Multifunctional structural supercapacitors based on vertically aligned graphene nanoflakes grown directly on carbon fibres

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Abstract

There is a strong need in electric-based transportation for structural energy storage systems that are lightweight and simultaneously offer both load bearing and electrochemical energy storage capabilities in a single multifunctional platform. These are emerging technologies for modern air and ground transportation vehicles, promising considerable mass and volume savings over traditional systems.

To this end, carbon fibre reinforced composites have attracted interest for structural supercapacitors, emanating principally from their similar laminate design. To create a structural supercapacitor, three multifunctional components are required: a structural reinforcement/electrode, a structural electrolyte and a structural separator. Due to their excellent mechanical properties so far efforts have been focused on carbon fibre electrodes. However, carbon fibre (CF) electrodes suffer from poor electrochemical storage performance, as they exhibit a surface area that is near 10000 lower than state-of-the art nanomaterials for conventional supercapacitors. On the other hand the separator and electrolyte/matrix play also important roles on the construction of the supercapacitor. Overall, currently, there exists a significant performance gap, in terms of storing performance, between currently available structural supercapacitors and conventional supercapacitor technologies.

To tackle this deficiency carbon fibre electrodes were modified with a 3D network of vertically aligned graphene nanoflakes (GNFs) to enhance their degree of graphitization and active surface area. We have shown[1] that the GNF surface morphology offers a ~9 times increase in specific capacitance (C_{sp}) of control CF structural supercapacitor. Moreover our new strategies induced further improvement on C_{sp} by ~14 times, while almost maintaining the elastic modulus of the control CF based device.

In the talk I will also present recent results on single fibre tensile strength of hybrid fibres[2] and fragmentation tests and provide an overview of the current state of the art of structural energy storage devices. Our findings provide important knowledge for the design of next-generation multifunctional energy storage electrodes by highlighting the importance of interfacial nanoengineering.

References

[1] A. Ganguly, A. Karakassides, J. Benson, S. Hussain, P. Papakonstantinou, "Multifunctional Structural Supercapacitor based on Urea Activated Graphene Nanoflakes Directly Grown on Carbon Fibre Electrodes", 2020, submitted, under review.
[2] A. Karakassides, A. Ganguly , K. Tsirka, A.S. Paipetis, P. Papakonstantinou, "Increased Tensile, Interfacial Strength and Electrical Conductivity in Carbon Composites with Directly Grown Graphene Nanoflakes" 2020, submitted, under review.

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