Strong and light-weight CVD graphene nanolaminates for highly efficient EMI shielding

Maria Giovanna Pastore Carbone[1]
Christos Pavlou[1], George Trakakis[1], Can Koral[3], Antonello Andreone[3,4], and Costas Galiotis[1,2]

[1]FORTH/ICEHT Patras, Greece,
[2]Dep. of Chemical Engineering, University of Patras, Patras Greece
[3]INFN Naples Unit, I-80126, Naples, Italy
[4]Department of Physics, University of Naples "Federico II", Naples, Italy

*c.galiotis@iceht.forth.gr

Abstract

In the last decade, graphene has attracted considerable interest for the development of light-weight, high strength composite materials with several multi-functionalities owing to its extraordinary material properties [1]: this two-dimensional lattice of sp^2-bonded carbon that is only one-atom thick, exhibits remarkably high electrical conductivity, mechanical and thermal properties. Graphene is also considered a promising material for the development of electrodes, optoelectronic devices, sensors and EMI shielding. To date, only graphene in a form of separated flakes, i.e. nanosheets of graphene oxide (GO), reduced graphene oxide (RGO) and graphene nanoplatelets (GNPs), has been adopted for the production of composites for large scale applications. For these nanocomposites, full exploitation of the extraordinary properties of graphene is very often limited. For instance, the actual mechanical performance of GNP composites is still below the expectations due to the small lateral size of the flakes that results in poor transfer of stresses from the polymer matrix. Other limitations are due the difficulties with dispersion and poor control of flake orientation and thickness, which require high filler loadings for decent electrical and thermal conductivities. The use of large-size graphene growth via Chemical Vapour Deposition (CVD) can overcome the aforementioned drawbacks by offering (i) large lateral size of continuous graphene and thus efficient stress transfer, and (ii) uniform and controllable dispersion in the polymer matrix. Actually, the sequential alternation of the layers consisting of matrix and filler in the nanolaminates can produce highly performant materials with interesting combination of physical properties. The use of CVD graphene as reinforcement in polymer laminates has been recently proposed [2, 3]; however, manipulating ultra-thin film is extremely delicate and high graphene volume fractions could not be achieved.

Here, we propose a novel bottom-up approach for the production of centimetre-size CVD graphene/polymer nanolaminates based on the combination of ultra-thin polymer casting, "lift off-float on" process and wet deposition. By casting ultra-thin polymer films, higher graphene volume fractions can be achieved and the resulting nanolaminates have been found to outperform the current state-of-the-art graphene-based composite materials in both mechanical stiffness, electrical conductivity enhancements (~ 60 S/cm) and specific EMI shielding effectiveness (~ 20000 dB cm^2 g^{-1}).

References

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[3] Liu P et al., Science 2016;353:364–7.

Figures

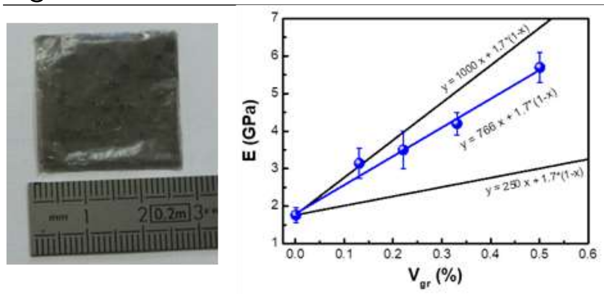

Figure 1: Image of a nanolaminate sample (left) and Young's modulus vs graphene content (right)