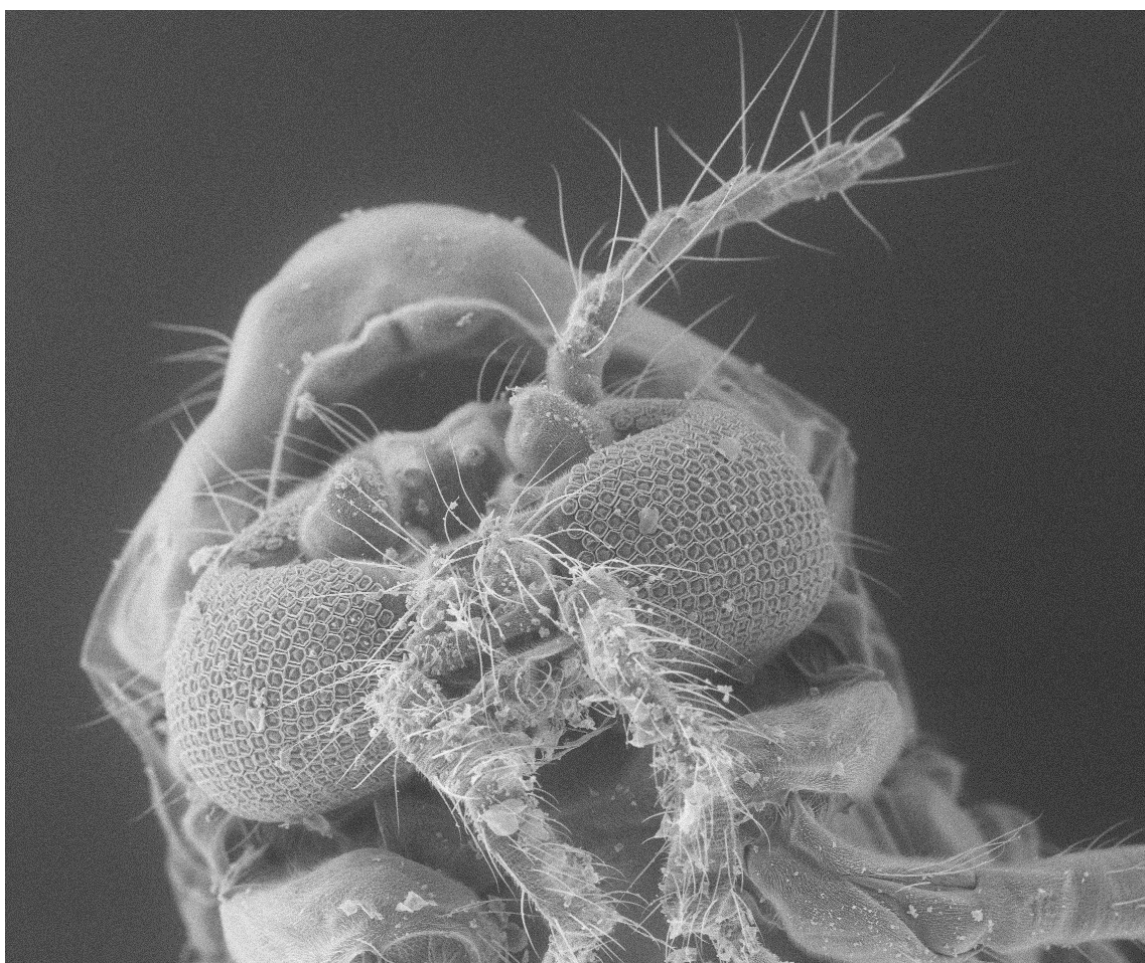


Centre for Doctoral Training in Fuel Cells and their Fuels

Newsletter
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CDT Fuel Cells and
their Fuels

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Welcome

Welcome to the September 2015 edition of the new newsletter for the Engineering and Physical Sciences Research Council funded Centre for Doctoral Training in Fuel Cells and their Fuels which is a research partnership between the Universities of Birmingham, Nottingham, Loughborough, Imperial College London and University College London.

This newsletter was compiled by University of Birmingham Editors James Walker and Aimee Jackson with contributions from Site Editors Tom Heenan (UCL), Daniel Smith (University of Nottingham), and Sharleigh Talbot (Loughborough University). The editors are grateful to Project Officer John Hooper for his assistance. Readers can contact the editors with comments and contributions at:

hfc-cdt-editors@contacts.bham.ac.uk



Top: Aimee and James.

Bottom: Daniel, Sharleigh and Tom.

Thanks to Geoffrey Maillard for our cover image: an SEM image of a fly, used in the FCH2 conference outreach session - see the outreach section for details. Other highlights in this edition include an insight into the recent conferences and a round-up of public outreach activities from across our network.

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What Have We Been Up To?

FCH2 Conference

From the 18th – 21st May, Birmingham hosted the FCH2 conference, at millennium point. Birmingham students and academics were joined by academics from other institutions and also industry speakers.

The conference consisted of talks from both academics and industry, an industry exhibition, and an outreach session to 200 school children.

Exhibitors included Hitachi, who brought their table top SEM for demonstrations, and Morgan and micro cab, who both brought along electric vehicles.

Talks covered a wide range of topics, including; hydrogen infrastructure, PEFC catalysts and membranes, SOFC; DMFC catalyst supports, and fuel cells in homes.



The industry exhibition at the conference.

Catalysis Improving Society, Royal Society, London

One of University of Birmingham 1st year CDT students attended the conference “Catalysis improving society”, held at the Royal Society in London. Over two days, the event covered a wide range of topics regarding the development of homogeneous/heterogeneous catalysts, as well as the challenges that these face to be economically and environmentally sustainable. Speakers covered the capabilities of zeolites to selectively separate CO₂ and CH₄ upon nanostructuring (Prof. Avelino Corma, CSIC-UPV, Spain), the use of computational tools to benchmark catalysts for the Fischer-Tropsch synthesis (Prof. Matthew Rosseinsky, University of Liverpool), and the development of catalysts to use CO₂ as a reagent for added value organic synthesis (Prof. Walter Leitner, RWTH Aachen University, Germany). The relevance of fuel cells in the future energy system came into play in the use of microbial systems as fuel cell anodes (Dr. Petra Cameron, Bath University, UK) and the development of earth-abundant materials for the hydrogen

evolution reaction (Prof. C. N. R. Rao, Jawaharlal Nehru Centre for Advanced Scientific Research, India). The talks were accompanied by stimulating discussions as well as by an early stage researcher poster session that enabled a dynamic knowledge exchange between academics and PhD students. An overview lecture by Sir John Meurig Thomas (University of Cambridge) summarized the contents covered and analysed the recent advances in catalysis, that include the surprising use of single atoms.

European Fuel Cell Forum, Lucerne

At the beginning of July, a contingent of Birmingham's PEFC researchers and a couple of Loughborough students headed over to Switzerland for the 5th European PEFC & H₂ Forum. The conference, held in Lucerne's beautiful Kultur- und Kongresszentrum (KKL), brought together approximately 300 members of the international PEFC community. Presentations and posters at the conference covered a wide range of themes including catalysis, degradation testing, hydrogen production & storage and economic and analyses of developments in fuel cell markets. Participants enjoyed an array of networking opportunities and many

were delighted by the varied exhibition of relevant industrial products and 'green' solutions at the Green Salon. A particular highlight for attendees, as ever, was the 'Dinner on the Lake' boat excursion which took in the wonderful scenery of Lake Lucerne. Well done to all those of our students and collaborators who gave presentations. The quality of the talks was excellent! We're already looking forward to next year's 12th European SOFC & SOE Forum!



Left to right: Yaxiang, Lois, James, Ahmad, Scott and Amrit enjoying the sun by the lake in Lucerne.



Left to right: Carolina and Lois looking fancy on the boat trip.

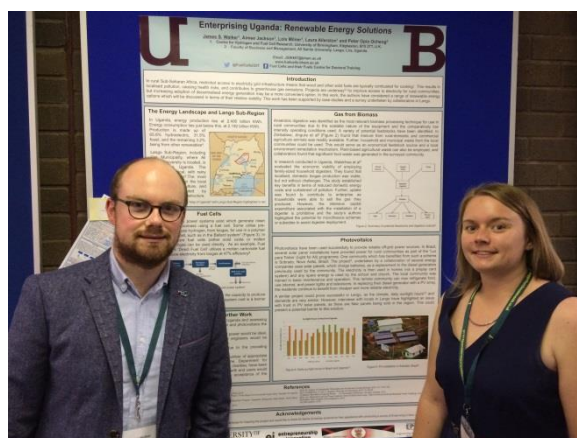
1st Chemistry in Energy Conference

Lois, James and Rosalind from the Birmingham group made the trip up to Edinburgh to attend the 1st Royal Society of Chemistry 'Chemistry in Energy' conference which was held at Heriot Watt University between the 20th and 22nd of July. The conference took in a very broad range of themes including research ongoing in fossil, nuclear and renewable energy sources and carbon capture and storage. Delegates were welcomed to the University by Professor Mercedes Maroto-Valer from the Heriot Watt Energy Academy and were welcomed to Scotland by Fergus Ewing MSP, who is the Scottish Minister for Business, Energy and Tourism. Thereafter, insightful talks introduced the broadly multidisciplinary, multinational audience to a swathe of the energy research projects ongoing throughout the UK and further afield. Rosie presented work she's been doing on lithium amide halide hydrogen storage materials. James and Lois presented posters – James's detailing work that he, Lois, Aimee and Laura have been doing with Birmingham's Entrepreneurship & Innovation team on evaluating renewable energy options for a rural Ugandan community as part of their 'Enterprising Uganda' project, and

Lois's covering the viability of fuel cell auxiliary power units for aircraft.

In addition to enjoying the interesting talks and posters that were presented, conference delegates also enjoyed traditional Scottish haggis as part of the conference dinner menu and threw themselves onto the dance floor for a ceilidh in the evening. Lois and Rosie, like other attendees, made valiant efforts at keeping up with the instructions from the ceilidh band while James, token Scot, was finally thankful for all those years of lessons that he'd been forced to take part in while at high school!

All in all the conference was a great success and we're grateful to the organisers for all their hard work.



Left to right: James and Lois presenting the Uganda poster.

Pioneers into Practice

Birmingham's Lois and James are

currently taking part in a European Climate-KIC programme called 'Pioneers into Practice'. The programme aims to take professionals and students working in sustainability-related fields and place them on secondment projects in collaboration with academic, public sector, industrial and start-up partners working in this wide reaching area. The aim of the project is primarily knowledge sharing and the encouragement of innovation diffusion. The process sees participants – 'Pioneers' – go through training on aspects of 'transitions thinking' before they are placed first of all with an organisation in their home region – in this case the West Midlands – and later with an organisation in a partner European region, for month-long secondments. In their domestic placements, Lois worked with the owners of a listed country manor on a project to develop a business plan for incorporating renewable energy infrastructure on their estate, and James conducted a review of best practice in municipal waste management for Birmingham City Council. For their international placement both James and Lois will be heading to Frankfurt in September. We can no doubt expect an update on their progress in the next edition of the newsletter...

ECS SOFC in Glasgow

In July, researchers from all of our partner institutions attended the ECS Conference on Electrochemical Energy Conversion and Storage with SOFC-XIV in Glasgow, Scotland. The conference consisted of 5 days of talks followed by poster sessions and an industrial exhibition each evening. UCL's Tom additionally manned the Science and Technology Facilities Council (STFC) stall promoting the use of facilities such as Diamond Lightsource, ISIS neutron source and the Central Laser Facility. On the Wednesday evening the conference dinner took place at Glasgow's Science Centre, where the guests enjoyed traditional Scottish cuisine and entertainment.

U.C. Davis Visit

PhD Student, Scott Hardman, has just completed 4 months as a visiting scholar at the University of California, Davis. He was researching the consumer market for fuel cell vehicles in the Institute of Transportation Studies. The research shows some promising early results and suggests that consumers do demand some of the attributes of fuel cell vehicles. Scott is hoping to present his findings at the Transportation Research Board Annual

Meeting in Washington D.C. in January 2016.



Scott loved the Linde hydrogen filling stations in California.

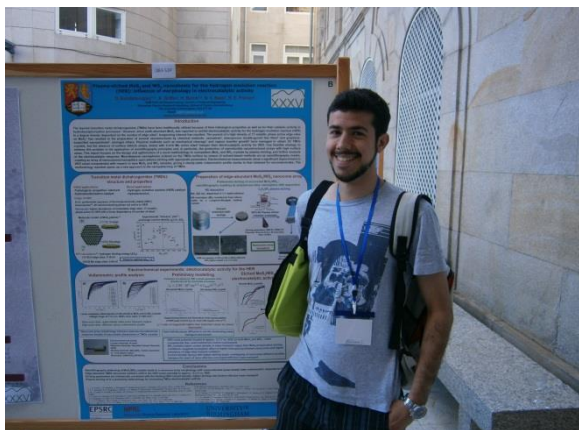
Scott had this to say about his experience; "It was a worthwhile trip. Working in a different institution enabled me to make some new contacts in my field and learn new methodologies which I will be able to apply to my research. The experience was valuable and I highly recommend that other students attempt such exchange visits."

Spanish Royal Chemistry Society Meeting – Electrochemistry Group

Daniel Escalera Lopez attended the

XXXVI Meeting of the Electrochemistry group from the Spanish Royal Chemistry Society, which took place between the 13th and 15th July 2015 at the "Escola de Enxeñaría Industrial" in Vigo, Spain. A broad range of electrochemistry themes were covered during the conference. Among the plenary presentations, Prof. Annick Hubin (VUB, Belgium) provided a brief introduction on a novel impedance spectroscopy technique known as Odd Random Phase Electrochemical Impedance Spectroscopy (ORP-EIS), and later on, Prof. Roberto Torresi (Universidade de São Paulo, Brazil) gave some insight on the application of ionic liquids (ILs) as an electrolyte for lithium-air batteries, supercapacitors and their polymerization for conductive membranes. Finally, Dr. Carlos M. Sánchez-Sánchez (LISE, France) explored the possibilities that Scanning Electrochemical Microscopy offers for detecting redox intermediates (collection mode with micropipette), screening the electrocatalytic activity of single nanoparticles (NPs) and the photoactivity of semiconductor NPs (Photo-SECM).

The conference also included numerous presentations related to fuel cell research. Rosa M. Arán-Ais (Universidad de Alicante) presented a hydrothermal method to synthesize PtNiCo NPs for oxygen reduction reaction applications; Pilar Ocón (Universidad Autónoma de Madrid) provided some insight into the use of hybrid polybenzylimidazole-based membranes for PEMFCs with the incorporation of ILs to increase conductivity. Briefly, other speakers focused on the study of IL microemulsions for the preparation of Pt-alloy catalysts (Albert Serra, Universitat de Barcelona), the preparation of TaC-supported Pt NPs to mitigate Pt agglomeration/dissolution under fuel cell operating conditions (Javier Monzó, University of Birmingham) and the use of PtRu(Cu)/C core-shell NPs for DMFCs (Griselda Caballero, Universitat de Barcelona).



Daniel presented a poster at the conference.

Anyone interested in finding out more

about these topics can e-mail Daniel on DXE411@bham.ac.uk.

3 Minute Thesis – University of Birmingham Finals

The University of Birmingham's 3 minute thesis competition finals (3MT) were held in June as part of the graduate school awards event, with representation for the fuel cells group from Rosalind Davies. Check out her experience of the day on her science blog: babelfishofscience.blogspot.co.uk/



Rosie and her University of Birmingham heat certificate.

Midlands Electrochemistry Group Meeting 2015

A number of University of Nottingham and Loughborough University CDT students attended the annual Midlands Electrochemistry Group meeting held this year at the University of Warwick

on 22nd June. Talks were given by invited speakers including Professor Alan Bond of the University of Monash, Melbourne, and research students. As at all MEG meetings, there was a prize available for the best student presentation, which was won by Sean Goodwin, who will now go on to present at the national Electrochem 2015 conference held at the University of Durham later this year.

Q&A Session with DECC Chief Scientific Advisor, Professor John Loughhead

On 15th July Professor John Loughhead visited the University of Birmingham to give a talk hosted by Professor Richard Williams, Pro – Vice Chancellor and Head of the College of Engineering & Physical Sciences and Professor Martin Freer, Head of Nuclear Physics and Director of the Birmingham Energy Institute as part of the Vice-Chancellor's distinguish lecture series. Before his lecture, students Lois Milner, James Walker, Scott Hardman, Rosalind Davies and Daniel Edward Smith were given the opportunity to meet with Professor Loughhead to ask questions pertinent to his role as the Chief Scientific Advisor to the Department for Energy and Climate Change. The Q&A session saw some important topics

raised over the hour and gave unique insight into the role of a government advisor.

Music and Theatre from University of Nottingham Students

University of Nottingham Students Sean Goodwin and Daniel Edward Smith have both been involved with exciting theatre and music projects in their own time. Sean recently starred in a musical production of 'Our House' performed at the Nottingham Arts Theatre which saw the budding electrochemist/actor sing, dance and act whilst accompanied by the music of 'Madness' in the lead role of a young man living the consequences of a decision taken on his sixteenth birthday.



Sean's musical.

Daniel had has the opportunity to sing as part of the CBSO Chorus in the City of Birmingham Symphony Orchestras's performance of Beethoven's Ninth

Symphony at the BBC Proms on 19th July which was broadcast live on BBC 4. The concert saw a sold-out Royal Albert Hall with the words of Schiller's poem resonating as strongly as ever – "Freude"!



The Proms. Photo comes courtesy of Chris Christodoulou of the BBC.

On September 11th 2015 Daniel will be returning to the Royal Albert Hall to sing as part of the BBC Proms Youth Chorus in a performance of Elgar's 'The Dream of Gerontius' with the Vienna Philharmonic Orchestra under conductor Sir Simon Rattle, before performing the work again the following week at the Lucerne Festival, Switzerland.

Outreach Activities

FCH2 Outreach session

During the FCH2 conference, Birmingham students Aimee, Laura and James, along with Jon Wood – Birmingham Chem Eng's resident outreach guru - delivered a 2 hour outreach session to approximately 200 school children from 5 different schools. The session was split into 2 sections: water, and fuel cells, with the water session being presented by Jon and the fuel cells section being presented by Aimee, Laura and James.



Left to right, James, Laura and Aimee proudly showing off their outfits.

The session included demonstrations showing weird water properties, the energy held in hydrogen gas, and a working fuel cell. The team were hoined for the session by Patrick from Hitachi, who used their tabletop SEM live in the

auditorium to show amazing images of flies, pencils, and a TEM grid. This demonstration was really useful to help the pupils to understand the small scales that were discussed in fuel cells, and really gave a 'WOW' factor to the finale.

An image of the fly can be seen on the front cover of this edition.

UCell Update

Since the last newsletter, there's been a change of leadership in the UCell team. Vidal Bharath and Erik Engebretsen stepped back from leading roles with Josh Bailey and Thomas Heenan taking their place.

UCell visited the Innocent Unplugged Festival in Kent where they provided power to the bar tent, keeping the pints nice and cold for all the festival goers. They engaged with a variety of people, including some from the Department for Energy and Climate Change (DECC).

UCell also attended the UCL Hackathon Event where several PhD student groups had been working over the course of two days to compete in a coding competition.

Next up was the Big Bang Fair, held at Westminster College London. Here, UCell showcased applications of hydrogen and fuel cells using 'Hydrocar' demonstration kits. These kits were used to exhibit water electrolysis and fuel cell operation.

Erik Engebretsen was one of seven invited to attend an afternoon at Parliament in June to represent the Institute of Chemical Engineering (IChemE) and UCell for his work in public engagement. The visit had a focus on science policy and ensuring the longevity of science in the UK.

Green Man Festival 2015

Over a weekend in August, the CDT was represented by 2 stalls which appeared in Einstein's Garden at Green Man Festival in Wales. Aimee, Lois and James formed part of the University of Birmingham's Think: Green Futures stall, while Tom represented UCL at their UCell stand.



The Think: Green Futures marquee.

The Think: Green Futures stall concentrated on engaging experiments for children and adults alike and included build-your-own electrolyzers, fuel cell scalextric and handheld burning



Aimee's fire wielding entertained many a child.

butane demonstrations. UCell had their fuel cell on show and were powering a tent filled with science-themed comedy and drama (which impressed festival goers immensely!) and they also used their mini- fuel cell car kits to keep the kids engaged.



Lois, left, and Aimee, right, helping a young scientist to construct an electrolyser.

Your Publications

Here's a summary of some of the work that's been published from across our network since April's edition. Well done to everyone involved! Remember to keep John Hooper (J.C.Hooper@bham.ac.uk) updated with all of your publications.

1. Hardman, S.; Chandan, A.; Steinberger-Wilckens, R., Fuel cell added value for early market applications. *Journal of Power Sources* 2015, 287 (0), 297-306.
2. Majewski, A.; Morris, D. J.; Kendall, K.; Wills, M., A Continuous-Flow Method for the Generation of Hydrogen from Formic Acid. *ChemSusChem* 2010, 3 (4), 431-434.
3. Redwood, M. D.; Orozco, R.; Majewski, A. J.; Macaskie, L. E., Applications of extractive fermentation and hot compressed water to enhance bioenergy production from food wastes. *Journal of Biotechnology* 2010, 150, Supplement (0), 179.
4. Redwood, M. D.; Orozco, R. L.; Majewski, A. J.; Macaskie, L. E., Electro-extractive fermentation for efficient biohydrogen production. *Bioresource Technology* 2012, 107 (0), 166-174.
5. Redwood, M. D.; Orozco, R. L.; Majewski, A. J.; Macaskie, L. E., An integrated biohydrogen refinery: Synergy of photofermentation, extractive fermentation and hydrothermal hydrolysis of food wastes. *Bioresource Technology* 2012, 119 (0), 384-392.
6. Majewski, A. J.; Wood, J.; Bujalski, W., Nickel–silica core@shell catalyst for methane reforming. *International Journal of Hydrogen Energy* 2013, 38 (34), 14531-14541.
7. Majewski, A. J.; Wood, J., Tri-reforming of methane over Ni@SiO₂ catalyst. *International Journal of Hydrogen Energy* 2014, 39 (24), 12578-12585.
8. Newton, J.; Preece, J.; Rees, N.; Horswell, S., Nanoparticle catalysts for proton exchange membrane fuel cells: can surfactant effects be beneficial for electrocatalysis? *Physical Chemistry Chemical Physics* 2014, 16 (23), 11435-11446.
9. Brack, P.; Sagu, J. S.; Peiris, T. A. N.; McInnes, A.; Senili, M.; Wijayantha, K. G. U.; Marken, F.; Selli, E., Aerosol-Assisted CVD of Bismuth Vanadate Thin Films and Their Photoelectrochemical Properties. *Chemical Vapor Deposition* 2015, 21 (1-2-3), 41-45.
10. Davies, R. A.; Anderson, P. A., Synthesis and characterization of two new amide chloride compounds: Potential H₂ storage materials. *International Journal of Hydrogen Energy* 2015, 40 (7), 3001-3005.
11. Davies, R. A.; Hewett, D. R.; Korkiakoski, E.; Thompson, S. P.; Anderson, P. A.,

Phase space investigation of the lithium amide halides. *Journal of Alloys and Compounds* (0).

12. Davies, R. A.; Hewett, D. R.; Anderson, P. A., Enhancing ionic conductivity in lithium amide for improved energy storage materials. *Advances in Natural Sciences: Nanoscience and Nanotechnology* 2015, 6 (1), 015005.
13. Kannan, R.; Silva, A. A.; Cardoso, F. M.; Gupta, G.; Aslam, Z. P.; Sharma, S.; Steinberger-Wilckens, R., Study of FePt deposited reduced graphene oxide's utility as a catalyst towards oxygen reduction and methanol oxidation reactions. *RSC Advances* 2015.
14. Blackmore, C. E.; Rees, N. V.; Palmer, R. E., Modular construction of size-selected multiple-core Pt-TiO₂ nanoclusters for electro-catalysis. *Physical Chemistry Chemical Physics* 2015.
15. Elmer, T.; Worall, M.; Wu, S.; Riffat, S. B., Emission and economic performance assessment of a solid oxide fuel cell micro-combined heat and power system in a domestic building. *Applied Thermal Engineering* (0).
16. Robinson, J.B.; Brown, L.D.; Jervis, R.; Taiwo, O.O; Heenan, T.M.M.; Millichamp, J.; Mason, T.J.; Neville, T.P.; Clague, R.; Eastwood, D.S. ; Reinhard, C.; Lee, P.D.; Brett, D.J.L.; Shearing, P.R., Investigating the effect of thermal gradients on stress in solid oxide fuel cell anodes using combined synchrotron radiation and thermal imaging. *Journal of Power Sources* 2015, 288, 473-481.

Announcements & Closing Remarks

Don't forget to let John Hooper (J.C.Hooper@bham.ac.uk) know about any conferences that you attend, along with your talk or poster title.

That's all for this issue - thanks for reading! Any comments, captions or contributions to the next edition can be sent to the editors at hfc-cdt-editors@contacts.bham.ac.uk or tweet us at @FuelCellsCDT. You'll also find us on Facebook as 'Fuel Cells and their Fuels CDT'.