SEAM
ARC TRAINING CENTRE
Surface Engineering for Advanced Materials

Annual Report 2020

ARC Training Centre in Surface Engineering for Advanced Materials

We respectfully acknowledge the Wurundjeri People of the Kulin Nation, their Elders past, present and emerging, as Traditional Owners of the land on which Swinburne's campuses are located in Melbourne. We are honoured to recognise our connection to Wurundjeri Country, history, culture and spirituality through these locations, and strive to ensure that we operate in a manner that respects and honours the Elders and Ancestors of these lands.

We also acknowledge the Traditional Owners of lands across Australia, their Elders, Ancestors, cultures and heritage.

SWINBURNE UNIVERSITY OF TECHNOLOGY   RMIT UNIVERSITY   University of South Australia

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The ARC Training Centre in Surface Engineering for Advanced Materials (SEAM) is funded by the Australian Research Council (ARC) through the ARC Industrial Transformation Training Centre (ITTC) scheme via Award IC180100005. SEAM is a partnership between Swinburne University of Technology (host institution, headquarters to SEAM), RMIT University and University of South Australia, along with other collaborating organisations in Australia and overseas. We are grateful for the support of the industrial, university and other organisation partners who have contributed to the establishment of SEAM.

@arcseam @arcseam

DIRECTORS MESSAGE

2020 marked SEAM's second year in operation. We were excited to ramp things up. 2020 started off with the global conference on Materials Innovation in Surface Engineering (MISE) in Melbourne and concluded with our team growing: bringing us to a total of 19 chief investigators across three nodes, 18 doctoral candidates, ten postdoctoral fellows, six interns, one masters student, two new agreements; all totalling 15 core partners and 18 affiliate partnerships.

Chris C. Berndt
Distinguished University Professor, Director SEAM

We may look back at 2020 as the year of the pandemic and the changed way we worked due to the restrictions in access to laboratories. COVID-19 transformed the way we communicate and engage and showed us the strength and need for collaborations and team building. I am extremely proud to be the Director of a team that came together during the challenges of a global pandemic, and find new ways to grow stronger and build on its capacity to create foundations while still working towards exceptional scientific outcomes.

SEAM chief investigators in 2020 delivered a total of 285 research outputs including 211 journal articles in high impact journals, 29 conference publications, 28 published reviews, and was successful in issuing three patents. Our centre staff secured close to AUD $4,000,000.00 in additional research funding, and signed two new agreements with esteemed international institutions: The University of Nottingham and the American Welding Society (AWS) on behalf of the International Thermal Spray Association (ITSA), which strengthens our international outreach (see page 55).

While many of our research staff were not able to access laboratories, we were delighted to see some colleagues deep dive and showcase their research on mainstream news outlets. Dr Christiane Schulz (UniSA) and Dr Thomas Schlaefer (LaserBond) appeared on the evening 7-News for their work on mitigating the survival of the SARS-CoV-2 (COVID-19) virus on surfaces. Thermal spraying is especially suitable for the application of anti-viral coatings and these SEAM Investigators developed coatings for touch-surfaces such as door handles and rails by developing anti-viral coatings that can kill the virus in hours (page 52). Also, Professor Elena Ivanova (RMIT) was interviewed by the BBC Future program for her work on 'surfaces that kill bacteria and viruses'. Her research focused on stopping infections before they even get into the body and employed the creation of surfaces that mimicked the texture of insect wings or using new types of materials that kill or inhibit microbes. Two examples of amazing outcomes that are related to SEAM objectives!

Other staff were hard at work in ensuring that our laboratories are furnished with state-of-the-art equipment, which saw SEAM acquire the High Velocity Oxygen Fuel (HVOF) kit, an atmospheric plasma spray system, laser cladding equipment and a continuous impact abrasion tester, see page 50.

SEAM not only maintained but developed its resources across many sectors. SEAM staff were the driving force to create new ways to engage and, among many, launched the SEAM Webinar Series, hosting a range of speakers with a global audience reach (page 34). SEAM succeeded in sustaining active engagement with its Industry Partner Organisations and Associate Researchers as well as developing new relationships. Dr Rogerio Lima (National Research Council of Canada), Dr Steven Matthew (The University of Auckland), Dr Filofteia-Laura Toma (Fraunhofer Institute for Material, IWS), Professor Rhys Jones AC (Emeritus Professor, Monash University), and Associate Professor Justin Leontini (Swinburne) joined SEAM as Senior Associate Investigators.

International visits may have not been a reality but our relationship with our international community continued to strengthen. The 2020 SEAM Webinar Series debuted in July 2020. We ramped up immediately and hosted ten research presentations by SEAM Chief Investigators and invited leading international researchers (see page 39), as well as additional presentations by our staff members. Assuredly, SEAM succeeded in reaching out and bringing acclaimed presenters into our community.

The 2-year mark of SEAM is a milestone. SEAM has pivoted quickly and positively in response to a new, vibrant R&D landscape. SEAM has been a leader in the exploration of new frontiers in communication and the engagement of manufacturing research for industrial outcomes. We have leveraged the initial investments to build a collaborative environment. Opportunities have been uncovered for the industrial training of early career researchers.

In summary: SEAM has demonstrated success in creating a community of academicians, industrialists and managers who have a shared vision of 'SEAM Covers it ALL'.

Chris C. Berndt

Distinguished University Professor
Director
ARC Training Centre in
Surface Engineering for Advanced Materials
Swinburne University of Technology

CENTRE SNAPSHOT

Our 2020 Success

PhD researchers 18

Masters students 2

Interns 6

Postdoctoral researchers 10

Chief Investigators 19

Associate researchers 11

Partner investigators 21

Members 87

Industry placements 7

Public paper presentations 62

Public industry/community briefings 8

Journal articles 216

Conference/Industry publications 33

Patents 3

Peer/other review papers 31

Awards 4

Other accolades 4

Media related outputs 19

LinkedIn followers 474

LinkedIn page views 1,711

Additional Grant funding secured AUD$3.6M

ABOUT SEAM

The Australian Research Council (ARC) Industrial Transformation Training Centre in Surface Engineering for Advanced Materials (SEAM) is Australia's premier manufacturing Research and Development centre that focuses on applied research with tangible outcomes to nurture and cultivate the industrial innovation leaders of tomorrow.

RESEARCH THEMES

SEAM aims to solve crucial surface engineering problems, such as the design, fabrication, testing, analysis, and pathways towards value-added applications, all of which enable the Australian manufacturing industry to be more efficient and profitable in the global marketplace.

To spearhead enrichment of Australia's manufacturing industry, SEAM research will draw upon a global surface engineering expert network that covers Australasia, Asia, Europe, and North and South America.

SEAM has four goals aligned with its initiative toward the industrialisation of academic outcomes. Implementing industry/academic projects that tackle specific surface engineering issues of critical consequence for partner organisations. For example, wear and corrosion resistance within the mining sector, or antibacterial films for medical implants. Solutions will evolve from applied research based on a foundation of scientific understanding rather than the current trial and error methods that lead to quick but highly risky and costly short-term fixes. Creating a strong and pervasive training team where industry will work closely with academia to maximise their return by leveraging members of the SEAM team. Additional joint projects will be nurtured within SEAM so that industry can maximise growth and achieve its potential. Establishing a pragmatic mindset where SEAM research feeds into the economic and productivity needs of industry aimed at enhancing economic growth and competitiveness.

Three surface engineering themes form the technological foundation of SEAM, which promotes interaction between and among these technologies.

THEME 1

Nanoscale surface modifications and thin films such as PVD and CVD are used in applications ranging from films for bacterial and infection control, to microelectronics, to hard coatings for the machining industries.

THEME 2

Thick coatings are manufactured by laser and thermal spray technologies. These overlays are used in heavy industries, mining, and in commercial transportation for repair and remanufacturing of components.

THEME 3

Additive manufacturing (AM) is a layer-by-layer deposition process that creates a new surface. The two prime AM technologies explored include laser technology and cold spray.

Image: Christiane Schulz, SEAM Chief Investigator University of South Australia

RESEARCH PROJECTS

RESEARCH THEME: THIN FILMS

THIN FILMS FOR INFECTION CONTROL

Industry Partner: Commonwealth Scientific and Industrial Research Organisation (CSIRO)

With an increase in demand for orthopaedic surgeries, a growing number of implant related infections has become great concern of all modern orthopaedic surgical procedures. Bacterial adhesion to various biomaterials and the formation of biofilm on implant surfaces are key steps in the development of most infectious condition, which starts from bacteria adhere to implant surface, followed by proliferation and the multi-layer accumulation of extracellular matrix, which often leads to severely implant failure and repeated surgery procedures for chronic wounds.

Nevertheless, surface engineering has been helping biomedical science with better understanding and control of implant related infections. For example, surface modification of implant surface enables to interfere with bacterial adhesion as well as delay the initial stage of infection happening within implant–tissue interfaces. As biological systems are inherently complicated and hierarchically structured, we believe a better preventative approach can be achieved particularly by combining multiple antimicrobial strategies in the same device or coating. Here, we are aiming to develop new antimicrobial coatings with multifunctionalities providing a broad range of antimicrobial spectrum and multiple layers of defence. Thermal spray methods will be mainly used to deposit new antimicrobial coatings in the form of mixture or multiple layers of coatings with bioactive species including polymers, metals, and nanoparticles, molecules that could interfere with microbial signalling. The coatings will be characterized using XPS, IR, AFM, SEM, Raman, XRD, contact angles, profilometer, and their antimicrobial properties and biocompatibilities will be tested using a range of medically relevant microbes and different cell lines.

LAYER-BY-LAYER DEPOSITION OF NANOMETER THIN FILMS ON ARBITRARY 3D STRUCTURES

Industry Partner: GrapheneX Pty Ltd

Conformal coatings over a complex 3D structure are needed to achieve additional functionalities and prevent corrosion. However, the complete covering the complex 3D surface is extremely challenging for conventional coating techniques, especially when the parts are intricate and of small dimensions with intricate gaps or channels involved. The incomplete covering on 3D structures with conventional coating techniques will introduce defects, thus compromise the functionalities and, in particular, the anti-corrosion performance. Therefore, it is required to develop a new conformal coating technique with the capability of the complete coating of 3D structures. In this project, the Team will develop a scalable and low-cost layer-by-layer conformal coating technique based on a patent pending wetchemical coating method SUT researchers have developed. The research will focus on the attachment of the coating to different substrates. The strength and longevity of the coating will also be investigated according to the industry requirements. The anti-corrosion performance under a number of harsh conditions will be understood versus the coating parameters, including the compactness, coating thickness and structure complexity to meet the industry standards. SEAM Project Team will be trained in advanced nanotechnology coating techniques. They will master the coating process and the coating properties to be suitable for the industry demands.

HIGH PRECISION COATING WITH A GRAPHENE LAYER

Industry Partner: Innofocus Photonics Technology Pty Ltd

Optics industries rely on thin film coating technologies to manipulate light reflection, transmission, and absorption within specified wavelength ranges. However, the coatings are fabricated at a high cost using complicated vacuum coating machine, greatly limiting their effectiveness and accessibility. These processes are also of low efficiency and require an experienced workforce. Therefore, it is necessary to develop a low-cost, simple and large-scale coating method that is able to precisely control the coating properties and thicknesses with nanometer accuracy.

The SEAM project team aims at achieving two important milestones through this project: The first one is to demonstrate nanometer precision coating on a flat substrate to achieve simple functionalities. The second one is to use a laser to pattern the film to achieve more complicated functionalities. The Team will first focus on the development of the multilayer deposition technique of graphene materials to target the nanometer film thickness and large-scale uniformity requirements placed by the optical coating industry. Then through employing and developing advance nanofabrication technology by ultrafast lasers, nanopatterning of the thin film can be achieved, enabling sophisticated tenability of light in the nanometer scale. Advanced device architectures can be developed in collaboration with industry partners, thriving the photonics industry in Australia. The SEAM team will be trained in the area of precision optical coating and optical design. In particular, advanced computer modelling skills will be developed in combination with nanotechnology fabrication.

EDGE PREPARATION, SURFACE FINISH, AND THEIR EFFECTS ON MODERN PRECISION CUTTING TOOL PERFORMANCE

Industry Partner: Sutton Tools Pty Ltd

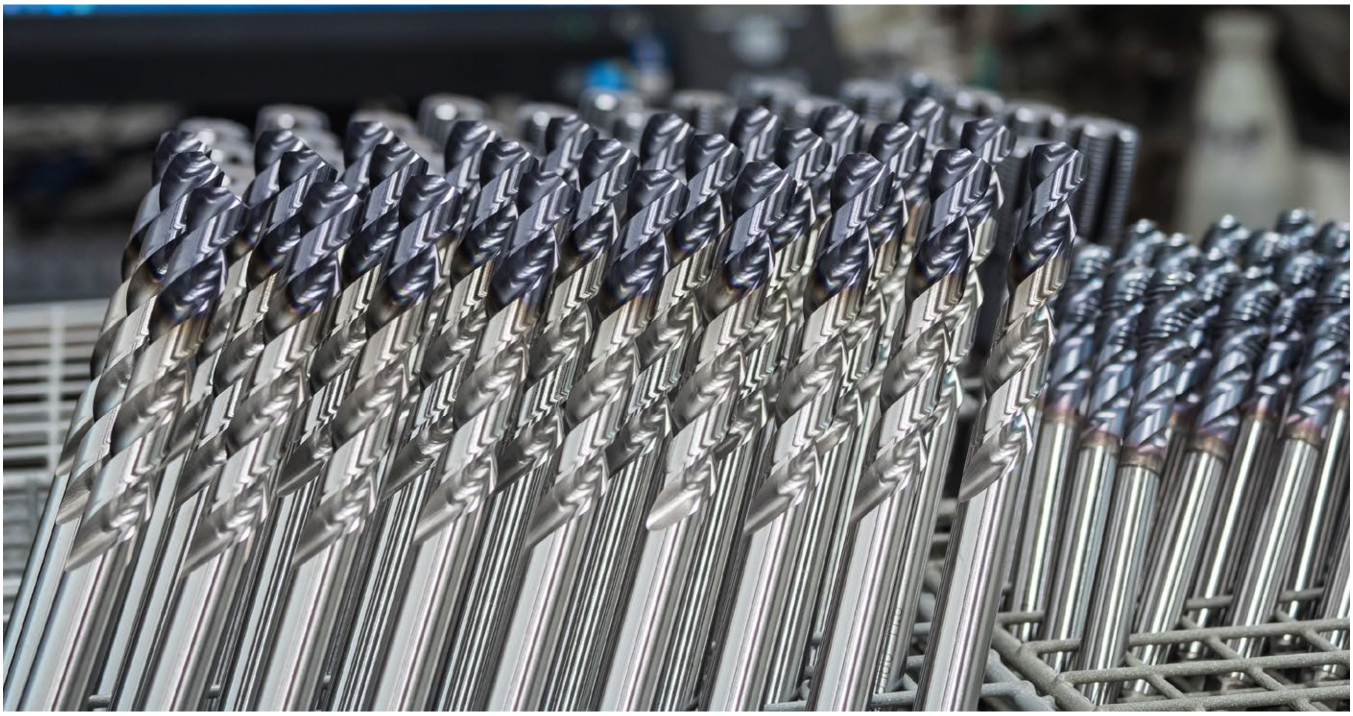

Image credit: Sutton Tools

Edge preparation and surface finish are vital considerations in the manufacture of modern precision cutting tools, as they may significantly impact tool efficacy and life. Existing methods of preparing tool surfaces are principally based on honing operations through abrasive mechanisms such as drag finishing, micro-blasting, and diamond polishing. While cost-effective, these methods are limited in their application to many tool materials due to the high hardness of tool materials, and/or limited dimensional control. Although other methods of tool preparation, based on thermal or (electro)chemical processes have been developed, there is limited understanding of these edge preparation techniques and the relationships between process parameters and the resulting cutting tool geometries.

In this project, a comparative evaluation of various existing edge-preparation processes will be performed, and the key characteristics associated with satisfactory edge preparation will be identified. Next, a novel electro-polishing edge-honing process will be developed, and the impact of the various associated process parameters on the resultant edge preparation will be investigated; this will be used to develop protocols to achieve the optimum surface quality of the cutting edge. In addition, various wear resistant thin films will be deposited onto cutting tools with different geometries and sizes using physical vapour deposition technique. The coated thin films and the cutting tools will be evaluated in terms of their chemistry, microstructure, crystal structure, micro hardness, wear properties and tool life.

FUNCTIONAL COATING MATERIALS FOR INDUSTRIAL APPLICATIONS

Industry Partner: GrapheneX Pty Ltd

Multifunctional coatings with the advancement of nanotechnology and nanomaterials have emerged as a fascinating field with the potential to have significant impacts on industry and society. Superhydrophobic, easy-to-clean coatings for sensors; self-cleaning, hydrophobic/hydrophilic coatings for aerospace and automotive industries, anti-fingerprint and anti-glare coatings for touch-screen displays are few examples of smart coating applications. Owing to the stimuli-response behaviour of the smart materials towards various intrinsic or extrinsic events in the form of altered temperature, electric current, pressure, sound, pH etc., key challenges such as the enhanced coating lifetimes, effective performances under real-world conditions, conversion of laboratory smart coating concepts to practical coating systems need to be addressed. Poor mechanical strength, slow response and undesirable environmental instability of conventional smart materials leads to the introduction of advanced materials such as polymer nanocomposites, nanoparticles and nanostructured materials such as CNTs, graphene etc. that can enhance the properties of existing coatings and thereby fulfill the modern industry needs. This project will develop an innovative and cost-effective pathway to create advanced coating materials and improved methodologies for the synthesis of functional coatings for industrial applications.

RESEARCH THEME: THICK COATINGS

ADDRESSING ASH-RELATED CHALLENGES FROM BIOMASS COMBUSTION USING CERAMIC AND COMPOSITE COATINGS

Industry Partner: SCG Chemicals Co Ltd

Although the use of biomass as an energy source has been growing, some challenges related to biomass combustion are inevitable and they can negatively affect the efficiency and performance of the boiler. The degradation of the boiler is a result from high temperature corrosion from corrosive compounds released from biomass combustion and erosive wear due to impingement of solid particles.

The new desired coatings to address the challenges must be capable of reducing slagging deposition and corrosion attack from biomass combustion, contain both tough and hard phases to resist erosion as well as be compatible to the existing substrate in a practical working environment.

According to previous studies, metal-based Ni-Cr coating has shown excellent corrosion and erosion resistance in a practical boiler environment. In addition, it is evident that adding appropriate content of ceramic phase to the coatings as a reinforcing hard material can enhance erosion resistance of the coatings. The research team aims to implement these finding to create a new generation of composite coatings that positively modify surface properties such as resistance to corrosion, wear and oxidation to prolong the life span of the boiler component and improve its performance.

DEVELOPING TECHNOLOGIES FOR THERMAL SPRAYING COMPOSITE SUB-STRATES

Industry Partners: Defence Materials Technology Centre (DMTC) Limited, MacTaggart Scott Australia (MTSA) United Surface Technologies (UST) Pty Ltd

Thermal spray coatings have shown the ability to improve the properties of a variety of structures/components in relation to their wear, corrosion, conductivity and/or thermal protection performance. These coatings have traditionally been applied to standard metallic substrates. For many applications, however, industry has been increasingly looking at the use of different substrate materials/designs to manufacture their products and also to develop coatings that can allow structures/components to be used in harsh environments. For example, there is an increasing demand for the reduction of the weight of components and structures, while maintaining required performance/operational characteristics. This project will investigate the development of the thermal spray coating processes that are used to functionalise composite material structures. To achieve this the research team, comprising of industry and research experts, will look at the coating process from a holistic perspective in terms of the coating materials, coating application parameters and the substrate properties. Test components as specified by industry partners will be developed as prototypes, which will then be trialled in the field to determine the performance in relevant operational environments.

MAINTENANCE AND REPAIR OF AGEING INFRASTRUCTURE IN REMOTE AUSTRALIAN LOCATIONS

Industry Partner: Santos Limited

Like many companies in the oil and gas sector, SANTOS have an extensive gas and oil pipeline network made from steel. Some of these pipelines suffer accelerated corrosion inside the pipes due to the activity of microbes, and this is referred to as microbially induced corrosion (MIC). This project aims to look at several aspects of MIC in gas pipelines. Firstly, anti-microbial coatings on the inside of large diameter pipes will be studied, with a view to improving the pipelines that may be built in the future. External pipeline repair using laser cladding will also be examined, as this has many advantages over existing repair technology such as longevity and resistance to the harsh Australian environment, in particular, the expose to ultra-violet radiation from sunlight. Lastly, a dedicated surface study will be carried out to investigate how the implementation of new chemicals such as foaming agents and newly developed anti-microbial additives effect the corrosion behaviour inside the pipeline.

REFURBISHMENT AND ENHANCEMENT OF MINING EQUIPMENT

Industry Partner: D&T Hydraulics Pty Ltd

D&T Hydraulics’ core business involves the refurbishment of hydraulic shafts, cylinders and associated components, primarily for the mining and manufacturing industries. In 2018 the business invested in the

Image credit: Laserbond, Adelaide.

installation of a high-speed laser cladding facility. This technology is state-of-the-art, and offers a range of new capabilities that in turn have the potential to both deliver existing refurbishment services at a higher rate and quality, as well as extending in-house capabilities further and enabling applications in new markets to be tapped.

By partnering with Swinburne under a SEAM project, D&T benefits from additional resources to assist with accelerating the development and refinement of laser cladding capabilities at D&T. Samples prepared via laser cladding have been provided to Swinburne for microstructural analysis, with results used to optimise processing conditions. In turn, Swinburne benefits from the opportunity to be at the forefront of research around this cutting-edge advanced surface engineering process, and supporting the training of new surface engineering researchers. To date, under this collaboration a broad range of cladding materials have been tested and studied using high-speed laser cladding, with the capability demonstrated to be clad alloys from different metal alloy classes. Specific alloys have been identified for targeted commercial applications, and further work is now underway to validate the performance of the cladding through accelerated environmental and wear testing. Further research continues in parallel, working to optimise process control in order to ensure consistent and reliable cladding, as well as studies underway to investigate interactions between different cladding and substrate materials to ensure reliability under different environmental conditions.

This project also falls under the Additive Manufacturing theme.

RESEARCH THEME: ADDITIVE MANUFACTURING

COATING AND REPAIR OF ADDITIVE MANUFACTURED COMPONENTS

Industry Partner: LaserBond Ltd

Laser Cladding can be used for Laser Metal Deposition (LMD) as an Additive Manufacturing (AM) method to repair or add structures to structural components. These components can find uses in mining, agriculture, aerospace and automotive industries. Anywhere, in which complex structures, normally made via substrative processes, need to survive tough environments. Through LaserBond ASX:LBL, partnering with UniSA, this project will address the need to understand the possibilities and limitations of added and/or repaired LMD structures. It will develop quality control techniques for these structures, so as to give end-users confidence in the expected performance.

In addition, the role of advanced feedback systems in controlling the critical parameters in LMD structure manufacture will be investigated. This will enable LaserBond to offer an advanced AM process and capitalise on the inherent advantages of AM, that is low wastage (cf – subtractive processes) leading to a more economical and ecological production process. Finally, coating protocols will be investigated, this can include graded coatings, duplex systems and the investigation of the effect of the deposition pattern on the AM part. This will cumulate in prototype fabrication and testing.

OPTIMINIZATION OF SURFACE PROPERTIES OF ADDITIVE COMPONENTS USING AN ADDITIVE/SUBTRACTIVE MACHINE

Industry Partner: Romar Engineering Pty Ltd

Metal additive manufacturing has many advantages including the ability to reproduce from CAD designs and develop intricate structures as well as significant energy and material savings compared to traditional manufacture. However there are however some areas where improvements can be made: additive manufacturing is relatively slow, it can induce residual stresses in parts , surface finish may be rough requiring post processing and it needs high quality and expensive powders. This project will assess whether the use of a hybrid machine in which both additive and subtractive manufacturing is possible can reduce these issues.

The project will use a the DMG Mori Lasertec 3D 5axis have several interesting functionalities including faster deposition rates (10 times faster than other additive machines) plus the ability to undertake laser deposition welding and milling in the one machine. The project will assess if the use of subtractive manufacturing (i.e. milling) interspersed with additive can reduce residual stress and also control the surface finish. The effect of powder shape and chemistry will also be investigated to determine if lower cost powders can be used. In addition to training post-doctoral fellow and PhD students the project aims to produce higher quality parts that require either less or no post processing in a faster and more economical way. The technology will be used in aerospace, defence and biomedical applications.

ADDITIVE METAL MANUFACTURING FOR AEROSPACE APPLICATIONS – HIGH SPEED LASER DEPOSITION OF THIN METAL COATINGS

Industry Partner: RUAG Australia Pty Ltd

Laser metal deposition (LMD) is a surfacing technology used for obtaining high quality wear and corrosion resistant coatings on a range of substrates. The technology is now well established as an industrial process and complements other coating technologies such as thermal spraying. The current research efforts in LMD in the context of surface repair focus on processing and microstructural optimisation, novel coating alloy design and knowledge transfer from traditional fabrication technologies. However, the process operates at a relatively low laser scanning speed (typically ~2 m/min) which makes it less attractive in relation to large surface area repair.

A new process which has been reported in the literature and which is attracting increasing attention from industrial perspective is Ultra High Speed LMD (UHSLMD). The UHSLMD process has a capability to deposit metal alloys at speeds of 100 m/min or 500 cm2/min. As an emerging rapid repair technology, the potential of UHSLMD to efficiently produce competitive clad layers with various materials on large surface areas has not been investigated in depth. This project has identified a need for the development of thin film coatings (< 100 micron thick) for wear and corrosion protection based on UHSLMD technology for a range of aerospace components. The technology to be investigated and developed will examine the process parameters for depositing high quality coatings and characterise their microstructure and wear and corrosion performance. The project has the potential to deliver new laser coating technology for repair of large surface areas of aerospace components more economically and environmentally friendly.

CREATING THE TITOMIC KINETIC FUSION® SMART FACTORY

Industry Partners: Titomic Ltd and Australia’s Nuclear Science and Technology Organisation (ANSTO)

Titomic (ASX:TTT) is an Australian public company specialising industrial scale metal additive manufacturing using its patented Titomic Kinetic Fusion® (TKF) technology. The TKF technology provides unique capabilities for producing commercially viable additively manufactured metal products, competing directly with traditional manufacturing methods. Titomic provides OEM production and R&D services from its TKF Smart Production Bureaus to the global Aerospace, Defence, Shipbuilding, Oil & Gas, Mining and Automotive industries. Titomic also provides an extensive range of metal powders for 3D Printing, especially titanium and super alloys, and provides sales and support services for their TKF production systems.

SEAM and Titomic have outlined several specific areas of need for research going forward. These goals including further optimisation of the Kinetic Fusion process, the exploration and development of operations with mixed-materials, and the development of advanced predictive models to validate part manufacture and ensure ongoing part reliability. The use of advanced sensors and process control feedback enables auxiliary data sources to be used and compared to the results obtained from traditional destructive and non-destructive sample analysis techniques. Foundational process development will be supported by analysis of prepared samples at Swinburne to verify cladding quality, with active involvement ramping up in early 2020 with a PhD student joining the project in Q1. Planning is presently underway into the design of advanced process monitoring systems that are expected to form key inputs into both research studies, as well as providing data that will be used to develop models for predictive process quality control monitoring.

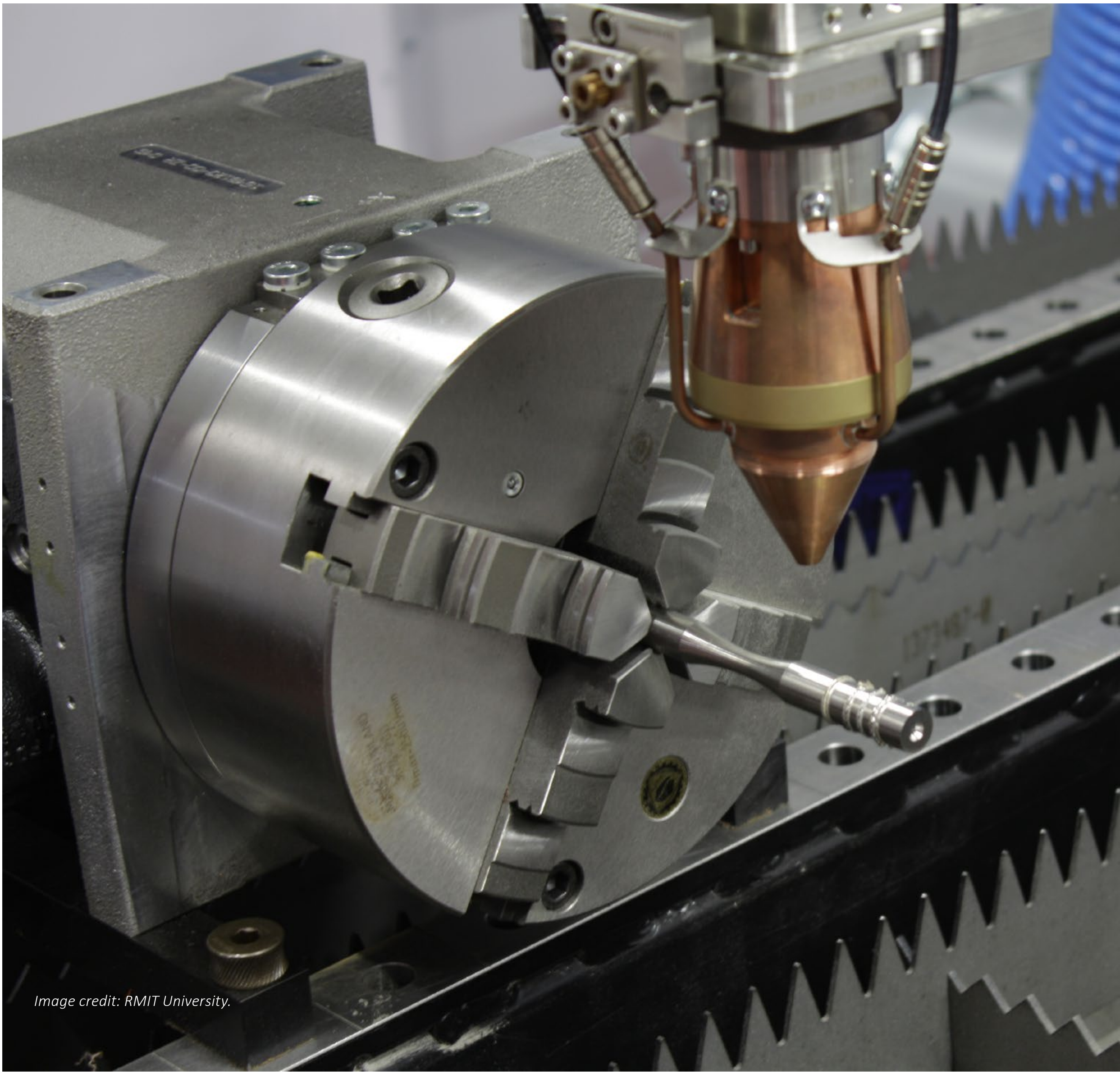

Image credit: RMIT University.

SEAM PEOPLE

Image above: Rosalie Hocking
Swinburne University of Technology

THE SEAM Team

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Distinguished Professor
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Deputy Director
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THE SEAM Team

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THE SEAM Team

PEOPLE OF SEAM - CHIEF INVESTIGATORS

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Swinburne University of Technology

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Distinguished Professor
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South Australia

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South Australia

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THE SEAM Team

PEOPLE OF SEAM - DOCTORAL & MASTER STUDENTS

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THE SEAM Team

PEOPLE OF SEAM - DOCTORAL & MASTER STUDENTS

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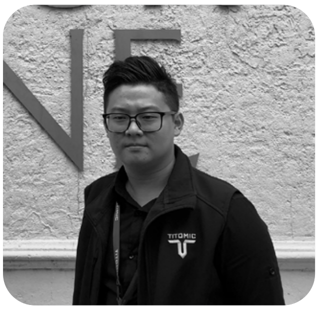


MPhil Candidate
Wesley Tai
Swinburne University of Technology

PhD Candidate
Nouman Tariq
Swinburne University of Technology

PhD Candidate
Zefeng Wu (Ricky)
RMIT University

Five more PhD candidates have been successfully recruited and will commence their candidature in 2021.

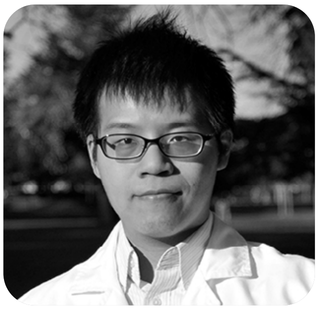
THE SEAM Team

PEOPLE OF SEAM - POSTDOCTORAL FELLOWS

Postdoctoral Fellow
Dr Arne Biesiekierski
Swinburne University of Technology

Postdoctoral Fellow
Dr Qinye Li
Swinburne University of Technology

Postdoctoral Fellow
Dr Han Lin
Swinburne University of Technology



Postdoctoral Fellow
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Postdoctoral Fellow
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Swinburne University of Technology

Postdoctoral Fellow
Mr Samuel Pinches
Swinburne University of Technology

Postdoctoral Fellow
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Postdoctoral Fellow
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Two more Postdoctoral researchers successfully recruited and will commence in 2021.

THE SEAM Team

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Senior Associate Investigator
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Senior Associate Investigator
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Indian Institute of Technology Ropar

Senior Associate Investigator
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Fraunhofer Institute for Material IWS

MPhil Candidate
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Partnered PhD Candidate
Ameey Anupam
Swinburne/IIT Madras

PhD Candidate
Hongshou Huang
University of South Australia

PhD Candidate
Bruno Kahl
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PhD Candidate
Ashok Meghwal
Swinburne University of Technology

PhD Candidate
Duy Quang Pham
Swinburne University of Technology

Partnered PhD Candidate
Malkeet Singh
Swinburne/IIT Ropar

PARTNERS

PARTNER ORGANISATIONS

PARTNER INVESTIGATORS

Mr Miles Apperley - ANSTO

Dr Vladimir Luzin - ANSTO

Dr Paul Savage - CSIRO

Dr Helmut Thissen - CSIRO

Mr Miles Kenyon - DMTC

Dr Stephen van Duin - DMTC (UOW)

Mr Warren Smith - D&T Hydraulics Pty Ltd

Mr Stephen Wee - GrapheneX Pty Ltd

Mr Tao Frank Yao - Innofocus Photonics Technology Pty Ltd

Dr Thomas Schläfer - Laserbond Ltd

Mr Peter Richings - MacTaggart Scott Australia MTSA

Mr Neil Wilson - Romar Engineering Pty Ltd

Mr Neil Matthews - RUAG Australia

Mr Michael Little - Santos Ltd

Mr Damien Doherty - Santos Ltd

Dr Noppakun Sanpo - SCG Chemicals Ltd (Thailand)

Dr Songsak Klamklang - SCG Chemicals Ltd (Thailand)

Dr Jaturong Jitputti - SCG Chemicals Ltd (Thailand)

Mr Guy Stephens - Sutton Tools Pty Ltd

Mr Jeff Lang - Titomic Ltd

Mr Hugo Howse - Laserbond Victoria (formerly) United Surface Technologies Pty Ltd

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AWS International Thermal Spray Association

ASB Industries, Inc.

The Australasian Corrosion Association Inc.

Flame Spray

GTV

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暨南大學 Jinan University

Materials Australia

Nanyang Technological University Singapore

oerlikon metco

Stony Brook University

Victoria University of Wellington – Te Herenga Waka

The University of Nottingham

Weld Australia

Image: Christiane Schulz, SEAM Chief Investigator University of South Australia

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Associate Professor Scott Wade
Swinburne University of Technology

ENGAGEMENT AND OUTREACH

Image: Welcome to Country at the MISE2020 Conference by Dr Willy-John (Pou Pūtaiao/Director, Māori Research, Science and Innovation at the Ministry of Business, Innovation and Employment, New Zealand).


Te Tiriti o Waitangi
1840
Foundation treaty outlining
Crown-Māori relationship
• Partnership
• Participation
• Protection
CAPITAL THINKING.
GLOBALLY MINDED.
National
SCIENCE
Challenges
WELLINGTON
TE HERENGA WAKA
SEAM
RESEARCH
RMIT

CONFERENCES

31 January - 3 February 2020: *Nanomaterial and Atomaterial Science and Applications* Conference, Swinburne

Conference convenor: Professor Baohua Jia (Swinburne)

The International 4-day Conference on Nanomaterial and Atomaterial Science and Applications (ICNASA 2020) was held at Swinburne University of Technology in Melbourne and co-hosted with the Centre for Translational Atomaterials (CTAM). The conference focused on the most recent advances in the fields of micro/nano/atomic-materials and optoelectronics, especially the new ideas and concepts in modelling, synthesis, fabrication and testing of new materials, structures, devices and systems, and their applications. It provided a global forum to exchange knowledge on nano and atomic materials, engineering, manufacturing and industrialisation.

Paper presentations by SEAM personnel

Graphene-based Solar Selective Absorbers
by Keng-Te Lin (Swinburne)

Femtosecond Laser Fabrication 2D Material Functional Optical Devices
by Dr Han Lin (Swinburne)

Multifunctional Polymers and Composites for future manufacturing
by Dr Nishar Hameed (Swinburne)

Why Has Redox Chemistry Got to Do with Catalyst Design?
by Dr Rosalie Hocking (Swinburne)

Topology Optimization of Acoustic and Optical Metamaterials
by Professor Xiaodong Huang (Swinburne)

10-12 February 2020: *Materials Innovation in Surface Engineering* Conference (MISE2020), Swinburne University of Technology, Melbourne

Conference chairs: Distinguished Professor Christopher C Berndt (Swinburne) and Industry Associate Professor Colin Hall (UniSA)

Materials Australia with SEAM successfully hosted the third international Materials Innovations in Surface Engineering conference, held at Swinburne University of Technology, Melbourne.

Modification of a material's surface to improve its performance is applicable to both metallic and non-metallic materials and is of interest to a myriad of sectors in industry, all of which are striving for innovation in a globally competitive world. Surface engineering is a broad topic and includes the application of organic and inorganic coatings, surface modification by heat treatment or chemical treatment or alloying, plating, weld overlays, thermal or cold spraying, to name but a few. The conference hosted an array of esteemed academic and industrial presentations, which provided delegates an insight into the innovative developments and trends in the industry. The conference also provided industry representatives, academic institutions and research centres the opportunity to showcase their skills and foster relationships for future collaboration. Panel session from industry and academic

Image above: Margaret Hyland (Vice-Provost (Research) Victoria University of Wellington)

Image above: Filofteia-Laura Toma (Fraunhofer IWS Dresden).

perspective opened up thoughtful and enlightened discussions of what is required to work with each other. An ECR session gave a chance for new researchers to address the entire conference. The conference covered a range of topics, including: surface modification, analysis and characterisation; heat treatment; wear & corrosion protection; CVD & PVD; surfaces for biomaterials; laser metal deposition, cold and thermal spray and modelling.

SEAM was proud to sponsor such a successful conference and looks forward to supporting future events that support the surface engineering space.

Paper presentations by SEAM personnel

Investigating the feasibility of laser metal deposition for coating and repairing of components with structural stability
by Mr Andre Hatem (UniSA)

One-step Aminomalononitrile based Coatings containing Zwitterionic Copolymers for Antifouling applications
by Miss Tzu-Ying Liao (Swinburne)

Multi-material refurbishment of cylindrical components with high-speed laser cladding
by Mr Samuel Pinches (Swinburne)

Ultra-high-speed laser metal deposition (UHSLMD) of hardfacing materials
by Mr Zefeng Wu (RMIT)

Data Constrained Modelling of Plasma Sprayed Coatings Using Dual Energy X-Ray Computed Topography
by Dr Andrew Ang (Swinburne)

Corrosion Resistance of Laser Clad and Thermal Spray Wear Resistant
by Dr Christiane Schulz (UniSA)

Image: MISE 2020 Conference

Regenerative, robust, and decorative thin films on plastics
by Industry Associate Professor Colin Hall (UniSA)

Development of Preventive Corrosion/Erosion Coatings Using for Biomass Boiler
by Dr Noppakun Sanpo (SCG Chemicals)

Titomic Kinetic Fusion® for Additive Manufacturing
by Mr Jeff Lang (Titomic)

Coatings for the prevention of medical device related infections
by Dr Helmut Thissen (CSIRO)

Neutron Stress Analysis for Surface Engineering
by Dr Vladimir Luzin (ANSTO)

Advanced materials processing trends: towards a more integrated and data-intensive approach for sustainable manufacturing
by Professor Michael Khor (University of Nanyang, Singapore)

WEBINAR SERIES

29 July 2020: *Additively manufactured metal surfaces and their influence on tensile and fatigue performance*

by Distinguished Professor Ma Qian (RMIT University)

Convenor: Distinguished Professor Milan Brandt (RMIT University)

Additively manufactured intricate designs often involve internal features or surfaces that are difficult to post-process for an improved surface finish. Their existence affects the performance of the manufactured part, especially under cyclic loading conditions. The topography of an as-built metal surface by powder-bed-fusion additive manufacturing (PBF-AM) is complex and determined by a myriad of factors, beginning with the slicing of the STL file to the removal of support structures from the part after AM. Using the PBF-AM of the Ti-6Al-4V alloy as an example, the first part of this article discusses the formation of different types of surfaces by PBF-AM. Representative surface features are outlined through selected examples. The second part presents a systematic investigation of the influence of the as-built surface condition on the tensile and fatigue properties of Ti-6Al-4V additively manufactured by selective electron beam melting (SEBM). Four distinctly different surface finish conditions are studied, without or with subsequent hot isostatic pressing (HIP) to eliminate the influence of internal defects. A range of useful observations are made from these detailed experimental studies. On this basis, the last part of this article discussed essential design considerations in order to achieve consistent as-built surface conditions for desired mechanical performance.

Professor Ma Qian currently holds a Distinguished Professor appointment at RMIT University. His research is centred on metallic materials and their manufacturing by various approaches, including additive manufacturing, solidification processing, powder metallurgy, dealloying and surface deposition. With his team members and collaborators, he has published 240 journal papers and 62 other peer-reviewed articles, which have attracted nearly 10,000 Scopus citations. He is a highly ranked metallurgist based on a published study of the research impact of author outputs in Scopus from 1996 to 2017.

12 August 2020: *Challenges in molecular design of protective paint films for actual service conditions*

by Professor Ivan Cole (RMIT University)

Convenor: Dr Rou Jun Toh (RMIT University)

Recent advances in inhibitor design and discovery allow the selection of the exact molecular structure of inhibitors to incorporate in paints to minimize corrosion for a given substrate in given service conditions. The application of computational materials modelling permits an estimation of the effective lifetime of the inhibited paint film. To reach this level of design reliability several theoretical, computational and experimental tools are required. An experimental approach must test all the isomers of a particularly corrosion inhibitor for all the inhibitors in a family and for all the inhibitor families of interest-. literally tens of thousands of inhibitors. This requires rapid testing and several methods have been developed including the “wells method” and robotic electrochemistry. Molecular modelling of corrosion inhibitors promises a world where we can directly calculate how effective an inhibitor will be in slowing corrosion on a given substrate. Continuum modelling can then connect the electrochemical performance on a surface to the probable performance of a component in service. These concepts are illustrated with reference to major industrial projects including, “the computational modelling of inhibited paint films”. This project built a multi-scale model to both select and estimated the service of inhibited film on Al2024 when used on aircraft with diverse flight paths.

Professor Ivan Cole is Enabling Capability Director for Advanced Manufacturing and Fabrication at RMIT University and chief investigator with SEAM leading a project with industry partner Romar Engineering, Sydney. His research interests are in additive manufacturing and other advanced metal fabrication processes, surface finish, passivation and corrosion and corrosion inhibitors, nano structures and nano-sensing, modelling of materials and life prediction of materials. He has led a number of research projects, received numerous awards including the CSIRO Lifetime Achievement Award in 2016. Ivan is a regular presenter at international conferences, with an impressive number of publications. He is a member of numerous societies including the Australasian Corrosion Association.

25 August 2020: Webinar on *Surface Engineering* (panel presentation)

Convenor: Dr Christiane Schulz (UniSA)

Surface engineering is a sub-discipline of material science with applications in many industries including mining, oil & gas, steel, agriculture, automotive, and other key areas. If a material degrades over time, it always starts from the surface as a result of interaction with the environment, causing wear and corrosion. Surface engineering processes in combination with smart material choices can significantly extend a components service life. Thus, saving resources, time and money. The webinar hosted a three-panel presentation who addressed the research needed to address these concerns.

Challenges and opportunities in surface engineering of advanced materials by Distinguished Professor Christopher C Berndt (Swinburne)

Laser cladding and thermal spraying as coating processes used for wear and corrosion protection in heavy industries by Dr Thomas Schläfer (LaserBond Ltd)

Challenges in coating development for the automotive industry by Dr Patrick Keil (BASF Coatings GmbH)

Materials Australia, Weld Australia and Australasia Corrosion Association sponsored this event.

8 September 2020: *Understanding how much thermally sprayed Thermal Barrier Coatings (TBCs) protect jet engines against major failure: A tutorial presentation*

by Dr Rogerio S. Lima (National Research Council of Canada)

Convenor: Distinguished Professor Christopher C Berndt (Swinburne)

Perhaps common knowledge that when we travel on a jet-powered aircraft, among many critical components, there is one specifically engineered to impede the catastrophic failure of the turbine engines in flight. This critical component is a thermally sprayed ceramic Thermal Barrier Coating (TBC) (250-500 µm thick) located in the hot metallic zones of the turbine (e.g., combustion chambers). These types of ceramic TBCs are deposited via air plasma spray (APS). A TBC architecture typically exhibits a bi-layered structure, which includes the ceramic topcoat and a metallic super-alloy bond-coat. The ceramic topcoat (e.g., ZrO_2-Y_2O_3, a.k.a., YSZ) provides thermal insulation and reduces the heat flow to the turbine metallic part. The metallic bond-coat (100-200 µm thick) is an oxidation/corrosion-resistant metallic layer protecting the underlying component and improving the adhesion of the ceramic topcoat on the part. Dr Lima presented, in Layman's terms, the importance and operation of TBCs, exploring the longevity of TBCs on the engines, the temperatures in which TBCs and the metallic components of turbines work, their thermal gradients and how to simulate and study them in laboratory experiments.

Dr Rogerio S Lima is a Senior Research Officer with the National Research Council of Canada. Dr Lima has published 65 refereed journal papers and 63 conference papers. His scientific papers have been cited more than 3000 times and his h-index is 30 (source: Scopus – June 27, 2020). Dr Lima is invited regularly to review papers for international materials science journals and has given numerous invited talks. Dr Lima's main research interest is R&D of thermally sprayed thermal barrier coatings (TBCs) and environmental barrier coatings (EBCs) for aerospace applications.

Image above: Rogerio S. Lima (National Research Council of Canada) Presenting at MISE 2020 Conference

30 September 2020: *Tribology of WC-Co coatings in sliding and rolling contacts*

by Dr Rehan Ahmed, Heriot-Watt University, UK

Convenor: Distinguished Professor Christopher C Berndt (Swinburne)

Almost 23% of the world's total energy consumption originates from tribological contacts. Thermal spray WC-Co coatings provide excellent wear resistance for a range of industrial applications in sliding or rolling contacts. Some of these applications in abrasive, sliding and erosive conditions include sink rolls in zinc pots, conveyor screws, pump housings, Impeller shafts, aircraft flap tracks, cam followers, and expansion joints. Rehan provided an expert review of the tribological considerations dictating the wear performance of these coatings. Structure-property relationship and failure modes are discussed to comprehend the design aspects of WC-Co coatings for sliding and rolling applications. Recent developments in the area of suspension sprayed nanocomposite coatings in terms of performance and failure mechanism are compared with conventional coatings. The dependency of binder material, carbide size, fracture toughness and hardness on wear performance and test methodology is discussed. Mathematical models related to the influence of tribological test conditions and coating characteristics are analysed for sliding contacts. Maps of failure modes in rolling contact are included to clarify the interplay between coating design and tribological considerations of contact stress and lubrication regime with recent developments in the area of numerical modelling of the wear phenomena are included.

Dr Rehan Ahmed is an expert in the tribology of surface coatings. He is the Associate Director of Research in the School of Engineering and Physical Sciences at Heriot-Watt University. As at 2020 he has successfully secured more than seventeen competitive research grants with a value of £2.2 million from Industry and Research Councils, including two patents in the area of biomedical coatings and solid oxide fuel cells. Dr Ahmed has published more than 100 scientific papers. He is the Associate Editor for IET- The Journal of Engineering, and serves on the Editorial Boards of the Journal of Thermal Spray Technology (JTST) and Advances in Mechanical Engineering.

14 October 2020: *Thermal Spray as an Additive and Layered Manufacturing Technology for Applications in Energy Systems*

by Distinguished Professor Sanjay Sampath (Stony Brook University)

Convenor: Distinguished Professor Christopher C Berndt (Swinburne)

Thermal spraying is a directed melt spray deposition process, in which inorganic particles in the diameter range of 1-100 microns are heated, melted (in some cases partially), propelled and impacted onto a prepared substrate. A rapid sequence of events occurs including melting, impact (in some cases shock), spreading and rapid solidification, all of which take place in microsecond timescales, enabling materials synthesis from extreme conditions. The sprayed coating is resultant from successive assemblage of such micro scale impacted droplets (splats) producing mesoscale thick films or coatings. The coatings thus produced are anisotropic, layered structures with multiple length scales of material character and interfacial defects, with concomitant implications on properties. The layered assembly also imparts gradients in residual stresses within the thickness of the coating. These effects are in large part deemed "unintentional" and incorporated in many applications with limited manipulation. With advancements in understanding of process dynamics and the ability to control microstructures at both the splat and coating level, a fresh opportunity is available to engineer the layered assembly to provide novel through thickness properties and functionalities. In a sense, thermal spray can be considered within the context of emerging additive manufacturing concepts where the characteristics of the assembly can be manipulated across different available length scales. In this presentation, several embodiments of such concepts will be shown using the interplay among coating architecture design, materials and manufacturing. Specific examples include novel multilayer, multifunctional thermal barrier coatings, multifunctional coatings in fuel cells, thermoelectric devices and smart coatings with embedded sensors. Illustrative examples of their applicability in industrial systems will also be highlighted.

Dr Sanjay Sampath is Distinguished Professor of Materials Science and Engineering at Stony Brook University (SUNY) and director of the Center for Thermal Spray Research. Dr Sampath has 180 journal publications to his credit, 13 patents and winner of several best paper awards. He has received numerous awards and accolades, including being inducted as Fellow of the American Ceramic Society and in 2011, was recognised as a State University of New York Distinguished Professor, highest faculty designation of the SUNY system. In 2015 he was inducted into the Thermal Spray Society Hall-of-Fame. In 2017 he received the Application to Practice Award from TMS the Materials Society, the recipient of the John Jeppson Award from the American Ceramic Society in 2019 and Albert Sauveur Achievement award from ASM International in 2020.

28 October 2020: *Challenges in Powder Production for Additive Manufacturing, Laser Cladding and Thermal Spraying*

by Dr Christiane Schulz (UniSA)

Convenor: Dr Andrew Ang (Swinburne)

In recent years an upsurge in interest for fine, spherical, metallic powders can be observed. This is mainly driven by an increased demand in powders for Additive Manufacturing and coating processes including selective laser melting and laser metal deposition, cold spraying and other thermal spray techniques. Properties and quality of a powder feedstock material is a major influencing factor for the properties and quality of the part/coating produced with it. Dr Schulz introduced the different production methods for metallic powders with a focus on the different atomizing processes, explaining how the atomizing technique, the atomizing medium (e.g. water vs. gas), the alloy and its inherent material properties influence the achievable particle size and morphology of the resultant powder. Another aspect lies on the economy of powder production and how the costs of powder feedstock can be reduced by widening the powder specification without sacrificing quality of the final product.

Dr Christiane Schulz is a surface engineer, with experience in both, industry and academia. She holds a PhD degree from RWTH Aachen University, Germany, her research focused on the development of wear and corrosion resistant thermal spray coatings in several industry-led projects. In 2014 she moved to work for industry as a product manager for the powder manufacturer Castolin Eutectic. Christiane is currently a Senior Research fellow at the University of South Australia, a certified materials professional (CMatP), a committee member of the SA branch of the Australasian Corrosion Association and a SEAM chief investigator.

11 November 2020: *Structural Disorder in Metal Oxides- From Catalysts to Novel Surface properties*

by Dr Rosalie Hocking (Swinburne)

Convenor: Professor Peter Kingshott (Swinburne)

One of the greatest challenges of the 21st century will be securing cheap and renewable sources of energy. One of the most promising approaches to this challenge is to design catalysts from earth abundant materials capable of implementing key chemical reactions including splitting water into hydrogen and oxygen (H2O → 2H+ + O2);

and both the oxidation ($H_2 \rightarrow 2H^+$) and reduction ($2H^+ \rightarrow H_2$) of hydrogen among many others. Structural type and disorder have become important questions in catalyst design- it is often noted in studies of functional materials that the most active catalysts are "disordered" or "amorphous" in nature. But the impact of this "disorder" on catalysis and other material properties including surface properties has been hard to quantify- in part because of the challenges of characterising disordered materials. Synchrotron based X-ray Absorption Spectroscopy (XAS) is a unique tool which enables us to study materials in their "functional active state" even when materials are thin films which are disordered and amorphous. In this talk I will examine some of the things we have learnt about electro-catalysts from XAS – from dopants to disorder, how we have discovered new catalysts and how we have improved others. I will talk to you about some of the unique properties of disordered materials that which if engineered properly may prove to be useful and novel class of materials.

Dr Rosalie Hocking is a chemist who leads a program studying small molecule transformations at Swinburne University of Technology. She is particularly fascinated with the chemical reactions of carbon dioxide, nitrogen and water as they key for the development of a carbon neutral economy. Her works uses a variety of analytical and chemical methodologies including the Australian synchrotron where her group are regular users of the XAS beamline. Rosalie completed her PhD in physical and inorganic chemistry from the University Sydney in 2004. She has since held positions Stanford University/Stanford Synchrotron Radiation Laboratory, CSIRO Land and Water, Monash University and James Cook University.

17 November 2020: *The 4 Waves of Physical Vapor Deposition (PVD) development*

by Professor Allan Matthews (The University of Manchester)

Convenor: Distinguished Professor Christopher C Berndt (Swinburne)

In this seminar Professor Matthews traced the development of Plasma Assisted Physical Vapour Deposition

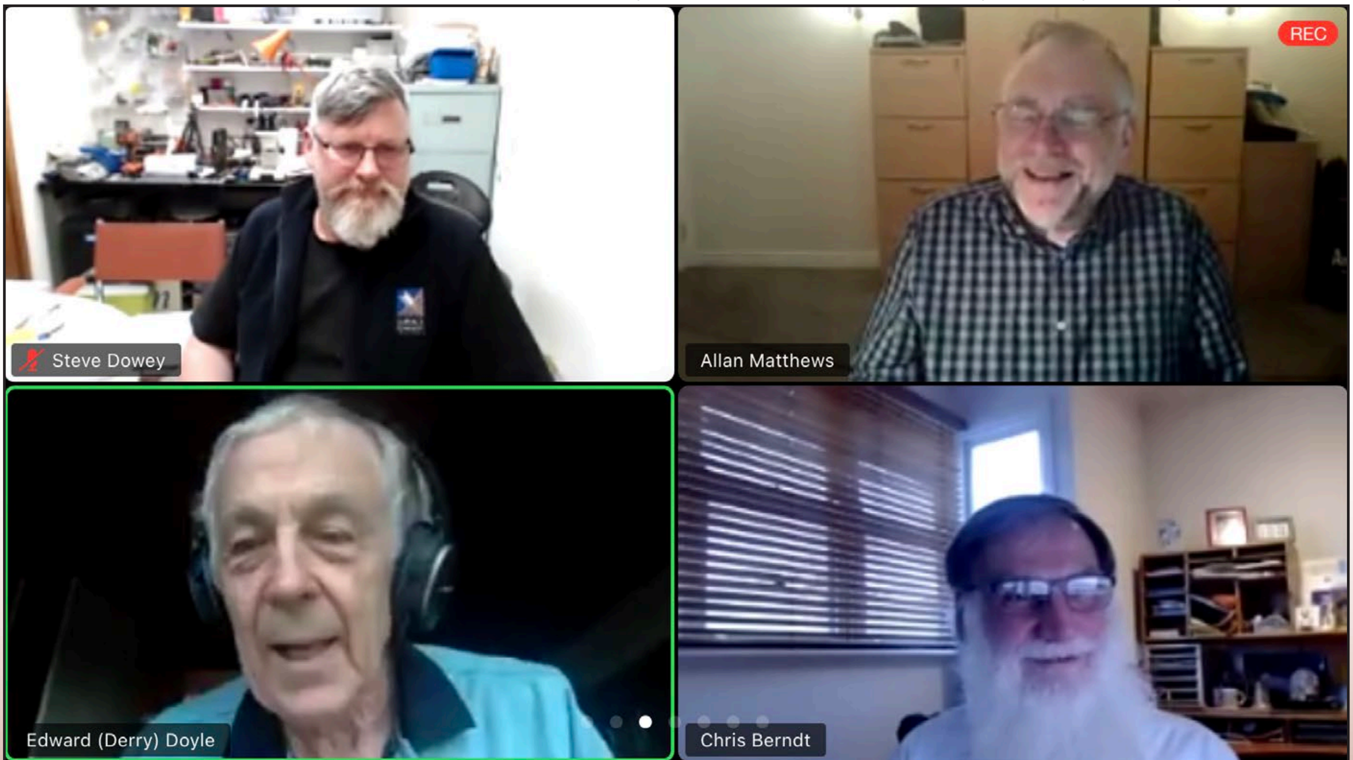


Image above: (top row left to right) Steve Dowey (Sutton Tools, and RMIT); Allan Matthews (Manchester); (bottom row left to right) Derry Doyle (Swinburne Adjunct); Chris C Berndt (Swinburne).

(PAPVD) from its beginnings, and charted the key developments in process understanding and the related innovators who allowed the processes to have such a huge impact on product manufacturing methods and functional enhancement. Over a period of more than 50 years Professor Matthews outlined how we have seen the invention, development, and exploitation of PAPVD to become a key enabling technology for products across all key applications sectors in the world today. Products as diverse as diesel engines, computer hard drives and touch screens could not function without these developments. Understanding the role of the ionization efficiency on film properties and related developments in the understanding of materials and structures (including the substrate role), together provide the basis for the present high technological level for PAPVD. The First Wave: DC diode Ion Plating; Metallic coatings to provide protection. The Second Wave: Enhanced Plasma Systems; Ionization enhancing additions to the diode layout; Development of a wider range of coatings, including ceramics. The Third Wave: Further ion and vapour source developments; Additional ionizing systems to further optimise processes, especially for sputtering; Development of further multi-component, layered, nanocomposite and duplex coating systems. The Fourth Wave: Further hardware and control software developments; Will include: Improved process monitoring and control, including developments to meet the coating needs of specific products and applications (including high volume continuous/semi-continuous and batch processing).

Allan Matthews is known internationally as a pioneer in the surface coating field. He is a Professor of Surface Engineering and Tribology in the Department of Materials and Director of the EPSRC NetworkPlus in 'Digital Surface Manufacturing' based in Henry Royce Institute (HRI) at The University of Manchester. Allan completed his four-year term as a member of the EPSRC Strategic Advisory Network (SAN). Allan is a Fellow of the Royal Academy of Engineering. He is the Editor-in-Chief of the Elsevier Journal in Surface Coatings Technology. Allan has published more than 400 refereed papers and numerous book chapters. Allan has received many awards, including the 2020 Leading Scientist Award from the European Society of Thin Films. Recently he was identified in the top 2% list of the world's scientist, released by Google.

9 December 2020: *Smart Composites and Coatings – Pushing the Boundaries*

by Dr Nishar Hameed (Swinburne)

Convenor: Professor Peter Kingshott (Swinburne)

With the adoption of automation and robotics, the materials and product manufacturing demonstrate a huge development in novel polymers and composites that incorporate multiple functionalities and non-traditional behaviours. This includes polymers with tuneable physical and chemical properties and fibres and composites with smart functionalities. Important considerations are to be able to achieve fast processing rates, flexibility and formability, recyclability and self-healing behaviours in the polymers and also to develop materials that can sense and communicate with device and environments. The recent research performed in our group showcase the technical feasibility of these new functionalities in composites and coatings. Especially, the team has identified new interactions between polymers and novel functional additives that are able to transform the traditional characteristics of polymers to enable them to fit with advanced manufacturing. The complex interactions between the functional groups of compounds enable the materials to exhibit several distinct physical behaviours. These unique characteristics were achieved at different compositions, making them processable and scalable at several environmental conditions.

Dr Nishar Hameed is an ARC DECRA Fellow and Senior Research Fellow at Swinburne University of Technology. His research focuses on the novel and faster processing of next generation 'smart' polymers and composite materials. Nishar developed a new method to produce flexible, toughened and fast cure resins that can be integrated to make formable and rapid cure fibre reinforced composites, concrete preforms and graphene nanocomposites. His research has also led to the development of a new, environmentally processing route to make plastics films and fibres from natural polymers (cellulose, wool, silk) and biomass. Nishar is a Charted Chemist at the Royal Australian Chemical Institute and also holds the chair of Carbon Division since 2017.

10 December 2020: *An Introduction to Microbially Influenced Corrosion & Current Research*

by Associate Professor Scott Wade (Swinburne)

Convenor: Dr Christiane Schulz (UniSA)

Microbially influenced corrosion (MIC) has been suggested to be responsible for up to 20% of all corrosion in aqueous systems. It can cause extremely rapid corrosion rates (e.g. localised corrosion rates of several mm/yr), is generally poorly understood and is very hard to diagnose and predict. This talk will cover some of the basics of MIC and then discuss some of the recent MIC research being undertaken at Swinburne University.

Associate Professor Scott Wade is the program coordinator of the biomedical engineering degree at Swinburne, and a chief investigator with SEAM. His research includes studies of fundamental and applied aspects of corrosion in collaboration with leading researchers and industry partners. Scott leads a research team investigating various aspects of corrosion, including microbiologically influenced corrosion, accelerated low water corrosion, corrosion of novel materials and corrosion sensing. He has published extensively and is a member of the Australasian Corrosion Association (Victorian Branch Senior vice-president), NACE and the International Biodeterioration and Biodegradation Society.

FORUM

9 September 2020: *4th International Forum on Additive Manufacturing*, RMIT University, Melbourne

Forum Chair: Distinguished Professor Milan Brandt (RMIT) Co-Chairs: Dr Andrey Molotnikov, Dr Alex Kingsbury, Professor Martin Leary, Distinguished Professor Ma Qian and Dr Joe Elambasseril (RMIT)

The 4th International Forum on Additive Manufacturing was held as a one-day virtual conference highlighting recent developments in additive manufacturing locally and globally in the context of defence, aerospace and medical applications.

Additive manufacturing is now globally recognised as a mainstream manufacturing technology in a range of industries such as aerospace, automotive, defence and medical. Compared to more traditional subtractive technologies, additive manufacturing offers greater advantages for part complexity, material utilisation and environmental impact. Fully functional parts or products, with many different components, are able to be produced simultaneously and on demand, thereby reducing the cost of production and dramatically accelerating the time it takes to take a product to market. This Forum presented an opportunity for Australian companies to further their understanding of the prospects, challenges, and opportunities in applying Additive Manufacturing technology.

Paper presentations by SEAM personnel

Additive manufacturing by thermal spraying to form near net shapes
by Distinguished Professor Christopher C Berndt (Swinburne)

Effect of particle feedstock shape on laser clad structures using SS 431
by Industry Associate Professor Colin Hall (UniSA)

Life cycle qualification via hybrid AM
by Mr Steve Milanoski (Romar Engineering)

Additive Manufacturing of heterogeneous materials for Aerospace and Defence applications
by Mr Jeff Lang (Titomic)

SPECIAL EVENTS

18 June 2020: *Coatings for Anti-Virus, Bacteria and Fungus Applications*, International Thermal Spray Conference (ITSC), Canada

SEAM was proud to sponsor the International Thermal Spray Conference (ITSC) 2021 Preview Virtual Session special event. Organised by the Thermal Spray Society of ASM International this global virtual event provided some 500 international participants a suite of great presentations and a taster of the forthcoming international ITSC event (May 2021 in Quebec City, Canada).

Leading industry experts participated and presented in this important discussion regarding how thermal spray applications can be used to deposit antimicrobial compounds on different types of high-touch surfaces. This learning session included discussions around mechanisms of anti-bacterial or anti-viral behaviour of coatings to help thermal spray researchers and fabricators with proper materials selection and processing. By applying these biocidal thermal spray coatings in large scale, the industry will potentially be able to support the effort to reduce the risk of propagation and transmission of viruses and bacteria in a variety of places (e.g., public transportation and hospitals); thereby protecting all of us.

Moderator

Mr William Lenling (Vice President, ASM Thermal Spray Society, US)

Speakers

Bio-engineering applications for thermal spray coatings: challenges and opportunities
by Distinguished Professor Christopher Berndt (Swinburne)

Different approaches for producing biocide coatings at CPT
by Dr Sergi Dosta (Universitat de Barcelona)

Thermal spray construction of nanostructured photocatalytic coatings for biocidal applications
by Professor Hua Li (Chinese Academy of Sciences)

Antibacterial copper coatings for frequently touched and heat sensitive surfaces
by Professor Javad Mostaghimi (University of Toronto)

Antibacterial coatings: challenges and opportunities
by Professor Federico Rosei (Université du Québec)

17 September 2020: 22nd Annual Technologists' Picnic, *Surface Engineering: 'Designing the Face' that interacts with demanding environments*

SEAM Director, Distinguished Professor Christopher C Berndt was the guest speaker for this 2020 Materials Australia 22nd Annual Technologists' Picnic and presented on the topic of 'Surface Engineering: 'Designing the Face' that interacts with demanding environments'. Chris presented the ARC Training Centre SEAM and showcased how it aspires to be the model centre that integrates industry-university cooperation for applied training within an industrial setting. He showcased its desires to be the nexus for an international collaborative network and the pursuit of ambitious outcomes that are reflected in terms of industry-fit researchers and commercial benefits for industry.

4 December 2020: *Science, Technology and Engineering STEM Blitz* Seminar Series (Swinburne)

Surface Engineering for Advanced Materials' leverages Swinburne's capabilities
by Distinguished Professor Christopher C. Berndt (Swinburne)

SEAM celebrates Swinburne's core mission in working with industry in the crucial area of materials innovation. A capsule history of SEAM will signal the trajectory towards self-sustainability. The many opportunities that have arisen from interacting and collaborating within SEAM will be outlined. The over-arching science concepts behind SEAM will be woven into the crucial industrial outcomes that underpin Swinburne's DNA. In summary: This presentation open doors for our extended community of scientists, engineers and academicians.

Technologies for thermal spraying composite substrates
by Associate Professor Scott Wade (Swinburne)

Industry is looking for different substrate materials and designs as well as coatings that can allow structures/components to provide improved performance, e.g. increasing demand for weight reduction. The application of specialist coatings is an important aspect of this, allowing materials to be used in harsh environments. This talk will provide an overview of work to be performed with industry partners to develop thermal spray coating processes for composite material structures to be used in marine applications. It will include the manufacture of test component prototypes as specified by industry partners and trials in the field.

Goggles on: the lasers are coming
by Mr Samuel Pinches (Swinburne)

The significance of surface engineering to future applications cannot be stressed enough, and the goal of the SEAM group is to be at the forefront of industrial research in this area. While lasers have been used in industry and research for decades, emerging techniques and processes are likely to see their adoption further increase.

*Image above: Taking a moment to celebrate **International Day of Women and Girls in Science**, at the MISE2020 Conference dinner - 11 February 2020.*

EQUIPMENT

SEAM is delighted to have successfully acquired equipment across its nodes directly aligned with the needs of applied industrial research projects. This equipment will compliment the universities basic infrastructure, equipment and facilities already available, however these newly acquired significant pieces will significantly enhance our collective research capability to leverage

- **New High Velocity Oxygen Fuel (HVOF) system**
- **New plasma system**
- **New laser cladding system**
- **CIAT (Continuous Impact/Abrasion Tester)**

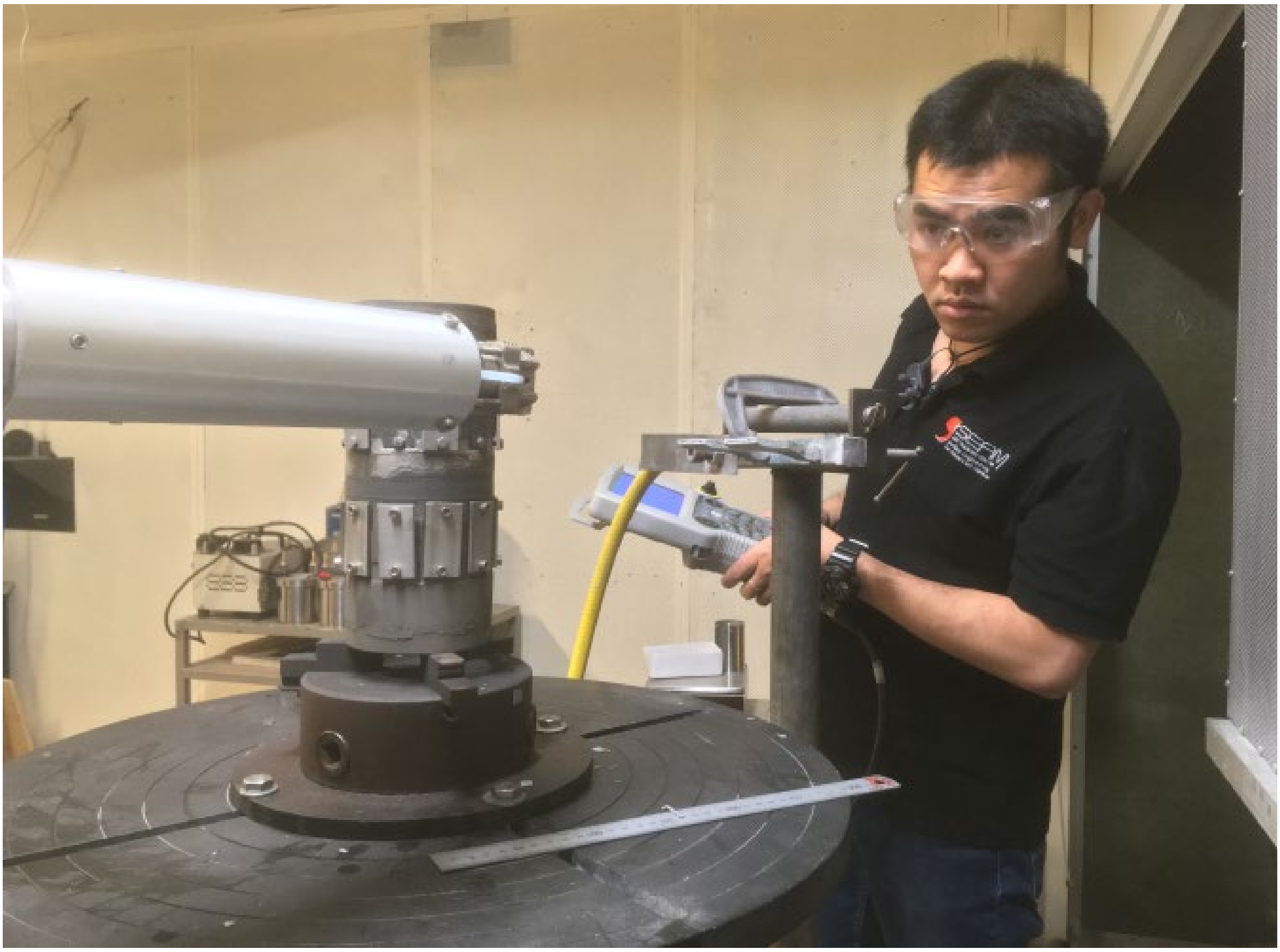


Image: Duy Quang Pham operating the New High Velocity Oxygen Fuel (HVOF) system

Image: CIAT (Continuous Impact/Abrasion Tester) located at University of South Australia

RESEARCH HIGHLIGHT

With the beginning of the COVID-19 pandemic in March 2020, in Australia, researchers put their thinking hat on how could researchers apply their research and expertise, skills, experience and knowledge to battle the virus. As engineers, and material scientists in surface engineering, it was clear that we must develop a coatings solution.

Copper (Cu) and silver (Ag) are well known for their anti-microbial properties. Studies have shown that SARS-CoV-2 virus can live on copper surfaces for 4 hours, whereas the virus remains alive and active on other surfaces, like stainless steel or plastic, for up to 72 hours. Copper is expensive and Ag 100 times the cost of copper, is an uneconomic choice. Copper was chosen as the best material for surfacing of frequently touched surfaces. Frequently touched surfaces such as door handles and handrails, countertops, and machine panels are a major source for spreading of microbes through contact transmission. The COVID-19 global pandemic highlights the importance of having clean surfaces in public areas, especially in hospitals, schools, airports, and other frequented public spaces. Anti-viral surfaces, especially those that inactivate viruses, make a significant contribution to public health in such high-contact settings.

Instead of replacing all frequently touched parts with bulk copper components, existing or new parts can be coated with copper. Thermal spraying is especially suitable for the application of anti-viral coatings. Every surface that can be roughened is coatable with this surfacing technology. Out of the different thermal spray processes, Wire Arc Spraying provides the best cost-performance ratio. Wire Arc Spraying is an industrial scale technology. Coatings are created when two electrically charged wires intersect to create molten metal droplets that are then propelled towards a substrate. Ci coatings with >85% copper are already used in wear and corrosion resistant as well as selected anti-microbial applications, which are appropriate for high touch surfaces.

As a mobile process, Wire Arc Spraying can be applied to larger structures that are not easily dismountable for coating in a workshop. With wire instead powder as a feedstock material, comparably low investment costs and ease of use, wire arc spraying of copper is the most suitable coating process for the application of anti-viral coatings.

URL: https://twitter.com/7NewsAdelaide/status/1317383806903439360

Christiane Schulz
University of South Australia

Thomas Schläfer
Laserbond (Adelaide)

MEDIA HIGHLIGHTS

Select media highlights from SEAM researchers.

Nishar Hameed interviewed by ***Composites World*** magazine for an article on *Multifunctional epoxy formulations show potential for future composite manufacturing*. Additive manufacturing (including composite automation) is predicted to be the future of the high-volume composite manufacturing. Bringing capabilities and expertise from many different areas, ultimately to address manufacturing challenges for composite industries.

Nishar Hameed also interviewed for the ***AuManufacturing Forum*** magazine for their edition of *Working smarter with data* series for the article on *Working smarter with data: Manufacturing the next generation of smart materials*.

Elena Ivanova interviewed to provide expert opinion on *The surfaces that kill bacteria and viruses* for the ***BBC Future*** program. **Elena Ivanova** further showcased the research on *The multi-faceted mechano-bactericidal mechanism of nanostructured surfaces* in an interview for ***Proceedings of the National Academy of Sciences of USA (PNAS) News***. A third media appearance was in the news section of ***PhysOrg*** for an article on *A new mechanism improves the efficiency of antibacterial surfaces*.

Image: Elena Ivanova.

RMIT University

Image: Nishar Hameed, holding a 3D-printed screen prototype in a Swinburne laboratory.

Photo credit: Swinburne

COLLABORATION HIGHLIGHT

New trans-pacific partnership in thermal spray

A new partnership signed in 2020 between Swinburne University of Technology and the American Welding Society (AWS) on behalf of the International Thermal Spray Association (ITSA) will strengthen the international outreach of both organisations across the Pacific.

This partnership aims to further surface engineering science and technology within a global context.

This partnership between AWS and SEAM is a great outcome and will have significant benefits by training early career researchers who will share their excitement and enthusiasm in surface engineering. The collaboration between SEAM and AWS/ITSA will ensure a pathway for the promotion and advancement of fundamental knowledge and understanding of surface engineering.

The International Thermal Spray Association (ITSA), a standing committee of the American Welding Society, is a professional industrial organisation dedicated to expanding the use of thermal spray technologies for the benefit of industry and society.

SEAM benefits include establishing a global network with industry and academics through AWS/ITSA; finding technical solutions for industrial issues; and providing early career researchers with future opportunities within a professional environment.

AWARDS

Milan Brandt

Distinguished Professor, SEAM Chief Investigator, RMIT

Awarded **Arthur L Schawlow** award by the Laser Institute of American recognising his outstanding, career-long contributions to basic and applied research in laser science and engineering which has lead to fundamental understanding of laser materials interaction and transfer of laser technology for increased application in industry, medicine and daily life.

Saulius Juodkazis

Professor, SEAM Chief Investigator, Swinburne

Awarded 2019 **Royal Society of Chemistry** award for Outstanding Paper, celebrating incredible work published in two of journals: *Materials Horizons* and *Nanoscale Horizons*.

Sam Pinches

Postdoctoral Fellow, Swinburne

Awarded **3-Minute ECR research presentation**, at MISE2020 Conference, Swinburne.

Keng-Te Lin

Postdoctoral Fellow, Swinburne

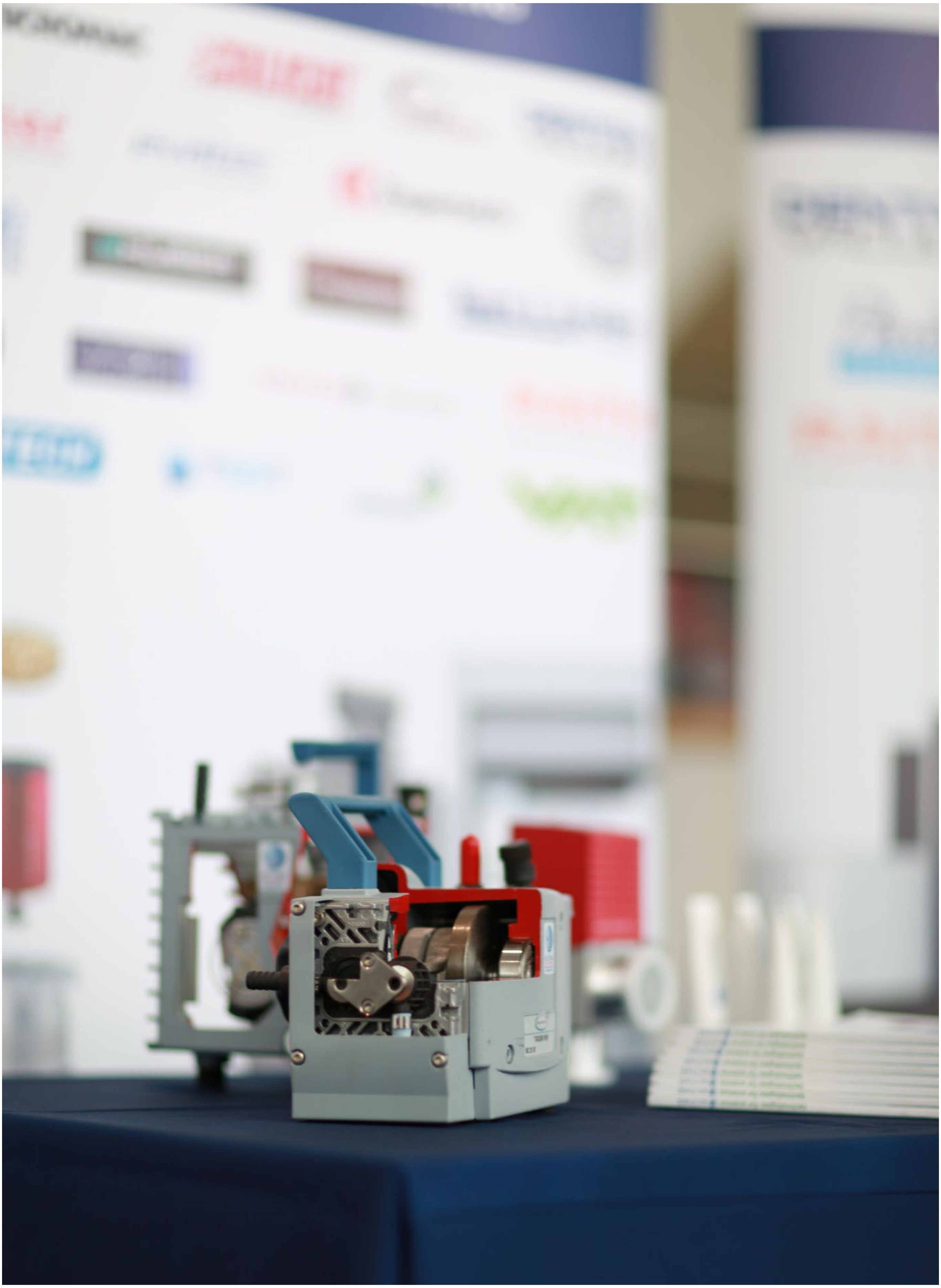
Awarded commendation of the 2020 Science, Engineering & Technology **Early Career Researcher** award, Swinburne.

Han Lin

Postdoctoral Fellow, Swinburne

Awarded 2020 **Best ECR Talk Award**, at International Conference on Nanomaterials & Atomaterials Science and Applications (ICNASA).

Image: Milan Brandt
RMIT University



THE SEAM "10,000 FOOT VIEW"

	SEAMs "10,000 Foot View"
1	Specific projects to be defined by ***Industry***.
2	A Training Centre for future engineer and science leaders. ***"Plug Play"***
3	***Embed*** Post Docs, Post Grads and Under Grad Interns into Industry.
4	University resources (***staff and kit***) used to address industry issues.
5	High level ***concept testing*** for surface engineering and additive manufacturing.
6	Time relevance: Industrial R&D that can be transferred in 2-3 year projects; i.e. focused on ***Manufacturing Readiness Level (MRL) of 4 5.***
7	Innovation focused: Use ***a combination of technologies*** to modify surfaces.
8	***Leverage*** the existing technologies among the Team.
9	Apply manufacturing robotics via ***Industry 4.0; i.e., automation.***

Engage and Collaborate with SEAM

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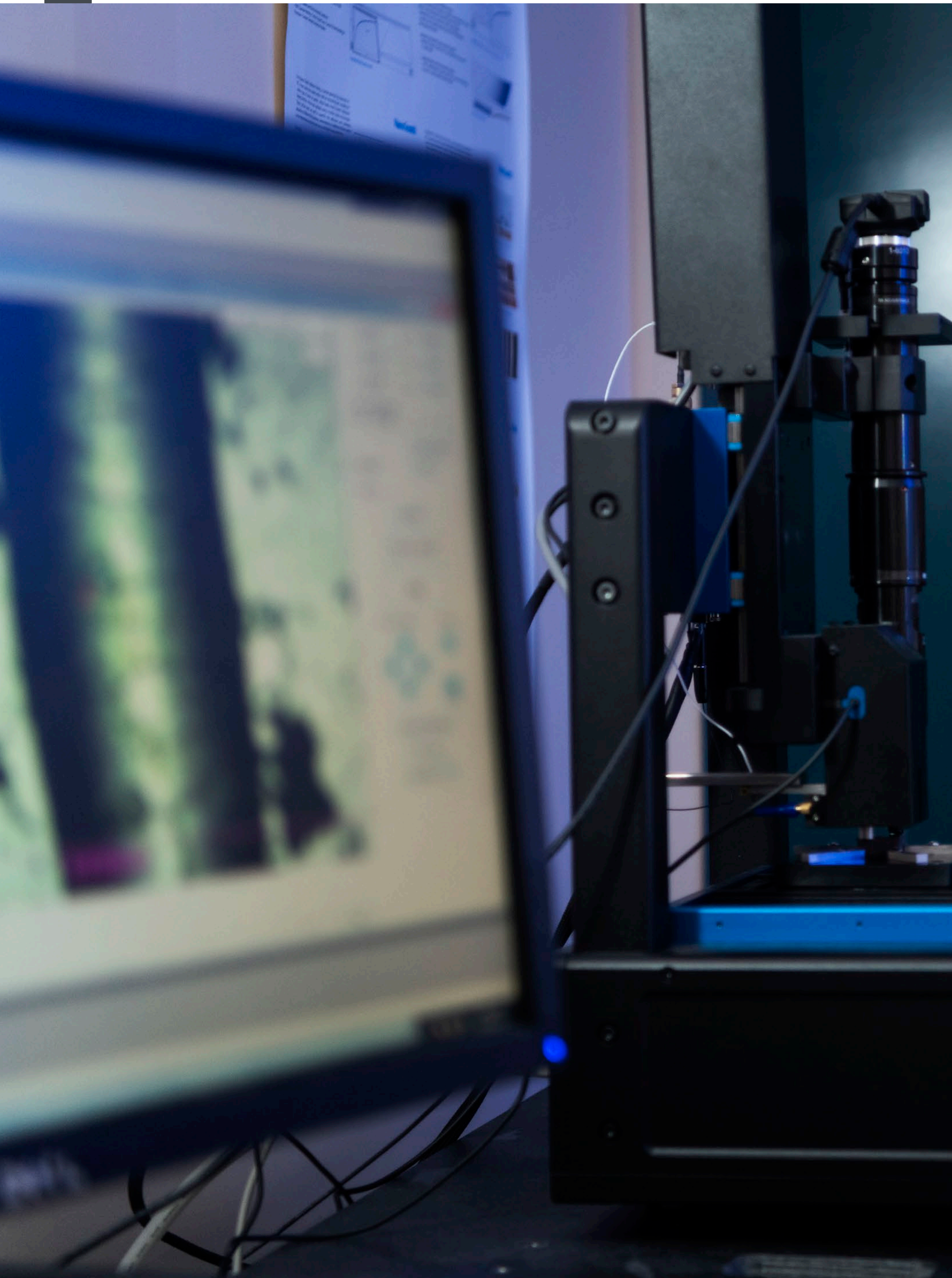
+ 61 (0) 428 237 638

KEY PERFORMANCE INDICATORS

Performance Indicators	Outcome
1. Early Career Researchers	
PhD/MPhil students Candidates	18
MPhil	2
Interns	6
Postdoctoral researchers	10
2. Partner Organisations placements	
ICHDRs	5
Postdoctoral researchers	2
3. Professional short courses/workshops	
Media/Public speaking	2
Professional short course	2
4. Joint industry/academia publications	
Blogs	1
Journals/Conference presentations	6
TV/Media	1
5. SEAM visits	
Industry International visitors	6
6. Centre briefings	
Government Industry briefings	4
Non-government organisations briefings	2
Professional/Tertiary organisation bodies briefings	2
7. Public talks by SEAM staff	
Conferences	30
Seminar Series	9
Forums	21
Scientific talks	2
8. Research Outputs	
Journal articles	240
Published to inform industry	4
Patents	3
Reviews/Review Peers	28
Editorial/ Erratum	3
Awards	5
University and Professional associations	4
9. Commentaries about SEAM achievements	
Media coverage	20
Social media coverage: LinkedIn impressions	1,711
10. Additional funding attributable to SEAM engagement activities	
Grants	$3,6M



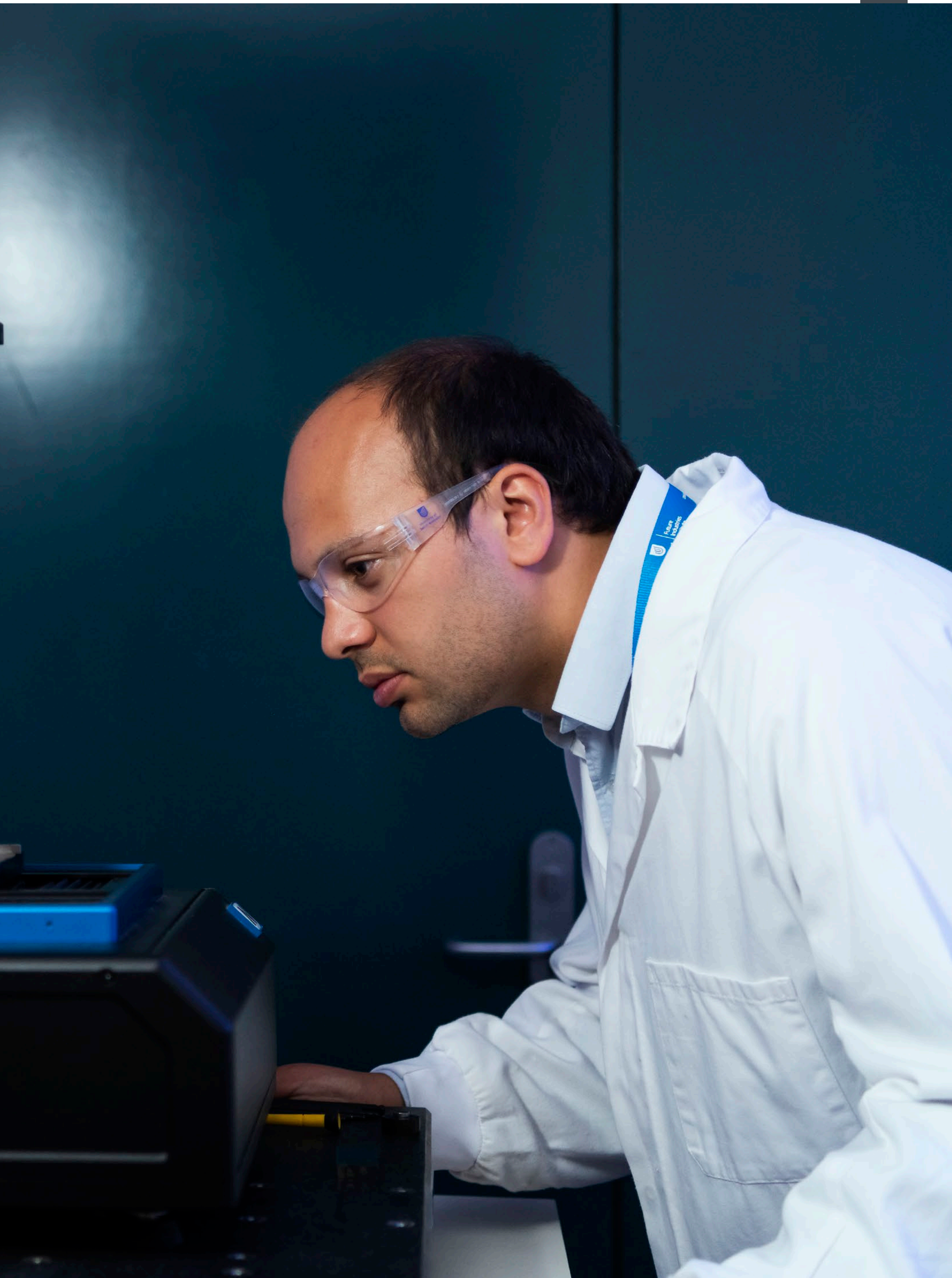


Image above: (left to right) Alexander Osi (PhD candidate, Swinburne) and Dr Arne Biesiekierski (Postdoc Swinburne).

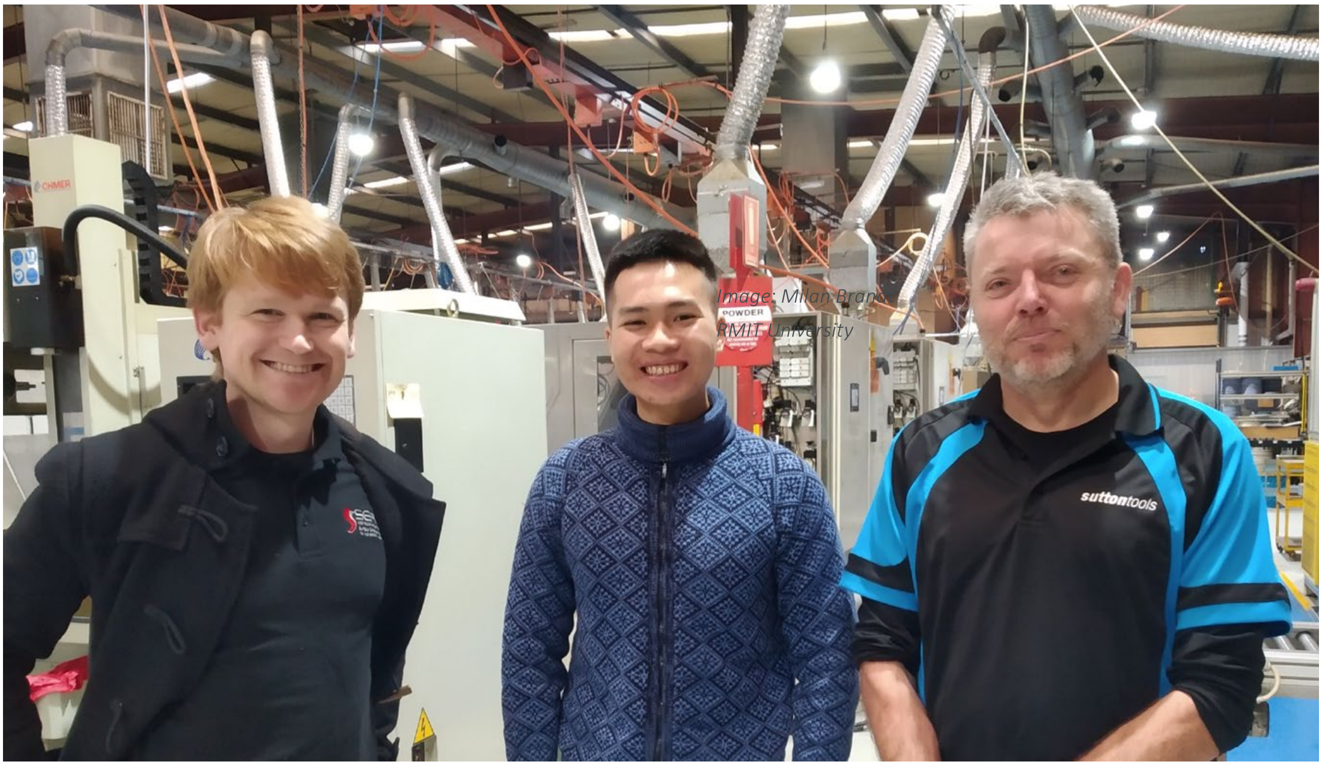


Image above: (left to right) Arne Biesiekierski (Postdoc Swinburne), Minh Nhật Đặng (PhD candidate, Swinburne) and Guy Stephens (Sutton Tools).

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