Graphene potentialities for space and defense applications: focus on mechanical properties

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The promising properties of graphene have motivated considerable research effort in recent years [1]. Surprisingly, the potential advantages offered by the technology based on graphene structures extend to a great variety of physical phenomena, including those affecting to electrical, optical, magnetic, thermal, chemical and mechanical properties. In some cases, the parameters predicted and measured have reached even the highest values reported for any known material (e.g., the highest carrier mobility at room temperature or the greater strength). However, much work must still be carried out to bring the inherent advantages of graphene to practical applications. Such work comprises the development of an efficient method to synthesize graphene in the proper form for each desired application without degrading its intrinsic properties. Further steps should also ensure the suitability of other technological aspects such as the compatibility with device-oriented fabrication processes, the scalability or the affordability.

Here we provide a comprehensive overview of the potential uses of graphene-based devices and components for space and defense sectors. Basically, funded programmes have promoted next generation electronics and fundamental research topics. The development of future radio-frequency (RF) electronics is of paramount importance to improve the ever more demanding systems, especially taking into account the difficulty to maintain the historical trend predicted by Moore's law with traditional Si-based electronics. In addition to the more conventional approach of improving performance parameters of active devices, new functionalities or uses, such as those derived from the ambipolar nature of graphene or the possibility to achieve low-resistivity interconnects, respectively, have also been proposed [2]. Nevertheless, the benefits explored have not only been restricted to the utilization of graphene's superb electrical properties. Graphene has also been studied as building block of metamaterials and plasmonic components, as well as for transparent conductors, and high-speed electro-optical modulators and photodetectors [3]. Another remarkable areas which deserve attention in the present work are sensors and coatings (e.g., for inflatable structures or impermeable membranes) [4],[5]. In all cases, the success of graphene-based devices will depend on whether this material can lead to substantial improvement over competing technologies.

The case of mechanical properties and the corresponding applications will be discussed in further detail. Three topics, namely, piezoelectricity (both engineered by chemical modification of the surface or introducing stressor structures), graphene papers and graphene composite materials, will be addressed [6],[7]. The analysis performed for the later structures will be focused on determining their effective Young's modulus, intrinsic strains and failure strains, as well as the proper parameters to account for the interlayer and intralayer bond strengths. It is worth noting that graphene composites could be exploited to enhance the macroscopic properties of the matrix material. Therefore, other macroscopic behaviours such as those due to the impact resistance will be assessed for suitable structures. The applications considered regarding mechanical properties will include the use of graphene as filler material, the control of mechanical motion, energy harvesting and sensors (e.g., resonator-based mass sensors).

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