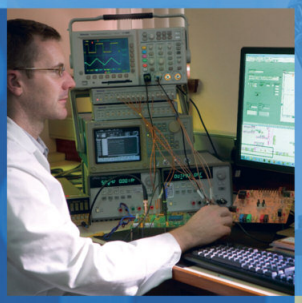
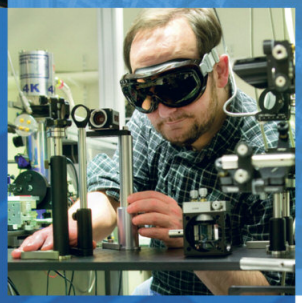
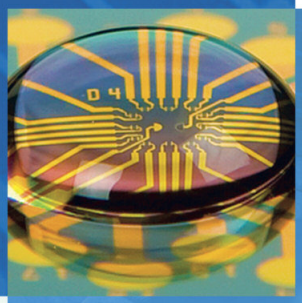


# Annual Report

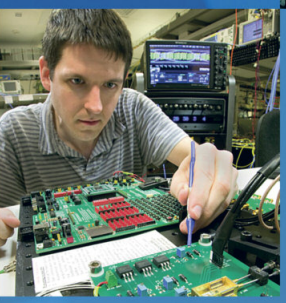


# 2013

Tyndall
National Institute
Institiúid Náisiúnta



## Impact From Excellence



www.tyndall.ie

Tyndall has helped MACOM's Cork base strengthen its hand when it comes to making a continued case for investment and growth with the company.

**David Ryan,**
**Business Development Manager, MACOM**

www.tyndall.ie

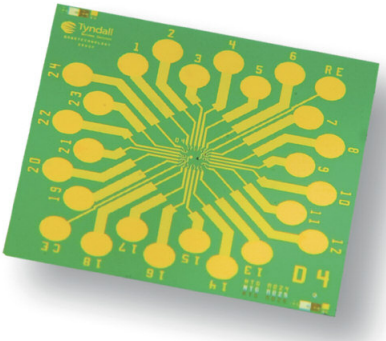
When it comes to the transfer of technology from academia to industry, Tyndall is ahead of the curve. They have a strong focus on commercialising technology with industry partners that add value to the world.

**Miles Murray,**
**CEO PMD Solution**

Tyndall National Institute
Institiúid Náisiúnta

# Report **Contents**





# Message from the Chairman

2014 is the tenth anniversary of the establishment of Tyndall National Institute, and ten years later we see a remarkable transformation. The Institute was created by the Department of Jobs, Enterprise and Innovation (DJEI) together with Science Foundation Ireland and University College Cork (UCC) by bringing together the Information and Communications Technology (ICT) research strengths in UCC, Cork Institute of Technology and the National Microelectronics Research Centre (NMRC) to better serve Irish industry and academia.

Tyndall is indeed playing a key role as a driver of Ireland's growing international scientific reputation, through its globally competitive ICT research. We are proud that Tyndall is an Institute that consistently punches well above its weight in terms of the quality of its workforce, the results it achieves, and the accolades and prestigious international awards received both from industry and from the research community.

As the Irish economy emerges from recession, it is important to evaluate Tyndall's contribution and impact in economic terms. In support of Enterprise Ireland Tyndall aids the growth of Irish Small and Medium Enterprises (SMEs), by giving them access to its state-of-the-art facilities, but just as importantly, to its often unparalleled expertise in niche technology areas. Central to the success of these relationships is the establishment of close and trusted partnerships.

The Institute also supports a range of Irish multi-national companies by offering access to expertise, key staff training in semiconductor fabrication, and the opportunity to have on-site research incubators including researchers-in-residence at Tyndall.

Tyndall also offers valuable support to the IDA in its quest to attract more Foreign Direct Investment (FDI) to Ireland. The Institute was an important factor in the decision making processes of many international multinationals such as UTRC and Hittite when considering a move to Ireland, and can therefore take appropriate credit for the creation of related new Irish jobs. In addition, Tyndall is increasingly focusing on new ICT-led research opportunities for the medtech sector, and is becoming an important contributor in attracting new FDI and further embedding existing medtech companies in Ireland.

Tyndall provides important support for start-up companies and during 2013 there were 9 such companies supported by Tyndall, building businesses around our technologies and taking advantage of the expertise and infrastructure at Tyndall.

The research infrastructure has expanded greatly in the past ten years with the addition of a new state-of-the-art research building with 5,500 $m^2$ of clean room and shared laboratory space, a new conference centre and 7,000 $m^2$ of new office, labs and general space. Over 130 high quality postgraduates are currently in training and during the course of 2013 Tyndall graduated 31 new PhDs, many of whom go on to work in Irish industry.

2013 saw significant momentum build in each of the four national centres within Tyndall: The IERC (International Energy Research Centre), CCAN (Collaborative Centre for Applied Nanotechnology), MCCI (Microelectronic Circuits Centre Ireland) and IPIC (Irish Photonic Integration Centre). These Centres have dramatically increased the ability of the Irish research community to support industry in key areas.

2013 also marked the first year at the helm for CEO, Dr. Kieran Drain, who is providing strong leadership for the next phase of Tyndall's development. He has already put in place an ambitious 5-year strategic business plan, providing a confidence-building focused framework for future economic impact.

2013 was a year of impressive achievements for Tyndall, as attested to by the results and positive feedback that fill the pages of this annual report.

Finally, I would like to recognise the contributions of the Tyndall Board. This Board has strength in all aspects of innovation, from basic research through development, government policy and venture capital and has been hugely important in guiding the development of the Institute. My term as Chairman will end in October 2014, and I would like to express my sincere thanks to all the Board members, past and present, for their valuable service to Tyndall. It has really been a wonderful journey seeing the early development of this important Institute, and I look forward to watching its continued development and international impact over many years to come.

**Dr. Alastair Glass**
Chairman

# Message from the CEO

2013 was an exciting year for Tyndall and with the breakthroughs and progress made, together with our enhanced capabilities, we expect 2014 to be even better.

A primary focus of my first year as CEO has been the completion of a new 5-year strategic plan for the Institute. We have set out a clear strategy to derive economic impact from research excellence. The plan is focused on generating employment and building capacity within the technology space across Ireland. An implementation scorecard has been developed, to measure **"Impact from Excellence"**, and detailed planning is in place for our first sector strategy (ICT for Health).

Tyndall's organisation structure has been adjusted to support the delivery of our ambitious new plan and we are actively engaged in recruiting for key new leadership positions.

Building on our success in securing the SFI-funded Irish Photonic Integration Centre, Tyndall competed in a number of centre bids, as part of the 2013/2014 call.

Tyndall's world-class reputation in photonics was further underpinned when we teamed up with EU ePIXfab, a silicon photonics initiative with partners including IMEC, CEA-LETI and Fraunhofer to provide advanced optical packaging technology. We also partnered with MOSIS, a US-based silicon IC foundry service, to supply solutions for a range of telecommunications and healthcare applications.

Great strides were made within the Health sector during 2013, ICT for Health now accounts for over 15% of our activity. Two global medtech companies, Lake Region Medical and Boston Scientific, now have researchers in residence at Tyndall, with active research programmes underway.

By the end of 2013 Tyndall's participation in 7th EU Framework Programmes rose to 90 projects, 26 as co-ordinator, drawing down €38m to Tyndall and €10m for SMEs, representing a two-fold increase over FP6. Programme officer resources are now in place to support our goal to significantly grow our impact in the new Horizon 2020 programme.

> By 2013 Tyndall's participation 7th EU Framework Programme rose to 90 projects, 26 as co-ordinator, drawing down €38m to Tyndall, €10m for SMEs, a two-fold increase over FP6.

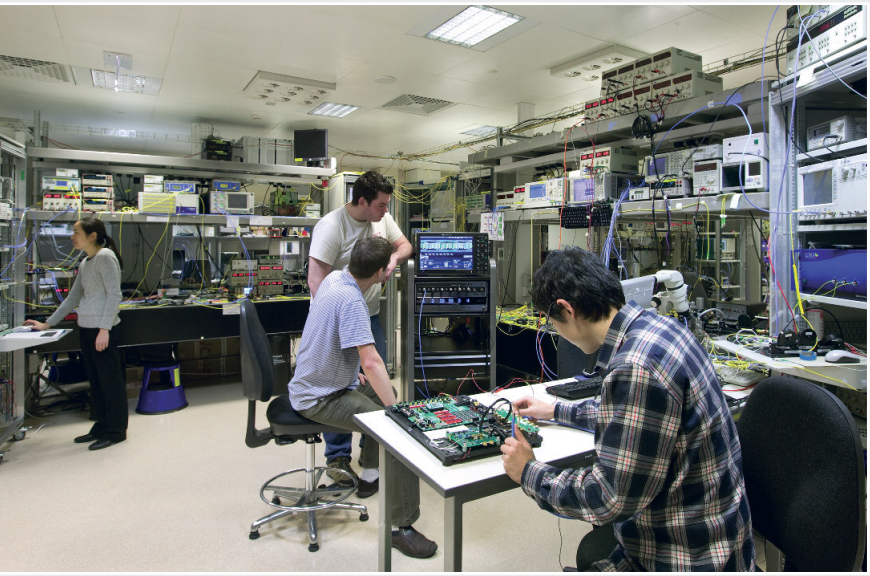
Many exciting materials science advances were made throughout the year. The prestigious Nature Physics Journal published Professor Steven Fahy's work on how atoms vibrate and change when hit with intense bursts of light. Tyndall launched a new laboratory for research and advanced teaching of radio frequency integrated circuits for high-speed wireless data communications and contactless sensors, with sponsorship support from Agilent Technologies.

A number of new strategic partnerships were entered into, including an MOU with PCH International to support new high-tech start-ups, and an MOU with Telecommunications Software and Systems Group to combine their software skills with our hardware strengths. Our partnerships with Polytechnic University of Turin and Cork Institute of Technology (CIT) were further strengthened to foster research and staff / student exchanges.

> Tyndall delivers new opportunities for Ireland's economic growth through excellent research, graduate education, company engagement and a passion for impact.

Tyndall continued as a national gateway institution for ICT research, with an impressive range of novel devices fabricated during 2013, under the SFI-funded National Access Programme (NAP).

Since 2005 NAP has funded access to Tyndall for researchers from all third level institutions on the island of Ireland. This programme will become a fee based model of access from 2014.



Photonic Systems Laboratory at Tyndall National Institute.

Tyndall's hosted technology centres IERC, MCCI and CCAN all expanded, with industry membership exceeding 45 companies. The Centre's, supported by Enterprise Ireland and IDA are delivering on ambitious industry-led programmes to help drive job creation in Ireland, while providing globally competitive technologies to the market place.

Tyndall researchers continue to receive international recognition for their work;

- Brian Corbett received Tyndall's third successive Intel Outstanding Researcher Award'. Intel has made only 11 of these global awards to date.
- Prof. Martyn Pemble received the first Irish Gold Medal for excellence in surface engineering by the Institute of Materials Finishing.
- At the time of writing this report Prof. Eoin O'Reilly was named winner of the prestigious 2014 Rank Prize for his pioneering work on optoelectronics, and named Chief Scientific Officer for Tyndall.

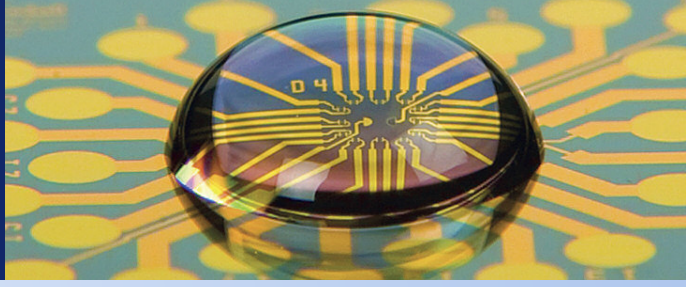
Delivering skilled graduates to the economy is one of our key impact factors, and 2013 was an excellent year with over 30 PhD students graduating from Tyndall. A key contribution of the Tyndall Graduate Studies activity for the year has been the development of the Flexi-Learn.ie web site and virtual learning environment. FlexiLearn.ie is developed so that any national graduate education programme may avail of the platform.

The Tyndall management team, most especially myself, would like to thank our Chairman Alastair Glass and the Board for their continued leadership and thought partnering, and for their support of our new 5-year strategic plan to achieve accelerated growth. I would further like to thank President Michael Murphy of University College Cork and the Department of Jobs Enterprise and Innovation for their continued strong support.

Finally, I would like to thank our staff and students for their commitment and hard work. The following pages of the report attest to their many achievements during 2013.

**Kieran F. Drain,** Ph.D.,
Tyndall CEO

# 2013 Highlights



Highlight 1

## Tyndall Researcher wins the Intel Outstanding Researcher Award

During 2013, Mr. Brian Corbett became the third Tyndall researcher to win the **Intel Outstanding Researcher Award**. This award recognised truly outstanding contributions by researchers funded by Intel's Semiconductor Technology Council. Mr. Corbett is specifically recognised for his work in developing photonics for applications in semiconductor technology.

The award was presented by Intel Fellow and Director of Advanced Device Technology at the Technology Manufacturing Group, Dr. Kelin Kuhn, who commented "in making these awards we give careful consideration to both the excellence of the research and its practical applications. I am delighted to say that Brian Corbett has excelled in both categories."

Dr. Kieran Drain, Tyndall; Prof. Anita Maguire, UCC; Mr. Brian Corbett, Tyndall; Dr. Kelin Kuhn and Leonard Hobbs, Intel.

Highlight 2

## Walton Fellowship & Stanford Collaboration Published in Nature Physics

Tyndall hosted Professor David Reis of Stanford University under the **SFI Walton Visiting Fellow Programme** during 2013. The ground-breaking research sought to improve knowledge of coupling between electronic and atomic motion in materials, and was the main focus of the collaboration. It has directly enhanced the understanding of charge transport and energy dissipation in nanoscale semiconductor devices, which are relevant in a range of high-speed electronic and photonic devices, and in semimetals, which are relevant for thermoelectric applications.

The work has been recognised through publication of a paper in the prestigious journal, Nature Physics. Explaining the significance of their research, Prof. Fahy, Head of the Materials Theory Group at Tyndall and Professor of Physics at University College Cork said: *"Understanding and controlling how light alters the forces between atoms is central to our understanding of photo-chemistry and underpins many areas of energy science, such as photocatalysis. Tyndall and its collaborators are one of only a few groups worldwide with the ability to measure and calculate such atomic motion and we are delighted to have our work recognised by Nature."*

Prof. David Reis of Stanford and Prof. Stephen Fahy UCC/Tyndall.

Highlight 3

# Advanced Diagnostic Devices for Animal Health & Welfare

Researchers in Tyndall have developed a new thematic research focus on novel diagnostic devices that will permit real-time on-farm disease detection at a much earlier stage of disease onset than current methods. The new technology, based on application of nanosensor technology, will permit earlier clinical intervention by veterinarians and will reduce both the economic and animal welfare costs of infection.

Bovine respiratory disease (BRD) in cattle is a highly infectious disease responsible for 30% of deaths in stock under one-year old in Ireland. Affecting both beef and dairy herds, it is a major source of lost revenue to the global agri-food industry e.g., $4bn in the US per annum. The **"AgriSense"** project will provide a low-cost yet extremely precise and quick method for early detection and diagnosis. This will allow infected cattle to be isolated and could also facilitate more tailored treatment programmes, eradicating the current practice of costly and indiscriminate dosing with antibiotics to stop the spread of infection.

Liver fluke parasite infection costs Irish farmers €25m annually, and represents a €90m annual cost to the Irish food industry. The "Flukeless" project will provide a blueprint for new, on-farm parasite control, allowing farmers to rapidly intervene and correct parasite-related animal health issues such as reduced live-weight gain, calving rates and milk yield. The new toolkit will combine state-of-the-art diagnostic devices, tracking systems, immunity and DNA testing to tackle the common liver fluke.

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

Highlight 4

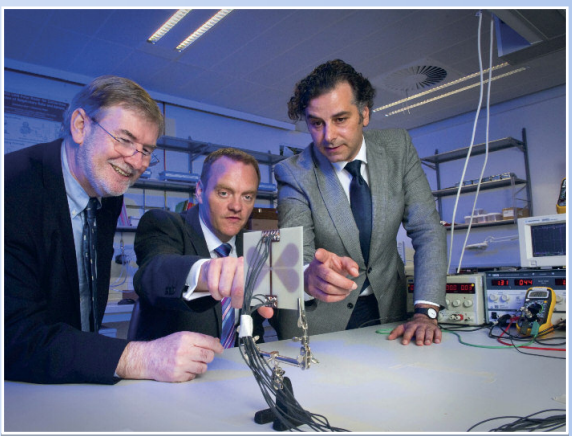
# Tyndall Opens State-Of-The-Art Teaching & Research Laboratory for Wireless Communications

Tyndall opened a new laboratory for research and teaching in next-generation wireless communications during 2013.

This state-of-the-art laboratory enables advanced training and research on radio frequency integrated circuits for high-speed wireless data communications and on contactless sensors for biomedical and security applications.

The laboratory is named after the 1909 Nobel prize-winning Italian scientist, Guglielmo Marconi (also known as the father of wireless communications), who moved to Ireland to carry out his research.

The Marconi Laboratory at Tyndall is home the latest industry-standard equipment, thanks to support from Agilent Technologies and the HEA Programme for Research in Third Level Institutions (PRTLI).



Dr. Kieran Drain, Tyndall CEO; Mr. Julian Brecknock, Agilent and Dr. Domenico Zito, Tyndall at the opening of the Marconi Laboratory at Tyndall.

Highlight 5

# Tyndall Industry Conference

Kieran Drain, Tyndall; Alan Mathewson, Tyndall; Stephen Keeney, Global Foundries; Norbert Meyer, XFAB; Terry Ma, Synopsys; Anne Kelleher, Intel; Leo Clancy, IDA, Michael Grufferty, Tyndall.

Shazrinizam Shaharan, RCSI; Minister Seán Sherlock TD.; Kieran Drain, Tyndall CEO and Donncha Ryan, RCSI.

Over 320 delegates attended the inaugural Tyndall Industry Days Conference on 17th-19th September. It was a key platform for Tyndall to deepen our understanding of our stakeholder needs, showcase the level of expertise and capabilities at the institute and create new partnerships. We had a unique programme of world leading companies, clinicians and scientists speaking and participating at the conference. It proved to be a dynamic meeting place to share expertise, capabilities and solutions to key challenges in the converging world.

Leo Clancy, IDA; Stephen Kenney, Global Foundries; Terry Ma, Synopsys with Jim Greer, Tyndall.

ICT for Health conference day.

The three-day conference featured leading international speakers on technology roadmaps in: ICT for Health, Emerging Devices and Technologies, Advanced Thin Film Technologies for Nano-manufacturing, Energy Efficient Buildings and Micro-grids. These sessions covered ICT solutions for healthcare, communications, energy and the environment.

The ICT for Health day brought together clinicians, medtech companies and scientists examining the challenges and solutions around themes such as cardiac rhythm management, connected health, diagnostics, surgical innovations and many more. The Emerging Devices and Technolgies session highlighted: industry challenges in electronics from below 10nm devices right up to Heterogeneous Systems Integration. The sessions on Advanced Materials and Energy Efficient Buildings and Micro-Grids led to the establishment of new partnerships and collaborations to answer challenges in these areas. We were proud to welcome back a number of our alumni to speak at the conference, all now in senior roles with leading global companies.

Dr. Kieran Drain, Tyndall CEO with Dr. Jason Roche, IDA at the conference.

# **Tyndall Impact** Score Card

## Job Creation

- Jobs target defined at 500 for new strategic plan.
- 80 jobs announced by Hittite, Ublock and Qualcomm crediting Tyndall and MCCI support.
- Tyndall SME partners PMD, Endecco and Brockley currently expanding.

## Research Excellence

- 2013 Intel Outstanding Researcher Award for work on developing photonics for applications in semiconductor technology - Mr. Brian Corbett.
- Rank career award for pioneering work on optoelectronics - Prof. Eoin O'Reilly.
- IMF Gold Medal for excellence in surface engineering - Prof. Martyn Pemble.
- More than 200 peer reviewed publications in 2013.

## Skilled Graduates

- 31 PhD viva examinations completed during the year.
- Over 120 active postgraduate students.
- 20 nationalities represented.

## Industry Investment

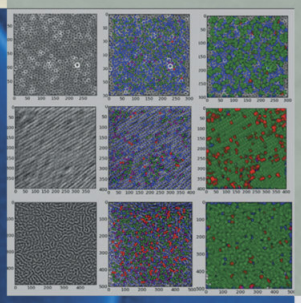
- Research contracts secured with 4 of the world's top ten Medtech companies.
- MCCI increases membership to 24 companies.
- Preferred partner to Industry in Microelectronics and Photonics.
- Researchers-in-residence from 10 companies.
- Tyndall Technology Days with over 300 attendees.

## Funding

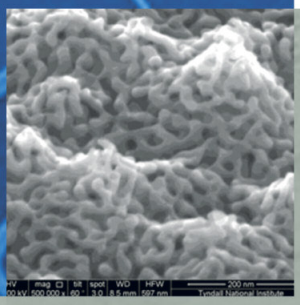
- Funding from EU FP7 twice that from FP6.
- Industry contribution increased to €7m.
- New Irish Photonic Integration Centre funded by SFI up to €30m.
- Strong performance in a challenging funding environment.

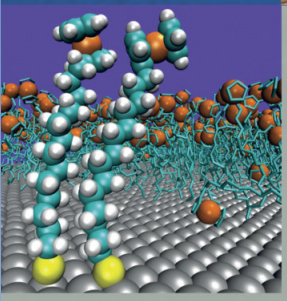
## International Reach

- Partnership agreement with PCH to accelerate start-up activity.
- MOU with Politechnico Turin to support H2020 collaboration.
- Launched University of Notre Dame collaboration in NanoElectronics, Microsystems & Photonics.
- Led ICT section of SFI China ISCA building collaboration with Beijing Institute of Technology.
- Training fab supports international reach in EMEA.



# Research





> We appreciate and applaud the developments that have taken place at Tyndall, they certainly complement our road map.

**Jim Somers,**
**CEO Eblana Photonics**

# Micro/Nanoelectronics


Prof. Martyn Pemble was awarded the Gold Medal from the Institute of Materials Finishing for his 'outstanding contribution to surface engineering in Ireland'.

## Introduction

Research in the Micro/Nanoelectronics Centre (MNE) focuses on the preparation of materials and nanostructures for future electronic devices, the understanding of the electrical and electronic properties of materials and device structures with particular attention to the role of interfaces, nanostructures and defects, together with the development of a range of materials for other technologically important applications including photovoltaic and other sustainable energy devices, ferroelectric and ferromagnetic sensors, actuators and memory devices and advanced battery technologies.

2013 was a particularly productive year for researchers in the Centre. Professor Martyn Pemble was awarded the Gold Medal from the Institute of Materials Finishing for his 'outstanding contribution to surface engineering in Ireland'. Tyndall Associate Members, Professors Justin Holmes and Michael Morris, were major contributors to and co-Principal Investigators of the new SFI AMBER Centre based at Trinity College Dublin (Advanced Materials and Bio-Engineering Research) which was awarded €30m over a 6 year period.

Our work continues to be underpinned by extensive collaborations with a number of key industrial partners, such as Intel and Applied Materials, who have provided us with state-of-the-art equipment and researchers-in-residence.

## Tyndall Researchers RENEW International Collaboration To Unlock Energy Potential in Water

Researchers in the MNE Centre at Tyndall, working in the area of novel water splitting technology, were awarded funding to facilitate a partnership with scientists from the United States and Northern Ireland in 2013. The €1m initiative is entitled 'Research into Emerging Nanostructured Electrodes for the Splitting of Water' (RENEW), and is led by Professor Martyn Pemble and Dr Paul Hurley at Tyndall, together with Professor Paul McIntyre at Stanford University and Professor Andrew Mills at Queen's University Belfast, and is jointly funded by the National Science Foundation in the US, Science Foundation Ireland and the Department for Employment and Learning for Northern Ireland under the US-Ireland Research and Development Partnership Program.

RENEW Team: Dr. Ian Povey, Mr. Adrian Walsh, Mr. Jan Kegel, Dr. Karim Cherkaoui, Dr. Paul Hurley, Dr. Scott Monaghan, Prof. Paul McIntyre, Prof. Andrew Mills and Prof. Martyn Pemble.

The main focus for the project is to design, fabricate and test a stacked arrangement of materials that is very similar to structures employed in advanced CMOS devices. Previous work has shown that these structures can act as basic 'artificial leaves' for splitting water and the aim now is to make them more efficient. Unlike other projects of this type, RENEW focusses on natural light using a range of materials to achieve an impenetrable top layer that can withstand water's corrosive effects.

## State-of-the-art Directed Self Assembly

Professor Michael Morris has been working with Institut Català de Nanociència i Naotecnologia (ICN2) collaborating on a unique tool developed to address the gap existent in the metrology area of sub-10 nm line patterns, a unique methodology able to quantify line arrays critical dimensions and defect density, in regimes where optical inspection cannot reach. The software has been developed by the Phononic and Photonic Nanostructures Group at ICN2, led by Professor Clivia Sotomayor-Torres, in collaboration with University College Cork and the Tyndall National Institute.

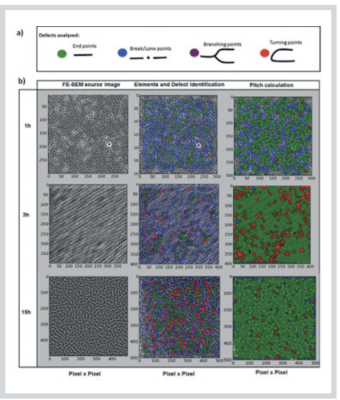


Figure left shows defect analysis of three typical block copolymer patterns.

To meet the increasing demand for smaller, faster and more powerful devices a continued decrease in the size of device components is required. Directed self-assembly (DSA) is fast gaining the attention of the alternative lithography community as it is already compatible with the technologies existent today in the fab. This pioneering line pattern image analysis software is state-of-the-art, user-friendly and adaptable, successfully addressing the issue of the metrology associated with DSA.

## Germanium Nanowires Conduct Current

Dr. Ray Duffy has been making huge advances in the area of Germanium technology, developing the smallest top-down patterned Germanium nanowires ever reported. This is the first such in-depth analysis of Germanium nanowires. This work was performed in collaboration with the Tyndall Central Fabrication Facility and Electron Microscopy and Analysis Facility and the Materials Chemistry and Analysis Group in the Department of Chemistry at UCC. Figure A shows an image of the Germanium nanowires. The nanowires were patterned using e-beam lithography with HSQ resist, and Reactive Ion Etching.

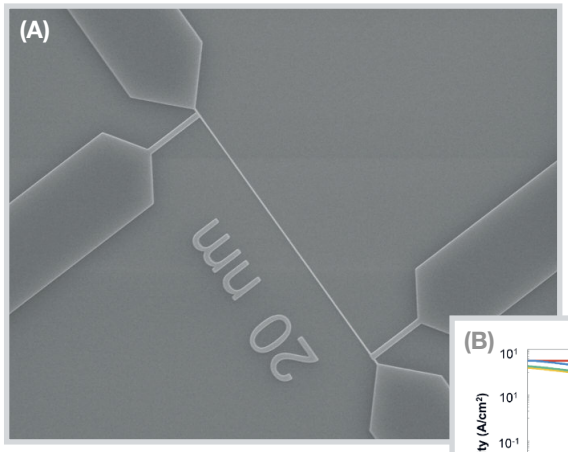



**Figure A:** Top-down patterned Germanium nanowire fabricated on a Germanium-on-insulator substrate.

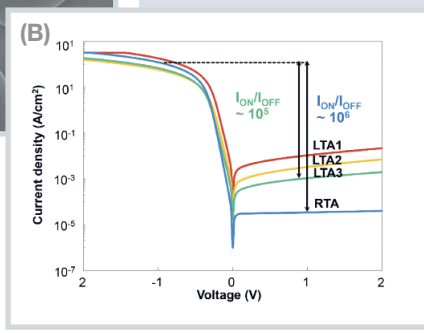



**Figure B:** Germanium diode forward bias and reverse bias current density.

The nanowires were then doped by a novel processing technique, and electrical characterisation proved the nanowires conducted current in accordance with Ohm's Law. The aim of the work is to understand the influence of excimer Laser Thermal Annealing (LTA) on the reduction of access resistance to Germanium devices, and compare to a standard Rapid Thermal Anneal (RTA) approach. Dr. Duffy has filed a patent application in Europe, US, and Taiwan titled "Improved low resistance contacts for semiconductor devices".

## Thin Film Form for Memory Apps at Room Temperature

Growth in the creation of digital data continues to outpace the growth of storage capacity. 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 promising architectures for memory scaling beyond current technologies. Until very recently, there were no materials showing genuine multiferroic effects at room temperature, therefore no such devices exist.

However, one highly significant output of the SFI-funded FORME Strategic Research Cluster project has been the fabrication of a single-phase magneto-electric multiferroic material in the Aurivillius phase, $Bi_6Ti_{2.8}Fe_{1.52}Mn_{0.68}O_{18}$ (B6TFMO). This work was selected for publication as a feature article in the Journal of the American Ceramic Society and highlighted on the journal front cover in August 2013.

Building on this research, a Science Foundation Ireland - Technology and Innovation Development Award (TIDA) was made to Dr. Lynette Keeney collaborating with Intel and Professors Martyn Pemble and Roger Whatmore.

# Microsystems


Dr Saibal Roy working in the Micropower-Nanomagnetics Lab.

## Introduction

It is envisaged that, over the next decade the **Internet of Things** or the **Internet of Everything** will facilitate a paradigm shift in the management of the health, people, security and well-being of people.

During 2013, the Centre progressed significantly with this agenda through:

- the delivery and transfer of technologies for intelligent sensors to companies and organisations such as Analog Devices, CERN, ON Semiconductor, PMD Solutions and UTRC. A particular highlight was the delivery of 1400 packaged RADFETs to CERN for use in the Large Hadron Collider (LHC) ring.
- being successfully funded as a partner under the SFI Centres Programme within both the INFANT and INSIGHT Centres and as a coordinator under the EU FP7 NMP Programme within the MANpower project.
- formulating an institution-wide strategy for ICT for Health which is targeting annual funding of more than €15m by 2018.

The Centre also put in place Tyndall's first dedicated EU Programme Officer and hosted the EU Smart Systems Annual Forum and FP7 MicroNanoBioSystems Workshop. We co-led the submission of two large-scale, SFI Centre pre-proposals, in Biomedical Diagnostics and Future Networks & Communications, as well as being a partner in other Centre bids in Advanced Manufacturing and Earth Observation.

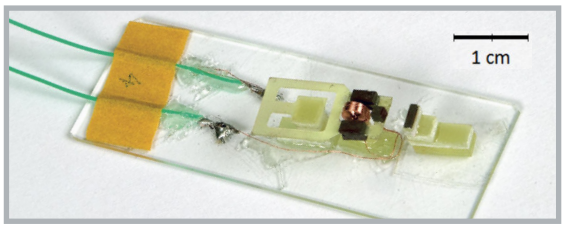
## Most Advanced Wireless, Inertial Monitoring Platform

Complex motion analytics, employing low-cost, miniature, inertial sensor technology, have wide ranging applicability in many fields ranging from wearable healthcare, fitness and digital sports to emerging areas such as precision agriculture and marine energy. While there are advances in bandwidth, noise floor, dynamic range, cross-axis sensitivity, linearity and shock survivability, there are still many technological limitations including the need for in-use calibration, drift compensation and power optimisation. With this in mind, the Wireless Sensor Networks group, led by Brendan O'Flynn, has developed the world's most advanced, MEMS-based, wireless, inertial monitoring platform. This miniaturised, wearable system is capable of sampling movement at a rate of over 30,000 samples per second. In conjunction with proprietary, real-time, data analytics and sensor-fusion algorithms, accelerations, angular velocities, magnetic field variations, 3D orientations and 3D linear displacements are recorded enabling many complex, fundamental and commercially-exploitable, in-the-field problems to be addressed for the first time.

Wearable wireless inertial monitoring platform.

## Vibrational Energy Harvesting for Wireless Sensors

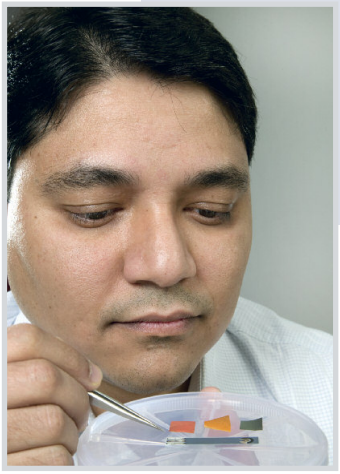
For autonomous wireless sensors, the requirement to change batteries, or recharge other power sources, places an unsustainable maintenance and cost burden on such networks. In order to achieve the challenge of “deploy and forget” smart sensor nodes, it will be necessary to develop miniaturised, long life-time, power sources based on harvesting energy from the environment. To address this, Dr Saibal Roy and the Micro-power-Nanomagnetics group are researching vibrational energy harvesting using electromagnetic transducers. The team have demonstrated prototypes of the first reported “wide-band, bi-stable” electromagnetic vibration energy harvesting devices on printed circuit board (PCB) for powering wireless sensor nodes.




Prototype of first reported “bi-stable” electromagnetic vibration energy harvesting device.

## Nanowire BioSensor Arrays for Autonomous Sensing

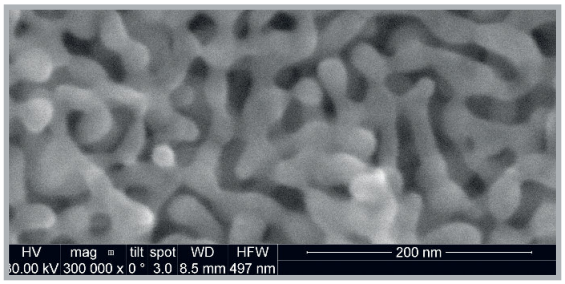
Electrochemical sensors and biosensors are widely used to detect different analytes. The most versatile and widely-used sensor is the glucose sensor. These sensors use enzyme or sensitive biological elements (e.g. antibody, nucleic acid, etc.) and are expensive to produce, sensitive to environmental conditions and subject to deterioration of sensitivity over time. Research undertaken by the Nano-Interconnection team, led by Dr. Kafil M. Razeeb, is focused on the development of electrochemical sensors without using any biological elements. The team was able to fabricate glucose, glutamate and pH sensors based on vertically aligned coaxial Ni/NiO nanowire arrays without using any enzyme or bio-elements. The sensors showed high selectivity and very good repeatability compared to state-of-the-art sensors. The work is carried out in collaboration with multinational industries with funding from both national agencies and EU FP7.



Dr. Kafil M. Razeeb reviews electrochemical sensors.

## Nano-Sensors for Safe & Cost-effective Detection of Contamination in Liquids

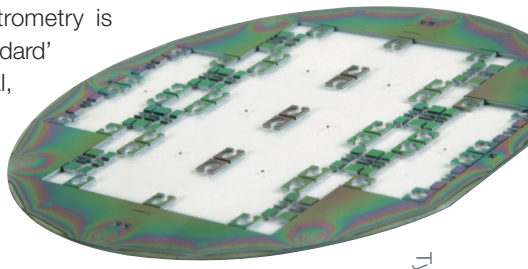
The measurement of organic contamination in liquids in the form of total organic carbon (TOC) is required in environmental, clinical and industrial settings. Current techniques require hazardous reagents or high temperature processing. The development of a safe and cost-effective electrochemical device to detect low ppm levels of organic materials was the focus of the ‘NPGold’ project, completed in 2013 by Dr. Lorraine Nagle, with local SME’s, Biotector and Glantreo, as industrial partners. The study verified enhanced electrocatalytic activity at nanoporous gold (NPG), first reported by Tyndall for fuel cell oxidation reactions. This study has led to a follow-on research project, with Biotector and Nanoflex as industrial partners, to optimise the miniaturised sensor platform for industrial applications.




SEM image of high catalytic activity nanoporous gold for sensing applications. The pores in the interconnected gold measure approximately 15nm.

## World’s First MEMS-based Triple Quadrupole Mass Spectrometer System

MEMS-based, triple, quadrupole, mass spectrometer.



Triple, quadrupole, mass spectrometry is widely regarded as the ‘gold-standard’ for analysis of pharmaceutical, clinical, environmental, forensic, food and drink samples providing unrivalled sensitivity and selectivity. Limiting factors such as size, cost of ownership, solvent and power consumption limit deployability. Commercially available triple, quadrupole LC-MS systems, which today are the size of a filing cabinet are very expensive with only 7,200 triple, quad systems installed globally.

The goal of the Tyndall-coordinated EU FP7 ARROWS project was to deliver the functionality of a laboratory-scale, triple, quadrupole, LC-MS system, in a mass-deployable tool the size of a desktop PC and at a significantly reduced cost. To enable this size reduction, MEMS-based components were used and, over the course of the project, the world’s first MEMS-based, triple, quadrupole, mass spectrometer was designed and built using a Tyndall fabricated chipset.

# Photonics

Minister for Research and Innovation Sean Sherlock TD; Prof. Paul Townsend, Director of IPIC at Tyndall National Institute and Prof. Mark Ferguson, Director General Science Foundation Ireland.

## Introduction

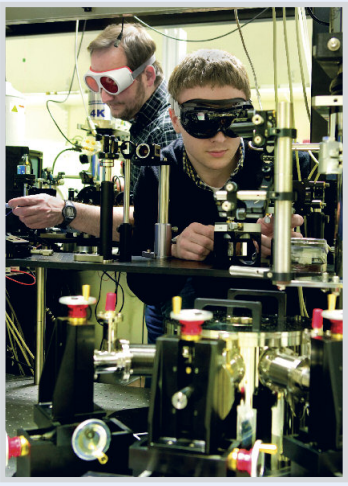
Photonics is the generation, manipulation and utilisation of light, and forms an important enabling technology that impacts our everyday lives; including for example, the fibre-optic communication technologies that enable the global internet and new light-based medical diagnostics and therapeutics that are increasingly being used to provide advanced healthcare solutions. The centre's research programme is constructed to align with the needs of the international photonics industry, which is a fast-growing business sector, with a global market of around €350bn, projected to reach over €600bn by 2020.

Importantly, Europe has established a strong position within this market with an overall total share of approximately 18% (€66bn in 2012), which is estimated to impact 10% of the European economy. Major growth is expected in medical technologies, life sciences and optical communications, which are key areas of focus for the Photonics centre. Tyndall currently supports a vibrant community of 120 photonics researchers and students with capabilities that span from 'atoms to systems' and is recognised as one of Europe's leading photonics research centres.

Highlights in 2013 included the Intel Outstanding Researcher award to Brian Corbett, significant world-firsts in photonic materials science and the launch of the new SFI Irish Photonic Integration Centre (IPIC), which is hosted by Tyndall.

## Entangled Photons from Site Controlled Quantum Dots

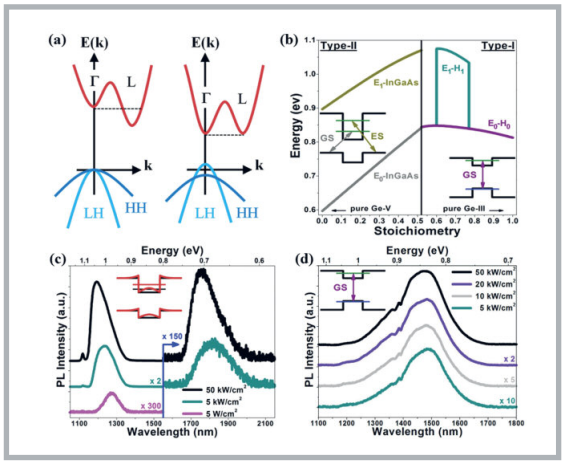
Quantum Dots are thin, nanoscale layers of atoms employed in semiconductor devices to confine electrons and their oppositely charged counterparts, holes, to small regions of space where they combine efficiently to generate light. These structures bear remarkable similarities with real world atoms and will potentially be important constituents in future quantum information systems, which will exploit the strange quantum phenomenon of entanglement to achieve dramatic improvements in computation speed and communications security. Entanglement is the ability of a quantum system to simultaneously coexist in multiple states, which enables a quantum computer to operate in a fast, intrinsically parallel fashion not achievable with a classical computer. Dr. Emanuele Pelucchi's team has shown for the first time how this can be achieved, by using the metal-organic vapour phase epitaxy (MOVPE) fabrication technique to make quantum dots with record symmetry properties. The results were published in the July edition of the premier journal Nature Photonics.



Low temperature quantum optics and micropl set-up.

## Light Emission from Germanium Nano-layers

As Moore's law continues to drive integration densities and processing speeds in computers, the potential use of high-speed optical interconnects for ultrafast data transfer between and within microchips is gaining increasing attention. To achieve this goal it will be necessary to integrate electronic and optical components on the same silicon chip. Silicon waveguide device technology enables many of the required optical functions to be realised. However, silicon is an indirect bandgap semiconductor and hence does not emit light, so the question of how to generate an efficient on-chip light source is still open. Germanium provides one potential solution, as it is compatible with silicon fabrication technology and, under strain, the bandgap in germanium becomes direct enabling light generation. Dr. Guillaume Huyet's team working with collaborators from Stanford University has shown for the first time how thin nano-layers of Germanium, which are strained by being sandwiched between layers of another semiconductor with a different inter-atomic spacing, Indium Gallium Arsenide, can be used for light emission.



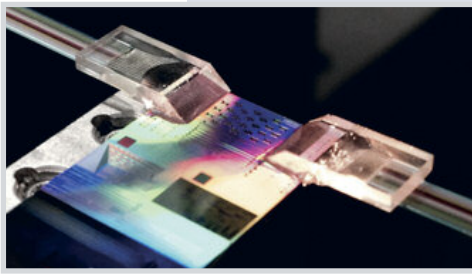

Schematic band structure of bulk Ge (left) and highly tensile-strained intrinsic Ge.

The research demonstrated that different types of optical transitions favouring either light generation or transistor action could be generated, opening the potential to achieve integrated circuits with complex optical and electronic functionalities coexisting on the same wafer.

## Silicon Photonics Research

Silicon photonics offers a cost-effective route to achieve the very high optical transceiver integration densities that will be required for Terabit-class optical interconnects for future high performance computers and data centres. Tyndall is playing a leading role in the development of silicon photonics, with significant emerging opportunities in the areas of photonic packaging, microelectronic circuits for laser and modulator drivers and receivers and laser integration.

For example, Dr. Peter O'Brien's Photonics Packaging group is already supplying packaged devices through the EU ePIXfab silicon photonics initiative with partners including IMEC, CEA-LETI and Fraunhofer and has recently partnered with MOSIS, a US-based silicon IC foundry service, to supply devices into the North American market. Prototype silicon photonic sub-systems have been designed and delivered to both industry and academic partners for applications including metrology and sensing, bio-diagnostics and data communications. Tyndall was also a partner in the EU FP7 "Access Center for Photonics Innovation Solutions and Technology Support (ACTPHAST)" proposal, which was funded in 2013. ACTPHAST provides financial support to European SMEs to develop photonic prototypes and is expected to drive further growth in Tyndall's photonic packaging activity including silicon photonic systems.



Patented fibre array integration on a silicon photonic device for use in aerospace sensing.

## Launch of Irish Photonic Integration Centre (IPIC)

The new €30million Irish Photonic Integration Centre (IPIC) is a Science Foundation Ireland (SFI) Research Centre that brings together over 100 researchers from four institutes to develop new light-enabled technologies. IPIC is led by Tyndall in collaboration with University College Cork, Cork Institute of Technology and Dublin City University.

IPIC
BRINGING PHOTONICS TO LIFE

Targeting the ICT and medical devices sectors, IPIC is working with 18 industry partners to develop the next generation of highly-compact and miniaturised photonic technologies. This will require major advances in photonic integration, similar to the development of electronic integrated circuits some fifty years ago, to enable much higher levels of functionality whilst simultaneously reducing the cost and size of devices. IPIC is developing solutions to this challenge that are 'bringing photonics to life' by opening new ways to connect people and their environments through the application of light.

For example, the centre will develop new solutions for:

- Faster, more energy-efficient optical communication.
- Smart, optically-enabled medical devices that better connect doctors to their patients.
- Novel optical sensors for monitoring food quality and our environment.

# Theory Modelling & Design

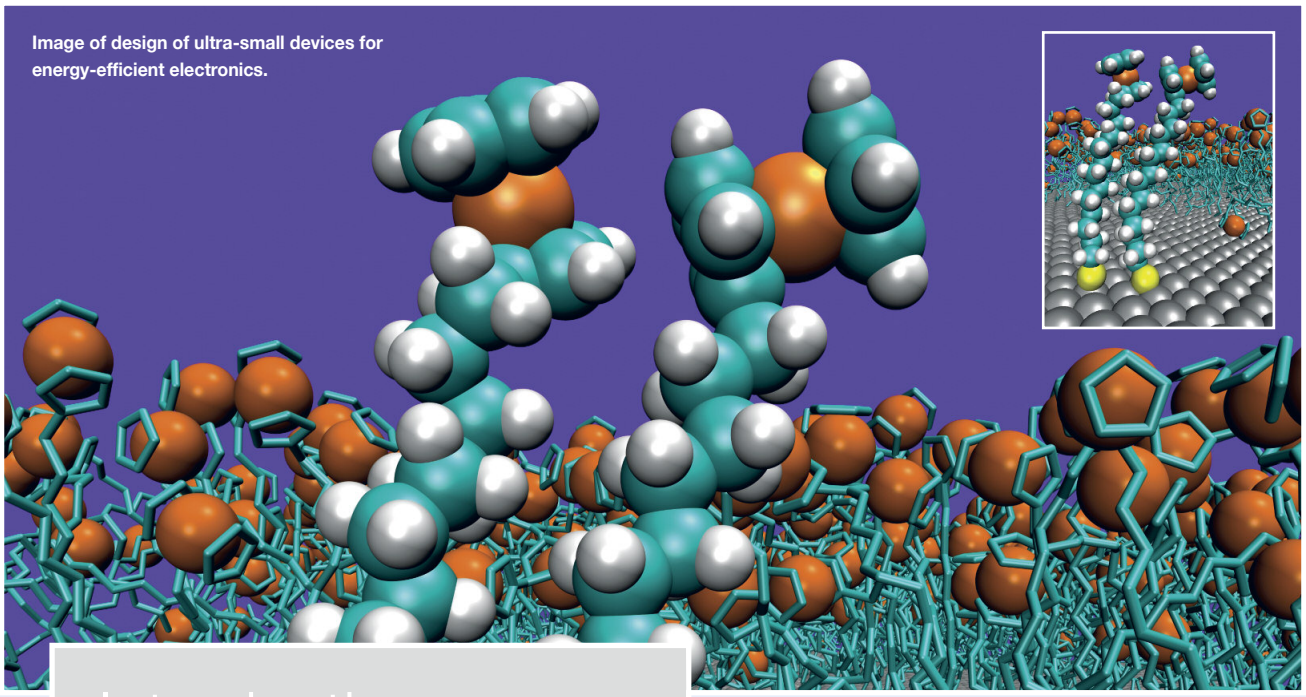


Image of design of ultra-small devices for energy-efficient electronics.

## Introduction

The Theory Centre is built upon a very strong cohort of researchers, who make a major contribution to Tyndall's overall reputation and impact. During 2013 this included publications in Nature journals by Stephen Fahy and by Damien Thompson and in Physical Review Letters by Michael Nolan and Felipe Murphy-Armando, as well as the patenting and licensing of novel ideas on exact frequency synthesizers by Peter Kennedy to Analog Devices. Research in the Centre focuses on Photonics, Micro/Nanoelectronics and Microsystems, addressing issues that range from fundamental physics and materials problems through to novel system design and applications.

Research in the Theory Centre is strongly supported by SFI – Stephen Fahy was awarded a new PI Award which started in 2013, using first-principles electronic structure theory to investigate ultrafast energy dissipation in semimetals and semiconductors, while Eoin O'Reilly is a PI in the new Photonics Centre IPIC. The Centre has a strong portfolio of European funding, with several new EU projects starting in 2013 (Elliott, Fagas, Greer, Nolan, O'Reilly). The wider immediate relevance of research in the Centre is also validated through direct industry funding of Simon Elliott's work and SFI Industry Fellowship funding for Stephen O'Brien to work with Intel, as well as funding from CCAN and MCCI supporting further research in the Centre.

## Divide-By-Three Frequency Synthesizers

Injection-locked frequency dividers (ILFDs) offer great potential for frequency synthesis applications in wireless communications systems. Traditionally, ILFDs have been used mainly to divide radio frequencies by even integers, most often by two, because division by odd numbers has been difficult. In collaboration with colleagues Antonio Buonomo and Alessandro Lo Schiavo from the Seconda Università degli Studi di Napoli, Peter Kennedy and his students have discovered a previously unknown synchronisation mechanism which can be used to extend the locking range, and thereby the robustness, of ILFDs. The new mechanism makes the locking region for divide-by-three as wide as that for divide-by-two, extending the potential range of uses. An application has been filed for a US patent and the idea has been explained theoretically in a paper which has been published in the IEEE Transactions on Circuits and Systems.

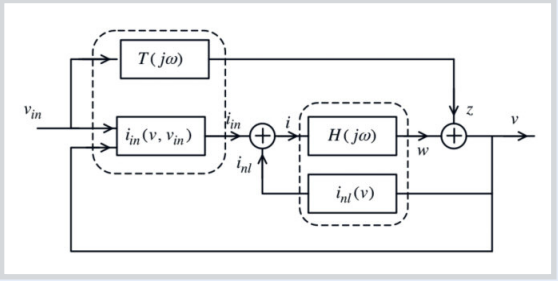



Figure above shows block diagram of the new ILFD structure.

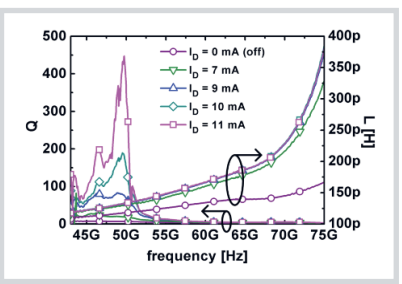
Peter Kennedy presented measured results for the prototype frequency-accurate fractional-N frequency synthesizer, which has been developed in collaboration with and licensed to Analog Devices, at the European Solid-State Circuits Conference (ESSCIRC) in September.

## Stand Tall & Keep Cool

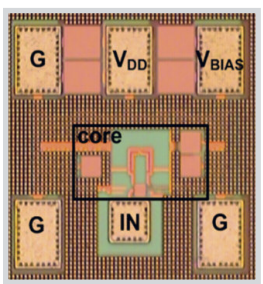
A collaboration between SFI-funded Starting Investigator Damien Thompson and the National University of Singapore has led to the design and fabrication of ultra-small devices for energy-efficient electronics. By establishing how molecules behave in these devices, a ten-fold increase in switching efficiency was obtained by changing just one carbon atom. These devices could provide new ways to combat overheating in mobile phones and laptops, and could also aid in electrical stimulation of tissue repair for wound healing. This breakthrough appeared in the February issue of Nature Nanotechnology. The devices are based on molecules that act as diodes by allowing current to pass through them when operated at forward bias and blocking current when the bias is reversed. This new research demonstrates that dramatic improvements in device performance may be achieved by controlling the van der Waals forces that pack the molecules together. Simply changing the number of carbon atoms by one provides significantly more stable and more reproducible devices that exhibit an order of magnitude improvement in ON/OFF ratio.

## 50 GHz mm-wave CMOS Active inductor

The low quality factor (Q) of spiral inductors due to losses in the silicon substrate is one of the most severe limitations for the implementation of high-frequency integrated circuits, with dramatic impact on selectivity and gain. Active circuits capable of providing a behaviour equivalent to that of a high Q inductor, traditionally called active inductors, can provide a solution to the severe selectivity and gain limitations. Domenico Pepe and Domenico Zito designed a millimetre-wave active inductor circuit implemented in 65 nm bulk CMOS technology. The results show an equivalent inductance of 133 pH with a quality factor exceeding 400 at 50 GHz, demonstrating experimentally the world-first implementation of high-Q active inductors in CMOS technology operating in the millimetre -wave spectral region.




Measured quality factor (Q) and inductance (L) of the mm-wave active inductor, for a set of bias currents.

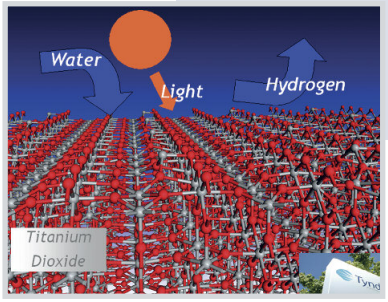



Chip design and layout.

This circuit significantly advances the previous solution operating at 13 GHz demonstrated by the same authors in 2009, consolidating their world-wide leadership of the topic.

## Design of New Photocatalysts

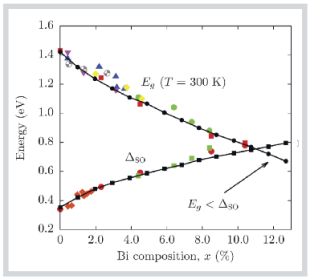
Anna Iwaszuk and SFI-funded Starting Investigator Michael Nolan have designed a number of new $TiO_2$ -based materials that will function as photocatalysts for water oxidation, which is an important step in the renewable generation of hydrogen from water. A particular highlight of this work is the development of anatase $TiO_2$ modified with nanoclusters of tin oxide (SnO) and exploiting the stereochemical lone pair in SnO to extend the valence band edge of anatase and thus shift the band gap into the visible region, while using earth abundant, non-toxic and cost effective materials. At the same time the separation of electrons and holes is enhanced over unmodified $TiO_2$, thus considerably improving the efficiency of the photocatalyst. Collaboration with experimental groups in Ireland, Japan and the USA has confirmed the potential of new $TiO_2$ photocatalysts based on this novel surface modification concept and simulation-led design.




Harnessing sunlight and water to fuel our mobile devices.

## Energy-Efficient Telecom Lasers

Today's telecom lasers are plagued with Auger-related losses, which limit efficiency and make device cooling mandatory. A breakthrough is required to eliminate these losses from telecom lasers. The EU project BIANCHO, coordinated by Eoin O'Reilly, enables for the first time widespread deployment of uncooled telecom systems. The combined theoretical effort at Tyndall and the experimental effort by partners in Marburg, Vilnius and Surrey has garnered three key insights: the band gap energy of the alloy Ga $Bi_x$ $As_{1-x}$ decreases dramatically with bismuth composition, thereby offering a possibility to achieve emission at telecom wavelength on a GaAs substrate; the spin-orbit-splitting energy increases rapidly with bismuth richness and exceeds the band gap energy at a content of 9-10 percent, critical to the elimination of Auger recombination; and Ga $Bi_x$ $As_{1-x}$ has a type-I band offset relative to the GaAs substrate, a condition favourable for realising large optical gain and an efficient laser. Using laser designs developed by Chris Broderick in Tyndall, partners in Marburg and Vilnius have demonstrated the first electrically pumped lasers based on this novel material system, a crucial first step towards the realisation of Auger-free telecom lasers.



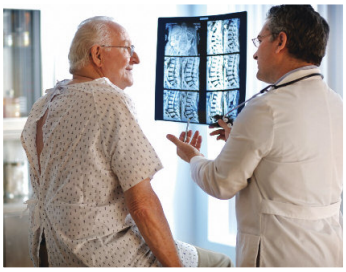

Variation of the band gap and spin-orbit-splitting energy as a function of the bismuth composition (x) in GaBiAs.

# Tyndall Solutions

## Healthcare

Tyndall is actively engaged with academic, business and clinical partners, leveraging innovative ICT technologies to provide solutions for healthcare applications. New healthcare solutions are being developed by Tyndall researchers, through the convergence of ICT with clinical, biotechnology, bioengineering and pharmaceutical research. This is enabling new solutions to a broad spectrum of healthcare challenges, including:

- new technologies for early diagnosis and continuous monitoring
- new technologies enabling personalised and /or targeted therapeutic delivery
- new integrated systems which combine early diagnosis and therapy
- new or less invasive surgical interventions
- new sensors and systems for technology enhanced learning to ensure clinical competence



The new innovative technologies being developed by Tyndall and its collaborators are targeting affordable solutions to the above challenges. Tyndall researchers are actively collaborating with various research active clinicians and clinical experts through the School of Medicine in University College Cork (UCC) and in the Royal College of Surgeons in Ireland (RCSI), to provide the full spectrum of expertise to enable the development of these next generation healthcare technologies from concept right through to clinical validation. Collaborations between Tyndall researchers working on technology solutions for Health, are also active within several large national research initiatives including the Irish Photonics Integration Centre (IPIC), the Biomedical Diagnostics Institute (BDI), the Insight Centre for data analytics, the Infant Centre for perinatal research, the Competence Centre for Applied Nanotechnology (CCAN), the Microelectronics Circuits Centre Ireland (MCCI), the National Access Programme (based in Tyndall), the Health innovation Hub at UCC, and the ASSERT for Health Centre (Application of Simulation to Education and Research for Training).

## Communications

The widespread use of electronic devices and communications in our everyday lives is driving demand for new technologies for data storage, higher speed, and more energy efficient communications.

Tyndall exploits its core competence in ICT research and development to provide new communications solutions that will deliver:

- Reduced cost, energy efficient and high bandwidth next generation Fibre-to-the-Home (FTTH) networks
- High capacity, Terabit/sec coherent communication systems
- New technologies for beyond standard fibre capacity limits
- High speed electronic solutions for extended reach transmission
- 'Colourless', energy efficient metro switching nodes
- Ultrafast on-the-fly all optical packet processing
- High speed all-optical sampling for device characterisation
- Ultra-secure quantum key distribution networks
- 1 Terabit/in$^2$ magnetic storage technology

Through partnerships with Irish based multi nationals such as BT, Alcatel-Lucent, Intel and Seagate and indigenous Irish companies such as Intune Networks, Eblana Photonics, Firecomms and SensL, Tyndall is delivering its technology for commercial exploitation.

> Tyndall exploits its core competence in ICT research and development to provide new communications solutions.

# Energy

It is recognised that the application of ICT to the integration of systems in our homes, commercial and industrial buildings and our living and working environment provides major opportunities for energy efficiency and savings.

Tyndall applies its ICT technology to deliver solutions for:

- Building energy management
- Micro-grid management (generation and storage) and integration with the smart grid
- Energy efficient lighting
- Energy harvesting and storage
- High efficiency solar cells
- Advanced power semiconductors
- Conditional monitoring of devices, machinery and systems to monitor energy and resource efficiency and enable predictive maintenance and auto-commissioning
- ICT wired and wireless networks for home and industry, from buildings & factories to micro-grids and extending to smart cities and smart grid systems

Through multiple national, EU and industry funded projects such as ITOBO, ME3Gas, MOSYCOUSIS, ERG, GENESI, AUTHENTIC, ROWBUST & GreenCom, along with the International Energy Research Centre (IERC), Tyndall is developing high impact, commercially realisable and retrofittable solutions with major national and international partners to deliver smarter and greener energy solutions. This delivers important energy, resource and cost savings, increases integration of renewable energy into our ecosystems and improves system reliability, as well as reducing $CO_2$ emissions.

# Environment, Food, Security

As global environmental pressures increase there is a need for new tools and technologies for monitoring, prevention and mitigation of these pressures and their associated health risks. Environmental protection and food/beverage quality and safety have therefore become of significant importance in Europe, and assuring the highest standards of simultaneous and rapid identification of potentially dangerous species is a key priority. Using its expertise in new materials, sensors, communications systems and modelling, Tyndall is developing new smart system technologies, demonstrating their impact in addressing these challenges and deploying them in real environmental, food and security scenarios, such as:

- Air, water and soil quality monitoring;
- Flood risk alert and management
- Pollution monitoring and associated health risks
- Remote chemical sensing for safe clean harbours
- Marine ecology
- Smart agriculture
- Process analytical technologies for monitoring of beverages
- On-site sensors for forensic Chemical, Biological, Radiological & Nuclear (CBRN) investigation at crime scenes
- Environmental and border security
- On-farm animal disease detection

Examples of on-going research collaborations include the SFI-funded CSET, CLARITY; an EI-funded project with Irish SME Biotector under the Collaborative Centre for Applied Nanotechnology (CCAN); an IRC-Enterprise project with PepsiCo and EU FP7 projects ARROWS, SHOAL, GIFT and ECO-India.

# Industry

> A significant part of Tyndall's 2013 Industry Strategy was to focus on the application of ICT for Health sector.

Tyndall continues to deliver outstanding research and economic impact through its world leading state-of-the-art facilities, capabilities and expertise. A key goal for Tyndall's Industry engagement, is to build solid, long-term relationships with existing clients to attract new clients from targeted sectors that are best placed to leverage Tyndall's capabilities and facilities for their own gain. There is increasing awareness about how ICT creates new opportunities and innovations across a wide variety of sectors thus bringing new RD&I opportunities to Ireland which in turn sustain Irish jobs. The success of Tyndall and its hosted centres; MCCI, CCAN, IERC and IPIC, mutually benefit each other in establishing market leader positions in RD&I.

Tyndall is well placed to address new challenges, deliver, innovative and disruptive solutions in areas such as: Health, Energy, Communications, Environment, Food and Security. The Institute has a long, standing history of innovation in Ireland, employing over 460 researchers from 38 nationalities.

This environment creates diverse multidisciplinary ecosystems which continues to drive innovation and inward investment. Tyndall's contributes significantly into the local, regional and national economy.

- Industry contribution: **€7m**
- Industry collaborators: **200**
- Researchers-in-residence: **22**

As Ireland's National ICT Institute, Tyndall continues to expand its working partnership with IDA. The Institute has become one of the key contributors in assisting IDA to bring FDI (Foreign Direct Investment) to Ireland. Some of this year's announcement included Qualcomm, Tyco, Stryker's expansion, the establishment of X-Celeprint, Lake Region Medical and Boston Scientific with researchers-in-residence at Tyndall. Tyndall's successful engagement across the divisional sectors of IDA's Lifescience, ICT & Engineering are opening up new opportunities for Ireland to look to new emerging markets as IDA increases its presence in China and India.

2013 marked a milestone on that journey, as a year when Tyndall further expanded its reach into the Medtech sector with the development of its research activity with Stryker Corporation (now a top 10 medical

device company). This comes on top of the on-going successes with Lake Region Medical (world's largest guide wire manufacturer) and the successful collaboration with Boston Scientific (a global leader in the development of less-invasive medical device products). Over 80 of the Institute's researchers are involved in work related to the ICT for Health strategic programme. Tyndall uniquely works with both the local operation and the R&D HQ of these companies. The Institute will continue to develop this strategy in 2014 with exciting announcements already on the horizon.

Tyndall has industry and academic partners from more than 420 countries around the world, spanning across a wide range of industry sectors. The Institute is partner to a strong network of industry influencers that are key contributors to the definition of global industry roadmaps. Gathering together this network around specific challenges in ICT-based solutions was the driving objective behind establishing our inaugural Tyndall Industry Conference from Sept. 17-19.


The central theme of the three-day event was "The impact of ICT on industry roadmaps". The event attracted over 320 international attendees. Each day focused on different roadmaps and the next generation of ICT developments likely to emerge as solution providers or enablers. The conference covered the following topics; ICT for Health; Emerging Devices and Technologies; Advanced Thin Film Technologies for Nano-manufacturing; Energy Efficient Buildings and Micro-grids.

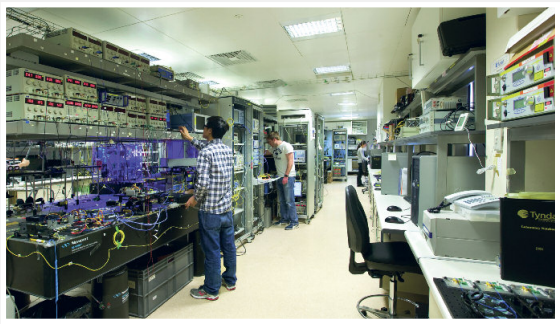
As part of its strategy to explore new markets and opportunities, Tyndall began working with partners PCH International on start-up acceleration and also with software experts such as the Technology Systems Software Group (TSSG) at Waterford Institute of Technology. Tyndall plans to expand this network to build a stronger working relationship with Enterprise Ireland to develop its in-out and in-in capabilities in 2014. Tyndall's reputation is based on its expertise and the Institute focuses on the areas where it can clearly demonstrate leadership, innovation and added value.

By working closely with small/medium enterprises (SMEs) and multinational companies Tyndall seeks to develop solutions that will create value for its partners. The following case studies provide an insight into some of Tyndall's engagement with our partners over the past year. Our collaborations with SMEs, indigenous and multinational companies have generated some outstanding research, development and innovation, which in turn are driving economic impact and job creation.

## Supporting Foreign Direct Investment (FDI)

Case Study 1

IDA Ireland



Throughout 2013 Tyndall continued to attract top flight multinationals, a growing number of which operate in the dynamic and research-driven medical device sector. Organisations from that sector that partnered with Tyndall during 2013 included Stryker, Boston Scientific, Lake Region Medical and Covidien.

Ireland's inward investment promotion agency, IDA Ireland (Industrial Development Agency) is responsible for the attraction and development of foreign investment in Ireland. Leo Clancy, Divisional Manager, ICT at IDA Ireland isn't surprised by the growth achieved by Tyndall in this sector. **"Tyndall is an Institute of real scale in terms of research staffing and it has a long-established credibility in its field from the early days when it was known as the National Microelectronics Research Centre. Today, Tyndall is highly regarded as a home to real-world activity where inventions and research are brought to life."**

For medical companies the possibilities of driving further product improvements by harnessing electronics, photonics and other core ICT specialities, all central to Tyndall's offering, are rapidly expanding. Based on feedback from companies with a global perspective

who have partnered with Tyndall, or those that are familiar with the workings and offerings of the Institution, Leo Clancy reports that Tyndall holds its own with the best in the world in terms of the quality of its research.

Tyndall is widely perceived as a business-focused Institute operating to well-conceived business models, engaging in proactive partnership with its clients. These are qualities that haven't gone unnoticed by the IDA. Leo Clancy draws attention to **"Tyndall's flexible model, with a scale of offering to suit different company requirements. I'm particularly impressed by the business focus of Tyndall's senior team. They go above and beyond to meet clients and provide the right answers to questions."**

From his perspective it is a great bonus to have such a high performing Institute as Tyndall, to help underpin the offering Ireland has in microelectronics, photonics, sensor technology and medical technologies. He sees the relationship between Tyndall and the IDA as genuinely symbiotic. **"Tyndall is a great partner and I like to think the relationship works both ways. Our hope is that we can continue to grow together and to improve the strength of Ireland's already vibrant research community."**

Case Study 2

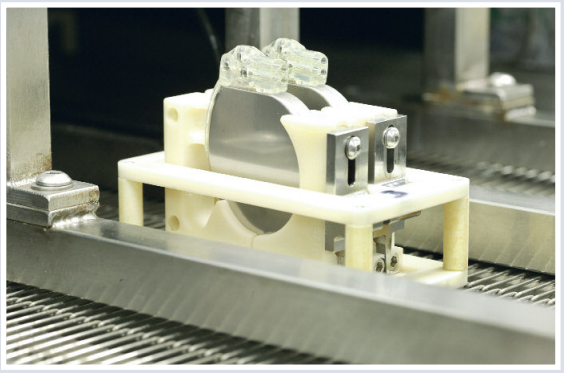
Boston Scientific

*Advancing science for life™*

Boston Scientific is a global leader in the development of less-invasive medical device products. Such is its commitment to R&D and innovation, that it invests $1bn annually in new products and technologies. Since 1994, Boston Scientific has grown to be the largest medical device employer in Ireland. It operates three Irish sites, located in Clonmel, Cork and Galway. The Irish manufacturing operation is an integral part of the corporation's manufacturing strategy and capability.

Tyndall currently works with Boston Scientific's Clonmel -based operation. This site specialises in the development, manufacture and distribution of implantable pacemakers and defibrillators for the cardiac RHYTHM MANAGEMENT Business, which represents a key growth area for the company. The site also supports some products for the Neuromodulation Division.

Boston Scientific started working with Tyndall in 2013. Outlining what attracted them to Tyndall, Michael Kane, Fellow, Process Development says, **"Tyndall has a good reputation as a technological centre, so they were already on our radar. They are especially well regarded for their capabilities in the areas of micro-fabrication, integrated circuit analysis, and reliability domains, plus they have the ability to branch into different applications around those technologies."**



Michael Kane confirms, **'We have a strong commitment to our Clonmel plant and our people there, and that's why it is useful for us to have active liaisons within the greater and the technical communities of Ireland. Tyndall can't be missed if you are paying attention to where the skills lie."** Boston Scientific has three researchers in residence at Tyndall, and Michael is due to join that team shortly. **"We are excited about the progress we have made so far within Tyndall and look forward to the prospect of productive engagement in the coming years."**

The skills and strengths that Tyndall can leverage for the medtech sector may not be immediately obvious to those outside the sector, but those working within it can appreciate what Tyndall has to offer. **"With medical devices, the part that most people focus on is the interface to the body and to medicine, but that's like looking at the pacemaker from the outside only,"** observes Kane. **"If you look deeper into the pacemaker it's about sophisticated electronics: precision circuits, clinical algorithms, bio-sensors and radio communications, all of it contained within this €2 coin-sized pacemaker. Those are perfect matches for the excellent technologies on campus at Tyndall, especially the MCCI working group at Tyndall."**

**"Boston Scientific cares very much about engaging Irish research institutions and cultivating the skill sets in those institutions that we require for our own prosperity to continue."** Going to Tyndall has proved productive for Boston Scientific. **"We are able to engage with Irish talent, so that technical competence is accessible to us in the place where we make pacemakers and implantable defibrillators, which is in Ireland."** Boston Scientific has already increased the depth of its engagement with Tyndall. According to Kane, **"By continuing and growing our engagement with Tyndall we are voting with our feet and our Euros."**

Case Study 3

MACOM™
Partners from RF to Light

M/A-COM Technology Solutions (MACOM) is a leading provider of high performance analog semiconductor solutions for use in wireless and wireline applications across the radio frequency (RF), microwave and millimeterwave spectrum. With a heritage in the RF industry that dates back to 1950, it designs and manufactures standard and custom devices, integrated circuits, components, modules, and sub-systems for customers who demand high performance, quality and reliability.

MACOM operates (ISO-9001) facilities in Lowell, Massachusetts; Long Beach, California; Cork, Ireland, and Shenzhen, China. The facility in Cork is the headquarters for all MACOM operations outside the USA, including HR and international finance, as well as having a sizeable engineering group on-site. According to David Ryan, Business Development Manager, MACOM's Cork facility focuses on the management and design of infrastructure products. Its strategic focus on integrated circuits featuring higher levels of integration and functionality resulted in the establishment of the Monolithic Microwave Integrated Circuits (MMIC) design centre in Cork in 2012. MACOM has enjoyed a long working relationship with Tyndall. **"We recognise Tyndall's standing as a leader in the field of photonics and we appreciate the quality of skills available at Tyndall. We hold Tyndall in high esteem and are delighted to have such an excellent resource so close by. We enjoy strong levels of engagement with Tyndall who have helped us grow our design team."**

According to David Ryan, **"Being able to demonstrate the benefits we gain from access to the resources at Tyndall has helped MACOM's Cork base strengthen its hand when it comes to making a continued case for investment and growth with the company. "** He reports, **"We are currently working on several research projects with Tyndall, all of which are at an early stage, having commenced within the past year."**

In general, he finds the optical research team at Tyndall excellent to partner with and is similarly impressed by the work carried out by the MCCI technology centre, hosted at Tyndall.

Optical and photonics are both earmarked as growth areas for MACOM globally, and because there is such good alignment between that strategy and Tyndall's core strengths, David Ryan expects MACOM to continue to work closely and to further develop its relationship with Tyndall in the future.

Case Study 4

InnaLabs®
www.innalabs.com

INNALABS is an international knowledge-led, high technology company that develops and manufactures high accuracy inertial sensors for use in several diverse markets and applications. These markets span agriculture, transport, healthcare, civil engineering and aerospace. Applications include anti-roll devices in ferries, anti-tilt devices on high-speed trains, stabilisation platforms for optical systems, survey instruments and vibration monitoring. Safety health and maintenance monitoring of buildings, bridges, cranes and undersea pipelines, as well as artificial horizons for aircraft and star tracker navigation systems.

The decision to headquarter the business in Ireland was predicated on Innalabs development of a CVG technology coriolis vibrating gyroscope that was a huge improvement on any of its competitor's products. It was at prototype stage and help was needed in qualifying the product. Ireland won out as the site for Innalabs HQ because of its good track record in supporting research and development, ready availability of very strong manufacturing experience, competitve costs and the willingness of the supply chain to help Innalabs cause.

Having worked in the electronics manufacturing sector for nearly 30 years, mainly for USA multinationals, Innalab's General Manager, John O'Leary was aware of Tyndall although he admits he did not fully understand their total offering.

**"As Innalabs was a new start-up with a new technology we required some external support. During our DVT (Design Verification Testing) we got some mixed results that required root causing. One of our chosen suppliers blamed our design. The speicifc issue was ultrasonic wire bonding of the gold surface to a chip.**

**We approached Tyndall with this technical problem and asked for a full investigation and a proposed solution that could be used on a repeatable basis. Tyndall responded in a very professional manner providing us with clear data and evidence of how we should progress. They recommended the type of bond required, type of setting and the best machines available. We were delighted with the results. Innalabs CVG product has since gone to market in volume and customer feedback has been excellent as its price to performance is really outstanding in its market sector."**

Based on Tyndall's reputation, John O'Leary says he was expecting a good service. **"But honestly, the professionism shown and the data driven manner in which my companies issue was addressed exceeded expectations. Based on this success I decided to look further into their offerings and our CEO Dmitri Simonenko and myself were very impressed. The Tyndall team is very experienced from a manufacturing perspective, and the fact that these very well-educated professionals had real industry experience, understood our challenges and offered practical solutions, impressed us.**

**We have developed a 5 year Technology Road Map and see Tyndall as an extension of our current research and development team. We want to establish a highly successful Irish company that can compete on a global stage in the world of inertial sensors and our partnership with Tyndall is key to this vision."**

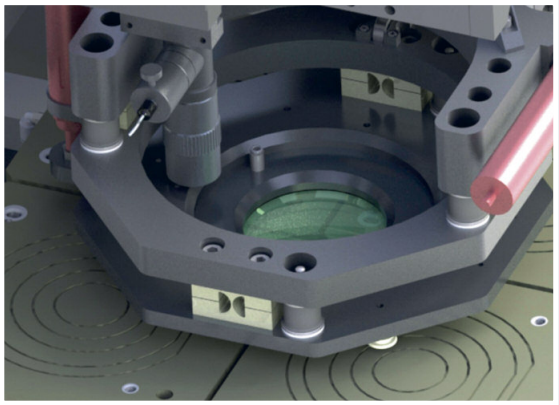
Case Study 5

## X-Celeprint

X-Celeprint, located at Tyndall, is the developer and sole licensor of patented Micro-Transfer-Printing (µTP) technology. Originally invented in Professor John Rogers' laboratory at the University of Illinois, µTP is a cost-effective and scalable manufacturing platform for heterogeneously integrating microscale devices such as lasers, LEDs or integrated circuits onto non-native substrates. X-Celeprint works globally with partners to adapt its µTP technology for their specific applications. This technology can have a far-reaching impact on reducing assembly and manufacturing costs for electronic and photonic devices or enabling new applications.

CEO Kyle Benkendorfer is very positive about X-Celeprint's decision to establish its HQ in Ireland. **"We greatly appreciate Tyndall's technical capabilities and the very business-friendly environment that exists both in Tyndall and more widely throughout Ireland."**

As one of 18 industry partners of Tyndall's new Irish Photonics Integration Centre (IPIC), X-Celeprint is already tapping into some of the networking opportunities presented onsite.



Although the X-Celeprint team had no previous connections with Tyndall or indeed Ireland, Kyle Benkendorfer says the decision to locate there was simple. **"We had two large potential customers who recommended that we check out Tyndall. When we did, we were very impressed by the people, the work going on here and the facilities. I also had heard very positive feedback from contacts at Seagate, who had worked with Tyndall in the past. "Initially, we thought of establishing our company in the U.S. with a satellite in Tyndall. However, because our parent company is European and we began to discover just how much Tyndall had to offer, we realised that setting up in Tyndall with a satellite in the U.S. was a better business decision."**

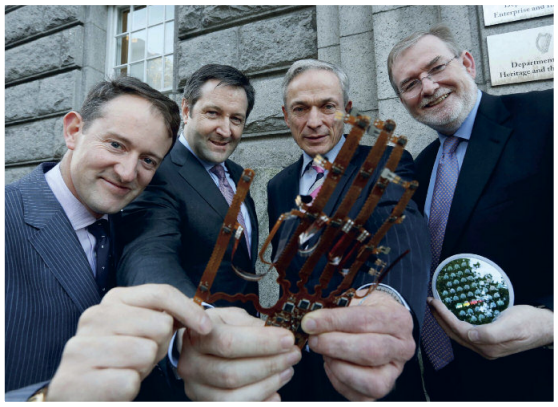
Locating in Tyndall makes good commercial sense for X-Celeprint. **"We need access to special facilities, and being on campus allows us to leverage excellent facilities without investing in costly equipment. Instead, we hire Tyndall to carry out work for us, and by using their skills and facilities we achieve a lot more with fewer people."**

He observes that few places can match the concentration of facilities and expertise found in Tyndall, particularly in some key areas important to X-Celeprint, namely photonics and compound semiconductors. Kyle makes a special point of highlighting just how business-friendly Ireland has proven to be. **"We are always only two or three people away from talking to anyone we want to talk to, whether at industry or government level. People within Tyndall and the state agencies such as IDA constantly ask us if there is anything they can do to help, and we find that quite refreshing. Such a culture starts at the top with a government that's encouraging and supportive of people who bring good jobs to Ireland. Another significant and pleasant surprise for us is that being an Irish company opens so many doors in Europe – far more than we had anticipated."**

Case Study 6

PCH International

Tyndall signed a Memorandum of Understanding (MOU) with PCH International to support the generation and scaling of new high tech start-up companies in Ireland targeting the global market. The MOU provides for close collaboration between PCH's two programmes for startups, Highway1 and PCH Accelerator and Tyndall's international network of over 200 industry clients to identify market opportunities. Potential projects will target the electronics, medical devices, energy and communication industries with research and development at Tyndall's unique state-of-the-art research and pilot-line fabrication facilities in Cork.



Minister for Research and Innovation, Sean Sherlock TD; Liam Casey, PCH International CEO; Minister for Jobs, Enterprise and Innovation, Richard Bruton TD and Dr. Kieran Drain, Tyndall CEO.

Commenting on the partnership, PCH International CEO, Liam Casey said: **"We are delighted to partner with Tyndall. The research work we have seen from them is world-class, particularly in the health and wellness market, and we are both focused on promoting successful high potential hardware start-ups. Tyndall's expertise in ICT hardware research, combined with PCH expertise in getting products to market, means that we are creating huge opportunities for entrepreneurs in Ireland to achieve success on a global scale.**

**Powerful synergies exist between Tyndall's skill in breakthrough ICT research and product development and PCH's world class design for manufacturing and delivery. Together we aim to provide end-to-end support for high-tech start-ups from concept to shelf, benefiting from PCH's insights as a market leader to extend commercial reach from Ireland to China and beyond."**

## Supporting SME's

eblanaphotonics

Eblana Photonics has its origins in advanced research programmes in photonics, involving Ireland's leading Universities and Research Centres including Tyndall. Photonics is an enabling technology that underpins a wide range of application areas. The European photonics market alone is worth €58bn and is estimated to impact 10% of the European economy. Eblana has continued to have solid links over the years with Tyndall because of its expertise in laser physics and semiconductor device fabrication. As CEO Jim Somers explains, **"Eblana's pivotal role as lead supplier of laser components to EU sponsored research projects means that we remain at the forefront of technological developments in photonic systems for advanced communications and other sectors."**

Photonics Packaging Laboratory at Tyndall.

The team at Eblana recognise that the Institute's capabilities and facilities have grown significantly since the early days, especially in the areas of photonics and photonics integration, which are of special relevance to the company.

**"We appreciate and applaud the developments that have taken place at Tyndall, they certainly complement our road map."** On another level Eblana Photonics is an industry partner in the new Irish Photonic Integration Centre (IPIC) at Tyndall. This centre brings together internationally recognised Irish research capabilities in photonics and biomedical science and 18 industry partners, many of whom are indigenous SMEs.

The Centre addresses major scientific and technological challenges confronting these companies by working in close partnership with them within world-class facilities, to develop and apply new integrated photonic solutions.

Somers said, **"As partners within iPIC, we don't necessarily interact with the other industry partners, our interaction is primarily with the Centre's team. The research work that Tyndall is carrying out for us in the area of photonics is very important for us and that's what made us decide to partake in the iPIC programme."** He adds, **"Some of the individual researchers, people like Frank Peters, Peter O'Brien and Brian Corbett, within Tyndall are highly regarded experts in their fields worldwide and to be able to tap into this and literally have it on our doorstep is very significant. We find the team at Tyndall to be very proactive. They listen and they respond. It's a very positive interaction."**

As a small company with 12 people, seven of whom have PhDs in laser physics, Eblana has a strong academic core, which they plan to continue to complement with input from the researchers at Tyndall.

PMD SOLUTIONS

Established in 2011, PMD Solutions (PMD) is a Cork-based company, with Enterprise Ireland 'High Potential Start Up' status. This endorsement recognises the global sales potential of PMD's products and its vision of establishing their premier product **'RespiraSense'** as the global industry standard in respiratory rate monitoring. RespiraSense is currently being prepared for commercialisation this year into a market valued at €2.2bn. Heart rate, temperature, blood pressure, pulse oximetry and respiratory rate, all need to be monitored to paint an overall picture of a patient's health. However, up to now, respiratory rate has been known as the 'Lost Vital' due to the lack of a comprehensive monitoring apparatus. Currently the gold standard in respiratory monitoring is a nurse, intermittently recording respiratory rate through observational techniques.

According to Myles Murray, CEO of PMD Solutions, **"To identify deterioration in a patient as early as possible, ubiquitous, continuous, and comprehensive monitoring devices are what's needed. The significance of respiratory rate as an early indicator of patient deterioration is well known and it's what healthcare providers are calling out for. PMD has specifically developed RespiraSense to deliver this 'Lost Vital' to the global healthcare community."**

While PMD is one of five competing companies in the world at commercialisation phase, PMD differentiates itself by offering a discreet wireless solution that can continuously and comprehensively monitor a patient's respiratory rate from admission to discharge, all with a single application. This will best solve the current technology deficit for the continuum of patients across all clinical areas. It will ultimately give PMD an edge in the marketplace and in positioning RespiraSense as the industry standard for respiratory rate monitoring.

**"PMD first engaged with Tyndall in 2012 and their subsequent input at that stage supported the growth of the company from idea to concept validation. What attracted us in the first instance was their innovative modular electronic platform. Since then, PMD has committed to sponsor Tyndall in an SFI (Science Foundation Ireland) funded initiative to develop pipeline products that add value to the healthcare community."**

The team at PMD believes that that the Tyndall team is as focused as the company when it comes to achieving their goals. According to Myles Murray, **"When it comes to the transfer of technology from academia to industry, Tyndall is ahead of the curve. They have a strong focus on commercialising technology with industry partners that add value to the world."**

## Host to Industry Aligned Research Centers

MCCI Microelectronic Circuits Centre Ireland

The vision of MCCI is to be the world's number one industry-led analogue and mixed-signal research centre by 2018. After 4 years in existence, MCCI is well on its way towards this goal with 23 industry member and 15 projects spanning applications from high-end computing to medical devices. To date MCCI has transferred 9 staff into industry and executed 5 technology licenses to Irish based companies with the first IP appearing in commercial products during 2013. MCCI has also helped member companies to create over 500 new jobs in Ireland.

**"MCCI had a strong influence on the Xilinx decision to make the recent R&D investment in Ireland. MCCI helped a lot in building confidence with Xilinx senior management here in the US that we could grow a high-performance design team in Cork."**
- Liam Madden, Corporate VP, Xilinx

Quality of research has been validated to be at the highest international level with 4 new Tier 1 publications in 2013. The past year also saw the growth of many bi-lateral projects with companies including collaborative research with Irish company Powervation to reduce

energy consumption in data-centres, and with US multinational M/A-COM on new wireless communications technologies. MCCI has grown funding of the centre to €2.4m per annum and in tandem has grown staff to over 30, including the creation of a new core research team in the smart sensors area. Following a successful 3 year review recently, EI/IDA announced that core funding for the centre will be extended to 2018, giving MCCI the opportunity to continue to positively impact the economy into the future.

Domenico Zito, Mat[illegible] and Ivan O'Connell demonstrating a 95GHz radiometer test-chip.

**"MCCI is very important to MIDAS Ireland (Microelectronics Industry Design Association) as it gives clear focus to publically funded microelectronics research in the country. MCCI is building capability in areas of relevance to industry and producing a pipeline of easily accessible skilled people and IP for MIDAS companies, promoting growth in the sector."** – John Blake, Chairman of MIDAS Ireland.

CCAN
Collaborative Centre for Applied Nanotechnology

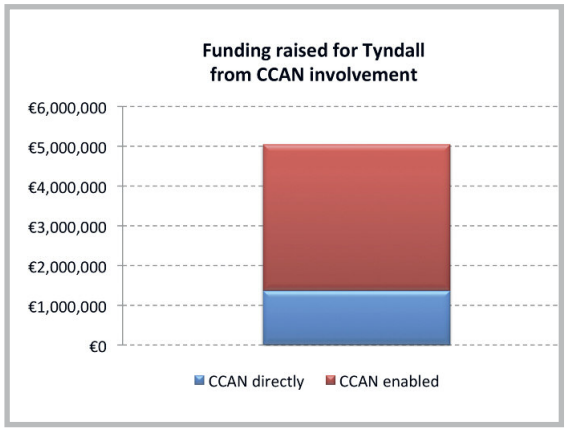
CCAN, co-hosted by Tyndall, continued to grow in 2013, finishing the year ahead of target with 16 member companies, 10 of which were SMEs. All member companies are actively engaged in the development of nano-enabled products. New members in 2013 include Alere, Applied Materials and Nanoflex, all of whom are participating in projects based at Tyndall.

Through its offices in Tyndall and CRANN in TCD, CCAN acts as a national organisation making it easier for Irish-based companies to locate and access the best combined nanotech and advanced nanomaterials expertise from across the country and from within its international partner network.


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 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 nanotechnology sphere.

Successful CCAN projects with Tyndall industry customers such as Seagate, Intel, Applied Materials, Nanoflex, Alere, Biotector, Analog Devices and GenCell Biosystems have to date:-

- Enabled two new companies to locate in Ireland: X-Celeprint in Cork, Nanotox Innovations in Dublin.
- Generated more than €3m in funding for the Irish economy directly from non-State funded research projects.
- Deepened the relationship with industry customers generating six follow-on industry contracts for Tyndall.
- Triggered equipment and labour investments in Analog Devices in Limerick for new process capability.




IERC
International Energy Research Centre

The IERC delivers world leading collaborative research to meet global societal needs for secure, affordable and sustainable energy services. The centre enables partners to develop new products and services that will ensure real energy demand reductions across society. It provides an energy research environment that combines business innovation with research excellence for energy demand side efficiency and systems integration challenges. 2013 was another exciting year for the IERC working with global industry leaders, while our extended national team grew to 55 people, building a strong foundation for the centre.

The IERC has developed a robust process for identifying key themes and research opportunities for its key stakeholders, testing potential research activities against a number of key drivers (affordability, security, sustainability, impact and return on investment) as well as examining the knowledge gaps from five different perspectives – which are technology, analytics, behaviour, business models, and policy & regulation.

This methodology is a unique aspect of the IERC, and will provide translations between industry need and academic researcher capability, as well as providing continual testing of research assumptions and business relevance of research outcomes.

The centre has driven five large research projects and two smaller projects to date, with a total value of approximately €5m. The IERC has established 4 test bed environments in the areas of air conditioning unit monitoring, thermal energy storage, energy management in a factory environment and home energy management.

**IERC Core Team** Barbara Fogarty, Long Pham, Michael Whelton, Joe O'Callaghan, Lacour Ayompe, Prof. Tony Day and Maeve McGinn.

# Specialty Products & Services

> The aim is to best cater for customer needs, and to build industrial revenues while continuing to develop leading edge process technologies and devices in collaboration with Tyndall researchers.

2013 saw organisational changes take place within Tyndall, particularly in the area of services where all service provision for internal and external users was consolidated into one high-quality service centre.

Heading up this re-structured new Specialty Products & Services Centre (SP&S) is Graeme Maxwell. The objective of SP&S is to best cater for all customer needs, and to substantially increase industrial revenues while continuing to develop leading edge process technologies and devices in collaboration with Tyndall researchers.

The key areas of expertise within the new centre are:

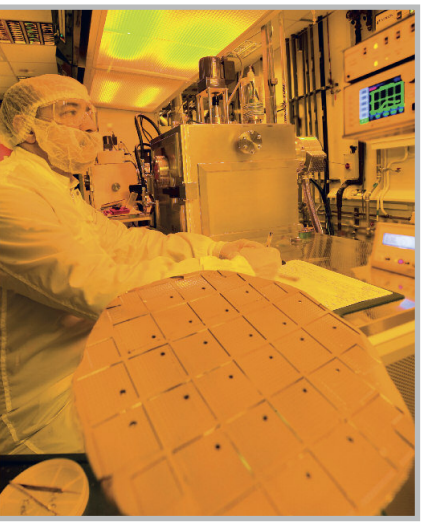
**1. Process & Product Development, encompassing;**

- **The Central Fabrication Facility** with the state-of-the-art silicon MEMS capability including wafer bonding, deep silicon and oxide etching, in addition to the newly established UV Enhanced Substrate Conformal Imprint Lithography (UV-SCIL) system capable of delivering nanoscale imprint lithography.

Tyndall's new 3D optical imaging system in use for high magnification internal visual inspection of photonics device.

- **Silicon CMOS Device Fabrication**, commercialising advanced components with customers and delivering components used to provide sensor capabilities to satellite systems used by the European Space Agency (ESA) – with whom Tyndall has an on-going relationship. 2013 saw the introduction of exciting new process developments to help customers achieve their product development goals, featuring high power handling devices such as low cost SiC transistors on silicon and wafer scale Insulated Gate Bipolar Transistors (IGBT) for smart grid applications.

- **Compound Semiconductor Material & Device Processing**, supporting SMEs through the manufacture of leading edge sensing devices for medical applications amongst others, electron beam lithography delivering nanoscale patterning for imprint masters nanoscale electrodes and advanced photonic bandgap structures for commercial customers.



- **Training Fab Facility** once again continued to provide the introduction into the world of device fabrication for new students and companies looking to learn the skills and gain the necessary hands-on experience to enter this field. With their newly acquired skills, these individuals can graduate into the other more advanced fabrication facilities within Tyndall. This unique capability is available to all postgraduate students in Ireland. International graduates benefit from the training provided through the facility with funding from the International Centre for Graduate Education in micro and Nano-Engineering (ICGEE).

- **National Access Programme (NAP)** continues to provide the portal through which other academic institutes within Ireland can access the extensive and unique infrastructure at Tyndall. Over its nine year history it has supported several hundred projects, and has served the role of filling the research pipeline with projects that have led to successful follow-on collaborations of increasing size and scope and ultimately commercial success. With the recent change in funding model announced by SFI, the NAP team will now broaden its reach and use its valaubale expertise to link with SMEs seeking this capability, and in doing so develop other commercial opportunities for the companies and Tyndall.

## 2. Device Forensics

- The analysis groups within SP&S focus on device forensics, including Design Technology Evaluation (DTE), Reliability Services and Electron Microscopy & Analysis. These groups forensically examine materials, devices and components to analyse how they operate, and establish why they may have failed or how they can be improved.

This activity is hugely relevant across a wide range of customers and sectors, including Pharma and medical devices as well as the more traditional electronic component sector.

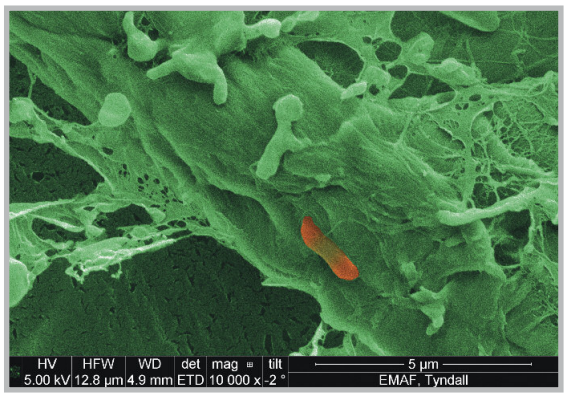
High precision 'mixed signal' characterisation being performed by the DTE group.

The groups in more detail:

- **Design Technology Evaluation**, which carries out investigative analysis into; electrical designs of 'mixed signal' and RF systems, including diagnostic measurements; intellectual property investigation – encompassing counterfeit investigation and patent infringement analysis; and IC design re-engineering.

- **Reliability Services** provides failure mode analysis, destructive physical analysis (DPA) for space applications as well as terrestrial systems, reliability testing and electronic packaging. Troubleshooting reliability problems for industries ranging from advanced gyroscope manufacturers to world leading consumer product manufacturers is a key expertise.

- **Electron Microscopy & Analysis Facility with SEM and Cryo-SEM Imaging** allows analysis of organic and inorganic systems including micro-organisms, cells and proteins in their native state. These systems also yield elemental analysis allowing the diagnosis of contaminants as well as the presence of intended dopants. Coupled with focussed ion beam and dual focussed ion beam systems, these tools enable the most detailed dissection of materials and devices possible.




Sensitive biological materials such as bacteria are cryogenically frozen to preserve their structure before imaging in a scanning electron microscope.

Underpinning these capabilities is the equipment maintenance group, responsible for the smooth running and maintenance of the facilities on which the centre depends.

Having a highly trained in-house equipment maintenance group ensures much faster response times to the repair of any occuring faults. The team is trained to a very high level, across a wide range of processing tools, which is very reassuring for clients. This capability provides a significant advantage to Tyndall and its time-pressed industrial clients.

Tyndall has been engaged in research and support collaborations with the European Space Agency (ESA) for over 25 years. Tyndall acts as a Microelectronics Technology Support Laboratory to ESA, under which it provides expertise & evaluation services in the component & integrated circuit quality and reliability. Tyndall also develops and evaluates new technologies, materials & assembly processes and assesses their suitability for use in the space environment.

Another area under the SP&S remit is quality, which is key for industry customers, especially SMEs, who take great comfort in the knowledge that Tyndall is ISO 9001 and ISO 50001 accreditated across the entire Institute.

In the following pages the case studies highlight how some of the capabilities and expertise at Tyndall are benefiting our partners.

Case Study 1

ANVIL SEMICONDUCTORS

Conventional, cheap and proven silicon devices are used to switch and control power in electrical systems, from laptops to industrial machines to smartgrids. However, Silicon Carbide (SiC) devices are considerably more efficient, although, they are currently ten times more expensive.

That's about to change thanks to the design of SiC devices from Coventry-based Anvil–Semiconductors that will offer a far superior performance to conventional silicon, at the same price.

Not surprisingly, Anvil-Semiconductors has secured £1.4m in funding to enable the development and commercialisation of its revolutionary SiC technology and it is partnering with Tyndall to help them move along the process. As CEO Jill Shaw explains, **"The benefit of SiC-based devices is their increased efficiency, resulting in much reduced carbon emissions and running costs.**

**However, the high cost of producing devices in SiC has discouraged widespread adoption, particularly in cost-competitive consumer applications. Consequently, the use of SiC devices has been largely restricted to niche markets where system benefits justify the cost premium."**

Anvil co-founder Dr. Peter Ward, developed a unique technology for the production of epitaxial 3C-SiC layers on silicon substrates that promises a substantial reduction in the cost of manufacturing power switches in this material.

Dr. Ward, having previously worked with the team at Tyndall, was instrumental in recommending the Institute to partner Anvil through the development process. **"Although Tyndall didn't have the direct silicon carbide experience we wanted, they have considerable experience in device fabrication in Si and compound semiconductors. They had the facilities we required and were willing to take on the challenge to quickly climb the learning curve,"** says Jill. **"We knew through Peter's previous experience that Tyndall had good people who worked well, so we decided to go ahead and partner with them. We are more than happy with how the project has gone thus far, and with Tyndall's performance and can do attitude."**

Jill is pleased with Tyndall's access to a wide range of facilities and by the fact that no time has been lost through equipment maintenance or service issues, due to the fact that Tyndall employs an in-house specialist maintenance team.

Looking to the future, she says, **"Tyndall can accommodate small production batches which is a real advantage for us. We don't view this as a one-off job, we anticipate a long-term relationship and we already have an on-going contract in place."**

Coating of wafers using Plasma Enhanced Chemical Vapour Deposition System (PECVDS).

Case Study 2

Radisens DIAGNOSTICS

Radisens Diagnostics has developed a pioneering point-of-care diagnostic platform that breaks new ground in the decentralisation of routine blood tests, moving them from laboratories into the GPs surgeries, hospital bedsides and other point-of-care settings.

With a finger-prick of blood, this multi-mode diagnostic device will return laboratory-grade results within minutes during a patient's physician visit. The Cork-based, venture-backed diagnostics company, plans to launch its IP protected platform initially targeting the decentralised chronic disease management of diabetes, heart disease, thyroid function and kidney disease. Not only will this new platform provide a step improvement in blood test performance, it will remove the many anxious days or weeks of waiting for routine blood test results, provide better patient outcomes and introduce much needed efficiencies into healthcare systems worldwide.

Founded in 2008, Radisens first engaged with Tyndall in 2012, initially through a very successful Enterprise Ireland sponsored Innovation Partnership project, the outcome of which the company is currently building upon. CEO Jerry O'Brien says, **"From there, we have extended the relationship through our participation in the Irish Photonic Integration Centre (IPIC) at Tyndall, within which Tyndall is working on a multi-year targeted project for us."**

He is impressed by the level of expertise at Tyndall. **"The Principal Investigator (PI) at Tyndall which leads our collaboration has several years of relevant industry and start-up experience. Therefore, the Tyndall team has a great understanding of industry needs coupled with a practical can-do attitude. Our working relationship is very focused, with weekly face-to-face interactions between both teams. Such interactions expand the overall inter-disciplinary capability, which result in a more innovative and competitive solution."**

Access to Tyndall is very easy for this Cork based company. **"The convenience factor of its location in Cork is significant. Our engineers are in Tyndall every week, ensuring that the engagement is truly collaborative rather than an intermittent relationship. Access to the capital equipment, modelling and simulation infrastructure and research expertise is very attractive, especially as we push the technology boundaries of blood testing at the point of care. Multinational customers are impressed when they see the range of expertise, facilities and infrastructure available to an SME such as Radisens, through the Tyndall partnership."**

Looking to the future, Jerry O'Brien is in no doubt that the relationship between Radisens and Tyndall will continue and evolve. **"The IPIC framework is much more flexible and industry friendly than any previous academic/industry collaboration mechanism that I have seen. We are already exploring follow-on projects."**


High-precision metrology for advanced material characterisation.

Case Study 3

ANALOG DEVICES

Analog Devices Inc (ADI) has been in business in Ireland for the past 30 years and currently employs over 1,000 people at its Irish headquarters in Limerick.

The company is a world leader in the design and manufacture of very high performance analog, mixed-signal, Digital Signal Processing (DSP) and RF (Radio Frequency) integrated circuits used in electronic equipment. These technologies are used to convert, condition and process real-world phenomena such as light, sound, temperature, speed, motion and pressure into electrical signals to be used in wide array of electronic devices.

Analog has been an industrial partner of Tyndall for over thirty years. During those years both organisations have flourished and grown and along the way they have shared research output and they have transferred knowledge.

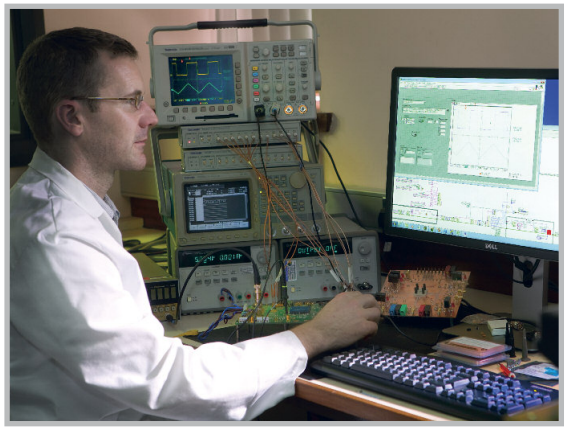
A significant part of the relationship is formalised through a rolling contract, which was renewed in 2013 for a further three years.

Although as John Liddy, Director of Manufacturing Operations explains, **"We do a lot of one-off projects with Tyndall that fall outside the parameters of our contract agreement, which mainly focuses on work carried out by Tyndall's DTE Group, under Ted O'Shea. The DTE group provides measurements, analysis an intellectual property expertise in support of ADI's drive in its 'More-than-Moore' technology developments."**

During 2013, the DTE group investigated passives, high voltage power products, RF MEMS, integrated transformers, resonators and materials for the company. In parallel with this work, the DTE group also performed extensive 'mixed signal' product characterisation in support of ADI's 'swing Fab' policy to ensure certain products can be fabricated in more than one foundry. A number of the one-off R&D type projects carried out by Tyndall are funded by ADI on an individual project basis, while larger projects have European backing.

With so many projects happening in and around Tyndall at any given time, ADI has a dedicated member of staff on-site for part of every week to monitor progress. John Liddy confirms that knowledge transfer is also an important element of ADI's relationship with Tyndall. **"We have recruited good people from Tyndall over the years and we definitely see it as a talent pool for skilled people."**

Regarding R&D he confirmed that ADI and Tyndall have worked closely together on many projects, some of which are now undergoing commercialisation. **"Our relationship with Tyndall continues because they give a good service, and right now our relationship with Tyndall represents our highest interface with any Irish research centre, by virtue of alignment."**



Forensic analysis of electronic chips.

Case Study 4

## Royal Philips

Royal Philips (NYSE: PHG, AEX: PHIA) is a diversified health and well-being company, focused on improving people's lives through meaningful innovation in the areas of healthcare, consumer lifestyle and lighting. Headquartered in the Netherlands, Philips posted 2013 sales of €23.3bn and has approximately 112,000 employees in more than 100 countries. Philips is the world's leading patent applicant at the EPO in the categories 'medical technology' and 'instrument measurement' and the Philips IP portfolio reflects the company's strategy and the businesses in which it operates.

Today, more than 40 percent of its patent filings are in the area of healthcare and over 30 percent is related to lighting. With more than 64,000 patent rights, 93,000 design rights, 46,000 trademarks and 4,700 domain names, Philips successfully manages one of the largest and strongest IP portfolios in the world. Gunnard Franssen Senior IP Counsel and European Patent Attorney with the Philips Intellectual Property & Standards division explains that his division manages Philip's IP portfolio and proactively pursues the creation and protection of intellectual property in close co-operation with all of the Philips businesses.

An important part of his department's fact-finding work is in electronic forensics, specifically the information gleaned from reverse engineering of third party products that are suspected to use Philips' proprietary technology. Next to Philips' own in-house capabilities Philips outsources products for reverse engineering purposes to Tyndall. Based on Tyndall's work, a patent attorney of Philips is able to determine whether Philips' proprietary and patented technology is used. No matter the product, Philips will always demand the same highly detailed and meticulous service from Tyndall. Working together for two years already, Philips is pleased with the standard and quality of Tyndall's work and is set to continue its partnership.

# National Access Programme

## Impact of National Access Programme 2005-2013


NAP is a SFI programme that provides funded access to Tyndall's state-of-the-art facilities and expertise to all researchers in Ireland. NAP successfully completed its 9th year of operation in 2013 and 338 collaborative projects have been funded across all Tyndall's technology areas in health, communications, energy and the environment.

NAP is governed by an independent Access Committee of 14 senior academics representing all of the Universities and large Institutes of Technology, chaired by Prof. Greg Hughes of Dublin City University. The Access Committee ensures that projects with excellent scientific quality, strong potential impact and representing good value for money are funded.

From 2014 the NAP funding model will change and project costs will be written into researchers own grants rather than being funded directly by SFI. The new model will allow NAP to extend out and serve a wider national and international community, including supporting SME access to Tyndall.

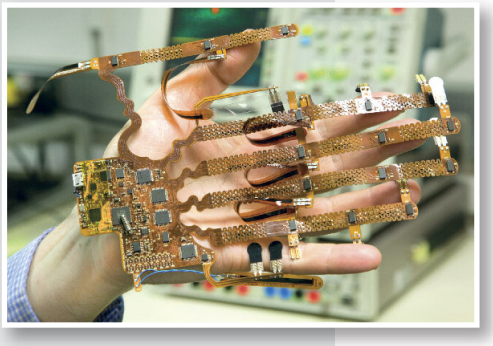
## NAP Highlights

- **652 researchers** have been funded from all **9 Universities** (including QUB & UU), **10 IT's** & **2 Research Institutes** (RCSI and Teagasc).
- **2,030 researchers** have attended NAP Talks and Open Days.
- **648 publications** have resulted from projects to date, including **153 Journal publications**.
- **30% of participants** are postgraduate students and **81 completed PhD & Masters Theses** have acknowledged NAP.
- **NAP projects** have seeded collaborations which have led to follow-on SFI, EI and EU funding.
- **9 patent applications** have been reported resulting directly from NAP projects.

## NAP348 Wearable Sensor Enabled Glove Device for Measuring Finger Movement in Arthritic Patients

Dr Kevin Curran (University of Ulster)

Arthritis is a disabling and painful disease and accurate measurement of the patient's movement is essential for effective rehabilitation. Researchers in UU are looking at replacing traditional measurement methods that require exhaustive physical examination, with a wireless glove sensing system. The sensors must be strategically placed to allow highly accurate measurement of the movement in each part of the hand. The results are then visually displayed and can be read and interpreted remotely enabling the patient to be monitored at home. In this project the wireless team at Tyndall built two customised gloves that deliver accurate measurements of finger movement and wrist/hand rotation.

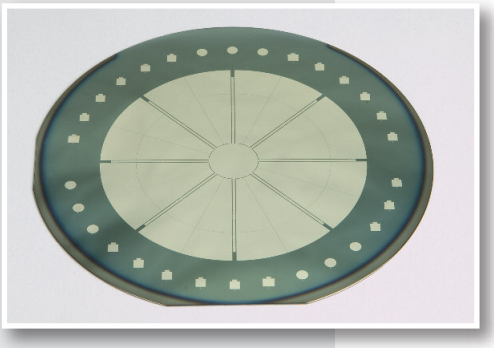


Wireless glove with a range of sensors enabling accurate measurements of finger movement.

## NAP413 Fabrication of Wafer Scale IGBT Switches for Smart Grid Applications

Prof. John Shen (Visiting SFI Walton Fellow at Tyndall)

Power electronics convert electric power into usable forms and play a critical role in renewable energy, smart grids and efficient energy utilisation. Insulated Gate Bipolar Transistors (IGBTs) are widely used for low to medium power applications but are not practical for use in the very high power applications needed for emerging renewable energy applications. Professor Shen's research involved scaling up an IGBT from chip-scale to make the world's first wafer-scale IGBT that can be used for these applications. The project was undertaken in the Tyndall silicon fabrication facility and prototype devices were successfully designed and fabricated that proved the new wafer-scale concept.

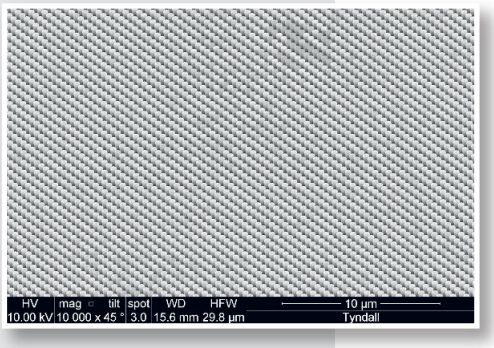


Wafer-scale IGBT fabricated at Tyndall for use in high power applications.

## NAP370 Development of nanostructured substrate for Surface Enhanced Raman Scattering (SERS) Bio Sensing

Nigel Phillipson & Prof. Malini Olivo (NUI Galway)

Raman spectroscopy is a powerful bio-sensing tool as it allows unique 'finger-printing' of every Raman-active compound and can be used, for example, to detect specific molecules in blood or saliva. One of the drawbacks for practical applications is the weak emission of the Raman signal and strong background noise. This can be overcome by creating 'hot-spot' regions that enhance the Raman signal. In this project NUIG and Tyndall researchers designed and fabricated low cost substrates with a range of nm-scale SERs designs to enable ultra-sensitive sensing elements which will be used in NUIG's cancer research.




Micrograph of low-cost metal nanostructures used to develop ultra-sensitive bio-sensing tools.

# Skilled Graduates

> 2013 was a record year for Graduate Education in Tyndall as no less than 31students successfully completed their PhD degrees.

## 2013 saw a record number of 31 PhD graduates

2013 was a record year for Graduate Education in Tyndall has 31 students successfully completed their PhD degree. At the end of 2013 there were 121 post-graduate students based in Tyndall, 109 of these are PhD students and 12 are pursuing Masters degrees. 20 nationalities are represented in our student population: 51% of students are Irish; 19% from other EU countries and 30% from non-EU countries. Female students account for almost a quarter of our student population.

## PhD Engineering Science – A structured PhD programme enabling skilled graduates

Tyndall continues to develop its flagship PhD programme in Engineering Science and recuitment into the programme continues to increase. In addition to a technical curriculum that is customised to each PhD candidate's research topic, the programme also provides students with a unique opportunity to gain a postgraduate level certificate in Innovation, Commercialisation and Entrepreneurship (ICE) alongside their PhD degree. The certificate is delivered in partnership with UCC's College of Business and Law and students are given access to modules in topics including: innovation finance, technology business planning, marketing for technology entrepreneurs and intellectual property law.

It is recognised that today's science and engineering graduates in addition to technical excellence require a broader set of business and communication skills in order to compete in an increasingly more challenging employment environment. The PhD (Engineering Science), complemented by the ICE certificate, is designed to equip graduates with the highest standards of technical skills and business acumen needed to develop an entrepreneurship culture and to make our graduates attractive to ICT employers. This specifically addresses Tyndall's objective of providing skilled graduates for Irish industry by providing training that is both technically on the leading edge and relevant to our industry partners.

## National Curriculum in Nanoscience and Nanoscale Engineering

Tyndall continues to lead two national inter-institutional graduate education programmes (GREPs): Graduate Education in Micro and Nano-engineering (ICGEE) and the Integrated NanoScience Platform for Ireland (INSPIRE) with partners from Athlone Institute of Technology, Cork Insttitue of Technology, Dublin City University, Dublin Institute of Technology, National University of Ireland – Galway, Trinity College Dublin, University College Cork, University College Dublin, and the University of Limerick. As part of these national programmes, over 20 inter-institutional taught modules were offered to students of the partner Institutes in 2013, with more than 70 postgraduate students taking modules as part of their structured PhD training. Tyndall and UCC Graduate Studies have commenced collaboration with our academic partners to investigate the possibility of a new software system enabling inter-institutional credit transfer amongst the GREP partners.

FlexiLearn.ie
Anytime, Anywhere Learning

## A National eLearning Platform

Tyndall continued to develop its' e-learning training initiatives in 2013 and the FlexiLearn platform was launched during the year (**www.flexilearn.ie**). FlexiLearn is a national portal for postgraduate education and continuous professional development in Ireland, which is supported by a virtual learning environment (VLE) enabling remote and block delivery of modules. Existing graduate research programmes have pooled resources to provide a national catalogue of modules to postgraduate students and industry. The goal is to improve ease of access to relevant structured training for graduates in academia and to provide industry training and up-skilling across a range of topics in flexible learning formats that best suit their schedules.

FlexiLearn provides maximum flexibility for both students and lecturers and provides multiple learning options such as web-based pre-recorded course work and real time video-streamed lectures. Ultimately, FlexiLearn aims to become the de-facto national repository and catalogue for Irish graduate students seeking advanced level courses to complement their doctoral training with university level accreditation.

The portal is available to students from all higher education institutions that contribute by providing courses to the FlexiLearn initiative – which includes a national catalogue of graduate level courses including when they are to be delivered, the means of delivery, and appropriate contacts at the providing institution.

## Graduate Student Committee

The Tyndall PG Studies Committee is the forum through which the graduate student community at Tyndall can put forward ideas and suggestions to improve graduate education. The committee represent the interests of all students and in 2013 the committee included; Monika Zygowska, Conor Coughlan, Tuhin Maity, Michele Conroy and Barry Hutchinson. Every year the committee organises the Annual Student Poster Competition. In 2013, this was held in conjunction with Tyndall's internal conference in May and the student committee took on the considerable task of organising the entire poster session. They collated all entries, prepared a book of abstracts and arranged all judging. Despite the record number of posters – the final session included 95 posters of which 61 were from students – the event management by the committee was excellent.

The committee also arranges an annual student survey, designed to assess all aspects of the student experience in Tyndall, as well as organising regular social events catering for our diverse student population.

Postgraduate Studies Committee: Monika Zygowska, Conor Coughlan, Michele Conroy, Barry Hutchinson and Tuhin Maity.

## PhD Theses 2013

**Lida Ansari**
*"Atomic scale simulation of nanowire and nanotube transistors".* Tyndall

**Des Brennan**
*"Integrated systems for genetic analysis".* Tyndall

**Micheal Burke**
*"Development of CMOS-compatible electrostatic supercapacitors".* Tyndall

**Miguel Caro**
*"Theory of elasticity and electric polarisation effects in the group-III nitrides".* Aalto University, Finland

**Ciaran Cleary**
*"High speed nonlinear optical components for next-generation optical communications".* Intel

**Vladimir Djara**
*"Development of inversion-mode and junctionless indium-gallium-arsenide MOSFETs".* IBM Zurich

**Farzan Gity**
*"Development of germanium/silicon integration for near infrared detection".* Tyndall

**Konstantin Grygoryev**
*"Investigations of micro-devices for neurobiological applications".* Tyndall

**Laura Horan**
*"Hollow core photonic crystal fibre as a viscosity and raman sensor".* Tyndall

**Sarah Jones**
*"Carbon nanotubes as materials in nanotechnology".* Tyndall

**Gediminas Juska**
*"Pyramidal quantum dots: single and entangled photon sources and correlation studies".* Tyndall

**Sylwia Klejna**
*"First principles modelling of nucleation and growth during atomic layer deposition onto III-V substrates".* Poland

**Ian Mathews**
*"Mechanical stacking for high efficiency photovoltaics".* Bell Labs, Ireland

**Nicola Pavarelli**
*"Optical emission properties of band structure tailored semiconductor nanostructures".* Tyndall

**Jaroslaw Pulka**
*"Ultrafast carrier dynamics in semiconductor nanostructures".* Tyndall

**Pedram Razavi**
*"Simulation of multigate SOI transistors with silicon germanium and III-V channels".* Tyndall

**Natalia Rebrova**
*"Dynamics of passively mode-locked lasers with optical injection".* Tyndall

**Laura Russell**
*"Characterisation and spectroscopy of laser-cooled atoms with an optical nanofibre".*
Valeo Vision Systems, Ireland

**Monika Rutowska**
*"Biosensors using a photonic crystal fibre".*
Leibniz Institute for Astrophotonics, Germany

**Masoud Seifikar**
*"Dilute nitride semiconductors: band structure, scattering and high field transport".* Tyndall

**Dimpy Sharma**
*"Investigation of numerical atomic orbitals for first-principles calculations of the electronic and transport properties of silicon nanowire structures".*
University of Namur, Belgium

**Robert Sheehan**
*"The Design of Curved Optical Waveguide: Analytical and Numerical Analysis".* University College Cork

**Mahdi Shirazi**
*"Multi-scale modelling of atomic layer deposition".*
University of Antwerp

**Brad Snyder**
*"Hybrid integration and packaging of grating-coupled silicon photonics".* Imec

**Ehsan Sooudi**
*"Properties and applications of injection locking in 1.55 μm quantum-dash mode-locked semiconductor lasers".* Tyndall

**Jiri Thoma**
*"Novel GaAs-based materials for reconfigurable electro-modulated lasers in optical interconnects".*
ELI Beamlines, Institute of Physics, CAS,
Czech Republic

**Wensi Wang**
*"Energy harvesting system design and optimisation for wireless sensor networks".* Tyndall

**Andreas Wieczorek**
*"Integrated spot size converters for InP based photonic systems".* Huawei Ipswich UK

**Irene Yeriskin**
*"Properties of molecules in tunnel junctions".* Intel

**Ran Yu**
*"A study of silicon and germanium junctionless transistors".* Synopsys

**Aleksandra Zydor**
*"Ab initio calculations of group 4 metallocene reaction mechanisms".* Canada

## Student Awards & Prizes 2013

**Christopher Broderick**, a PhD student in the Photonics Theory group, was jointly awarded the 2013 BOC Gases Bursary Award for his research on the theory of novel highly-mismatched semiconductor alloys, with a view to the development of next-generation semiconductor optoelectronic devices with reduced power consumption. Christopher was also awarded 1st runner up prize in the annual Tyndall postgraduate poster competition for his poster entitled *"Development of germanium/silicon integration for near infrared detection".*

Farzan Gity (left) and Christopher Broderick win the BOC Gases Bursary Award 2013.

**Farzan Gity**, PhD student with III-V Materials and Devices group, was the joint winner of the 2013 BOC Gases Bursary Award. Farzan's research was concentrated on development of germanium/silicon integration for near infrared detection and he also received 1st runner up prize in the annual Tyndall postgraduate poster competition.

**Lisa Helen,** PhD student with the Life Science Interface, Sensing and Separation group was selected to present her final year project, *"Investigation of tissue bioimpedance using a marco-needle for biomedical applications"* at the Academy of Medical Laboratory Science annual conference, BioMedica 2014, to compete for the President's Prize in April 2014. Lisa's PhD research is focussed on development of a "smart" needle integrated with an impedance sensor to determine nerve proximity for nerve blocking (anaesthetic) procedures. She received a Government of Ireland postgraduate scholarship from the Irish Research Council.

**Tuhin Maity**, PhD student with the Micropower-Nanomagnetics group, is undertaking research in the area of static and dynamic magnetic properties of nanoscale materials for miniaturised ICT devices.

He received an IEEE student travel grant of to attend the 12th Joint MMM/Intermag conference, Chicago, USA, January 14th – 18th 2013, organised by IEEE Magnetic Society. This prestigious award is given to typically 20 students in a worldwide competition. Tuhin also receive a student travel grant to attend JEMS 2013, Rhodes, Greece, August 25th - 30th. This is a competitive award given to a select number of students worldwide by the conference organisers.

**Eoin O'Connell**, PhD student with the Wireless Sensor Networks group received a best paper award at the seventh international Conference on Sensor Technologies and Applications, SENSORCOMM 2013, August 25th - 31st, Barcelona. Eoin's paper was entitled *"Techniques for increasing network functionality while remaining within legal maximum TX duty cycle requirements"*, authors Eoin O'Connell, Victor Cionca and Brendan O'Flynn.

**Nicola Pavarelli**, PhD student with the Photonic Device Dynamics group, received the Instrumentation, Systems, and Automation Society 2013 Post Graduate Award for his research on *"Carrier dynamics in optical semiconductors".*

**Cormac Ryan & Rosemary O'Keeffe**, PhD students with the Heterogeneous Systems Integration group, received 2nd place in the UCC Entrepreneur of the Year competition, dynamic and emerging award category. The competition involved developing and presenting a plan for a new business called RunSmart, a running shoe designed to provide real time information on a runners gait, allowing them to correct bad running techniques and reduce injury.

Cormac Ryan and Rosemary O'Keeffe.

**Niall Savage**, PhD student with the Life Science Interfaces group, was awarded joint-winner of the best poster award at the Micro-NanoBio Systems /European Platform on Smart Systems (MNBS/EpoSS) 2013 for his poster entitled *"Micro-structured impedance electrodes for the detection of breast cancer and ductal carcinoma in situ"*; Authors, Niall T.P. Savage, Brian D. O'Donnell, Martin J. O'Sullivan, Eric J. Moore.

**Tingcong Ye**, PhD student with the Wireless Sensor Networks group, received the best paper award at the Seventh International Conference on Sensor Technologies and Applications, SENSORCOMM 2013, August 25th – 31st Barcelona. Tingcong's paper was entitled *"Transceiver–power-control for 802.15.4a UWB-IR ranging in the presence of multipath propagation"*; Authors Tingcong Ye, Brendan O'Flynn, Michael Walsh and Cian O'Mathuna.

# What Our Students Say About Tyndall

## Abulaiti Hairisha

**PhD Eng Sc student, Theory Modelling and Design Centre**

**Undergraduate Degree:** Chemical Engineering, Heifi University of Technology, China
**PhD Research:** Synthesis, modelling and deposition of organic films

*"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!"*

## Tuhin Maity

**PhD student, Microsystems Centre**

**Undergraduate Degree:** BSc Physics,University of Calcutta, Kolkata, India; MSc Physics, University of Pune, Pune, India.
**PhD Research:** Manipulation of anisotropy in magnetic nanostructures

*"I chose Tyndall due to its unique structure of research in close collaboration with industry. Tyndall gives an opportunity to work in interdisciplinary research projects and to collaborate with other groups and highly motivated people. There's a comfortable working environment and an opportunity to meet friendly and warm individuals from many nationalities and cultures which makes life in Tyndall more interesting and full of fun."*

## Svetlana Slepneva

PhD student, CIT, Photonics Centre

**Undergraduate Degree:** Ms in Physics, Moscow State Pedagogical University
**PhD Research:** Swept sources for optical coherence tomography

*"I was given a chance to join Tyndall as a Marie-Curie Fellow within the Tyndall co-ordinated EU project PROPHET (Postgraduate Research on Photonics as an enabling Technology). The Marie-Curie Fellowship is a great opportunity for a graduate student to experience all aspects of scientific work within a relatively short period of time, it combines working in the lab, studying, collaborating with other institutes, industrial partners, writing, meetings and workshops"*

## Barry Hutchinson

PhD Eng Sc student, Micro/Nanoelectronics Centre

**Undergraduate Degree:** Physics and Chemistry of Advanced Materials, Trinity College, Dublin
**PhD Research:** An investigation of high-k materials in metal-insulator-metal capacitor

*"I really like Tyndall's friendly atmosphere and the easy access to experts from many disciplines that are delighted to share their knowledge with you. I would advise potential students to come to Tyndall with high expectations, you won't be disappointed. Enjoy your research and make the most of every conversation. You never know what you might learn!*

# Prizes, Awards & International Reach

## Martyn Pemble Awarded Irish Gold Medal For Excellence in Surface Engineering

Prof. Martyn Pemble of the Tyndall National Institute in Cork has been awarded the first Irish Gold Medal for excellence in surface engineering by the Institute of Materials Finishing. Martyn received the award based on his outstanding contribution to the fundamental understanding of surface engineering technologies and his work to commercialise the technology. Dr. Denis Dowling, Chair of the Irish Branch, Institute of Materials Finishing, said: **"The award was given to Martyn based on his extensive research over many years in the field of surface engineering and his outstanding contribution to the commercialisation of advanced techniques. The relatively new technologies that Martyn has particular expertise in has growing potential within the semiconductor and broader ICT sector and represent the next generation in materials finishing."**

## Rising Stars in EECS at MIT

Dr. Caroline Lai Photonics Systems.

Dr Caroline Lai from the Photonics Systems group was among 40 female graduate students and post-doctoral scholars invited to participate in the 2013 MIT Rising Stars in Electrical Engineering and Computer Sciences, the annual workshop that brings together top women in EECS for two days of scientific discussions and informal sessions aimed at navigating the early stages of their academic career. During the workshop, held in MIT in early November 2013, Dr. Caroline Lai, gave a talk titled ***"Energy-efficient colorless photonic technologies for next-generation wavelength-division-multiplexed metro and access networks".***

# International Reach

## Dr. Saibal Roy on Sabbatical in Stanford

Dr. Saibal Roy, Head of the Power-Micromagnetics group within the Microsystems centre visited the Electrical Engineering and Materials Science Departments of Stanford University, for six months during 2013 on sabbatical from Tyndall. He was hosted jointly by Prof. Roger T Howe, William A. Iyer Prof. of Electrical Engineering, Member of National Academy of Engineering, US and Prof. Shan X Wang, Director, Magnetic Nanotechnology Divison, Materials Science Department.

Dr. Saibal Roy visited Stanford in 2013.

During this sabbatical visit Dr. Roy was invited to deliver seminars on his area of research by a number of corporate R&D multinational companies in Silicon Valley such as Kilby Labs, Texas Instruments, Qualcomm, Maxim Integrated etc.

As a result of further interactions with these companies, a number have expressed keen interest on pursuing reserach collaborations with Dr. Roy's team at Tyndall.

## Tyndall Hosts NATO Summer School on Science for Peace as Part of Two Week Science Festival

The 2013 NATO Summer School on Science for Peace, was the first of its kind to be held in Ireland and was officially opened by Cork City Lord Mayor, Cllr. Catherine Clancy. The NATO summer school programme has been in operation since the 1950s and was the first of three international science meetings organised by Tyndall between July 1st and July 12th.

Dr. Maria Bardosova, Tyndall; Lord Mayor of Cork Councillor, Catherine Clancy and Prof. Martyn Pemble, Tyndall at the NATO Summer School.

**"The summer school is designed to provide a complex overview of a range of hot topics in nanoscale materials synthesis, characterisation and application in areas such as energy, the environment and security,"** said Prof. Martyn Pemble, Tyndall co-ordinator of two of the EU projects involved in the series of events. The event was the first major dissemination event associated with the EU Framework 7 Marie Curie IRSES (International Research Staff Exchange Scheme) project "*Photonic Applications of Nanoparticle Assemblies & Systems*" (acronym PHANTASY) and is supported by this award together with a prestigious grant from the NATO Science For Peace Division awarded to the organisers of the event.

## EU-US Infrastructure Partnership Development Workshop July 2013

This workshop sponsored by the Higher Education Authority (HEA), UCC and Tyndall was organised by Prof. Stephen Fahy and Mary O'Regan and was opened by Mr. Simon Coveney TD, Minister for Agriculture, Food and the Marine. Mr. Sean Sherlock TD, Minister for Research and Innovation, also addressed the workshop, setting its context within current and developing research policy at national and European levels.

Dr. Eucharia Meehan, HEA, Prof. Pat O'Shea, UMD, Dr. Peter Heffernan, Marine Institute, Minister Simon Coveney TD, Minister Seán Sherlock TD, Prof. Richard Milner, MIT, and Dr. Michael Murphy, President UCC.

Presentations from representatives of the HEA, the Irish Environmental Protection Agency, the Marine Institute, US Oceanographers and the European Commission set the development of research infrastructures in a European and Irish context.

## International Nano-Optoelectronics Workshop 2013 (iNOW 2013)

The EU Framework Programme 7 project PROPHET (Postgraduate Research on Photonics as an Enabling Technology, www.prophet-itn.eu) is an initial training network funded through the FP7 Marie Curie actions, aiming to train the next generation of photonics researchers in the full range of skills required for a multi-disciplinary, industry-focused career in photonics. Photonics, the generation and manipulation of light, is an important enabling technology for a diverse range of application areas. The PROPHET network is coordinated by Dr. Guillaume Huyet at Tyndall, and involves 9 academic partners and 4 industry partners across Europe, with total project funding of €4.8m. It is training 14 PhD students and 5 early-stage post-doctoral researchers in the applications of photonics to areas such as communications, energy, environment and life sciences.

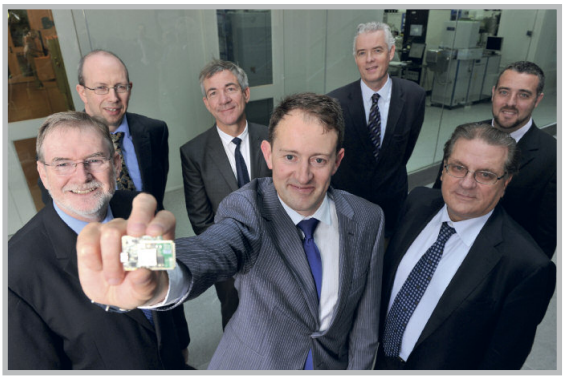
Attendees at the iNOW 2013 Summer School in Cargèse, Corsica.

As part of the PROPHET training activities, the network co-organised a two-week summer school in August 2013, in the picturesque village of Cargèse, in Corsica. The International Nano-Optoelectronics Workshop (iNOW 2013) was the latest in an annual series of iNOW schools, with this event organised by Tyndall, CNRS-LPN (France), SFB 787 School of Nanophotonics, Berlin (Germany), and the iNOW consortium. The programme included talks by 44 high-profile invited speakers, including the 2000 Nobel Prize Laureate, Prof. Zhores I. Alferov, and was attended by over 70 international participants (mostly PhD students), from Europe, USA, China and Japan.

# Conferences

## The 7th Annual Concertation and Consultation Workshop on Micro-Nano-Bio Convergence Systems & EPoSS General Assembly and Annual Forum 2013.

Tyndall hosted the 2013 EU Smart Systems Annual Forum and MicroNanoBioSystems workshop: Based on Tyndall's profile in Europe, the EPoSS (European Technology Platform on Smart Systems) annual forum and the associated MicroNanoBioSystems (MNBS) workshop was held from 23th-26th September 2013.



Dr. Kieran Drain, Tyndall CEO; Mr. Seán Sherlock TD; Dr. Carmelo Papa, STMicroelectronics, EPoSS Chairman. Back row: Francis Mullany, Alcatel-Lucent; Willy van Puymbroeck, European Commission; Prof. Cian Ó Mathúna, Tyndall; Dr. Eric Moore, Tyndall.

It was the first time that the annual Consultation and Concertation Workshop on Micro-Nano-Bio Convergence Systems was held in conjunction with the EPoSS General Assembly and Annual Forum. With strong support from the EC, this conference and workshop brought several senior EC ICT programme managers to Cork to discuss and review ongoing and future EC programmes, as well as attracting some of the leading medical device manufacturers based in Europe.

1. Delegate numbers: **187**
2. International delegates: **133**
3. Company delegates: **62**
4. Student delegates: **15**

EuroNanoForum 2013
18 - 20 June 2013 Dublin

Tyndall participated in the EuroNanoForum 2013, in Dublin in June with a number of papers and posters as well as a booth at the event. The exhibition was selected amongst the top 3 best booths and allowed us to showcase recent work on materials, devices and systems. CCAN played a prominent role in the successful running of Europe's largest nanotechnology event which provided a significant promotional opportunity for nanotech in Ireland.

CCAN Director, Alan Hynes chaired the session on "Commercialisation of Nanotechnology" and CCAN presented Ireland's national nanotech capabilities through the organisation of the "Ireland Showcase" at the event. The showcase enabled Irish companies and research institutes to present their nanotechnology expertise and development requirements in advance of Horizon 2020.

## MCCI Research Forum

The forum focussed on showcasing innovative research happening nationally within MCCI. Research collaborations ongoing with both industry and academia were on display.

Prof. Bogdan Staszewski and Dr. Marcel Pelgrom, keynote speakers at the MCCI Research Forum, October 2013, with MCCI Director Mark Barry.

1. Delegate numbers: **89**
2. International delegates: **5**
3. Industry delegates: **40**

## IERC Annual Conference – Integrated Energy in the 21st Century

The 2013 conference, the IERC's third, with the theme 'Integrated Energy in the 21st Century', was seen as a coming of age conference for the IERC. It brought together a dynamic line-up of speakers, representing industry, policy and academia.


Prof. Tony Day, IERC, Dr. David Parekh, UTRC and Mr. Bob Hanna DCENR at the 2013 IERC Annual Conference.

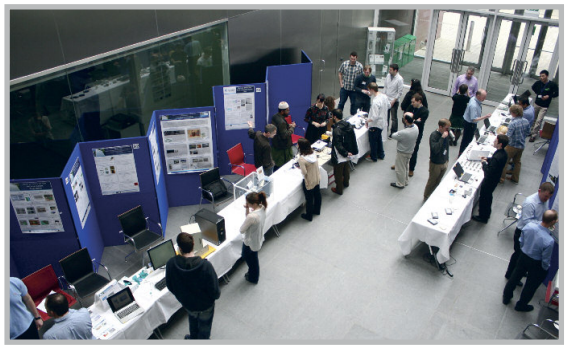
The conference took place in Dublin and was aligned with the European Strategic Energy Technology (SET) Plan Conference - under Ireland's Presidency of the EU - the focus of which was to help formulate a strategic energy technology plan for the EU into the future. The conference contributed directly to the energy efficiency discussions around the SET plan.

1. Delegate numbers: **102**
2. International delegates: **5**
3. Industry delegates: **55**

## Tyndall Internal Conference

Tyndall held its inaugural Internal Conference in April 2013. The conference was organised to provide Tyndall staff and students with greater visibility of the extent of expertise and capabilities within the Institute. The one-day conference included technical presentations, posters and demonstration sessions in our thematic areas of Health, Communications, Energy and the Environment.

Opportunities to showcase internal services were also provided through demonstrations and posters. The conference proved to be a great success in facilitating the exchange of ideas and expertise across the Institute, and will help drive further collaborations.



# Financial

## Income & Expenditure Summary

| INCOME | 2013 | 2012 |
|---|---|---|
| | €'000 | €'000 |
| Government grant | 2,900 | 3,738 |
| Research | 25,666 | 26,323 |
| UCC contribution | 2,110 | 2,160 |
| | **30,676** | **32,221** |

| EXPENDITURE | 2013 | 2012 |
|---|---|---|
| | €'000 | €'000 |
| Remuneration costs | 17,094 | 17,231 |
| Equipment and infrastructure | 2,939 | 6,256 |
| Consumables and related costs | 8,054 | 6,667 |
| Other operating and deferred costs | 2,589 | 2,067 |
| | **30,676** | **32,221** |

# Key Figures

Over
**460**
People
**38**
Nationalities

Over
**120**
Graduate Students

**90**
EU FP7 Projects with a Total Budget of
**€300m**
of which
**€38m**
to Tyndall

ca. **200**
Peer Reviewed Publications

Over
**85%** of
Income from Competitively-Won Contracts

Co-ordinator of
**26**
EU FP7 Projects

Only Full CMOS, MEMS and III-V Fabrication Facilities & Services in Ireland

Over
**200**
Industry Partnerships & Customers Worldwide

Exceeded by
**33%**
Energy Efficient Targets for 2020 set by the Irish Government

# Tyndall Board

**Dr. Alastair Glass**
Chairman

**Dr. Kieran F. Drain**
CEO

**Dr. Lisa Amini**
(IBM)

**Mr. Martin Cronin**
(Forfás)

**Mr. Dermot Curran**
(Department of Jobs, Enterprise & Innovation)

**Mr. Kevin Fielding**
(Alta Berkeley)

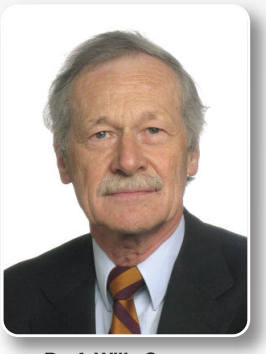
**Dr. Ann Kelleher**
(Intel)

**Prof. Anita Maguire**
(University College Cork)

**Prof. Jim Merz**
(University of Notre Dame)

**Mr. John Mullins**
(Amarenco)

**Mr. Ian Quinn**
(Creganna-Tactx Medical)



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

> MCCI had a strong influence on the Xilinx decision to make the recent R&D investment in Ireland. MCCI helped a lot in building confidence with Xilinx senior management here in the US that we could grow a high-performance design team in Cork.
>
> **Liam Madden, Corporate VP, Xilinx**

www.tyndall.ie

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University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Ireland's EU Structural Funds Programmes 2007 - 2013
Co-funded by the Irish Government and the European Union

EUROPEAN REGIONAL DEVELOPMENT FUND