

**CSIRO Cutting edge science and engineering symposium**

# **SAMAM**

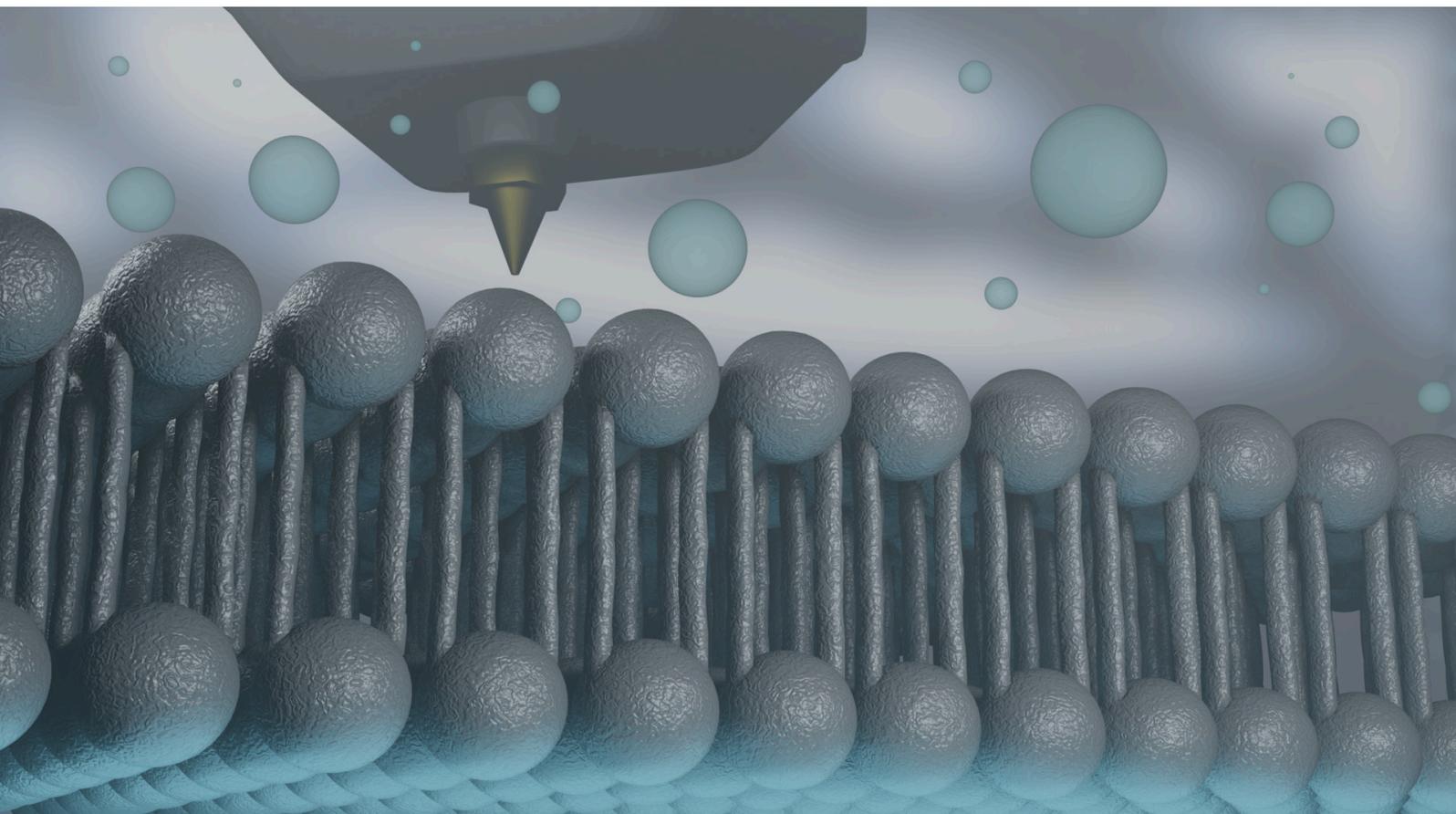
“Self-assembly meets additive  
for durable supply chains  
and transformative manufacturing”

*Commonwealth Scientific and Industrial Research Organisation*

*Ian Wark Theatre – Clayton, VIC, Australia*

*29 November to 1 December 2022*

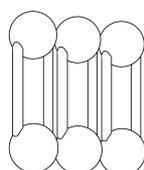
*<https://wp.csiro.au/samam/>*



# Acknowledgements



This event is supported by the Research Office of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) through the "R+ Cutting edge science and engineering symposia" program, FY 2021/22 (RO-ID: CES22-1-1380).



CSIRO Cutting edge symposium  
Self-assembly meets additive manufacturing  
Clayton, 29 Nov to 1 Dec 2022

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# Sponsorship

Silver sponsor



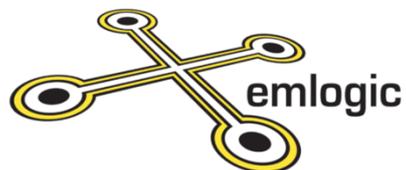
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## Exhibitors

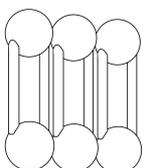


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# Welcome to SAMAM

CSIRO is hosting the Cutting edge science and engineering symposium on “Self-assembly meets additive for durable supply chains and transformative manufacturing”, or SAMAM.

The main goal of the symposium is to explore what has been done in this field to date and investigate new ideas that can bridge the gap between additive manufacturing and self-assembly. These two manufacturing methods working together at scale will enable automated, programmable, and efficient production of functional parts incorporating macro and nanoscale components.

Advancing precision manufacturing in Australia is beneficial for our industrial landscape, particularly in areas such as nanoelectronics, optics, energy storage and harvesting, and medicine.

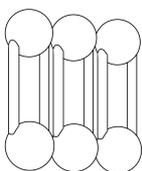
The conference will not only serve to highlight this area of research, but also to build collaborations and catalyse effort across industry, government, and academia. Participants will help establish whether there is a current or future need in Australia for an Academic Centre, Future Science Platform, and/or Industry De-Risking Facility to enhance Australian competitiveness in advanced materials and manufacturing.

The symposium is promoted by CSIRO’s Chief Scientist, Prof. Bronwyn Fox, and supported by CSIRO’s Research Office. Renowned academics and industry leaders will be participating as panel members for Q&As, representing views from multinationals, SMEs, and biotech manufacturing innovators.

Running from 29 November to 1 December 2022, the 3-day high-profile scientific program, in a Gordon Research Conference format, will include:

- Invited talks from international leading scientists and industry representatives
- Poster session open to everybody
- Round table
- Small exhibition
- Networking activities

***SAMAM is enabling the next generation of precision manufacturing by exploring the combination of additive manufacturing and self-assembly at scale.***



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## **Symposium headliner**

Prof. Bronwyn Fox, Chief Scientist, CSIRO

## **Symposium chair**

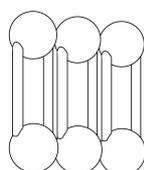
Dr. Antonella Sola, Science Leader in Active Materials, CSIRO

## **Symposium mentor**

Dr. Anita J. Hill, Honorary Fellow, CSIRO

## **Organising committee**

Dr. Lyndsey Benson  
Dr. George Feast  
Ms. Amy Garland  
Dr. Shaun Howard  
Dr. Richard Hannink  
Dr. Johnson Jacob  
Dr. Ahmad Kandjani  
Dr. Ylias (Louis) Kyratzis  
Dr. Kathie McGregor  
Dr. Christian Ruberg  
Dr. Dejana Simunek Pejak  
Dr. Adrian Trinchi  
Ms. Gael Vanderven  
Dr. Damien Watkins  
Dr. Marcus Zipper



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## Invited speakers



### **Bronwyn Fox**

Professor Bronwyn Fox, CSIRO's Chief Scientist, is an internationally recognised expert on carbon fibres and composite materials. She has a keen interest in the manufacturing of lightweight materials and the combination of design with manufacturing in more integrated and robust ways.



### **Gordon Wallace**

Professor Wallace is an Australian Laureate Fellow at the University of Wollongong. He is the Executive Director of Australian Research Council (ARC) Centre of Excellence for Electromaterials Science and also Founder and Director of the Intelligent Polymer Research Institute.



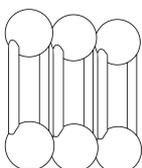
### **Gwénaëlle Proust**

Gwénaëlle Proust is a Professor of Materials Engineering in the School of Civil Engineering and the Director of the Sydney Manufacturing Hub at the University of Sydney. Her research projects encompass investigating and modelling manufacturing processes for more efficient devices.



### **Mark Hodge**

Dr. Mark Hodge has served as Chief Executive Officer of DMTC since its inception in June 2008, overseeing the organisation's success in a range of activities centred on Australia's defence and national security. Mark has worked with over 500 Australian SMEs and multinational manufacturers to address key defence and national security challenges and drive capability outcomes to meet Australia's sovereign national security objectives.





### **Kourosh Kalantar-Zadeh**

Professor Kalantar-Zadeh is an Australian Laureate Fellow and the Director of the Centre for Advanced Solid and Liquid-based Electronics and Optics at UNSW. His research interests include liquid metals, 2D materials, chemical and bio sensors, gastroenterology, medical devices and microfluidics.



### **Becca Murray**

Dr. Murray is the chair of Standard Australia's MB-028 Additive Manufacturing committee, Innovation Advisor to the Australian Defence Innovation Steering Group, and a senior research fellow at Herston Biofabrication Institute. She drives evidence-based innovation and implementation in the highly regulated medical and defence industries.



### **Benny Freeman**

Professor Freeman is the William J. (Bill) Murray, Jr. Endowed Chair of Chemical Engineering at The University of Texas at Austin. He is also Director of the US Department of Energy, Energy Frontier Research Center for Materials for Water and Energy Systems (M-WET), and Editor-in-Chief of Polymer.



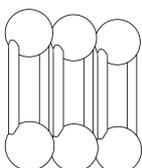
### **Cuie Wen**

Professor Wen leads the biomaterials research group at RMIT University, conducting research into biocompatible titanium, magnesium, iron, zinc and their alloys and scaffolds for biomedical applications, applying advanced manufacturing techniques.



### **Erol Harvey**

Professor Harvey is the CEO at the Aikenhead Centre for Medical Discovery. He has been on many Australian Government committees, is on the Board of the National Imaging Facility and serves as Chair of the Industry and Innovation Forum of ATSE.





### **Sally McArthur**

Professor McArthur is the Director of Deakin University's Institute of Frontier Materials and is a fellow of the ATSE. She leads a diverse group working to develop functional materials and processes to address the challenges of sustainable manufacturing.



### **Andrey Molotnikov**

Associate Professor Molotnikov is the Deputy Director of RMIT's Advanced Manufacturing Precinct and recognised as a leader in additive manufacturing. His areas of expertise are macro-processing with lasers and developing novel additive manufacturing techniques.



### **Sophie Primig**

Sophie Primig is a Scientia Associate Professor of physical metallurgy at UNSW. Her group's research is on designing alloys for high-performance applications such as aerospace, with interests in additive manufacturing.



### **Michael Edwards**

Michael Edwards is the Director, Boeing Research & Technology – Asia Pacific. Mr. Edwards carries executive responsibility for the delivery of the Company's research portfolio in the region and oversees a research team focused on creating the future for the Boeing enterprise globally.



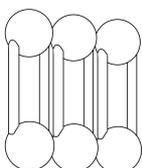
### **Laura Villanova**

Dr. Villanova is a Research Scientist from Institute of Molecular Biotechnology at the Technical University of Graz, Austria. Her areas of expertise include statistical analyses, experimental design and understanding dataset characteristics (meta-features) for meta-learning for molecular classification.



### **Peter Lynch**

Associate Professor Lynch is the Director of InSitX at Deakin University. He is a world-renowned expert in the characterisation of materials with X-rays, particularly developing novel in-situ techniques.





### **Paolo Falcaro**

Professor Falcaro leads a research group at the Institute of Physical and Theoretical Chemistry at the University of Graz, Austria. His research spans the fields of self-assembled materials, film deposition and crystal engineering.



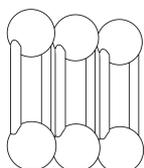
### **Natasha Wright**

Natasha Wright is the Research Director of CSIRO's Materials Characterisation and Modelling program, where she acts as a trusted advisor for CSIRO and industry regarding the most appropriate and holistic way of determining materials properties.



### **Matthew Barnett**

Professor Barnett has been a researcher at Deakin University for the past 23 years. His current focus is developing alloys and processes that better suit sustainability and the circular economy. He was formerly the director of the Institute of Frontier Materials and has spent 7 years working in the steel industry.



# Program

Day 1, Tuesday 29 November 2022

## **“Advancing precision manufacturing”**

Chair: Dr. Ahmad Kandjani

Day 2, Wednesday 30 November 2022

## **“Industry day”**

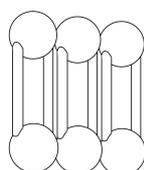
Chair: Dr. Johnson Jacob

Day 3, Thursday 1 December 2022

## **“Smart and sustainable manufacturing”**

Chair: Dr. Dejana Pejak

*There is a need to stimulate a new field of manufacturing research that combines the programmability and responsivity of biomolecular self-assembly with the unique physical properties of inorganic nanomaterials and also embraces 4D printing,*

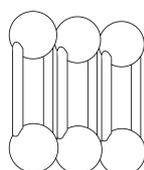


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# Program, Tuesday 29 November 2022

Tuesday 29 November 2022 - Chair: Dr. Ahmad Kandjani (CSIRO)	
8:30-9:00	<b>Registration</b>
9:00-9:30	<b>Marcus Zipper (CSIRO), Bronwyn Fox (CSIRO)</b> Opening
9:30-10:00	<b>Bronwyn Fox (CSIRO)</b> How to build and grow a manufacturing ecosystem in Australia
10:00-10:30	
10:30-11:00	<b>Morning tea and exhibition</b>
11:00-11:30	<b>Rebecca Murray (Herston Biofabrication Institute)</b> Innovation to standardisation - progressing novel work towards acceptance and use industrially
11:30-12:00	<b>Peter Lynch (CSIRO/Deakin University/InSITX)</b> Application of laboratory X-ray Microscopy for additive materials research
12:00-12:30	<b>Benny Freeman (The University of Texas at Austin)</b> Can self-assembly meet additive overcome property tradeoffs in membranes?
12:30-13:00	<b>Lunch and exhibition</b>
13:00-13:30	
13:30-14:00	<b>Sophie Primig, Maxwell Moyle (University of New South Wales)</b> Self-assembly meets additive in manufacturing of structural metallic materials for aerospace
14:00-14:30	<b>Cuie Wen (RMIT University)</b> Titanium alloy scaffolds manufactured by selective laser melting for bone implant applications
14:30-15:00	<b>Kourosh Kalantar-Zadeh (University of New South Wales)</b> Smart systems based on liquid metal
15:00-15:30	<b>Afternoon tea and exhibition</b>
15:30-16:00	<b>Laura Villanova (TU Graz)</b> – Towards the efficient development of robust SAMAM production processes – can statistical planning and artificial intelligence help?
16:00-16:30	<b>Andrey Molotnikov (RMIT University)</b> Technology, innovation and the role of Research Centres-led research
16:30-17:00	<b>Welcome cocktail with poster session and exhibition</b>
17:00-17:30	
17:30-18:00	

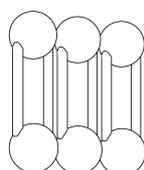


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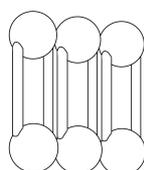
# Program, Wednesday 30 November 2022

Wednesday 30 November 2022 - Chair: Dr. Johnson Jacob (CSIRO)	
8:30-9:00	<b>Registration</b>
9:00-9:30	<b>Paolo Falcaro (TU Graz)</b>
9:30-10:00	Biom mineralization: An opportunity to combine self-assembly with additive manufacturing
10:00-10:30	<b>Discussion with Q&amp;A - Mark Hodge (DMTC)</b> How new materials and technologies contribute to Australia's defence and security
10:30-11:00	<b>Morning tea and exhibition</b>
11:00-11:30	<b>Industrial workshop led by George Feast (CSIRO)</b>
11:30-12:00	<b>Speakers: Oliver Hutt (Boron Molecular), Kiriti Rambhatla (Metakosmos), Cherry Chen (CSIRO), Christopher Berndt (Swinburne University of Technology)</b>
12:00-12:30	
12:30-13:00	<b>Lunch and exhibition</b>
13:00-13:30	
13:30-14:00	<b>Round table, Moderator: Marcus Zipper (CSIRO)</b>
14:00-14:30	<b>Specialist board members: Erol Harvey (Aikenhead Medical), Neil Matthews (Titomic), Barrie Finnin, Jason Miller and Dacian Tomus (Amaero), Kathie McGregor (CSIRO)</b>
14:30-15:00	
15:00-15:30	<b>Natasha Wright (CSIRO)</b> Advanced characterisation and modelling of novel materials
15:30-16:00	<b>Networking and exhibition</b>
TILL LATE	<b>Social dinner at Max's Restaurant - Red Hill Estate</b>



# Program, Thursday 1 December 2022

Thursday 1 December 2022 - Chair: Dr. Dejana Pejak Simunec (CSIRO)	
8:30-9:00	<b>Registration</b>
9:00-9:30	<b>Sally McArthur (Institute for Frontier Materials, Deakin University)</b> Idea to Industry: How IFM helps translate molecules into materials and products
9:30-10:00	<b>Matthew Barnett (Deakin University)</b> Designing alloys with durability of supply in mind
10:00-10:30	
10:30-11:00	<b>Morning tea and exhibition</b>
11:00-11:30	<b>Gwénaëlle Proust (The University of Sydney)</b> Heat-Responsive self-morphing structures fabricated via fused filament fabrication
11:30-12:00	<b>Gordon Wallace (University of Wollongong)</b> 3D bioprinting is 4D printing
12:00-12:30	
12:30-13:00	<b>Lunch and exhibition</b>
13:00-13:30	
13:30-14:00	<b>Michael Edwards (Boeing)</b> Technologies that are disrupting the future of aerospace
14:00-14:30	<b>Marcus Zipper (CSIRO), Kathie McGregor (CSIRO)</b> Closing ceremony and "best poster presentation" announcement
14:30-15:00	<b>Lab tour to Clayton site:</b> - Lab22 (Daniel East, CSIRO) - Mixed Reality Lab (Matt Bolger, CSIRO Data61) - Testlab 4.0 (Jimmy Thomas, Swinburne University of Technology)
15:00-15:30	
15:30-16:00	
16:00-16:30	
16:30-17:00	
17:00-17:30	
17:00-17:30	



	29 Nov. 2022 - Day 1 (Tue.) Chair: Dr. Ahmad Kandjani (CSIRO)	30 Nov. 2022 - Day 2 (Wed.) Chair: Dr. Johnson Jacob (CSIRO)	1 Dec. 2022 - Day 3 (Thu.) Chair: Dr. Dejana Pejak Simunec (CSIRO)
8:30-9:00	Registration	Registration	Registration
9:00-9:30	Marcus Zipper (CSIRO), Bronwyn Fox (CSIRO) - <i>Opening</i>	Paolo Falcaro (TU Graz)	Sally McArthur (Institute for Frontier Materials, Deakin University)
9:30-10:00	Bronwyn Fox (CSIRO)		
10:00-10:30		Discussion with Q&A - Mark Hodge (DMTC)	Matthew Barnett (Deakin University)
10:30-11:00	Morning tea and exhibition	Morning tea and exhibition	Morning tea and exhibition
11:00-11:30	Rebecca Murray (Herston Biofabrication Institute)	Industrial workshop led by George Feast (CSIRO)	Gwénaëlle Proust (The University of Sydney)
11:30-12:00	Peter Lynch (CSIRO/Deakin University/InSitX)		Gordon Wallace (University of Wollongong)
12:00-12:30	Benny Freeman (The University of Texas at Austin)		
12:30-13:00	Lunch and exhibition	Lunch and exhibition	Lunch and exhibition
13:00-13:30			
13:30-14:00	Sophie Primig, Maxwell Moyle (University of New South Wales)	Round table, Moderator: Marcus Zipper (CSIRO)	Michael Edwards (Boeing)
14:00-14:30	Cuie Wen (RMIT University)		Marcus Zipper (CSIRO), Kathie McGregor (CSIRO) - <i>Closing and poster award</i>
14:30-15:00	Kourosh Kalantar-Zadeh (University of New South Wales)		
15:00-15:30	Afternoon tea and exhibition	Natasha Wright (CSIRO)	Lab tour to Clayton site - Lab22 (Daniel East) - Mixed Reality Lab (Matt Bolger) - Testlab 4.0 (Jimmy Thomas)
15:30-16:00	Laura Villanova (TU Graz)	Networking and exhibition	
16:00-16:30	Andrey Molotnikov (RMIT University)	Social dinner Max's Restaurant - Red Hill Estate	
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18:00-18:30			
18:30-19:00			
19:00-19:30			
19:30-20:00			
20:00-20:30			
20:30-21:00			

# Industrial workshop

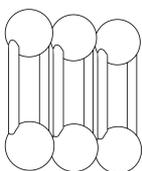
Wednesday 30 November 2022, 11:00 am to 12:30 pm

The Industrial workshop, led by Dr. George Feast (CSIRO), will explore the need for advanced precision manufacturing in Australia, the existing challenges in this field, and the prospective advantages enabled by SAMAM, with the contribution of industry representatives, research scientists and academic centre directors.

Speakers:

- Dr. Oliver Hutt (CEO Boron Molecular),
- Kiriti Rambhatla (Founder Metakosmos),
- Dr. Cherry Chen (Research Scientist, CSIRO Manufacturing),
- Prof. Christopher Berndt (Director SEAM, Swinburne University of Technology)

*With this symposium, CSIRO will contribute to promote Australia at the forefront of innovation in self-assembly-assisted additive manufacturing, where the material hierarchies (porosity, morphology, structure, composition) and their fabrication come in to play to enable a new bottom-up approach to nano-structuring that leverages the intrinsic properties of matter.*



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# Round table

**Wednesday 30 November 2022, 1:30 pm to 3:00 pm**

The Round table will provide the opportunity for a critical and constructive exchange of ideas on the future of Australian manufacturing ecosystem.

Under the guidance of Dr. Marcus Zipper, Director of the Manufacturing Business Unit at CSIRO, the panel will bring together areas of expertise in materials and processing, that do not yet work together hand in glove, to pave the way for a new field of research in precision additive manufacturing.

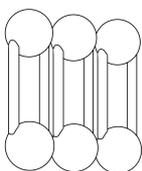
In addition to exploring the science, senior thought leaders from industry and research hubs will discuss the current tension between domestic policy that promotes national security and self-sufficiency, and the flow-on effects of such policy acting to suppress access to foreign talent and investment. The round table will also highlight the role that industry de-risking facilities play in innovation and to sketch what such a facility or a Public-private partnership platform (PPPP) might look like for Australia.

The focus will be on emerging challenges, including

- synthetic approaches to enable scalable assembly of matter,
- computational methods and models to transform how manufacturing and refinement processes are controlled,
- new characterisation and imaging tools that can handle the complexity, scales, and processing speeds to meet real-time manufacturing and refinement needs,
- new science to address opportunities relevant to sustainable and energy efficient manufacturing, and
- approaches to co-design of materials, processes, and products for manufacture and reuse.

Specialist panel board members:

- Dr. Erol Harvey (Aikenhead Medical)
- Neil Matthews (Titomic),
- Barrie Finnin, Jason Miller and Dacian Tomus (Amaero),
- Dr. Kathie McGregor (CSIRO, Advanced Materials and Processing Program)



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# CSIRO's lab tour

Thursday 1 December 2022, 2:30 pm to 5:30 pm

The symposium will close with a tour to CSIRO's facilities. The Industry 4.0 Testlab, Lab22, and the Mixed Reality Lab feature world-class equipment and play a key role in supporting the growth of Australia's science and technology.

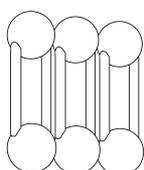
## Swinburne-CSIRO National Industry 4.0 Testlab

The Swinburne-CSIRO National Industry 4.0 Testlab for Composite Additive Manufacturing provides fully digitally supported engineering and manufacturing solutions for parts, processes and entire systems for automotive, aerospace, production and much more.

The centrepiece of the Testlab is the world's first industrial scale 3D printing multilayer approach to near net composite manufacture. The process enables the cost-effective fabrication of commercial grade fibre-reinforced composite parts with minimal preform trimming at a lower cost, with reduced waste and improved quality.

The Testlab, strategically nested within the Australian Manufacturing and Materials Precinct in Clayton, creates opportunities for industry partners to innovate their products, supply chain, and manufacturing or delivery systems, aiming for optimisation in performance, sustainability and cost.

Tour leader: Dr. Jimmy Thomas



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## Lab22

Lab22 in Clayton is CSIRO's metallic additive manufacturing research lab. Lab22 features a variety of machine types from large format robotic systems such as laser direct energy deposition and cold spray, to high resolution processes such as Ebeam and laser powder bed systems.

Specialists at Lab22 conduct research on a variety of alloy systems such as Invar, shape memory alloys, titanium, nickel and magnesium-based alloys.

Lab22 is an industrially focused lab with projects in industry sectors such as biomedical, defence, resources and the space industry.

Tour leader: Dr. Daniel East

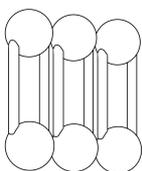
## Mixed Reality Lab

The Mixed Reality Lab at CSIRO's Data61 enables manufacturing and other industries to create 'Digital Twins', or virtual replicas of physical objects and systems. Located in Clayton, the lab houses a set-up of industrial and consumer optical cameras and sensing equipment to capture detailed information about a physical object and the space surrounding it. The equipment is underpinned by sophisticated algorithms (Workspace) which merge the enormous amounts of data collected to create a digital twin in a matter of minutes.

By comparing a digital twin of a manufactured object against the original design, developers can quickly, accurately and cost-effectively identify defects and map entire manufacturing processes across a global supply chain. With the ability to be scaled to the size of the object being scanned, the Mixed Reality Lab can be tailored to create products for a variety of businesses, including health, agriculture and mining.



Tour Leader: Dr. Matt Bolger



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# Posters

## Poster session, 29 November 2022, 4:30 pm to 6:00 pm

The poster session, open to everybody with a focus on students and young researchers, will take place during the welcome cocktail on 29 November 2022.

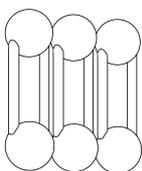
## Best poster presentation award

All participants are invited to vote the best poster presentation during the poster session and welcome cocktail on Tuesday 29 November 2022, 4:30 pm to 6:00 pm.

The most voted contribution will be announced during the Closing ceremony on Thursday 1 December 2022, 2:00 pm to 2:30 pm.

Rules:

- Poster presentations can only be voted during the poster session and welcome cocktail;
- Each participant to the symposium can only vote one poster presentation using the form provided in the symposium satchel;
- To avoid any conflicts of interests, none of the authors can vote. *Please note: this rule applies to all authors, including corresponding authors and co-authors*



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## Confirmed poster contributions

- SAMAM-CES\_poster\_2022-01

Piezoelectric properties of two-dimensional Bi<sub>2</sub>O<sub>3</sub> nanosheets by liquid metal printing  
*Xiangyang Guo, Chung Kim Nguyen, Ali Zavabeti, Yongxiang Li\**

- SAMAM-CES\_poster\_2022-02

Recycling of metal swarf waste particles as feedstock material via additive manufacturing technology  
*Malkeet Singh\*, Harpreet Singh*

- SAMAM-CES\_poster\_2022-04

The application of SAXS/WAXS for understanding the structure-property relationship of 2D nanomaterials  
*Jizhen Zhang, Joselito M. Razal\*, Peter A. Lynch\**

- SAMAM-CES\_poster\_2022-05

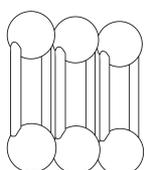
Single-step fabrication method toward 3D printing composite diamond–titanium interfaces for neural applications  
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CSIRO's Cross Cutting Capabilities-*Creating Connections*  
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- SAMAM-CES\_poster\_2022-07

Thermodynamics meets kinetics in SAMAM  
*Richard Hannink\*, Anita Hill, Aaron Thornton, Benny Freeman, James Mardel, Anthony B. Murphy, Stefan Gulizia, Antonella Sola, Adrian Trinchi*



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- SAMAM-CES\_poster\_2022-08

Expectation vs Reality: Can in-process monitoring detect defective builds in the high-value world of automated AM?

*Timothy Herzog\*, Milan Brandt, Adrian Trinchi, Antonella Sola, Andrey Molotnikov*

- SAMAM-CES\_poster\_2022-09

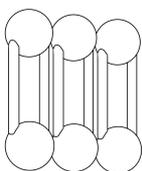
SAMAM and wearable sensors: Governing the anisotropic response of conductive composites through 3D printing-induced shear stress

*Dejana Pejak Simunec\*, Michael Breedon, Faizan U.R. Muhammad, Louis Kyratzis, Antonella Sola*

- SAMAM-CES\_poster\_2022-10

Application of a synchrotron-like laboratory X-ray facility for screening additively manufactured materials

*Sitarama Kada, David Fox, Jizhen Zhang, Jun Wang, Antonella Sola, Adrian Trinchi, Johnson Jacob, Natasha Wright, Peter Lynch*



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# Piezoelectric properties of two-dimensional $\text{Bi}_2\text{O}_3$ nanosheets by liquid metal printing

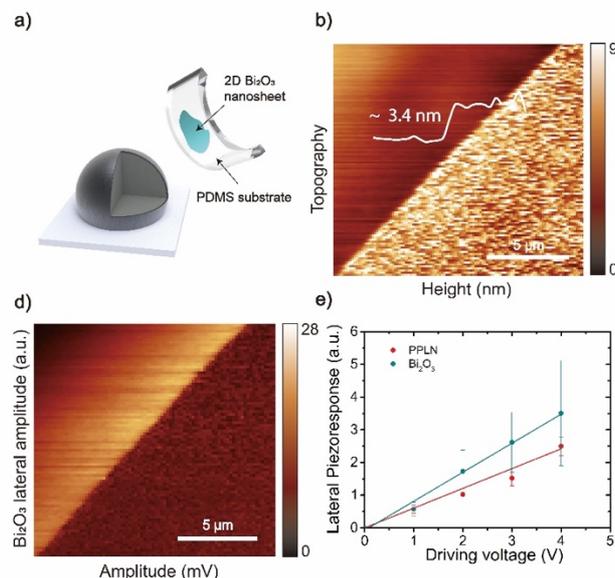
Xiangyang Guo<sup>1</sup>, Chung Kim Nguyen<sup>1</sup>, Ali Zavabeti<sup>1,2</sup>, Yongxiang Li<sup>1,\*</sup>

<sup>1</sup>School of Engineering, STEM College, RMIT University, Melbourne, VIC 3000, Australia

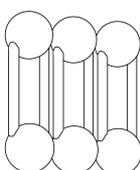
<sup>2</sup>Department of Chemical Engineering, The University of Melbourne, Victoria Parkville 3010 Australia

\* Corresponding author. Email yongxiang.li@rmit.edu.au

In this talk, we report the new piezoelectric properties of liquid metal synthesized 2D  $\text{Bi}_2\text{O}_3$  nanosheets. Bismuth metal was heated to 350°C on a heating plate, and the  $\text{Bi}_2\text{O}_3$  nanosheets formed on the surface of bismuth metal, then the surface layer was transferred to  $\text{SiO}_2/\text{Si}$  substrates and flexible polydimethylsiloxane (PDMS) surfaces using the touch print method. PFM measurements were performed on the 2D  $\text{Bi}_2\text{O}_3$  nanosheets for piezoelectric properties, and it was found that the measured lateral piezoelectric value  $d_{31}$  can reach 10.4 pm/V, which is twice higher than the value measured by the standard sample Periodically Poled Lithium Niobate (PPLN). In addition, the fabricated flexible nanogenerators can achieve a maximum voltage output value of ~3 V peak (~6 V peak-to-peak) by using a cyclically external force machine to apply vertically. The excellent piezoelectric properties of 2D  $\text{Bi}_2\text{O}_3$  nanosheets have stable voltage output on the flexible substrates, which provides opportunities for further far-reaching applications. The piezoelectric properties were generated by the unique crystal arrangement of the 2D  $\text{Bi}_2\text{O}_3$  structure. In the future, 2D  $\text{Bi}_2\text{O}_3$  nanosheets can be applied in various scenarios, such as energy harvesting, ultrathin actuators, adaptive electronics, and biomedical wearable devices.



**Figure.** a) The schematic diagram of the synthesis of liquid metal. 2D  $\text{Bi}_2\text{O}_3$  nanosheets are obtained by adding bismuth metal to 350°C and PDMS substrate is used to touch print the surface of molten metal. b) AFM topography of 2D  $\text{Bi}_2\text{O}_3$  nanosheets. c) Amplitude distribution of lateral piezoelectric response under 4 V AC drive voltages. d) The lateral piezoelectric response of 2D  $\text{Bi}_2\text{O}_3$  nanosheets to different driving voltages.



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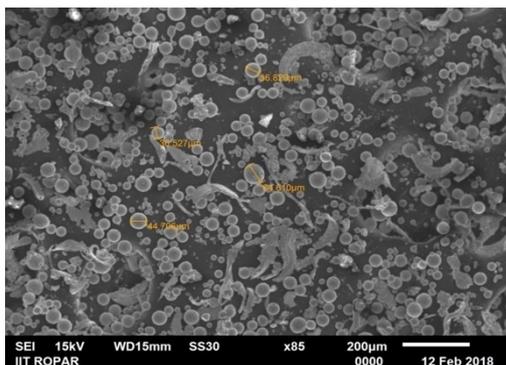
# Recycling of metal swarf waste particles as feedstock material via additive manufacturing technology

Malkeet Singh\*, Harpreet Singh

Department of Mechanical, Engineering, Indian Institute of Technology Ropar, Rupnagar, Punjab, 140001, India

\* Corresponding author. Email: [malkeet.singh@iitrpr.ac.in](mailto:malkeet.singh@iitrpr.ac.in)

One of the most innovative manufacturing methods nowadays is additive manufacturing (AM). Due to its distinct advantages over traditional manufacturing, such as the capacity to produce complex shapes with high efficiency, shorter lead times, reduced waste, quick prototyping, and in-house production, AM technology is playing a crucial role in the advancement of various industries. Equally important is encouraging waste reduction and recycling among enterprises, industries, and consumers, as well as helping emerging nations shift to more sustainable consumption practices. One such waste comes from the industries that process machining micro swarf particles such as the production of low carbon steel swarf micro particles during grinding process. The swarf powder can directly be produced during the grinding of work piece without using any supplicated equipment and external source. Therefore spherical and non-spherical micrometer sized swarf particles being high-value materials, the creation of environmentally friendly technologies to recycle the swarf is urgently needed [1, 2]. The present observation is based on a novel scrap utilization-based sustainable technology to recycle the swarf particles into feedstock material that can be used for additive manufacturing. It is confirmed from the size and shapes of the collected swarf particles, as shown in Figure 1, that the powder developed from waste is suitable for AM technology as feedstock material. Spherically shaped particles with an average size of 35 $\mu$ m are observed in the swarf powder. One of the major obstacles to effective production and environmental preservation is the production of industrial waste, such as metal scrap materials. Therefore, it is highly desirable to recycle industrial waste as a viable feedstock

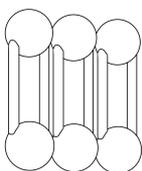


material for AM technology to make usable goods. This study presents an applicability of the recycling and use of metallic waste as feedstock materials for additive manufacturing (AM).

**Figure.** SEM analysis of micro-sized low carbon steel swarf particles produced during one of the machining processes, which is the grinding process, reveals the utilisation of machining scrap into metallic feedstock powder for additive manufacturing applications.

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# The application of SAXS/WAXS for understanding the structure-property relationship of 2D nanomaterials

Jizhen Zhang<sup>1,2</sup>, Joselito M. Razal<sup>2\*</sup>, Peter A. Lynch<sup>1,2\*</sup>

<sup>1</sup>Manufacturing, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Waurn Ponds, 3216 VIC, Australia

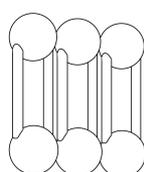
<sup>2</sup>Institute for Frontier Materials, Deakin University, Geelong, VIC 3216, Australia

\* Corresponding author. Email: Peter.Lynch@csiro.au and Joselito.Razal@deakin.edu.au

Due to its unique mix of electrical conductivity, large surface area, and good dispersibility in different solvents, the 2D nanomaterial MXene recently gained enormous attention. In order to create functional macro structures from nanomaterials, a few solution processing techniques, including as wet-spinning, coating, 3D printing, and freeze casting, have been developed. In our studies, the highly electrical conducting MXene fiber [1] and composite fiber [2] are achieved and small angle and wide angle X-ray scattering (SAXS/WAXS) is introduced to reveal the orientation of MXene sheets in different spinning conditions. The SAXS/WAXS investigation shows that the alignment and orientation of nanosheets have a significant impact on the properties of their macrostructures. For instance, the excellent mechanical strength and EMI shielding performance is attributed to the aligned and tightly packed MXene sheets following blade coating [2-4]. Furthermore, understanding the effect of sharing force on 2D MXene orientations is crucial to achieving advanced control over macroscopic alignments and macroscale properties. Using in-situ SAXS, we first investigated the orientation changes as functions of share rate, nanosheet size, and concentration. Most importantly, the successful coordination of SAXS/WAXS and advanced materials will bridge the gap between structural preparation and structural performances.

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# Single-step fabrication method toward 3D printing composite diamond-titanium interfaces for neural applications

Nour Mani<sup>1,2,7\*</sup>, Arman Ahnood<sup>1</sup>, Danli Peng<sup>3</sup>, Wei Tong<sup>3,4</sup>, Marsilea Booth<sup>1</sup>, Alan Jones<sup>2</sup>, Billy Murdoch<sup>5</sup>, Nhiem Tran<sup>6</sup>, Shadi Houshyar<sup>1</sup>, Kate Fox<sup>1,2\*</sup>

<sup>1</sup>*School of Engineering, RMIT University, Melbourne, VIC 3001, Australia*

<sup>2</sup>*Centre for Additive Manufacturing, RMIT University, Melbourne, VIC 3001, Australia*

<sup>3</sup>*School of Physics, The University of Melbourne, Parkville, Melbourne, VIC 3010, Australia*

<sup>4</sup>*National Vision Research Institute, Australian College of Optometry, Carlton, VIC 3010, Australia*

<sup>5</sup>*RMIT Microscopy and Microanalysis Facility, Melbourne, VIC 3001, Australia*

<sup>6</sup>*School of Science, RMIT University, Melbourne, VIC 3001, Australia*

<sup>7</sup>*CSIRO Manufacturing, Clayton, VIC 3168, Australia*

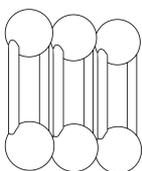
\* Corresponding author. Email Kate.Fox@rmit.edu.au and Nour.mani@student.rmit.edu.au

Diamond is an extraordinary material that has been investigated extensively in multiple medical fields due to its many favourable properties, such as durability, selective conductivity, biocompatibility, and antimicrobial capability [1]. In parallel, additive manufacturing (AM) provides a manufacturing platform that facilitates fabricating customised patient-specific implants [2]. Hence, Diamond Titanium (DTi) is a new biomaterial that can address the previously mentioned gaps by facilitating 3d printing of compatible composite interfaces [3].

This research provides details of the 3D printing of planar DTi samples. Moreover, we report that the DTi with percentages from 20-50% diamond provides a superior biomaterial to 3D printed titanium alone. Further studies have shown that the DTi can also provide an improved neural interface material with charge injection measured equivalent to traditional bionic materials such as platinum (30% DTi samples provide a  $430 \mu\text{Fcm}^{-2}$  electrochemical capacitance, low impedance ( $0.55 \pm 0.03 \text{ k}\Omega$  at 1 kHz) and a high charge injection capacity ( $0.22 \text{ mCcm}^{-2}$ ). This indicates that incorporating diamond into the implant's surface provides a more favourable interface for neural cells to grow and that DTi supports the cell attachment to the implant [4].

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# CSIRO's Cross Cutting Capabilities-*Creating connections*

Michael Breedon, Andreas Duenser, Paul Flick, Veronica Glattauer\*, Sharon Hook,  
Cass Hunter, Manolo Per, Andy Wilkins, Charlotte Williams

*Office of the Chief Scientist, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Clayton, 3169 VIC, Australia*

\* Corresponding author. Email [Veronica.Glattauer@csiro.au](mailto:Veronica.Glattauer@csiro.au)

CSIRO has been solving the greatest challenges through innovative science and technology for more than 100 years. To continue this pattern, we looked at where our future science and technology capability needs to be and identified nine Cross-Cutting Capabilities (CCCs) as key enablers of CSIRO's decadal plan:

- Genomics
- Synthetic Biology
- Robotics, Internet of Things and Sensing
- Digital Twin, Modelling and Simulation
- Advanced Materials
- Engineering
- Quantum Technologies
- Indigenous Knowledge and Science
- Social Science and User Experience

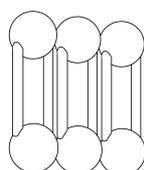
The CCCs enable connectivity of interdisciplinary and multidisciplinary expertise across CSIRO beyond the traditional organisational structure to enable greater focus and efficiencies. By establishing Communities of Practice, the CCCs have enhanced collaboration and ways of working to deliver opportunities through knowledge sharing, identifying growth opportunities, and fostering career development.

Since their establishment in 2020, the CCCs have

- built communities of practice with over 1200 members
- contributed to national reports (2021 State of Social Sciences, government's Quantum roadmap)
- created skills databases where people can find their next collaborator (genomics, digital twins)
- been involved in strategic workforce planning – identifying key skills gaps
- awarded micro-funding to support small projects, establish collaboration, or perform a proof-of-concept experiment
- hosted webinars, workshops, and other events.

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## Thermodynamics meets kinetics in SAMAM

Richard Hannink<sup>1\*</sup>, Anita Hill<sup>1</sup>, Aaron Thornton<sup>1</sup>, Benny Freeman<sup>2</sup>, James Mardel<sup>1</sup>,  
Anthony B. Murphy<sup>1</sup>, Stefan Gulizia<sup>1</sup>, Antonella Sola<sup>1</sup>, Adrian Trinchi<sup>1</sup>

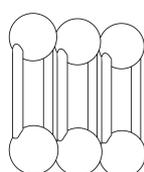
<sup>1</sup>Manufacturing, CSIRO, Clayton, 3169 VIC, Australia

<sup>2</sup>Department of Chemical Engineering, University of Texas, Austin TX, USA

\* Corresponding author. Email richard.hannink@csiro.au

Presently materials are designed to meet performance specifications, such as mechanical properties, heat and corrosion resistance. These specifications arise from the conditions over which a material must perform. Thus materials are designed to offer a limited set of responses to external and environmental stimuli such as load, impact, heat, radiation, corrosion or vibration. Significant margins of safety are required for their design often leading to waste of material, while changes in operating conditions for the material may require complete redesign.

Current material design principles must evolve to utilise the “Internet of Material Properties”, through digital twin and clone material modelling, to develop materials with dynamic functionality which can be tailored as part of the additive 3D manufacturing process. A critical parameter to manipulate the design for material properties and their responsiveness is the empty space within the material. The empty space controls the transport of atoms and molecules through materials as well as their interactions with each other and the materials themselves, enabling microstructural development. Transport is the property that allows a material to manipulate neutral atoms, molecules, and ions. Transport governs nanostructure, microstructure, and macrostructure, over 10 orders of magnitude and hence determines how engineering- and bio-materials behave. The new design principles for materials rely upon the ability to measure and manipulate atoms, molecules, ions, and empty space from sub-nanometer to meter length scales during or as part of the manufacturing process. Self-assembly meets additive manufacturing (SAMAM) utilises kinetics and thermodynamics to tailor materials and offers the materials designer an ability to innovate. These developments in materials science-manufacturing processes will lead to next generation of products with a clear performance edge.



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# Expectation vs Reality: Can in-process monitoring detect defective builds in the high-value world of automated AM?

Timothy Herzog<sup>1,2\*</sup>, Milan Brandt<sup>1</sup>, Adrian Trinchi<sup>2</sup>, Antonella Sola<sup>2</sup>, Andrey Molotnikov<sup>1</sup>

<sup>1</sup>Centre for Additive Manufacturing, School of Engineering, RMIT University, Melbourne, VIC, 3000, Australia

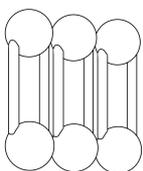
<sup>2</sup>CSIRO Manufacturing Business Unit, Clayton, VIC, 3168, Australia

\* Corresponding author. Email [s3826323@student.rmit.edu.au](mailto:s3826323@student.rmit.edu.au) ; [tim.herzog@csiro.au](mailto:tim.herzog@csiro.au)

As Additive Manufacturing transitions to higher-value markets through automation, self-assembly and microstructural control, how can the integrity of such parts be monitored and assured? In-situ monitoring provides an avenue to assess the quality of printed parts throughout the building process - enabling early detections of defects and thermal abnormalities [1, 2]. The present work demonstrates a thermal monitoring system that has been shown capable of detecting signals from the formation of porosity in metallic parts produced by Laser Directed Energy Deposition at an early stage during the build process. This presents an opportunity to reduce current reliance on costly and time-consuming post-production inspection methods [3]. Exploitation of this approach will lead to enhanced conformity between desired structures and the resultant components, supporting future advancement of high-value metal AM.

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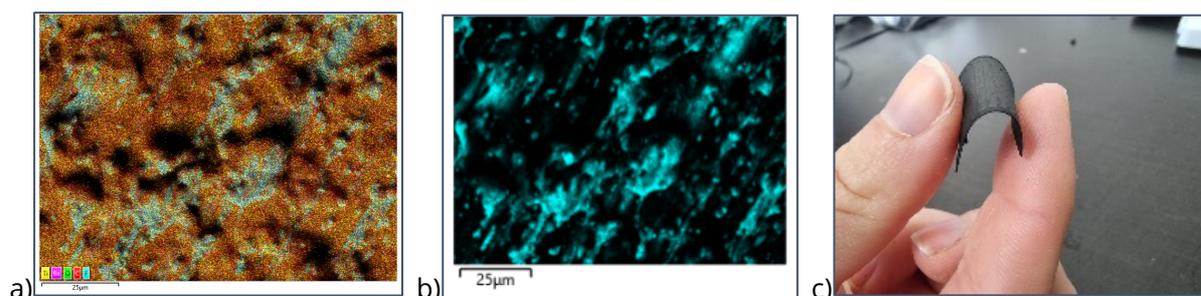
# SAMAM and wearable sensors: Governing the anisotropic response of conductive composites through 3D printing-induced shear stress

Dejana Pejak Simunec\*, Michael Breedon, Faizan U.R. Muhammad, Louis Kyratzis, Antonella Sola

Manufacturing Business Unit, Commonwealth Scientific and Industrial Research Organisation (CSIRO)  
Clayton, 3169 VIC, Australia

\* Corresponding author. Email [dejana.pejak@csiro.au](mailto:dejana.pejak@csiro.au)

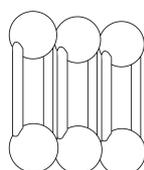
Fused filament fabrication (FFF) is ideally suited to assist with the growth of smart electronics. Unlike traditional metallic conductors, polymer-based composite feedstock for FFF can be specially imbued with a combination of ideal properties for sensor applications like piezoelectricity, conductivity, flexibility and corrosion resistance [1–3]. Additionally, the shear stress associated with the flow through the print nozzle can be leveraged to induce a controlled preferential orientation that dictates the directionality of the electrical response of the printed part. In this research, a new multi-component material for 3D printing flexible sensors was developed, and a novel treatment aimed to amplify its electrical properties without external poling was thoroughly assessed. Thermoplastic polyurethane and carbon black provided the flexible, conductive pathway, whilst polyvinylidene fluoride (PVDF) and barium titanate ( $\text{BaTiO}_3$ ) were added to induce any potential piezoelectric behaviour. Immiscible PVDF regions in the FFF parts were orientated through shear-induced stress, and it was shown that this anisotropy affected the sensor output. Through texturing and size reduction of  $\text{BaTiO}_3$ , there was an improvement in dispersion and electrical response of the sensors via the interaction between the electrical charges of side groups of PVDF and the surface charges of  $\text{BaTiO}_3$ . There was also evidence of improvement in conductivity following finger tapping whilst under very low voltage (0.1V).



**Figure.** EDS mapping of 3D printed sensor (a) showing aligned PVDF regions (aqua, detail in b) and printed sensor (c).

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# Application of a synchrotron-like laboratory X-ray facility for screening additively manufactured materials

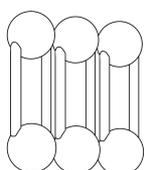
Sitarama Kada<sup>1,2\*</sup>, David Fox<sup>2</sup>, Jizhen Zhang<sup>1,2</sup>, Jun Wang<sup>1</sup>, Antonella Sola<sup>2</sup>, Adrian Trinchi<sup>2</sup>, Johnson Jacob<sup>2</sup>,  
Natasha Wright<sup>2</sup>, Peter Lynch<sup>1,2</sup>

<sup>1</sup> *InSitX, Institute for Frontier Materials, Deakin University, Waurn ponds, VIC, 3217*

<sup>2</sup> *Manufacturing Business Unit, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Clayton, 3169 VIC, Australia*

\* Corresponding author. Email: s.kada@deakin.edu.au, Sitaramaraju.kada@csiro.au

InSitX represents an exciting new laboratory X-ray facility dedicated to the study of new materials based on advanced manufacturing processing pathways. InSitX is a joint program between CSIRO and Deakin University with a focus on the development of new in-situ and in-operando X-ray experiments to realize material design and discovery. InSitX is a world first with near synchrotron capabilities. It creates an unprecedented capacity to explore material structures outside of a synchrotron. The facility also serves to interface with the Australian Synchrotron by enabling 'off-line' development of complex X-ray experiments prior to accessing limited Synchrotron beamtimes. The X-ray facility is equipped with an ultra-high brightness liquid metal jet X-ray source. Comprising of two beamlines with small and wide angle scattering (SAXS-WAXS), diffraction and microcomputer tomography (Micro-CT). An overview of the experimental capabilities in terms of technique and its application to additive manufacturing is presented.



CSIRO Cutting edge symposium  
Self-assembly meets additive manufacturing  
Clayton, 29 Nov to 1 Dec 2022

<https://wp.csiro.au/samam/>

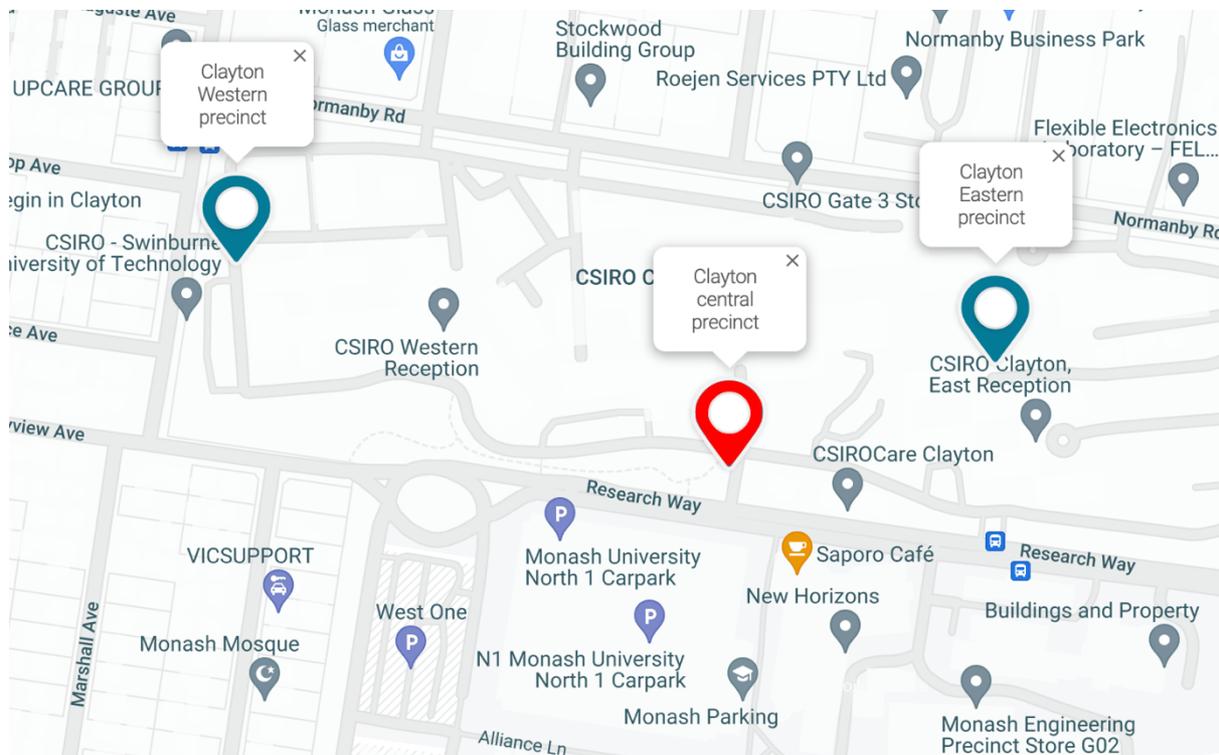
# Venue

The SAMAM Symposium will take place in the Ian Wark lecture theatre at CSIRO's Clayton campus in Melbourne, Victoria, Australia. The Ian Wark lecture theatre is located next to the central reception.

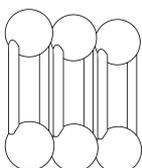
When attending the site, please enter via the main gate on Research Way (Clayton, VIC 3168) and head to the central reception.

Detailed information about the CSIRO Clayton site location may be found in the link below

<https://www.csiro.au/en/about/locations/state-locations/vic/clayton>



<b>Main reception</b>	
<b>Call us</b>  <a href="tel:1300363400">1300 363 400</a>	<b>Address</b>  Research Way Clayton Vic 3168
9.00 am to 4.00 pm AEST Monday - Friday	



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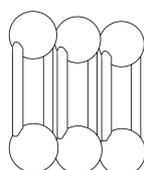
<https://wp.csiro.au/samam/>

## Gala reception

The Gala Reception will be held at the internationally acclaimed Max's Restaurant at Red Hill Estate and Winery on the Mornington Peninsula, one of Victoria's premier scenic regions. Attendees can enjoy ocean views whilst overlooking the famous winery and partake in social networking activities intended to foster collaborations.

Private chartered bus will be used to ferry attendees from the conference venue to the winery, and at completion of the reception, buses will return guests to the conference venue.

*Please Note: The Gala Reception is included in the registration*



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