2-Minute-2-Slide Quick-Fire Project Introductions

Second Year CDT Students
Polychromatic Composite Structures

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www.bris.ac.uk/composites
Background and objectives

- Photonic crystals
  - Periodic (200~700 nm)
  - Dielectric
  - Photonic bandgap

- Objective: design and assemble photonic crystal structures based on colloidal self assembly and silica sol-gel chemistry.
Results and future work

- The photonic band gap can be tuned by changing some physical parameters of the system.

\[ m\lambda = 2d_{hkl}\sqrt{n_1^2 - n_0^2\sin^2\alpha} \]

- Orientation (\(\alpha\))
- Refractive indexes (\(n_1\), \(n_2\))
- Lattice parameter (or interplanar distance \(d_{hkl}\))
Results and future work

Future work: Use of smart and stimuli responsive materials, to reversibly tune and tailor the colour of these materials.
Development of Liquid Processable BT Resins

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Ian Hamerton and Carwyn Ward

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Background

- Bismaleimide-triazine (BT) resins widely used in micro-electronic and stealth applications
- Low dielectric constant
- High $T_g (> 300 \, ^\circ C)$

**BUT** toxic solvents are required to enable processing

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Cyanate Ester (CE)  
Bismaleimide (BMI)
Research Challenge

Is it possible to produce processable, high performance BT resins without the need for harmful solvents?

- Development of liquid processable resins, using novel blends
- Optimise system performance in terms of key properties
- Test resins in composite specimens

Example liquid BT systems (Room temperature – solvent free)
Piezoelectric Atomistic Finite Element Modelling

Mat Tolladay
Different scales, different models

- Macro scale: Finite element modelling
- Nano scale: Molecular mechanics
- Electronic scale: Density functional theory
Method and Results
Effect of Foreign Object Damage on composite aerofoils and structures

Ashwin Kristnama, Michael Wisnom, Stephen Hallett, David Nowell *

*University of Oxford

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What, Why, How?

• **WHAT?** – Understand damage process and overall failure
  - Low speed impacts (1–10 m/s)
  - High speed impacts (<500 m/s)

• **WHY?** – Recent introduction of composites to aircraft engines
  - Crack initiation concerns, component strength & integrity
  - Expensive test programmes

• **HOW?** – Experimental investigations

[Image of an aircraft on the runway]

www.airbus.com
Results

[-45/0/45/90]_s and [-45/0/45/90]_2s

Impact configuration at 45° to the LE

Before impact

After impact

Tensile response after impact

Residual strength (baseline)

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Residual Strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mm</td>
<td>824</td>
</tr>
<tr>
<td>2 mm</td>
<td>939</td>
</tr>
</tbody>
</table>

- Knockdown of 59.8% in residual strength for 45° LE impacts
Design Optimization of a Multistable Composite Compliant Actuator for Wearable Robotics

Chrysoula Aza

Alberto Pirrera¹, Lorenzo Masia², Paul Weaver¹

5th Annual ACCIS CDT Conference
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www.bris.ac.uk/composites
Introduction

**robotic devices**

- stiff components
- heavy
- bulky

**wearable robotics**

- safe human-robot interaction
- power efficiency
- agility & dexterity


Chrysooula Aza
Compliant Actuator

- mechatronic technology

+ multistable composite transmission, i.e. double helix architecture

nonlinear stiffness characteristics:
- Compliance.
- Force and position control authority.
- Power efficiency.

Design Optimization

- Design requirements
  - Minimizing dimensions for space & weight limitations.
  - Composite transmission in stable equilibrium at pitch $\theta = \pm 45^\circ$.
  - Maximum axial force $F = 50$ N.

Cappello L et al., IEEE Int Conf Rehabil Robot (ICORR), 2015

Chrysoula Aza
Ellipsoidal Lattice Structures

Maximillian Dixon, Isaac Chenchiah, Alberto Pirrera

www.bris.ac.uk/composites
Background/Context

Cylindrical Lattices Properties & Applications

- Large Deformation
- Highly Tailorable
- Non-linear Stiffness
- Etc..

ALTERNATIVE GEOMETRY = ADDITIONAL EXPLOITABLE BEHAVIOUR

Potential Ellipsoidal Lattice Applications

- Enclosed volume – Capture/containment
- Variable aperture – Flow regulating nozzle
- Adaptive geometry – Spherical antenna
- Tailorable stiffness – Spring/energy absorber
**Progress/Future Work**

**Modelling Procedure**
- Manufacture
- Assembly
- Operation

**Ongoing/Future Work**
- General model for lattices of arbitrary shape
- Energy landscape tailoring
- Characterisation of dynamic response
- Experimental demonstrators
Effects of Porosity on the Interlaminar Behaviour of Carbon/Epoxy Composites

Iryna Gagauz, Luiz Kawashita, Stephen Hallett

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Background and Aim

Voids - the most crucial defects:
- Difficult to eliminate
- Promote damage & fracture (e.g. delamination)
- Detrimental effect on mechanical properties

There is no established model to describe the relationship between void characteristics (e.g. size, shape, aspect ratio etc.) and mechanical properties

The aim of the project was to correlate simple void characteristics to mechanical properties of carbon/epoxy composites, starting from the interlaminar shear strength.
Results

- **20% ILSS decrease** between 1.5% and 6%
- Reasonable correlation ($r=0.858$)

**Effective radius**, based on void volume

$$r_{eff} = \sqrt[3]{\frac{3V}{4\pi}}$$

- Better correlation ($r=0.863$)
A Closed-Loop Recycling Method for Highly Aligned, Short Carbon Fibre Composites

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Kevin Potter, Ian Hamerton, Marco Longana, Hana Yu
## Recycling Incentives and Impact

### Incentives

- Adoption hindered by **economic** and **environmental barriers**.
- **Far outweigh** the potential light-weighting benefits.

### Impact

- Multiple operative lifetimes - reduction of cost barriers.
- Increase in CFRP desirability - over Al/Mg/Steel.
- No industrially scalable process exists.
- Carbon fibre from pyrolysis incorporation.

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**ELG - Recycled carbon fibre**

**BMW - Composite inclusion zones in vehicle**
Closed Loop Methodology

Carbon Fibres

Alignment

Thermoplastic

Matrix impregnation

Operative Life

Carbon fibres

Thermoplastic

Separation

Initiator Material
Improvement of Composite Drape Forming Quality by Enhancing Interply Lubrication

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Hana Yu, Kevin Potter, BC Eric Kim
Composite Forming & Challenges

Drape forming processes

1. Stack multiple prepregs
2. Uncured laminate
3. Place laminate on top of tool
4. Shape with heat and external pressure
5. Prepreg preform, ready for curing

Improvement method

1. Improve forming quality by promoting ply slippage.
2. Toughen ply interfaces.

Challenge

Interleaving lubricant

Forming

High interfacial friction

Fibre

Resin

Lubrication layer

Compression
Feasibility Study Results

**Interply friction test**
- Pull out force
- Lubrication material
- Normal pressure
- Fixed prepreg
- Promote ply slippage

**Drape forming test**
- Veil interleaving
- Powder interleaving
- Non-interleaving
- Fibre buckling

**Fracture toughness test**
- Mode-I DCB test
- Increase fracture toughness