Institution: 10007857 Bangor University

Unit of Assessment: 13, Electrical and Electronic Engineering, Metallurgy and Materials

a. Overview

Research in Bangor University, Electronic Engineering (BUEE) is structured in two groups - Organic & Bio Electronics (OBE) and Optical Devices & Systems (ODS). The research themes pursued within these groups are:
OBE: Organic Electronics (Kettle, Mabrook, Taylor); Smart Materials (Campo); Micro-system Technology and Bio-electromagnetism (Palego); Medical Microwaves (Hancock);
ODS: Photonics Devices (Chen, Hong, Spencer, Shore); Optical Communication Systems (Giddings, Tang); Nano-optics (Nezhad, Wang)
A cross-cutting theme of 'Green Electronics' has been promoted via new staff appointments in 2012 of Campo, Chen, Giddings, Wang and in 2013 of Hong, Palego and Nezhad.

b. Research strategy

Vision and Strategic Plans: BUEE undertakes locally-responsive but globally significant research activity having industrial and societal impact. The long-term goal of the research is to improve quality of life by enhancing the economy, improving the environment and raising standards of healthcare. In practice this involves deploying organic electronics and photonics technologies to assist the growth of high-value industry and simultaneously to help create a low-carbon economy. Here work in organic photo-voltaics, nano-optics and advanced optical communications will figure prominently. BUEE has a strong track record in bioelectronics and will add to that activity with inter-disciplinary research on sensors and actuators for agricultural, bio-science and bio-medical use as well as therapeutic applications of microwaves.
The global significance of the research is enabled through productive international collaborations in Europe, the Americas and the Pacific Rim. Established collaborations in Australia and Argentina (**Shore**); Brazil and Portugal (**Taylor**); China and Europe (**Tang**) have been enhanced through the activities of new staff including **Campo** from U. Pennsylvania; **Palego** from Lehigh, PA and **Nezhad** from UC San Diego/Aachen University who will strengthen collaborations both in North America and Europe.
BUEE is committed to delivering strategic, scientific and technical support to stimulate the regional economy. The thrust for the University investment in new staff was to enable the School to build on existing research themes in photonics and organic electronics to play a strong international and regional role in the development of low-carbon electronics. The twin drivers for the investment relate to global awareness of requirements for reducing carbon emissions and regional developments pursued by the Welsh Government and local partnerships in promoting the concept of nearby Anglesey as an 'energy island'. Anglesey has a broad range of renewable energy sources including on-shore and off-shore wind turbine farms and has potential for tidal and solar power. (A major pump-storage hydro-electricity power station in Llanberis near Bangor adds to the local renewable generation capabilities). **Spencer** is closely engaged with plans for an £8 billion Hitachi-led investment in renewing nuclear power generation capacity on Anglesey by 2020 and is a member of the Skills and Training Steering Committee which is charged with coordinating local educational engagement through to PhD level. In the shorter term, **Spencer** is contributing to the utilisation of the £10M Welsh Government investment in a Bangor University-led Science Park, due for completion in 2014, which will provide a bespoke environment for exploiting university research. **Spencer** is also strongly engaged in the establishment by the university of the £46M Arts and Innovation Centre 'Pontio' which is due to open in May 2014. Within Pontio significant investment will be made in 3D digital printing and digital scanning which will be allied to BUEE expertise in laser micro-machining, polymeric device fabrication and material characterisation. BUEE is establishing an 'Innovation Quarter' to facilitate the development of large inter-disciplinary research projects, as well as providing incubation space to seed activity for the Science Park.
Implementation of the research strategy will be further enhanced via engagement in the Swansea

University-led Advanced Engineering and Materials, National Research Network (NRN) supported by the £50M Welsh Government 'Ser Cymru' / Wales Stars programme (2013-2018). BUEE's **Nezhad** will lead the NRN Devices and Sensors theme. The NRN will support collaborative PhD projects involving industry and HEIs in Wales.

Progress since 2008: In 2008 an incremental growth in activity was envisaged wherein specific themes in photonics and organic electronics would be promoted. The actual development in activity was given a major stimulus by the recruitment of new staff in 2011 and 2013 to pursue a research theme of 'Green Electronics' in both research groups. These appointments brought new capabilities in smart materials, MEMS technology, nano-optics and nano-lasers. The new staff appointments will ensure that the research themes can be addressed over a substantial period.

As envisaged in 2008 work on nonlinear and chaotic dynamics in semiconductor laser devices has been pursed vigorously, including collaborations in the Americas, Europe and the Pacific Rim, with nascent applications in random number generation and optical logic subsequently emerging. Particular success has been achieved in the design of nano-scale laser devices suitable for inclusion in lab-on-a-chip devices. This latter activity was begun by **Shore** in Japan and has been developed in collaboration with Sandia National Laboratories in the US and with Swansea University. The recruitment of **Nezhad** in 2013 provides a route to practical implementation of nano-lasers.

The optical communications activity led by **Tang** works closely with telecommunication companies, research institutions, universities and Standards bodies, to conduct research and exploit cost-effective, high-speed, flexible, 'future-proof', secure and 'green' technology to satisfy the fast growing broadband requirements of end-users. In the REF period, activity has focused on research in optical orthogonal frequency division multiplexing (OOFDM) for next generation optical access networks. OOFDM was proposed by Bangor in 2005 and has become a highly active area of research. The group experimentally demonstrated a series of ground-breaking end-to-end real-time OOFDM transceivers at record-high speeds of 20Gb/s with product-like functionalities. Fruitful, world-wide collaborations have also been undertaken with telecommunication equipment vendors, service providers, component manufacturers, research institutes and universities. Having successfully completed the €12M EU project ALPHA, **Tang** co-ordinates the €6M project OCEAN with major telecommunication players such as Fujitsu and Finisar. As well as generating some 200 publications, the group has filed 8 patents. Commercialisation of OOFDM technology via the Smarter Light spin-off is described in an Impact Case Study.

The commercialization of lab-on-a-chip technology via the spin-out company LML, where Burt remains seconded, is a continuing success. This is described in an accompanying Impact Case Study. A second commercial enterprise led by Pethig did not prosper in the way envisaged in 2008. With Pethig's departure from the School at normal retirement age, connection with this activity was lost. Similarly the international head hunting of Lawrence and John curtailed planned growth in their particular areas. However, the replacement appointments of **Kettle** and **Mabrook** brought new vigour and expertise in photo-voltaics and carbon-based electronics. The appointment of Perepichka to the chair of synthetic organic chemistry in the School of Chemistry at Bangor during the REF period has complemented these developments.

During the present period **Taylor** took partial retirement but has maintained a strong fundamental research focus – emerging from his studies of organic interfaces he was the first to report an organic version of the charge injection device, the forerunner of the ubiquitous CCD, while simultaneously expanding industry-facing activity in plastic electronics via a collaborative Innovative electronic-Manufacturing Research Centre (IeMRC) Flagship grant, with Oxford, Manchester and Leeds Universities and sKTP and KTP projects with SmartKem Ltd, an SME developing high performance organic semiconducting inks for the Plastic Electronics Industry. **Taylor** has also played an important role in mentoring new staff in the OBE group.

A significant sub-theme of activity has been the pursuit of pedagogical research with specific emphasis in photonics. **Shore** led the establishment of the Photonics Academy (PA) of Wales in 2005 under the auspices of the Welsh Optoelectronics Forum and has chaired the PA since its inception. In 2011 BUEE provided a base for the Photonics Academy of Wales@ Bangor (PAWB) which has rapidly established itself as the main focus of PA activity. PAWB has gained support to enable it to vigorously pursue the development of educational and training techniques which has been delivered in local, national and international academic and industrial contexts. The work has

been disseminated through presentations at the 2009 and 2013 IEEE/OSA/SPIE Education and Training in Optics and Photonics (ETOP) conferences. Having contributed to the development of the EPS Manifesto for the UN Declaration of 2015 as 'The Year of Light', PAWB plans to engage strongly with this initiative. A further boost to outreach activities has been given by **Campo** who was the lead organizer of the Education Symposium at the Materials Research Society (MRS) Spring 2013 'Towards a Lab to Classroom Initiative' and is an advisor to the 'Strange Matter Green Earth' consortium of the MRS Education and Outreach Department.

c. People, including:

i. Staffing strategy and staff development

Research and Infrastructure The underlying theme of staffing strategy has been the recruitment and development of rounded academics who recognise opportunities in research, teaching and third mission activities. A conscious effort has been made to sustain critical masses in the two research groups whilst simultaneously developing the cross-cutting 'Green Electronics' theme. Those themes are supported by key experimental facilities (detailed in **d.** below). Ensuring the continued availability of technical staff to enable efficient functioning of this range of facilities has been a major staffing success. Here a former contract researcher **Hong** was first appointed to a permanent research position with responsibility for the surface analysis laboratory and then appointed to the academic staff. Similarly the clean room facility is managed by a permanent research officer. In recent staff recruitment, care was taken to effect an alignment of appointees with the defined physical infrastructure. **Kettle** and **Mabrook** make extensive use of clean room facilities. Surface analysis facilities underpin activities of **Campo**, **Nezhad** and **Pelago**; laser micro-machining capabilities support the work of **Chen** and **Wang**. **Giddings** utilises optical communications system test equipment. **Hong** uses photonic device characterisation facilities. Additional specialist equipment has also been provided including a solar test bed for **Kettle**.

Career Development In the REF period 8 new staff appointments were made and, in order to provide adequate time to kick-start their research, new appointees are excused all teaching duties during their first year and a phased increase in subsequent years. Start-up funding totalling £250k has been provided to new appointees who have also been provided with assistance to secure PhD studentships. New appointees have also been supported to make research trips, attend international conferences and host overseas researchers for extended periods. **Chen** was funded to gain laser micromachining experience at LML. New appointees are assigned a mentor who advises on opportunities to gain external support including industry-facing funding streams. Following mentoring advice both **Kettle** and **Chen** gained Royal Society Research Grant support for equipment purchases and **Kettle** gained funding for CLARET. **Kettle** and **Mabrook** have engaged with the Welsh Crucible which aims to identify future research leaders by the promotion of inter-disciplinary research.

Established staff gain CPD principally via national and international conferences and meetings or institutional provision. **Spencer** as Head of School, Dean of College, and Member of the University Executive has taken advantage of university CPD opportunities including training on leadership, safety and insurance. **Shore** had leave of absence to work in Japan in 2010. Facilities support for Professors Emeritus **Lewis** and **Last** enables their continued contributions to both research and professional services. (**Lewis**, in his 90th year, made a significant contribution to understanding electrical conduction in polyethylene: J.App.Phys,**113**, 223705,2013.)

Concordat The University has a Concordat and Researcher Development Group that oversees researcher development and addresses the standards of the Concordat to ensure that researchers are effectively supported in the University. The University has achieved the European Commission's HR Excellence in Research which acknowledges the University's alignment with the principles of the European Charter for Researchers and Code of Conduct for their Recruitment.

Personal Fellowships: Tang Royal Society Brian Mercer Award (2008); **Shore** Invitation Fellowship, Japan Society for the Promotion of Science (JSPS) for a 5 month visit to the Nara Institute of Science and Technology (NAIST) in 2010 to initiate work on nano-lasers.

International Staff Appointments: Incoming visitors were hosted by: **Shore** Prof. T. Sahu, Berhampur, India, Commonwealth Fellowship (2009-10); **Taylor**: Productive collaborations with Brazil in which senior staff (Profs. J Giacometti and N Alves), a PDRA and 2 PhD students have

spent periods up to 12 months in the OBE Group. Dr M Ibrahim from the National Center for Radiation Research and Technology, Egypt, spent 12 months with the group (all leading to joint publications). **Tang**: Prof. K. Qiu, School of Communication and Information Engineering, University of Electronic Science and Technology of China (UESTC), Chengdu, China, 2008. Dr A. Hamié, Computer & Communication Department, Arts, Sciences & Technology University in Lebanon (AUL), Beirut, Lebanon, 2008 and 2009; Dr Gunnar Jacobsen, CTO of Broadband Communications Centre, Acreo AB, Sweden, 2009; Dr Evgeny Vanin, Acreo AB, Sweden, 2009; Dr Christian Sanchez Costa, Universidad Politécnica de Valencia, Camino de Vera, 46022 Valencia, Spain 2010 and 2011; Prof. Chang Shu, (UESTC), Chengdu, China, August 2010-August 2011; Mr Luiz Anet Neto, French Telecom R&D Division, Lannion, France, 2010; Prof. Baojian Wu, UESTC, Chengdu, China, Jan-April, 2010; Prof. Christelle Aupetit-Berthelemot, National Superior Engineering School of Limoges (ENSIL) France, 2011.
Outgoing staff appointments include: **Palego** Adjunct Professor, Lehigh, PA, USA; **Tang**: Visiting Professor University of Electronic Science and Technology of China (UESTC), Chengdu, China; **Wang**: Visiting Fellow, Data Storage Institute, Singapore, Spring 2013.
Diversity Bangor University is a signatory to the Athena SWAN Charter and gained the Bronze University Award in November 2011. With a prime driver of increasing the quality of its staff, BUEE has actively broadened its recruitment horizons and thereby diversify its staff. The success of the approach is exemplified by recent recruitment which has resulted in 16% of this REF return being female (sector average 13%) and 40% being non-European (sector average 15%). **Shore** is a member of the University Athena SWAN advisory group.

ii. Research students

Research Student Recruitment and support of research students is effected by a number of mechanisms. 4 PhD students have been funded by the University's '125th Anniversary Scholarship' scheme. PhD student support has also been gained from Y Coleg Cymraeg Cenedlaethol (the pan-Wales Welsh-medium virtual HE institution funded by the Welsh Government). PGRs have also been recruited through the Bangor-led pan-Wales ESF-funded 'Knowledge Economy Skills Scholarships (KESS)' scheme. In the latter case, emphasis has been given to supporting studentships for newly appointed staff members. International PGRs normally are government-supported including the Brazil 'Science without Borders' programme.
Student Support PGRs have access to a broad spectrum of training provided by the University including tHE courses for those engaged in laboratory supervision. Several students have been trained for and undertaken 'International Student Ambassador' roles. Within the Aberystwyth-Bangor CAFMaD collaboration, annual conferences have been organised at which students have made presentations and prepared proceedings papers available on the school web pages. PhD students in Organic Electronics also attended extra-curricular courses at Imperial College's Plastic Electronics Centre (2011-12). PhD students are supported to make presentations at national and international conferences (e.g. CLEO Pacific Rim, EOS, ICOE, ECME, META, MRS). The development of writing skills is emphasised and all students submitting their PhDs are expected to have published at least one journal paper. Students have been supported during 2013 to establish an IEEE Student Branch and an SPIE Student Chapter at Bangor.
Support from the Wynn Humphrey Davies benefaction has enabled PhD students supervised by **Taylor** and **Kettle** to undertake summer research projects at MIT leading to joint papers (e.g. Advanced Materials, 24, 6136-6140, 2012; Optics Express, 17, 329-336, 2009). An active collaboration between **Kettle** and Horie at the National Tsing Hua University allowed a PhD student (Huw Waters) to perform Small- and Wide-angle X-ray Scattering measurements of organic PV material at the National Synchrotron Radiation Research Center, Taiwan. The activities of **Campo** have enabled one of her PhD students (Douglas Winter) to perform experiments at Brookhaven National Laboratory.
Progress Monitoring All PGRs have a graduate committee including a supervisor and a second advisor. Attendance of students at regular progress meetings is recorded via an on-line system and progress monitored at both School and University level. Students involved in industry-linked collaborative projects are also required to make presentations to external advisory boards. The efficacy of these procedures is evidenced by the fact that all students eligible to complete their PhDs during the REF period did so successfully.

d. Income, infrastructure and facilities

Specialist Infrastructure The research of the School is under-pinned by key infra-structure facilities including: an up-graded Class 1000 clean room for organic device fabrication; a surface analysis laboratory for material assessment (including SEM, AFM, FTIR, Raman and SNOM/ NSOM facilities); excimer and femto-second laser micromachining facilities; an electrical characterisation laboratory for both DC and AC measurements for device characterisation; device and systems measurement facilities for photonics and optical communications; mechanical workshop to support experimental measurements.
Investments The provision of a nitrogen glove box and a 4-source organic/metal evaporator within an expanded clean room facility was enabled via a Welsh Government Academic Expertise for Business (A4B) project (2008-9) and has subsequently supported interactions with industry and notably in plastic electronics. A £25k investment in an environmental chamber and a probe station for plastic electronics research also supported KTP activity. Creo Medical Ltd has loaned microwave test and measurement equipment and has also provided mechanical design and manufacture support facilities with a total value ~ £150k.
In late 2013 BUEE received £0.5M Welsh Government A4B funding to establish a 'Centre for Lifetime And Reliability Testing' (CLARET) which will operate as an industry-facing facility specialising in plastic electronic devices. In 2014 BUEE will procure a major precision optics manufacturing and metrology capability for 'Precision Optics Fabrication with Ion-beam Technology' (PROFIT) consequent to a £2M A4B investment in association with Qioptiq and Cranfield University (Paul Shore).
Funding Portfolio RCUK, EU and the Royal Society funding has been utilised to support research in BUEE. Knowledge transfer to industry has been supported using: the pan-Wales ASTUTE advanced manufacturing project; an EU Inter-Reg WIN-IPT programme led by **Kettle**; an ESF Knowledge Transfer Centre in Semiconductors and Photonics with Swansea University with the BUEE input led by **Spencer**. Support for pedagogical research led by **Shore** has been gained from the HEFCE/HEFCW HE-STEM programme and via ESF funds. **Shore** and **Hong's** collaboration with Macquarie University, Australia benefited from a substantial equipment transfer from the University of Helsinki, Finland enabling initiation of research on diode-pumped solid state lasers.
Staff in post in the period 2008-2012 sustained research expenditure averaging over £115k per FTE per annum. With new appointees in 2011-2013 having little time to contribute, the per capita expenditure over the entire REF period is reduced but nevertheless exceeds £95k per FTE per annum. The £2.5M investment in CLARET and PROFIT will provide a strong foundation for research income in the next REF period. In the context of increasing pressure on RCUK budgets, effort will be made to broaden EU and global funding sources. Here several new appointees offer both European and North American connectivity. **Campo** has projects with beam time granted from 2012 to 2015 at the Brookhaven National Synchrotron Light Source, US; **Chen** used Banco Santander travel support to develop the iPhoto-Bio EU project detailed below. **Pelago** has continuing funding of MEMS activity at Lehigh, PA.

Professional Services: **Taylor** and **Last** have provided expert advice in patent and legal cases as well as consultancy advice to UK and US companies and organisations. **Shore** led the HE-STEM 'Capability Matrix for Photonics Up-Skilling' (CAMPUS) project which, in collaboration with the Welsh Optoelectronics Forum, detailed photonics capabilities available to industry within all HEIs in Wales.

e. Collaboration or contribution to the discipline or research base

International Collaborations have been pursued by: **Campo** who is a life-member user at the National Synchrotron Light Source at the Brookhaven National Laboratories, National Synchrotron Light Source, New York; College of Nano Science and Engineering, New York; University of Texas; Institute of Polymers, Slovak Academy of Sciences, Zeiss Microscopy; **Chen** Coordinator EU FP7-PEOPLE-2013-IRSES project iPhoto-Bio with collaborators: University of Valencia (Spain), University of São Paulo (Brazil), Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Science , Shenzhen Institute of Advanced Technology (China)

and Saint Peter's University (USA); **Kettle**: Wales-Ireland Innovative Photovoltaic Technology Project ("WIN-IPT") funded through Interreg IVA. Academic collaborators include the WCPC, Swansea University and Waterford Institute of Technology; Phillips, Eindhoven on development of 3D lithography; material development with TsingHua University and National Taiwan University of Science and Technology, Taiwan; nanolithography with Nikos Kehegias, Institute of Catalan Nanotechnology, Barcelona; new electrode material for OPVs with Centro TecnológicoI TMA, Asturias, Spain; synchrotron grazing-incidence small-/wide-angle X-ray scattering at the National Synchrotron Radiation Research Center, Taiwan; development of 3D nanolithography using Focused Ion Beam with Philips Research, Eindhoven; **Mabrook** with MASDAR Institute, UAE (and Durham) on Carbon Nanotubes; **Nezhad** with Aachen University,Germany and UC San Diego on nano-photonics; **Pelago** MEMS work with Lehigh, PA, USA ; **Shore** and **Hong** with Macquarie University, Sydney, Australia on diode-pumped solid-state lasers and with UPC, Barcelona and Tandil, Argentina on laser diode dynamics. **Taylor**'s expertise was key to explaining results on organic resistive RAMs produced by Philips (Dago de Leewu now at Max Planck in Mainz) and measured by Gomes in Portugal and on n-type fullerene TFTs produced by Bauer and Sariciftci in Linz; Long standing collaborations with Brazil led by Taylor are being sustained via the 'Science without Borders' programme and expanded via Santander support for Kettle. **Tang** and **Giddings** have been engaged in collaborations with industry and academia including France Telecom, BT, Huawei (USA), Fujitsu (UK), ECI (Israel), 3S Photonics (France), Luceat (Italy); Acreo AB (Sweden); Universidad Politécnica de Valencia; Athens Information Technology (AIT); University College Cork; Dublin City University and the University of Essex; **Wang** has worked on nanoscope and nano-optics computing at the Data Storage Institute and National University of Singapore.

National Collaborations: **Campo** with the Cavendish, Cambridge (Eugene Terentjev and Shery Huang); **Chen** Institute of Photonic Technologies, Aston University; **Kettle** with the Welsh Coating and Printing Centre (WCPC) – 'Welsh Intelligent Polymer Processing Consortium for Functional Applications (WIP2C)'; Manchester/Imperial College on organic semiconductor material testing; Cardiff on nanolithography; **Taylor**: TSB project (CHBS/004/00091C) with Oxford University, GVE, Scott-Bader and CAMVAC which led to an IeMRC Flagship Grant with Oxford, Manchester and Leeds Universities for which the TSB industrial partners and Silvaco act as an Advisory Board; long term collaboration with SmartKem through sKTP, KTP and ASTUTE programmes; organic CCDs research (EPSRC grant EP/J021857/1) is supplemented by a Science without Borders PhD student and CASE-like funding from Merck. **Spencer** and **Shore**: the pan-Wales ASTUTE advanced manufacturing project (2010-2015); **Wang**: Liverpool (Ken Watkins on laser micro/nano-processing; National Physical Laboratory, UK (Richard Leigh) on nanoscope development. View Holographics Ltd, on lighting solutions for holography;

Interdisciplinary research is exemplified by the FP7 EU-NMP 22896 Nano-optical Mechanical Systems (NOMS) project in which **Campo** and collaborators combined computer science and nano-engineering to enhance Braille capabilities using tactile screens that enable the visually impaired to read complex representations including graphical images using devices which may be incorporated in ATMs and mobile phones. **Chen** is using integrated photonics technologies for advanced biosensing and biomedical applications. **Kettle** works with Aberystwyth (IBERS) and Swansea (MNC) with Welsh Crucible funding (2013) on sensors for the agricultural industry (ARMed). Medical microwaves research led by **Hancock** is directed towards products and services in the healthcare sector. **Taylor**'s IeMRC Flagship Grant is a collaboration with chemists (Leeds and Manchester) and materials scientists (Oxford). Inter-institutional interdisciplinary collaboration between Bangor and Aberystwyth was enabled by HEFCW support of the Centre for Advanced Functional Materials and Devices (CAFMaD) (2006-2011) which brought together research in physics, chemistry and electronic engineering and notably in organic electronics by **Kettle, Mabrook** and **Taylor**.

Influence of research users on research activity is seen in organic electronics where TSB-supported industrial collaboration and exposure to the organic TFT specifications aimed for by leading Asian electronics manufacturers via sKTP, KTP and Go Wales programmes with Smartkem, led to an expansion of **Taylor**'s research interests from fundamental studies of interfaces to the development of production routes to organic circuits (IeMRC Flagship grant)

where solving interconnect problems is relevant to CCD research EPSRC grant (EP/J021857/10). **Kettle** is developing sensors for the agricultural industry using specifications provided by IBERS, Aberystwyth. **Tang** and **Giddings'** work in Optical Communications has been rapidly developed through strong industrial synergies. Engagement with photonics research users is effected regionally via the Welsh Optoelectronics Forum and includes interactions with Welsh Government. Those interactions led to the development of links with Qioptiq and Cranfield University which provided the impetus for the development of the precision optics facility 'PROFIT' being led by **Shore**. Research user interactions will be accentuated by engagement in the Anglesey 'Energy Island' initiative, the University Science Park and the National Research Networks of the Welsh Government 'Sêr Cymru' project.

Leadership roles have been effected through:

Advisory Boards: **Campo** Chair of SPIE Senior member Subcommittee (2013-2015); MRS Green Strange matter Adviser – examining how material science is responding to the global demand for sustainable development; **Palego** IEEE Microwave Theory and Technique Committee 10, Biological effects and medical applications of RF and microwaves. **Shore** Advisory Board Member of the Australian Research Council Link project between Macquarie University, Sydney, Australia and ARQ Indigo R+D Pty Ltd, Sydney, NSW, Australia (2010-12); Welsh Optoelectronics Forum Steering Committee (2008-2015); Council member of the Learned Society of Wales (2012-2015). **Taylor** External Advisory Board member for Imperial College's Centre for Doctoral Training and Plastic Electronics Centre (2009-2014) and the Cambridge-led EPSRC Centre for Innovative Manufacturing in Large-Area Electronics (2013-2015); the Center for Electronics, Optoelectronics and Telecomms, Algarve University, Portugal; local organiser and programme committee member for IOP International Conference Electrostatics 2011; Member IoP Static Electrification Group Committee. **Spencer** Energy Island Research Committee, Skills and Training Steering Group.

Industry and Commerce: **Shore** Chair of the Photonics Academy for Wales; **Tang** Coordinator the EC FP7 PIANO+ project 'OCEAN'.

Learned Societies: **Shore**: Chair Quantum Electronics Commission, International Union of Pure and Applied Physics (2008-2011)

Conference chairs and Keynote Lectures by **Campo** Chair Organizer of the 1st international conference on Nano-Opto-Mechanical Systems (NOMS), SPIE, San Diego 2011; Co-chair, SPIE Nano-engineering (OP111),San Diego, August 2013; MRS Spring 2013 Education Symposium 'Towards a Lab-to-classroom Initiative' (with $15k NSF funding); **Shore** Chair 2009 IEEE/ SPIE/ OSA conference on Education and Training in Optics and Photonics (ETOP 2009) Technium OpTIC, Wales; **Shore** Chair Annual SIOE Conference Cardiff, 2008-2012; **Tang** Co-Chair of the Technical Programme Committee for International Conference on Communications, Circuits and Systems 2009, San Jose, CA, USA; Co-Chair of the Technical Programme Committee for International Conference on Communications, Circuits and Systems 2010, Chengdu, China; **Taylor** Keynote talks at the Brazilian Physical Society conference Águas de Lindóia, May 2010; Brazilian MRS meeting,Sept 2011 and Int Conf on Adv.Materials and Devices, Korea Dec 2013.

Learned Society Membership: Shore Fellow of the Learned Society of Wales (2010); **Tang**: Fellow the ERA Foundation (2008); **Journal editorships**: **Taylor** Proceedings Editor for the IoP International Conference on Electrostatics (Electrostatics 2011). **Shore** Proceedings Editor for ETOP 2009.

Awards and prizes*:* **Campo** featured in the 2012-2013 SPIE 'Women in Optics' 18-month planner for her work with under-served populations in Puerto Rico and Pennsylvania; **Last** 2010 Harold Spencer-Jones Gold Medal of the Royal Institution of Navigation; **Wang**: 1st prize in nano-engineering poster competition, Royal Academy of Engineering Regional Lecture and Early Career Researcher Engineering Showcase 2011; in 2011 White-light Nanoscope work was highlighted by RCUK as one of the '50 big ideas for the future'. In 2011 **Kettle** was shortlisted for the 'Global Nano Innovation Contest' by the Industrial Technology Research Institute, Taiwan.

Other Contributions included refereeing for NSF (**Wang**), NSERC Canada and Science Foundation Ireland (**Taylor),** CONICYT Chile and FWO Belgium **(Shore)**, EU (**Tang** and **Taylor**).