

Newsletter

September 2023

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Engineering and
Physical Sciences
Research Council

Welcome to the autumn edition of the 2023 Hub newsletter

Hub Research [1/2]

Researchers Network Online Event - 3 May 2023

The Researchers Network (RN) organised an online event for Hub Students and Researchers. Seven RN members from different Hub spoke institutions each presented for five minutes on their research. It was an excellent opportunity to share research ideas, make connections and new collaborations within the Hub.

The presentations were judged by attendees and prizes were awarded to the following presenters:

First Place – Paloma Rodriguez Santana, University of Bath

Title: A Quick Overview of Structural Batteries

Short Description: Structural batteries are devices that combine the load-bearing and electrochemical storage capabilities of carbon fibres (CFs), thus enabling reversible electrochemical energy storage whilst simultaneously under mechanical loading conditions. This offers significant opportunities for weight saving in aerospace and automotive applications. Recent research has shown the potential of polyacrylonitrile (PAN) based fibres for structural battery anode applications [1], with LiFePO₄ coated fibres showing potential as cathodes [2]. By embedding these fibres in a biphasic structural electrolyte, the resulting carbon fibre-polymer composite structure has the high specific strength/stiffness required for lightweight structural applications and the high ionic conductivity required for battery functionality [3].

[1] L. E. Asp and E. S. Greenhalgh, 'Structural power composites', *Compos. Sci. Technol.*, vol. 101, pp. 41–61, Sep. 2014, doi: 10.1016/j.compscitech.2014.06.020.

[2] M. S. Islam, R. Dominko, C. Masquelier, C. Sirisopanaporn, A. R. Armstrong, and P. G. Bruce, 'Silicate cathodes for lithium batteries: alternatives to phosphates?', *J. Mater. Chem.*, vol. 21, no. 27, p. 9811, 2011, doi: 10.1039/c1jm10312a.

[3] L. E. Asp, S. Leijonmarck, T. Carlson, and G. Lindbergh, 'Realisation of structural battery composite materials', *20th Int. Conf. Compos. Mater. Proc.*, pp. 1121–1122, 2015.

Hub Research [2/2]

Runner up 1 – Patrick Sullivan, University of Bristol

Title: Recycling Carbon Fibre

Short Description: A quick snapshot of 3 years of research undertaken to explore the issues of commercial scale recycling of carbon fibre reinforced polymers and materials that use reclaimed carbon fibres.

Runner up 2 – Dr Monali Dahale, National Composites Centre

Title: Influence of weave parameters on the mechanical and crash performance of 3D woven composite

Short Description: The application of 3D woven composites in advanced structural components is limited by a lack of understanding of the influence of textile weaving parameters on the final architecture, mechanical and impact performance. This work investigated effect of fundamental and easily adjustable weave parameter (weft density) on the mechanical and crash performance in 3D woven warp interlock layer-to-layer carbon/epoxy composite structures. The purpose of this work was to enhance the performance of 3D woven composites by reducing the manufacturing time, cost, and complexity. 3D fabric preforms were manufactured in two different weft densities: 4 and 10 wefts/cm and a constant warp density of 12 warps/cm. Increasing the weft density improved mechanical and crash performance along both the longitudinal and transverse directions. This work shows that minor weft direction (transverse) weave changes can lead to sizeable improvements in warp direction (axial) energy absorption and mechanical performance without fundamentally redesigning the weave architecture.

School Open Day - Advanced Manufacturing Building (AMB), University of Nottingham - 19 June 2023

The annual School Open Day took place on 19 June at the AMB, University of Nottingham. Students from three local schools were introduced to the world-class manufacturing equipment in the AMB laboratories. Academics, PhD students and researchers were on hand to discuss their research, answer questions and provide demonstrations of the equipment. These events are important in promoting STEM learning and careers, and feedback received shows the students were really inspired by what they heard and saw so we hope to have contributed to shaping the next generation of engineers!

International Conference on Composite Materials (ICCM23), Belfast - 30 July to 4 August 2023

The 23rd edition of the International Conference on Composite Materials (ICCM23) was held in Belfast from 30 July to 4 August 2023. Approximately 1200 delegates from 57 countries attended the world's largest conference on composite materials, where 900 presentations were delivered over five days. Plenary and keynote presentations were given by preeminent members of the composites community from both industry and academia, in addition to tours to local industrial sites: Spirit AeroSystems, Artemis Technologies and the Northern Ireland Advanced Composites and Engineering Centre (NIACE).



ICCM23 was an excellent forum for the Hub to engage and network with the global composite's community in both the technical sessions and the social activity. In total there were 36 presentations from academics and researchers presenting the latest findings from Hub research, as well as the chairing of several sessions, in addition to the organisation of special sessions and workshops. Conference sessions ranged from computational methods, fatigue, fracture and damage, liquid moulding, process modelling, and design and manufacture. There was a noticeable focus on circularity and sustainability with sessions on bio-composites, the circularity of composites, life cycle assessment and recycling.

Researchers Network Event, Belfast – 1 August 2023

The Researchers Network organised a tour of the Northern Ireland Advanced Composite and Engineering Centre (NIACE), a regional Centre of Excellence for innovative composites manufacturing Research and Technology. The tour showcased the centre's 3D weaving Facility, Thermoplastic Manufacturing, Spirit Aerospace SPAR and RTI, training and Digital RTM Cell. A dinner was organised after the tour and provided further opportunity to socialise with other researchers from the Hub and Industrial Doctorate Centre (IDC).



The Researchers Network tour of Northern Ireland Advanced Composite and Engineering Centre (NIACE) facility.



The Researchers Network dinner at Villa Italia in Belfast.

International Composites Summit and Hub Open Day, Marshall Arena, Milton Keynes – 6 September 2023

The Hub Open Day took place on 6 September 2023 at the Marshall Arena in Milton Keynes, held in parallel with the International Composites Summit (ICS). We were pleased to have Hub academics, researchers and students presenting on their projects, as well as a poster competition and Quick-Fire session. We were grateful for presentations from the National Composites Centre (NCC) and keynote speakers, Professor Ian Lane from Vertical Aerospace Group and Dr. Emer McAleavy from Artemis Technologies. Over 100 delegates registered for the Open Day and over 200 guests attended the delegate dinner following the event.

Hub Outreach (3/5)

Holding the Open Day alongside the ICS presented an excellent opportunity for industry to hear about Hub research and gave our delegates the chance to strengthen their links with many of the industrial exhibitors on site.

Congratulations to the following students and researchers on their achievements:

Poster Competition

1st Place prize: George Street, University of Nottingham, "The Influence of Laminate Thickness on CFRTP Intra-Ply Shear Behaviour".

Runner up 1: Guy Lawrence, University of Nottingham, "Measurement of Mesoscale Inter-ply Contact Area using μ -CT and Machine Learning".

Runner up 2: Ángela Lendinez Torres, University of Nottingham, "How does breather distribution affect drapability during DDF?"



George Street, University of Nottingham, receiving 1st placed poster presentation prize from Prof. Nick Warrior, Director of the Hub, University of Nottingham.

Quick-Fire Presentation Competition

1st Place prize: Jack Holyoak, SHD/University of Nottingham, "High-Rate Production of Automotive Components using Sustainable Composite Prepregs".

Runner up 1: Laura Pickard, University of Bristol, "NextCOMP: Human-Robot Collaborative Manufacture of Hierarchical Composites".

Runner up 2: George Street, University of Nottingham, "The Influence of Laminate Thickness on CFRTP Intra-Ply Shear Behaviour".

Hub Outreach (4/4)



Jack Holyoak, SHD/ University of Nottingham, receiving 1st placed Quick-Fire presentation prize from Prof. Nick Warrior, Director of the Hub, University of Nottingham.



Delegates enjoying the poster presentation session.



Keynote presentation from Dr. Emer McAleavy, Artemis Technologies.

Upcoming Events

Advanced Engineering Show, NEC, Birmingham - 1-2 November 2023

The Hub is pleased to announce it will be returning to exhibit at this year's Advanced Engineering Show (AES), NEC, Birmingham. The Hub's stand number is X168 so if you are attending, please stop by to say hello!

The annual SAMPE Design and Make Competition, supported by the Hub will also take place at the AE show on 1st November.

The objective is to design and manufacture a scaled single-deck composite footbridge to support a central load, using creativity and composites manufacturing knowledge. The design process of the bridge will require extensive research into different cross-sectional designs to identify the one with the highest failure load relative to the weight.

The event is sponsored by SHD Composites, Instron UK and the National Composites Centre, with a prize being awarded to the team with the winning structure.

There are eight teams participating in the competition, ranging from academia and industry. It will be an interesting competition – we hope to see you there! For more information on the SAMPE competition



https://cimcomp.ac.uk/wp-content/uploads/2023/08/SAMPE_Competition.pdf

The AES is the UK's largest annual gathering of the engineering and manufacturing community of professionals. With over 400+ exhibitors across all sectors, it creates the opportunity to network, build connections and learn about industry development. For more information and to register to attend:



<https://www.advancedengineeringuk.com>

To keep up to date with our events visit



<https://www.cimcomp.ac.uk/hub-news>

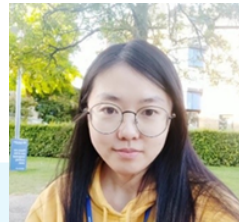
Hub Business Development Staff Changes

Hub Business Development Manager, James Whyman left the Hub at the end of July 2023 to join Rolls Royce. We wish him all the best in his new job. All business development queries can be addressed to Simon Quinn.

New staff – Post Doctoral Fellows and PhD students

Dr Qinrong He obtained her PhD in Materials Science, Queen Mary University of London in 2023 and is currently working as a postdoctoral fellow in the group of Dr Han Zhang contributing to the Hub Synergy Project **Energy Efficient Composite Tooling with Integrated Self-Regulating Heating and Curing Capabilities based on Recycled Composite Waste (ECOTOOL)**.

Qinrong's research project concentrates on design and manufacturing functional materials and composites for sustainable energy application, developing energy-efficient methods for multifunctional composites manufacturing.



Alex Trenam graduated with an MMath Mathematics from The University of Sheffield in 2019. He is currently a mathematics PhD student, in Cohort 2 of the Advanced Automotive Propulsion Systems Centre for Doctoral Training (AAPS CDT) at the University of Bath, working under the supervision of Prof Tristan Pryer. His research lies in the field of numerical analysis and is currently centred around

the design of structure-preserving numerical methods for battery electrolyte models, with a particular focus on discontinuous Galerkin finite element methods.

Alex became involved with modelling the formation process of composite materials as part of the NCForm project' as part of the 'Design Simulation Tools and Process Improvements for NCF Preforming' Hub funded Core Project, whilst undertaking a three month Research Assistant role at the Institute for Mathematical Innovation at the University of Bath.

Hub Staff News [2/2]



Yushen Wang is a PhD student under the supervision of Dr Han Zhang at Queen Mary University of London, whilst simultaneously contributing as a research assistant to the Hub Synergy Project **Energy Efficient Composite Tooling with Integrated Self-Regulating Heating and Curing Capabilities based on Recycled Composite Waste (ECOTOOL)**. Yushen's research project concentrates on developing energy-efficient, out-of-oven manufacturing methods for multifunctional natural fibre composites. As part of her PhD studies, she looked at enhancing the temperature uniformity of self-regulating heating elements.

Hub Equality, Diversity and Inclusion (EDI) [1/3]

The Hub has recently created a dedicated EDI page on the website, to read more about it please click here:



<https://cimcomp.ac.uk/equality-diversity-and-inclusion-committee/>

In this edition, we welcome an EDI experience provided by **Dr Connie Qian**, Assistant Professor, University of Warwick.

“I was brought up in a semi-closed community in China, surrounded by the same friends that I grew up with. At the age of 17, I moved out of my hometown for the first time and travelled halfway around the world to study at the University of Nottingham, as it gave me the opportunity to study at one of the world’s top universities. I did my first degree in mechanical engineering as I was very good at maths and physics in school and was particularly interested in mechanics. However, studying a subject I was good at didn’t make my university life any easier. I struggled with homesickness, cultural shock, and language barriers. I also struggled to socialise with people therefore didn’t make any friends. I wasn’t happy, and wanted to go back to China and find a decent job as soon as I got my degree.



However, the turning point happened during my 3rd year at university, when I did my individual project on bending behaviour of composites within the Nottingham Composites Group. I knew hardly anything about composites when I was allocated the project, but I really enjoyed working on it, as it was strongly related to my favourite subject – solid mechanics. I also developed strong interests in FEA, particularly on how to represent real life problems using mathematical equations.

Towards the end of my 3rd year, an opportunity came along for a funded PhD placement at Nottingham. I took the offer straight away as funded PhD positions for international students were rare. I continued the journey on building my expertise in FEA during my PhD, where I worked on multi-scale modelling and structural optimisation for discontinuous fibre composites. My supervisors offered me a lot of support and encouragement during my PhD. During my PhD I started developing mental health problems due to the high stress.

Hub Equality, Diversity and Inclusion (EDI) [2/3]

I had an eating disorder and anxiety and had to visit my GP and therapist on a regular basis. I felt ashamed to let anyone at work know about it, but one of my supervisors, had been telling me that I needed to have some hobby instead of working all the time. I took his advice and picked up an old hobby – playing the piano, which I had been doing since my childhood but stopped shortly after I arrived in the UK. Surprisingly, playing the piano daily didn't jeopardise my work at all. Quite the opposite, it made me less stressed about my PhD and more productive at work. Mental health problem is something that keeps coming back to me, but the main thing I've learned is to speak to the people you trust instead of bottling it up and ask professionals for help when it gets too much, as they can help you to rationalise things, and suggest useful coping techniques to survive.

After the completion of my PhD, I stayed at Nottingham as a postdoc. My career didn't progress very well during my postdoc time at Nottingham, as I didn't know what I wanted to work on. I couldn't identify what problems were there waiting to be solved, and I didn't have blue sky research ideas either. Therefore, I just took whatever projects that was readily available, even though I didn't like the topics. Consequently, I was no longer motivated and didn't generate much research output. After three years, things weren't getting any better so I decided to move to a place where I could start fresh and develop the skills and abilities I was lacking at the time. I joined WMG at the University of Warwick, who had a strong focus on medium-high TRL projects. I was exposed to real-life problems, which allowed me to think about how to solve them at fundamental levels. This has allowed me to develop ideas for proposals, so that I can bring in my own projects rather than working on a project that I'm given. I have won several grants during my time at WMG, with the most important one being my Innovation Fellowship funded by the Composites Hub, as it paved my way to become an independent academic. I have gradually moved away from structural modelling into process modelling, but I don't mind. It has allowed me to broaden my research interests which means I have been able to keep bringing new projects in.

Hub Equality, Diversity and Inclusion (EDI) [3/3]

During my innovation fellowship I was appointed the EDI champion of the Composites Hub and I've been in the role since then. Engineering is a field that lacks diversity. I remember visiting another university and the engineering department not having any woman's toilets. I have had co-workers make verbally abusive, disparaging and racist comments towards me. An effective EDI strategy is not just to defend protected characteristics (e.g., race, gender, religion, sexual orientation, disability) but to go above and beyond to celebrate these different characteristics. We all experience the world differently, but I don't feel my social background has been a detriment to any of the problems I have faced. If anything, it has allowed me to spot problems and solutions that were not obvious to my colleagues. Diversity encourages different perspectives which inspires creativity. I would like to be a champion for change that allow researchers to receive the support they need and the opportunities they deserve, I hope my story can inspire other researchers who might experience difficulties to keep going and remind you that you are not alone."

If you are interested in joining the Equality, Diversity and Inclusion committee please contact the EDI Champion, Dr Connie Qian:



cimcomp.ac.uk/people/connie-qian/

Hub Training [1/1]

The quarterly training course continues to be a success as Hub students and researchers participated in the three-day intensive training session at Pentaxia in July this year.

It was good to hear such positive comments from attendees:

"It was a fantastic training course. It was great to see the production process from start to finish and to get some hands-on experience in the real world."

"The hands-on training, particularly the laying up, bagging up and making something were the best elements of the training. The trainer was very knowledgeable and enthusiastic. The presentations were pitched to the right level and concise, overall it was superb."



Hub students and researchers with Pentaxia trainers, displaying their carbon fibre creations.

The Hub hope to organise another training session in the first quarter of 2024. If there are any students or researchers who would like to participate, please contact joanne.eaves1@nottingham.ac.uk

If students and researchers have suggestions for specific training opportunities which the Hub can support, please get in touch: EN-INFO-CIMCOMP@exmail.nottingham.ac.uk

Congratulations to Dr. Dipa Roy

The Hub would like to congratulate **Dr. Dipa Roy**, University of Edinburgh, on being shortlisted as a finalist for her work based on waste plastics/waste glass fibre.



<https://www.iom3.org/resource/the-iom3-sustainable-future-awards.html>

The Hub wish Dipa and her team the very best at the IOM3 Fellows Day in November 2023, when the IOM3 Sustainable Awards Ceremony will take place.

Dipa commented *"Thanks to Hub Feasibility project funding and EPSRC IAA funding. Whatever be the final outcome, we are glad we have come this far."*

EPSRC Funding Award

Hub members, **Dr. Mike Johnson** and **Prof. Shuguang Li** (University of Nottingham) were recently awarded funding by the EPSRC for their Carbon Fibre Axle (CaFiAx) project which will begin 1st October 2023. The project (£810k over 18 months.) will produce a computational design tool to optimise the layout of rotating composite axles/shaft subject to combined loading. The Institute of Rail Research at the University of Huddersfield will generate rotating bending, fatigue data and ACS-Australia are developing a reversible technology for attaching elements (bearings, gears, wheels, etc.) to the composite shafts.

The partners include Lucchini, Network Rail and Rolls-Royce. While railway axles are the immediate requirement, aerospace gearbox applications are of interest. The Hub has given constant support to this emerging work in the rail sector with a number of publications by Johnson et al. available to view



<https://cimcomp.ac.uk/publications/>

The Hub wish Dr. Mike Johnson and Prof. Shuguang Li the very best with the grant.

EPSRC Grant Award

The Hub would also like to congratulate **Dr. Philip Harrison**, University of Glasgow on receiving an EPSRC grant to continue the work that he started with the Hub in 2017, following on from the Feasibility Study, [Multi-Step Thermoforming of Multi-Cavity Multi-Axial Advanced Thermoplastic Composite Parts](#) and in addition to the two publications that were generated in 2021.



<https://cimcomp.ac.uk/publications/>

The grant titled “Induction Melt Incremental Thermoforming of Advanced Thermoplastic Composites” will commence on 1st October 2023 and will run for three years.



<https://gow.epsrc.ukri.org/NGBOViewGrant.aspx?GrantRef=EP/X02766X/1>

EPSRC and EU Funding Award

Researchers at the Universities of Edinburgh and Sheffield will work together to investigate the development of recyclable thermoplastic composites for tidal turbine blades, with over £4.4M of new funding from the EPSRC and from the European Union Horizon Europe Programme.

The first project, called **MAXBlade**, will investigate the full lifecycle of tidal turbine blades, from materials, manufacture, and operation, to decommissioning and recyclability. The project’s long-term aim is to ensure the European composite sector becomes the international leader in tidal blade manufacture. The project plans to increase the area harnessed by Scottish tidal technology company Orbital Marine Power to generate power – known as the rotor swept area – by 70 percent, to more than 1,000 square metres. **MAXBlade** will increase the length of the turbine blades from 10 to 13 metres – making them the longest of their kind in the world. The team says that boosting blade length will have the single greatest impact on reducing the cost of tidal energy.

Other News [3/4]

The project will involve a two-year design and development phase, followed by an 18-month build, during which blades will undergo advanced structural testing at the University of Edinburgh's FastBlade structural testing facility.

The second project, called **CoTide**, is backed by a £7 million investment from EPSRC and will address key challenges that are currently preventing the tidal energy sector from reaching its full potential. The group will work to make renewable energy generation from ocean tides cheaper, more reliable and scalable. **CoTide** "Co-design to deliver Scalable Tidal Stream Energy" and will bring together four multi-disciplinary teams from the Universities of Oxford, Edinburgh, Strathclyde and Sheffield.

The team at the University of Edinburgh will demonstrate the unique rapid testing capability of the FastBlade facility in both projects. Edinburgh and Sheffield will work together to lead the development of thermoplastic resins and the circular economy roadmap needed for future tidal blade manufacturing and recycling. It is anticipated that a full-scale thermoplastic tidal turbine blade will be designed, constructed and tested during the projects and recycling demonstrated for other tidal energy components.

Researchers at Edinburgh include Prof. Dilum Fernando, Dr. Eddie McCarthy and Dr. Dipa Roy. Researchers at Sheffield include Prof. Conchúr Ó Brádaigh and Dr. Colin Robert.



[FastBlade facility](#)



[Co-Tide website](#)



Accelerated testing of full-size tidal turbine blades at Edinburgh's FastBlade testing facility.

NCC TPT Programme Launch

The National Composites Centre are pleased to announce that they are launching their TPT programme for next year.

The launch will take place with a webinar on 4th October at 13.00.

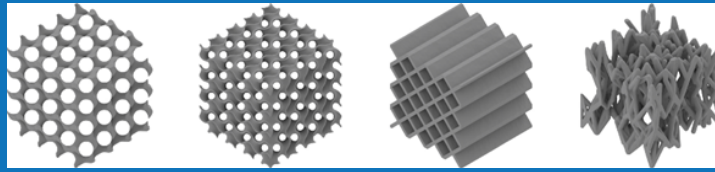
The information and sign-up page for the TPT Launch webinar is through this link:



<https://www.nccuk.com/events/technology-pull-through-programme-webinar/>

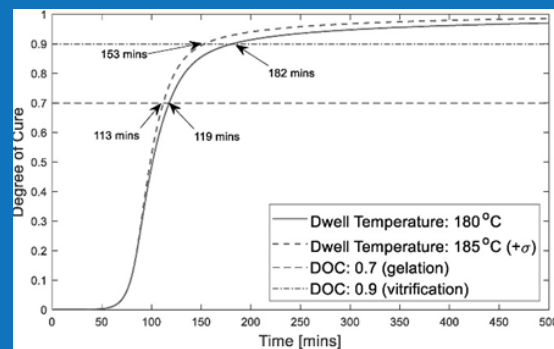
Publications [1/2]

1. Valentine, M.D.A., Radhakrishnan, A., Maes, V.K., Pegg, E.C., Valero, D.R., Kratz, J., Dhokia, V. (2023) Additively Manufactured Cure Tools for Composites Manufacture, The International Journal of Advanced Manufacturing Technology.
<https://link.springer.com/article/10.1007/s00170-023-11254-y>



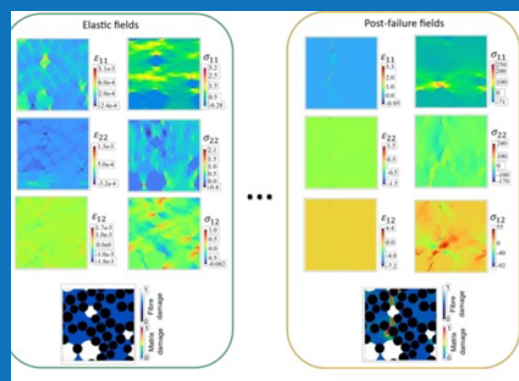
Lattices of the repeated gyroid, dual-wall gyroid, planar diamond, and stochastic unit cells (in order left-right)

2. Fisher, A., Radhakrishnan, A., Kratz, J. (2023) The Influence of key Processing Parameters on Thermoset Laminate Curing, Composites Communications.
<https://doi.org/10.1016/j.coco.2023.101686>



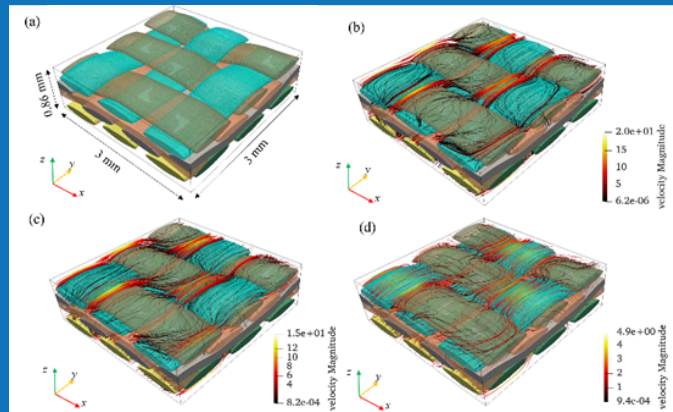
Degree of cure (DOC) with time for dwell temperatures of 180 and 185 °C. Arrows mark gel time (0.7 DOC) and vitrification time (0.9 DOC) with the two dwell temperatures.

4. Chen, Y., Dodwell, T., Chuaqui, T.R.C., Butler, R. (2023) Full-Field Prediction of Stress and Fracture Patterns in Composites using Deep Learning and Self-Attention, Engineering Fracture Mechanics 286.
<http://dx.doi.org/10.13140/RG.2.2.17744.17924>



Typical outputs from the direct numerical simulations: strain, stress, and damage fields at the elastic loading step (left) and the final loading step after failure (right).

5. Chen, Y. (2023) High-Performance Computational Homogenization of Stokes-Brinkman flow with Anderson-accelerated FFT Method, International Journal for Numerical Methods in Fluids. <https://doi.org/10.1002/flid.5199>



Flow in a dual-scale textile fabric. (A) geometry of the woven architecture; (B-D) velocity streamlines of the flow for different local permeabilities, $k_s = \text{diag}(10^{-6}, 10^{-7}, 10^{-7})$, $k_s = \text{diag}(10^{-4}, 10^{-5}, 10^{-5})$, and $k_s = \text{diag}(102, 10^{-5}, 10^{-5})$, respectively. [Colourfigure can be viewed at wileyonlinelibrary.com].

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If you would like to contribute to our quarterly newsletters, please contact Joanne Eaves:

 joanne.eaves1@nottingham.ac.uk

2023