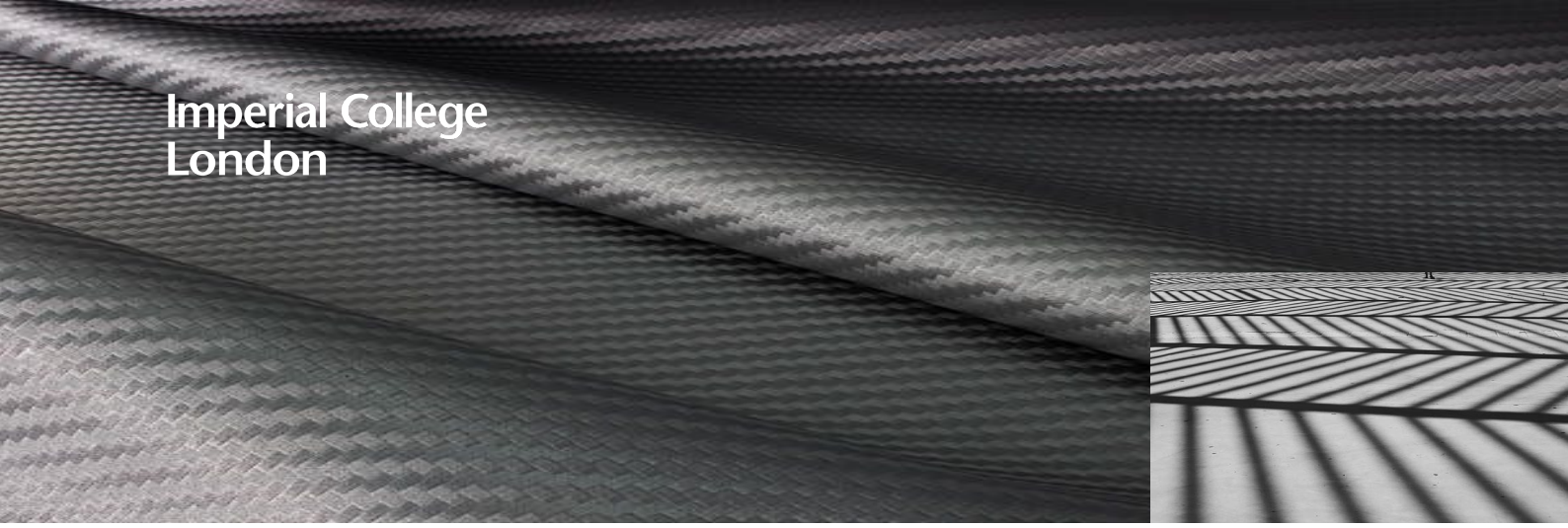

Imperial College London

Damage-resistant Fibre Reinforced Plastic (FRP) with tailorable Herringbone microstructures

Proposed use

Fibre Reinforced Plastic (FRP) are materials with high strength-to-weigh ratio, and they have application not only in aerospace, automotive, marine transportation but also in wind energy, sport, leisure and protective equipment.

Problem addressed

FRP are part of the architectural structure of many components, and they are susceptible to damage. Catastrophic fibre failure affects the performance and safety of the laminate materials.

Methods to tackle the poor damage resistance of fibre reinforced composites are widely investigated. Inspired in microstructures found in nature, this new technology presents a solution to enhance the damage resistance of fibre reinforced composite materials by tackling their inherent brittleness and tendency to fail, avoiding delamination and enhancing energy dissipation.

Technology overview

Researchers in the Department of Aeronautics at Imperial College London have developed a novel technique to manufacture FRP with improved damage tolerance. This method consists in locally tailor the through-the-thickness orientation of the fibres at the ply-level in a laminated FRP, mimicking the microstructure found in the mantis shrimp's dactyl club (*Odontodactylus scyllarus*), to create controlled out-of-plane patterned features to avoid large delaminations and sudden fibre failure. Laminates with locally tailored Herringbone structures within a region show an:

- improvement of the damage resistance through-the-thickness and impact resistance;
- enhancement of the energy dissipation;
- increase safety of the composite structure by contain the in-plane damage within the region and not spreading to neighbor areas.

Comparing materials with analogue microstructures, the Herrinbone FRP bear 10% higher loadings, 13% increase in the energy dissipated and 71% reduced projected delamination area.

The patterned features can be used with existing manufacturing technologies such as Automated Tape Placement (ATP) and Additive Manufacturing (AM).

Benefits

- Enhanced damage and impact resistance of fibre reinforced composites (FRP), and increase energy dissipation.
- Resistance to through-the-thickness.
- Improved safety of the composites. Damage contained within the region with the tailor patterned features.
- Cheaper and more efficient repair in case of damage.

Advantages

- Tailorability enabling the design of point-by-point solutions.
- Tailoring at macro- and micro-scales, controlling features within the bulk and surface.
- Versatility: it can be used with different laminated composite materials.

Applications

- Automotive and sports cars.
- Aerospace.
- Wind turbines.
- Sports equipment.

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Intellectual property information

An international patent application is filed (WO2022/058702) to protect the method to manufacture the Herringbone engineered structures.

Technology Readiness Level (TRL): 4

Link to published paper(s)

L. Mencattelli and S. T. Pinho, 'Herringbone-Bouligand CFRP structures: A new tailorable damage-tolerant solution for damage containment and reduced delamination' *Composites Science and Technology,* 2020, **190**, 108047.

Inventor information

This invention has been developed by Silvestre Pinho, Professor in Mechanics Composites, and Lorenzo Mencattelli, Honorary Academic, in the Department of Aeronautics at Imperial College London.