Progress Details

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The JRI in ECPS has developed increased research capability and research capacity in a number of research segments launched within the first phase of the initiative. Progress has been summarised in terms of joint research activities between the partners but and increased capacity through secured funding, the number of researchers working through the activities and published material. This includes the outputs of joint research activities within the SRPe and other pools such as WestChem.

Renewable Energy Technologies

Infield, Dysko, Brown (SU)

Knox, Acha, Cossar, Montecucco (RA), Buckle (RA), Campobasso (GU)

Sustainable Energy

Research activity within sustainable technologies has grown quickly, particularly in the wind energy sector, and the area of distributed generation resources (DERs). An outdoor photovoltaic test facility has been constructed and instrumented, including a spectro-radiometer to measure the solar spectrum on a regular basis. During 2010 the outdoor facility was extended to include insulated test cells for the assessment of solar glazing materials.

A new battery test facility was installed in the DSM Laboratory in 2010 that allows discharging of batteries back into the power network in a V2G mode.

A wind energy systems doctoral training centre (DTC) has been established and 21 students now in place. Links have been established with Dr Sergio Campobasso of Glasgow University who will be supporting the DTC in the area of wind turbine aerodynamics with opportunities for co-supervision of DTC students. There has been continuing growth in research funding for wind energy and demand side management (DSM), and in particular the potential of electric vehicles to contribute to DSM and the integration of high penetrations of wind.

Thermo-electrics for heat pumping (Peltier effect) and energy scavenging (Seebeck Effect), and Stirling engines for improved thermal conversion efficiency are new areas of research in Prof Knox's group, also at Glasgow. In addition to basic research work on devices, mathematical characterisation and performance validation applied research on their use is also in progress. A project in conjunction with Doosan Power Systems has been funded (DTA, CASE award from ETP and an undisclosed sum from Doosan) for application of both to Carbon Capture and Storage equipped thermal power stations. Work on optimum and learning-based MPPT algorithms for Solar PV systems continues.

Power System Protection

The main focus in this review period was to continue the development of the research portfolio in power system protection.

A doctoral Training Grant has been submitted and subsequently awarded for one PhD student to undertake research on “Communication of system wide quantities using emerging communications technologies to enhance the stability of DG during grid system disturbances”. A candidate is still to be recruited.

Two previously established R&D projects with TOSHIBA have been extended for another year. The first project concerns optical measuring techniques in power system protection. In the review period the project developed a working laboratory demonstrator of a distance protection scheme based on the optical current measurement technique. The second project investigates advanced fault location techniques in power system protection. In the past year the project explored various DSP techniques for extraction of fundamental frequency phasors from sub-cycle duration waveforms.

A specialised laboratory environment has been established at Strathclyde where new protection and control strategies as well as prototype devices can be assessed within the context of power networks, both in through software and hardware real-time simulation. The facility is being continually enhanced and upgraded.

The JRI in ECPS has developed increased research capability and research capacity in a number of research segments launched within the first phase of the initiative. Progress has been summarised in terms of joint research activities between the partners but and increased capacity through secured funding, the number of researchers working through the activities and published material. This includes the outputs of joint research activities within the SRPe and other pools such as WestChem.

Researchers Funded or Leveraged by GRPe

1. Ibrahim Abdulhadi
2. Xinyao Li
3. Maria Carla Vincenzo
4. Sikai Huang
5. Wu Lei
6. Akram Dandu

7. Tobias Erhart
8. Adrianti
9. Liam MacIsaac
10. Jeremiah Matthey
11. Craig Clanachan
12. Jonathan Siviter

Funding

1. EPSRC Doctoral Training Centre (DTC) "Wind Energy Systems" £5.7M
2. EPSRC "HiDEF SuperGen consortium" £4M
3. EPSRC UK/India STAPP collaboration in PV systems £270k
4. DTD Grant - "Communication of system wide quantities using emerging communications technologies to enhance the stability of DG during grid system disturbances" £61k
5. Scottish Energy Research Academy, "Evaluation of the performance of Thermoelectric Modules for Energy Scavenging." £25K
6. TOSHIBA funded projects:
    a. "Feasibility Study of Distributed Optical Distance Protection" £36k
    b. "Improving Fault Location by Analysing Electrical Parameters During Circuit Breaker Operation" £36k

Applications for Funding

1. Power Network Research Academy (PNRA) "Communication of System Wide Quantities using Emerging Communications Technologies to Enhance the Stability of DG during Grid System Disturbances." £105k
2. Scottish Funding Council, "Securing and Diversifying Sustainable Energy Supplies." £1.2M
3. EPSRC "Community-scale Sustainable Energy Provision" £1.6M

Publications

Journals

1. A. Dyśko, W.E. Leithead, J. O'Reilly, "Enhanced Power System Stability by Coordinated PSS Design", IEEE Transactions on Power Systems, Vol. 25, No 1, pp. 413 – 422, February 2010. (DOI: 10.1109/TPWRS.2009.2036704).
2. A. Zaher , S.D.J. McArthur , D.G. Infield , and Y. Patel, "Online wind turbine fault detection through automated SCADA data analysis", Wind Energy**,** Volume 12 No. 6, pp574 – 593, 2009
3. L. Mei, D.G. Infield, R. Gottschalg, D.L. Loveday, D. Davies and M. Berry; "Equilibrium thermal characteristics of a building integrated photovoltaic tiled roof", Solar Energy, Volume 83, Issue 10, October 2009, pp 1893-1901
4. D.G. Infield, "An overview of renewable energy technologies with a view to stand alone power generation and water provision", Desalination, Vol. 252 (2010), pp 77–82.
5. J. Zhang, A. Dyśko, W.E. Leithead, and J. O'Reilly, "Trade-offs in Transient Stability and Oscillation Stability in Wind Power Systems" – submitted to IEEE Transactions on Power Systems.
6. L/MacIsaac, A Knox, "Learning-Based Maximum Power Point Tracking for Photovoltaic Systems" - submitted to IEEE Transactions on Power Electronics
7. A. Dyśko, J. Zhang, W.E. Leithead, and J. O'Reilly, "SVC Transient Stability and Oscillation Stability in Co-generation Systems" – to be submitted to IEEE Transactions on Power Delivery.
8. I. Abdulhadi, F. Coffele, C. Booth, A. Dyśko, G. Burt, S. Le Blond, R. Aggarwal, "Adaptive Power System Protection: Drivers, Challenges and the need for Flexible Solutions and Approaches" – to be submitted to IEEE Transactions on Power Delivery.

Invited Conferences

9. D. Infield, Chinese Association of Science and Technology (CAST) Annual Meeting, Chongqing, China, September 2009
10. D. Infield, Invited REN lecture on Wind Integration, Lisbon, May 18th 2010
11. D. Infield, invited paper for POLYCITY conference, Stuttgart, September 2010: "Decentralised electricity generation and demand side management opportunities in the urban environment".
12. A. Dyśko, "Preferential subject 2 – Impact of renewable generation and cogeneration on substation automation and protection" - special report and general report prepared for the Study Committee B5 (Protection and Automation) – Paris Cigre Session , August 2010.

Conferences

13. M.C. Di Vincenzo and D. Infield**;** Maximum Power Point Tracking Under

Realistic Operating Conditions; CISBAT 2009, Lausanne, September 2009.
14. L. MacIsaac and A Knox; Improved Maximum Power Point Tracking Algorithm for Photovoltaic Systems; ICREPQ'10, Granada, March, 2010
15. D. Hill, D.McMillan, K. Bell, D. Infield, G.W. Ault; Application of Statistical Wind Models for System Impacts, UPEC09, Glasgow, September, 2009.
16. S. Huang and D.G.Infield; The Potential of Domestic Electric Vehicles to Contribute to Power System Operation through Vehicle to Grid Technology, UPEC09, Glasgow, September 2009.
17. Ian Richardson, Murray Thomson, David Infield, and Alice Delahunty; A Modelling Framework for the Study of Highly Distributed Power Systems and Demand Side Management; UK-China Sustainable Energy Conference, Nanjing, 2009.
18. Xiaotao Zhong, Andrew Cruden, David Infield, Piotr Holik, Sikai Huang; Assessment of Vehicle to Grid Power as Power System Support; , UPEC09, Glasgow, September, 2009.
19. Ian Richardson, Graeme Hodgson, Murray Thomson, David Infield and Alice Delahunty; "Simulation of high-resolution domestic electricity demand based on a building occupancy model and its applicability to the study of demand side management; EEDAL, 2009.
20. P. Orr, P. Niewczas, A. Dyśko, C. Booth, "FBG-Based Fibre-Optic Current Sensors for Power Systems Protection: Laboratory Evaluation", Proceedings of the 44th International Universities' Power Engineering Conference, Glasgow, UK, September 2009.
21. A. Dyśko, C. Booth, G. Burt, H.T. Yip, "Simulation Based Testing Methodology for LOM Protection Performance Assessment", abstract accepted to the 10th International Conference on Developments in Power System Protection – DPSP 2010
22. H.T. Yip, G. Millar, G. J. Lloyd, A. Dyśko, G.M. Burt, R. Tumilty, "Islanding Detection using an Accumulated Phase Angle Drift Measurement" abstract accepted to the DPSP 2010.
23. F.Coffele, C. Booth, A. Dyśko, T. Spearing, "Centralised Loss-Of-Mains Protection using IEC 61850" abstract accepted to the DPSP 2010.
24. Dilay Kesten, Maria Carla Di Vincenzo Aysegul Tereci, Tobias Shulze, Jerko Labus, Meltem Bayraktar, Ivan Korolija, Rafal Strzalka, Julie Ann Futcher; What are the features of an Urban Energy Management tool:
Analysis and Optimization Tools for building and plant performance. IAQVEC 2010 the 7th International Conference on Indoor Air Quality, Ventilation and Energy Conservation in Buildings, August, 2010.
25. Dilay Kesten, Maria Carla Di Vincenzo, David Infield; Assessment of performance of building shading device with integrated photovoltaics in different urban scenarios. 5th ENERGY FORUM on solar building skins – 2-3 December 2010, Bressanone, Italy.
26. I.F. Abdulhadi, G.M. Burt, A. Dyśko, R. Zhang, J. Fitch, "The Evaluation of Distance Protection Performance in The Presence of Quadrature Boosters in Support of a Coordinated Control Strategy", 10th International Conference on Developments in Power System Protection, Manchester – UK, published electronically, March 2010
27. A. Dyśko, C. Booth, G. Burt, H.T. Yip, "Testing Methodology for LOM

Protection Performance Assessment", 10th International Conference on Developments in Power System Protection, Manchester – UK, published electronically, March 2010
28. H.T. Yip, G. Millar, G. J. Lloyd, A. Dyśko, G.M. Burt, R. Tumilty, "Islanding Detection Using an Accumulated Phase Angle Drift Measurement", 10th International Conference on Developments in Power System Protection, Manchester – UK, published electronically, March 2010.
29. F. Coffele, P. Moore, C. Booth, A. Dyśko, G. Burt, T. Spearing, P. Dolan, "Centralised Loss of Mains Protection Using IEC-61850", 10th International Conference on Developments in Power System Protection, Manchester – UK, published electronically, March 2010.
30. J.A. González, A. Dyśko, G. Lloyd, "The impact of renewable energy sources and distributed generation on substation protection and automation" – Study Committee B5 session (Protection and Automation), Paris 2010.
31. H.T. Yip, G.Lloyd, A. Dyśko, G.M. Burt, R.M. Tumilty, "Islanding Detection Using an Accumulated Phase Angle Drift Measurement" – Study Committee B5 session (Protection and Automation), Paris 2010

Advanced Optical Networking

Glesk, Michie, Andonovic (SU)

Kelly, Sorel, Ironside (GU)

McMeekin (GCU)

This research has demonstrated advanced optical transmission between laboratories at Strathclyde and Glasgow through the dark optical fibre connection across the city. Advanced modulation schemes based on optical code division principles have been implemented and transmitted through installed optical fibre. Components have been specified and produced at Glasgow have been developed for the test. Based on international collaboration with OKI, the influence of chromatic dispersion on ultrafast coded optical transmission was studied. In order to develop new expertise, an International collaboration with National Research Council of Canada in the area of sub-wavelength and nano-wires structures was established. The CIDCOM laboratory capabilities were enhanced in the area of ultra-fast all-optical signal processing.

In parallel a number of Passive Optical Networks (PON) system characterisations have been executed. Semiconductor optical amplifiers (SOAs) have been core in this respect and the GRPe has continued to concentrate on SOA design, optimisation of the design for manufacture, analysis of the performance of the SOA within specific network configurations and experimental demonstration and validation of the analysis. The work has now moved on to consider wavelength agnostic WDM architectures for PONs with the objective of modifying the design of RSOAs for material systems that may support

un-cooled operation.

Novel SOA devices providing the capability to adjust gain without compromising linearity have been demonstrated and published through the GRPe; we have also bid unsuccessfully to EPSRC to support this work. A bid into an EU programme (JePPIX) was however successful and will fund the fabrication of these novel device structures. Understanding the dynamic behaviour of these devices has significantly improved over the past year through a combination of analytical modelling supported by experimental analysis. The work has targeted dynamic packet strength equalisation where we have demonstrated nanosecond gain adjustment and stabilisation times, well within the 26ns guard band required for signal equalisation in PONs.

Researchers Funded or Leveraged by GRPe

1. Mohd Nazri Mohd Warip; "Towards Green Photonic Networks"
2. Siti Idris-Othman; "Semiconductor Optical Amplifiers for Optical Processing"
3. Lin Liu; 'Optical Devices and Systems; Semiconductor Optical Amplifiers for PON Systems'.
4. Yaqoob Hammad; **'**Integration of WiMax and PON'
5. Alan Proudfoot, Eng D BAe; 'Next Generation Optical Communications Platform for Airbus'
6. Eoin Murphy, Eng D BAe, 'Wavelength Agnostic WDM Strategies for Avionic Telecommunications'
7. Siti Idris-Othman; "Semiconductor Optical Amplifiers for Optical Processing"
8. Tolulope Osodola: "All optical Signal processing"
9. Vincenzo Pusino: "Novel SOA based Devices"

Funding

1. "Strathclyde - OKI Test-bed for joint OCDMA and ultrafast OTDMA activities" to establish joint research activities with OKI Ltd Japan £35k
2. JePPIX participation call Adjustable Gain Clamped SOA (AGC-SOA) €120k
3. EU Marie Curie/People Fellowship
€100k

Applications for Funding (Unsuccessful)

1. Piano $^{+}$ Application – 'LOw Cost COMponents for WDM-PON networks' application withdrawn at last minute due to partner leaving consortium €3M
2. Piano $^{+}$ Application, invited to 2nd round but application withdrawn budgetary

issues of our German partner €2.5M
3. Innovation for Mega Information Communication (iMIC), a multinational proposal of European partners in response to EU call KICS-2009, multi-million
4. The Leverhulme Trust –"Multidisciplinary International Network of excellence in Advanced Communications." Partners: Princeton University, Osaka University, Shanghai Jiao Tong University, NEC Research Labs America, National Research Council Institute for Microstructural Sciences, Canada, Heriot-Watt and Strathclyde. after the 2nd round of the Review stage £125k

Publications

Journals

1. A E Kelly, C Michie, Wende Zhong, S Karagianopoulos, W I Madden, C Tombling, I Andonovic, 'High Performance Polarisation Independent Reflective Semiconductor Optical Amplifiers in the S, C and L bands', IEEE Journal on Selected Areas in Communications, vol. 28, no. 6, August 2010
2. Jonathan McKendry, Richard P. Green, A. E. Kelly, Zheng Gong, Benoit Guilhabert, David Massoubre, Erdan Gu and Martin D. Dawson "High Speed Visible Light Communications Using Individual Pixels in a Micro Light-Emitting Diode Array" Photon. Tech. Lett., vol. 22, No.18, pp 1346-1348, Sept 2010.

3. Ivan Glesk, Marc Sorel, Anthony E. Kelly and Paul R. Prucnal "Enhancing Performance of Optical Communication Systems with Advanced Optical Signal Processing" Journal of Networking, Nov 2010

4. B. Romeira, J. M. L. Figueiredo, C. N. Ironside, A. E. Kelly, T. J. Slight, "Optical Control of a Resonant Tunneling Diode Microwave-Photonic Oscillator", IEEE Photonics Technology Letters, Nov 2010

5. Glesk, I. Andonovic, C. Michie, "Increasing Transmission Efficiency with Advanced Signal Processing," Renewable Energy and Power Quality Journal, 8, 270 April (2010); RE&PQJ-8, ISSN 2172-038X.

Invited Lectures

6. Glesk, "Ultrafast all-optical signal processing how and why?" European Optical Society Annual Meeting, Parc De Paris, France, 26th-29th October 2010
7. Glesk, "100 Gigabit Internet why and how - the technology behind it" 17th Conference on Wave and Quantum Aspects of Contemporary Optics, 6–10 Sept. 2010, LMSK.
8. Glesk, I. Andonovic, M.N.M Warip, Proc. 12th International Conference on Transparent Optical Networks ICTON 2010, paper We.A1.4, Munich, Germany, 27th

June – 1st July, 2010
9. Glesk, “Approaches to Ultrafast All-Optical Signal Processing,” in Technical Digest ACP 2009, 2-6 Nov 2009, Shanghai, China, ISBN: 978-1-55752-877-3.

Conferences

10. Craig Michie, A E Kelly, Lin Liu, Ivan Andonovic, Wende-De Zhong ‘Semiconductor Optical Amplifiers in Future Passive Optical Networks’ ICICS 2009 Macau, China.
11. N Laurand, J McKendry, B. Guilhabert, R P Green, A E Kelly, E Gu and M. D.Dawson, “Modulation bandwidth and effective carrier lifetime of colloidal quantum-dot nano-composites”, QD 2010 conference, Nottingham, Poster II, P47 (April 2010)
12. B. Romeira, J. M. L. Figueiredo, C. N. Ironside, A. E. Kelly, T. J. Slight, "Optical injection locking of a resonant tunnelling diode - optical waveguide photo-detector", 15th European Conference on Integrated Optics (ECIO 2010), paper ThF4, Cambridge, , 7-9 April, 2010.
13. Hou, L.; Haji, M.; Dylewicz, R.; Stolarz, P.; Kelly, A.E.; Arnold, J.M.; Marsh, J.H.; De La Rue, R.M.; Sorel, M.; Bryce, A.C.; Qiu, B.C “Monolithic 40 GHz passively mode locked AlGaInAs/InP 1.55 μm MQW laser with surface-etched Bragg gratings” ; Lasers and Electro-Optics (CLEO) and Quantum Electronics and Laser Science Conference (QELS), 16-21 May 2010
14. B. Romeira, T. J. Slight, A. E. Kelly, C. N. Ironside, J. M L Figueiredo,"Microwave Photonic Oscillators for Femto-cellular Access Networks", 15th European Conference on Networks and Optical Communications (NOC 2010*),* Components and modulation strategies, Faro-Algarve, Portugal, 8-10 Jun 2010.
15. Lin Liu, C Michie, A. E. Kelly, I Andonovic “Numerical analysis of adjustable gain-clamped semiconductor optical amplifier (AGC-SOA) performance”. 12th International Conference on Transparent Optical Networks, June 27 2010-July 1 2010.
16. B. Romeira, K. Seunarine, C. N. Ironside, A. E. Kelly, T. J. Slight, J. M. L. Figueiredo “An Optoelectronic Oscillator based on a Resonant Tunnelling Diode Photo-Detector Integrated Chip”, ” 23rd Annual Meeting of the Photonics Society, , Denver, 17-20 November 2010
17. N. Laurand, J. McKendry, B. Guilhabert, A. E. Kelly, B. Rae, R. Henderson and M.D. Dawson “Hybrid organic/inorganic nanocrystal-based composite for color-conversion and visible light communications”, 23rd Annual Meeting of the Photonics Society, , Denver, 17-20 November 2010
18. M Haji, L Hou, A. E. Kelly, R. Green, G. Mezosi, J. Javaloyes, A.C. Bryce, J. M. Arnold “Sub-Picosecond Pulse Generation using Fast Saturable Absorption in AlGaInAs/InP Quantum Wells”, 23rd Annual Meeting of the Photonics Society, Denver, 17-20 November 2010
19. Lin Liu, Craig Michie, Anthony E. Kelly, Ivan Andonovic “Packet Equalisation

in PONs using Adjustable Gain-Clamped Semiconductor Optical Amplifiers (AGC-SOA)", Photonics Global Conference, Singapore 14-16 December 2010.
20. A Proudfoot, C Michie, W Johnstone, H White, "Operation and Power Consumption of Amplified Optical Networks for Future Aerospace Applications", Marriott Conference Centre, Denver, Colorado, 21 – 23 September 2010
21. A. Proudfoot , C. Michie, W. Johnstone, H. White, "Analysis of Performance and Power Consumption Requirements for Future Aerospace Amplified Optical Networks Fibre Optics in Harsh Environments", GWR Steam Museum, Swindon, UK ,8-9 May 2010
22. M.N.M. Warip, I. Andonovic, I. Glesk, "GMPLS aware Traffic Engineering for Green Photonic Networks", The 2nd international Workshop on Computer Networks and Communication (CoNeCo 2010), Ankara, Turkey, submitted.
23. M.N.M. Warip, I. Andonovic, I. Glesk, D. Harle, "GMPLS-enabled Routing Applied to Energy Photonic Networks," WGN9: IX Workshop in G/MPLS networks, Girona, Spain, 5th–6th July 2010, [online] http://bcds.udg.edu/wgn9/index.php
24. M.N.M. Warip, I. Andonovic, I. Glesk, "A Power Reduction Technique for GMPLS-Based Photonic Networks", The 11th Annual Postgraduate Conference on the Convergence of Telecommunications, Networking and Broadcasting (PGNet2010), Liverpool John Moores University, UK, 21–22 June 2010. [online] http://www.cms.livjm.ac.uk/pgnet2010/index.html
25. M.N.M Warip, I. Andonovic, and I. Glesk, *"GMPLS-Enabled Routing or Green Photonic Networks," in UK-MEC 2010*, University College London (UCL), 8 – 9 April 2010, UK. [online] http://www.ukmec2010.info/
26. Glesk, I. Andonovic, C. Michie, "Increasing transmission efficiency with advanced signal processing," International Conference on Renewable Energies and Power Quality (ICREPQ'10), Granada (Spain), 23-25 March, 2010, paper 270, ISBN: 978-84-613-7543-1

Polymer Electronics; Materials and Technologies for Planar Topographic Integration of New Electronic Systems

Gleskova (SU)

Gadegaard (GU)

This program focuses on the further development of plastic-based electronics, a clear exemplar of a research segment which the GRPe investment has added to the portfolio since the fabrication capabilities for plastic-based electronics did not exist. This project relies on and enjoys support from both, Glasgow and Strathclyde Universities; the device growth laboratory is located in the Rankine Building of Glasgow University, while the measurement laboratory is in Royal College of the University of Strathclyde.

This project is progressing in two parallel directions. Gleskova is leading the

development of baseline technology for plastic transistors based on vacuum deposited organic semiconductors. The aim is to develop state-of-the-art plastic transistors that exhibit performance comparable to that of transistors from other leading groups. To follow up on the demand for 'greener' electronics, the transistors should operate at low voltages. Different sets of transistors have been fabricated using distinctly different gate dielectric materials. Although the most recent transistor design met the low-voltage requirement and the transistors operate at voltages below 5V, the transistor field-effect mobility is still low. Careful investigation of the transistor performance led us to believe that the low field-effect mobility is a consequence of high impurity concentration in the purchased organic semiconductor. Consequently, additional funds were deployed to purchase equipment that will allow in-house purification of organic materials. The purification equipment is on order and we expect to have a fully functional system by the end of 2010. The cost if this investment was about £18k. The GRPe-funded student at Strathclyde is now in his second year. In the past year his efforts have been focused on developing new type of dielectric for low-voltage plastic transistors. This dielectric has been deployed in the recently fabricated devices and it shows very promising results. Another PhD student was added to the group in September of 2010. The student was awarded SORSAS Scholarship together with a Scholarship from the Faculty of Engineering. As a result, the group now consists of 2 PhD students.

Gadegaard has in the past 12 months focused on 4 main areas of his research activities on: 1. Expanding nanofabrication capabilities, 2. high volume polymer replication, 3. conducting polymer electrodes for cell sensing and 4. stem cell research. The expansion of nanofabrication capabilities are currently funded by FP7 and EPSRC projects, however, a plasma polymerisation facility funded by the GRPe is now fully operational and has been calibrated by a final year project student. It is now producing significant results which are in the process of being written up and submitted. Also, this semester a final year project student will be working on aspects of plasma polymerisation for nanofabrication. In spring a large investment (£50k-60k) was made on the procurement of an injection moulding machine (funded through an FP7 project) to expand the group's abilities for high volume polymer replication. The arrival of the machine has sparked a significant burst of interest from industry and has already lead to over £100k of funding related to this facility. The GRPe funded student, Affar Karrimullah, has made significant progress in the past 12 months and are now collecting data from biological cells with expectation of submission for publication before Christmas. Finally, a large effort on stem cell research has been sustained and we are now directly pursuing KT of IP to leading industrial partners.

Researchers Funded or Leveraged by GRPe

1. Affar Karimullah (Glasgow) "Patterned conducting polymers for bio-sensing applications**"**
2. Krishna Chytanya Chinnam (Strathclyde) "Organic thin-film transistors on plastic substrates"
3. Swati Gupta (Strathclyde) "Improving the performance of plastic transistors through device engineering"

Funding

1. AO Foundation. “Patterning PEEK for orthopaedic devices” £101k
2. EPSRC/University of Glasgow KTA, “Stem cell culture devices” £97k
3. Invibio/SPARK award, “Controlling cell adhesion by surface patterning” £20k

Applications for Funding (Unsuccessful)

FP7 application ~£1M

Publications

Journals

1. E. Hendry, T. Carpy, J. Johnston, M. Popland, R. Mikhaylovskiy, A. J. Lapthorn, S. M. Kelly, L. D. Barron, N. Gadegaard and M. Kadodwala, "Ultrasensitive detection and characterization of biomolecules using superchiral fields", in press, Nature Nanotechnology
2. Lina Altomare, Mathis Riehle, Nikolaj Gadegaard, Mariacristina Tanzi, Silvia Farè, "Microcontact printing of fibronectin on a biodegradable polymeric surface for skeletal muscle cell orientation", Int J Artif Organs 2010; 33 (8): 535-543
3. L. Csaderova, E. Martines, K. Seunarine, N. Gadegaard, C.D.W. Wilkinson, M.O. Riehle, "A biodegradable and biocompatible regular nanopattern for large-scale selective cell growth", Small in press
4. Roana Melina de Oliveira Hansen, Morten Madsen, Jakob Kjelstrup-Hansen, Rasmus Haugstrup Pedersen, Nikolaj Gadegaard and Horst-Günter Rubahn, "Electrical properties of in-situ grown and transferred organic nano-fibers", Proc. of SPIE Vol. 7764 77640L-1, (2010)
5. Bozhi Ji, Maggie Cusack, Andy Freer, Phil S. Dobson, Nikolaj Gadegaard, Huabing Yin, "Control of crystal polymorph in micro-fluidics using molluscan 28kDa Ca2+- binding protein", Integrative Biology, In Press (2010)
6. P. Roach, T. Parker, N. Gadegaard, M.R. Alexander, "Surface strategies for control of neuronal cell adhesion: A review", Surface Science Reports, 65, 145-173 (2010)
7. Ruby Majani, Mischa Zelzer, Nikolaj Gadegaard, Felicity R. Rose, Morgan R. Alexander, "Preparation of Caco-2 cell sheets using plasma polymerised acrylic acid as a weak boundary layer", Biomaterials, 31, 6764-6771 (2010)
8. R.H. Pedersen, M. Hamzah, S. Thoms, P. Roach, M.R. Alexander, N. Gadegaard, “Electron beam lithography using plasma polymerized hexane as resist”, Microelectronic Engineering, 87(5-8), 1112-114 (2010).
9. Ainhoa Gaston, Ali Z. Khokhar, Leire Bilbao, Virginia Sáez-Martínez, Ana

Corres, Isabel Obieta, Nikolaj Gadegaard, "Nanopatterned UV curable hydrogels for biomedical applications", Microelectronic Engineering, 87(5-8), 1057-1061 (2010).
10. L. Altomare, N. Gadegaard, L. Visai, M.C. Tanzi, S. Farè, "Biodegradable microgrooved polymeric surfaces obtained by photolithography for skeletal muscle cell orientation and myotube development", Acta Biomaterialia, 6, 1948-1957 (2010)
11. Biggs, MJP; Richards, RG; Gadegaard, N, et al., "The use of nanoscale topography to modulate the dynamics of adhesion formation in primary osteoblasts and ERK/MAPK signalling in STRO-1+enriched skeletal stem cells", Biomaterials, 28, 5094-5103

Invited Conferences

1. J-MRS, “Strategies for tissue engineering using nanotechnology”, Yokohama, Japan, December 2009
2. “Nanotechnologies for tissue engineering”, Tohoku Dental School, Sendai Dec 2009
3. “Nanoengineering for bioengineering”, University of Milan, Italy January 2010
4. “Biological applications of micro- and nanopatterning”, University of Milan, Italy January 2010
5. “Biometrology” , Measurement needs and opportunities in nanobiotechnology, NPL, April 2010
6. Session chair at Gordon Research conference, “Nanostructure Fabrication”, July 2010
7. Scottish Rubber and Plastics Association meeting at Glasgow University, “Injection Moulding of Nanostructured Surfaces for Medical Applications”,

MEMS Technologies

Uttamchandani (SU)

Paul, Porr (GU)

Dr Lijie Li, the only GRPE appointee in the Centre for Microsystems and Photonics (CMP) of the EEE Department of Strathclyde University, tendered his resignation in early 2010 and took up a post in Swansea University (Wales) on 1st April 2010. Recruitment for a replacement post in the same area has been completed, and a new appointment has been made. The new appointee is currently working through his notice period, and will be joining the CMP in early November 2010.

The GRPE supported MEMS technologies activities, which were being pursued by Dr Li, have thus been dormant since April 2010, but will become active from November 2010. In the interim period, MEMS research has continued under Uttamchandani, but this work

has been supported by other researchers who are not GRPE supported.

Funding

Leverhulme Trust Research Grant, “Modelling of Micro Nuclear Battery” £100k

Publications

There were no journal or conference publications involving Dr Lijie Li during the three months January to March 2010.

Advanced Devices and Systems

Paul, Knox, Cumming (GU)

Cronin (GU, Chemistry)

MacLaren (GU, Physics)

Paul has also started new joint work on thermo-electrics, in particular using nano-engineering to improve the efficiency of thermo-electric generators. He is coordinating an EC proposal on Ge/SiGe a superlattice thermoelectric generator which has enable thermo-electrics work at Glasgow to be initiated. This EC proposal has enabled 2 new researchers: a post doctorial researcher and a PhD student. A second networking grant has been funded by the EC which is aimed at delivering a number of workshops, summer schools, outreach activities and roadmaps for energy harvesting technologies at a European level. An EPSRC Programme Grant was awarded in February 2010 with Cronin (WESTChem) and MacLaren (SUPA) aimed at investigating bi-stable state inorganic poly-oxometalate molecules integrated into CMOS templates as self-assembled molecular flash memories. This is aimed at producing molecular scale memories beyond the scaling limits of present CMOS flash memory as a post CMOS technology. The grant has funded a post doctorial researcher and a further PhD student is also working on the project.

The THz Laboratory refurbishment has been completed and Paul has now moved his laboratory from Cambridge to Glasgow. Through the year, a number of snagging issues have and are still being corrected and at present 2 FTIR systems are fully operational. Furthermore, the cryocooler and TEA CO_2 laser are both now functioning and the joint programme in the THz domain with Strathclyde will proceed before Christmas. An EPSRC awarded grant started in July 2010 aimed at producing Ge/SiGe THz quantum cascade lasers. For this a time-domain THz system is being setup to allow gain measurements of THz quantum cascade lasers. Also the grant has funded a post doctorial researcher and a PhD student.

The resonant tunneling work has produced a novel Si/SiGe non-volatile memory that could be integrated with CMOS. At present we are developing a full dataset and theory for operation before deciding whether it is appropriate to protect some IP before publication. Paul's group now consists of 5 postdoctoral fellows (1 funded by GRPe) and 5PhD students. This year has been predominantly related to generating sufficient research funds to start a number of new research directions at Glasgow which have been leveraged by the GRPe funding. Critical mass has now been reached with people and funds and the next year is expected to deliver original research results and publications. Prof Paul was appointed the Director of the James Watt Nanofabrication Centre at the University of Glasgow in April 2010. Prof Paul has also been appointed to another Westminster Scientific Advisory Committee, the Defence Scientific Advisory Council (MOD) in addition to continuing his work for the Home Office CBRN Scientific Advisory Committee and the Enhanced Detection "Jason Group" that was set up by John Beddington to undertake a counter terrorism review for the Government Office of Science.

Researchers Funded or Leveraged by GRPe

1. Dr Gary Ternant; Research Fellow "RTD Devices" EPSRC funded

2. Dr Barry Holmes; Research Fellow "THz Sources" GRPe funded

3. Dr Isa Kiyat, Research Fellow "Molecular MOS" EPSRC funded

4. Dr Philippe Velhe Research Fellow "Ge/SiGe THz quantum cascade lasers and Ge Lasers" EPSRC funded

5. Dr Antonio Samarelli Research Fellow "Si/SiGe thermoelectric generators" EC funded

6. Kevin Gallacher; "Ge/SiGe Quantum Cascade Lasers" EPSRC DTA funded

7. Jamie Gallagher; "Nanofabricated BiTe Thermoelectric Materials and Generators" (with Andy Knox (GRPe Energy)) Glasgow University Kelvin Smith Scholarship

8. Derek Dumas "Ge/SiGe Quantum Cascade Lasers" EPSRC funded

9. Muhammad Mirza "Single electron transistors and Si nano-wires for charge detection on molecules" EPSRC funded

10. Lourdes Fere Llin "Si/SiGe thermoelectric generators" EC and EPSRC DTA funded

Funded in 2009/2010

1. EPSRC “Molecular-Metal-Oxide Nano-electronics” £3.6M

2. EPSRC “Room temperature THz quantum cascade lasers on Si substrates” £763k

3. EC ICT FET “Generate Renewable Energy Efficiently using Nanofabricated Silicon (GREEN Silicon)” 930k Euro

4. EC ICT FET “ZEROPOWER” 138kEuro

Applications for Funding

1. EC ICT FET 2nd stage “Smart sensor Hetero-structures on Integrated Photonics SiGe” 720kEuro

2. EPSRC “Village-Level Energy and Sustainable Power in Africa (VESPA)” £1.9M

Publications

Journals

1. D.J. Paul “The progress towards THz quantum cascade lasers on Si substrates” Laser & Photonics Reviews **4**(5), 610 (2010)

2. G. Matmon, D.J. Paul et al., “Si/SiGe quantum cascade superlattice designs for terahertz emission” J. Appl. Phys. **107**, 053109 (2010)

Invited Conference

3. D.J. Paul, “Thermoelectric Generation”, NIPs Energy Harvesting Summer School, Umbria, Italy, August 2010

Signal Processing

Stankovic, Stankovic, Stewart (SU)

Thayne (GU)

Since October 2009, research has been focussed on: intelligent data gathering using wireless sensor networks and multimedia distribution across wireless networks. Signal processing algorithms developed for these topics range from error protection, cooperative network coding, distributed source and video coding, routing and clustering protocols and on-line dictionary learning (sparse coding). We have further consolidated our relationship with British Waterways Scotland and Scottish Water, resulting in three joint funding proposals being put forward and a PhD studentship. A realistic wireless sensor network test-bed based on TinyOS has being established during a summer internship (funded by EPSRC). This test-bed is intended to enhance funding applications.

Researchers Funded or Leveraged by GRPe

1. Dejan Vukobratovic; Senior Academic Fellow "Multimedia Streaming in Wireless Networks"
2. Sajid Nazir; "Multi-media Transmission over Wireless networks"
3. Bojana Begovic, "Sparse Signal Representation"
4. Hani Attar, "Network Coding for Wireless Multi-User Networks Exploiting Co-operative Diversity"
5. Shikha Sarkar, "Intelligent Data Gathering using Wireless Sensor Networks"

Funded

EU FP7-PEOPLE-IEF-2008-236234 Marie Curie "MMSTREAM: Dr Dejan Vukobratovic" Eu124k

EPSRC internship, "Wireless Monitoring of Banks and Canal Structures" £2K

Applications for Funding

SFC, "The Scottish Sensor Systems Institute (SSSI)" £3.4M

Applications for Funding (Unsuccessful)

1. EPSRC "Power-friendly distributed algorithms with efficient correlation tracking" (rejected but ranked top half) £80k 2. Technology Strategy Board; Technology Inspired Initiative "Feasibility Studies on WSN for Canals" with EnviroCentre and British Waterways Scotland £33k

3. EU FP7 Cooperation, "SEWERSENSE: An Integrated Wireless System for Urban Wastewater Management", Oct 2009 £2M

4. EPSRC, "Wireless Advanced underwater Transmission techniques for Efficient and Reliable communications" (rejected but ranked top half) £242K

Publications

Journals

1. Uppal, M., Liu, Z., Stankovic, V., Xiong, Z., Compress-forward coding with BPSK modulation for the half-duplex Gaussian relay channel, IEEE Transactions on Signal Processing, vol. 57, pp. 4467-4481, November 2009.
2. Vukobratovic, D., Stankovic, V., Sejdinovic, D., Stankovic, L., Xiong, Z., Scalable video multicast using Expanding window fountain codes, IEEE Transactions on Multimedia, Special Issue on Quality-driven Cross-layer Design for Multimedia Communications, vol. 11, pp. 1094-1104, October 2009.
3. C. J. Nelson, L. Stankovic and B. Honary, "Partial-Unit Memory based Turbo Codes," IET Electronics Letters, Vol. 45, No. 21, Oct 2009.

Invited Conferences

4. Stankovic, V., Stankovic, L., Cheng, S., Distributed source coding: Theory and applications, Proc. Eusipco-2010 18th European Signal Processing Conference, Aalborg, Denmark, August 2010
5. Stankovic, L., Stankovic, V., Wang, S., Cheng, S., Distributed video coding with particle filtering for correlation tracking, Proc. Eusipco-2010 18th European Signal Processing Conference, Aalborg, Denmark, August 2010
6. Barquero, D.G., Nybom, K., Vukobratovic, D., Stankovic, V., Scalable video coding for mobile broadcasting DVB systems, Proc. ICME-2010 IEEE International Conference on Multimedia and Expo, Singapore, July 2010,

Conferences

7. Vukobratovic, D., Stankovic, V., Unequal error protection random linear coding for multimedia communications, Proc. MMSP-2010 IEEE Multimedia and Signal Processing Workshop, Saint Malo, France, October 2010 (**top 10 award**).
8. Vukobratovic, D., Stefanovic, C., Stankovic, V., Fireworks: A random linear coding scheme for distributed storage in wireless sensor networks, Proc. ITW 2010 IEEE Information Theory Workshop, Dublin, Ireland, September 2010.
9. Nasir, H., Stankovic, V., Marshall, S., Image registration for super resolution, Proc. Eusipco-2010 18th European Signal Processing Conference, Aalborg,

Denmark, August 2010.
10. Rastovac, D., Vukobratovic, D., Stankovic, V., Stankovic, L., The design of rate-compatible LDPC codes for IR-HARQ systems over erasure channels, Proc. ICC-2010 IEEE International Conference on Communications, Cape Town, South Africa, May 2010.
11. Li, L., Mirza, M., Stankovic, V., Li, L., Stankovic, L., Uttamchandani, D., Cheng, S., Optical imaging with scanning MEMS mirror – a single photodetector approach, Proc. ICIP-09 IEEE International Conference on Image Processing, Cairo, Egypt, November 2009.
12. Li, L., Li, L., Stankovic, V., Stankovic, L., Uttamchandani, D., Single-pixel camera using MEMS scanners, Proc. IECON-09 35th Annual Conference of IEEE Industrial Electronics Society, Porto, Portugal, November 2009.
13. Stankovic, V., Stankovic, L., Cheng, S., Compressive image sampling with side information, Proc. ICIP-09 IEEE International Conference on Image Processing, Cairo, Egypt, November 2009.
14. H. Attar, L. Stankovic, V. Stankovic and C. Khirallah, “Physical Layer Multi-Source Packet Network Coding with PUM Turbo Codes,” 3rd Mosharaka Intl Conf on Communications, Signals and Coding (MIC-CSC-2009), November 2009, Amman, Jordan
15. Stefanovic, C., Vukobratovic, D., Stankovic, V., On distributed LDGM and LDPC code design for networked systems, Proc. ITW-2009, IEEE Information Theory Workshop, Taormina, Italy, October 2009.