IMPERIAL

The Composites Centre

FOR RESEARCH, MODELLING, TESTING AND TRAINING IN ADVANCED COMPOSITES

In collaboration between the departments of:

» AERONAUTICS
» BIOMEDICAL ENGINEERING
» CHEMICAL ENGINEERING
» CHEMISTRY
» CIVIL AND ENVIRONMENTAL ENGINEERING
» DYSON SCHOOL OF DESIGN ENGINEERING
» MATERIALS
» MECHANICAL ENGINEERING

Research, Facilities and Expertise

Contents

Imperial College London, South Kensington

On the cover: carbon fibre fabric reinforced with carbon aerogel as viewed under crossed polarizers

1. Introduction

It is with considerable pride that we introduce

The Composites Centre at Imperial College London.

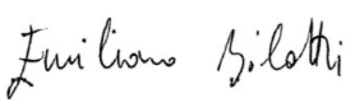
WELCOME TO THE COMPOSITES CENTRE 2025 REPORT, which provides an overview of our active composite research, experts and the associated facilities across Imperial College London. This is an update to the 2018 report, reflecting the significant growth of the Composite Centre since then. We anticipate that this document will provide a valuable insight into the world-leading and innovative work we are doing at Imperial College London.

Our research portfolio is grouped into six themes:

- **Synthesis of new and multifunctional materials;**
- **Composite design, life cycle analysis and recycling;**
- **Composite manufacture and repair;**
- **Composite analysis, modelling and prediction;**
- **Experimental mechanics; and**
- **Composite inspection and characterisation.**

Detailed information on the active research topics within each of these themes is briefly given within, but to demonstrate the breadth and range of maturities (i.e. TRLs) of our research, we have also highlighted some selected activities in depth. We introduce the academic staff affiliated with the Composites Centre, and then detail the facilities we have for manufacture, characterisation and testing of composites. Finally, we have provided details of the mechanisms by which you can interact and collaborate with us.

We hope this report will provide a valuable and informative snapshot of the work we are currently doing. Finally, if you wish to receive further information on any of the projects, experts or facilities listed in this report, you are most welcome to contact either us or the staff directly involved.



PROFESSOR EMILE S. GREENHALGH

Professor of Composite Materials

Co-Director of the Composites Centre

RAEng Chair in Emerging Technologies

DOCTOR EMILIANO BILOTTI

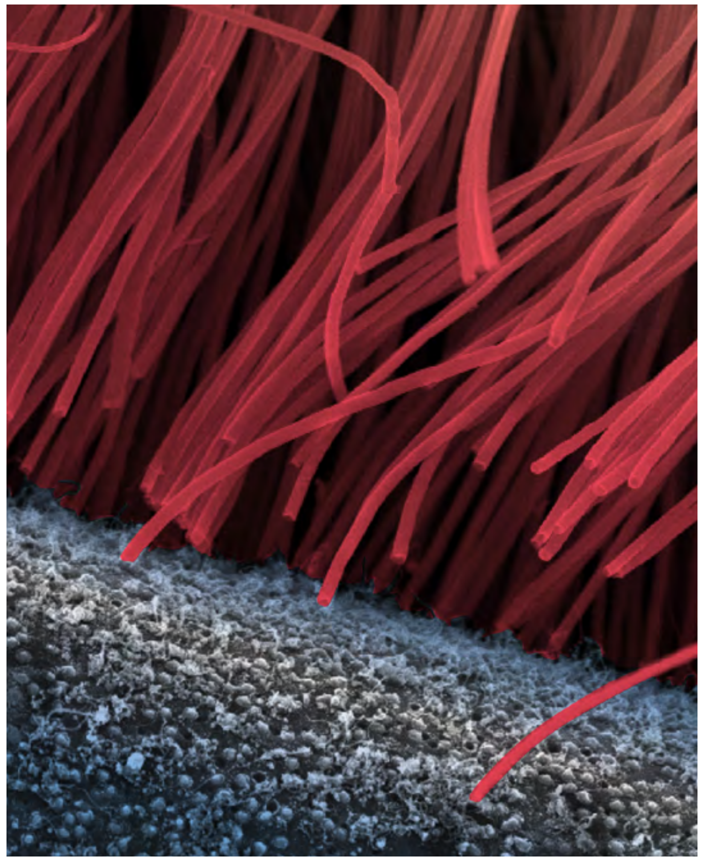
Reader in Multifunctional & Sustainable Polymer Composites

Co-Director of the Composites Centre

Professor Emile S. Greenhalgh

Doctor Emiliano Bilotti

Carbon nanotubes grafted onto a structural fibre.



2. About the Centre

Over the last forty years the Composites Centre has provided the focus for the entire composites expertise across eight Departments in the College: Aeronautics, Biomedical Engineering, Chemical Engineering, Chemistry, Civil and Environmental Engineering, Dyson Design School, Materials and Mechanical Engineering. Over this time we have maintained a track record in delivering world-leading and ground-breaking research over a huge spectrum of different composite constituents, architectures, manufacturing routes, characterisation and modelling techniques and design for final applications. Given that composite materials are recognised as a critical technology for the future prosperity of the UK, and UK-based composite product manufacture is anticipated to grow by more than fivefold by 2030*, the expertise that resides in the Composites Centre is well positioned to collaborate with industry and research funders.

We have about forty academics with an established reputation in innovating and undertaking research and industrial development in composites. Based on the 2021 Research Excellence Framework (REF), we have the most world-leading composite academics in any UK University. A team of highly skilled and experienced technicians maintains our comprehensive composite facilities. Our extensive research program is complemented by our training programs, with both bespoke short courses and the renowned MSc in Composites, which was started in 1988 – before anywhere else in the UK.

As described herewithin, we take great pride in the unique breadth and quality of the Composites research that we undertake, and strive to inspire innovation in this exciting and growing field. In particular, we have led the synthesis of novel constituents and their resulting composites. We lead development of new modelling methods and design philosophies for composites and have developed innovative methods to characterise composites, particularly regarding damage and failure processes.

**Composite Leadership Forum, www.compositeleadershipforum.com*

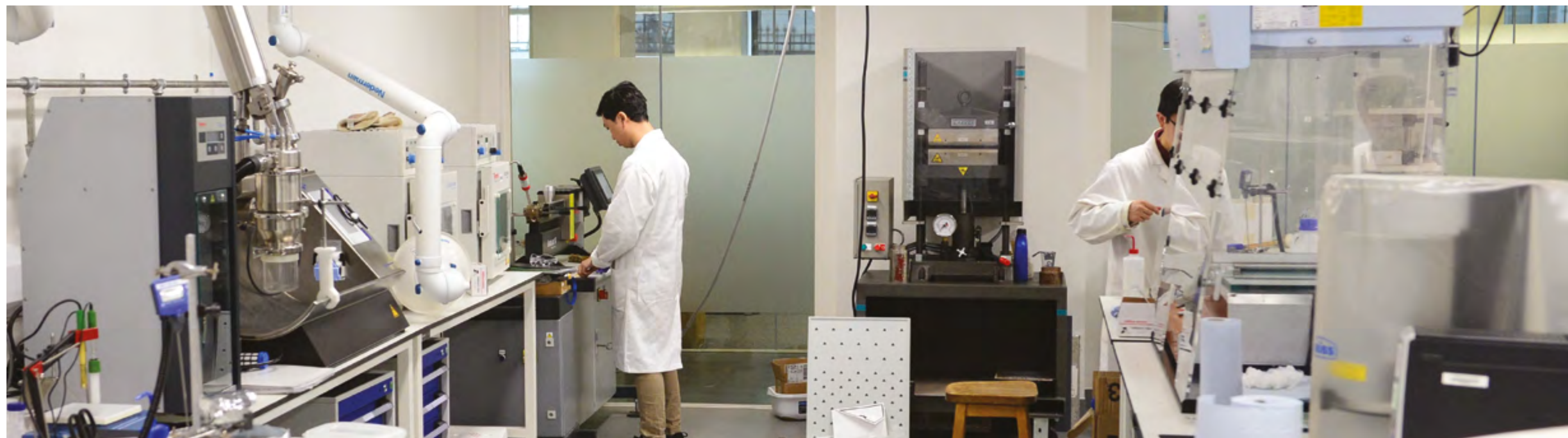
ElectroPuls electrodynamic mechanical test machine

Our vision is to be the world leading resource for composite knowledge, research and training, ranging from conception of novel and new composites and architectures, to the design, testing and analysis of full-scale composite components in support of industry.

OUR MISSION

- To create, utilise and disseminate knowledge in the field of composites to meet the needs of the industry and to contribute to the continued success and ambitions of our academics.
- To provide potential collaborators and stakeholders with comprehensive visibility of, and access to, all the composite expertise and knowledge across Imperial College London, and hence facilitate new collaborations and nurture new ones.
- To educate and train engineers and scientists in composites.
- Communicate and advocate for composite technologies to the public through accessible, engaging outreach.

We engineer new composites in our Materials Synthesis laboratory.



Top 10 of world universities

1st IN EUROPE
2nd IN THE WORLD

QS World University Rankings 2025

3rd IN EUROPE
9th IN THE WORLD

Times Higher Education (THE) World University Rankings 2025

Imperial is a one-of-a-kind institution in the UK, focusing solely on science, engineering, medicine and business.

Research Environment and Impact

RESEARCH EXCELLENCE FRAMEWORK (REF-2021)

Imperial has a greater proportion of world-leading research than any other UK university, according to the last Research Excellence Framework (REF) published in 2021 (the next REF will be published in 2029). The results are Imperial's best-ever in the UK's research assessment exercise, showing improvements in every area of assessment and confirming our position as a world-class research university.

The Complete University Guide 2025

UK University League Table Ranking

NO. 1 AERONAUTICAL ENGINEERING

NO. 1 BIOENGINEERING

NO. 3 CHEMICAL ENGINEERING

NO. 5 CHEMISTRY

NO. 3 CIVIL ENGINEERING

NO. 3 MATERIALS TECHNOLOGY

NO. 2 MECHANICAL ENGINEERING

3. The Brahmal Vasudevan Institute for Sustainable Aviation

The Brahmal Vasudevan Institute for Sustainable Aviation is Imperial College London's flagship cross-disciplinary research centre dedicated to achieving a net-zero aviation sector. Our mission is to enable pioneering blue-sky research with truly transformational potential, to cultivate the skills required for a net-zero economy, and to support evidence-based decision-making across technology development, innovation, and policy.

The institute was established in 2022 following a £25 million gift from alumnus Brahmal Vasudevan (Aeronautical Engineering, 1990), Founder and CEO of private equity firm Creador, and Shanthi Kandiah, founder of legal firm SK Chambers. It builds on Imperial's successful track record in developing foundational technologies with significant societal impact, as well as its world-leading innovation ecosystem.

We are acutely aware of the challenges posed by the net-zero transition for the aviation sector. Consequently, our research rethinks the way flying operates by adopting a holistic approach that encompasses all elements of air transport, from composite materials and aircraft design to fuel, flight paths, regulatory practices, policy, and behavioural change.

We achieve this by bringing together teams of researchers from Imperial and beyond to address system-level challenges that benefit from expertise across diverse fields.

The Institute hosts a series of live-streamed seminars that review the current state of the transition to net-zero aviation. It also runs Imperial's Doctoral Programme in Sustainable Aviation, which supports 15–20 doctoral students at any given time, working on a mixture of exploratory and industry-driven projects. Topic-specific research networks linking researchers across the Imperial ecosystem are currently being established.

Our research aims to:

- **Improve understanding of the interactions between aviation and the environment,**
- **Identify technology and regulatory pathways with the greatest potential to accelerate the net-zero transition, and**
- **Ensure that our technology choices continue to guarantee equitable access to a future aviation system.**

4. Research highlights

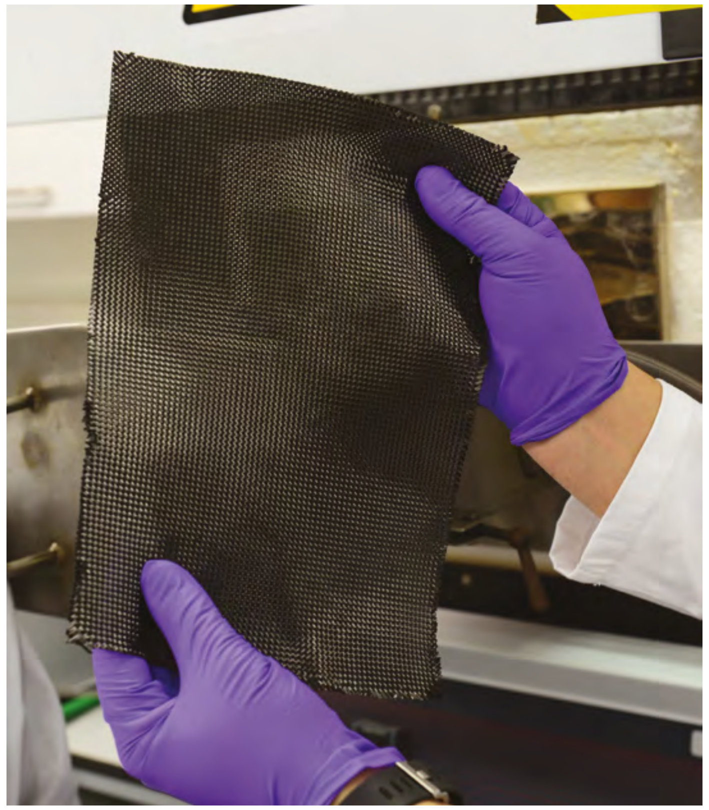
Our research covers a very broad spectrum of topics, with a strong partnership between prediction and experiment, as well as strong links with industry.

01 Multifunctional structural power composites

Academic lead ▪ PROF EMILE S. GREENHALGH

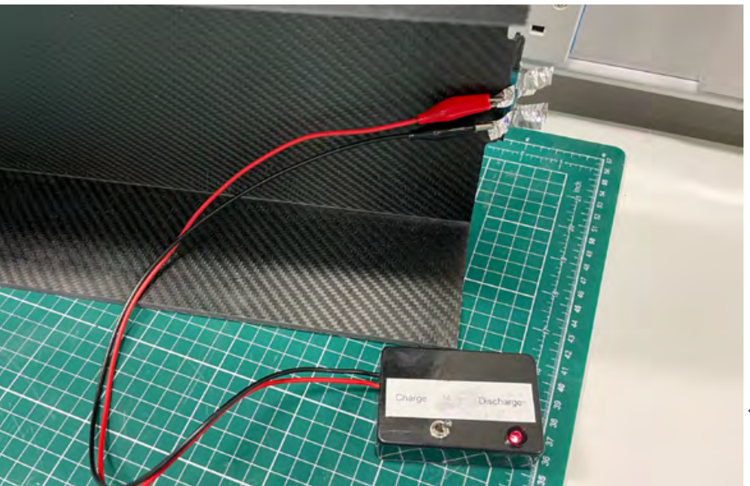
We have established an alternative concept to smart structures, in which the constituents themselves are multifunctional, acting in synergy to give truly multifunctional materials which inherently perform two (or more) disparate functions simultaneously. This step beyond smart structures has attracted enormous academic, public and industrial interest. Our focus has been structural power composites – structural materials which have the ability to store/deliver electrical energy. These materials offer considerable performance advantages whilst presenting fascinating opportunities for innovative design. The potential for weight and volume savings by adopting intrinsically multifunctional materials are compelling, but the research challenges are immense.

We have an active group and large portfolio of research to investigate and develop these materials. We have funding from the Royal Academy of Engineering (Chair in Emerging Technologies) to develop structural power composites, with the aspiration to commercialise this technology. But we have also been investigating the fundamental science that underpins the electrochemical and mechanical performance of our multifunctional materials. In conjunction with Durham University and University of Bristol, under EPSRC funding we are investigating the manufacturing and design challenges associated with using these structural power materials. In parallel, we are developing predictive models of both the mechanical and electrical performance of these materials, with the aspiration to meld them to deliver a multifunctional predictive tool. Through EU funding we have addressed the application challenges associated with these materials and demonstrated this technology in aerospace components. Structural power composites are an exciting technology which addresses the key areas of energy storage and light weighting, and we anticipate they will herald a completely different approach to using structural materials in the future.



▲ Lamina being prepared for carbon aerogel infusion.

▲ Prof Greenhalgh demonstrates a structural power component.



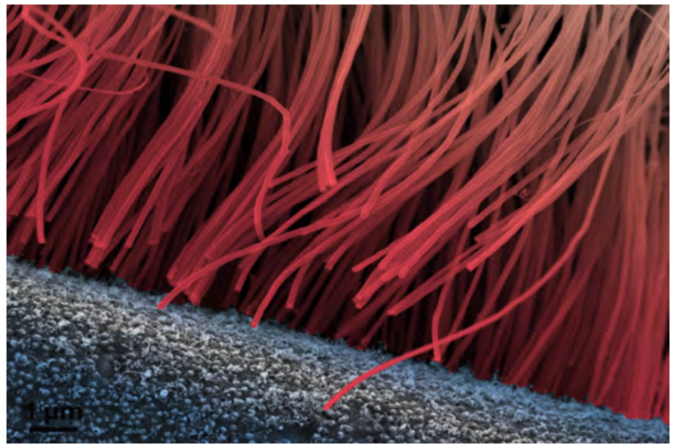
◂ A structural power composite component.

02 Nano and hierarchical composites

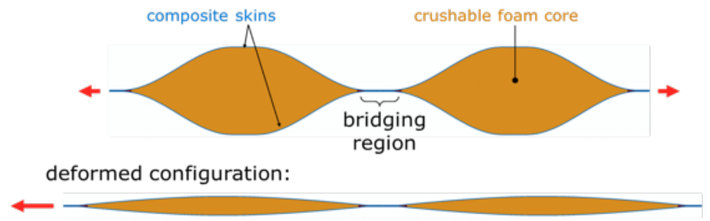
Academic lead ▪ PROF MILO SHAFFER

Certain nanomaterials, particularly carbon nanotubes (CNTs), graphenes and other 2D nanomaterials, offer the potential for fundamental improvements in mechanical performance and associated weight reduction. Individual nanocarbons have been shown to have a significantly higher strength than other known materials, combined with excellent stiffness, high lateral flexibility, high aspect ratio, and low weight. In addition, they have good electrical and thermal conductivities, and interesting optoelectronic characteristics, all relevant to multifunctional performance. There is a large body of work on nanocomposites often showing useful improvements but at a relatively modest scale, based on the introduction of only very low loading fractions. On the other hand, assemblies based on pure CNTs, high loading contents and macro pre-forms have demonstrated significant promise, providing reports of ultra-tough/ultra-strong fibres.

At Imperial we have developed unique methods to process undamaged nanomaterials, whilst modifying the interfacial chemistry, to develop a new generation of high strength, high ductility structural fibres. In the nearer term, nanocarbons may have the biggest impact by enhancing the performance of existing state-of-the-art carbon fibre composites, particularly by addressing critical matrix-dominated failures, for example related to compression and delamination. We have developed new, continuous/scalable processing methods that deliver hierarchical composites with high loading fractions of nanomaterials, either within the bulk matrix, within an interleave or grafted at the interface of conventional structural fibres.



▲ Carbon nanotubes grafted onto a structural fibre to improve interfacial performance of fibre reinforced composites.



▲ *Pseudo ductile composite*

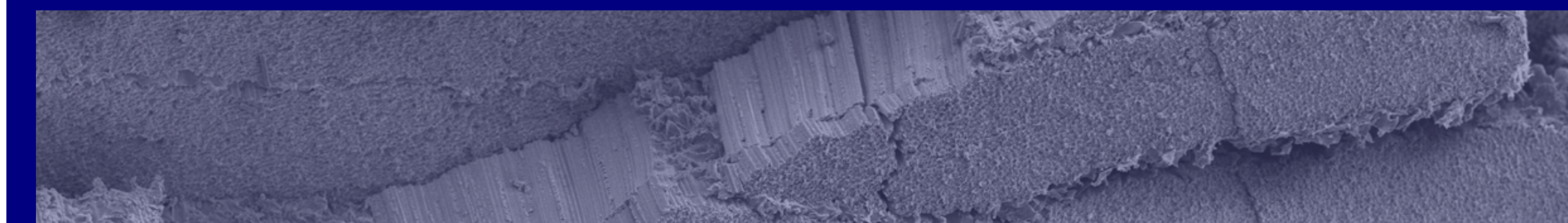
03 Ductile composites

Academic lead ▪ PROF PAUL ROBINSON

We have been examining strategies to introduce a more ductile failure process in high performance composites which generally exhibit brittle failure with little or no prior warning. The research has involved staff from the Departments of Chemistry, Chemical Engineering, Mechanical Engineering and Aeronautics at Imperial together with colleagues at the University of Bristol.

A variety of mechanisms have been proposed to impart a yielding-like behaviour and to ensure this occurs in a distributed manner under uniform tensile loading. One technique exploits the 'hidden length' in wavy configurations. A wavy skin sandwich panel with a light crushable foam core has been developed which exhibits a failure strain in excess of 8% and ultimate failure stress of around 1800 MPa.

Another approach has looked at the potential of introducing cuts or perforations in selected plies in a laminate. The aim is to initiate delamination growth from these cuts and to ensure that this delamination growth will occur in a stable distributed manner throughout the specimen which is manifested by a yielding characteristic on the tensile stress-strain curve. Using perforations enables the pseudo yield stress to be tailored by adjusting the geometry of the perforation pattern. With this technique the ultimate strain cannot be increased above that of the pristine composite but the yielding-like behaviour could help alleviate premature failure due to stress concentrations. Another advantage of this technique is that the initial stiffness is very close to that of the pristine composite.

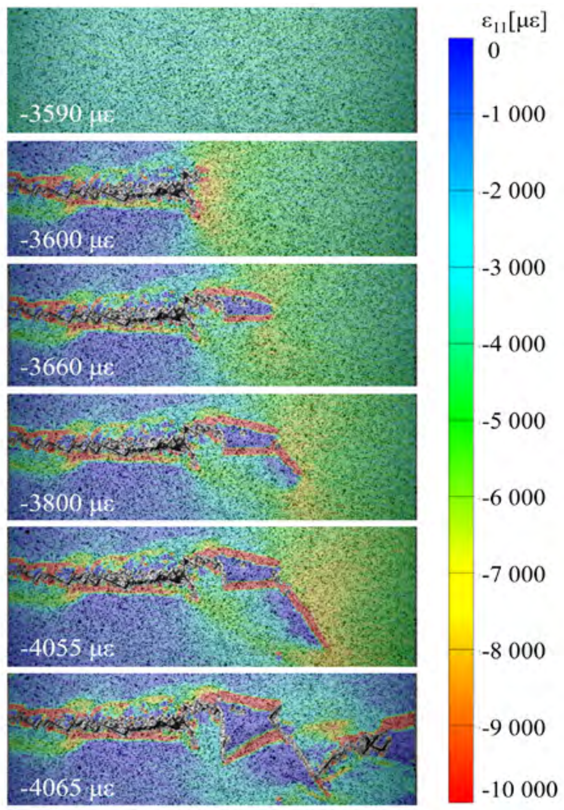


04 Designing the next generation of composites for high performance in compression (NextCOMP)

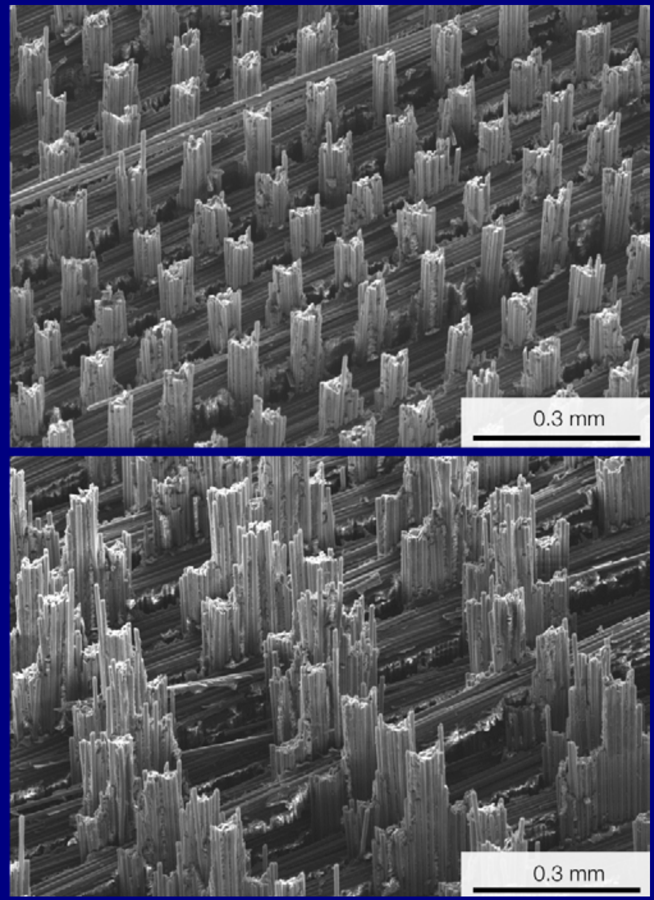
Academic lead ▪ PROF MILO SHAFFER

High performance fibre-reinforced composites provide excellent specific performance in tension but often fail at significantly lower loads in compression. The sequence of failure spans multiple lengthscales, from the atomic structures controlling the shear properties of the constituents, through the shear instabilities at the fibre scale that lead to kink band initiation, to the kink band propagation as it interacts with the composite architecture, to final fracture. This sequence can be delayed, deflected or arrested, by introducing new materials or structures at different stages; even greater benefits can be accessed by integrating these new mechanisms across the different lengthscales, using quantitative analysis to drive a holistic redesign of the whole system. Next Generation Fibre-Reinforced Composites (NextCOMP) is an EPSRC Programme Grant (EP/T011653/1) working in collaboration with the University of Bristol on this challenge. The project has developed accelerated computational methods to study large models that capture realistic composite architectures, whilst implementing new tests on composite constituents to ensure that the models are correctly parameterised.

New mechanisms have been developed at all scales, from the constituent fibres and matrices, through nano-interphases, to plies, bundles, and whole components, demonstrating improvements at every scale. For example, CNT-grafted carbon fibres increase the compression strength of pultruded rods, by improving the shear performance of the matrix whilst simultaneously supressing interfacial failure. At a larger scale, carefully designed bands of alternative stacking sequence can arrest unstable translaminar fractures, dramatically increasing ultimate strength and failure strain. Please visit the NextCOMP website (www.nextcomp.ac.uk) for more information on the grant including the team and partners, and the latest news and videos; many of the sub-projects are outlined in the Research Themes section.



▲ Compression crack arrest using ply discontinuities.



▲ Scanning electron micrographs of engineered fracture surfaces to elevate fracture toughness

05 Engineering fracture surfaces in CFRP: key to damage tolerance

Academic lead ▪ PROF SILVESTRE T. PINHO

The damage tolerance of composites can be improved via micro-structural design — in fact, by tailoring the local architecture and microstructure, the resulting fracture surfaces can be engineered to enhance the composite performance. To this end, we took inspiration from various natural composites (including wood, bone, nacre and the Gigas shell) and carefully designed CFRP composites with significantly improved damage tolerance.

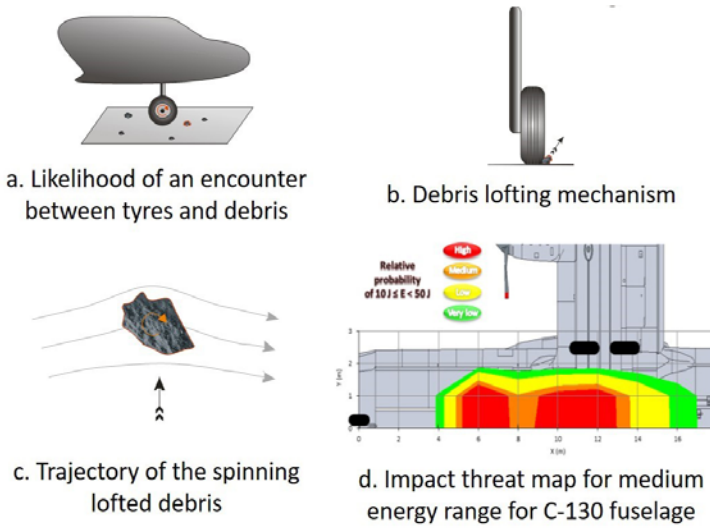
By adopting these approaches, we have obtained an over 60% increase in notched strength and 500% increase in translaminar fracture toughness, as well as improved damage diffusivity. This work is supported by EPSRC (Engineering Fellowships for Growth: Next generation of lightweight composites — how far can we go?), EU Horizon 2020 "Fibre Break Models for Designing novel composite microstructures and applications". This also led to higher TRL research and applications funded by the ATI (Fantastical and Fandango with Rolls-Royce, and IVI with Spirit).

06 Prediction of the runway debris impact threat to aerostructures

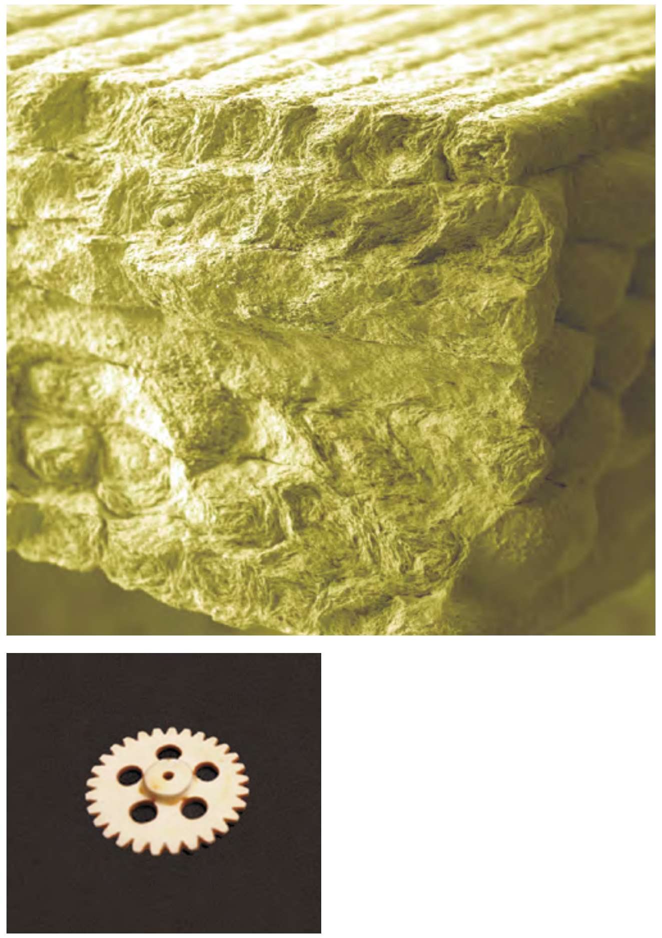
Academic lead ▪ PROF EMILE S. GREENHALGH

We have developed and demonstrated a design tool to predict the threat to aircraft from runway debris thrown up by the undercarriage wheels. From runway debris characteristics, aircraft and tyre geometries, and take-off and landing profiles, our model predicts the likelihood of a tyre/debris encounter. We have then numerically modelled the contact mechanisms by which the debris, tyre and runway surface interact to cause lofting and determined the initial direction and speed of the projected debris. All these models were validated against bespoke drop-weight experiments, monitored with high speed video, which reproduced key aspects of the contact conditions between the stones, tyres and ground. This led to a physically-based analytical model which provided an insight into the critical parameters which dictated the severity of the stone lofting processes.

Having established a reliable model for the initial state of the lofted stone at the start of its projected motion, the next stage investigated the subsequent trajectory of the debris to enable prediction of the severity of any resulting impact on the aircraft. Aerodynamic models were developed for the interaction between the spinning lofted stone and the airflow in the wake of the undercarriage wheels and beneath the fuselage. This culminated in 'threat maps' which identify the sites on the lower fuselage that are exposed to the most severe impact conditions. Hence, these maps have been used to identify which sites on the underside of the aircraft need to be armoured to negate the threat from such events. Our models have been adopted by industry to design a nosewheel debris deflector shield for aircraft now in service. This has dramatically reduced the incidence and severity of the runway debris impacts and the associated maintenance costs and downtime.



▲ Phases of the runway debris lofting process.



▲ Additive manufactured ceramic composite component.

07 Additive manufacturing of ceramic-based composites

Academic lead ▪ PROF EDUARDO SAIZ

We have been working on the development of additive manufacturing technologies to fabricate ceramic-based composites. In particular, we are concentrating on the use of robotic assisted deposition (robocasting) to fabricate fibre and platelet-reinforced composites. The goal is to build composite parts with a range of geometries that will exhibit complex hierarchical microstructures. To achieve this goal, we are developing ceramic inks with controlled rheology for 3D printing and using external fields to manipulate particle alignment.

The microstructures can be designed to direct crack propagation at the microscopic level in three dimensions and develop tough materials with high specific strengths. We have developed a series via in-situ mechanical tests in the scanning electron microscope that enables us to identify the salient toughening mechanisms. The work was initially supported by CASC Industrial Consortium and EPSRC through MAPP (Future manufacturing hub on manufacture using advanced powder processes).

08 Recycled carbon-fibres and their composites for (semi-) structural applications

Academic lead ▪ DR SORAIA PIMENTA

The world-wide demand for carbon fibres has grown to approximately 150 thousand metric tonnes in 2025, and is expected to continue growing exponentially, making it imperative to establish recycling routes for carbon fibre waste. Carbon fibres can be recovered through a variety of processes, with some (e.g. pyrolysis) already implemented at the industrial-scale and operating commercially. Recycled carbon fibres can be recovered using up to 70% less energy compared to producing new fibres, and obtained at 25-50% of the price of their virgin precursors.

We have benchmarked the morphology, mechanical properties and adhesion of recycled fibres against their virgin precursors for a range of recycling processes. We have shown that batch pyrolysis can recover virgin-like fibres, but continuous pyrolysis implemented at industrial scale recovers fibres with a wider range of performances, depending on the exact recycling conditions. We have also correlated fibre surface damage and loss of fibre mass with degradation of fibre mechanical properties during recycling.

We have characterised the microstructure and the mechanical properties of recycled composites manufactured through a range of processes, and showed that recycled carbon fibre composites are a higher-performance alternative to aluminium and glass fibre composites. We have also shown that residual bundles (i.e. recycled fibres held together by a residual matrix) toughen recycled composites significantly and arrest cracks, and we have developed models to predict this toughening effect. This shows that recycled carbon fibre composites are suitable for applications with damage-tolerance and lightweight requirements, for instance in automotive and aircraft interiors.

▲ Application of recycled carbon fibre composites.

▲ Short sisal fibre composites without (top) and with (bottom) bacterial cellulose.

09 Nanocellulose composites

Academic lead ▪ PROF KOON-YANG LEE

Nanometre scale cellulose fibres, or nanocellulose, are an emerging green nano-reinforcement. The major driver for utilising nanocellulose as a reinforcement is the possibility to exploit the stiffness and strength of cellulose crystals. Theoretical calculations and numerical simulations have estimated that the stiffness and strength of cellulose crystals are as high as 180 GPa and 22 GPa, respectively. Raman spectroscopy and X-ray diffraction have also shown experimentally that a single nanocellulose fibre possesses a tensile stiffness of between 100-160 GPa. Tensile strength of a single nanocellulose fibre was estimated to be 1 GPa based on experimental results for elementary plant fibres. Thus, nanocellulose fibres could potentially serve as a replacement for glass fibres given their low toxicity and density (~1.5 g cm^{-3}). We work on microbial-synthesised bacterial cellulose, with a focus on understanding the mechanics of the nanofibre network. This will allow us to engineer the microstructure of the reinforcing nanocellulosic fibres to maximise material performance for various advanced composite applications. We also work on the use of bacterial cellulose as a Pickering emulsifier to produce low density microporous polymers.

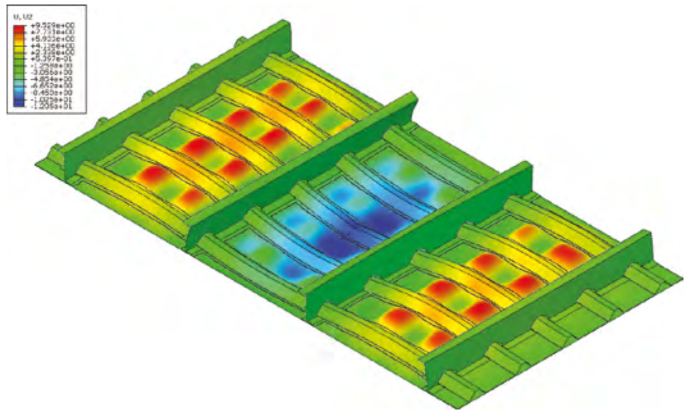
10 Multiscale analysis of composite structures

Academic lead ▪ PROF SILVESTRE T. PINHO

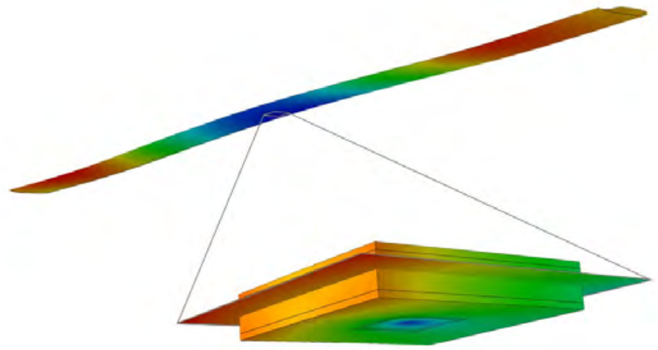
We have a long tradition of pioneering novel modelling approaches for multiscale simulation of the mechanical response for composites. These include: the first smeared crack model for simulating failure in composites (now available in the commercial releases of Abaqus and LS-Dyna); one of the first cohesive models in explicit FE analyses; failure criteria that were ranked top in the second World-Wide Failure Exercise; a Mesh Superposition Technique that makes multiscale simulation of composite structures more efficient; and more recently the Floating Node Method.

The Floating Node Method allows for complex networks of interacting cracks to be simulated efficiently. We have implemented this method in a commercial FE code and demonstrated the effective simulation of 3D problems involving hundreds of cracks in complex networks involving delamination, splitting, migration of delaminations and fibre failure.

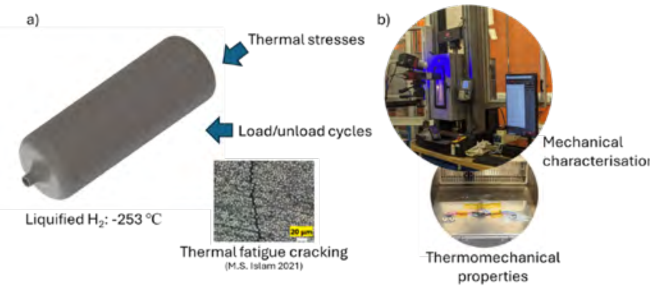
Ongoing and future focus will be directed to using some of the modelling techniques developed as a springboard for the development of a dedicated multiscale design engineering method tailored to specific design scenarios.



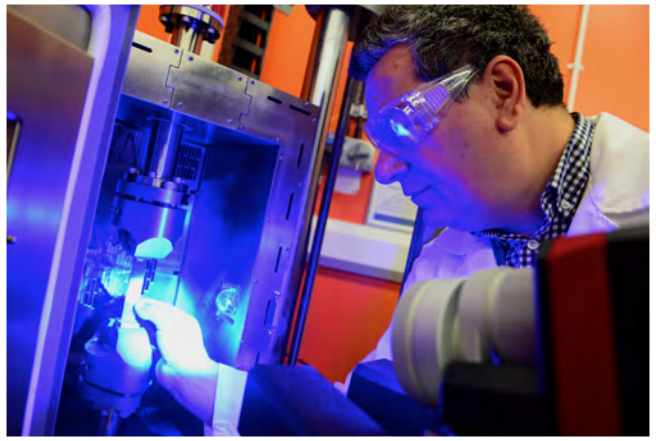
▲ FEM of buckling stiffened wing component.



▲ Multiscale model of aerostructures.



▲ Damage processes in composites under extremely low temperatures.



▲ Mounting coupon in test machine and environmental chamber.

11 Mechanical characterisation of composites under extremely low temperatures

Academic lead ▪ DR GUSTAVO QUINO

While hydrogen is a promising alternative for further decarbonising aviation, its use presents several engineering challenges, one of which is storage. The use of polymeric and polymer-based materials for storage tanks offers advantages such as weight reduction and the prevention of metal embrittlement. Since the storage of liquefied hydrogen requires extremely low temperatures, it is essential to ensure that the materials used remain reliable under such extreme conditions. Low temperatures induce internal stresses due to the distinct thermal expansion coefficients of the constituents. Furthermore, repeated load-unload cycles, as the tank is refilled after being emptied, can, over the long term, lead to fatigue and damage. We are currently developing and implementing novel experimental methodologies and a modelling framework to accurately capture the effects of extremely low temperatures upon composites.

12 Aerial robotics: composites in lightweight robot design

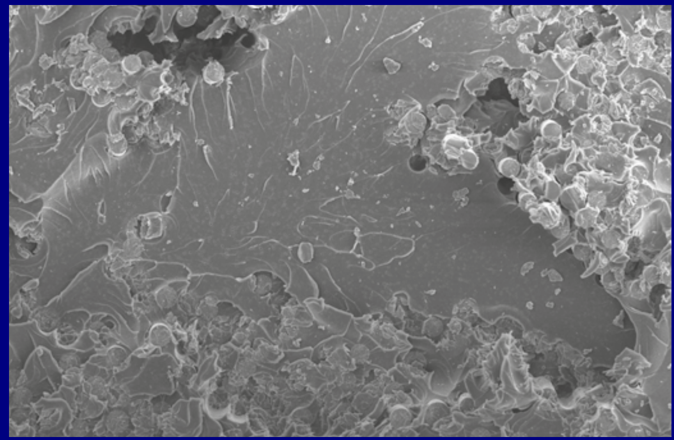
Academic lead ▪ DR SOPHIE F. ARMANINI

Future aerial robots will require novel capabilities, such as physically interacting with their environment and operating safely and robustly in challenging urban and natural surroundings - e.g. close to building and people, or in dense forests or mountainous regions. To meet these challenges, our research seeks inspiration in nature and in other engineering disciplines, to explore new design solutions resulting in more efficient, versatile and safe robots.

Composites play a central role in our design work, where they are routinely exploited to develop in-house prototypes exploring new flight behaviours or new robotic applications. The advantageous combination of high strength and low weight, in particular, is essential for lightweight micro aerial vehicles with low endurance and minimal payload. Composites are thus a key element in achieving much smaller, lighter, more efficient and versatile aerial robots, to populate the skies of tomorrow.

▲ Drone inspecting pipeline.

▲ Aerial Robotics Laboratory.



▲ Fracture surface from short fibre composite automotive component

13 Discontinuous composites for high-volume structural applications

Academic lead ▪ DR SORAIA PIMENTA

Tow- (or tape-) based discontinuous composites (TBDCs), also known as advanced sheet moulding compounds, consist of randomly-oriented carbon-fibre tows (or tapes / bundles) embedded in a polymer matrix, and are manufactured via compression moulding. Their ability to form complex 3D geometries in under two minutes makes them ideal for high-volume applications (e.g. automotive). With fibre contents up to 60%, TBDCs offer outstanding stiffness and toughness.

A key challenge in TBDCs lies in the large size of the randomly-placed carbon fibre tows, which introduces significant spatial variability in mechanical properties; this can interact with structural features such as holes or reinforcements, and potentially lead to unexpected failures. We have addressed this challenge through projects funded by the Royal Academy of Engineering and the European Union, in collaboration with industrial and academic partners.

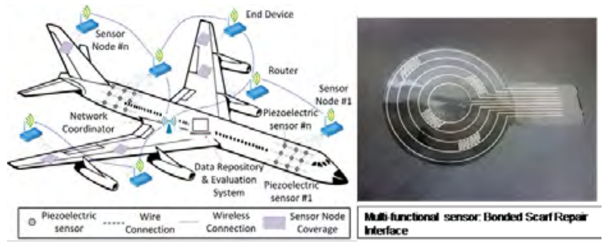
We introduced the new concept of "characteristic lengthscale" to quantifies this spatial variability, and showed how this varies with tow dimensions. We developed an experimental method to measure the characteristic lengthscale and validated against detailed FE simulations that represent the tows explicitly.
Using the concept of characteristic lengthscale of a TBDC, we have developed a stochastic finite element framework that integrates manufacturing simulations and assigns mesh-objective stochastic fields to structural models. This framework accurately reproduces the spatial variability of TBDCs, enabling Monte Carlo simulations to assess design reliability and identify critical failure regions. This approach has been applied to real automotive components.

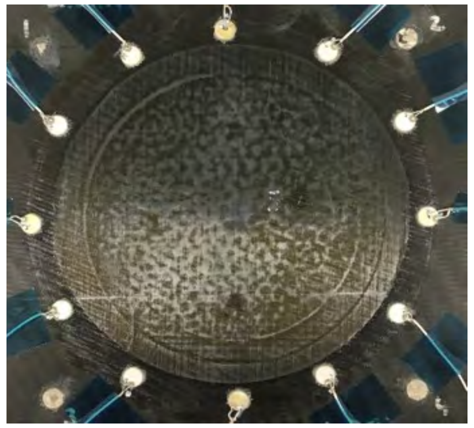
These simulations are powered by physically-based material models which link microstructural features to local mechanical properties and support the design of optimised microstructures. Our finding that reducing tow thickness significantly enhances TBDC strength and homogeneity drove a patent co-held with Tape Weaving Sweden (Oxeon AB) and their commercialisation of TeXtreme® 360. We have since demonstrated record-breaking performance for randomly-oriented TBDCs, rivalling that of conventional continuous-fibre quasi-isotropic composites.

14 Structural integrity and health monitoring

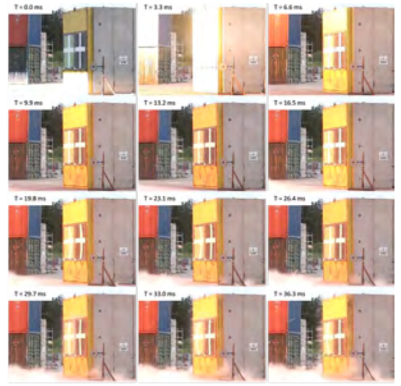
Academic lead ▪ PROF ZAHRA SHARIF KHODAEI

Our research successfully advanced Structural Health Monitoring (SHM) technologies from laboratory research to near-industrial application by leading the SHERLOC CleanSky2 core-partnership project. For the first time, a university-led team guided SHM systems for composite airframes from TRL 3 to TRL 6, demonstrating their viability under real-world operational and environmental conditions. This included the development of a comprehensive testing matrix, novel sensor integration methods, and wireless monitoring systems. The resulting work represents one of the most comprehensive verification and validation efforts to date for SHM technologies operating under representative flight conditions. These achievements have laid the foundation for certifiable, scalable SHM solutions and significantly influenced the future of smart, cost-efficient aerospace structures. We have currently expanded our research into two other areas: 1) development of digital twins for real time monitoring of aircrafts in flight, to optimise their operation and end of life (AVATAR H2020 project); as well as 2) SHM application and digital twin development for space vehicles (ESA project). Our team has also developed wireless and miniaturised multi-sensing solutions to be integrated on board of structures, for remote assessment.





▲ Instrumented repair of a composite aerostructure.



◄ Composite component exposed to blast event.

15 Blast performance of marine composites

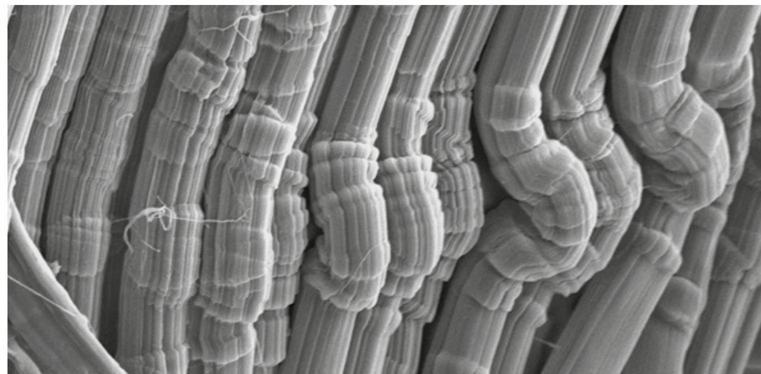
Academic lead ▪ PROF JOHN P. DEAR

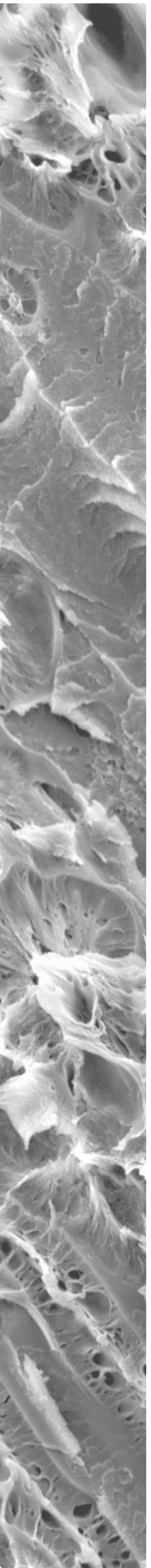
We have developed reliable large-scale experimental techniques to record the panel response during air and underwater blast experiments. This experimental setup has been used to understand the response of a wide variety of marine sandwich structures along with laminated glass. The ability to record full-field data during the blast event using digital image correlation techniques has led to widespread industrial interest and continuous support from the Office of Naval Research.

The marine sandwich structures evaluated have demonstrated exceptional blast resilience. A wide variety of materials have been investigated, including various polymer foam cores and face-sheet fibre-reinforcements. The research has revealed the superior performance of SAN polymer foam cores, along with the benefits of implementing a stepwise graded density core with density increasing from the front to the rear of the panel. A graded density core prevents through-thickness crack propagation and results in minor cracking and debonding between core layers. Overall, this results in the retention of greater structural integrity and post-blast strength. Intralaminar hybrid carbonfibre and glass fibre facesheets and the influence of polymer interlayers has been studied. The addition of polymer interlayers reduces front facesheet cracking which is beneficial for preventing water ingress following a blast event. The combination of glass fibre and carbon fibre layers within the facesheets results in reduced deflection during blast due to interaction and damage development between the dissimilar fibres. The experimental results have led to the development of finite element models which help to inform experimental decisions.

There is huge potential for further use of composite sandwich structures in the naval industry. These largescale, representative experiments demonstrate the suitability for composite structures under the harsh loads expected in the marine environment.

▼ Dyneema fibres exposed to ballistic impact.





16 Additive manufacturing of composite metamaterials

Academic lead ▪ DR AJIT PANESAR

Innovative DEsign and Advanced Manufacturing Lab (IDEA lab)

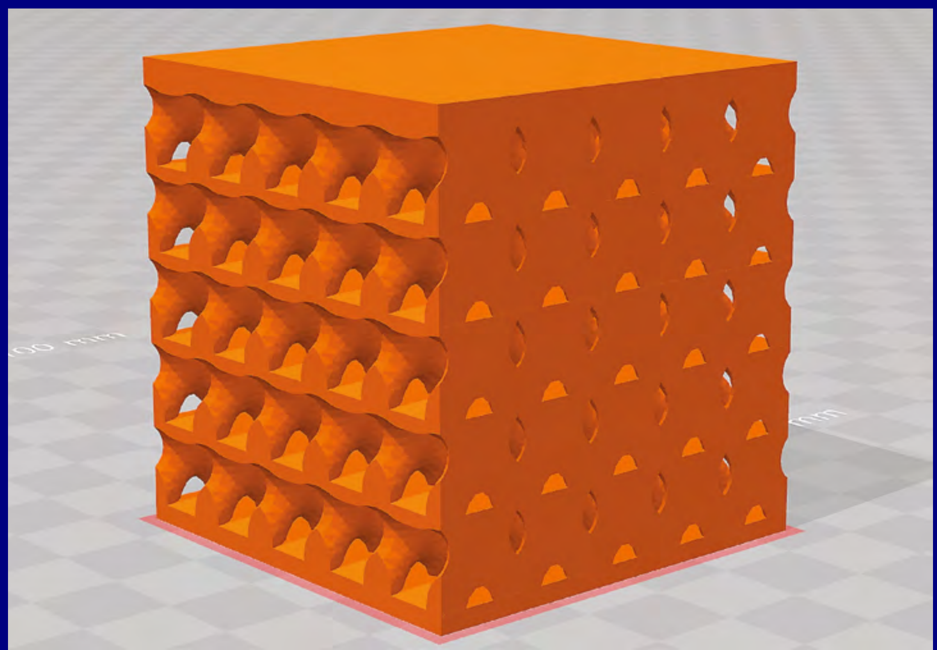
Metamaterials (MM) are architectured materials offering unique properties not typically found in nature. Additive manufacturing (AM) has enabled exploitation of these MM for complex engineering applications. IDEA lab has been working at the forefront of additively manufactured composite metamaterials, some examples include: i) Machine Learning (ML) assisted design of multiscale functionally graded meta-material (FGMM), ii) Scientific-ML or SciML to expedite process-simulation, and iii) experimentally evaluate the performance of these FGMM solutions under demanding scenarios (e.g. dynamic loading)

i) Our proposed two-step multiscale FGMM method fuses topology optimisation (TO) with a multi-layer perceptron (MLP)-based inverse generator. The revealed optimal structures' stiffness is comparable to standard from TO but our technique provides a 40x speed-up. Moreover, the framework demonstrates tremendous versatility where both isotropic and orthotropic materials can be used to generate FGMM for single- and multi-objective (e.g. mechanical, thermal etc.) considerations with minimal need for retraining. The orthotropic solutions enabled by fibre-reinforced polymer AM exhibited three times improved specific compliance compared to that of the isotropic counterpart.

ii) Having successfully implemented a physics-informed neural network (PINN)-based framework to predict the temperature history during metal AM process, we are now investigating its applicability in composite process simulation by embedding curing kinetics within the SciML framework. Progressing from the current data-less configuration that reveals the potential of SciML as a solver, attempts at incorporating physical/simulated data in training are being made to enhance the fidelity of the solution as well as to calibrate and fine-tune the embedded physical model.

iii) Crashworthiness, a common objective for MM, is experimentally investigated for the composite FGMM designed by our frameworks and manufactured through material extrusion. Under dynamic loading, the short-fibre composite FGMMs absorbed up to 10x higher energy when compared to that of the polymer-only counterpart. Different MM cell types and loading scenarios have been explored, revealing consistent benefits enabled through the complex interfaces in additive manufactured composite materials.

Our aspiration is that this holistic approach of design-optimisation, process-simulation and experimental-validation provides greater confidence in the value-proposition of MM for complex multifunctional engineering requirements.



▲ Additively manufactured metamaterial.

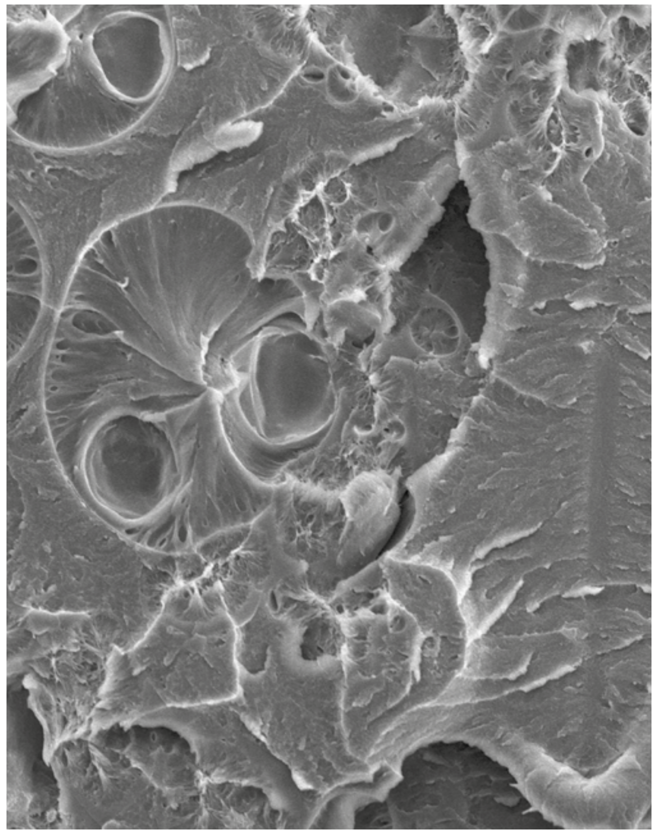
17 Fractography of polymer composites

Academic lead ▪ PROF EMILE S. GREENHALGH

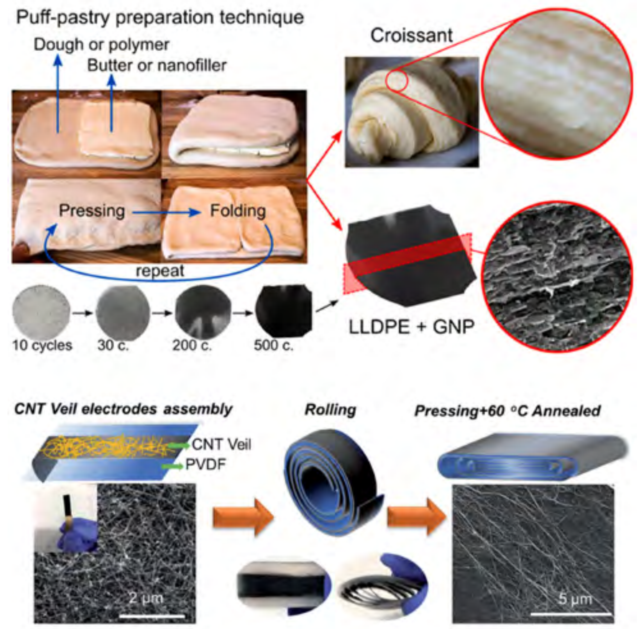
Failure processes in polymer composites are inherently complicated and are dominated by strong interactions between different fracture modes. For instance, delaminations strongly interact with compression failure mechanisms, leading to a considerable depression in performance.

A key tool to support the research and development of composites, and the interpretation of both laboratory based and in-service failures, is fractography. This entails scrutinising the morphology of fracture surfaces in components using visual, optical and scanning electron microscopy to determine the origin, sequence, and modes of fracture. This draws on knowledge of the fracture morphologies associated with known failure modes (e.g. tension, compression shear, etc). Imperial College London is world-leading in fractography of polymer composites, with Prof Greenhalgh having published the seminal book in the field.

Fractography is used as a powerful research tool for studying micro-mechanisms in polymer composites, providing an important means of validating physically based predictive models. It is routinely used to investigate the failure of structural components, including supporting litigation cases and undertaking in-service failure and accident investigations. Finally, the team at Imperial College London have also delivered short courses on polymer composite fractography to industry.



▲ Fracture in toughened aerospace carbon fibre composite.



▲ A croissant-inspired processing technique was developed, enabling unprecedented nanoparticle dispersion and record-high energy densities in polymer film capacitors.

18 Processing of thermoplastic polymers and polymer (nano) composites

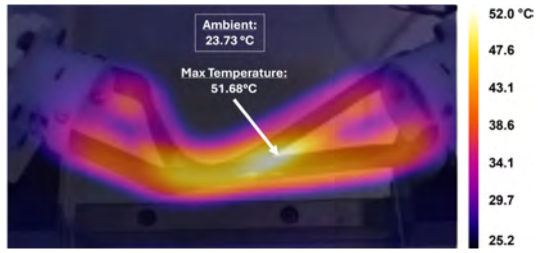
Academic lead ▪ DR EMILIANO BILOTTI

We possess extensive expertise in the processing of thermoplastic polymers and polymer (nano)composites, spanning a wide range, from hydrogels, adhesives, and elastomers to high-performance engineering plastics.

Supported by funding bodies such as the European Research Council, Innovate UK, and UKRI, and in collaboration with industrial partners, we have developed a suite of advanced processing strategies. These include techniques for inducing high levels of macromolecular orientation, engineering tailored microstructures and crystalline phases, and achieving precise control over (nano)filler dispersion.

These methodologies have been shown to significantly enhance material performance, enabling properties such as high tensile strength, superior thermal conductivity, ultra-high dielectric breakdown strength, enhanced gas barrier properties, and improved flame retardancy. The resulting materials are being applied across a diverse range of high-impact technologies, including capacitive energy storage systems, thermal interface materials, self-regulating Joule heating devices, energy harvesting platforms, and self-powered sensing technologies.

▲ Composite flexure for space applications.



19 High-strain composite flexures for deployable space structures

Academic lead ▪ PROF MATTHEW SANTER

The use of ultra-thin composite shell structures enables highly nonlinear deflections which can replicate the functionality of conventional hinges in deployable space structures. Exploiting advanced buckling responses can also enable multifunctionality in which deployment actuation and latching can be combined in a single mass efficient compliant structure.

We have developed finite-element based optimization frameworks to tailor flexure geometries to achieve precise buckling, viscoelastic and deployment characteristics and novel finite element formulations to capture complex post-buckling phenomena. We have refined manufacturing techniques to ensure high consistency thin shells with sub-twenty-micron individual lamina thickness. We have also explored the inclusion of polymeric interleaves to impart shape memory and controllable damping performance, and conductive inserts to enable data and power transfer through the folding hinge, further increasing the multifunctionality.

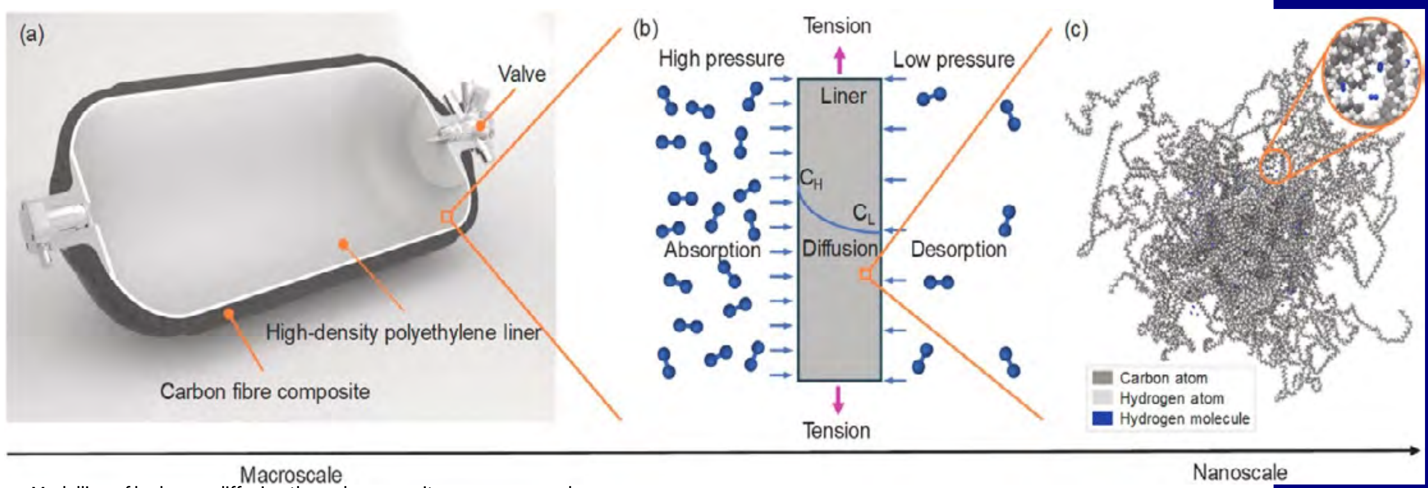
20 Composites for hydrogen storage and transportation

Academic lead ▪ DR CHAO WU

The UK's goal of achieving Net Zero by 2050 requires a fundamental transition from fossil fuels to renewable energy sources. Hydrogen is emerging as a promising green fuel to facilitate this transition. However, utilizing hydrogen efficiently requires handling it under extreme conditions, such as high pressure and cryogenic temperatures, to achieve an adequate energy density. Conventional metal systems face significant embrittlement issues, making them less suitable for long-term storage and transportation of hydrogen. Therefore, it is imperative to find an alternative, cost-effective material that can safely store and transport hydrogen under those critical conditions.

Our research addresses these challenges by focusing on advanced polymer-based composite materials, which present a promising solution for hydrogen storage and transportation, particularly in sectors like automotive and aerospace, where lightweight, resilience, and durability are paramount. The primary challenges in this area are (1) hydrogen permeation through polymer matrices, (2) material degradation under extreme hydrogen conditions, (3) the composite's behaviour under extremely low temperatures, and (4) ensuring safety and structural integrity under operational stresses.

To overcome these barriers, our interdisciplinary research integrates multi-scale modelling, in-situ testing under hydrogen environments, and advanced manufacturing techniques. By collaborating across fields such as polymer chemistry, nanomaterials, and molecular dynamics, we aim to develop next-generation polymer composites capable of providing reliable, safe, and efficient solutions for hydrogen storage and transportation. This research aims to contribute to the advancement of hydrogen infrastructure, facilitating a sustainable energy transition.

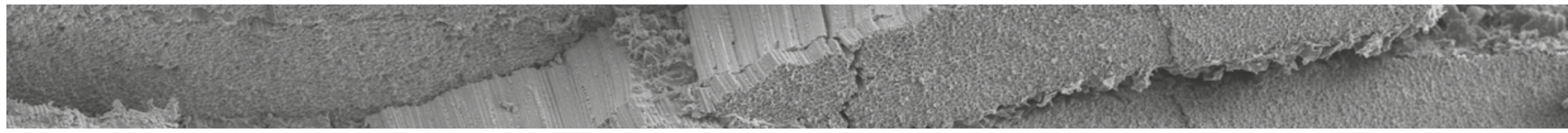


▲ Modelling of hydrogen diffusion through composite pressure vessel.

Research Themes

Synthesis of New and Multifunctional Materials

THE COMPOSITES CENTRE is very active in the conception and synthesis of new and multifunctional composites. These materials offer properties and functionalities which cannot be achieved with conventional systems, but present considerable processing and characterisation challenges. We introduce nanomaterials into fibre reinforced composites, and by having addressed the manufacturing issues, are now fully exploiting the properties of the nanophase in the resulting composites. We are world leading in the field of multifunctional and structural power composites: structural composites which have multiple functionalities, such as electrical energy storage. Despite being a relatively new field, multifunctional composites are quickly emerging as vital for the future transportation and mobile electronic sectors. Finally, we are addressing fundamental aspects of composites, such as their inherent brittleness, through the development of ductile composites.

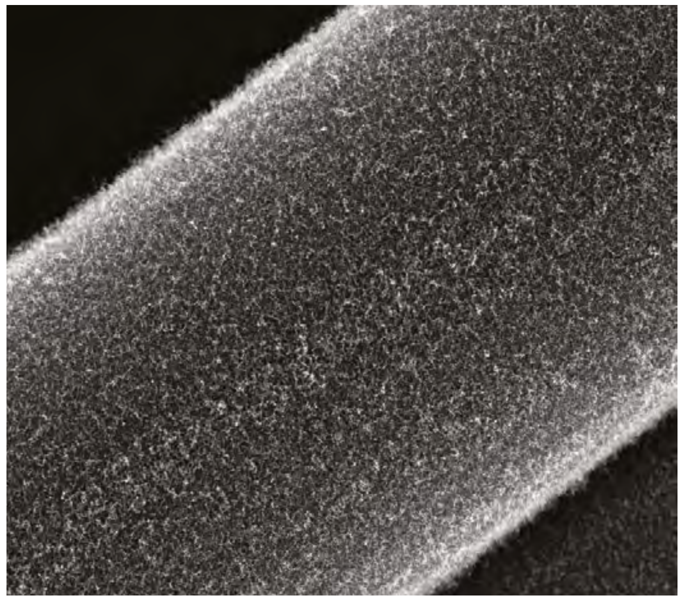


Hierarchical composites

Prof Milo Shaffer, Prof Emile S. Greenhalgh, Prof Alexander Bismarck

We have developed hierarchical composites; reinforcement at both the micro- (carbon fibres) and the nano- (CNTs, carbon aerogel or graphene) scales. We have two approaches to achieve high loading fractions of the nanophase; via matrix reinforcement and via growing CNTs on the fibres, achieving extremely high-volume fractions of the nanophase. Both approaches lead to significant improvement in performance over conventional systems, as well as added functionalities; the combination shows further synergistic gains.

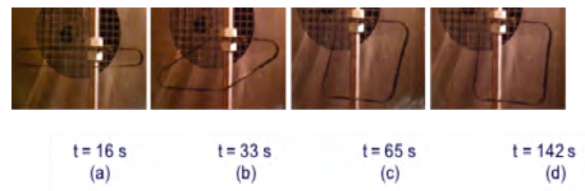
▼ Carbon fibre grafted with CNTs.



Structural Supercapacitors

Prof Emile S Greenhalgh, Prof Milo Shaffer, Prof Anthony Kucernak

We are world-leading in the development of structural supercapacitors – structural composites which have the ability to store/deliver electrical energy. These materials offer considerable performance advantages whilst presenting compelling opportunities for innovative design. We have a large portfolio of research addressing the fundamentals of these materials, manufacturing and design issues, mechanical properties and applications.



▲ Thermally activated composite shape memory material.

Composites with stiffness control and shape memory capabilities

Prof Paul Robinson, Prof Alexander Bismarck

We have developed composites which exhibit controllable stiffness and shape memory. One type consists of a carbon fibre thermoset laminates containing thermoplastic interleaf layers and another consists of thermoplastic coated carbon fibres in a thermoset matrix. The loss in shear stiffness of the thermoplastic at elevated temperature results in the temporary loss in flexural stiffness of the composite. These composites may find applications in deployable and adaptive structures.

Micro engineering the composite architecture

Prof Silvestre Pinho, Dr Soraia Pimenta

The damage tolerance of composites can be improved via micro-structural design. In fact, their fracture surfaces can be engineered by modifying their micro-structure accordingly. Inspired by nature, we have designed composites to create hierarchical pull-out features during fracture, tiled micro-structures and cross-lamellar microstructures. Using these approaches we have obtained increases of over 500% in translaminar fracture toughness, as well as improved damage diffusion.

Nanocarbon reinforced polymeric composites

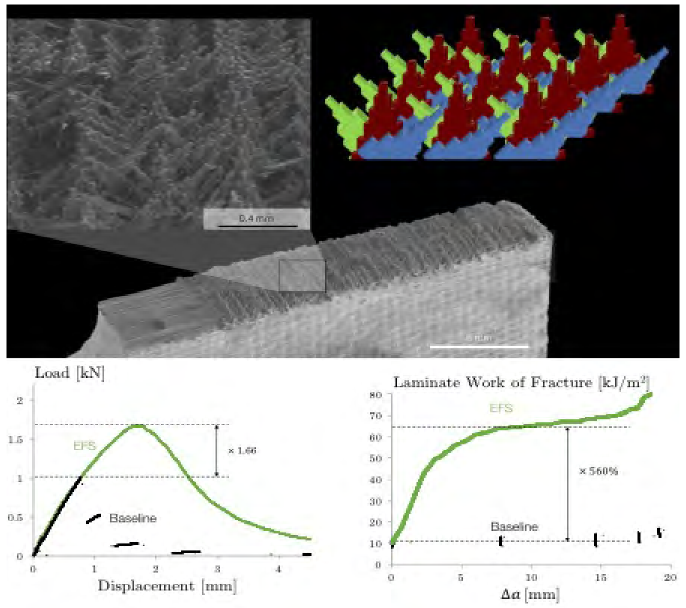
Prof Milo Shaffer, Dr Emiliano Bilotti, Dr Qianqian Li, Dr Vito Tagarielli, Dr Ajit Panesar

Nanocarbon reinforced polymer composites have been produced by various methods, including solution casting, hot pressing and 3D printing with optimised process parameters and desired interface design. The objectives are to develop suitable manufacturing methods to process strong and lightweight polymer composites, as well as enhance electrical properties, thermoelectric properties, piezoelectric, triboelectric properties, pyroresistive properties, thermal properties and shape memory.

(Pseudo-) Ductile and damage tolerant discontinuous composites

Dr Soraia Pimenta, Prof Paul Robinson

We have developed novel models to design discontinuous composites with a progressive failure and non-linear response. This has led to the development of (pseudo-) ductile discontinuous composites based on cut-prepregs with aligned short fibres, fibre hybrids and bio-inspired hierarchical microstructures with an initial stiffness akin to that of continuous composites but a more gradual and energy dissipative failure process.



Tailored microstructure to enhance the crack resistance of composites.

Emulsion templated inorganic/inorganic composites

Prof Eduardo Saiz, Dr Florian Bouville

We have developed a process to make inorganic/inorganic composites using emulsion and demonstrated its use by making strong and lightweight ceramic/ceramic and metallic fibre-reinforced ceramic composites. This scalable process starts with two different particle types in each solvent, producing a stable emulsion and shaping the emulsion using conventional processing.

Nanocarbon reinforced lightweight metal composites

Dr Qianqian Li, Prof Milo Shaffer

Nanoparticle reinforced lightweight metal composites such as Mg, Al and their alloys are produced via a melting process. Controlled surface modification of the nanoparticles with the metal matrix has been developed, leading to an effective interface and therefore desired microstructure and improved composite properties. Detailed 2D and 3D microstructure analysis provides the necessary understanding of process-microstructure-property relationships. State-of-the art synchrotron techniques including phase contrast tomography, diffraction contrast tomography and scanning transmission x-ray spectro-microscopy provide unprecedented information at the nanoscale.

Atomic Force Microscope examining nanocomposites.

Composite Design, Life Cycle Analysis and Recycling

Composites encompass a huge diversity of various constituents, architectures and applications, and hence designing with these materials presents considerable challenges, particularly for new adopters. Although the raw materials are somehow more expensive, unlike traditional materials, composites are not as susceptible to fatigue and corrosion, and hence ownership costs for composite components can be superior. The Composites Centre has extensive experience in composite design, ranging from established (such as aerospace) to emerging (such as infrastructure) applications. We have expertise in life-cycle analysis of composites, including recycling, and particularly in modelling of the performance of components manufactured from recycled composites.

Analysis of recycled fibres and composites

Dr Soraia Pimenta, Prof Silvestre Pinho

We have analysed state-of-the-art recycled fibres and composites in conjunction with industry. A cornerstone contribution was to show that residual fibre bundles (until then perceived as defects) actually enhance the fracture toughness and damage tolerance of recycled composites. Our work on characterisation and modelling of recycled composites has been recognised internationally.

Design for the threat of runway debris to aircraft structures

Prof Emile S Greenhalgh

Runway stones thrown up by the aircraft undercarriage can cause considerable damage. A predictive model has been developed which captures the wheel encounter with the stone, the lofting physics, stone trajectory and hence the severity of the impact on the aircraft structure as 'impact threat maps', thus informing design decisions. This model has successfully been used in the development of an aircraft now in service.

Binderless natural fibre preforms and their composites

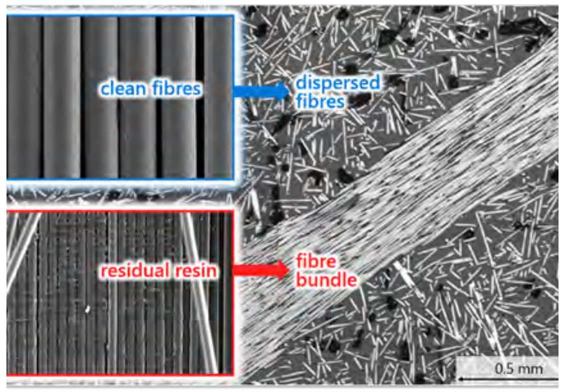
Prof Koon-Yang Lee

We have developed an elegant, intrinsically scalable and cost-effective technology for binding fibres together to create an in-plane non-woven fibre mat, utilising bacterial cellulose. Truly green non-woven fibre preform reinforced hierarchical composites have been prepared by infusing the fibre preforms with acrylated epoxidised soybean oil using vacuum assisted resin infusion, followed by thermal curing. Both the tensile and flexural properties of these hierarchical composites presented significant improvements over the parent materials.

All-Silk composites

Dr Emiliano Bilotti

We have recently developed a novel strategy to convert silk fibres (from B. mori silk to T. inaurata spider dragline silk to end-of-life silk fabrics) into high-performance (semi-)structural and optically active materials, which are bio-sourced, recyclable, and biodegradable.



Microstructure of recycled composite.

Electrochemical testing of structural supercapacitors.

Impact testing of CFRP.

Influence of short fibre order on the toughness of composites

Dr Florian Bouville

We studied the effect of arranging short fibres into dense and ordered microstructure, leading to composites with up to 80% fibre fraction in volume. The ordering and soft polymer used as the matrix triggered a toughness 40x higher than that of the matrix used through the formation of a large process zone

Design methodology with multifunctional materials

Prof Emile S Greenhalgh, Prof Milo Shaffer, Prof Anthony Kucernak

Multifunctional materials offer considerable savings in system-level mass and volume, hence contributing to reductions in energy consumption. However, given this field is relatively immature, the design methodologies to facilitate adoption by industry are fairly limited. We are developing analysis tools to predict performance requirements and design strategies for using multifunctional materials.

(Nano)cellulose for advanced composites applications

Dr Chao Wu, Prof Koon-Yang Lee

Nanocellulose fibres could be used as a structural reinforcement, and could potentially serve as a replacement for glass fibres given their low toxicity and density. We are tailoring the reinforcement architecture of various types of nanocellulose within the polymer matrix to produce composites for various applications such as transparent armour.

Additively manufactured functionally graded FRP lattice structures

Dr Ajit Panesar

Our investigation explores AM lattice structures produced via material extrusion, focusing on the effect of cell topology, grading strategy, and fibre reinforcement for improved energy absorption characteristics under dynamic loading. The results show that both stretching-dominated and bending-dominated architectures retained their characteristic failure modes across the strain rates tested, with bending-dominated lattices exhibiting greater strain rate sensitivity. The findings and insights gathered pave the way for designing high-performance AM lattices – through leveraging both geometry/topology and composite materials – for energy absorption applications.

Foam-templated macroporous polymers

Prof Koon-Yang Lee, Dr Vito Tagarielli

We have developed a simple, intrinsically scalable, rapid and waste-free manufacturing process for epoxy foam cores with densities of 0.18 g cm^{-3} without the need for a blowing agent. This process is based on the principle of liquid-foam templating, whereby an uncured epoxy resin is mechanically frothed and then can then be poured, shaped or moulded, followed by curing. Unlike the production of conventional foam core materials, no expansion or shrinkage occurs during curing.

Composite and multidisciplinary design optimisation

Prof Robert Hewson, Prof Matthew Santer

We are developing techniques for optimisation of stacking sequences of composite laminates to tailor the elastic response. This has been applied to reduced order beam models for aeroelastic tailoring of forward swept wing aircraft and fibre wound cylinders. This work was undertaken with aerodynamic research colleagues at ONERA in France.

Recycling waste wind turbine blades to make low carbon concrete

Dr Chao Wu

Wind turbine blades are primarily made of fiberglass, which is extremely hard to recycle. Our research transforms the ground blade powder into a new reactive binder that replaces cement in concrete, turning waste into value. This innovative solution tackles blade disposal while significantly reducing the carbon footprint of concrete.

Design and end-of-life solutions for wind turbine blades

Dr Soraia Pimenta

Wind turbine blades (WTBs) are large, complex composite structures whose design and disposal pose major engineering and environmental challenges. Our research integrates structural and material modelling to predict in-service degradation of glass fibre composites used in WTBs, coupled with life-cycle analysis to identify optimal end-of-life (EoL) routes. This research will support sustainable decision-making across the WTB lifecycle.

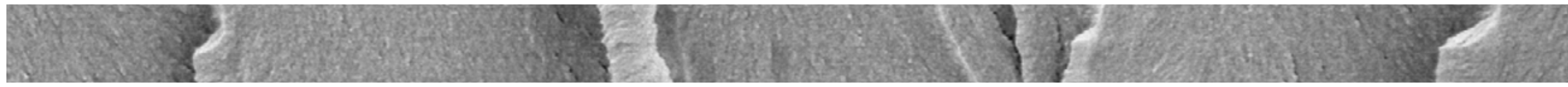
Upcycled leather waste

Dr Emiliano Bilotti

We have recently developed a novel strategy to upcycle leather waste into binderless, all-collagen materials, promising sustainable solutions in aviation, fashion, and beyond.

Composite Manufacture and Repair

Manufacture has been a critical bottleneck in the uptake of composites by industry, and the rapidly expanding and changing portfolio of composite constituents and architectures means a diverse range of processing routes need to be developed and understood. The Composites Centre has a knowledgeable and experienced team of staff to support this area as well as diverse range of facilities for research and development of composite manufacture. In parallel, we have expertise in predictive modelling processes associated with composite manufacture and repair.



Interleaved composites for easy repair of impact damage

Prof Paul Robinson, Prof Alexander Bismarck, Dr Emiliano Bilotti

An 'easy-repair' laminate concept has been developed to address the repair problem posed by interlaminar damage due to impact. A conventional carbon epoxy laminate is interleaved with thermoplastic polymers which can thermally bond to itself. On impact the interleaved composite would fail within the interleaf layer due to impact. The laminate is then heated to initiate bonding, perhaps accompanied by external pressure, and so restoring its initial pristine state.

Multifunctional composites via additive manufacturing

Dr Ajit Panesar, Prof Koon-Yang Lee

The recent developments in additive manufacturing have enabled the fabrication of composite components with tailored geometries which through traditional processes would have been either very challenging or impossible. However, these components often suffer from poor performance. This research is understanding the process- and material- related aspects to realise composites not only with high fibre content and superior mechanical properties but also with embedded functionalities.

Predicting filling efficiency of composite resin injection repair

Prof Joaquim Peiro, Prof Koon-Yang Lee

We have developed a two-dimensional reduced-order reconstruction, simulation and injection strategy to model resin injection repair which is scalable and practical for use with available equipment. The proposed method involves reconstructing a damaged composite laminate using ultrasonic C-scans to determine the damage zone geometry and porosity. The damage zone permeability is calculated via semi-empirical constitutive equations, and used as input data for the CFD simulation of a resin injection process through the composite. The ultimate aim is to guide repair operators by identifying suitable injection configurations.

Fabrication and scale-up of multifunctional materials

Prof Emile S Greenhalgh, Prof Milo Shaffer, Prof Anthony Kucernak

A critical challenge in the development of multifunctional composites is how to scale-up their fabrication. In conjunction with University of Bristol and Durham University, we are advancing manufacture of multiple devices, encapsulation and hybridisation with conventional materials, and electrical integration with the surrounding structures. Through this collaboration we are addressing the critical research hurdles which hinder the uptake of this emerging class of materials by industry.

Repair of composite components

Prof Zahra Sharif Khodaei, Prof Ferri Aliabadi

With new aircraft featuring composites in their primary structures, their repair whilst in service needs to be addressed by the maintenance and repair organisations (MROs). The structural integrity group in the Aeronautics department have been involved in developing smart bonded repair concepts to monitor the bonding quality of the composite patch repair as well as its integrity during operation. Various sensor technologies have been developed and tested to monitor the integrity of the bondline.

▾ Furnace for making carbon aerogel.

Composite Analysis, Modelling and Prediction

Over the last forty years, the Composites Centre has pioneered analysis and modelling of composites, and now are world-leading in this field. Models developed within the Composites Centre underpin many of the commercial predictive finite elements codes, such as ABAQUS. The research into analysis and prediction in the Composites Centre is diverse including composite failure prediction, damage growth modelling, impact behaviour and material design.

Development of failure models and criteria for composites

Prof Silvestre Pinho, Prof Paul Robinson, Dr Soraia Pimenta

We have developed physically-based failure models for various composite materials, including unidirectional (UD) and woven plies. Our models were ranked top in an international benchmark exercise and have been integrated in the commercial releases of the finite element codes. We have also developed analytical models to predict the mechanical response of unidirectional composites under longitudinal tension, predicting damage accumulation with progressive loading, stochastic size effects on strength, and the influence of fatigue on the tensile failure process and load-carrying ability.

Multiscale models for damage and deformation process prediction in highly filled polymer matrices

Prof Maria Charalambides

Modelling the deformation and failure processes in highly filled composites (approximately 95% volume fraction) is extremely complex as the very wide particle size distribution necessitates the development of multiscale models in the form of hierarchical simulations. The particle/matrix interface is characterised with a bi-linear cohesive law whereas the soft matrix is modelled through visco-hyperelastic or visco-plastic models. Once calibrated, the material laws are implemented in finite element models which allow the macroscopic response of the composite to be simulated.

Multiscale analysis of composites

Prof Silvestre Pinho

We work on various multi-scale modelling approaches for the analysis of failure in composites. Recently, we developed a Mesh Superposition Technique which can link different types of elements without creating artificial stress concentrations and without reflecting stress waves in dynamic problems.

Topology optimisation for multifunctional material design

Dr Ajit Panesar, Prof Emile S Greenhalgh

This research sets out to address a question "can we design the optimal microstructure to fulfil both structural and functional requirements?" We have developed a design-optimisation framework leveraging topology optimisation to realise novel multifunctional materials that offer both high stiffness and high ionic transport to maximise structural power functions (i.e. load bearing energy storage systems) have been promising.

Molecular dynamics finite element method

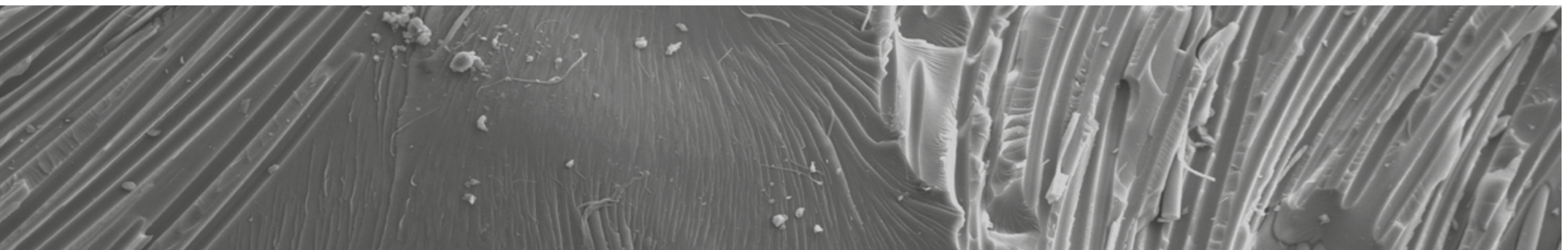
Prof Silvestre Pinho

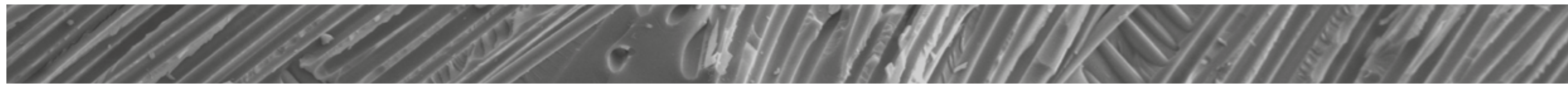
We have developed a molecular dynamics finite element method which allows for efficient simulation of complex atomistic structures atom by atom. This method represents the force fields from molecular dynamics exactly, but runs (as superposed non-linear user-elements) inside a finite element architecture. This makes it ideal for multiscale simulations with multiscale transitions to continuum descriptions.

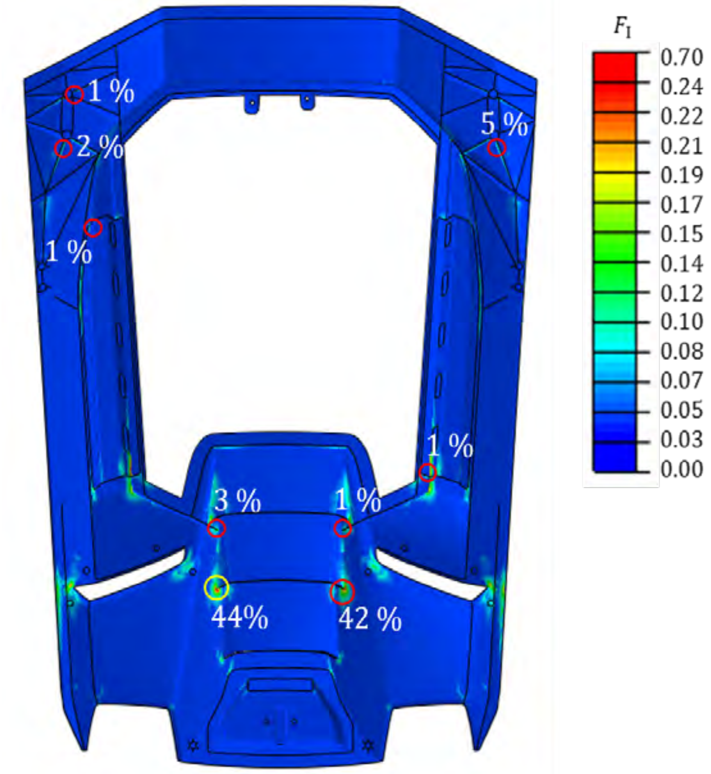
Unravelling the link between microstructure and bulk behaviour in multiphase food composites

Prof Maria Charalambides

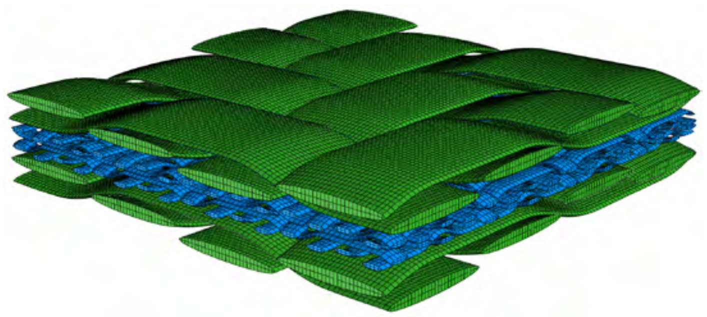
Food products are complex bio-based composite materials. Some have particulate structures (e.g., dough, chocolate) and others are cellular structures (cereal based foods). There is currently a drive to produce novel products by switching to more sustainable formulations or modified processes to enhance nutritional quality. Both formulation and processing have a direct impact on the microstructures produced, and in turn the bulk behaviour of the food when it undergoes further processing downstream in the production line (e.g. cutting) or inside the human body through the oral and gastric processes. We study this structure – property link of several foods and build constitutive models through calibration with experimental data and numerical simulation.







▲ Models have been used to design improved material microstructures. The results have been implemented in an FE framework to design automotive components in collaboration with Lamborghini.



▲ Finite element modelling of structural supercapacitor.

Aeroelastic tailoring

Prof Rafael Palacios, Prof Robert Hewson, Prof Matthew Santer, Dr Aditya Paranjape

The properties of composites can be harnessed to shape the large-scale deformation of aerostructures under aerodynamic forces. We are building high-fidelity computational models for optimization of composite layup in coupled fluid-structure interaction environments, and seek combined passive/active solutions in which aeroelastic tailoring is complemented by feedback control systems.

Floating node method

Prof Silvestre Pinho

The floating node method allows for complex networks of interacting cracks to be simulated efficiently. We have implemented this method in a commercial finite element (FE) code and demonstrated the effective simulation of 3D problems involving hundreds of cracks in complex networks involving delamination, splitting, migration of delaminations and fibre failure.

Tow-based discontinuous composites

Dr Soraia Pimenta, Prof Leif Asp

We have developed a framework for the mechanics of randomly-oriented tow- (or tape-) based discontinuous composites (TBDCs, manufactured via compression moulding) that accounts for their inherent stochastic variability and failure modes. We have introduced the "characteristic lengthscale" to quantify spatial variability in TBDCs, and combined it with new validated material models to enable accurate structural predictions. These models were also used to guide the development of TBDCs with record-breaking performance (TeXtreme® 360).

Multiscale multiphysics modelling of polymer composites for hydrogen economy

Dr Chao Wu

Hydrogen must be stored and transported under extreme conditions like high pressure and cryogenic temperatures. Polymer composites offer great potential, but their behavior in such environments remains unclear. We are developing multiscale, multiphysics models to understand these conditions and accelerate the design of next-generation composites for the hydrogen economy.

Simulation of real microstructures fibre-reinforced composites

Dr Soraia Pimenta, Prof Paul Robinson

The microstructure of fibre-reinforced composites is critical to their mechanical performance. We developed a shell-beam (SB) micromechanical framework to simulate real composite microstructures under longitudinal loading. By explicitly modelling thousands of fibres (using tomography data) above the millimetre scale, the SB method improves computational efficiently by over 99.9%, while maintaining over 95% accuracy. This enables efficient, high-fidelity analysis of microstructural imperfections and their influence on strength and failure mechanisms.

Multifunctional modelling for structural power composites

Prof Emile S Greenhalgh, Dr Ajit Panesar, Prof Milo Shaffer, Prof Anthony Kucernak

Our aspiration is to advance multifunctional materials through modelling efforts. We have developed a physics-based continuum pseudo 4D (P4D) model - a 3D macroscopic dynamic model for the full cell was established based on the PET and coupled with a 1D mean-field theory-based equilibrium EDL model for asymmetric ILs in cylindrical mesopores - multiscale electrochemical model to provide a comprehensive understanding of the electrochemical behaviour of structural supercapacitors (SSCs). A range of factors pertinent to the design of both SSCs and structural batteries are being studied extensively, including the separator thickness and porosity, and electrode thickness and fibre volume fraction. In general, this electrochemical model provides a stepping stone for further electro-chemo-mechanical models for structural power composites, as well as promotes the development of digital twins and virtual certification of these devices.

Data-driven modelling and characterisation of materials

Dr Vito Tagarielli

We apply machine learning to the characterisation and numerical simulation of the performance of advanced materials, including multiphase composites. We tackle two classes of problems: 1) we process data measured in lab-scale experiments to obtain data-driven and theory-free surrogate constitutive material materials models and 2) develop machine learning approaches to accelerate numerical simulations of material and structural response. We try to overcome the limitations of the human brain in comprehending and interpreting measured data on materials response, and to develop numerical tools to tackle problems that are currently considered as computationally intractable.

Modelling fibre-reinforced composites under longitudinal tension

Dr Soraia Pimenta, Prof Silvestre Pinho

We developed Hierarchical Scaling Law (HSL) to predict the micro-scale longitudinal tensile response and failure of composites under both static and cyclic loading, depending on environmental conditions. Validated through blind predictions against independently obtained experimental data, HSL proved to be the most accurate and computationally efficient among all models included in an international benchmark. It is now being coupled with full-scale simulations of pressure vessels and wind turbine blades for structural performance prediction.

Modelling collagen and bone materials across the scales

Dr Soraia Pimenta, Dr Ulrich Hansen

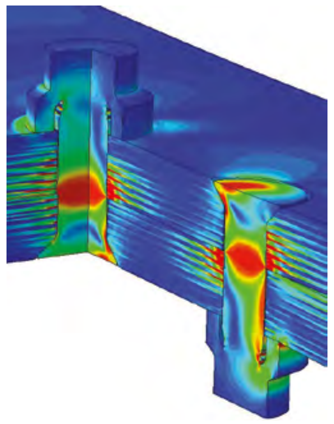
Bone is a biological composite primarily composed of collagen fibres, exhibiting exceptional mechanical properties. Its architecture and constituents are far more complex than those of synthetic composites and are directly linked to bone health. Conditions such as diabetes can alter collagen cross-linking, affecting bone mechanics. We developed large-scale simulations of collagen fibrils, incorporating real microstructural data and realistic cross-linking conditions, to reveal their significant impact on fibril strength and stiffness.

Machine learning based inverse design for composite meta-materials

Dr Ajit Panesar

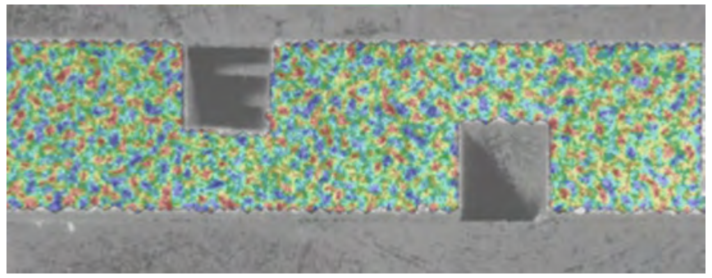
Metamaterials offer opportunity to realise properties not typically found in nature. Through the fusion of density-based topology optimisation (TO) and the ML based inverse generator, we have been able to demonstrate superior multifunctional performance through the realisation of multiscale structures utilising composite materials. Several ML models have been explored, ranging from: MLP, CNNs, GANs, and GNNs, to best map the property to design space. Multiple objectives are being considered to take the metamaterials beyond structural use-cases.

▾ Predicting the failure in bolted composites.



Experimental Mechanics

Research and development associated with the mechanical characterisation of composite materials and components is undertaken in The Composites Centre. Such studies provide an insight into the damage and failure mechanisms in these materials, and provide validation for predictive models. We have considerable experience in undertaking standard test methods for characterisation of new and current composite materials. But we have particular expertise in development of bespoke test methods to characterise composite materials, elements and components.



▴ DIC image from mechanical testing of composite laminate.

High strain rate characterisation of materials

Dr Gustavo Quino, Dr Vito Tagarielli

Real components and structures often experience intense dynamic loads, leading to high strain rates that alter material behaviour. We have developed experimental apparatus and methods to characterise polymers, composites, fibres, and other advanced materials under high-velocity loads, capturing responses at strain rates up to 10,000/s.

Environmental effects on composites

Prof Emile S Greenhalgh, Prof Silvestre Pinho, Dr Soraia Pimenta, Prof Paul Robinson

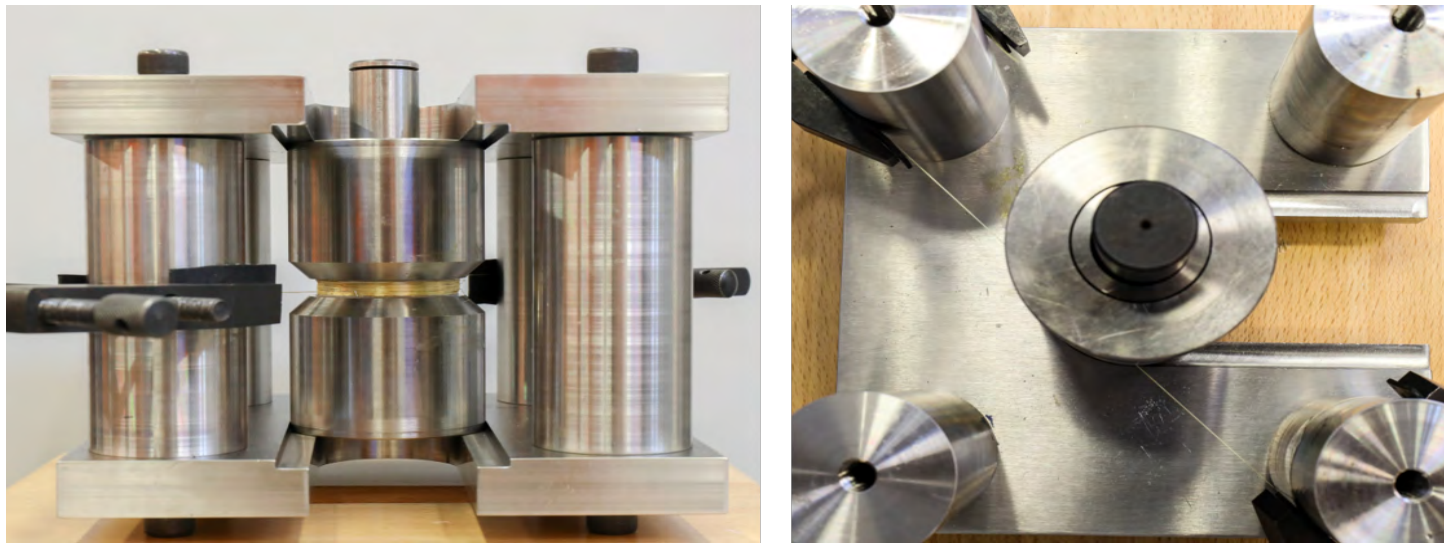
Under ATI (Aerospace Technology Institute) and industry funding we have characterised the influence of moisture, temperature and rate on the mechanical performance of highly toughened aerospace composites, with the results being complemented by fractographic studies. By investigating the equivalence of the fracture processes under different environmental conditions, with University of Bristol we have developed new TTSP (time-temperature-humidity superposition principle) models which link rate, temperature and moisture effects in these materials. The aspiration is to shorten the certification process for aerostructures.

Delamination

Prof Emile S Greenhalgh, Prof Paul Robinson, Prof Silvestre Pinho

We have pioneered understanding, characterisation and development of modelling methodologies for delamination growth in composites. We have led development of test methods to characterise delamination under quasi-static, high rates and under cyclic loading. We have investigated delamination growth at non-zero ply interfaces, using fractographic insights to motivate the development of new test methods to characterise delamination migration. These profound insights into delamination growth have underpinned predictive model development and formulation of methodologies for damage tolerant design.

▾ High strain rate testing rig.



New mechanical test for composite rods under compression

Dr Gustavo Quino, Dr Soraia Pimenta, Prof Paul Robinson

The high axial stiffness of pultruded rods makes compression characterisation difficult, as traditional direct compression methods often cause stress concentrations and failure near the grips. To address this, we developed the "cradle test," which introduces compression gradually through bending. Using detailed Digital Image Correlation data, our method accurately reconstructs the compressive strain-stress response.

Impact on composites

Prof Emile Greenhalgh, Prof Paul Robinson, Dr Vito Tagarielli

Impact, and its subsequent effects on the mechanical performance of composite structures, has been an important focus of the research in The Composites Centre. We have characterised impact response and thresholds, the influence of impactor and component parameters, and issues such impact whilst under load. In parallel we have developed predictive models for the impact response, damage threshold, damage development and residual performance. We have investigated a spectrum of impact conditions, from low velocity impacts, medium velocity (e.g. runway debris) to high velocity (e.g. ballistic impact).

Blast performance of composite sandwich panels

Prof John Dear, Dr Paul Hooper, Dr Hari Arora

This research group has continued to develop and test composite sandwich panels against full-scale explosive charges, pushing the materials to their limits yet demonstrating their exceptional blast resilience. The high strength-to-weight ratios and energy absorption capabilities of composite sandwich panels make them an attractive choice for many demanding applications, including within the defence sector. The group has developed reliable large-scale experimental techniques to record panel response during air and underwater blast events.

Thermomechanical degradation of CMCs

Dr Oriol Gavalda-Diaz, Prof Finn Giuliani, Prof Eduardo Saiz

This project investigates the thermomechanical degradation of ceramic matrix composites (CMCs) used in extreme environments like aeroengines and fusion reactors. We employ advanced characterisation techniques – from scanning and transmission electron microscopy to atom probe tomography – to study degradation mechanisms from the micron down to the atomic scale.

Translaminar fracture toughness

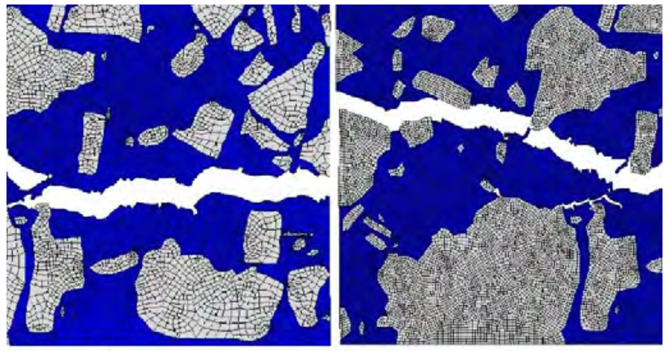
Prof Silvestre Pinho, Prof Paul Robinson, Dr Soraia Pimenta

The translaminar fracture toughness of CFRP (Carbon fibre reinforced polymer) plies and laminates defines how translaminar cracks may propagate. We have developed a now widely adopted test method to measure this property. Over the last decade, we have used this test method to characterise different material systems, fibre architectures, recycled composites, size effects, and have also adapted the specimen design and test method to suit a variety of emerging materials.

Micromechanical testing of fibre composites

Dr Oriol Gavalda-Diaz, Prof Finn Giuliani, Prof Eduardo Saiz

This project focuses on developing micromechanical tests using an SEM in-situ nanoindenter to evaluate the mechanical properties of fibres, matrices, and interfaces in fibre composites. We can measure toughness, strength, and stiffness across the various constituents of polymer and ceramic matrix composites, including CFRP, Si/SiC, and Al_2O_3/Al_2O_3 systems.



Modelling of fracture in particulate composite.

High temperature DIC

Dr Florian Bouville

We built a custom-made setup to track the displacement of samples during mechanical testing with a high resolution (few microns/pixel) and large field of view (3-5 mm). This setup can be used at room temperature and with our high temperature setup up to 2000°C, with the DIC operational up to 1200°C.

Novel mechanical characterisation of polymers

Dr Gustavo Quino, Dr Soraia Pimenta, Prof Paul Robinson

We have developed experimental techniques to characterise polymeric matrices, accounting for their plastic behaviour, to accurately calibrate computational models for micromechanical analysis. Using uniaxial compression tests with full-field strain measurements, we can measure plastic dilation, essential for Drucker-Prager models. Additionally, we have implemented tests to characterise pure shear and compression/shear multiaxial loads, without any edge effects, enhancing modelling accuracy.

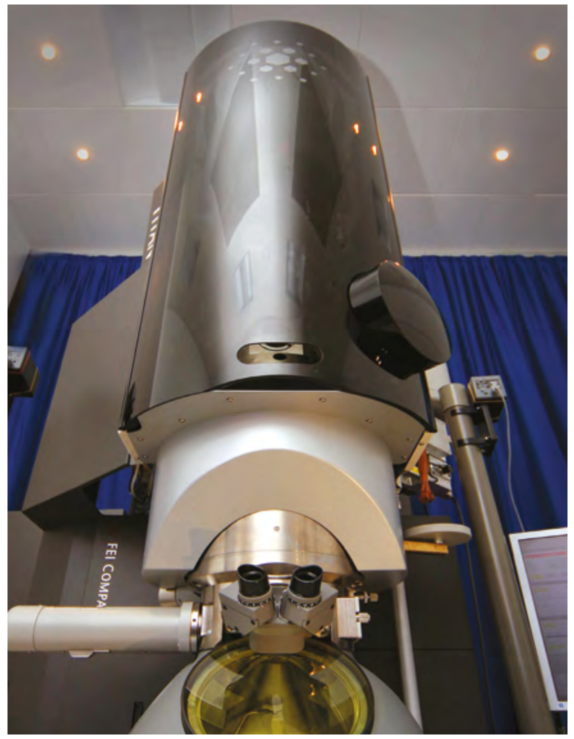
Composite Inspection and Characterisation

The increasingly complicated composite formulations and in-service conditions, as well as the advent of multifunctional composites, means inspection and characterisation of composites is challenging and requires well developed expert knowledge. The Composites Centre is world-leading in fractography of composites, which is used to underpin the research into composite damage and failure processes, and bridge between experimental observations and predictive models. There is also considerable activity on inspection methods for composites, including development and advancement of structural health monitoring methods for composite components.

AI for fractography of Composites

Prof Emile Greenhalgh, Dr Ajit Panesar

Fractography of polymer composites is time consuming and requires a high level of expertise to intrepret the failure surfaces. Much of the time is spent cataloging and mapping the fracture modes and directions on the failure surfaces using optical and scanning electron microscopy. By utilising automated micrograph tiling on the microscopes in combination with image recognition and machine learning, we are developing automated tools for fractography. These will considerably reduce the time taken to investigate failures and provide wider accessability for this powerful technique.



Transmission Electron Microscope.

Structural health monitoring of composite structures

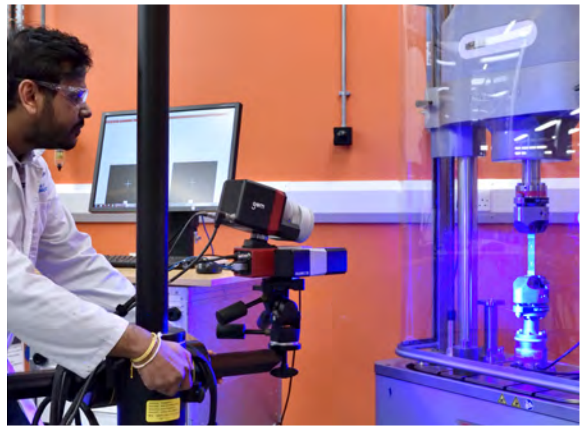
Prof Zahra Sharif Khodaei, Prof Ferri Aliabadi

Structural Health Monitoring (SHM) is an emerging technology covering the development and implementation of technologies and methodologies for monitoring, inspection and damage assessment based on integrated sensors. The acquired data in combination with advanced signal processing techniques can provide maintenance actions upon demand. We have developed various SHM methodologies and technologies for structural diagnosis of metallic and composite structures. We have been and are currently part of numerous EU funded SHM projects (e.g. SARISTU and SHERLOC).

Development of image-based numerical models for predicting the microstructure-property relationship in particulate composites

Prof Maria Charalambides

Numerical methods that can provide predictions of the mechanical response of particulate polymeric matrix composites as a function of volume fraction and particle mean diameter are needed as a design tool for composites engineers. A generic methodology has been derived, and the model predictions for the modulus and fracture strength are validated through independent experiments on the composite. This paves the way for a relatively simple methodology for determining structure-property relationships in composites design.



DIC of mechanical test on composite laminate.

NDE and SHM sensing and acquisition systems

Dr Frederic Cegla, Dr Bo Lan, Dr Peter Huthwaite, and Prof Mike Lowe

We have developed the DISPERSE and POGO simulation software to analyse wave propagation in complex structures. We also develop bespoke sensor and acquisition systems for the instrumentation of real-life structures. These sensors are optimised for specific applications to maximise their sensitivity. We have designed everything from permanently installed harsh environment sensors to drone deployable sensors.

Ply cutting of dry fabrics.

5. Academic Staff

Imperial people share ideas, expertise and technology to find answers to the big scientific questions, engineering hurdles and tackle global challenges.

With the composites research staff in the College spread across a broad range of disciplines, the Centre has been able to develop an unusually diverse research portfolio. There are around forty academics across the College affiliated to the Centre, and their research covers an enormous breadth of topics, ranging from the development of new composite constituents and architectures, manufacturing routes and characterisation techniques to predictive modelling and design for final applications.

Professor M. H. Ferri Aliabadi

Chair in Aerostructures

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Prof. Aliabadi's current research interests include fracture and damage mechanics, reliability- and robustness-based optimization, multiscale material modelling, and structural health monitoring (SHM). He has led several major EU-funded projects in SHM, including the $10M Clean Sky II core partnership project SHERLOC, which focuses on developing a smart, highly sensorised composite airframe. His ongoing projects include BAANG (morphing wing), AVATAR (digital twinning of an aircraft wing), and RACHEL, sponsored by the Aerospace Technology Institute (ATI) and led by Rolls-Royce, which aims to develop SHM technologies for hydrogen fuel tanks.

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Doctor Sophie Armanini

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Dr. Sophie F. Armanini is a Senior Lecturer in Aerial Robotics at the Department of Aeronautics. Her research focuses on flight dynamics, system identification and control, especially for unconventional and small-scale unmanned air vehicles -- with the goal of enabling improved performance, higher efficiency and novel applications. She is particularly interested in flapping-wing flight and bioinspired robots.

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Doctor Emiliano Bilotti

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Dr. Emiliano Bilotti is a Reader in Multifunctional and Sustainable Polymer Composites at Imperial College London, where he co-leads the Composites Centre and directs the MSc in Composites. Before joining Imperial in 2022, he held various academic positions in the UK Higher Education sector and worked as Research and Technology Manager at Nanoforce Technology Ltd. His research explores processing-structure-properties-sustainability relationships in thermoplastic polymer (nano)composites, with applications in energy storage, sensing, Joule heating, and shape programming. By integrating (nano)technology, he aims to enhance electrical, thermal, and mechanical properties for industrial impact and societal benefit.

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Professor Bamber Blackman

Professor in Mechanics of Materials

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Bamber Blackman is Professor in Mechanics of Materials and Structures in the Department of Mechanical Engineering where he leads the Adhesion & Adhesives research group. His research interests include the fracture mechanics of structural adhesive joints and polymeric composites materials, the study of adhesion related phenomena and the combination of mechanical and adhesive joining techniques in hybrid systems. He is co-chairman of the European Structural Integrity Society Technical Committee-4 on Polymers, Composites and Adhesives and a member of the Editorial Advisory Board of various journals. He is the author of over 100 refereed papers and book chapters in the area of structural adhesives and composites

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Doctor Florian Bouville

Senior Lecturer in Materials

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Dr. Bouville's research interests go from structural to functional ceramic materials with research on natural materials and bioinspiration. Ceramics are at the centre of high-end engineering products due to their resistance to extreme environments and their functional properties, with applications ranging from turbine blades in engines, bone replacement and batteries. The research focuses on processing and we have developed several processes based on colloids, water solidification, magnetic field, pressure-assisted densification, and additive manufacturing. To get insight into what is possible to achieve by changing a material structure, we look to natural materials for inspiration. To support these developments, we have worked on different types of modelling tools and image analyses of 3D microstructures.

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Doctor Agi Brandt-Talbot

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Dr. Agi Brandt-Talbot is a Senior Lecturer in the Department of Chemistry. Dr Brandt-Talbot's research interests lie in bio-derived materials and chemicals from sustainable biomass, for example, renewable carbon fibre composites, carbon-based electrode materials and biopolymer-derived films. She also devises advanced recycling processes for plastic packaging materials to enable the circular use of carbon in the economy and teaches sustainable chemistry at the undergraduate and postgraduate levels. Agi holds an Imperial President's Award of Excellence for Outstanding Early Career Researcher and the Department of Chemical Engineering's Sir William Wakeham Award. She is the Honorary Treasurer of the RSC Molten Salts and Ionic Liquids Discussion Group.

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Professor Maria Charalambides

Professor in Mechanics of Materials

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Dr Charalambides is the Head of the Soft Solids Research group. Her published research includes material modelling and mechanical characterisation of soft polymeric solids, micromechanics models of particulate filled polymeric composites as well as cellular structures, experimental and numerical modelling of industrial food processes, development of inverse indentation methods material characterisation of polymers, and fracture and deformation in coatings. Maria has published over 100 papers and has received funding from industry and RCUK.

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Doctor Frederic Cegla

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Dr. Cegla's research is focused on improving technology for non-destructive evaluation (NDE), structural health monitoring (SHM) and process monitoring of assets, spanning the whole spectrum from fundamental theoretical considerations of sensor physics, wave propagation and data acquisition all the way to commercial application of technology in industry. He has been the recipient of a prestigious EPSRC research fellowship, has been a key contributor to research collaborations such as the UK RCNDE and the ORCA Hub for robotics and AI in extreme environments. He is heavily involved in commercialisation and technology transfer and is a non-executive director of three spin out companies.

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Professor John Dear

Professor of Mechanical Engineering

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John has been an academic for 35 years in the Mechanics of Materials Division of the Department of Mechanical Engineering. His expertise is structural integrity of materials including manufacturing and micro-structural effects. He has published 420 journal and conference papers; contributed to 18 books, supervised 66 PhDs and 24 RAs. Examples include: impact performance of aerospace and automotive components, blast performance of laminated glass facades and composite structures, creep life of materials in power-station plant, water distribution plant and high-strain rate properties of polymers, composites and a wide range of other materials for defence applications and also for medical research. John is currently Head of the Composites, Adhesives and Soft Solids Group.

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Composites, Adhesives and Soft Solids Group

Doctor Oriol Gavalda Diaz

Lecturer in Ceramics

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Dr Gavalda is interested in understanding how ceramics and composites used in demanding applications fail. He focuses on a range of micro- and nanoscale characterisation and testing techniques that help explain how the microstructure and chemistry is linked to the failure processes. By understanding the local properties and chemistry of a microstructure we can efficiently support the development of new materials via microstructural design and predict the lifetime via multiscale models. He is focused on studying materials used in the transport and energy generation sectors such as polymer and ceramic matrix composites, layered materials and zirconia. The main techniques we use include scanning and transmission electron microscopy, atom probe tomography and in-situ testing and monitoring techniques.

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Professor Finn Giuliani

Professor in Structural Ceramics

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Prof Finn Giuliani has Chair in ceramics. His research interest centre around micro mechanics and electron microscopy, with particular emphasis on testing and characterisation of interfaces. His group specialises in in situ testing allowing both mechanical properties to be measured but also the failure mechanisms to be observed. He has deployed these techniques to a number of fibre composite systems including ceramic matrix composites supported by Rolls Royce and polymer matrix composites supported by Shell.

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Doctor Barbara Gordon

Senior Research Investigator

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Prior to joining Imperial, Dr Gordon worked in industry for 38 years, principally in the field of aircraft composite structures. This has involved work across the whole product lifecycle. She currently works with a number of members of the group on a variety of topics from new material and product development, through qualification and certification issues to in-service damage and repair.

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Professor Emile S Greenhalgh

Professor of Composite Materials

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A widely respected academic with over 38 years experience in initiating, developing, conducting and managing composites research whilst teaching over a broad range of aspects of fibre reinforced polymers. He is world leading in fractographic analysis of polymer composites, for which he has written the seminal book on the field. He has also pioneered and leads the development of structural power composites: multifunctional composites with the capacity to store/deliver electrical energy.

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Structural Power Composites

Doctor Firat Güder

Reader in Intelligent Interfaces

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Dr. Firat Güder is a principal investigator in the Department of Bioengineering at Imperial College London. Firat and his team work in the interface of material science, electronics, chemistry and biology, focusing on the development of intelligent interfaces to connect complex chemical and biological systems with machines. Firat is passionate about solving problems concerning animal and human health, agriculture and food systems. In addition to his scholarly activities, he has also co-founded multiple startups to translate his research to address real world problems.

For more information on Güder Research Group please visit www.guderesearch.com

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Professor Robert Hewson

Professor of Multidisciplinary Design Optimisation

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Prof Hewson's research focuses on multiscale methods and design optimisation, with applications spanning composite structures and advanced materials. He supervises multiple PhD students, including collaborations with Airbus UK, investigating multiscale design optimisation. He held a RAEng Industrial Fellowship and is Imperial lead for the EPSRC Programme Grant OncoEng. His work leverages response surface methods and gradient based free material optimisation to enhance composite structural design. This research extends topology optimisation by incorporating manufacturing constraints, ensuring practical realisation of optimised designs. Recent projects have focused on composite buckling and optimisation, addressing stability, manufacturability, and performance trade-offs in variable-stiffness composites.

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Professor Tony Kinloch

Professor of Adhesion

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Professor Tony Kinloch PhD, DSc (Eng), FCGI, FIMMM, FIMechE, FRSC, FREng, FRS holds a personal chair as 'Professor of Adhesion'. He has published over three hundred patents and refereed papers in the areas of adhesion and adhesives, toughened polymers, nanocomposites and the fracture of polymers and fibre-composites; and written and edited seven books in these areas.

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Professor Koon-Yang Lee

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Prof Lee's research focuses on the development and manufacturing of novel polymeric materials with a focus on tailoring the interface between multiple phases to bridge the gap between chemistry, materials science and engineering. He has particular emphasis on cellulose and nanocellulose engineering; design and fabrication of renewable polymer composites; surface and interface engineering to improve polymer (nano)composites; life-cycle assessment of composite materials; particle-stabilised emulsions and foams; novel manufacturing for polymer foams and recycling of waste materials.

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Doctor Qianqian Li

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Dr Li has extensive experience leading research in composite manufacture, process optimisation and material characterisation. She has proven track record on both metal and polymer composite development. Her primary research interests in lightweight composite fabrication, particularly reinforced with nanoparticles, 2D and 3D microstructure characterisation including synchrotron measurement, and nanoparticle surface modification and dispersion.

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Doctor Nan Li

Reader in Lightweight Design & Manufacturing

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Dr. Li's research focuses on breakthrough technologies for sustainable, lightweight vehicle design and manufacturing, including innovative forming processes for high-performance panel structures (e.g., stamping of Fibre Reinforced Thermoplastics (FRTPs) and hybrid FRTP-metal structures), as well as AI-driven design-for-forming platforms and tools for vehicle component design optimisation. Dr. Li and her team excel in translating research into real-world impact, and their work is widely recognised by international industrial collaborators.

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Professor Rafael Palacios

Professor in Computational Aeroelasticity

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Prof Palacios's research is concerned with shaping aeroelastic behaviour in the dynamic interactions between deforming structures, the surrounding fluid, and feedback control systems. We develop computational models for dynamic and performance predictions and use them to investigate aeroelastic tailoring (changing composite layup to shape the aeroelastic behaviour), simultaneous layout and shape optimisation, and feedback control (through discrete surfaces and integral actuation) to optimise performance of flexible air vehicles and offshore wind turbines in adverse conditions.

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Doctor Ajit Panesar

Reader in Computational Design for Advanced Manufacturing

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Dr Panesar has extensive experience in developing computational tools to help realise the full potential of advanced manufacturing processes catering for both additive manufacturing and advanced composites. He leads the IDEA lab where the focus is on three emerging themes: i) fusing design-optimisation with ML to develop metamaterials targeted at solving complex engineering problems, ii) leverage Scientific ML to expedite process simulation, and iii) advancing energy materials, like batteries and structural power composites, through multiscale modelling and optimisation.

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IDEA Lab

Professor Joaquim Peiró

Professor of Engineering Computation

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Professor Joaquim Peiró focusses on the development of CFD methodologies for the simulation of resin injection and moulding processes for composite manufacturing and repair. Such methodologies been successfully applied to the modelling of the RTM (resin transfer moulding) processes employed in the manufacturing of propeller blades and the quantitative evaluation of mould filling times for geometries, and to the analysis and design of injection strategies for composite repair. His other research interests in this area are the processing of viscous polymers such as thermoplastics, and the modelling of dispersion and aggregation of nanotube suspensions in molten metal composites.

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Reader in Mechanics of Materials and Structures

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Dr Pimenta's research focuses on the mechanics of composites, addressing the full life-cycle of materials and structures across the scales, and spanning from high-performance to high-volume applications. She has a leading track record of developing efficient and accurate models for a wide range of composites, and made seminal contributions to the mechanics of recycled and discontinuous composites. She has published over 60 journal papers, book chapters and patents, and is a member of the Executive Committee of the European Society for Composite Materials.

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Professor Silvestre Pinho

Professor in the Mechanics of Composites

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Prof Pinho is the Airbus Chair in Composites and his expertise includes; experimentally isolating failure modes in composites, and then simulating them using analytical models; developing numerical models to represent failure; measuring the energy associated with translaminar fracture and, developing more damage-tolerant composites via engineering their microstructures. He won an international benchmark on failure prediction for composite materials the 2nd World-Wide Failure Exercise. His models are commercialised worldwide (e.g. Abaqus and LS-Dyna), and custom models are used by different institutions.

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Doctor Gustavo Quino Quisepe

Lecturer in Structural Analysis and Materials

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Gustavo Quino, DPhil (Oxon), is a Lecturer in Structural Analysis and Materials at the Department of Aeronautics. His research focuses on the mechanical behaviour of polymers and composite materials under harsh environments and dynamic loads. He has extensive experience in multi-scale experimental and modelling techniques, including advanced imaging, full-field measurements, strain-rate effects, and hygrothermal ageing.

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Professor Paul Robinson

Professor of Mechanics of Composites

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Prof Robinson's research interests lie in polymer matrix composites. His earlier work had a particular focus on the susceptibility of these materials to delamination and included the development and investigation of tests for characterising delamination resistance and methods for predicting delamination development in composite components due to static, impact and fatigue loading. More recently his research has included development and investigation of ductile composite architectures, investigation of strategies to improve the compression response of advanced composites (as part of the EPSRC Programme Grant: Next Generation Fibre-Reinforced Composites), and the development of controllable stiffness and shape memory composites.

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Doctor Charles Romain

Lecturer in Chemistry

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Charles is a Lecturer in Chemistry at Imperial College London. He leads the Poly(Cat) lab, a research group interested in the development of sustainable polymers including the use of renewable resources, the design of new metal catalysts and improving material end-of-life. Among others, the group develops bespoke (co) polymers with well-controlled compositions and structures.

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Professor Eduardo Saiz Gutierrez

Chair in Structural Ceramics

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Prof Saiz's research interests include development of new processing techniques for the fabrication of ceramic-based composites, in particular hierarchical composites with bioinspired architectures, the study of high temperature interfacial phenomena such as spreading, the fabrication of graphene-based structures and composites and the development of new materials to support bone tissue engineering. He is the director of the Centre for Advanced Structural Ceramics.

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Professor Matthew Santer

Professor in Aerospace Structures

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Prof Santer has carried out research into the behaviour of high strain composite (HSC) flexures for deployable space structures, characterising and modelling their deployment mechanisms. Using thin ply laminates, self-deploying self-locking flexures have been investigated and developed. This work has been funded by the US Air Force Research Labs, Airbus Defence and Space, and DSTL.

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Professor Milo Shaffer

Professor of Materials Chemistry

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Prof Shaffer has extensive experience of nanomaterials synthesis, modification, characterisation, and application, particularly for nanocomposite and hierarchical systems, in combination with high performance reinforcing fibres. Exploitation of nanomaterials is limited by difficulties in synthesis and processing, and his research focuses on these problems for both structural and multifunctional purposes, for example in electrochemical devices. Notable recent work includes new, patented methods for the dissolution, surface functionalisation and characterisation of carbon nanomaterials, new hierarchical structures for improving the absolute compression performance of CFRP, and sustainable routes to bioderived carbon fibres.

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Nanostructures and Composites

Professor Zahra Sharif Khodaei

Professor in Aerospace Structural Durability & Health Monitoring

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Professor Sharif Khodaei's main area of research is structural integrity and health monitoring. She is developing an integrated Life Management approach incorporating intelligent manufacturing, real-time health and usage monitoring by integrating IoT sensors, and transformative digital twinning. She has been involved in several EU projects (SMASH, SCOPE, SARISTU, SHERLOC, AVATAR) were methodologies and technologies for maintenance and repair of composite structure have been developed and tested based on building block approach.

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Doctor Qilei Song

Reader in Chemical Engineering

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Dr Song has research interests in design, synthesis, and characterisation of functional polymers and nanoporous materials for applications in membrane separations, adsorption, catalysis, and energy conversion and storage. He has worked on several types of cutting-edge microporous materials and their applications in membranes for gas separations, notably metal-organic frameworks (MOFs) and polymer/MOF composites, polymers of intrinsic microporosity and novel porous molecular materials known as porous organic cages. He has worked on microporous polymer nanofilm membranes.

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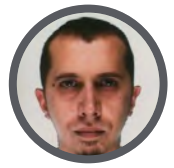

Doctor Vito Tagarielli

Reader in Mechanics of Solids

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Dr Tagarielli works at nonlinear problems in applied, solid and fluid mechanics, integrating experiments with theoretical and numerical modelling. His research contributions include constitutive modelling and characterisation of advanced materials, coupled fluid and structural response in explosion events in water and air, impact engineering, multiphysics modelling, new experimental techniques, data driven characterisation and modelling of solid materials, applications of AI to accelerate numerical simulations.

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Professor Ambrose Taylor

Professor of Materials Engineering

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Professor Ambrose Taylor aims to improve the toughness, durability and sustainability of thermosetting polymers. He specialises in the characterisation and modelling of polymers, including for use as coatings, adhesives and fibre composites. He also works with polymer recycling and the use of bio-based resins for formulating polymers. He has a special interest in the fracture processes and toughness of these materials. Applications include the construction, aerospace and automotive industries, as well as for the conservation of cultural heritage such as paintings and furniture.

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Doctor Felice Torrisi

Senior Lecturer in Chemistry of Two-Dimensional Materials

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Felice Torrisi is a Senior Lecturer in Chemistry of 2D materials and Wearable Electronics in the Department of Chemistry. He previously held a Lectureship in Graphene Technology at the University of Cambridge, where he jointly managed the Centre for Doctoral Training in Graphene Technology and the Cambridge Graphene Centre. He is an executive board member of the Centre for Processable Electronics and the Institute for Digital Molecular Design and Fabrication. He is the recipient of the Schlumberger Research Fellowship and the Harrison-Meldola Research Prize by the Royal Society of Chemistry. His research interests cover graphene and related two-dimensional materials for advanced fibres, flexible electronics and photonics, with particular focus on energy, sensing, wearable electronics and bioelectronics.

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Doctor Chao Wu

Reader in Civil Engineering Materials

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Dr. Chao Wu is a Reader in the Department of Civil and Environmental Engineering at Imperial College London. His expertise lies in the realm of composite materials and technologies with exceptional performance metrics to enable the new generation of energy infrastructure to achieve Net Zero and a green transition, with applications in wind, solar, tidal, geothermal, nuclear, and hydrogen energy.

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▾ Digitial Image Correlation of notched composite.

6. Facilities

The Composites Centre has world-leading facilities for composite synthesis, manufacture, characterisation and testing, underpinning the internationally renowned research we undertake in this field. These facilities are staffed by a team of research technicians with considerable experience in supporting research into composite materials and structures.

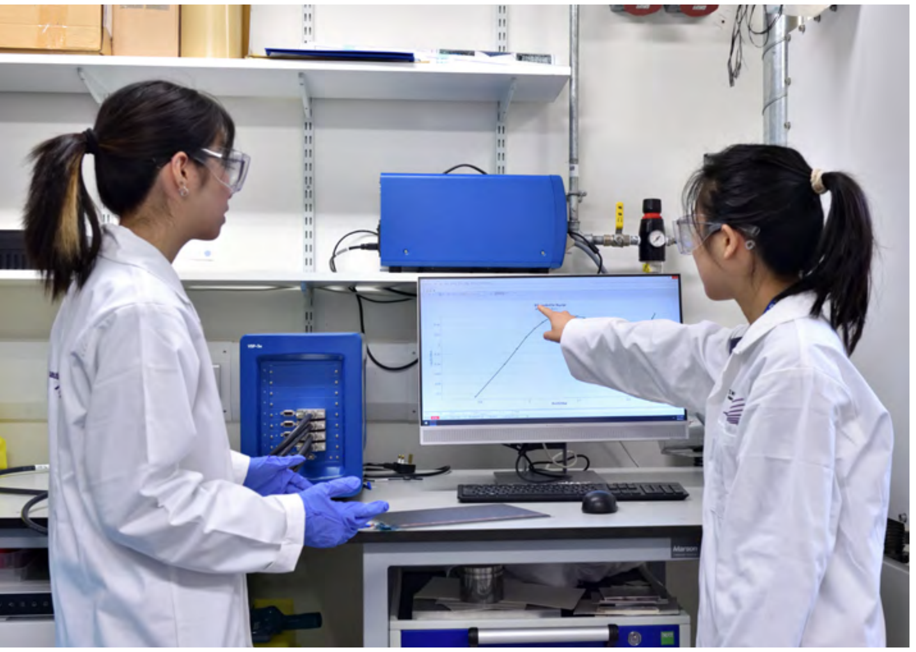
▴ Removing CFRP fabric from high temperature furnace.

▴ Extrusion of thermoplastic polymer.

Materials Synthesis and Multifunctional Materials Laboratories

Developing new constituents and their resulting composites is a key strength of the Composite Centre, and we have laboratories that are dedicated to the formulation of new and multifunctional materials. In the Materials Synthesis laboratory we have facilities associated with formulating, developing and characterising natural composites, such as nanocellulose based materials. In this laboratory we also have facilities for the fabrication of nanoreinforced metal matrix composites. Whilst in the Multifunctional Materials laboratory we have facilities for the synthesis of carbon aerogel (CAG) reinforced carbon fibre lamina, equipment to assemble structural power devices in a moisture and oxygen free environment and potentiostats with which to characterise their electrical performance. Other laboratories have facilities for ceramic coatings.

Research Facilities



▲ Electrochemical characterisation of structural supercapacitors.

Composite Manufacturing

For the assembly and manufacture of conventional composite systems there is a very well equipped Composite Manufacturing Suite with more facilities across multiple laboratories throughout the University. We can assemble and laminate both thermoplastic and thermoset based fibre reinforced composites, either via liquid resin methods or as prepregs. We can cut of all types of dry fabrics and prepreg types precisely and to bespoke shapes using our conveyor belt ply cutter. There is a Carbon Axis robot for accurate layup of prepreg tapes. We also have a large capacity autoclave to cure thermosets, and a smaller autoclave for use where that is appropriate, and several heated presses with which to process thermoplastic composites. There is also a 3-roll mill for the dispersion of nanoparticles. For out-of-autoclave routes we have liquid resin infusion and diaphragm/thermoforming capabilities as well as a heated RTM setup with resin injection system. We have facilities for filament winding and microbraiding, and finally we have the capability to 3D print using composite feedstocks.

For composite finishing we have comprehensive facilities for both wet and dry cutting, drilling, abrading and grinding of composites, including waterjet cutting, Electrical Discharge Machining and facilities for high precision cutting of composite components. Finally, we have facilities for composite repair.

It should be noted that we have put facilities in place, such as HEPA filters, such that we can process and finish nanoreinforced materials safely. Many of these are fixed to the equipment as a permanent extraction system, but we also have a portable extraction unit which is HEPA 14 filtered for use with any other equipment people require.

» **Fabrication of natural composites and their constituents**
We have a small injection moulder, intermediate twin-screw extruder, hydraulic hot press, large volume centrifuge (1.5 L), -60° C freeze dryer, automatic film applicator and a colloid mill. For the subsequent characterisation of these natural materials we have a Gurley densometer, helium pycometer, tensiometer and a microtensile tester with a 200 N load cell.

» **Fabrication of metal matrix nanocomposites**
We have a unique 'melt stirring furnace' with a controlled gas atmosphere. The temperature can be raised to 1100° C whilst applying either stirring or ultrasound to the metal melt. It is a tube furnace with two open ends such that different devices or instrumentation can be attached from both sides. It is also equipped with a HEPA filter for safely producing nanoparticle reinforced composites.

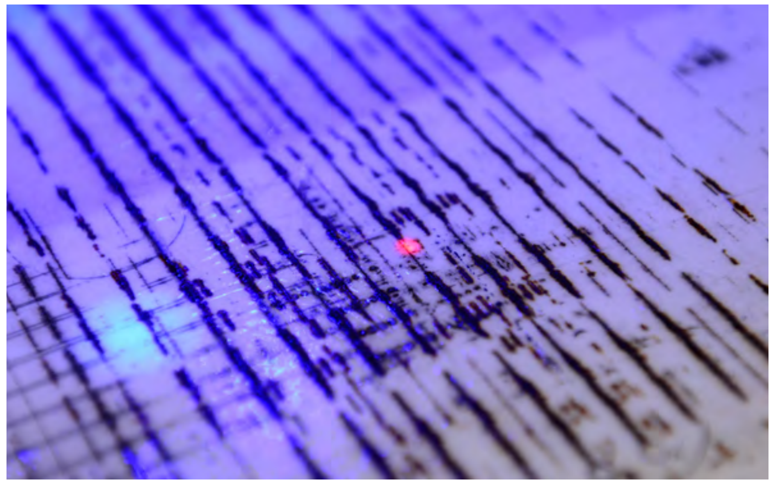
» **Development of structural power materials**
We have a double walk-in fumehood and ovens in which to infuse and age the CAG precursors, and a Carbolite Gero GLO 10/11 furnace with a maximum temperature of 1200° C to pyrolise the CAGed lamina under an inert atmosphere. We have a Braun glovebox with an argon atmosphere in which to assemble the structural supercapacitors, and a multichannel EC Lab SP-240 potentiostat with which to characterise the resulting devices.

» **Fabrication of high-temperature high-performance thermoplastic polymers and composites**
The most recent addition to our facilities is a high-temperature (45° C) twin-screw micro-extruder (Xplore MC40, first in the UK), able to process high-performance thermoplastic polymers (e.g. PEEK) and equipped with bespoke dies to manufacture films, filaments and tapes containing continuous carbon/glass fibres.

▲ Twin-Screw Micro-Extruder Xplore MC40.

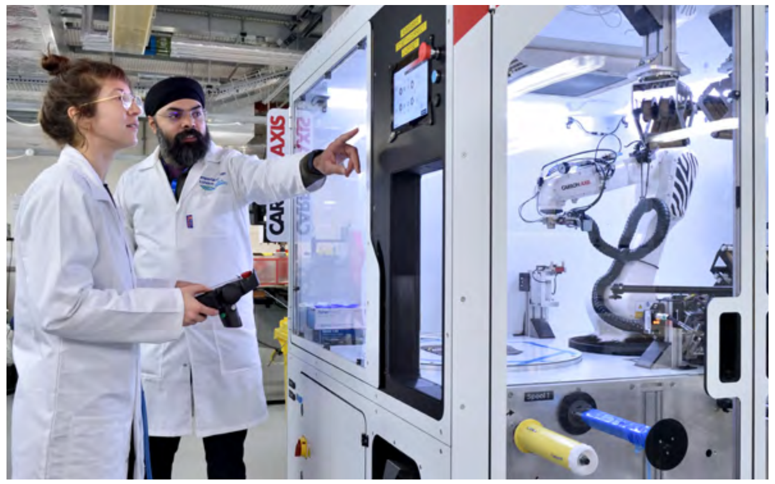
Research Facilities

▲ Out of autoclave manufacture of composite laminates.



▲ Laser cutting of composite fabric.

▼ Automated tow placement facility.



»**Fabrication of composites** For the cutting of dry fabrics and prepregs we have a conveyor belt cutter with an accuracy of ±0.1 mm and maximum cutting width of 1524 mm. These materials can then be fabricated into composites using our 1 m diameter autoclave with a maximum temperature and pressure of 450°C and 28 bar respectively, or the smaller 50 cm autoclave as appropriate. Alternatively we have several heated presses with a maximum platen size of 500 mm x 500 mm, and a maximum pressure and temperature of 400 kN and 400°C, respectively. One hot press also includes a water-cooling system for allowing rapid cooling of the hot plates, usable below 200°C. Lastly there is an induction heating machine, for the heating of electrically reactive materials, including carbon fibre reinforced composites. For advanced composite manufacturing, we use CarbonAxis XCell, a compact Automated Tape Placement (ATP) machine which uses both prepreg tapes and thermoplastic tapes (including in-house produced tapes), enabling high fibre volume content and excellent mechanical performance.

» **Out of autoclave processes** We have multiple liquid resin infusion facilities, including hot plates and a resin transfer mould with a CIJECT 3.1 pressurised resin injection system, as well as diaphragm/thermoforming using a heated vacuum press which can accommodate laminates 1450 x 1150mm in size at up to 250°C. For filament winding we have a robot system which can control mandrel rotation, material supply rate and filament tension. For microbraiding we have a Maypole-type machine with two working heads, providing varying combinations of up to sixteen carriers and eight horn gears at 30 m/h, permitting combinations of different yarns in a single braid and over-braiding of longitudinal yarns. Finally, for 3D printing of composites we have a Markforged 3D printer with continuous carbon, glass or Kevlar fibres in a nylon matrix. This has maximum printing dimensions of 320 x 132 x 154 mm.

» **Composite finishing** We have a full suite of facilities including a waterjet cutter with a maximum cutting size of 1.2 m x 1.0 m which can cut up to 10 m/min to an accuracy of ±0.07 mm. For dry cutting we have Startrite circular saw (300 mm diameter) and band saws, a Murg 24BB diamond wire cutter, as well as an Axiom CNC Router with a machining envelope of 610 mm x 610 mm x 153 mm. There is also an ATM Brillant 220 for precision cutting of small samples.

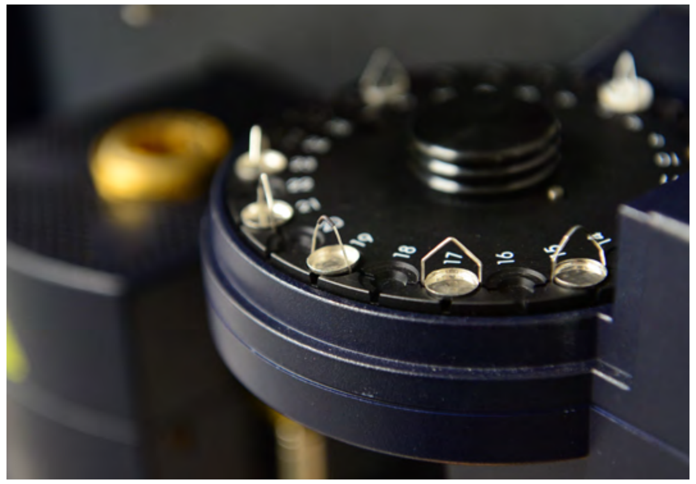
» **Composite patch repair** We have the LESLIE GMICRT 9201 Kit that provides the tools to prepare the surface of composites to conduct repairs. This enables us to apply different repair strategies such as scarf or step-sanded repair on flat or curved composite panels and allows us to do multiple different repair designs which can be tailored from a coupon level up-to a component level-structure, like a wing or a fuselage.

» **Out-of-autoclave or on the field repair applications**
The portable bonding console ANITA EZ09 provides a wide range of application for in-field operations through tailored head-blanket designs. Using a joint closed-loop temperature and vacuum control, this smart console is capable of curing of multiple matrix systems with repair sizes ranging from small cosmetic repairs up-to wide area sections, as those necessary to remotely repair aircraft wings and fuselage sections.

Composite Characterisation

We have an extensive range of facilities for characterisation of composite materials and structures. This includes non-destructive capabilities (ultrasonic and x-radiography), and vacuum and environmental conditioning ovens. We have capabilities for physical characterisation of composites and their constituents, including a Differential Scanning Calorimeter (DSC), ThermoGravimetric Analyser (TGA) and a Dynamical Mechanical Thermal Analyser (DMTA) to measure glass transitions, crystallisation, phase changes and cure kinetics. Finally, within the Composites Centre, we have a suite of optical and electron microscopes (with an in-situ testing capabilities), and the associated preparation facilities.

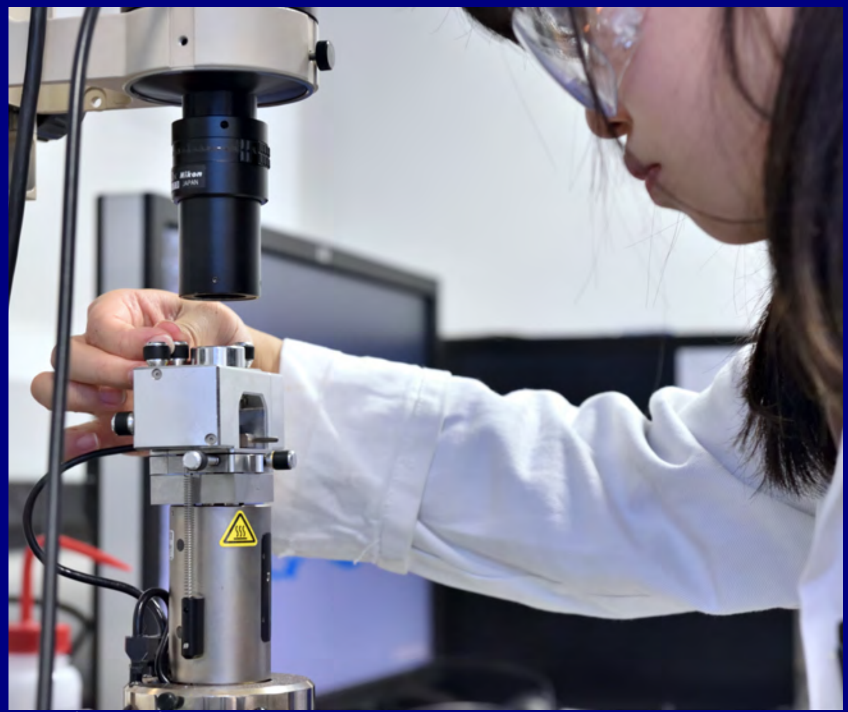
▲ Hirox 3D digital microscope.



▲ Composite characterisation using ThermoGravimetric Analyser (TGA).

Microscopy Suite

The Department of Materials, affiliated to the Composite Centre, has a wide range of facilities for characterising and imaging composite materials. This includes two atomic force microscopes; a Bruker Innova for routine analysis using standard tapping and contact modes, whilst the Asylum MFP-3D classic can also investigate electrical (KPFM), magnetic (MFM), piezoelectric (PFM) and nanomechanical properties (force mapping and AM-FM). We also have the Harvey Flowers suite of electron microscopes, which includes three scanning electron microscopes (SEMs) and three transmission electron microscopes (TEMs), the latest being the state-of-the-art monochromated FEI TITAN 80/300 and FEI Helios NanoLab 600 DualBeam. In addition, the dedicated microscopy team maintain the latest technology in the two sample preparation labs and data processing suite.



▲ Atomic Force Microscope.

Research Facilities

» Ultrasonic inspection We have an immersion tank system (1700 x 1300 x 500 mm) with a maximum scanning speed of 500 mm/s, with 1 MHz to 15 MHz probes. We also have a portable DolphiCam system which permits handheld inspection of components of up to 8 mm thick. We have a digital X-ray inspection system with an energy range of 10 kV to 90 kV, with a maximum sample size of 350 x 430 mm, giving a resolution of 5 – 45 µm. For environmental conditioning we have vacuum ovens and 100 litre conditioning chambers (TAS Thermal Vacuum and BINDER GmbH KMF 115) with a temperature range from -70°C to 180°C, with humidities from 10 to 98%, pressure ranges from ambient to 185 kPa and vacuum ranges of ambient to -2 kPa, permitting programmable heating and cooling ramps. There is also a Qsun Xenon Arc tester for testing photostability of samples.

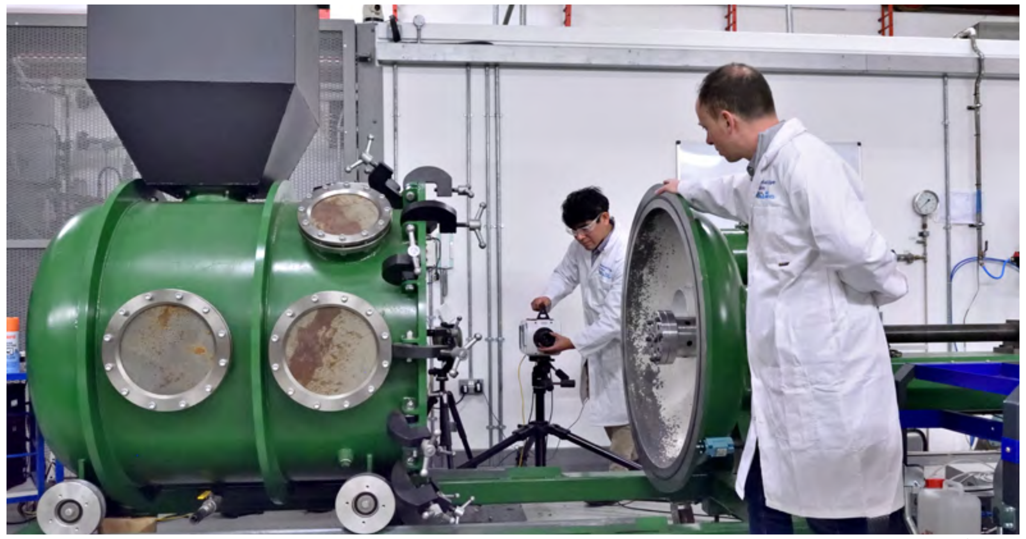
» Physical characterisation We have a range of thermal and rheological testing equipment including a Differential Thermal Analyser; Differential Scanning Calorimeters, with and without autosamplers; Dynamic Thermo Mechanical Analysers, with a variety of clamps and furnaces able to run tests between -155°C and 600°C , as well as under controlled humidity conditions; Thermogravimetric Analysers, some with associated mass spectroscopy; and Rheometers. FTIR and Raman spectroscopy, X-ray Diffraction for determining the crystallographic structure and X-ray Fluorescance for elemental composition analysis are also available along with Thermal conductivity testing. For assessing the particle and pore size in composites there is a mastersizer laser diffraction particle size analyser and a mercury intrusion porosimeter. Nanoindentation, Contact angle analysers and scratch and wear testing equipment provide a range of surface characterization techniques.

» Microscopy There is a wide range of imaging equipment, covering optical, scanning electron and atomic force microscopy. For optical microscope we have stereo and compound microscopy, with brightfield, darkfield, transmission and polarization including a Hirox 3D Digital Microscope. For metallographic inspection of composites we have a dedicated set of grinders and polishing wheels used exclusively for polymeric composites. For electron microscopy, we have a Hitachi S-3700N Scanning Electron Microscope with a large chamber (110 x 110 x 50 mm sample size). This has the capability to do in-situ mechanical testing using a Deben stage with a 50mm stroke and either a 150 N or 5 kN loadcell. There are also 2 Tescan FEG-SEMs, MIRA and CLARA, and a Zeiss Sigma 500VP. These are available for higher resolution work. MIRA is fitted with EDS and EBSD, a 300N Deben microtest stage and a Quorum PP3010 Cryo-stage for any materials which need to be cryogenically frozen before imaging. Finally, we have a Bruker Multimode atomic force microscope with Nanoscope V controller and Powertome Ultra Cryo Microtome to prepare samples for the AFM or for TEM in the Harvey Flowers Microscopy Suite.

▼ Large tank for ultrasonic inspection of composite components.

Mechanical Testing

The Composite Centre has considerable and extensive experience in mechanical testing of composite materials and components. Hence we have an extensive range of mechanical test machines to undertake quasi-static, fatigue and dynamic testing conditions, under loads ranging from 10 N to 2500 kN. We also have specialised capabilities such as a linear motor test frame which can undertake biaxial (tension/torsion) tests. We are able to undertake impact testing over a range of velocities, including drop weight impactors, one with a bespoke impact under load capability, as well as gas guns and Hopkinson bars. Most of our test machines can accommodate environmental chambers to permit hot or cold testing. We have the full range of standard (ISO and ASTM) test fixtures for composite testing, but also have the capability and substantial experience in the design and manufacture of bespoke test fixtures. We have access to a range of instrumentation techniques (both contact and non-contact) with which to capture test information. Finally, we have containment facilities in place with which to test nanoreinforced composites.



▲ High velocity impact facility.

Research Facilities

INSTRON MECHANICAL TEST MACHINES

We have a comprehensive suite of Instron mechanical test machines with advanced Instron 8800 controllers for dynamic machines using Wavematrix and BlueHill software for static machines. We have two conventional screw driven 50 kN machines with a range of load cells down to 10 N and a 250kN frame with hydraulic grips.

▲ Drop weight impactor.

» **Higher quasi-static and fatigue loading** We have servo-hydraulic machines with hydraulic grips with capacities of 100 kN (100 mm stroke) and 250 kN (250mm stroke). Our largest capacity machine is a 2500 kN hyperstiff screw driven machine capable of accommodating 1.5 m x 1.2 m panels with a maximum stroke of 2 mm/min. For higher rate loading we have a 25 kN frame (250 mm stroke) capable of 3 m/s with WaveMatrix dynamic testing software. Finally, we have a 10 kN (7 kN static) Instron Electropuls linear motor dynamic test machine with torsion (100 Nm) capability, capable of 60 mm stroke at 1.7 m/s. Most of these machines can accommodate our environmental chambers capable of testing over -150 (using Liquid Nitrogen) to +350°C.

» **Impact testing of composites** We have an Instron/Ceast with a maximum mass and velocity of 70 kg and 24 m/s, giving a maximum energy of 1800 J. This has an associated environmental chamber such that impacts can be conducted at -70°C to 150°C. The impactor can be used in conjunction with a bespoke compression frame capable of loading panels up to 1.2 m x 1.0 m in size to -1500 kN. We also have a medium velocity (crossbow) impactor to simulate runway debris up to 65 m/s.

▲ Gas gun for ballistic impact testing.

▲ Environmental chamber for mechanical testing of composite laminates.

SINGLE STAGE GAS GUN

The Centre has a 50 mm single stage gas gun which can fire projectiles between 10-250 g to 60-1400 m/s. The system fires into a vacuum chamber of 940mm diameter which accommodates large test panels. A smaller single stage gas gun is also available. It has a 25 mm bore and can fire projectiles of up to 10 g at a maximum speed of 500 m/s. It fires into a chamber which accommodates test panels that are typically 150 x 100 mm. The chambers of both guns both have viewing windows to enable the use of high speed cameras.

HOPKINSON BARS

The Centre also has a micro and conventional tensile Hopkinson bars for high rate characterisation of composites. A compression Hopkinson bar for the detailed characterisation of the compressive behaviour of composites is also available; this can be fitted with a newly developed apparatus to allow high strain rate tensile testing of composites and ceramics, as well as dry fibres, yarns and tapes used in composite manufacturing. A new tensile Hopkinson bar, with a maximum impact speed of 20 m/s and 20 mm diameter bars, is also available.

TEST INSTRUMENTATION

We have a range of associated test instrumentation, including strain gauge amplifiers; clip on extensometers; high speed digital oscilloscopes: three Imetrum Optical Strain systems with a range of lenses; a GOM DIC (Digital Image Correlation) system; a Mistras Acoustic Emission system; two Vision Research V12.1 High speed Cameras and a Vision Research 25.1 camera with FAST option (1 million fps).

THERMAL VACUUM CHAMBER

Finally, we have a TAS J2235 with temperature, pressure and humidity control. The temperature range is from -70 to +180°C and the pressure range is 20-180 kPa.

7. Collaborations

A summary of all the mechanisms by which you can collaborate with academics from the Composite Centre is given here.

We are world leaders in fractographic analysis of composites and regularly support industrial and in-service failure investigations.

UNDERGRADUATE (MENG) PROJECTS

All final year students undertake a research project which runs from October until May. We canvas for projects in the Summer and provide the list to the students from which they select and rank their potential projects. Once assigned to the student, the project scope can be modified based on discussions between the student, his internal supervisor and the host organisation. The student is not paid for the duration of such a project, but should be provided with access to facilities to undertake the research at the host organisation. The host should assign the student an external supervisor who will provide day to day guidance and will provide an assessment at the end of the project. If needs be, the project can be confidential and NDAs can be arranged to protect IP. This is a good mechanism for exploring a short piece of research with relatively little financial outlay.

MASTERS (MSC) PROJECTS

A wide variety of MSc Courses are available at Imperial College London. For instance, the Aeronautics Department run three MSc courses, the details of which are given here. As with undergraduate projects, we canvas for projects in the Summer (before August/September) and provide the list to the students from which they select and rank their potential projects. The project runs from April until August, and once assigned to the student, the project scope can be modified based on discussions between the student, their internal supervisor and the host organisation. For the Composite MSc, it is important that the project is clearly utilising the composite knowledge the student has developed during their MSc course. The student is not paid for the duration of such a project, but should be provided with access to facilities to undertake the research at the host organisation. The host should assign the student an external supervisor who will provide day to day guidance and will provide an assessment at the end of the project. If needs be, the project can be confidential and NDAs can be arranged to protect IP. As with undergraduate projects, this is a good mechanism for exploring a short piece of research with relatively little financial outlay.

POSTGRADUATE PROJECTS (PHD STUDENTSHIPS)

There are opportunities for industrial partners to support postgraduate students, covering their fees, stipend and costs for materials, facilities, etc. Such a mechanism will allow you to dictate the research direction and provide greater control of the intellectual property and knowledge generated from the research. The best means to initiate such projects is through direct contact with the relevant academic, who can formulate and cost such a research project. Furthermore, there are some opportunities for industrial CASE awards for PhD positions, as detailed here.

RESEARCH COLLABORATIONS

There are opportunities for industrial partners to steer and advise on research council funded research, and provide in-kind support through committing your staff time to advisory and progress meetings. Cash contributions or industrial facility access are also welcomed as a form of support to steer such projects. Alternatively, secondments to your organisation, or vice-versa, may also be valuable. To initiate such a collaboration mechanism it is best to approach the relevant academic.

FEG-SEM used for characterisation of composites.

INNOVATION COLLABORATIONS

Much of our research is focussed at the TRL0 to TRL3 level, and we welcome opportunities to translate and mature our research into real-world applications. The Composite Centre has a good track record in accessing funding from organisations such as ATI and Innovate UK. For large grants the associated Department within the Composite Centre may be able to supplement the research by funding PhD studentships to complement the research. To initiate such a collaboration mechanism it is best to approach the relevant academic.

HORIZON EUROPE COLLABORATIONS

The Composite Centre has a very strong track record in formulating, leading and securing European Union funding, and there are numerous mechanisms by which we can collaborate with industry via this route. Further details of these mechanisms can be found here. Imperial has a dedicated European Office which can advise on applying for, structuring and managing such projects. To initiate such a collaboration mechanism it is best to approach the relevant academic.

DONATIONS AND SCHOLARSHIPS

An alternative route to support the research is via philanthropy to support the next generation of composite engineers, help sustain academic excellence and develop frontier research areas. The Centre would be delighted to discuss priority areas including scholarships and flexible support funds. Please discuss this further with the Head of the Composite Centre or relevant academics.

Instrumentation for mechanical testing of composites.

Bespoke drop-weight impacted with compression frame to undertake impact whilst under loading.

CONSULTANCY

The academics in the Composite Centre have considerable experience and expertise which can be utilised to address your industrial challenges, near-term development problems and litigation/expert witness roles. Such consultancy is managed by Imperial Consultants who should be approached, along with the relevant academic, to initiate such work.

FACILITIES

The Composite Centre has a wide range of facilities for composite manufacture, characterisation and testing, with skilled technicians who can undertake the work. To initiate such work the Composite Suite Manager (Mr Jon Cole) should be approached.

GUEST LECTURING

We are keen to expose our students and researchers to an industrial perspective and outlook on composites, and would welcome guest lecturers from research providers, industry and government organisations. Please contact the Heads of the Composite Centre if you are interested in delivering a lecture.

8. Contact Us

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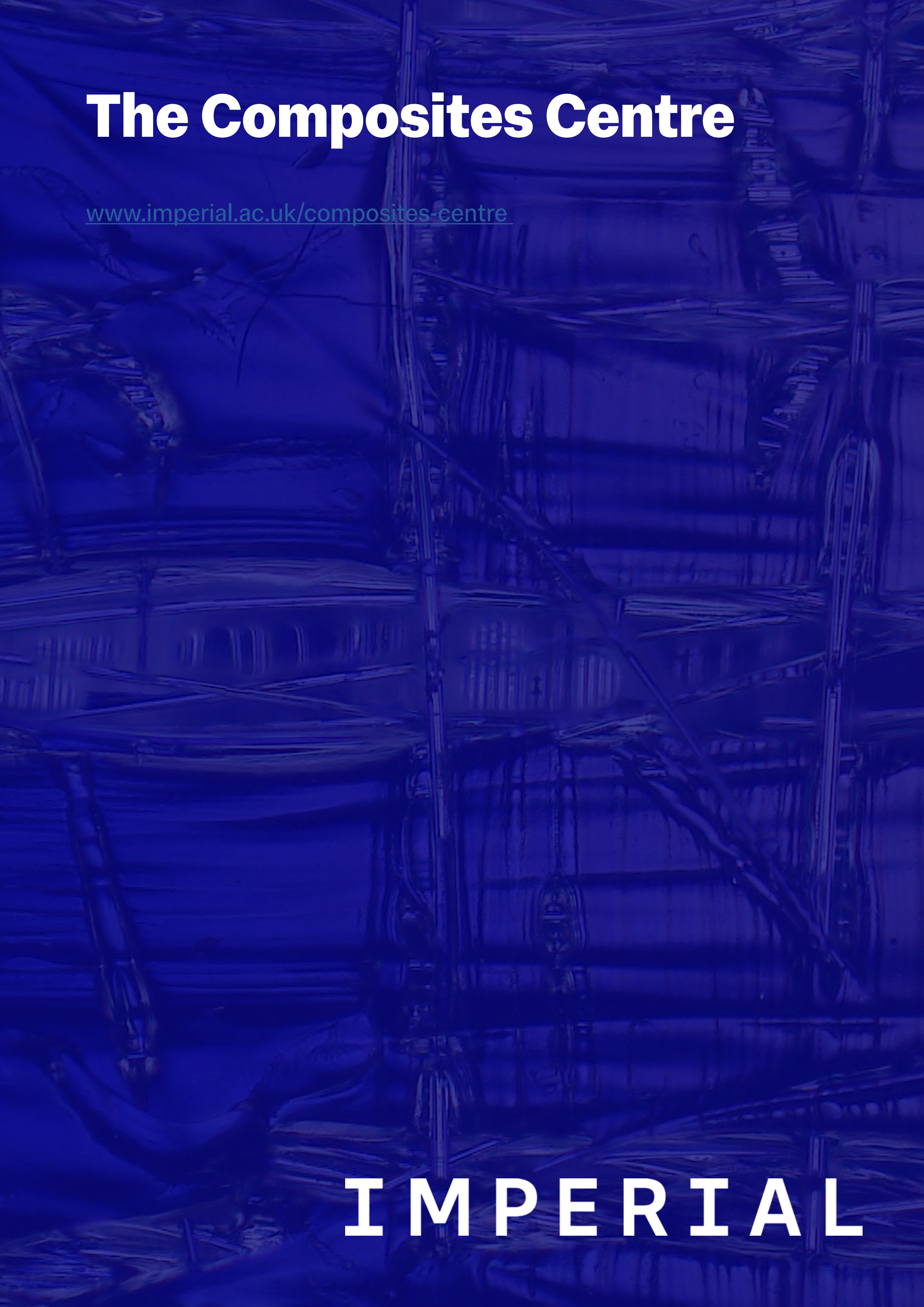

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