Multi-functional CVD graphene/polymer nanolaminates

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Abstract

Graphene has been termed the stiffest and strongest material known to date. Given its superior mechanical behaviour, combined with exceptional electrical and thermal properties, graphene is the ideal material for lightweight, high strength composite materials with several multi-functionalities. So far, only graphene in a form of separated flakes, i.e. nanoplatelets (GNPs), has been adopted for the production of composites for large scale applications. However, the actual mechanical performance of GNP composites are still below the expectations due to the small lateral size of GNPs that results in poor transfer of stresses from the polymer matrix. Other –typical- limitations are due the difficulties of graphene dispersion and flake orientation in order to enhance the mechanical properties of commercial resins. The use of large-size graphene growth via Chemical Vapour Deposition (CVD) can overcome the aforementioned drawbacks by offering (a) large lateral size of continuous graphene and thus efficient stress transfer, (b) uniform and controllable dispersion in the polymer matrix, and (c) controllable mechanical, electrical and thermal properties. The use of CVD graphene as reinforcement in polymer laminates has been recently proposed [1, 2]; however, due to criticalities in manipulating ultra-thin CVD graphene/polymer plies, the maximum graphene content that could be achieved was very small (less than 0.2%). Here, we propose a novel bottom-up approach for the production of macro-scale CVD graphene/polymer nanolaminates based on the combination of ultra-thin polymer casting, wet transfer and floating deposition. By casting ultra-thin polymer films (<50 nm), higher graphene volume fractions can be achieved (up to 0.66%) and the resulting nanolaminates (at the macroscale) have the potential to outperform the current state-of-the-art graphene-based composite materials in both mechanical property and electrical conductivity enhancements (~ 60 S/cm).

References

[1] Vlassiouk I et al., ACS Appl Mater Interfaces 2015;7(20):10702–9.
[2] Liu P et al., Science 2016;353(6297):364–7.

Figures

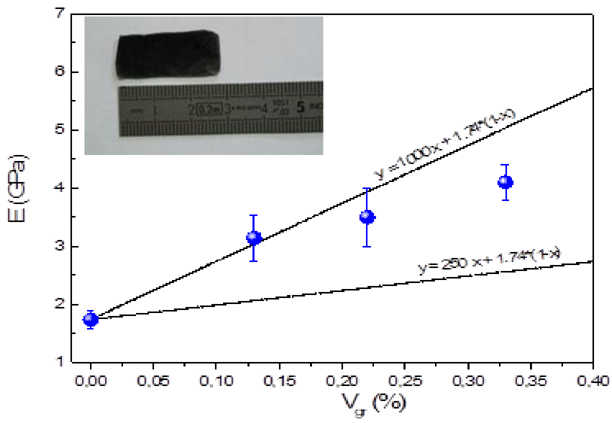

Figure 1: Young modulus of the nanolaminates as a function of graphene content. Inset: Photograph of a produced nanolaminate with 0.66% CVD graphene (b)