**EXTRAORDINARY MECHANICAL AND MULTIFUCTIONAL PROPERTIES OF CVD GRAPHENE/POLYMER NANOLAMINATES**

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**ABSTRACT**

Graphene, with its superior mechanical, electrical and thermal properties, is the perfect candidate as reinforcement in lightweight, high strength composite materials with interesting multi-functionalities. Since now, graphene has been adopted mainly in the form of separate flakes (e.g. GNPs) for the production of large-scale composites. Nonetheless, the overall physical performance (e.g. mechanical, electrical and thermal properties) of graphene-flake reinforced composites may be far below the expectations and this has been attributed to the small lateral size of the particles that leads to inefficient stress transfer with the polymer matrix [[1](#_ENREF_1)] . An alternative way to overcome this issue is represented by the incorporation of large size CVD graphene sheets in polymer laminates. In this work, by the use of an iterative “lift-off/float-on” fabrication process, it was possible to produce macroscale nanolaminates in a wide range of graphene volume fractions with the prospect to surpass the current state-of-the-art graphene-based composite materials in both mechanical properties, electrical conductivity and other multi-functionalities (e.g. thermal conductivity, EMI shielding, Joule heating) [[2](#_ENREF_2), [3](#_ENREF_3)]. Freestanding graphene/poly (methyl methacrylate) (Gr/PMMA) nanolaminates have been produced with layer numbers ranging from 10 to 100 and volume fractions of 0.044 to 1%. Uniaxial tensile tests have highlighted the effective reinforcement provided by graphene in the nanolaminate configuration, with effective contribution in both the Young’s modulus (with increase up to 250%) and the ultimate strength (up to 100%) of the produced Gr/PMMA nanolaminates. A systematic characterization of physical properties of the produced Gr/PMMA nanolaminates has been carried out and has highlighted excellent behavior in both electrical and thermal conduction. In fact, the in-plane electrical conductivity has been found to increases with graphene content up to 25000 S/m for 1% vol in graphene, and the in-plane thermal conductivity can achieve values of 10 W/mK for the same graphene content. Furthermore, other impressive multifunctionalities have been observed for the produced systems, such as a record EMI shielding behavior in the THz range and Joule heating phenomena.

**KEYWORDS:** Graphene, Nanolaminates, Multifuctional, Nanocomposites, EMI shielding

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