Graphene-Based Composites: From Nano to Macro Applications

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Abstract
Given its superior mechanical behaviour, combined with exceptional electrical and thermal properties, graphene is the ideal candidate for lightweight, high strength composite materials with several multi-functionalities. Over the last decade, our group has made significant progress in the design and the development of graphene-based composites, thus bringing the full nanoscopic functionality of 2D materials from nano- and microscale into the macroscopic world. These composites typically combine graphene and related materials with polymers to create components or even structures with enhanced properties, which are interesting for a wide range of applications. The talk aims to present our recent progress, opportunities and challenges in this field, including discussion on innovative production and assembly techniques, mechanical performance and other functional properties, real-world applications with examples spanning from strain sensing to EMI shielding.
An important area of our research, for instance, is the development of *ad-hoc* tailored composite architectures, in which the fine control of filler distribution within the matrix allows for full exploitation of graphene properties. In fact, we have demonstrated that the sequential alternation of continuous CVD graphene and ultra-thin polymer layers in the nanolaminate architecture results in the remarkable combination of mechanical reinforcement and multifunctionalities, such as impressive EMI shielding behaviour, thermal conductivity and barrier properties.
The development of lightweight graphene-enhanced fibre composites for use in the aerospace and automotive industry will be also discussed, as key area of focus towards the development of smart and functional components with reduced fuel consumptions and gas emissions. The incorporation of graphene nanosheets in fiber-reinforced polymers can enhance the mechanical properties - such as strength, stiffness, fracture toughness and damping – and offer other functionalities, such as fire retardancy.
We have also developed functional coatings with improved durability and corrosion resistance, and graphene-based sensors that can detect body motion and a wide range of chemicals and gases with high sensitivity and selectivity, making them useful in environmental monitoring and medical diagnostics.
Overall, our research reveals that the incorporation of graphene into various forms of composite materials can add multi-functionality and, in some cases, significantly improve their performance, making them more efficient, durable, at a cost which is not prohibiting for a number of applications. As research in this area continues to advance, it is likely that we will see the development of a wider range of applications in various industries.