COATED / M2A

OPEN DAY 2022

WEDNESDAY 9TH FEBRUARY 2022

M2A COATED

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Swansea University
Prifysgol Abertawe

UKRI Engineering and Physical Sciences Research Council

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About

The Materials and Manufacturing Academy (M2A), incorporating the Centre for Doctoral Training in Functional Industrial Coatings (COATED), is a Swansea University initiative, funded by the European Social Fund via the Welsh Government, EPSRC & Industry, to provide industry led postgraduate research training in the areas of Functional Coatings, Computational Modelling, and Advanced Materials and Manufacturing. The funding enables full support of research projects and aims to develop the future leaders of industry who will drive forward the transformation of the manufacturing industry to becoming a high-tech & high-value added sector that will contribute to a strong and stable economy.

On joining the M2A you will be transformed from a student into a Research Engineer (RE), enhancing your skill-set and applying yourself to solve industrial problems and advancing the academic boundaries of the discipline. To support your studies, you will be supervised by both academics and industrialists as well as receiving mentorship from colleagues to guide you through your research and subsequent career.

As a RE you will receive a generous stipend to support your studies and have your tuition fees covered*. And even better your stipend does not qualify for deductions (tax, NI, student load etc.)

- EngD: £20,000 pa + home fees for 4 years (equivalent to a salary of ~£28,000)
- MSc: £12,500 + home fees for 1 year (equivalent to a salary of ~£15,000)

On completion of your studies your higher qualification and experience will separate you from the competition and it is common for our graduates to have rapid career progression as a result of the skills they have gained.

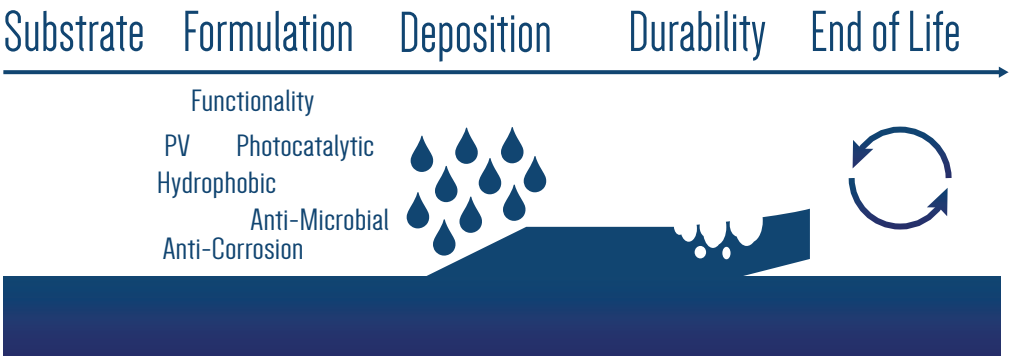
As well as the generous financial support, you will have many opportunities to network and showcase your work at trade events and international conferences around the world.

Overall, the aim of the M2A is to convert you into a well-rounded, highly employable individual who will be ready for your career – wherever it may take you.

*Subject to meeting eligibility criteria

Engineering Doctorate

The Engineering Doctorate is a 4-year professional doctorate that combines the scientific research of a PhD with the business skills needed to thrive in a competitive workplace. The research project is determined and sponsored by an industrial partner. The EngD offers 10 projects per year in the field of Functional Industrial Coatings that covers everything from development of substrate and coating formulations through to corrosion performance and end of life.



The typical structure of an EngD is shown below;

Year 1:

- 4 months of technical training to provide the researcher with relevant background knowledge.
- Completion of background research and production of a comprehensive literature review
- Presentation at 2 review meetings
- Poster presentation at annual conference
- Industrial site tour

Year 2:

- Core research
- Professional training modules
- Presentation at 3 review meetings
- Poster presentation at annual conference
- Production of annual summary report

Year 3:

- Core research
- Presentation at 3 review meetings
- Poster presentation at annual conference
- Production of annual summary report

Year 4:

- Final research
- Final professional training modules
- Presentation at 3 review meetings
- Presentation at annual conference
- Production of final thesis

MSc by Research

The MSc differs from the taught equivalent as it is solely assessed on the research thesis produced, with no formal training component. The student will work on the research problem from day one, but RE's are welcome to attend any of the EngD training modules. Typical structure would be:

- Approximately 3 months doing background research and initial experiments
- 6 months doing core research
- Present at 3 review meetings
- Poster presentation at annual conference
- Industrial site tour
- Final 3 months writing up their results

Training Programme

One of the major differentiators of an EngD to a PhD is the inclusion of the training programme that affords our students with both the technical and professional skills to excel in both their research and their careers. The initial EngD training programme takes place over the first 5 months where the focus will be on the technical modules to provide knowledge across a range of subjects. In subsequent years, further professional training takes place to ensure you have the skills to not only commercialise your ideas but to also become an effective leader in your chosen career.

Although the training programme is compulsory for EngD students, those on the MSc programme are welcome to attend any of these modules.

A summary of the training programme is provided in the table below.

Technical Modules	Professional Skills Modules
Elements of Materials Selection*	Ethics in Engineering
Literature Review of Industrial Problem (30 credits)	Interpersonal Skills for Engineers
Deposition of Functional Materials by Printing and Coating	Economic Appraisal of Engineering Projects
Public Engagement and Science Communication	Industrial Process Control and Optimisation
Applied Instrumental and Analytical Techniques	Entrepreneurship for Research Engineers
Application of Metallic Coatings	Leadership and Complexity Management
Substrate Technology for Functional Coatings	Responsible Research and Innovation
Degradation of Materials	
Organic Coatings	
Electrochemistry	
Functional Coatings	

* 'Elements of Materials Selection' is optional for Materials Engineering graduates.

In addition, ad hoc training sessions can be provided where demand exists. Examples include six-sigma training as well as a bespoke leadership programme for our BAME students. that was specifically aimed at addressing the barriers they may face in their careers. Funding is available for you to attend specialist training where required.

Cohort Approach

Whilst the M2A is an excellent avenue to fulfil continued academic training working alongside an industrial sponsor, there's also a great social aspect to the M2A program. You will join a cohort of 100 like minded individuals, a welcoming community, presenting opportunities to make new friends, work collaboratively and to support one another. You will have numerous opportunities to engage in social and academic activities as well as opportunities to join outreach events to help encourage more individuals into the discipline.

Industrial Site Tour

Each year the first-year researchers go on an industrial site tour of some of the UK's leading manufacturing sites. The tour provides an opportunity to gain an understanding of how large-scale manufacturing is completed and gain an understanding of how your research can be applied into the sector. In previous years we have visited sites such as Jaguar Land Rover, JCB, Airbus, Mini, Fusion Energy, Lotus, Morgan and Tata Steel.

Annual Conference

Every year the M2A hold an annual conference where research engineers have the opportunity to present their work to a mixed audience of academics and industrialists in the setting of the Great Hall at Bay Campus. The event is very well attended and is rounded off with a conference dinner providing an excellent prospect for networking and expanding your contacts.

Social Events

There's a Social Committee that meet regularly to plan out fun activities, giving you plenty of chance to let off some steam outside of the office. There's even an annual Sports Day event to take advantage of our beachside location for a day of fun in the sunshine! Other activities have included quiz nights, go-karting and stand up paddle boarding.

Outreach

There's plenty of opportunity throughout the year to take part in Outreach activities, getting involved with the public to spread the word about STEM subjects. This ranges from local visits to schools through to hosting science-themed tents at festivals. There's even an Outreach Committee to come up with bright new ideas on how to engage others about the interesting work being done, and how to capture the interest of the public to inspire the next generation of future engineers and scientists!

YOUR QUESTIONS ANSWERED

What is an EngD?
It is a 4 year Doctorate level qualification where the research project is determined and sponsored by an industrial partner. The EngD also provides training in business, management and leadership skills to enhance employability and create leaders within industry.

What is an MSc by research?
It is a 1 year research masters qualification where the research project is determined and sponsored by an industrial partner. The MSc is awarded purely on research with no formal taught component although you are welcome to attend modules where desired.

How much will I get paid?
£20,000 per annum for 4 years for the EngD.
£12,500 for 1 year for the MSc by research.

Who will I be working with?
Throughout your studies you will work closely with your industry sponsor, your academic supervisor and the M2A co-ordination and management team. Your industry sponsor will provide you with research supervision and potential opportunities to spend time within their business giving you valuable experience. Your academic supervisor will integrate you into their research group where you will collaborate with a wide variety of people from undergraduates to post-doctoral researchers.

What types of industrial sponsors are involved?
Current sponsors of projects include Tata Steel, BASF, SPTS, Johnson Matthey, Hexigone Inhibitors, Langley Alloys, National Nuclear Labs and many more.

What does postgraduate research entail?
Postgraduate research is very different from undergraduate life in that you have a specific research goal and it is completely self-driven. It is equivalent to a job in terms of working hours and holidays but affords you with the opportunity for creative research, development of your own scientific theories and the opportunity to utilise the world leading facilities at Swansea University.

How does EngD improve career prospects?
Our EngD graduates (of which there have been over 200) have achieved a 97% employability rate and many of our alumni are now in senior positions in businesses around the world. The advanced knowledge and skills that you gain along with the interface with industry ensures that graduates have a full complement of proficiencies to excel in their career.

How does the EngD compare to a traditional PhD?
In general, you will gain more industrial experience plus the addition of the training courses that provide you with business, leadership and management skills. These make a big difference to prospective employers.

Do I pay tuition fees?
Home fees are covered for 4 years for the EngD and 1 year for the MSc

Is this open to students from outside the UK?
Yes but you must have the legal right to live and work in the UK.

If I take an EngD how much time will I spend in taught modules?
The first five months of year one have 11 technical modules that run in an intensive format in two week blocks. You will then have 6 further courses during the remaining three years that focus on business and management skills in preparation for you exiting the scheme into employment. These are again taught in a short, intensive two week format.

Is there opportunity for overseas travel?
Yes. We offer the opportunity to present your research at an international conference (previous examples include Hawaii, LA, Beijing, Tokyo and Moscow) and also offer secondment opportunities in institutions or companies based overseas to work collaboratively or to develop new knowledge and skills.

Where will I be based?
This depends on the research techniques the project requires. Some students are wholly based with their industry partner, some wholly based at the University but most will have a mix of industrial and University based activity.

What are the facilities like?
The M2A is based at Swansea University's brand new £450 million Bay Campus. There has been an investment of over £10 million in new equipment and this means that Swansea now has world class expertise for:

- Materials imaging and characterisation
- Coatings development and production
- Corrosion research
- Printing technologies
- Computer modelling and simulation
- Advanced manufacturing techniques

Do I have to work for the sponsoring company once I've finished?
There is no commitment to work for the sponsoring company although the project provides you with an excellent opportunity to integrate into your sponsoring industry.

What degree subject and classification to I need to be eligible for the M2A?
Engineering, Science, Maths or Computer Science degree are typically suitable for our projects. Skills from many degrees are transferable so if you're not sure please get in touch to discuss. Candidates must normally hold an undergraduate degree at 2.1 level, or an appropriate master's degree (or Non-UK equivalent as defined by Swansea University).

What is the recruitment process?
Recruitment involves initially completing an application form that will pass through shortlisting with all applications being anonymised prior to being assessed. Shortlisted candidates will then be invited for an interview involving the M2A management team, Academics and Industrial sponsors. Successful candidates will then be offered a place on the scheme.

Does this count towards Chartered Engineer status?
The EngD has been accredited by the Institute of Materials, Minerals and Mining (IOM3) for meeting the Engineering Council standards. This means our graduates will have achieved part or all of the underpinning knowledge for professional registration. For both the EngD and MSc, many of the activities you undertake can also satisfy some of the criteria professional development requirements. We can assign mentors to you who can help you start the chartership process.

CASE STUDIES

DEVELOPMENT OF SENSORS AND NON-DESTRUCTIVE TECHNIQUES TO DETERMINE THE PERFORMANCE OF COATINGS IN CONSTRUCTION

Sponsor Research Engineer: Tim Savill

Impact Summary

Tim's research aims to develop methods that allow in-situ performance monitoring of organically coated steel products used in the construction sector. Currently, performance is often only estimated from laboratory-based accelerated testing, whereas live monitoring via sensors could allow far more accurate lifetime and maintenance data, facilitating early failure detection. Development of techniques to assess the 'aggressivity' of an environment are also being considered to determine the presence and effect of different building geometries on localised environmental conditions. It is hoped this may lead to an improved understanding of why organic coating failure occurs in certain building locations more prominently.

So far, Tim has begun a long-term monitoring experiment that aims to measure environmental factors such as humidity, temperature, time of wetness, and particulate build up in different locations across a building façade. This is paired with a number of coated and uncoated metal samples, with the intention of indicating the failure method and time in each location and, if this varies significantly, which factors are contributing to this. The image included below shows this set up, highlighting conditions on the exposed face, slightly sheltered face, and sheltered soffit region of a building.

Tim has also developed multiple sensor ideas which are in various stages of development. The most promising of these is an antenna-based RCS (radar cross-section) sensor; this is a passive reflector tag which resonates at a frequency defined by the coating material it is tethered to. If the properties of the coating or substrate change, the resonant frequency shifts and hence degradation can be determined.

If these sensor technologies prove effective then they will offer a great potential in terms of accurately monitoring integrity of coated products, and thus providing insights into not only the viability of warranty accompanying the products, but into appropriate coatings selection based on environment and location.

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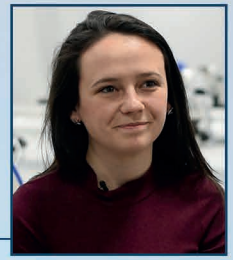
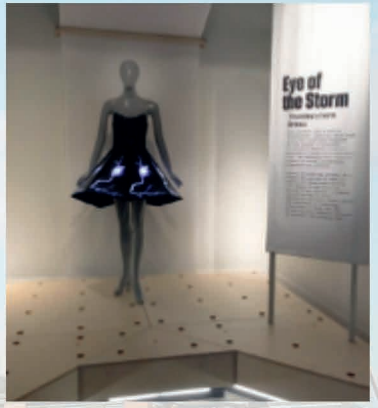
THE THUNDERSTORM DRESS

Sponsor Research Engineer: Caitlin McCall

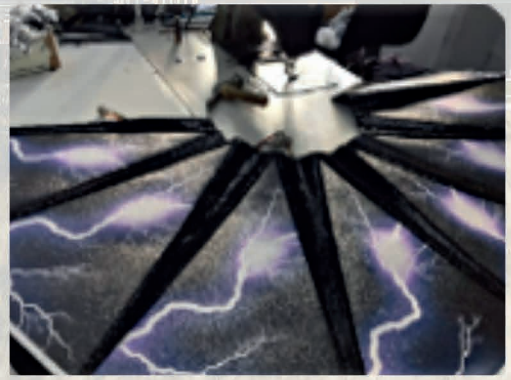


Impact Summary



Caitlin McCall, whose EngD project in conjunction with icmPrint, focused on the printing of intelligent packaging technology targeted towards food products. Alongside this, Caitlin worked on a project with a London fashion designer, Amy Winters. For this collaborative aim, Amy asked to update a design concept known as 'The Thunderstorm Dress' for the 2019 'Wired to Wear' Exhibition in the Chicago Museum of Science and Technology.

This work implemented novel printed micro-LED's from Nth Degree Technology to replace the previously used electroluminescent technology. The need to replace this prior solution was driven by the bulky high voltage battery that powered the electroluminescent lights. This previous construction had been useful for marketing videos and exhibitions however, this was not a practical solution as a wearable technology. Instead, the team worked to use the printed micro-LED technology to create lightweight panels that could be integrated into the dress. These panels were powered by a small lithium polymer battery that was sewn inconspicuously into the dress hence, making it suitable for catwalks.



The printed micro-LED's came in strips which were fastened to the inside of triangular panels and were programmed to light up in sequence. With an overlay of an image of a thunderbolt, the panels, when turned on, gave the effect of a thunderbolt lighting up across the dress. Eight panels were created and sewn into place on the dress with leather panelling and a leather bodice. The thunderbolts were programmed to be triggered by noise.

This acted as a prime example of how printed electronics can be used. The solution provided a lightweight, low voltage, small battery solution to create a truly wearable piece of haute couture and was on display in the Chicago Museum of Science and Technology in the 2019 "Wired to Wear" exhibition. This project work was then presented at the IARIGAI 2019 and E-Textiles 2019 conferences.

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Advanced Packaging Solutions for Shelf Life Management within Fresh Food

Sponsor Research Engineer: Alaa Alaizoki
Sponsoring Company: Klöckner Pentaplast
Academic Supervisors: Prof. Davide Deganello, Dr. Christopher Phillips
Industrial Supervisor: Craig Hardwick

Project Impact

Perishable and liquid-exuding food, such as red meat, poultry, fish and seafoods excrete aqueous juice into plastic packaging trays during their shelf life. This has a negative impact on safety, quality, and presentation of the packaged food. It also involves environmental challenges due to non-recyclable absorbent food pads used to soak the excessive liquid in the plastic trays. Klöckner Pentaplast is a global supplier of sustainable plastic packaging products for different sectors, including food and pharmaceutical packaging. It gains €2 billion in revenue per year with 20 manufacturing sites for food packaging across the world in 14 different countries. This research project has resulted in developing new technology for improving liquid retention in the plastic packaging trays. The invented technology is based on using the sharp raised rim of capillary recesses to enhance their liquid retention capacity. The new plastic trays with the adopted technology has been patented and the final trays are in release. Moreover, new ideas and solutions are currently being explored.

Invented packaging solutions

Raised peripheral rims were introduced to capillary recesses moulded on the bottom wall of plastic trays to improve their liquid pinning phenomenon, enabling larger quantities of liquid capture. Without using any non-recyclable components, the invented tray has a comparable capacity of liquid retention to the conventional absorbent meat pads; this avoids the use of large quantities of these pads, which end up as landfill waste (~750 million pads/year in Australia & New Zealand alone). Therefore, the new invented food trays will ensure production of millions of fully recyclable trays suitable for packaging of meat products. In the light of annual massive production of plastic food packaging, the fully recyclable food trays are eco-friendly and have low carbon footprint.

Another invented tray will be disclosed soon after being patented. It will also be a fully recyclable tray with increased capacity to retain and isolate the food exudate.

The competitive advantages and impact offered by the new liquid-holding food tray include:

- Fully recyclable materials. Easily cleaned and prepared for subsequent recycling processes (Avoiding any use of absorbent food pads)
- Low cost: no additional materials nor labour (reduced manufacturing and labour cost)
- Attractive and hygienic presentation
- Eco-friendly and conforming with new environmental legislation and governmental policy towards greener food packaging
- Economic benefit to the manufacturer by recovering the used plastic packaging based on its sustainability strategies
- Promote consumers' awareness of needs to protect our environment and reduce wastage

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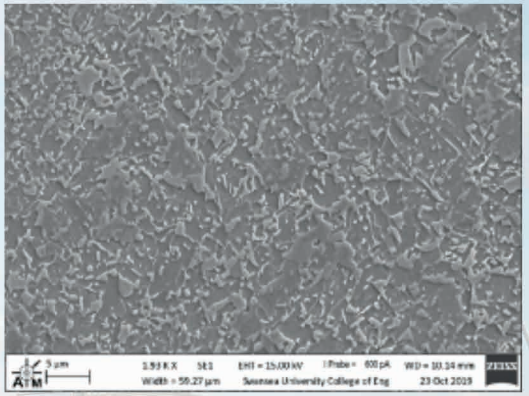
Galvanised Ultra High Strength Steels for Cold Formed Automotive Body in White Applications

Sponsor Research Engineer: James Ayres

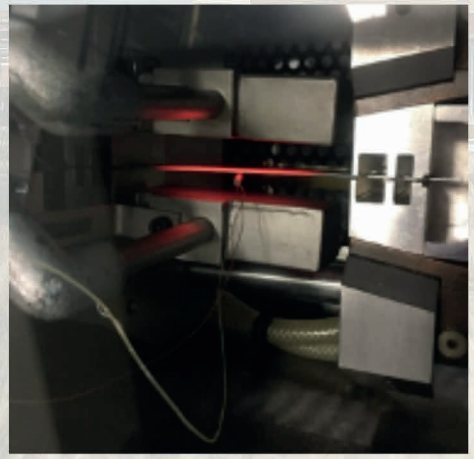
Impact Summary

This project is primarily looking at the role of silicon in dual phase steels. Three 50kg casts of DP800 material has been produced, with varying silicon content from 0% to 0.4%. It has then been rolled and annealed following typical industrial mill practises. The material has undergone testing to see the effect that silicon has on the final mechanical properties, with a focus on the bake hardenability. Further testing will look at the effect silicon has on liquid metal embrittlement (LME) of this material once it has been galvanised, an effect which can cause premature brittle fracture during resistance spot welding. The final aspect of this project is to create a viable galvanised and uncoated DP1000 product utilising a grade chemistry currently processed through Tata's plant in IJmuiden.

One of the noted benefits of the project this year was related to the DP1000 grade. Ongoing testing suggests that there is scope to rationalise the steel grades being produced in Tata Steel Europe, and in theory shorten the lead time for the material to be produced to satisfy the demand in the UK.



DP1000 material under SEM



Gleeble annealing DP1000 samples

Upcoming work is focussed on the development of a high yield DP1000 variant. If this can be produced successfully, it will satisfy an ever-increasing customer demand in the automotive industry for this product, as well as adding to the portfolio of advanced high strength steels available in the UK.

At the end of this project there should be a greater understanding of the role that silicon is playing in the effect of bake hardenability, potentially identifying a chemistry that can improve both bake hardenability of DP800, whilst maintaining the other critical mechanical properties that the material needs to achieve.

There have been limited research into silicon's effect in LME during spot welding. As more advanced high strength products come to market with increasing alloying content, in particular silicon, an understanding of how silicon behaves during the welding process could provide an insight as to whether silicon plays a role in LME. This can then be applied to the development of the next generation of advanced and ultra-high strength steels.

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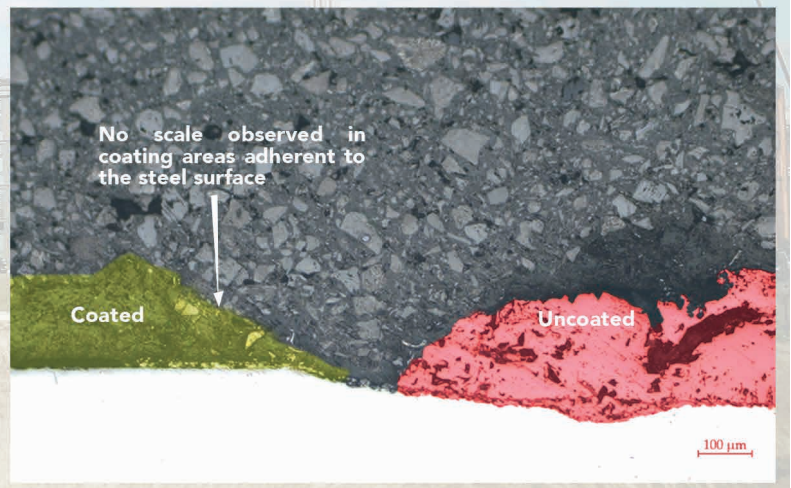
Development of Novel Solutions for the Improvement of Pre/Post Heat treatment of Carbon Steel Conveyance Tubes.

Sponsor Research Engineer: James Grant
Academic Supervisor: Dr Amit Das, Industrial Supervisor: Dr Chris Owen

TATA Steel Corby manufacture Carbon Steel Conveyance Tubes, using a high frequency induction process to weld the two edges, producing a Heat Affected Zone (HAZ) of a dissimilar microstructure to the bulk material. This HAZ is mechanically weaker than the rest of the tube materials and more susceptible to aqueous intergranular corrosion. A normalisation process is utilised to nullify the HAZ. However, this process leads to the production of scale on the tube surface. This scale consists of high-quality grade steel then lost to the process.

The project aims to introduce a coating to prevent high temperature oxidation of the product during the normalisation cycle and through so doing, improve surface condition of the tube.

Quality Grade Steel lost to oxidation Significant Yield loss due to this reheating process



Industrial Impact

Laboratory investigation of selected coatings is ongoing. These coatings, when applied to steel grade coupons from the mill undergo a heat treatment cycle. Subsequently, the oxide layers so formed are characterised using SEM techniques. Initial outcomes suggest a significant reduction in scale can be achieved by the application of a cheap phosphate solution incorporating recycled glass powder.

Future work will focus on optimisation of hybrid coatings to achieve the maximum possible oxidation reduction across the product range. The research has broader application across the sponsor's business, with a small-scale trial planned for the Hot Mill in Port Talbot.

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New-concept Rechargeable Batteries for Large Scale Energy Storage

Sponsor Research Engineer: Marcin Orzech

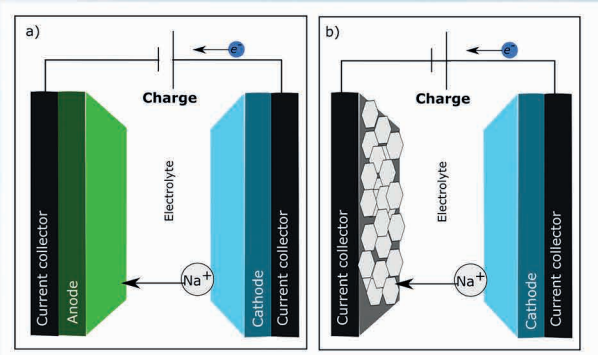
Background

Worldwide demand for electric energy continues to grow and at the beginning of his project demand was projected to double by 2050. Provision of an inexpensive energy storage mechanism is key to meeting this increased demand.

Sodium-ion batteries show promise as a technology for large scale stationary energy storage, facilitating wide implementation of renewable energy sources into the grid.,

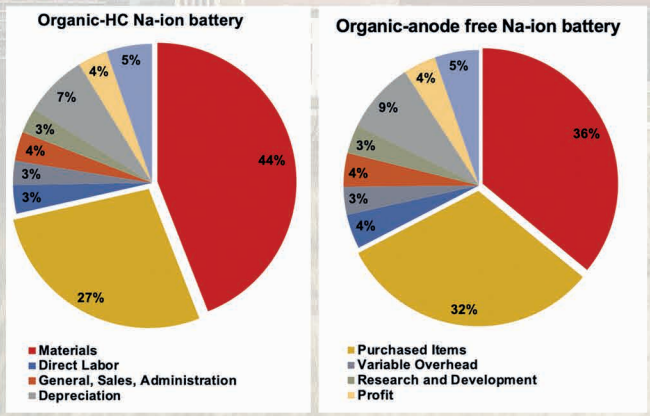
The major advantage of sodium-ion batteries (SIBs) over lithium-ion batteries (LIBs) is the abundance and lower cost of raw materials. The LIB's main electrode materials (Li, Co etc.) are both scarce resources and difficult to recycle, calling into question their long-term sustainability.

This research has focussed on delivering a Sodium-ion cell with potential for upscale to mass manufacture, through finding efficient, reliable, and low-cost anode material, electrolyte, and compatible cathode materials.



a) Scheme of conventional Na-ion battery; b) Scheme of anode-free Na-ion battery

Impact



A comprehensive analysis of electrode materials and electrolytes has contributed to knowledge of Sodium-ion batteries.

Results suggest the use of organic materials in electrodes are an attractive low-cost sustainable choice for batteries. Additionally, the work has demonstrated anode free Sodium-ion batteries to be capable of achieving energy densities comparable with that of a Lithium ion battery.

The impact arising from this research is therefore two-fold. There is an Environmental Impact through reduction in usage of scare resources (sustainability) and their replacement with materials abundantly available and easier to recycle. Secondly, Financial Impact delivered through the incorporation of lower cost materials into the battery, whilst maintaining the required energy density.

The sponsoring company has moved to patent the technology and intends to move the project forwards towards manufacturing. For this reason, we are unable to estimate the value of the financial impact, at the time or writing.

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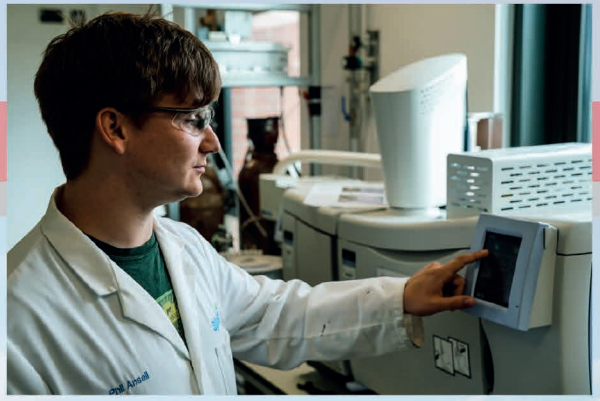
COATINGS TO PREVENT CORROSION

- PHIL ANSELL



Before I started the EngD I was working in Cardiff Bay in the service industry as a bar man, a supervisor, barista, chef and pot wash. Anything to keep my self-engaged and prevent myself falling into a boredom induced bouts of depression. I found this role to be personally dissatisfying as a graduate with a 2.1 BSc in chemistry and few employment prospects in relevant industries within the region.

Having completed an MRes and an EngD within the Materials Academy, I have recently moved into a new job as AkzoNobel sponsored technology transfer fellow in Swansea University. AkzoNobel, the industry sponsors of my EngD, is one of the top coatings producers in the world and a major manufacturer of specialist chemicals. It is now my role to manage the technical relationship between AkzoNobel and Swansea University. This involves thinking of innovative new ideas and avenues of research to pursue which will lead to new globally leading coatings to prevent corrosion, and overseeing existing and future research projects within the materials academy which compliment AkzoNobel's planet possibleTM approach to sustainability. My research aims to develop green, environmentally friendly and sustainable alternative coating additives which replace the toxic, carcinogenic and environmental damaging additives currently used in coatings for corrosion inhibition. I am also responsible for training and maintaining specialist analytical devises which were designed and built by Swansea University. This role I find to be extremely interesting and engaging. It not only allows me to build on the research and expertise developed during my EngD which is academically stimulating whilst enabling me to contribute to solving real world environmental problems, but also enables me to affect the people pipeline by bringing new EngD graduates through the M2A scheme on AkzoNobel sponsored projects to create more doctoral graduates with the skills to support much needed change through collaborative R&I with industry.

Through my EngD I have developed a myriad of transferable skills and specialised knowledge which have made me much more employable, and suited to the highly skilled position I now hold. The EngD involved taught modules with include specialised technical subjects targeted for my research project (e.g. Steel Processing Technology, Corrosion and Coating, Advanced Steel Metallurgy and Electrochemistry) as well as modules focused on continual professional development (e.g. Interpersonal Skills for Engineers, Financial Issues for Management, Investment Appraisal in Engineering and Ethics in Engineering). Also working closely with industry in academia on prevalent industrial problems has given me real world problem solving skills alongside an academic depth of knowledge. Upon completing my EngD I was head hunted for three jobs in engineering fields. I was delighted to have so many fantastic employment options which came as a direct result of my participation in the materials academy EngD scheme. I was delighted to accept my current role as my favourite option (although the lowest paid one!) because of my passion and interest for the research I began in my EngD and continue to pursue on behalf of AkzoNobel.

The scheme has changed my life entirely. I am now a world leading expert in corrosion and electrochemistry. I have spoken at an international world leading corrosion conferences on the research I conducted throughout my EngD. I am most proud of the positive environmental impacts which my research in anti-corrosion will bring and my contribution to a solution to a critical global industrial problem i.e. the inhibition of corrosion without toxic and non-REACH compliant inhibitors. Corrosion related issues cost 5% of the worlds GDP. Using our materials efficiently, particularly metals is a global sustainability issue. Achieving longevity for metal products through corrosion inhibition is therefore essential for global sustainability. The most widespread and effective corrosion inhibitor to date is toxic, carcinogenic and environmentally damaging. The REACH directive has prohibited it use and rightly so.

During my EngD research I have developed and tested several viable, green, sustainable and environmentally friendly replacements. I am also proud of the 3rd year students which I had the privilege of mentoring.

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R&D AT THE STEEL AND METAL INSTITUTE

- CARLOS LLOVO-VIDAL

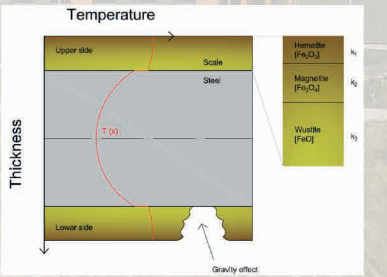
It was in Vigo, a traditional shipbuilding and automotive area in the north of Spain, where I studied my Degree in Mining Engineering and realized that I wanted to become a materials professional. Metallurgy and manufacturing processes have been areas of great interest for me during this four-years educational period. Among all, steelmaking has been specially interesting for me. The wonderful image of the hot metal being cast and hot rolled impressed and challenged me, and soon decided that I wanted to know more about it.

After finishing my degree, I got my first job as a research engineer in a welding institute. A year and a half of research-oriented work caught my interest and defined my will of keeping working in a similar environment in the future. Having been working for a while in welding research and with the aim of gaining new work and personal experiences, I finally decided to search for job opportunities in the steel sector.

It was easy to find an adequate programme for me among the ones offered by M2A on their main webpage. The web's excellent look and organization and the strong industry links that Swansea University has with the surrounding industry encouraged me to apply for an MSc by research position. I decided to start with a project funded by Tata Steel, and I have been working on it during almost the last 9 months.

The choice could not have been better. Since I joined the programme I have been given autonomy and freedom for managing and designing my project, accompanied by a high qualified and friendly supervisory team. A large amount of resources has been available both at University and Tata, allowing me to conduct high quality experimental research. Not only did I improve my work-related skills but also, I had the opportunity of improving my English language and personal skills through the diverse personal development activities that M2A organized during the course. Conferences helped me gaining confidence and fluency when presenting my work, and teambuilding events such as the Annual trip were both funny and stimulating, giving invaluable outputs in terms of networking and personal development.

Tata Steel and Swansea University when I gained a position on Tata's Graduate Scheme in July 2018, with the aim of starting in my new position in October. This excellent opportunity will give me the chance of joining the R&D team in the new Steel and Metal Institute, where I will work in different kind of research within the industry. This will imply much more contact with plant reality, thus expanding my understanding of the steelmaking processes. No better way of gaining understanding of how the steel works manufacture the products than physically seeing them, so I am very grateful for the opportunity that has been given to me. Swansea University facilitated my job insertion by giving me the chance of working together with Tata staff in my MSc project and thus showing my skills to them. This is common to all the research programmes offered by M2A, and it is in my opinion their most interesting feature.



Last but not least, the Swansea area has been shown to be a very nice place to live, with outstanding natural locations nearby and plenty of activities to do. I have met very good friends and I am looking forward to staying here a bit more and starting a new stage in my new job position.

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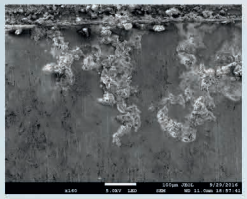
DEVELOPING FUTURE CORROSION RESISTANT COATINGS FOR FOOD CANS

- JAMES EDY

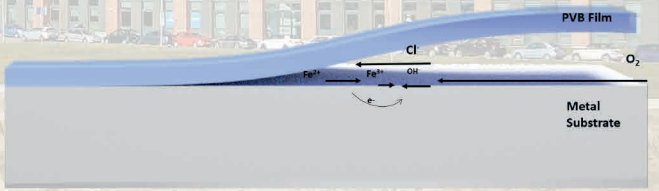
Although the humble 'tin can' is seen by many as a consumable that is simply tossed into the recycling, much research has gone into the coatings to ensure that the contents are delivered in a fresh and safe condition. Although the system hasn't seen major change in decades, the coating is going through some major changes that will see millions of cans produced with new updated coatings, all with the main aim of the consumer experiencing no difference what so ever. So why is there such a change afoot? The answer is the REACH legislation that has identified the requirement to phase out the use of hexavalent chromium (VI). Up until now the packaging sector has not seen such a major change since the 1960's when Electrolytically Chromium Coated Steel (ECCS) was developed as a result of rapidly increasing tin prices. ECCS is now being phased out due to the use of Cr (VI) in the manufacturing process. Much work has been done to identify alternative materials for its replacement such as titanium and zirconium however the most promising coating is indeed still chromium, albeit the trivalent variant Cr(III).



Tata Steel have been developing a new coating referred to as Trivalent Chromium Coating Technology that uses a plating bath containing Cr(III) ions that offers a solution to the challenge of replacing ECCS. There is a perfectly good reason why ECCS has not been replaced since the 1960's – it works extremely well, both from a corrosion perspective but also as a substrate for lacquers to adhere to due to its chromium/hydrated chromium oxide structure.

Tata Steel have been sponsoring Swansea University Researcher James Edy to assist in the development and characterisation of the coatings with a particular emphasis on corrosion, an expertise offered by the materials engineering group. James has been carrying out testing, utilising the advanced scanning techniques available at Swansea University, to identify how the coating performs under two main corrosion mechanisms; cathodic disbondment of organic coatings and filiform corrosion – both known problems that could plague the new coating. The research has focussed on a number of Cr(III) coating variations, in particular chromium and chromium oxide levels. His research has turned out many interesting findings and has identified that a critical level of both components is required to produce a coating that can offer comparable performance to ECCS.

This information is now being used by Tata Steel to make changes to their processing parameters to hone their coating to meet the requirements identified by James as the product is scaled up from lab scale to full production – a market potential of hundreds of thousand tonnes/ year. Without such advanced testing and the knowledge from the corrosion group, the end product could have been significantly different and arguably less corrosion resistant. The success of the project has led to Tata sponsoring further EngD's as they continue their work developing the new



Ultimately, over the coming years you will most probably open a can that has been influenced by the research carried out at Swansea University.

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MATTER Manufacturing Advances Through Training Engineering Researchers

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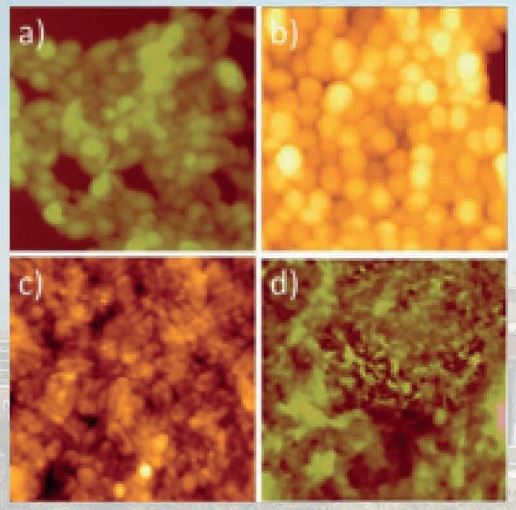
AFM, BACTERIAL ADHESION, AND THE APPLICATION OF NOVEL BIOCIDES

- SEAN JAMES

Before joining the M2A I was working as a quality analyst for Severn Trent Water at the Shrewsbury WTW. My role in this position was to process and analyse potable and raw water sources from throughout the Severn Trent territories. While this job was rewarding the technical progression was limited, it was for this reason that I chose to peruse the M2A scheme.



Following completion of my Eng.D. studies I am now working as a Research Manager for my sponsoring company Hybrisan Ltd; which was co-founded by another Eng.D. alumus Dr. Lee Bridgeman. The M2A scheme has proven invaluable in facilitating this transition for both myself and Hybrisan Ltd. With regards to Hybrisan the M2A scheme has produced a candidate of suitable calibre to allow for the knowledge and expertise generated throughout the project to be retained. For myself, the M2A scheme offered me numerous opportunities for continued professional development hence, preparing me for both the technical and managerial aspects of the role.

The Eng.D. has improved my employment prospects exponentially due to the numerous opportunities both academically and managerially for continued professional development. Academically speaking the M2A scheme has allowed me to become a leading expert in AFM, bacterial adhesion, and the application of novel biocides; as demonstrated by my publication history and invitation to review a paper for a notable journal. Furthermore, the M2A scheme has provided me access to numerous forums on which to discuss and present my work on both local and international stages, most notably in my trip to the IBBS in Dublin wherein I gave a keynote speech on the biological applications of AFM. With regards to professional development, the M2A scheme has allowed me to develop my managerial skills, through a number of managerial modules, as well as my knowledge of IP protection and its relevance to business.

Subsequently, the M2A scheme has allowed me to progress my career to a point wherein I am perfectly suited to facilitate the transfer of my academic research from an academic environment to a commercial one.

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SCIENCE CASE STUDY

Investigation into the corrosion mechanisms of next generation protective metallic coatings (ZMAs) for steel

Tom Lewis
Industrial Sponsor – Tata Steel
International Collaborator – The French Corrosion Institute

Tom has been investigating the metallurgy and corrosion behaviour of a new generation of functional coatings designed to sacrificially protect steel products. The new alloys (ZMA1 -3) are composed of Zinc with alloying additions of Magnesium and Aluminium ranging from 1 – 3 weight % of each element and offer improved corrosion performance and cost benefits over coatings based on Zinc alone. Tom's work has focussed on the application of novel techniques to assess the fundamental corrosion mechanisms at a microstructural level and rates of material degradation related to alloy content. A new time lapse microscopy technique developed at Swansea University permits corrosion to be imaged at a microscopic level whilst a sample is immersed in electrolyte (1% NaCl). Using this technique, it has been observed that corrosion preferentially occurs in the eutectic phases of the alloys' microstructure in regions that are rich in Magnesium intermetallics ($MgZn_2$) as shown in figure 1.

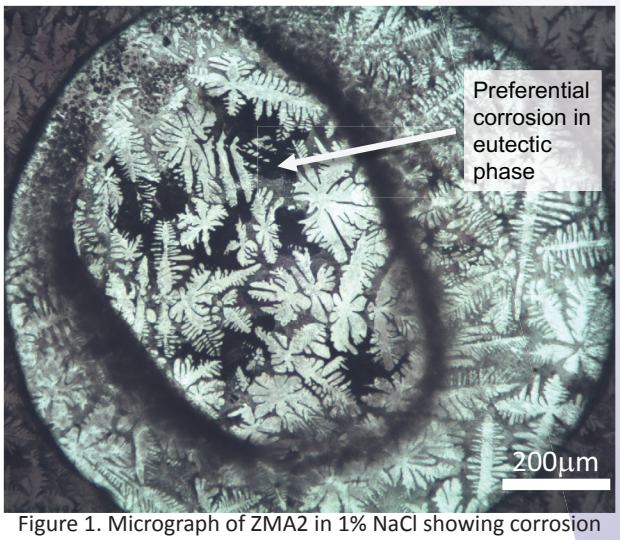

Figure 1. Micrograph of ZMA2 in 1% NaCl showing corrosion preferentially occurring in areas of the coating microstructure rich in Mg.

Through image analysis the corrosion rates have been determined for samples with increasing Mg and Al levels between 1 - 3 weight % and it was observed that the corrosion rate decreased as the alloying levels were increased as shown in figure 2.

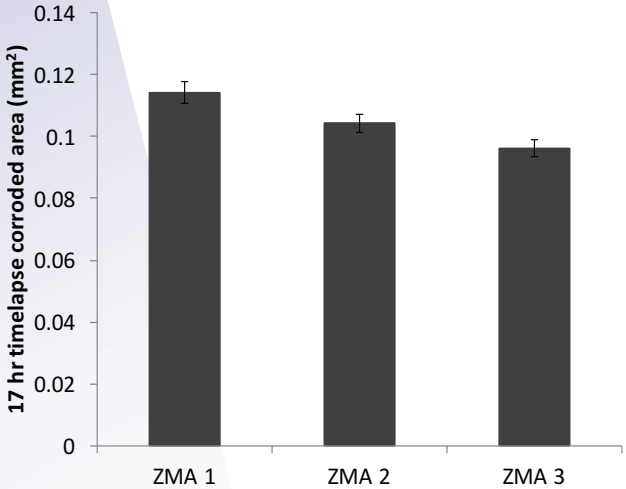

Figure 2. Graph showing that corrosion rate of the ZMA coatings decreasing with increasing Mg and Al alloying levels (ZMA 1 -3).

Scanning vibrating electrode technique (SVET) experiments were also carried out on the samples, a technique that maps corrosion spatially and in a time resolved fashion and this data confirmed the change in corrosion rate observed from the novel microscopy experiments. This data has been published in RSC Faraday Discussions[1] and formed the topic of a talk to the Corrosion Chemistry meeting of Faraday Discussions in April 2015. This investigation has also been presented at the largest electrochemistry conference in the world (PRiME 2016, Honolulu, Hawaii) and the research has formed the foundation of a funded Research for Coal and Steel European Consortium project (Microcorr) involving three steel companies and Academic groups from across Europe.

[1] Faraday Discussions, 2015, 180, 361-379, James Sullivan, Tom Lewis, Nathan Cooze, Callum Gallagher, Tomas Prosek and Dominique Thierry, DOI: 10.1039/C4FD00251B

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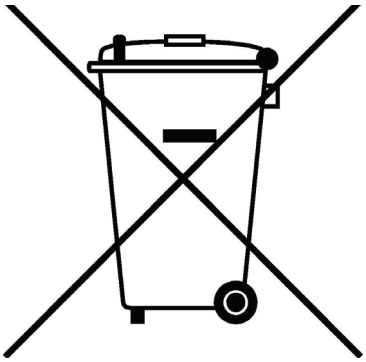
SCIENCE CASE STUDY

From e-waste to green energy - An investigation of trends in precious metal and copper content of RAM modules in WEEE: Implications for long term recycling potential

Rhys Charles
Industrial Sponsor – Metech



Rhys graduated from Cardiff University in 2007 with a 1st class BSc in Chemistry. After spending time working in waste management, Rhys enrolled in the COATED CDT working on a project sponsored by Metech examining the how to utilise waste electronics to recover precious and heavy metals for use in coatings in solar cell technology[1]. Here, Platinum from waste electronics was recovered as chloroplatinic acid, a critical chemical used in the manufacture of dye sensitised solar cells where it is used to deposit an optically transparent layer of Pt that catalytically controls chemical reactions permitting energy generation from such devices. He has since presented at 7 conferences and published a paper in a leading journal of the field[2].

Waste Electrical and Electronic Equipment (WEEE) is the fastest growing waste stream on the planet with global generation reaching 41.8 million tonnes per year in 2014. It is predicted to increase by 3 -5% annually and accounts for 5% of all municipal waste. Often critical materials such as gold, palladium, copper and silver exist in higher proportions in WEEE than in their naturally occurring ores and is thus a valuable source of such elements that have critical usage in the new generation of flexible solar cells for the construction sector. In Rhys' latest paper[2] he examined Dynamic RAM placed on the market between 1991 and 2008. The anatomy of a DRAM module in terms of metals is shown in figure 1. The miniaturisation and thrifting in manufacturing makes predictions of recycling rates of WEEE difficult. Rhys used Atomic Absorption Spectroscopy and image processing to conduct a linear regression analysis of compositional data ordered according to sample chronology to identify historic temporal trends in module composition resulting in changes to manufacturing processes. He found that quantities of metals such as gold and silver remained stable over the years and are likely to remain that way. Palladium is predicted to fall amount whilst copper is expected to increase by 75%. Rhys noted that changes away from PCs towards tablets and phones coupled with a greater reliance on cloud based data storage will help to drive the miniaturisation of WEEE.

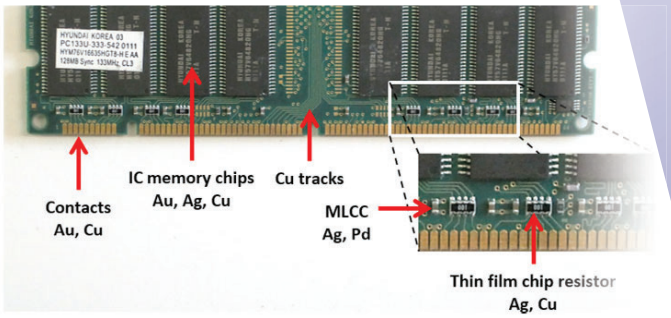


Figure 1. Anatomy of a DRAM module

Rhys' expertise has been utilised by the Welsh Government to inform policy on circular economy and he was also invited to the "APSRG Parliamentary debate" on the recast of UK WEEE regulations that led to participation in EU policy consultations in Brussels.

[1] https://www.youtube.com/watch?v=ptE1B-_hyXE
[2] Waste Management, 2016, article in press, DOI: 10.1016/j.wasman.2016.11.018

Scan for reference 1

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STUDENT CASE STUDY

DES BRENNAN

Industrial Sponsor
Tata Steel Colors

TATA STEEL

Des studied a Physics BSc at Cardiff University and during his studies witnessed his fellow students experience industrial placements during their undergraduate studies. Des wanted a similar experience for his postgraduate degree and was attracted to the COATED CDT Engineering Doctorate scheme at Swansea University due to the excellent links with industry, in addition to the CDT's training modules that he felt would prepare him for a leading technical role in industry. Des successfully applied and secured a place in the CDT with a view to applying his pure science background to real world issues to enhance his future employability.

Des' project, sponsored by Tata Steel Colors, investigates the 'up-scaling of concepts from lab to market place' and has provided him with the opportunity to apply his Physics background to an industry process to improve productivity. This has involved the modelling and experimental testing of near infra red curing technologies for rapid functional coating production for the construction sector. Not only this, Des has applied this industrial technique to new Photovoltaic functional coatings being developed at Swansea in order to help reduce their potential manufacturing time from 30 minutes to a matter of seconds.

The CDT has afforded Des with numerous academic and industrial experiences that he may not have obtained outside of the CDT. He spent much time at Tata Steel in the Netherlands to experience and investigate the curing properties of their industrial near infra red curing furnaces. His research has been presented at Materials 2016, an International conference in Dubai, as well as ACME 23rd Conference in Computational Mechanics 2015 in Swansea. As a result he was invited to write a paper on 'Mathematical framework for predicting the thermal behaviour of spectrally selective coatings within an industrial near-infrared furnace' in a special edition of the European Journal of Computational Mechanics.

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STUDENT CASE STUDY

Elinor Winrow

Industrial Sponsor
Bill and Melinda Gates Foundation

BILL & MELINDA GATES foundation

Elinor first decided to become a scientist 8 years ago, when a she attended a Swansea University outreach event focused on Women into Science and Engineering (WISE). The WISE event encompassed six different areas of science with her favourite being based on the popular TV programme CSI, where materials science and chemistry were used to solve a crime.

The outreach activity at Swansea was so successful it captured her imagination, so much so that Elinor decided that a career as a scientist was the only option for her. Since then Elinor has tailored all her studies to this effect undertaking a Chemistry degree at Plymouth graduating with a 2:1 in 2016. During her final year of her undergraduate programme Elinor was motivated to explore postgraduate studies and her previous experience at Swansea University led her to apply for a project in the COATED2 CDT.

It was quite a shock for one of the interview team when Elinor walked in! She was successful in her application and has now started an EngD with the Bill and Melinda Gates Foundation based on renewable energy. The project involves the evaluation of human waste streams for energy storage and the development of coatings systems in combination with organic waste matter as a thermal storage system for developing countries.

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USER CASE STUDY

HYBRISAN

Sponsor Research Engineer
Sean James

Assessment of the bactericidal activity of a novel polymeric biocide for coatings

Biofouling affects a broad range of industries from petrochemical to health sectors. Of the numerous adverse effects caused by the accumulation of biofilms two are of particular concern; microbial induced corrosion (MIC) with rates of 3mm per month reported within stainless steel systems, and, medical device colonisation a leading cause of nosocomial infection.

Sean has been working alongside Hybrisan to elucidate the mechanism through which a novel polymer based biocide can be implemented to control bacterial adhesion, prevent biofilm maturation, and destabilise established biofilms. Using classical microbial culturing techniques in conjunction with advanced microscopies, including: Atomic Force Microscopy (AFM) and Confocal Scanning Laser Microscopy (CLSM), Sean has been able to characterise both the minimum inhibitory and toxic concentrations as well as modification in bacterial surface charge and polarity. Further investigation into early biofouling events, in particular initial bacterial adhesion has implicated the biocide in the prevention of conditioning layer deposition and therefore biofilm formation.

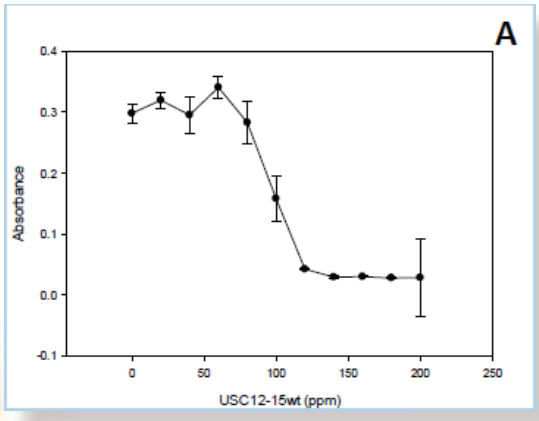

Figure 1. Graph showing the inhibition of microbial growth with increasing concentration of USC polymer biocide

The Industrial Impact

As a result of the information gained from this research Hybrisan have been able to refine their commercial product to the point that it has been accepted for trials at a large multi-national coatings manufacturer. Following a successful trial, it is hoped that this will lead to further contracts and the growth of this novel biocide product.

In addition, through their engagement with the COATED CDT, Hybrisan developed a working relationship with Tata Steel to evaluate their products in the water treatment facility at Tata Steel, Port Talbot. This business opportunity directly resulted from networking opportunities afforded through support of the CDT.

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USER CASE STUDY

TATA STEEL

TATA STEEL

Prof. Martin Brunnock
Manufacturing Director
Tata Steel Strip Products UK

Sponsoring projects across the COATED CDTs

Tata Steel employs over 15,000 people in the UK with approximately double that number working in the supply chain. It contributes over £2 billion per annum to the country's economy and is especially important to the regions where the production activity is based. Steel finds itself in a plethora of applications, each with its own challenges and requirements. Over 1000 tons of British made steel was used in the Shard building in London. Wembley and the Millennium stadium are clad in organically coated UK made steel. Nissan, Mini, BMW plus a number of other companies in the automotive sector all utilise steel manufactured in the UK. In the home, food cans, washing machines, dishwashers along with other white goods are produced using UK coated steel. If it is not made of steel, it will have been made with steel.

It is therefore unsurprising that we at Tata Steel have long been a supporter of the Engineering Doctorate training programmes at Swansea University in all their incarnations. Since its inception in 1992, EngD REs have worked on almost every aspect of the process and have been instrumental in the majority of new product developments. There are numerous examples including; research by EngDs to improve the corrosion resistance of our premium organically coated steel product allowed us to offer 40 year guarantees, something no other company could do at the time. Solving the problem of PVC plastisol coating discoloration and loss of adhesion saved the company £millions in potential complaints. Process models that elucidate conditions within the blast furnace have helped us improve efficiency. Scale reduction research helped win back a large customer who had left because of poor surface finish. The human capital produced by the EngD has been a talent pipeline for the business and we now have around 70 former EngDs working within the company, many in high level positions (including myself).

The more recent COATED CDTs have supported our aspirations to grow our value added products and diversify the markets and applications we supply to. Coatings are a vital part of our product and process mix. Our coatings plant in Shotton, Deeside produces over 100 million m^2 of coated steel products each year. The value of 20 tonne coated coil is commensurate with the value of a medium sized hatch back car. High quality functional metallic coatings allow us to sell steel for around £200 per tonne more than standard hot dip galvanised steel. Even incremental improvements in these areas can have a huge financial impact. Construction is another area where the COATED CDTs are providing critical support. We are currently sponsoring numerous EngDs through the COATED CDTs allowing us to explore more novel products and exciting science that can add value to our steel. Such research areas include flexible next generation photovoltaics for roofing, hydrophobic coatings, chrome free corrosion inhibitors, advanced metallic coatings, photo-degradation prevention, energy storage systems and many more. The research supports our UK plants and critically the CDT provides us with a talent pipeline for our future workforce who'll have in-depth understanding of functionalised coated steel products.

The CDT's use of industry and EPSRC funds to leverage Welsh European funds is another huge attraction for us. Coatings are a large part of our business but we also have a need for researchers in other areas such as process modelling, steel metallurgy and mechanical properties. The Advanced Materials and Manufacturing CDT, achieved through the leveraging of our funds, has been vital for our technological development outside of coatings.

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ALUMNI PROFILES

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Alumni Profiles

I was fortunate to have the opportunity to study for an Engineering Doctorate (EngD) at Swansea University in Materials Engineering, funded through the M2A scheme. My research focussed on the development of batteries for the storage of renewably generated electricity in buildings and commercial spaces. The scheme gave me exposure to the world of academia, input from an industrial sponsor, and a wide variety of taught courses on technical and interpersonal topics. Being in charge of my research, but with support available allowed me to develop time management skills which have since been invaluable.

Whilst initially daunting, the need to do a significant amount of background reading helped me to understand how to effectively and efficiently learn about any topic. It was through this demonstrated capability to quickly pick up and deliver technical expertise which led me to a job at an international supplier of aerospace components. There, I worked at the cutting edge to commercialise Additive Manufacturing (3D printing) technology. I was initially employed as a Materials and Process Engineer and was responsible for multiple customer focussed projects. By building upon professional development gained through the EngD scheme, I rapidly developed a reputation of being able to address complex problems such as how to demonstrate the integrity of printed components that were not suitable for traditional materials testing.

Finalising my doctorate alongside full-time employment presented significant challenges, but my employer was supportive, and once my doctorate was awarded I was able to successfully apply for Chartered Engineer and Chartered Scientist registration. My doctorate formed key evidence of my professional development and was pivotal to earning this recognition.

More recently, I have started a new job to direct government funding in the field of 'Zero Emission Vehicles'. Whilst this is not my technical background, I believe that demonstrating my ability to master technical topics was essential in being offered the position. I now have to work with a variety of companies that have received funding and will continue to build my knowledge and expertise in the future of e-mobility. I am really enjoying my new role and whilst I only use the knowledge directly gained through my EngD occasionally, I use the skills that I developed through the M2A EngD programme every day of the week.

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Dr Alistair Barnes

Innovation Lead
Zero Emission Vehicles

Innovate UK

Swansea University
Prifysgol Abertawe

UKRI Engineering and Physical Sciences Research Council

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Alumni Profiles

I have been driven, from a young age, by a desire to understand how things work. My favourite childhood TV programme was Playschool, not for the stories that were told, but because when we went through the square, round or arched window there was a factory on the other side, making stuff. So, maybe it's no surprise that I chose Engineering when I went to study at Swansea University in 1993. An EngD in Steel Technology followed, which then naturally led to a career in Tata Steel. The EngD provided me not only with an excellent academic background but also introduced me to the application of engineering principles to real world situations which provided me with the foundation needed to excel within my career.

I now work as a Senior Manager in the Tata Steel organisation, focussing on product management and the development of the steels of the future, but have also had roles in Customer Support, Product Development, Supply Chain and Operations. Working in the Steel Industry has it's challenges, but it's difficult not to be excited by the sheer scale of the operations, from 300t ladles of molten steel to 24 wagon trains carrying steel coils destined for all parts of the UK and Europe.

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Dr Laura Baker

Head of Product Management & Development

Tata Steel

Swansea University
Prifysgol Abertawe

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I have always had an interest in engineering and initially undertook a Batchelors degree in Electrical and Electronic Engineering. Following the completion of the course I decided to enhance my knowledge base by undertaking a MSc in Nanotechnology. Having thoroughly enjoyed my course I'd developed a thirst for engineering research and decided to study for a doctorate. I chose the EngD at Swansea due to the prowess of the department but also due to the opportunities it afforded me to develop myself not only academically but also professionally through the training programme and close link with industry. I was lucky enough to be awarded a place and undertook a project examining the developments for anti-corrosive coatings. Through the course I was given the opportunity to attend a number of conferences around the world and also work closely with my sponsor, Tata, to gain an insight into how engineering influences large scale manufacturing. One of my memorable moments was assisting Tata with the selection of corrosion resistant coatings for the large gas tank that can be seen from the M4 motorway. Following completion of my EngD I was fortunate enough to be in receipt of a number of offers of employment and started the next phase of my career with General Electric (GE) as a Project Engineer, enabling me to apply the skills I'd learnt from my EngD into an industrial environment. I progressed with GE and subsequently took on a role with the Ministry of Defence as a Systems Engineering Manager. I have since progressed to my current position as Lead Cyber Security Consultant. As well as the close cohort and the travel opportunities during the course, I would have to say that the best part of the course being working very closely with my sponsor and developing my skills as an engineer – something that I still apply today in my role.

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Dr Jonathan Davies

Lead Cyber Security Consultant

Ministry of Defence

Swansea University
Prifysgol Abertawe

UKRI Engineering and Physical Sciences Research Council

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Llywodraeth Cymru Welsh Government

Cronfa Gymdeithasol Ewrop European Social Fund

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Alumni Profiles

Dr Natalie Wint

Lecturer in Materials Engineering

Swansea University

Having completed a degree in Physics at Cardiff University I decided that I wanted to study a discipline in which I could apply my knowledge. A year later I had completed an MSc in Materials Engineering at Swansea. The course gave me a taste of what it was like to work within the field of research and, inspired by the Corrosion and Coatings Group within Engineering, I decided to apply for an EngD. The scheme provided me with opportunities to travel and present at international conferences, publish three papers and to work closely with my industrial sponsor to solve an engineering problem. Exposure to the working environment allowed me to acquire the skills and knowledge needed to obtain my first job at Tata. Since then I have taken a Postdoctoral position in the USA, before coming back to Swansea where I am now a lecturer within the department. I would highly recommend the M2A scheme to anyone thinking of studying at postgraduate level. The College has a thriving PGR community and I really felt the benefit of the significant peer and academic support available.

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European Social Fund

TEAM MEMBERS

Professor James Sullivan	Director	j.h.sullivan@swansea.ac.uk
Professor David Penney	Director	d.penney@swansea.ac.uk
Professor Richard Johnston	Director	r.johnston@swansea.ac.uk
Dr Andrew Rees	Director	andrew.rees@swansea.ac.uk
Dr David Warren	Operations Manager	d.j.warren@swansea.ac.uk
Dr Vivienne Jenkins	Project Coordinator	v.e.jenkins@swansea.ac.uk
Dr Tom Lewis	Project Coordinator	thomas.Lewis@swansea.ac.uk
Dr Rhys Faulkner	Project Coordinator	r.w.faulkner@swansea.ac.uk
Mrs Beverley Williams	Office Manager	b.j.williams@swansea.ac.uk
Mr Paul Harries	Graphic Designer	p.a.harries@swansea.ac.uk
Miss Vicky Thomas	Finance Officer	v.j.thomas@swansea.ac.uk
Mrs Rebecca White	Administrator	r.j.white@swansea.ac.uk
Miss Hayley McAuliffe	Administrator	h.r.mcauliffe@swansea.ac.uk
Ms Joanne Peters	Finance Assistant	joanne.Peters@swansea.ac.uk

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