

A continuous 3D-graphene network to overcome threshold issues and contact resistance in thermally conductive graphene nanocomposites

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Increasing thermal conductivity of polymers is a common goal in a wide range of applications usually achieved through dispersion and distribution of a conductive filler inside the matrix [1].

This approach however present some drawbacks related to the particle-to-particle contact resistance and to the percolation threshold.

This work focus on a smart way to overcome those issues by creating percolation and contact between conductive fillers beforehand the creation of the composite.

In particular we synthesized self-standing graphene aerogels to create a conductive preferential pathway through which phonons and electrons can move easily. Then we proceeded with the liquid infiltration of the mixture of a monomer and curing agent, that undergoes cross-linking to form the final graphene nanocomposite with enhanced transport properties.

Regarding graphene aerogels much work has been done [2,3] and in literature it is possible to find many papers regarding the formation and engineering of aerogels.

The synthesis can belong roughly to two types, the hydrothermal synthesis and the ice-template synthesis [4].

Following the first approach it is possible to obtain a more isotropic structure, as reported in Fig.1, in which the graphene walls are randomly oriented.

Following the second one we can instead obtain an anisotropic structure, in which the graphene walls are preferentially disposed, as we can see on Fig.2.

In both cases it is possible to tune the porosity of the structure (as we can see in Fig.1) leading to a different relative density of the aerogel, and thus to a different amount of filler inside the final composite material.

A scheme of the synthesis that was used to create the aerogel is reported on Fig.3

The synthesis started from a graphene oxide solution, from which the aerogel was formed following either the hydrothermal synthesis or the ice-templated one. Then, a thermal or chemical reduction was performed to remove the residual oxygen present on the graphene surface, since it is highly detrimental both for thermal and electrical conductivity.

The produced aerogels were then infiltrated with an epoxy resin to obtain the final composites.

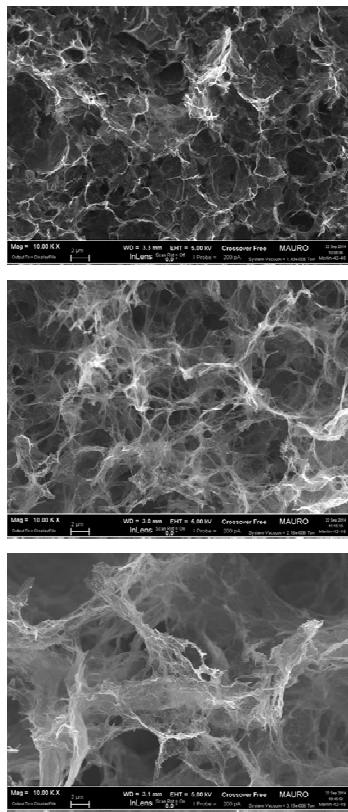
The thermal conductivity of the composites was then evaluated. With less than 1 wt.% of graphene, the thermal conductivity of the polymeric resin was increased from 0,30 to 0,54 $\text{Wm}^{-1}\text{K}^{-1}$, suggesting that this technique is a valid route to reduce the dispersion issues that currently reduce substantially the thermal performance of graphene-based composites.

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Increasing porosity

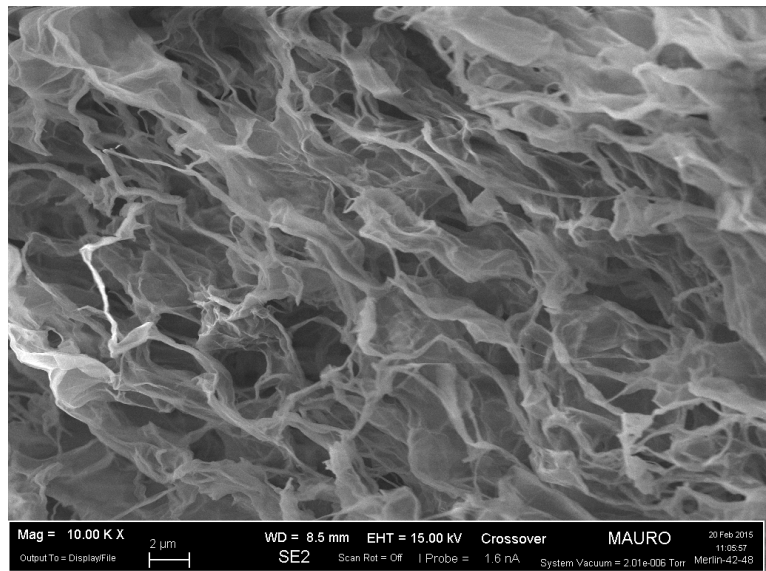


Figure 2: Anisotropic graphene aerogel

Figure 1: Isotropic graphene aerogels with increasing porosity

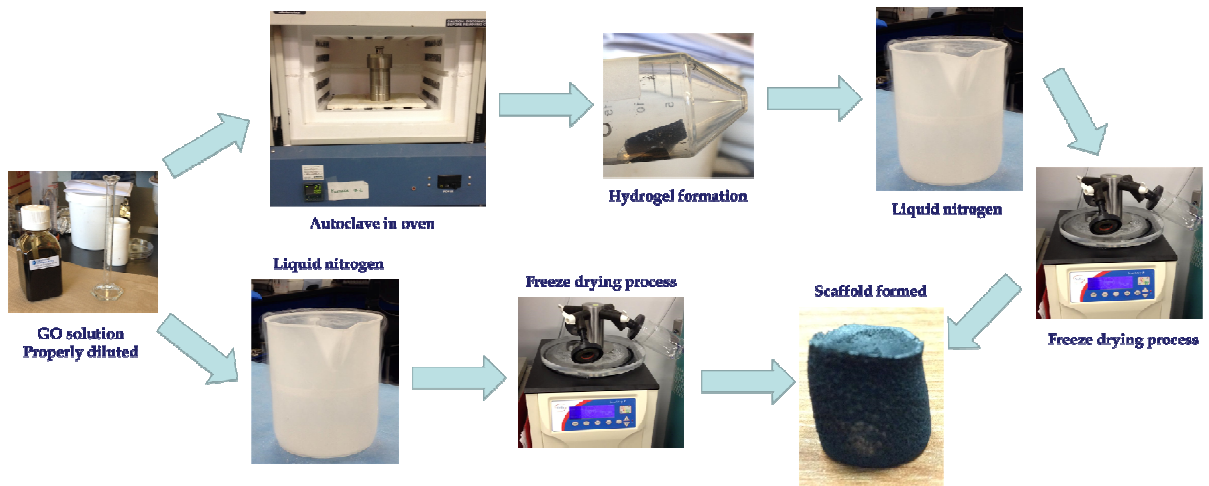


Figure 3: Scheme of the synthesis of an aerogel