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DALTON CUMBRIAN FACILITY NEWSLETTER

MARCH 2021

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WELCOME

Dear friends, colleagues and collaborators,

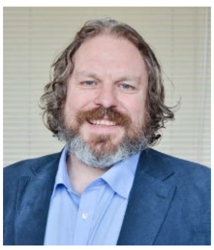
Now that the daffodils are flowering and the fields around DCF are filled with gambolling lambs, we're energised and looking forward to exceptional research progress over the next few months. The New Year ushered in an intense restructuring of laboratory space to make way for new equipment. We're also looking forward to our first experiments with our brand new x-ray irradiator and you can read more about the capabilities of this new piece of kit on page 2.

We're excited to announce two new PhD projects this year, which are currently advertised on findaphd.com. One is to design, build and text a flow loop for gamma and ion irradiation of spent nuclear fuel and the other involves using both computational and experimental methods to understand radiolytic hydrogen production. The project will start in October this year and interviews are underway soon.

Successful applicants to the above opportunities will fit in to our existing team of researchers who continue to impress us. Read on to learn more about Gyorgyi Glodan, our resident SEM expert who somehow manages to effortlessly balance so many commitments on page 3. The PhD opportunity on the flow loop will be an excellent complementary project to our ongoing work with Jacobs and you can read more about this in our project spotlight on page 5.

On a personal note, my thanks go Laura for her many contributions to DCF science and social life. She is leaving the University with plans to set up her own consultancy in technical writing for specialist audiences and the wider public. Laura's involvement with DCF goes back to an initial two year post-doc that commenced in 2013. Her enthusiasm for science, approach to management and flair for communicating complex topics are strengths that will serve her well as a consultant. As director of DCF, I am sure everyone will wish Laura all the best for the future and we hope she keeps in contact with her many friends and colleagues at DCF.

Fred Currell
Director of DCF



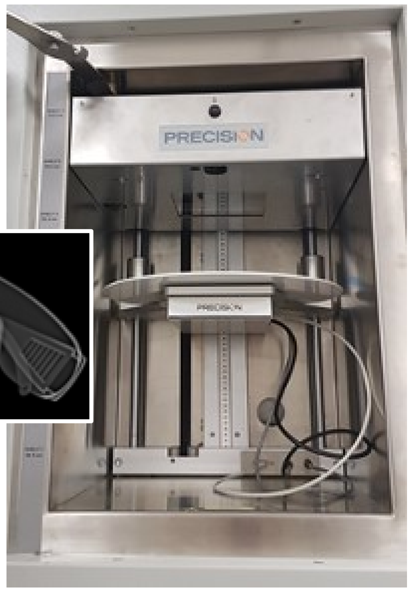
Laura Leay
Editor

EQUIPMENT DEVELOPMENT

New Equipment: X-ray irradiator and imaging systems

We are pleased to announce that we now have commissioned a new cabinet X-ray irradiator and a complimentary X-ray imaging system available for DCF users. The cabinet X-ray irradiator is complimentary to the ^{60}Co gamma irradiator but uses a very different technology – an electron beam is accelerated onto a tungsten plate to produce X-rays mostly through Bremsstrahlung. As a result, it produces a broad X-ray spectrum rather than the narrow high-energy spectrum produced by the gamma irradiator. Although providing a lower dose rate and sample penetration than the ^{60}Co gamma irradiator it also provides greater flexibility in irradiation conditions and a much bigger sample chamber.

The acceleration can be changed from 30 – 350 kV with the peak in the X-ray spectrum being at roughly 1/3rd of this energy. The current it can produce ranges from 0.1 – 30 mA although the total power can never exceed 4 kW. The irradiation chamber is 41 cm wide by 88 cm deep and 58 cm high. The sample position can be changed along with the electron current to produce dose rates from 140 Gy/min downwards with automatic dose rate sensing, a range of apertures and a turntable to improve dose homogeneity being available. Insertion chambers can be used to change the gas atmosphere (e.g. CO_2 or hypoxic) whilst access ports allow for connection to external instruments. With an imaging area of up to 23 cm by 29 cm and a spatial resolution of 5 µm at 10 times magnification the UltraFocus digital radiography system can provide X-ray images of samples, showing their radiographic density, using electron beams in the 10 – 100 kV range.



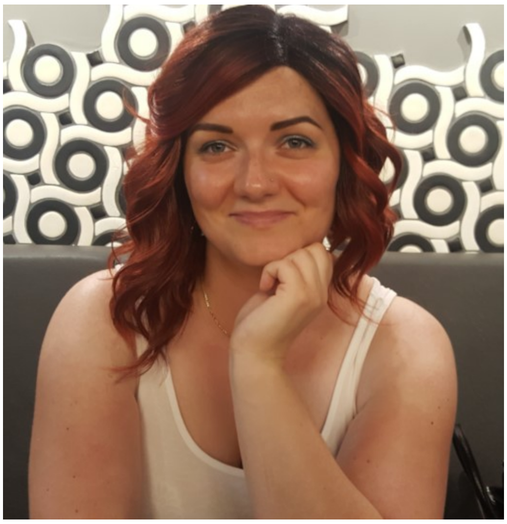
Left: Ruth Edge commissioning the MultiRad350 X-ray irradiator with the UltraFocus imaging unit visible in the background. The latter was used to capture the X-ray image of a pair of safety specs (inset). Right: The irradiation chamber of the MultiRad350.

More details of both pieces of equipment can be found at:

- https://www.accela.eu/files/products/238/multirad350-datasheet.pdf
- https://www.faxitron.com/uploads/2017/09/Ultrafocus_Data-Sheet_LS.pdf

This equipment was funded by The Henry Royce Institute.
Initial enquires to Ruth Ruth.Edge@Manchester.ac.uk or Kevin Kevin.Warren@Manchester.ac.uk

STAFF PROFILE



Gyorgyi Glodan
SEM and Materialography Experimental Officer

Q: Tell us about your career journey so far.
Two big turning points in my career happened during my PhD. Having completed a Masters degree in both physics and maths at the University of Debrecen in Hungary, I started doing research in my 2nd year the Solid State Physics department, and loved to work with the team so much that I decided to do my PhD there as well. My thesis was about solid-state reactions on the nanoscale that mainly investigated the Kirkendall effect in hemispheres, but as the only PhD student who was trained to use the electron microscopes, I was involved in a lot of other projects across the physics department. This was an invaluable experience for me, as it gave me a unique knowledge of how to prep and characterise a wide range of materials from dragonflies covered in gold to mapping grains in stainless steel. This is very handy in my current position at DCF.

Aside from the research expertise that put me on my current career path, I had a beautiful child in the final year of my PhD. I applied for a few postdoc positions, but I knew that lifestyle would not suit me anymore with the baby, so it was perfect when I saw that DCF was looking for an Experimental Officer in a field that I find so fascinating, and luckily for me I got the job!

Q: What do you enjoy most about your job?
What I love the most about my job is that no two days are the same. There is always a new challenge, so you can't do it from routine. You need to evolve constantly. I've supported many researchers with their PhD/Postdoc projects, but equally, they've supported me too, as I've grown so much both professionally and personally. I like how we can engage with so many researchers from so many different backgrounds, I learn something new every day and sometimes someone sends me a request that is too interesting to decline. For example, a few years ago I worked with a PhD student who was modelling drug trafficking by comparing SEM images that I took of flower pollens that were found in the drugs. I had no idea that it was possible to investigate drug trafficking in this way, so I'm so glad I was part of it.

Q: How do you balance work with your family life?
As my role in DCF is ever changing, sometimes it isn't easy to balance family life and work, especially since I have caring responsibilities and my own health to maintain. I was diagnosed with lupus 3 years ago. This is an autoimmune disease that can affect someone's life rather severely. This can be challenging as my main symptoms are fatigue and joint pain, and that is not ideal with a hands on job like mine. While lupus cannot be cured, luckily for me it can be managed really well with medication, a healthy diet and avoiding stress, so it does not restrict my work or lifestyle at all. I'm very grateful to have an incredibly supportive partner and an amazing job where I can have flexible working hours. This has proved invaluable during the recent national lockdowns to allow me to look after my family.

Q: What are your research interests?
I know most researchers have a specific research interest, but it isn't really the case for me. I have a passion for electron microscopy and materials characterisation in general, but I don't have a specific field within that. I characterise a piece of nuclear glass with the same interest as I do EBSD mapping of stainless steel. Every material has something special to show me, and I really can't choose!

Q: Tell us about some of your other interests.
I'm one of those people who never stops, when I'm awake, so I've got a few hobbies that I alternate between. I love cooking Japanese, Thai and Korean meals, I enjoy watching anime shows, I go fell walking, I crochet and sometimes design crochet patterns, and I often play Just Dance with my daughter. During lockdown I've got into cheese and gin making, and cake baking. I've just ordered a palette knife set, to unleash my inner Monet on a buttercream cake next!

PROJECT SPOTLIGHT

The effect of gamma radiation on zirconium alloy corrosion

Choen May Chan, Corrosion Scientist, Jacobs

THE CHALLENGE

In a pressurised water reactor (PWR), the corrosion of Zircaloy fuel element cladding is significantly enhanced relative to that predicted by ex-situ (autoclave) corrosion test data. These predictions use empirical models correlated to fast neutron flux to corrosions rates, however, neutron flux may not be the sole contributor to corrosion. Gamma radiation may also induce heterogeneous radiolysis in the porous oxide layer and, since ZrO2 is an n-type semiconductor, it is expected that it will lead to enhanced electrical conductivity. These two effects may be a cause for the enhanced in-pile corrosion, but, in a reactor, the effects of different radiation fields are difficult to separate.

THE SOLUTION

The unique set-up at DCF makes it possible to test the effect of gamma radiation alone on the corrosion of Zr alloys. The high temperature, high pressure recirculation loop can simulate PWR conditions and the mini-autoclave with electrochemical capability, in particular electrochemical impedance spectroscopy (EIS), allows in-situ measurements during gamma irradiation of test specimens. The programme to date confirms that gamma radiation has an effect on the electrical conductivity of Zr alloys. Furthermore, analysis of the electrochemical data supports the hypothesis that heterogeneous radiolysis is occurring in the porous oxide layer; the resultant oxidising environment and increased population of electron-hole pairs generated by gamma radiation lead to enhanced Zircaloy corrosion. Companion samples sit in a jig at the bottom of the autoclave to accumulate gamma dose. Characterisation of these samples, using TEM and SIMS, may provide supporting evidence for the corrosion mechanism. The experiments coupled with modelling will ascertain the significance of gamma radiation in conditions that are relevant to those in the reactor.

The recirculation loop is as tall as a person and involves a complex system which feeds through the ^{60}Co irradiator sample ports to an autoclave.

THE BENEFITS

The data can be used to ascertain whether gamma radiation can enhance corrosion. If it does, is it significant enough to explain the mis-predictions in corrosion rates? Improved corrosion predictions can lead to reduced plant outages and support extension of operating lifetimes.

NNUF National Nuclear User Facility

UKNIBC UK NATIONAL ION BEAM CENTRE

HENRY ROYCE INSTITUTE