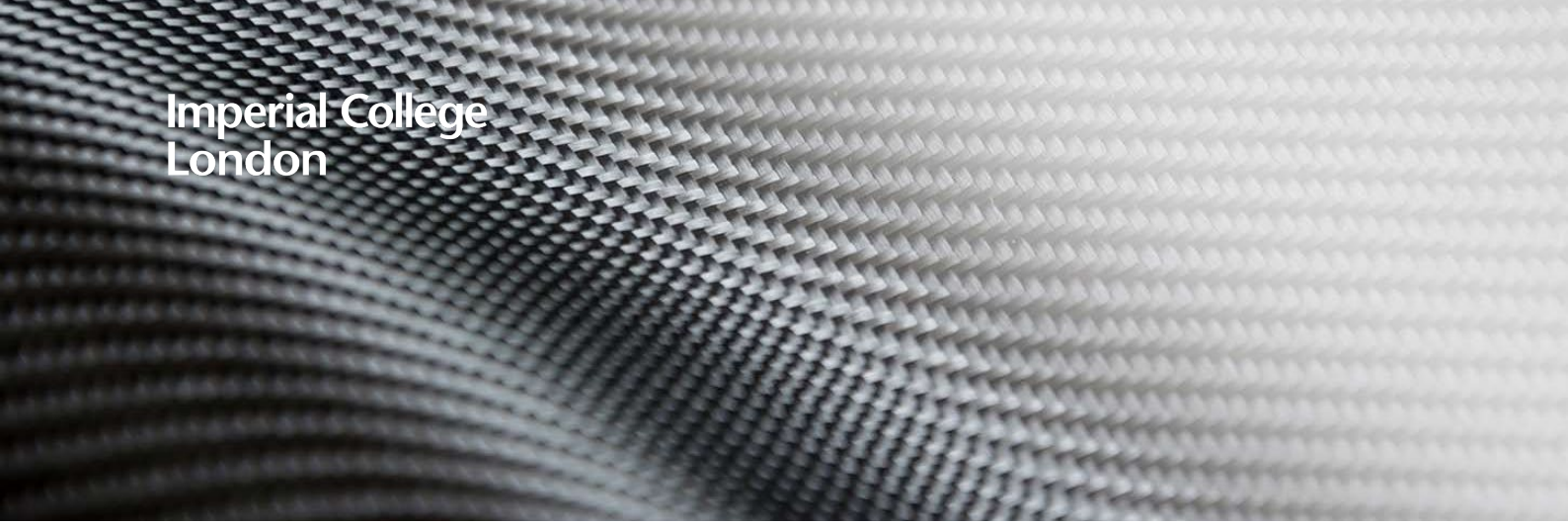

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Nacre-like decorated fibre for hierarchical ductile composite

Current issue

Conventional fibre 'sizes' (coatings) have no internal microstructure and poor control of thickness. The existing composites used to coat these fibres can accumulate damage which is not obviously visible and can lead to abrupt and unexpected failure. Catastrophic brittle failure of fibre-reinforced polymer composite materials under tension occurs due to the formation of critical cluster of fibre breaks that lead to high stress concentration in the composite. As a result, composite systems are hard to both design, inspect and maintain and they also typically have very wide safety margins that reduce the benefits of them being light weight.

Proposed solution

The invention describes a new approach comprising the coating of large numbers of fibres simultaneously with a thin layer of a nacre-like coating. The deposited coating reproduces the structure of natural nacre but scaled down by 1-2 orders of magnitude such that it fits the curved three-dimensional surface of a fibre.

The nacre-like coating acts as fibre crack shielding system and provides a possibility of uncorrelated controlled slippage of the fragmented fibres. The artificial nacre has a 'brick-and-mortar' nanostructure that provides the ability to deflect a propagating crack at the platelet interface to a tortuous pathway. In addition, activation of platelet sliding in region ahead and behind of the crack tip leads to high stresses which may stop or even arrest the propagation of the crack.

Substantial amounts of energy can therefore be dissipated and spread along the length of the fibre after fragmentation decreasing the stress concentration in the neighbouring fibres. Uncorrelated fibre fragmentation can then occur avoiding the formation of a critical cluster of breaks known to trigger the sudden rupture of the conventional fibre-reinforced polymer composites.

Benefits

- New approach comprising the coating of large numbers of fibres simultaneously with a thin layer of a nacre-like coating.
- The deposited coating reproduces the structure of natural nacre but scaled down by 1-2 orders of magnitude.
- The artificial nacre has a 'brick-and-mortar' nanostructure that provides the ability to deflect a propagating crack at the platelet interface to a tortuous pathway.

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The invention

A nacre like coating made of Mg2Al-CO3 layered double hydroxide (LDH) nanoplatelets embedded in a poly (sodium 4-styrene sulfonate) PSS organic phase, using LBL deposition method. Platelet thickness in the range 10-20nm that still maintains the correct geometric ratios of natural nacre.

The reduction of scale enables the (self) assembly of a higher quality nanostructure than conventional mimics leading to improve mechanical properties, approaching natural nacre, and allowing substantial plastic deformation.

The best properties of this coating emerge from an ordered microstructure generated using regular platelets with narrow size dispersion. These robust well-arranged bio-inspired hybrid nanocomposites offer opportunities to manufacture lightweight nanocomposites with excellent mechanical performance, including the combination of high toughness, strength and stiffness.

Application

High performance composites are the current state of the art for lightweight mechanical performance. They are widely used in aerospace and sporting goods with increasing interest in the bulk automotive sector. The invention may be applied to a range of high performance fibres, including tows of glass or carbon fibres, prior to resin impregnation.

Intellectual property information

Nacre-like decorated fibre for hierarchical ductile composite is protected by US, European and Japanese patents: US-2020-0239363, EP3555013 and JP2020-505528.

Link to published paper(s)

De Luca F, Menzel R, Blaker JJ, Birkbeck J, Bismarck A, Shaffer MS. Nacre-nanomimetics: Strong, Stiff, and Plastic. ACS Appl Mater Interfaces. 2015 Dec 9;7(48):26783-91. doi: 10.1021/acsami.5b08838. Epub 2015 Nov 30.

Inventor information

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