academic year, including a new module entitled Key Enabling Technologies delivered in NUI Galway which was attended by 30 students from across partner institutes.

INSPIRE and the Flexilearn portal are 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.

PhD Theses 2014

Eoin Clerkin
Closely Coupled Lasers: Dynamics & Applications

William Cotter
Photonic Integrated Circuit for the Manipulation of Coherent Optical Combs

Aidan Daly
Voltage Properties of Optically Injected Long Wavelength VCSELs

Nitin Deepak
Growth and Characterisation of Oxide-Based Ferroelectric, Ferromagnetic and Multiferroic Thin Films

Gangotri Dey
Atomic Layer Deposition of Copper - Study by Density Functional Theory

Gabriel Greene Dinez
Computational Modelling of Defects in Nanoscale Device Materials

Dirk Hagen
Atomic Layer Deposition of Copper

Anna Iwaszuk
Engineering of Metal Oxide Interfaces for Renewable Energy Applications

Syara Kassim
Polymer and Metallodielectric Based Photonic Crystals

Keith Lenihan,
Synthesis, Characterisation and Applications of Group IV Nanocrystals

Alfonso Martin
Highly Sensitive Surface Enhanced Raman Scattering (SERS) Detection Platforms Formed by Large Area Self-Assembled Au Nanorod Arrays

Walter Messina
Micro and Nanostructured Impedance Sensors for Biological and Biomedical Applications

Padraic Morrissey
Photonic Integrated Circuits for the Generation of Coherent Optical Signals

John Mullins
Atomic Layer Deposition of Interface Control Layers for the Fabrication of III/V MOS Devices

Naoise MacSuibhne
High Speed Optical Communication Systems: From Modulation Formats to Radically New Fibres

Joe McGrath
Development of Large-Scale Colloidal Crystallisation Methods for the Production of Photonic Crystals

Alan Naughton
Analysis and Optimisation of Semiconductor Reflective Modulators for Optical Networks

Postgraduate Studies Committee: Samarth Viswanath, Michele Conroy, Ricky Anthony and Niall O'Cuilleanain.

Eoin O'Connell
Networking Protocols for Long Life Wireless Sensor Networks

Eamon O'Connor
Investigation of Electrically Active Defects at the Interface of High-k Oxides and III-V Semiconductors

Andrea Pescaglini
Hybrid Nanostructures: Nanofabrication Techniques and Optoelectronic Properties

Stefano Porto
Burst-Mode Electronic Dispersion Compensation in Long Reach PONs

Mark Power
All-Optical Signal Processing using SOAs for Next Generation Optical Networks

Nasir Quadir
Research and Design of High-Speed Advanced Analogue Front-Ends for Fibre-Optic Transmission Systems

Azura Said
Electrochemical Biosensor Based on Microfabricated Electrode Arrays for Life Science Applications

Maryam Shayesteh
Novel Processes, Test Structures and Characterisation for Future Germanium Technologies

Amelie Wahl
Fabrication, Characterisation and Electroanalysis at 1-D Nanostructures

Monika Zygowska
Design, Fabrication and Characterisation of Components for Microfluidic Enzymatic Biofuel Cells

Student Awards & Prizes 2014

The annual Tyndall postgraduate poster competition is organised by the Postgraduate Student Committee and judged by members of the Tyndall Board. There were 45 entries for the competition in 2014.

Rosemary O'Keefe, a PhD Eng Sc student with the Heterogeneous Systems group, won first prize for her poster entitled "Piezoelectric Energy Harvesting for In-Vivo Applications". **Sveltana Slepneva**, a PhD student in the Photonics Centre won second prize for her poster entitled "Swept Sources for Optical Imaging" and **Cormac Ryan**, a PhD Eng Sc student with the Heterogeneous Systems Integration Group, won third prize for his poster entitled "Reliability Study of Radio-Frequency Microelectro-mechanical Switches".

L to R: Rosemary O'Keefe, Cormac Ryan and Sveltana Slepneva.

Rosemary also received the Best 2 Minute Presentation Award at the Tyndall Internal Conference for her presentation on "Energy Harvesting from Bloodflow".

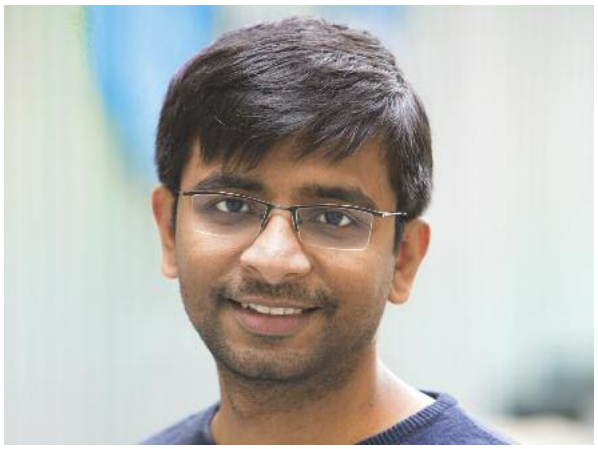
Ricky Anthony, a PhD student with the ICT for Energy Efficiency Group, received the Best Poster Award at the IEEE 3D Systems Integration Conference for his poster entitled "Advanced Processing for High Efficiency Inductors for 2.5D/3D Power Supply in Package". Authors: Ricky Anthony, S. Kulkarni, N.Wang and C.O'Mathuna.

Abulaiti Hairisha, PhD Eng Sc student with the Materials Modelling for Devices Group, received a Poster Prize at the Irish Polymers & Materials Conference for her poster entitled "Polymerization of Cyanoacrylate: A Density Functional Study with Van Der Waals Interaction". Authors: Hayrensa Ablat, I. Povey, R. O'Kane, S.D. Elliott.

Lisa Helen, PhD student with the Life Science Interface Group, won the Best Poster 2014 Award at the Smart Systems Integration 2014 Conference for her poster entitled "Development of a 'Smart' Needle Integrated with an Impedance Sensor to Determine Nerve Proximity for Nerve Blocking (Anaesthetic) Procedures". Authors: Lisa Helen, W. Messina, B. O'Donnell and E. Moore. She also received the runner-up prize for the Best Student Presentation at the 8th International Conference on Sensing Technology (ICST), for her presentation entitled "Investigation of Tissue Bioimpedance Using a Macro-Needle with a Potential Application in Determination of Needle-To-Nerve Proximity". Authors: Lisa Helen, W. Messina, B. O'Donnell and E. Moore. Lisa presented a paper entitled; "Investigation of Tissue Bioimpedance using a Macro-needle for Biomedical Applications" at Biomedica 2014 in Dublin.

The paper was highly commended and awarded second prize for originality and innovation in the President's Prize competition.

Tuhin Maity, PhD student with the Micropower Systems and Nanomagnetics Group received the Tyndall Bursary Award for his research on Manipulation of Magnetic Anisotropy in Nanostructures.



Dhiman Mallick, PhD student with the Micropower Systems & Nanomagnetics Group was awarded a UCC Strategic Research Fund PhD Studentship Programme 2014 Award for his research in the area of Vibration Based Electromagnetic Micro-power Generators using MEMS/ NEMS Techniques.

Carola Schopf, PhD student with the Nanotechnology Group, was awarded second place in the Poster Competition at NANOSMAT, for the poster entitled "Single Gold Nanorods for Optical Mercury Detection". Authors: Carola Schopf, A Martin Ruano, D Iacopino. Carola also received an attendance bursary for E-MRS 2014 in Lille.

Jing Tao, PhD student with the Heterogeneous Systems Integration Group received the Best Contribution Award at the MINAPAD, Grenoble for her presentation entitled "Nanowire Based Anisotropic Conductive Film (NW-ACF) for Low Temperature 3D Stacking Applications". Authors: Jing Tao, A.Mathewson and KM Razeeb.

What Our Students Say about **Tyndall**

Ricky Anthony

PhD Student, Microsystems Centre

Undergraduate Degree: M.Tech (Electronics & Communication Eng.), West Bengal University of Technology, India; M.Sc (Electronic Science) & B.Sc (Physics Honours), University of Calcutta, India

PhD Research: Technology Platform for the Fabrication of Advanced Micro-Magnetics.

"I applied for this PhD position because it is an industry related project. I had visited Tyndall previously so I was aware of its' international reputation. I like the friendly atmosphere in Tyndall and the fact that there is such a variety of nationalities amongst students and staff. Cork is a very convenient and vibrant city!".

Fabien Dubois

PhD Student, Photonics Centre

Undergraduate Degree: Physics and Applied Maths Joint Honours, University College Cork.

PhD Research: Coupled Lasers in Photonic Integrated Circuits

"I worked in Tyndall as an undergraduate and decided to do a PhD here as I really liked the hard-working and supportive atmosphere. I am surrounded by experts in my field and similar fields who will offer advice and help and I have access to expertise and training available in a few other locations in Ireland. There is a great balance here between giving students industry like experience while still offering a great learning environment".

Ekaterina Filatova

PhD Eng Sc Student, Theory, Modelling and Design Centre

Undergraduate Degree: BSc Aircraft engines construction, Samara State Aerospace University, Samara, Russia: MSc Advanced materials and nanotechnology, UFABC, Santo Andre (SP), Brazil.

PhD Research: Atomic Layer Deposition of Silicon Carbide, Theoretical Modelling

"Even though my background is different to my PhD research area, I would advise potential students not to be afraid of branching into new areas for their PhD research. Tyndall has a great environment to learn with many workshops and training opportunities to help in your learning process. Tyndall has a very friendly atmosphere, so you will always have support from other experienced researchers from different areas of expertise".

Melissa McCarthy

PhD Student, Micro/Nanoelectronics Centre

Undergraduate Degree: BSc Chemistry, University College Cork

PhD Research: Atomic Layer Deposition of Photovoltaics

"The friendly and enthusiastic environment makes studying at Tyndall a pleasure. Along with its industry-leading facilities, the training offered to PhD students at Tyndall is exceptional. Experts in a wide variety of disciplines are available to extend their vast knowledge to you and go beyond giving you the quick answer. Tyndall provides an opportunity to meet highly qualified individuals and build a network of like-minded professionals, while studying."

Outreach

At Tyndall, we are actively involved in the promotion of Science, Technology, Engineering and Maths (STEM) through a number of initiatives and projects designed for students, schools and the general public.

Our dedicated Outreach and Public Engagement Officer works in collaboration with our researchers to devise innovative and exciting projects to highlight the opportunities associated with a career in STEM. Enthusing and informing the public about our research is an important aspect of our contributions to the Irish society and economy.

Waking Up Rosetta

A team from Tyndall, in association with CIT Blackrock Castle Observatory and the European Space Education Resource Office, joined people all around the world to take part in the European Space Agency's "Wake Up Rosetta!" event, a daring attempt to land on a comet.

As part of the event, students experienced a live streamed tour of the microelectronics lab in Tyndall, where Finbarr Waldron and his team spoke about their work on reliability testing with ESTEC (ESA's Test Centre).

Two live demonstrations and presentations were also given by Donagh O'Mahony and SensL founding director, Carl Jackson. SensL, a Tyndall spin-out is a sensor component manufacturer currently involved in sensor testing for future ESA spacecraft missions.

Science Week 2014

Tyndall participated in a range of activities and events as part of Science Week 2014. The theme of "The Power of Science" echoed throughout activities, highlighting the range of STEM disciplines based in Tyndall. Approx. 4,000 members of the public attended the Discovery Science Festival, where Tyndall exhibited.

Tyndall's Outreach Officer, Karen McCarthy, took part in the SFI STEM Careers Roadshow in UCC. Over 100 students attended the event, where there were a number of talented speakers offering career and subject advice for interested students.

CEIA Transition Year Programme

The HighTechElec Transition Year work experience programme, a collaboration between CEIA and Tyndall, was developed to give Transition Year students an insight into the high-tech careers open to them in industry and academia.

Students partake in physics, electronics and technology based events, culminating in an innovation competition. Through meeting and working with scientists and engineers, students get firsthand experience of the choice of careers available to them.

Funding Awards

2014 has been a very successful year for Tyndall in terms of outreach project funding. Through the SFI Discover annual call, a collaborative project entitled "MakerDojo", involving Tyndall, INSPIRE Graduate Learning, Designer Dojo and Forma Labs was funded.

This unique and innovative project will centre on the development of a Makerspace within Tyndall, which will encourage visitors to think creatively around science, technology and engineering.

A second funding award came from the Royal Society of Chemistry, for a schools-based project entitled 'The Matter That Matters!'. This project encourages students to look at chemistry beyond the test-tube and highlights the importance of materials chemistry in our everyday lives.

International Reach

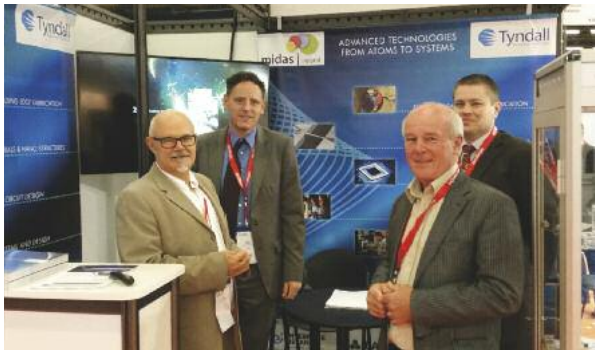
SFI St. Patrick's Day Science Medal Award Celebration in Washington D.C.

EI Innovation Showcase, 2nd December 2014, Dublin.

European Semiconductor Clusters Forum event held at Tyndall.

Kieran Drain, Tyndall and Arthur Forbes, EU Commission at the launch of the Tyndall Strategic Plan, Brussels.

CitySense launched at the Web Summit in Dublin with partners NCAD, PCH, TSSG and Vodafone.



Exhibiting at SEMICON Europe, 2014, Grenoble, France.

Exhibiting at Industrial Technologies 2014, Athens, Greece.

Conferences

Tyndall Technology Days

Tyndall held its second Technology Days event in November 2014. The unique format of this event brought together industry leaders, technology experts and end-users to give a 360° view of how world leading ICT can deliver growth for the Health, Agriculture, Food and Environment sectors.

The three day event was attended by 300 people, half of which were from industry. The high-calibre speakers and great networking opportunities were among the main highlights.

WODIM

The 18th Workshop on Dielectrics for Microelectronics was held in Kinsale, Cork, in June 2014 and attracted 110 delegates from Europe, Asia and USA. This was the second time the WODIM conference has been organised by Dr Hurley and colleagues in Tyndall National Institute.

The 2014 workshop facilitated the collaboration of specialists who work in the field of dielectrics and all aspects of their application in the field of micro and nanoelectronics whilst dealing with a range of issues in the field of advanced and new dielectrics, such as: growth and deposition, modelling and simulation, physical and electrical properties, reliability and dielectric applications.

IERC Conference

In May 2014, the International Energy Research Centre held its third annual conference in Cork, entitled 'Unlocking the Potential for Innovative Energy Services'. This event, opened by Minister Sean Sherlock, TD, brought together key global stakeholders involved in energy services for lively debate, discussion, networking and discovery. It was an occasion when ideas were shared about how to make society's energy systems more efficient and effective and we looked at this from every angle – research, industry, policy and the eventual user, the consumer.

Bob Hanna, DCENR; Jim Fritz, UTRC; Sean Sherlock TD; Tony Day, IERC and Kieran Drain, Tyndall National Institute attending the 2014 IERC Conference.

3DIC

The IEEE International Conference on 3D System Integration (3DIC) was held in Kinsale, Cork, in December 2014. The three day conference covered all 3D IC topics, including 3D process technology, materials, equipment, circuits technology, design methodology, thermal effects and applications. There were seven invited talks during the conference that addressed the broad spectrum of activities across the firmament of 3D IC.

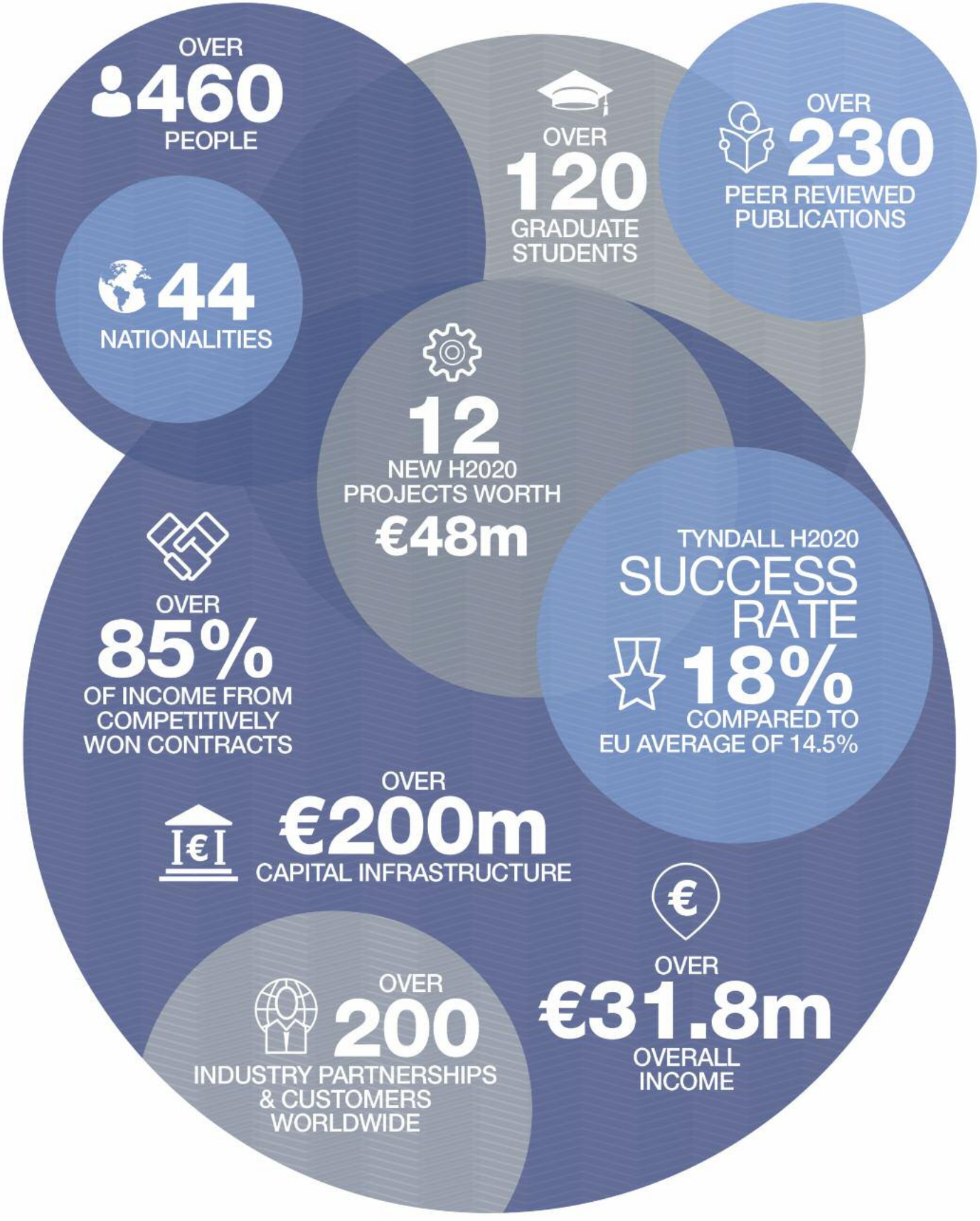
Financial

Income & Expenditure Summary

INCOME	2014 €'000s	2013 €'000s
Government grant	2,900	2,900
Research	26,687	25,666
UCC contribution	2,287	2,110
	31,874	**30,676**

EXPENDITURE	2014 €'000s	2013 €'000s
Remuneration costs	18,650	17,094
Equipment and infrastructure	2,654	2,939
Consumables and related costs	8,662	8,054
Other operating and deferred costs	1,908	2,589
	31,874	**30,676**

Key Figures


OVER
460
PEOPLE
44
NATIONALITIES
OVER
120
GRADUATE STUDENTS
OVER
230
PEER REVIEWED PUBLICATIONS
12
NEW H2020 PROJECTS WORTH
€48m
OVER
85%
OF INCOME FROM COMPETITIVELY WON CONTRACTS
TYNDALL H2020
SUCCESS RATE
18%
COMPARED TO EU AVERAGE OF 14.5%
OVER
€200m
CAPITAL INFRASTRUCTURE
OVER
200
INDUSTRY PARTNERSHIPS & CUSTOMERS WORLDWIDE
OVER
€31.8m
OVERALL INCOME

Tyndall Board

Left to Right:

Mr John Mullins (Amarenco)

Mr Martin Cronin (Forfás)

Prof. Anita Maguire (University College Cork)

Mr Eoin O'Driscoll (Chairman Tyndall)

Dr Kieran F. Drain (CEO Tyndall)

Ms Patricia Reilly (Member of the Cabinet of the European Commissioner for Education, Culture, Youth and Sport)

Mr Marcus Breathnach (Department of Jobs, Enterprise & Innovation)

Prof. Willy Sansen (Prof. Em. KU Leuven)

Mr Kevin Fielding (Alta Berkeley)

Missing from Photo:

Dr Lisa Amini (IBM)

Dr Ann Kelleher (Intel)

Mr Ian Quinn (Creganna-Tactx Medical)

Prof. Steven Ringel (The Ohio State University)

They are exceptionally knowledgeable in their respective fields and have the capacity to apply that knowledge in other applications. This is not a common thing.

Dr Ronan MacLoughlin,
Senior Scientist,
Aerogen

Intel can spend anywhere in the world, and we typically spend where the work is leading edge. We have found the work to be of an excellent standard at Tyndall.

Leonard Hobbs,
Director of Public Affairs,
Intel Ireland

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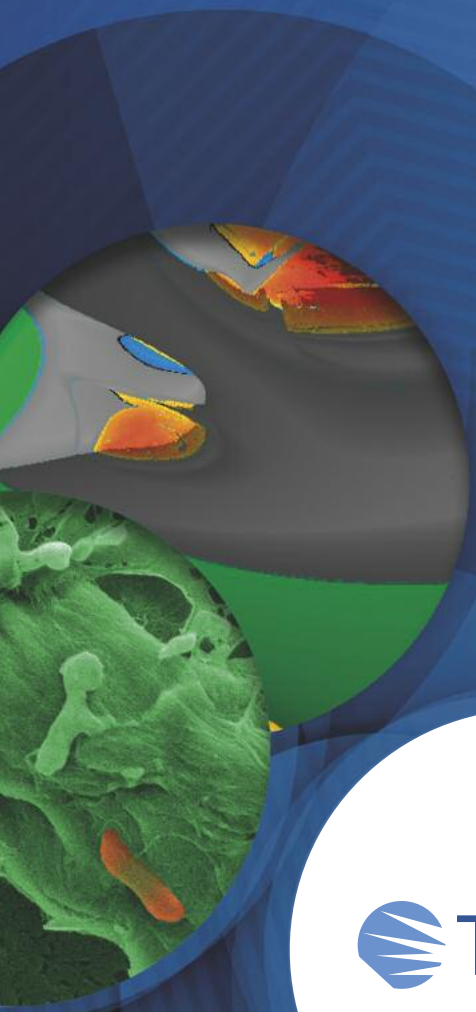

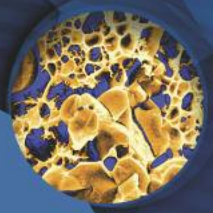

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