Lloyd's Register Foundation

UNIVERSITY OF Southampton

ICON International Consortium of Nanotechnologies

Review 2017

www.lrf-icon.com

Introducing the
Nanoworld
Athens, 2017

ABOUT US

Building a safer world with Nanotechnology

The International Consortium of Nanotechnologies (ICON), led by the University of Southampton and funded by the Lloyd's Register Foundation, aims to build capacity and knowledge in the application of nanotechnologies to support safety of life and property.

ICON intends to develop a network of nanotechnology experts from academia and industry to help address the 'Grand Challenges in Nanotechnology'. ICON will also support the development of more than 50 new international nanotechnology experts, 27 of whom have started or are about to start specific research projects, who will spend their training considering safety issues and advancing knowledge within a specific field related to the themes identified in the Foresight Review of Nanotechnology (2014).

The Lloyd's Register Foundation is a charity that helps to protect life and property and support education, engineering-related research and public engagement.

ICON International Consortium of Nanotechnologies

Nanotechnology-enabled innovations have for decades been impacting our daily life, yet often this goes unnoticed. The Foresight Review of Nanotechnology (2014) assessed the impact of nanotechnology in sectors relevant to the Lloyds Register Foundation and ICON aims to translating nanotechnology innovations for making the world safer.

As you will read in these pages, our second year has been very exciting and impactful. We have significantly expanded our network of Lloyd's Register Foundation Doctoral Students that are currently developing twenty-seven unique programs that surpass geographical and disciplinary boundaries. We are also attracting an exciting international audience, with strong industrial and policy making representation, willing to engage in the ICON network and growing this sustainably. We held our first annual conference in Athens Greece where all our students and stakeholders came together. We were delighted to see the drive in our students for describing their work and are thankful to our keynote speakers for engaging with our students and offering advice on future research and translation pathways.

In an attempt to inform the public of the exciting prospects lying ahead of us on where nanotechnology can take us, we have organised and delivered a unique outreach event for introducing the Nanoworld. We were thrilled that this event was attended by over 150 students from different backgrounds, who found this to be exciting as evidenced by the excellent feedback we received. We are also thankful to Nature Nanotechnology, the leading journal on ICON's remit, for showcasing our activity to the world. This activity has already attracted the attention of several policy makers and we are particularly looking forward in working closely with the Royal Academy of Engineering for delivering this activity to more schools.

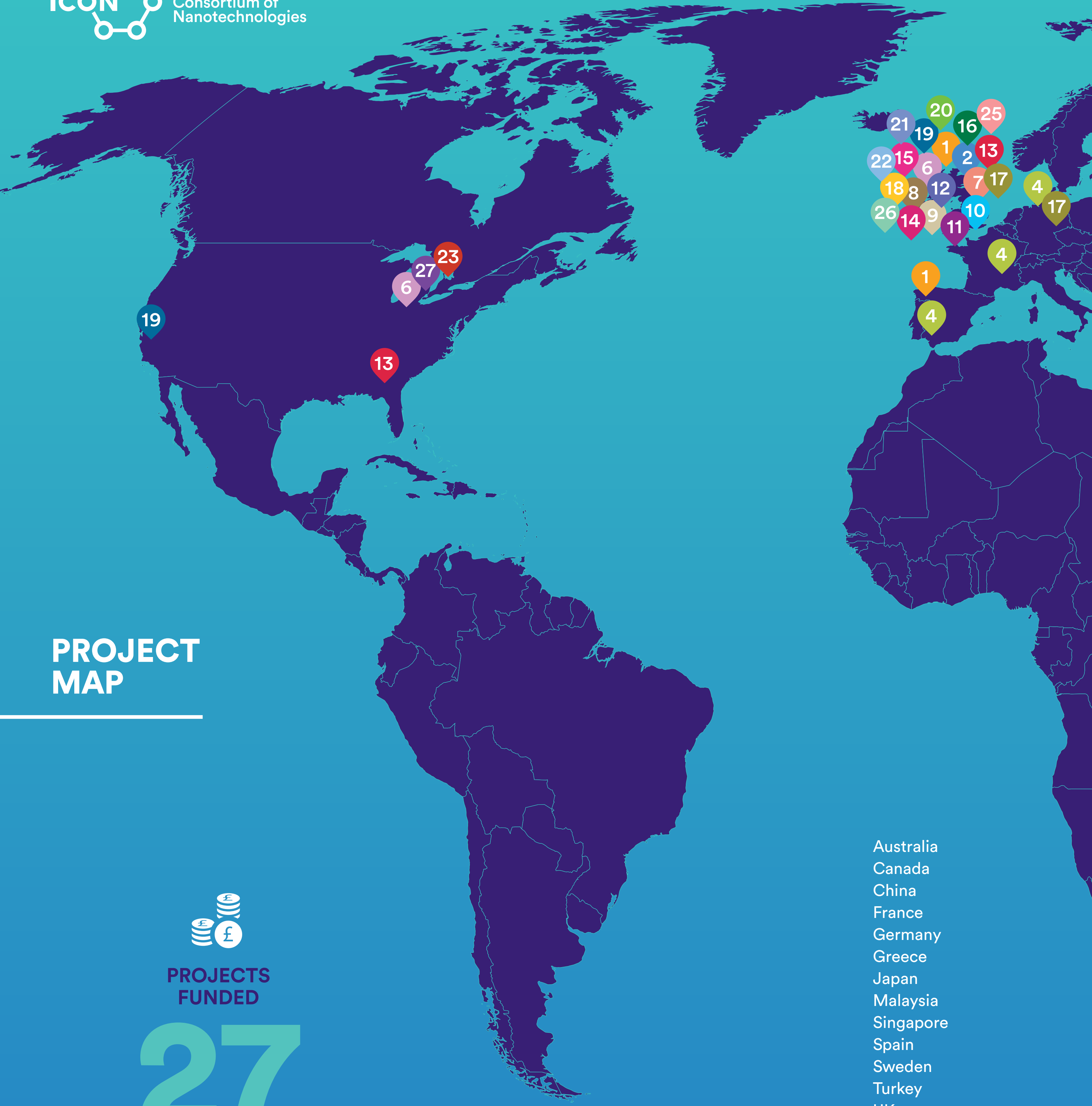
I hope you will enjoy reading about our research and the progress we are making in applying a wide range of Nanotechnologies towards meeting the Foundation's charitable aims.

Professor Themis Prodromakis
ICON Project Director, University of Southampton

The mission of Lloyd's Register Foundation is to enhance safety of life and property and to advance public education. During the last year ICON has grown significantly; there are more researchers and academic partners, more industrial stakeholders pulling research towards application, and more engagement with wider society. Taken together these are delivering impact in line with our charitable mission.

Professor Richard Clegg
Foundation Chief Executive, Lloyd's Register Foundation

International Consortium of Nanotechnologies



PROJECT MAP

PROJECTS FUNDED

27

Australia
Canada
China
France
Germany
Greece
Japan
Malaysia
Singapore
Spain
Sweden
Turkey
UK
USA

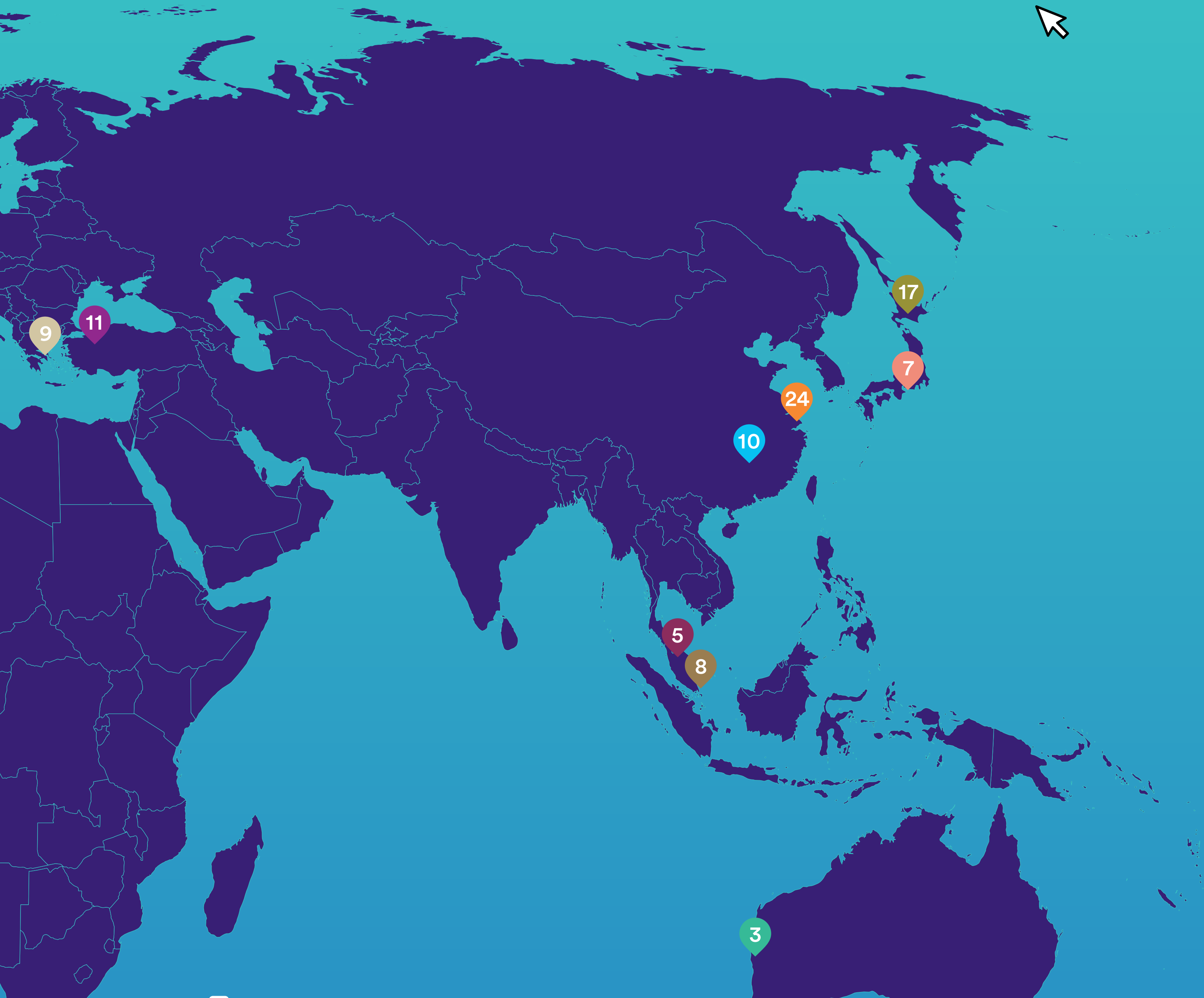
PROJECT LOCATIONS

43

COUNTRIES INVOLVED

14

www.lrf-icon.com/projects



INDUSTRIAL STAKEHOLDERS

33

Cobham Wireless (UK)
Conoco Phillips (UK)
Costain (UK)
Dow Corning (US)
Eight19 Ltd (UK)
European Thermodynamics (UK)
Haydale Ltd (UK)
MIMOS Ltd (Malaysia)
Morganic Metal Solutions (UK)
Nanomagnetics Instruments (UK)
AGC Glass
Airbus
AkzoNobel
Applied Graphene Materials
Bougues
Nanotypos (Greece)
National Physical Laboratory (UK)
Nokia Bell Labs Ltd (US)
NTT Basic Research Laboratories (Japan)
OPS Structural Engineering (UK)
RIKEN (Japan)
Statoil (UK)
Thomas Swann & Co (UK)
Total UK (UK)
WISEN Innovation (UK/China)
Graphenea
HR Wallingford Ltd
Johnson Matthey
NSG/Pilkington
Shanghai Robio-Tech Ltd
Sigma-Merck
STELIA North America
Versarien Ltd

PEOPLE INVOLVED

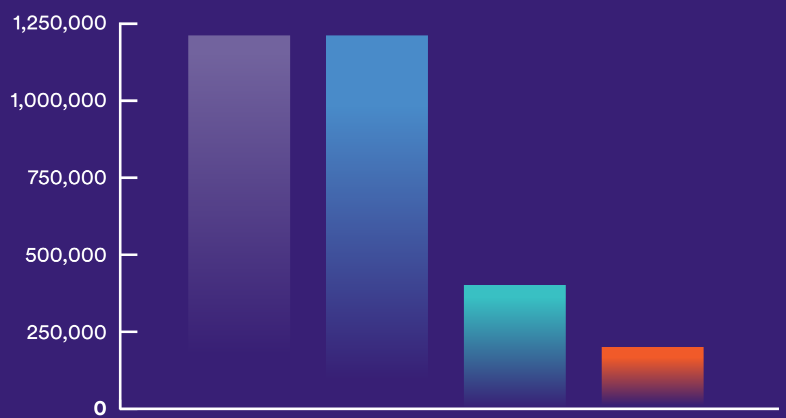
124

18 students
57 supervisors
7 PMB members
6 Theme Leads
36 reviewers

THE ICON PROJECTS IN NUMBERS

Funding

- Value of grants awarded: **£1,227,000**
- Matched by Institutions: **£1,226,000**
- Industrial funding: **£374,000**
- Other funding: **£220,000** (including charities, research councils etc.)



Geographical Distribution

OF LEAD INSTITUTIONS:

19 Europe
2 Asia
4 North America
1 Australasia

OF PARTNER INSTITUTIONS:

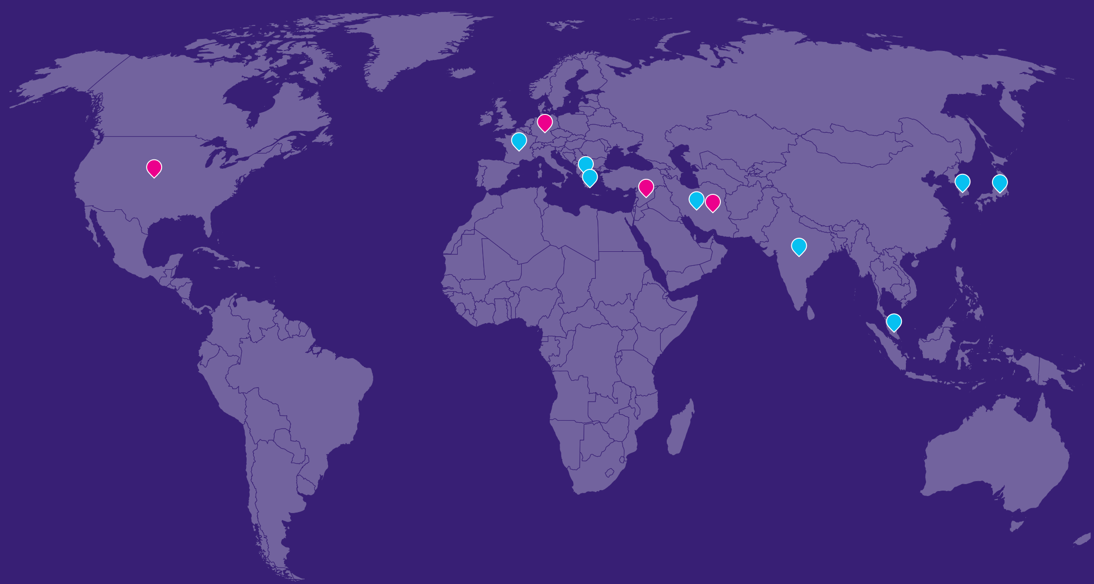
11 Europe
5 Asia
3 North America
0 Australasia

Equality, Diversity & Inclusion

12 NATIONALITIES

12 MALE STUDENTS

6 FEMALE STUDENTS



RESEARCH THEMES

SE | Sensors

Sensors rely on newly invented nanomaterials and manufacturing techniques to make them smaller, more complex and more energy efficient. For example sensors can be printed in large quantities on flexible rolls of plastic at low cost. Such sensors could be placed around critical infrastructure, say bridges or aircraft, to constantly check that everything is running correctly.

THEME LEAD:

Alain Nogaret (University of Bath)

Alain Nogaret's research group focuses on low dimensional electron systems confined by microscopically inhomogeneous magnetic fields, and micromachined transmission lines that propagate electrical impulses and mimic biological nerve fibres.

SM | Smart Materials

Changing the structure of materials at the nanoscale can give them amazing properties – by giving them a structure that repels water, for example. In the future, nanotechnology coatings or additives will even have the potential to “heal” when damaged or worn. For example, dispersing nanoparticles throughout a material means they can migrate to fill in any cracks that appear.

THEME LEAD:

Nicole Grobert (University of Oxford)

Nicole Grobert’s research group focuses on the synthesis, processing, and characterisation of novel carbon and non-carbon based nanomaterials, including nanoparticles, nanotubes, nanorods, graphene and other 2D nanomaterials.

CC | Computing and Communications

The trend of embedding sensors everywhere will produce more information than we have ever had to deal with before – so we will need technology to process it and spot patterns that will alert us to problems. This is providing the inspiration for ultra-efficient algorithms for processing, encrypting and communicating data without comprising its reliability. Computer design inspired by the brain could also use energy more efficiently and so would struggle less with excess heat, which is one of the key problems of shrinking electronic devices further.

THEME LEAD:

Bernabe Linares Barranco (University of Seville)

Bernabé Linares-Barranco’s research group focuses on exploiting nano-scale devices for event-driven learning and processing via circuit design for telecommunication circuits and other topics.

DM | Data Management

Nanotechnology is helping to create ultra-dense computer memory that will allow us to store the wealth of data generated by sensors. For example this will help us use the “big data” from traffic sensors to help manage congestion and prevent accidents or prevent crime by using statistics more effectively to allocate police resources.

THEME LEAD:

Ling Wang (University of Southampton)

Ling Wang’s research group focuses on condition monitoring for tribological systems.

NR | Nanotechnology and Risk

It is crucial that all nanotechnology innovations are developed responsibly and are not to be misused or generate any unexpected consequences. ICON strongly adheres to this principle and all developments will go hand in hand with the necessary safety, standards and risk assessments.

THEME LEAD:

William Keevil (University of Southampton)

Bill Keevil’s research focuses on environmental healthcare within biological sciences.

ES | Energy and Storage

Nanotechnology has helped create batteries that can store more energy for electric cars and has enabled solar panels to convert more sunlight into electricity. In the future, new nanomaterials that turn a flat surface into a three-dimensional one, with a much greater surface area, will mean there is more space for the reactions that enable energy storage or generation to take place, so devices operate even more efficiently.

THEME LEAD:

Eric Yeatman (Imperial College London)

Eric Yeatman’s research group focuses on optical devices and materials and micro-electro-mechanical systems (MEMS).

HIGHLIGHTS OF THE YEAR

Lloyd’s Register Foundation ICON Conference 2017

The first ICON Conference, held on 8 April 2017 in Athens, was hosted by Prof Themis Prodromakis (ICON Project Director), and provided an opportunity for the ICON network to come together to consider the grand challenges in nanotechnology.

Dr Jan Przydatek (Assistant Director of Programmes, Lloyd's Register Foundation) gave an informative overview of the Foundation and its mission, whilst Dr Ivy Fang (Lloyd's Register Group) also outlined some of the work undertaken by the Lloyd's Register Group. Dr Steve Hankin (IOM) then emphasised the need for a responsible approach to research and development of nanotechnology-enabled processes and products via the consideration and mitigation of risks.

We are grateful to Professor Vladimir Falko (Research Director of the National Graphene Institute), Professor Norani Mohamed (Universiti Tecknologi PETRONAS) and Professor Jamie Phillips (University of Michigan) for sharing exciting insights into their particular research fields.

Presentations from Laura Vivar (NSIRC) and Dr Rebecca Boston (Royal Academy and Lloyd's Register Foundation Fellow) gave the ICON students inspiration on how their careers may develop before Dr Giacomo Prando (Associate Editor Nature Nano) gave his keynote. Finally all ICON students presented how their work makes our world safer and had the opportunity to receive feedback on their approach.

Dr Giacomo Prando, Associate Editor Nature Nano, gave a keynote presentation on what it takes to write a successful publication for Nature. His presentation was very informative so we look forward to some interesting ICON publications in the future.

ICON students each made a short presentation at the conference. They also had the opportunity to present posters and further discuss their research with conference delegates.

HIGHLIGHTS OF THE YEAR

4 August 2017

ICON Outreach-Introducing the Nanoworld

In April 2017, we showcased the versatility of our approach and commitment by venturing an international nanotechnology outreach event held at the Intercontinental Hotel in Athens. Here, activities including dressing in cleanroom suits, and making their own photolithography samples (which they then take home as souvenirs), involved about 150 school children aged 8–15 *(pictured)*.

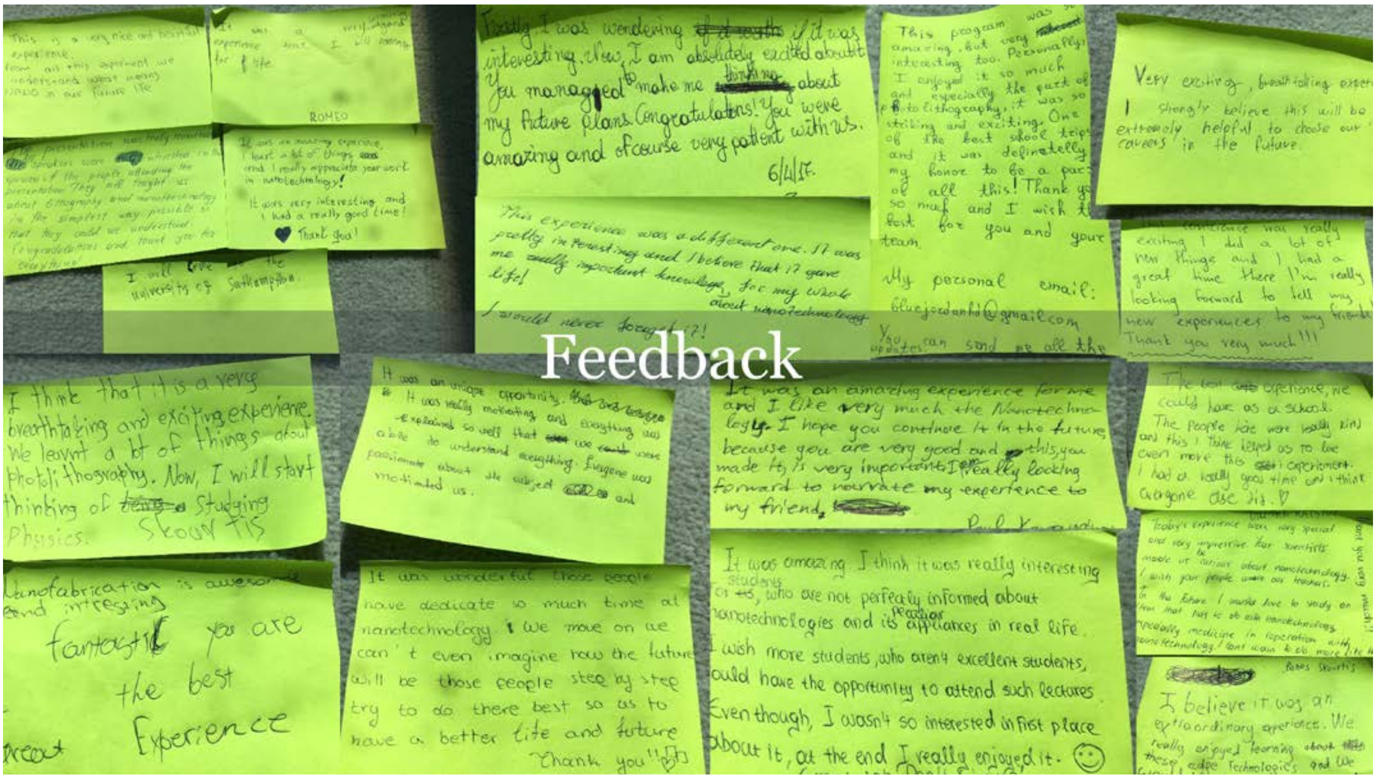
We were thrilled to see that both the students and their teachers enjoyed the day and gave us great feedback, with some students saying they "understand what nano brings to our future life", that it was "one of the best school trips" and, most importantly, that they "will start thinking of studying physics" or "would love to study nanotechnology in cooperation with medicine".

Engagement with events at the regional and national level are an important way to communicate nanotechnology developments with the general public. ICON encourages all those associated with the network to consider how they may contribute to enhancing safety and benefit society, as well as generate impact with excellent research.

This activity was showcased via an "in the classroom" article on Nature Nanotechnology in August 2017.

Professor Themis Prodromakis
ICON Project Director,
University of Southampton

FULL ARTICLE:
http://www.nature.com/articles/nnano.2017.164



HIGHLIGHTS & SUCCESSES

Theresa Schoetz received a poster prize from Professor David Stone (CDT Director University of Sheffield) at the 2nd Annual CDT conference in Energy Storage and Its Applications. The UK conference provided an opportunity to learn more about the wide range of ways storage systems can support the transition to a low carbon economy and provide an insight into future technologies. The programme included high-profile speakers from industry, academia and government including Centrica, Advanced Propulsion Centre and the Department for Business, Energy and Industrial Strategy (BEIS).

TTP Education in Action was founded by teachers who were passionate about providing an inspirational, motivational experience not possible within the confines of the classroom. By building on this original philosophy they have become the leading provider of external educational study days in the UK.

The ICON Project Director was delighted to join other world-class experts drawn from academia, industry and media to inspire and motivate hundreds of students in London. He provided an introduction to how functional materials can be turned into nanoscale devices for enabling brain-inspired electronics. Prof Prodromakis's two lectures were attended by over 1800 A-level students.

Congratulations to ICON student **Spyros Daskalakis** who has won the first year postgraduate research prize at Heriot-Watt University. Spyros presented his demonstrator of an FM radio ambient backscatter communication system.

ICON CASE STUDIES

Ambient Backscattering Sensors using for Ultra Low Cost and Low Power Wireless Applications.

STUDENT: **Spyridon Nektarios Daskalakis**

SE Sensors

The extremely high growth of Internet-of-Things-related applications has required the design of low-cost and low-power wireless sensors. Although backscatter radio communication is a mature technology used in radio frequency identification (RFID) applications, ambient backscattering is a novel approach taking advantage of ambient signals to simplify wireless system topologies to just the tags and a receiver circuit eliminating the need for a dedicated carrier source. My PhD project introduces the idea of novel lower-power wireless tags and receiver system that utilise ambient signals (FM, GPS, Bluetooth) for backscatter communication. The tags can accumulate data from sensors and transmit the information back to the receiver by means of reflections. Environmental sensors are used on tags for precision agriculture purposes thus remote sensing of agriculture is asignificant parameter for food security monitoring.

Motivation – why did you select your Phd?

Three years ago I enrolled in the master's program at Technical University of Crete, in order to start my research in backscatter radio sensors and RF harvesting. I participated in the ERC-04 BLASE project as a graduate research assistant. and on March 2017 i was subsequently joined the Ph.D. program of Heriot-Watt University advised by Associate Prof. Apostolos Georgiadis. Led by my enthusiasm for exploring more "RFID" world, i decided to continue in the same way. My goal is to make low-cost and low-power sensors in order to contribute in the "Internet of Things" topic and make the world a better place.

Method – what are you doing?

The project topology so far utilises music broadcast "frequency modulated" (FM) signals for backscatter communication. The proposed proof-of-concept tag comprises of an ultra-low-power microcontroller (MCU) and a radio frequency front-end for wireless communication. The MCU can accumulate data from sensors through an analog-to-digital converter, while it transmits the information back to the receiver through the front-end by means of backscattering. The front-end uses On-Off keying modulation and FM0 encoding on ambient FM station signals. High order modulation is a solution (4 PAM) in order to increase the bitrate. The receiver consists of a commercial low-cost software defined radio (SDR) which downconverts the received signal to baseband and decodes it using a suitable signal processing algorithm.The SDR is connected with smartphone and sends the information to the cloud for globally visualisation. The system is also novel because we have an ultra-low-cost platform, communicating using the ambient signals with inkjet printing as fabrication technique.

Impact – what have you achieved to date?

Publications:

1. A. Collado, S. N. Daskalakis, K. Niotaki, R. Martinez, F. Bolos and A. Georgiadis, Rectifier Design Challenges for RF Wireless Power Transfer and Energy Harvesting Systems, RADIOENGINEERING, Vol. 26, No. 1, Apr. 2017.
2. S.N. Daskalakis, A. Georgiadis, A. Collado and M.M. Tentzeris, An UHF rectifier with 100% bandwidth based on a ladder LC impedance matching network, IEEE European Microwave Week (EuMW) , October 2017, Nuremberg, Germany.
3. S. N. Daskalakis, A. Collado, A. Georgiadis, and M. M. Tentzeris, Backscatter Morse Leaf Sensor for Agricultural Wireless Sensor Networks, IEEE Sensors Conf., October-November 2017, Glasgow, Scotland, UK. (Received a "Best paper distinction" and invitation for publication to the IEEE Sensors Journal.)
4. S.N. Daskalakis, J. Kimionis, J. Hester, A. Collado, M. M. Tentzeris and A. Georgiadis,, Inkjet printed 24 GHz rectenna on paper for millimeter wave identification and wireless power transfer applications, IMWS-AMP Int. Microwave Workshop Series on Adv. Materials and Processes, September 2017, Pavia, Italy.
5. S.N. Daskalakis, J. Kimionis, A. Collado, M.M. Tentzeris and A. Georgiadis, Ambient FM Backscattering for Smart Agricultural Monitoring, IEEE MTT-S International Microwave Symposium (IMS), June 2017, Honolulu, Hawaii, USA.
6. A. Servent, S.N. Daskalakis, A. Collado and A. Georgiadis, A Proximity Wireless Sensor Based on Backscatter Communication, International Applied Computational Electromagnetics Society (ACES) Symposium, March 2017, Firenze, Italy.

Prizes:

1st Year Postgraduate Research Prize 2017 School of Engineering and Physical Sciences, Heriot-Watt University (Oct. 2017).

Participated in a Scottish entrepreneurship competition for commercializing academic work (http://www.sie.ac.uk/fresh-ideas-winners-for-december-announced). The submission was highly commended and currently we are invited for the next stage of this competition.

Next steps?

Optimise the backscatter system in order to achieve low consumption and higher communication range. Also apply ambient RF energy harvesting for the power supply of the sensors. This should allow implementation of a smartphone FM receiver.

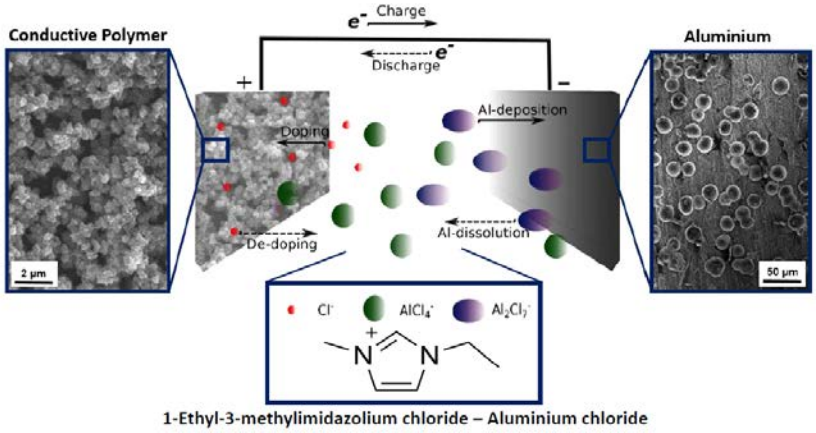
Preparation and Characterisation of a Rechargeable Conductive Polymer-Aluminium Battery in Ionic Liquids

STUDENT: **Theresa Schötz**

ES Energy and Storage

This project presents a new concept of a non-aqueous rechargeable energy storage technology based on aluminum and a conductive polymer as the active electrode materials in a chloroaluminate ionic liquid (Figure 1). The novelty of the study comprises the synthesis and combination of battery and capacitor characteristic materials. Therefore, the proposed system has the benefits and the specific energy and power in one system, the hybrid battery-capacitor. In addition, the used materials stand out by their sustainability.

Figure 1: Schematic illustration of the charge (doping) and discharge (de-doping) reaction of a rechargeable conductive polymer-aluminium battery with chloroaluminate ionic liquid electrolyte.



Motivation – why did you select your PhD?

Energy storage technologies, which combine high specific energy and power together with sustainability and low costs, are the fundamental drivers for an energy sustainable society, especially in terms of electro-mobility and consumer electronics. However, the monopoly of current high-performance batteries, such as lithium-ion batteries, has one major issue: sustainability. Thermal runaway, difficult recycling and limited resources raise the question: How can we develop sustainable high-performance batteries with safe cell reactions, earth abundant materials and long shelf life?

This project proposes a conductive polymer-aluminium battery in ionic liquid, focusing mainly on the conductive polymer electrode as it determines significantly the performance of the whole battery system. The studies comprise the synthesis of novel conductive polymer electrodes and their characterisation in ionic liquid electrolytes as well as the testing of the battery system and comparison with state-of-the-art rechargeable battery systems.

Method – what are you doing?

It started with an idea to implement a sustainable high-performance battery based on conductive polymers and aluminium in a non-aqueous electrolyte such as ionic liquids. The research plan envisages the proof-of-concept study in the first year of the PhD followed by improvements and fundamental research of the electrochemistry of the system in the following years. The main part of the PhD-project will account for the design and testing of the improved battery system in year three and four based on the studies done in year two.

Impact – what have you achieved to date?

We proved the feasibility of the conductive polymer-aluminium battery in ionic liquids and showed promising preliminary performances in the range of state-of-the-art nickel-metal-hydride and lithium-ion batteries [DOI:10.1007/s10008-017-3658-4]. However, the system required major improvements such as the stabilisation of the conductive polymer electrode by electro-polymerising the polymer in chloroaluminate ionic liquids. We achieved very stable conductive polymer electrodes synthetised in this ionic liquid, which also showed new findings in terms of the polymerisation of conductive polymers in ionic liquids [DOI:10.1016/j.electacta.2018.01.033]. Most recently we went one step further and reproduced the conductive polymer structure on a 3D-carbon substrate, improving the number of active sites and therefore the performance of the electrode.

Next steps?

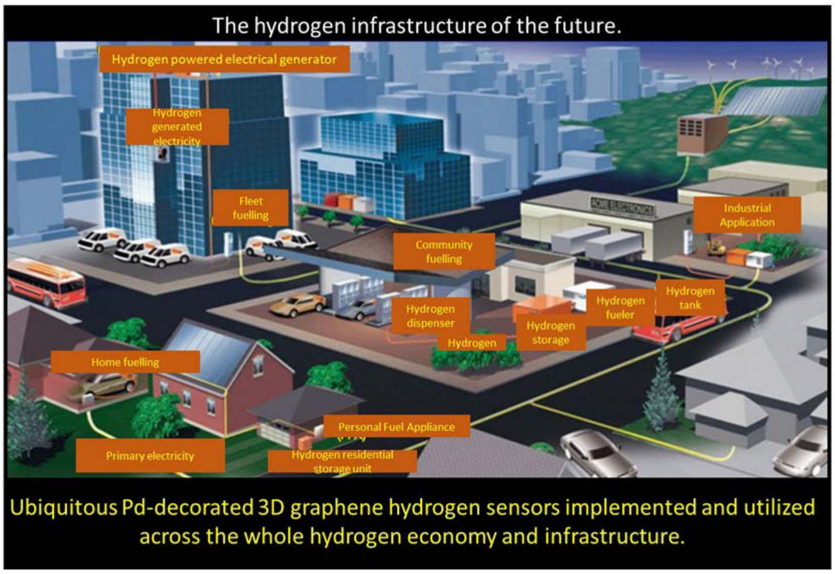
The next experimental milestone will take one step back to the fundamental research of the interaction of conductive polymers and ionic liquids as well as the reversible deposition of aluminium as nano-scale particles in ionic liquids. These studies will include in-situ electrochemical quartz crystal microbalance (EQCM) and in-operando atomic fore microscopy (AFM) measurements. The investigations aim to clarify the electrochemical reactions at the interface conductive polymer-ionic liquid and nano-scale structural changes of the polymer during charging and discharging. These studies will provide information on how to improve the performance of the proposed hybrid battery-capacitor systematically and will help to explain the mechanism of the electrochemical reactions taking place.

Pd-Decorated 3D Graphene for Hydrogen Sensing

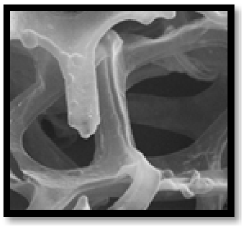
STUDENT: **Adel Eskandar Samsudin**

SE | Sensors

Developing 3D-graphene material into a sensor that measures the presence of hydrogen gas.



(a)



(c)

(b)

(a) Side view and (b) front view of 3D graphene samples grown in the CVD system.
(c) 3D graphene.

Motivation – why did you select your PhD?

The group has been finding applications for the 3D-Graphene to be functionalized into useful devices especially for safety. One of the area is the hydrogen gas detection which is widely utilized in various industries to the effect of having a whole hydrogen economy from production to the end user. Sensing hydrogen is crucial to detect leaks, dangerous buildup of gases especially in enclosed facilities, provide information for corrective measures to be taken for dangerous hydrogen gas levels and assist first responders to the presence of residual hydrogen gas.

Method – what are you doing?

3D graphene sensing elements are grown using CVD method, processed and decorated with palladium by electrochemical method. The produced 3D graphene will then be integrated into a sensor configuration for detection of hydrogen gas at various concentrations.

Impact – what have you achieved to date?

The research has the impact of contributing to easy detection of hydrogen gas, potentially without the need for elevated temperature with miniature size which enables many embedded and integration potential to various systems in a facility and as portable handheld devices.

Conferences:

1. Graphene 2016 Conference & Exhibition; on 19 -22 April 2016, Genova, Italy, Tuneable layers of Three Dimensional Graphene Structure Grown using Chemical Vapour Deposition.

2. LRF ICON 2017, 7 April 2017, Athens, Greece; Study on 3D-Graphene Synthesis and Au Decoration.

Publications:

1. NM Mohamed, MSM Saheed, BSM Singh, MSM Saheed, Synthesis and characterizations of 3-dimensional graphene scaffold via low pressure chemical vapour deposition, eProceedings Chemistry 3 (1), 2017

2. MSM Saheed, NM Mohamed, BSM Singh, MSM Saheed, Precursor and pressure dependent 3D graphene: A study on layer formation and type of carbon material, Diamond and Related Materials 79, 93-101, 2017

Next steps?

Verification of the response to hydrogen in terms of on sensitivity, selectivity, stability, reproducibility, response & recovery time.

Our Worldwide Projects

1 Reconfigurable nanowires phononics for temperature sensing

LOCATIONS: Imperial College London, London, UK | University of Salamanca, Salamanca, Spain

The combined control of phonon and electron transport will be used to implement temperature sensing and data processing.

SE Sensors — STUDENT: Ali Hamid | INDUSTRIAL PARTNER: European Thermodynamics

2 Perovskite structure nanocrystals for light harvesting and light emission

LOCATION: University of Cambridge, Cambridge, UK

We aim to develop new functional nanoparticles, based on lead halide perovskite materials, for use in light emission and in solar cells. These show extremely promising properties and have the potential to further advance both solar cells and also solid state lighting. In common with many other semiconductor families, there are issues to address concerning the use of low levels of potentially toxic elements (here, lead). Though quantities of these materials used are very low, understanding of the correct protocols to handle such elements safely, through process manufacture, use and disposal is critical and will form an important component of the project.

SM Smart Materials — STUDENT: Zahra Andaji Garmaroudi | INDUSTRIAL PARTNER: Eight19 Ltd

3 Fast night vision imaging - enhancing road safety for drivers and pedestrians

LOCATION: University of Western Australia, Perth, Australia

For civilian and paramilitary applications, uncooled thermal imagers are the least weight and most cost-effective. However, the most serious shortcoming of un-cooled thermal imagers is the trade-off between thermal sensitivity and speed of response preventing applications in high speed/motion environments. This project aims to overcome this limitation in thermal imagers by using microscale engineering of a nano-porous silicon.

SE Sensors — STUDENT: Yaman Afandi

4 Continuous knowledge acquisition embedded devices based on novel nanotechnology synaptic emulators for enabling enhanced security in everyday life situations

LOCATIONS: University of Sevilla, Sevilla, Spain | Jacobs University, Bremen, Germany | CEA/LEI, Grenoble, France

Here we propose to exploit learning systems with novel nano-scale learning devices, that result in ultra low power and very high density microchips, capable of performing powerful cognitive tasks, like detecting novelty within routine habits. In present days, Neuroscience is achieving an unprecedent rate of continuous discoveries, unvealing many intrigue details on how the brain learns profound cognitive meanings from continuous sensory data. Computational Neuroscience is the field which tries to understand the computing principles within the brain by developing software programs that follow the internal brain operations, as discovered in biological Neuroscience.

CC Computing and Communications — STUDENT: Charanraj Mohan

5

Detection of low concentration hydrogen gas using highly sensitive three-dimensional palladium decorated graphene encapsulated in poly (methyl methacrylate)

LOCATION: Universiti Teknologi PETRONAS, Perak Darul Ridzuan, Malaysia

Hydrogen gas (H2) is known as one of the cleanest and most promising energy sources for future energy related applications in transportations and power generations due to its energy density, renewability, and ecofriendly nature. However, the use of hydrogen gas is associated with serious safety concerns since it is highly flammable and explosive when mixed with air at volume concentrations higher than 4%. Thus, systems utilizing hydrogen as an alternative fuel requires fast, accurate and constant monitoring for the leaks. In this research work, graphene foam doped with palladium nanoparticles will be developed as the sensing element as it has large surface area that provides huge, highly sensitive and selective gas adsorptive capacity. The proposed graphene foam sensor will have fast response and recovery time that lead to low power consumption and miniaturization of the device.

SM | Smart Materials

STUDENT: Adel Eskandar Samsudin | INDUSTRIAL PARTNER: MIMOS Ltd

6

Ultrafast nanostructuring of wide bandgap SiC for electronics in harsh environments

LOCATIONS: University of Michigan, Ann Arbor, USA | University of Michigan, Ann Arbor, USA

new approach for localized control of electrical charge transport in SiC is proposed based on non-thermal nanostructuring on ultrafast (femtosecond) time scales. Such materials modifications are anticipated to provide both breakthrough technologies for SiC electronics, and a new enabling technology for realizing resistive memory devices (RRAM).

SM | Smart Materials

STUDENT: Minhyung Ahn | INDUSTRIAL PARTNER: Dow Corning

7

Single electron manipulation in silicon nano-wire for quantum technologies

LOCATIONS: University of Southampton, Southampton, UK | Tokyo Institute of Technology, Tokyo, Japan

We will develop a manufacturing process technology of silicon nano-wire and manipulate single electron for quantum technologies. The primary goal of this project is to understand the transport mechanism in silicon nano-wire at the single electron level. This will be important for the application to new definition of the current. A 'quantum' redefinition of the SI system of physical units is presently under discussion, based on the fundamental physical constants of nature.

SM | Smart Materials

STUDENT: Kouta Ibukuro | INDUSTRIAL PARTNERS: National Physical Laboratory (UK), NTT Basic Research Laboratories and RIKEN

8

Hierarchical fibre reinforced nanocomposites for multifunctional improvements in safety

LOCATIONS: Imperial College London, London, UK | NTU, Singapore

Certain nanomaterials, particularly carbon nanotubes (CNTs) and graphenes, offer the potential for fundamental improvements in mechanical performance and functional properties of composites. Individual nanocarbon structures have been shown to have a significantly higher strength than any other known materials, combined with excellent stiffness, high lateral flexibility, high aspect ratio, and low weight; in addition, they have good electrical and thermal conductivities, and interesting optoelectronic characteristics, all relevant to (multi) functional performance.

SM | Smart Materials

STUDENT: Hugo de Luca

9 Nanoparticle sensor arrays on flexible substrates

LOCATIONS: NTUA, Athens, Greece | Imperial College London, London, UK

This project explores the fabrication and real time reading of sensors. Theses can be used for the early detection of cracks in large marine, aerospace and civil structures enhancing safety. Other application areas include vehicles and train rails, safety equipment, environmental monitoring, homeland security as well as robotics and prosthetics.

SE Sensors

STUDENT: Vaggelis Aslanidis | INDUSTRIAL PARTNER: Nanotypos

10 Nano/micro-electro-mechanical-system self-powered sensors for infrastructure safety monitoring

LOCATIONS: University of Southampton, Southampton, UK | UC Berkeley, Berkeley, USA | Central South University, Changsha, China

Existing infrastructure is challenged by the need to increase load and usage – whether the number of passengers carried, the number of vehicles, or the volume of water used – and by the requirement to maintain the existing infrastructure while operating at current capacity. To ensure structural integrity and operational safety as infrastructure ages and deteriorates, long-life and dynamic structural health monitoring systems must be developed to detect infrastructure strain and to provide clear warning signs when the infrastructure is in danger.

SE Sensors

STUDENT: P. Adam Li | INDUSTRIAL PARTNERS: Cobham Wireless, WISEN Innovation and Costain

11 Graphene Hall-effect nanosensors to optimise high current superconducting tapes for applications in 'smart' power grids

LOCATIONS: University of Bath, Bath, UK | Middle East Technical University (METU), Ankara, Turkey

There is an urgent need for new scanned sensors to map and characterise current flow around microscopic defects in second generation high temperature superconductor (2G-HTS) tapes being developed for applications in energy storage and transmission. Novel graphene-based sensors will be developed for nanoscale magnetic imaging which will be smaller, more durable and able to detect much lower fields. Device development will take place in collaboration with partner company NanoMagnetics Instruments who will provide CVD graphene and test prototype sensors in their scanning probe magnetic imaging products.

SE Sensors | SM Smart Materials

STUDENT: David Collomb | INDUSTRIAL PARTNER: NanoMagnetics Instruments

12 Development of liquid infused surfaces as novel antifouling materials for mineral scale prevention

LOCATION: University of Leeds, Leeds, UK

The project brings together expertise in nanotechnology and surface engineering to deploy novel, environmentally-friendly antifouling materials to effectively mitigate mineral build-ups. This will be achieved through two strands of research focus. Firstly, prevention of mineral surface crystallization process, and secondly, if fouling has already occurred, minimizing the adhesion strength of the fouling layer to the substrate to facilitate easy detachment and cleaning. This alternative approach has been deployed successfully in the control of bio-fouling (e.g. paint preventing growth of subaquatic organisms on ships) but as yet remains an entirely new approach for mineral scale prevention.

SM Smart Materials

INDUSTRIAL PARTNERS: Statoil, ConocoPhillips and Total

13 Additive manufacturing of millimetre wave wireless sensors based on nanoparticle inks for pervasive IoT sensing and 5G communications

LOCATIONS: Heroit Watt University, Edinburgh, UK | Georgia Institute of Technology, Atlanta, USA

The project effectively combines two timely trends for 5G communications and IoT and additive manufacturing and 3D printing of nanotechnology based matetials, and aims to reduce cost, footprint and energy requirements. There are numerous applications within the 5G and IoT framework which the results of this work can be applied including environmental sensing, asset aging and degradation due to humidity, temperature or mechanical degradation, but also communication, presence detection, through wall radar, and collision avoidance in autonomous vehicle systems.

SE Sensors STUDENT: Spyros Daskalakis

14 Development of a nano-structure deposition process to integrate energy harvesting materials and heat management systems into single-piece, hot, structural elements such as exhaust/fluid manifolds

LOCATION: Coventry University, Coventry, UK

This project will integrate thermo-electric heat scavengers and attendant heat management systems into a single-piece, high thermal conductivity, structural part made of nano-structured Copper (free of toxic Beryllium). This will allow optimum energy harvesting from the waste heat of hot fluids. Single-piece manufacture will enable improved safety through vastly improved leak-tightness and structural integrity of the installation with minimised space usage.

ES Energy and Storage INDUSTRIAL PARTNER: Morganic metal solutions Ltd

15 Stronger, lighter, safer, materials by length scale engineering and a next generation, nano particle free, 3D additive manufacturing process

LOCATION: Coventry University, Coventry, UK

The ultimate strength of a material comes from the chemical bonds that hold it together. Like a zip fastener, it is hard to pull the zip apart (break the bonds) all at once. However, materials have very small defects (“dislocations”), which can move easily through the material, sequentially breaking individual bonds (like a zip unfastening) to generate permanent deformation (plasticity). Thus, materials are generally very much weaker than their theoretical strength and their strength is dependent on the distance dislocations can move and the size of the source generating them. “Strength is determined by length.” Hence, this project will exploit a new “joined up” understanding of plastic deformation to design smart, ‘length-scale engineered’ materials that have increased strength, adequate ductility/toughness for safe use, and self-healing properties. It will produce nano-enabled materials using a new, safer, additive manufacturing route, and design rules for more sustainable, safer (higher performance/lifetime in harsh environments) and energy efficient components (reducing weight for equal strength).

SM Smart Materials STUDENT: Naresh Radaliyagoda | INDUSTRIAL PARTNER: Morganic metal solutions Ltd

16 Structural health monitoring with graphene-silicone strain sensors

LOCATION: University of Bath, Bath, UK

The detection and localization of structural damage with sensor networks will prevent catastrophic bridge collapses, reduce inspection costs while providing increased public safety, assist with infrastructure maintenance, help design appropriate retrofit measures, safeguard modifications to existing infrastructure, improve seismic risks assessment, assess load carrying capacity, assist with emergency response efforts by informing evacuation and traffic control.

SE Sensors STUDENT: Alize Gaumet | INDUSTRIAL PARTNERS: Haydale Ltd and OPS Structural Engineering

17 Preparation and characterisation of a rechargeable battery based on a conductive polymer and aluminum in an ionic liquid electrolyte

LOCATION: University of Southampton, Southampton, UK

Energy storage devices like rechargeable batteries have currently a minor contribution to the challenges of the energy conversion to sustainability. Nevertheless, the growth of renewable energies will define the energy storage devices as an indispensable element of the power grid. Therefore, it is necessary to overcome the main problems of current high performance batteries like safety, an upper capacity limit and confined raw material resources. This project proposes the concept of a non-aqueous rechargeable battery characterised by safe cell reactions, a high storage capacity and earth-abundant materials like aluminum and conductive polymers.

ES | Energy and Storage

STUDENT: Theresa Schötz

18 Assessing the potential risks of 2D nanomaterials in the environment

LOCATION: Imperial College London, London, UK

This project will assess the potential environmental hazards of 2D nanomaterials, such as graphene and graphene oxide, which have been mooted for a wide range of applications, including those intrinsically involving environmental exposure, such as water treatment. The project will use very powerful imaging and characterization techniques to reveal the underlying pathways for the influence of these materials as they partition through a waste water treatment plant to the environment to stream sediments and soils. The student will also assess the resulting toxicological effects on ecosystems.

NR | Nanotechnology and Risk

STUDENT: Seigo Masuda

19 Scalable manufacturing of few-layer van der Waals materials from bulk

LOCATIONS: UC Berkeley, Berkeley, USA | Imperial College London, London, UK

This project targets mechanical exfoliation, which receives less attention than competing techniques such as chemical vapor deposition (CVD) and atomic layer deposition (ALD), but yields monolayers with unrivaled electronic quality. Our project seeks to overcome the mechanical limitations of manual, low-yield exfoliation processes, by developing an automated, repeatable process with controlled yield and throughput. The far superior electronic performance of these materials compared to those made by competing processes demands investment to turn exfoliation into a viable manufacturing process.

SM | Smart Materials

STUDENT: Hannah Gramling | INDUSTRIAL PARTNER: Thomas Swan & Co Ltd

20 Sustainable Biotemplated Syntheses and characterisation of Nanoparticulate sodium-ion battery cathode materials

LOCATION: University of Sheffield

Research on novel biotemplated syntheses of next-generation sodium-ion battery (NIB) cathode materials, will be developed, for grid-scale storage and load-leveling applications to ensure consistent and secure electricity supplies. This is a pressing concern for both sustainability and performance.

ES | Energy and Storage

INDUSTRIAL PARTNER: Johnson Matthey

21 Risk assessment in nanotoxicology: modelling long term fate of nanoparticles in aquatic media

LOCATION: Queen Mary University of London

Nanoparticles are entering our lives through a variety of products, from paints to personal care products. Prediction of the long-term fate of free nanoparticles in the environment and their potential toxicological consequences is a crucial challenge faced by the nanotechnology industry. We aim to improve understanding of the fate of nanoparticles once they are delivered to the aquatic environment via industrial and domestic waste streams.

NR | Nanotechnology and Risk

INDUSTRIAL PARTNER: HR Wallingford Ltd

22 Understanding the health limitations for a safe use of graphene and 2D materials

LOCATION: University of Manchester

The project will focus on a 2D materials which are likely to be used in a form where pulmonary exposure may occur during production or processing of the end-products, such as inkjet 2D/3D printing, or large surface spraying. State of the art methodologies and brain cell models will be used.

NR | Nanotechnology and Risk

23 Towards invisible nanoscale chemical tagging

LOCATION: York University, Canada

The proposed goals of this project are to perform theoretical work to analyze the potential and capabilities of tags using molecular communication and to propose an experimental design project to miniaturize an existing tag-reading system to demonstrate the potential of our approach.

SM | Smart Materials

24 Carbon nanodot devices for detecting toxic metal ions

LOCATION: Shanghai Jiao Tong University, China

As a new category of nanomaterials, fluorescent carbon nanodots (CNDs) have outstanding optical properties, good biocompatibility, and surface functional division of regulatory and other characteristics; and they have the extensive applications in photocatalysis, biochemical analysis, bioimaging, drug delivery, and tracing the toxic metal ions sensitively, etc. This project will develop an effective and quantified methodology based on fluorescent carbon nanodots (CNDs) for tracing the toxic metal ions.

SE | Sensors

INDUSTRIAL PARTNER: Shanghai Robio-Tech Ltd

25 Nanoengineered smart surfaces

LOCATION: UCL

The project aims to design, fabricate and test the next generation of low-energy surfaces in order to combat a range of issues that can have a significant impact across a multitude of industries. For instance, controlling water condensation and freezing on surfaces can vastly improve the efficiency of heat exchange systems, which suffer from a reduction in the efficiency by up to 70% as a result of ice formation.

SM | Smart Materials

STUDENT: Sophia Laney | INDUSTRIAL PARTNER: AGC Glass

26 Diamond-based high temperature strain sensors for hostile environments

LOCATION: Aston University

The practical application of the diamond pressure sensor at high temperatures in hostile environments is expected to open up an avenue for diamond MEMS. The proposed device offers high-temperature and high-sensitivity operation within a simple device structure.

SE | Sensors

INDUSTRIAL PARTNER: Oak Ridge National Laboratory (ORNL)

27 Polymer Nanocomposite based radiation shielding material

LOCATION: University of Waterloo

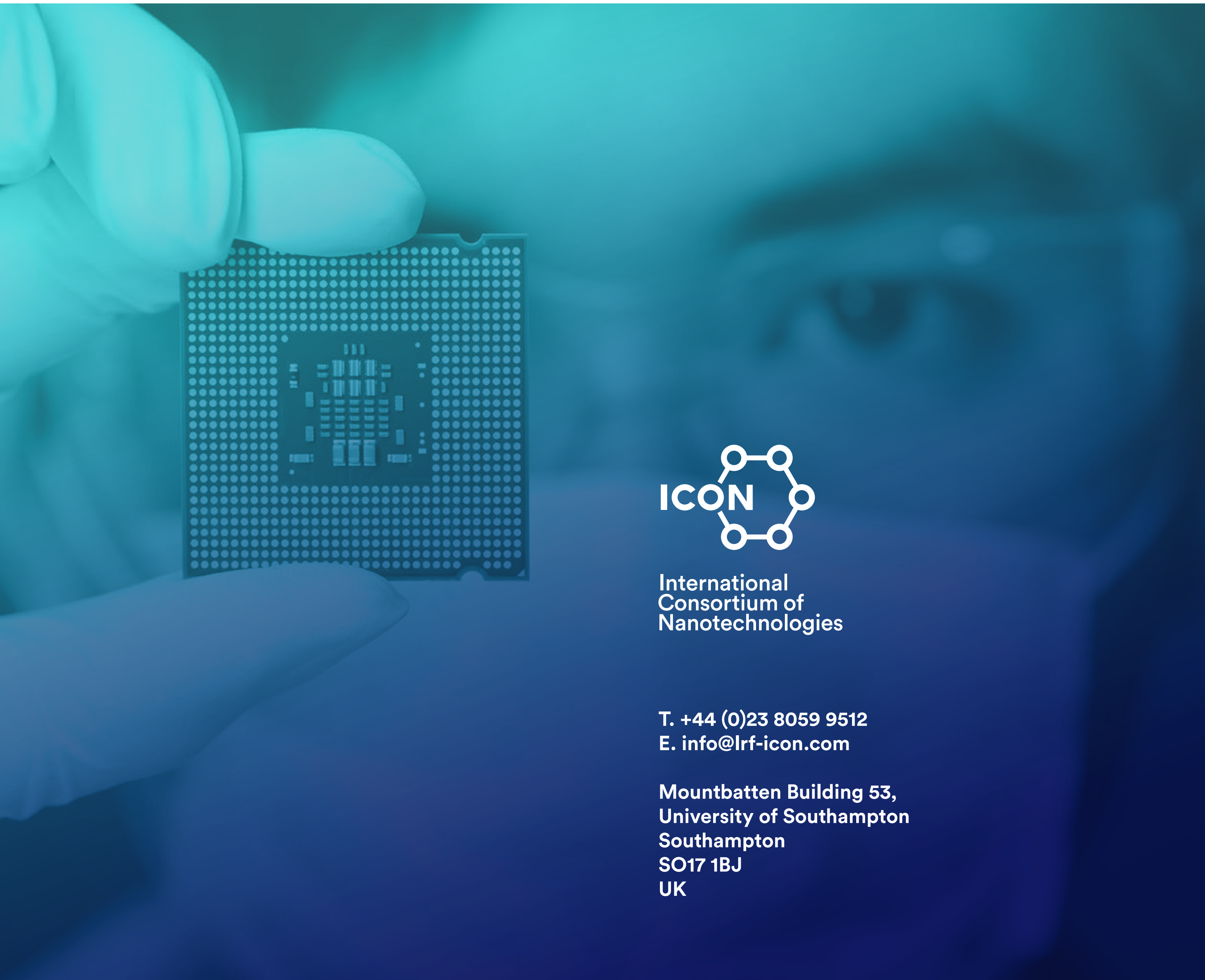
The driving need for a multi-functional Carbon-Fiber-Reinforced-Plastic (CFRP) is to reduce the overall weight of the craft, increase the payload, reduce the fuel consumption, increase thermal conductivity for heat dissipation and protect the craft from radiation, EMI, and corrosion. The objective of this project is to develop two types of technologies for improving the CFRP.

SM | Smart Materials

INDUSTRIAL PARTNER: STELIA North America

Review 2017

www.lrf-icon.com



ICON

International Consortium of Nanotechnologies

T. +44 (0)23 8059 9512
E. info@lrf-icon.com

Mountbatten Building 53,
University of Southampton
Southampton
SO17 1BJ
UK