University of Southern Queensland

UniSQ Advanced Manufacturing

Professor Xuesen Zeng, Acting Director
Centre for Future Materials

Acknowledgement of Country

UniSQ would like to acknowledge the traditional custodians of the land on which we gather. We would also like to pay our respect to Elders – past, present and emerging.

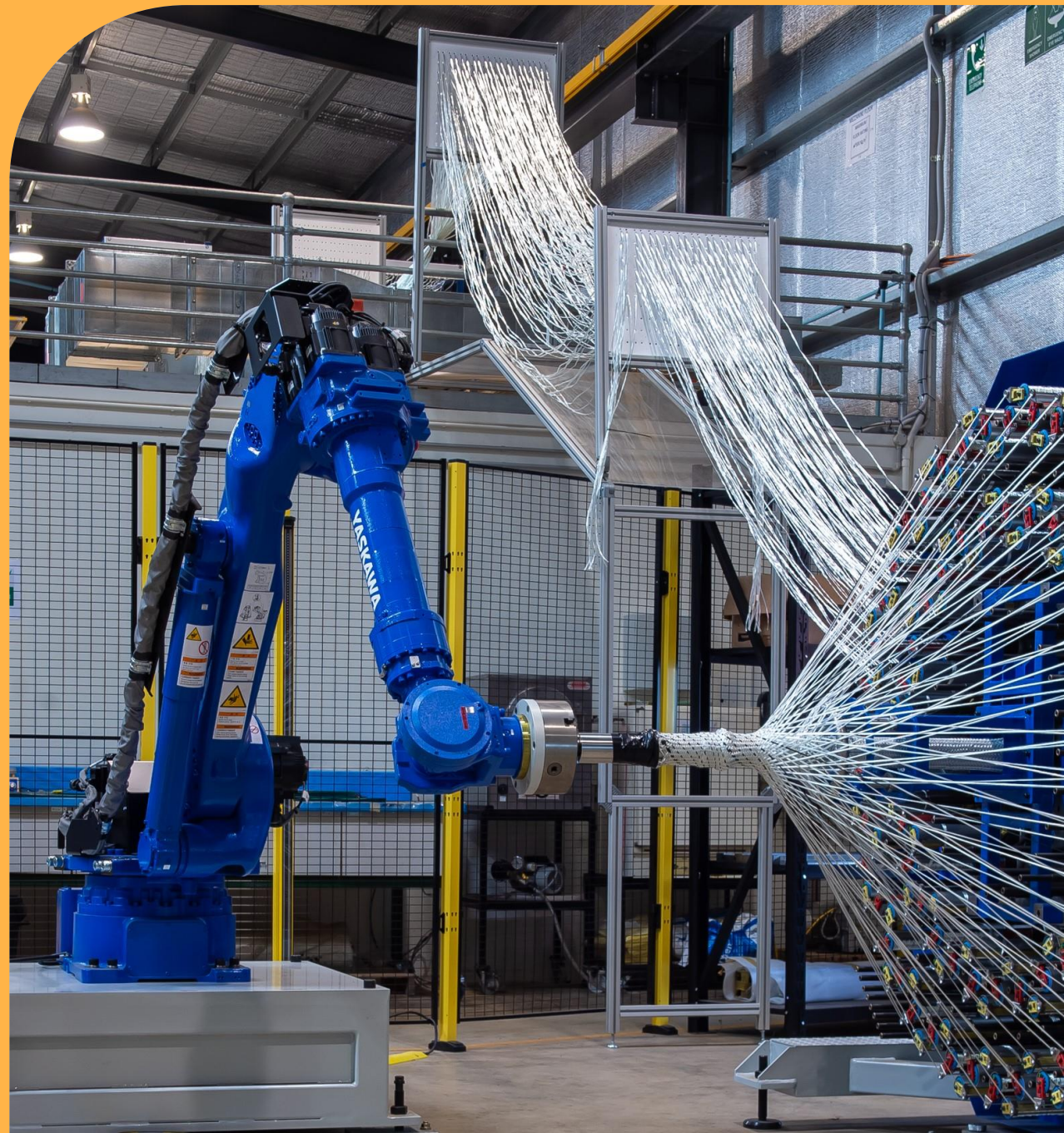
Flagship Research Areas

Space and Defence, incl Astrophysics, Hypersonics, Rocketry and *Materials Engineering*

Regional Development, incl Sustainable Economic Development, Regional Decarbonisation, Innovation, *Workforce Development*

Agriculture and Environment, incl Climate Science, Drought Mitigation and Adaptation, Crop Health

Health, incl Sport and Exercise Science, Mental Health and Allied Health



Centre for Future Materials

Introduction

- Established in 1995
- One of the leading research centres in Australia for engineered fibre composites
- Delivering R&D to Reality
  - Working closely with industry partners
  - Development of advanced/sustainable materials & manufacturing
  - Application in resilient structures
  - From research laboratory to real-life applications
- www.youtube.com/c/USQCentreforFutureMaterials
- https://composites.unisq.edu.au/research/facilities/

"In the field of Composite Materials, we name USQ as Australia's top research institution, with most citations in the top 20 journals in the field in the last five years."

RESEARCH SPECIAL REPORT SEPTEMBER 2020,THE AUSTRALIAN

THE AUSTRALIAN

Research Programme

Advanced Composites Manufacturing

Theme Leader: Xuesen Zeng

- Filament Winding
- Pultrusion
- Repair
- Infusion Processing

Functional Materials

Theme Leader: Hao Wang

- Flame Retardant
- Morphing Material
- Energy Material
- Environmental Material
- Geopolymer

Civil Composites

Theme Leader: Allan Manalo

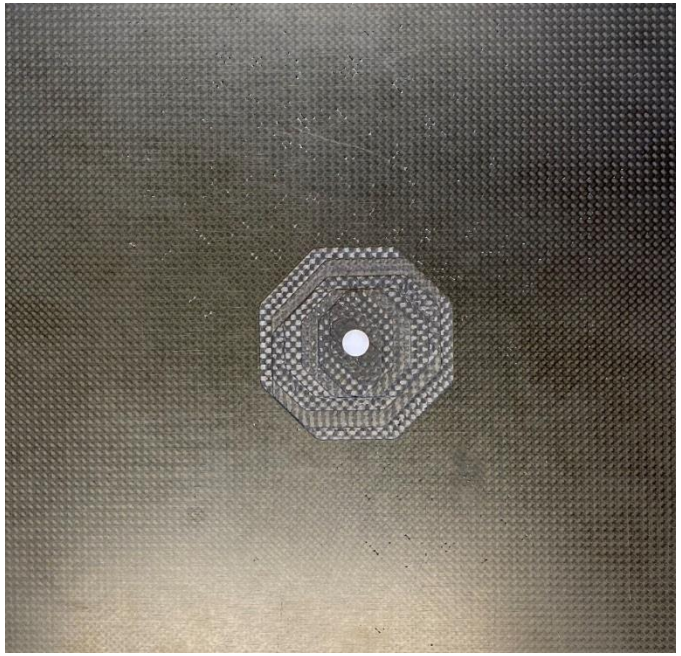
- FRP Bar
- Rock Bolt
- Polymer Sleepers
- Repair/Rehabilitation
- High Performance Concrete

Sustainable Industry Design

Theme Leader: Polly Burey

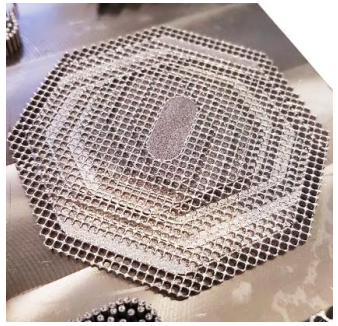
- Circular Economy Modelling
- Materials Recycle & Reuse
- Microprocessing
- System Design

Adhesive Bonded Repair – Additive Manufactured Metal (ABR-AMM)

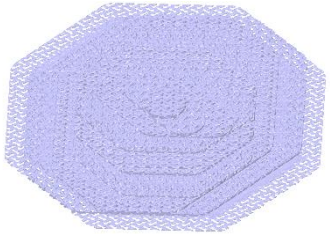


Compact scarfing on damaged carbon fibre composite panel

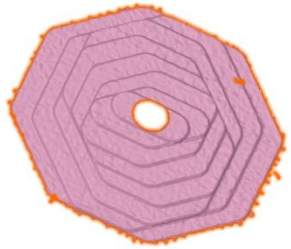
Repair bonding



Titanium alloy 3D printing
(Material: Ti6Al4V ELI Extra-Low Interstitial grade 23
Machine: Renishaw RenAM500Q)



Cellular lattice design optimisation

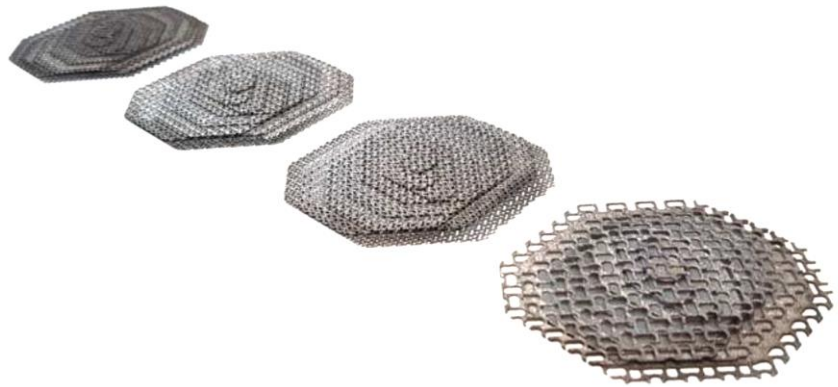


Laser scanning 3D model

Additive Printing Process

Renishaw RenAM500Q

Powder: Ti6Al4V ELI Extra-Low Interstitial grade 23



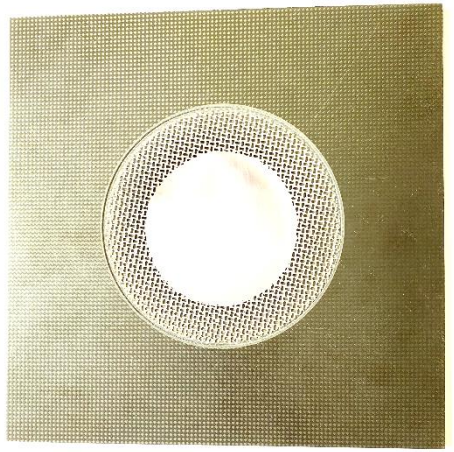
Print time = 70 minutes

In-situ monitoring data, link any deviations as a result of laser input, splatter, gas flow and design of the samples.

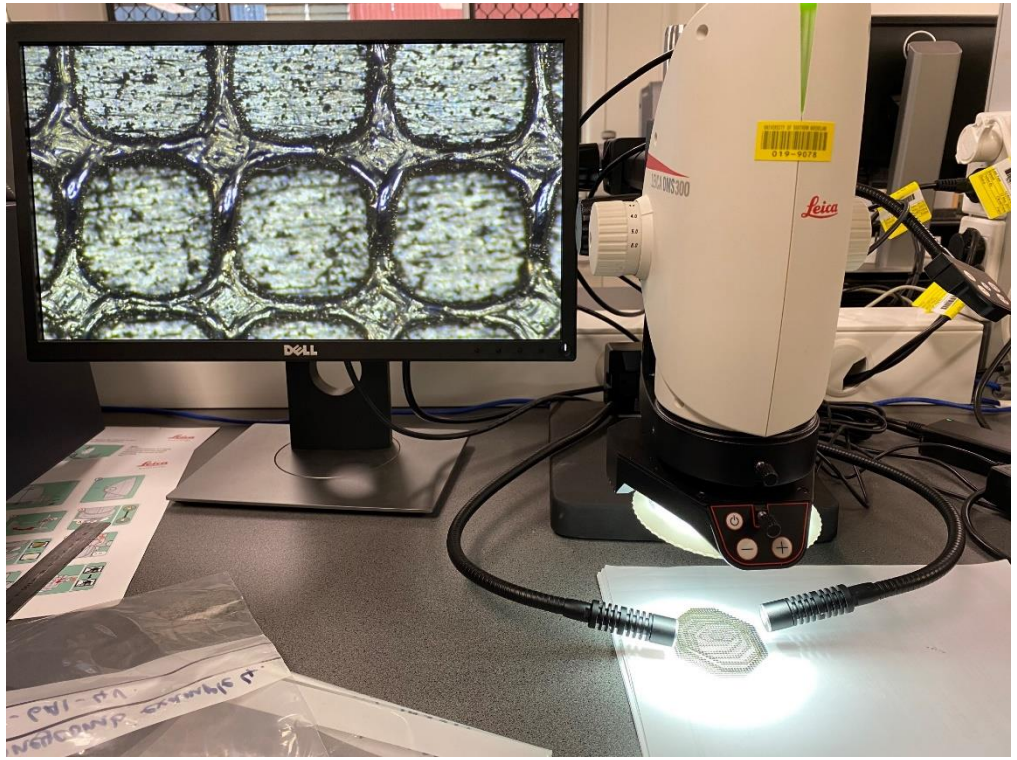
Post Build: vacuum heat treated and wire Electrical Discharge Machining (EDM) processed

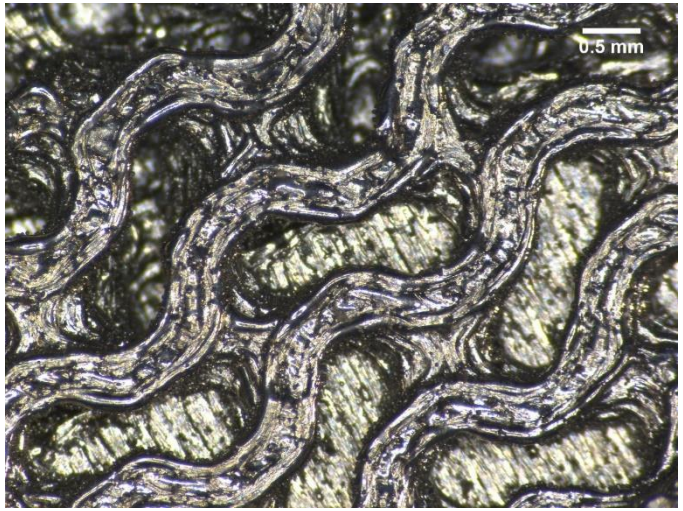
Print quality of demonstrators

Compact scarf



Standard scarf





- ✓ High dimensional accuracy
- ✓ No distortion
- ✓ Sub mm lattice structure

High temperature ceramic composite manufacturing

Enabling Australian commercial suppliers to design, manufacture, and integrate low-cost oxide-oxide cermamic matrix composites for Space and Defence.

Ceramix matrix composite offers weight reduction for high temperature applications (>1000^{o}C).

Ceramix matrix composite market values at AU$600M by 2024.

Ultra-lightweight liquid hydrogen fuel tanks

Composite cryotanks can achieve up to 25% cost saving and 30% weight savings (NASA).

Industrial scale with max tank dimension: 1.5 meter diameter x 4.3 meter length

Challenges

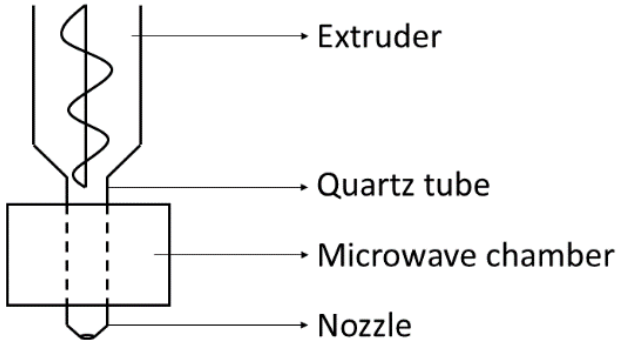
- Pressurised LH2 at cryogenic conditions (930KPa, and −252 °C)
- Tank permeation level to sustain a lunar lander mission (1.55×10^{-6} $m^3/s/m^2$)

→ Stringent manufacturing defect requirement

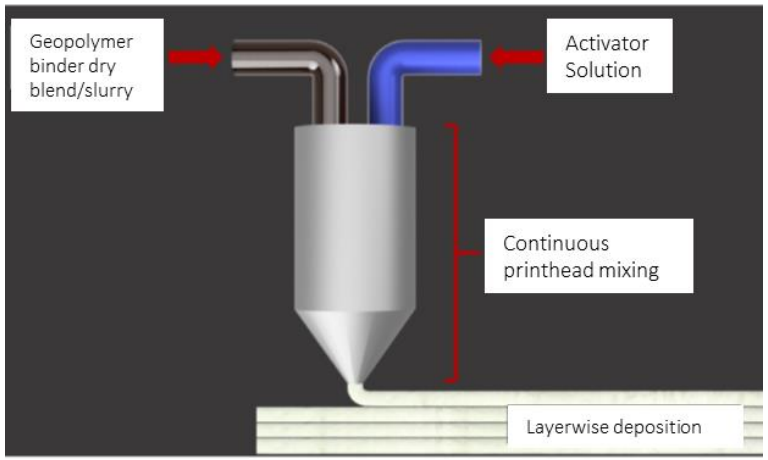
Solutions

- High precision composite tank manufacuring with robotic filament winding
- Digital twin
- Novel nanocomposite for multifuctional hydrogen tanks

3D printing of geopolymer composites



Microwave heating at printhead



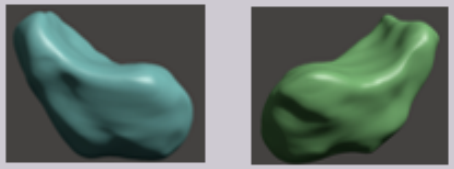
Printhead mixing of geopolymer binder and slurry

Waste reduction (40-60%), high productivity, Design flexibility, Safety in Construction

- Microwave heating at printhead accelerates the geopolymer reactions after printing for continuous building
- Print-head mixing of binder and activators in geopolymer composites enables geopolymer reactions after printing

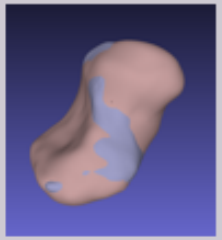
Novel technique for surgical management of scaphoid nonunion

- Health sector responsible for 4.4% of greenhouse emissions
- Operating theatres ~25% of hospital emissions
- Revision surgery is resource intensive and still no guarantees



Paired scaphoid models reconstructed in Vitrea

- ICP creates a meshwork of points on overlayed models
- It sequentially finds the closest points to give a measured variance between models
- It gives a measure of average error in mm



Dominant (mm^3)	Non-Dominant (mm^3)	Avg Err (mm)
2851	2705	0.255
p=0.001		

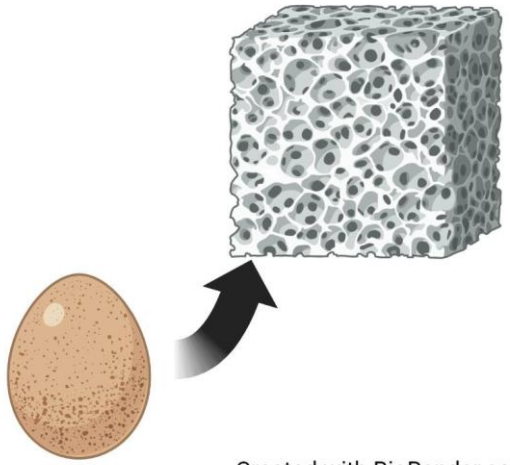
- Bespoke template to create bone graft shaped for defect
- Clinical trial – TGA notification
- HBI to 3D print
- DDHHS for recruitment & surgery+

Australian Government
Department of Health and Aged Care
Therapeutic Goods Administration

HERSTON BIOFABRICATION INSTITUTE

TOOWOOMBA HOSPITAL foundation

3D bioengineered bone microenvironments



Created with BioRender.com

- Late-stage metastatic cancers need reliable models to test potential treatments
- 3D bioengineered microenvironment will increase the ability to accurately test new treatments
- To use eggshell waste in the scaffold

Create a optimal bioink

Testing the use of:

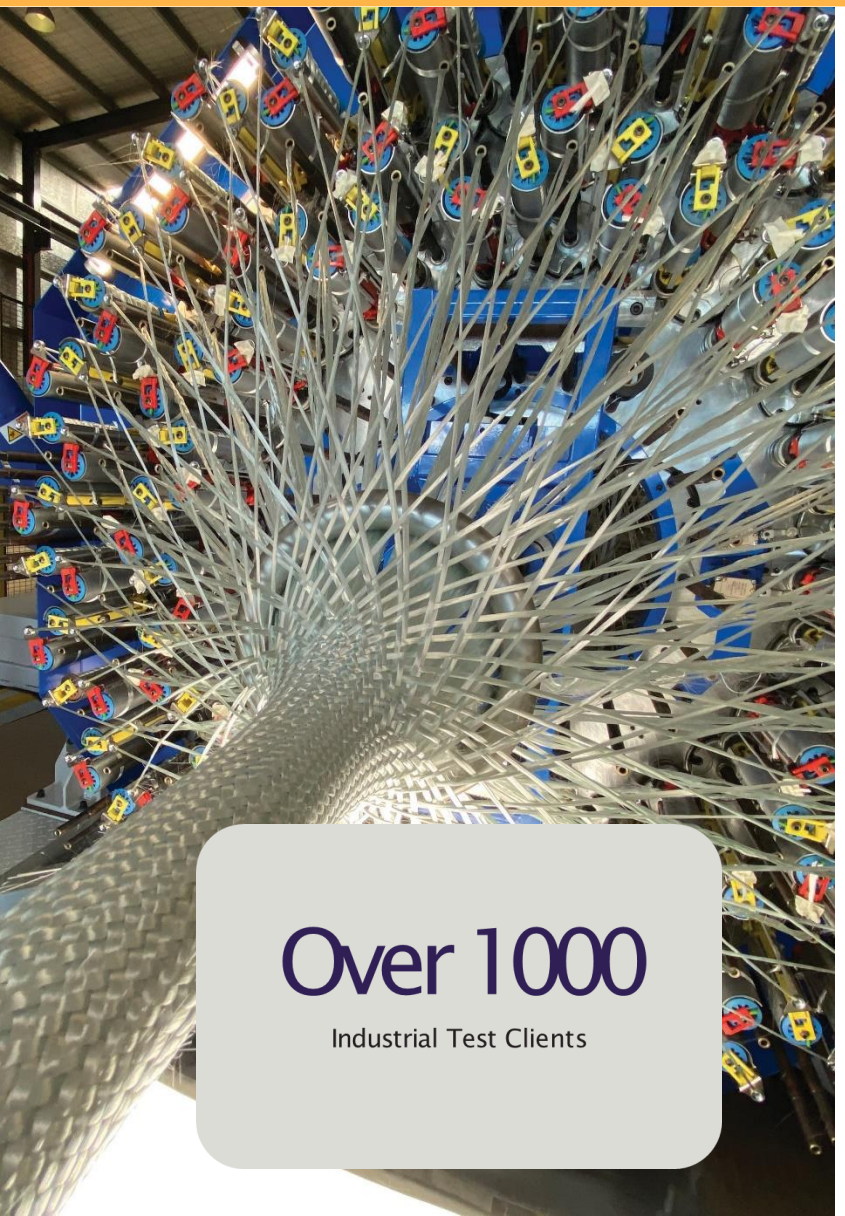
- Eggshell with and without membrane (less than 100 micron)
- Carbon dots
- BioGlass
- PLA
- Chitosan

Bioprint 3D scaffold

Biological testing

Scale model for commercialisation

Facilities and Services



Fire Testing Lab

Cone Calorimeter - FTT iCone Classic Limited Oxygen Index - FTT Oxygen Index

Horizontal/Vertical Burning Chamber - FTT UL94 Chamber Smoke Density and Smoke Toxicity - Govmark Smoke Chamber

Pyrolysis Gas Chromatography/Mass Spectrometry - Shi- madzu Py-GC/MS

Composite Manufacturing

Robotic Braiding Machine - T4L Double Ring 86/64 Carrier Braiding Machine

Robotic Filament Winding Machine – MF Tech max 3 m length x max 0.8 m outside diameter

Pultrusion Machine - Pultrex

Structural Testing Services

Materials Characterisation and Analysis

Simulation Services

FEA Simulation CFD Simulation Injection moulding and RTM

Discrete Element Method (DEM) Simulation Multibody Dynamics (MBD) Simulation

More Information on

https://composites.usq.edu.au/research/facilities/

Institute for Resilient Regions

Institute for Resilient Regions

multidisciplinary collaborative research to help regional communities embrace and adapt to change

Regional innovation: innovative business models and integrated value chains for new markets, global trades and to meet everchanging consumer demands

Policy development: providing a comprehensive and integrated policy framework by assessing the impact of policy and identifying areas for improvements

Economic tools and analysis: helping communities ride the wave of economic growth and decline, by developing the digital economy, diversifying into new sectors, and attracting workers to rural communities.

Institute for Resilient Regions and AMCRC

Examples of research areas relevant for regional manufacturing :

- Transition of regional economies and regional workforce to a low emissions future;
- Attraction and retention of regional workforce;
- Development of tools to enhance employability, to enable vocational success and healthy workforces in regional communities

- UniSQ’s Australian Collaboratory for Career Employability & Learning for Living (ACCELL) Research team led by Prof Peter McIlveen.

Questions?

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