Size-controlled functional graphene foams for applications in energy storage and piezoresistive sensing

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Abstract
3D graphene materials have attracted a lot of interest due to their ability to transfer many of the unique properties of 2D graphene to a larger scale, with high surface area, high electrical conductivity, and good structural integrity. Good quality graphene may be grown on templates of virtually any shape by Chemical Vapour Deposition (CVD), and in this way free-standing macrostructures called graphene foams (GF) were first produced from nickel foam templates in 2011 [1]. Since then there have been many investigations into their use either alone or in composites with other materials in applications such as electrodes for supercapacitors [2] and batteries [3], gas sensors [4] and adsorbents [5].

We present the promising preliminary results of two different applications that we are exploring for graphene foams. In the first, they are electrochemically functionalised with iron hydroxide, which is subsequently heated to produce flower-like iron (III) oxide nanocrystals completely covering the surface (Figure 1). The resulting composites show great potential for use in electrodes for Li-ion coin cell batteries. In the second application, graphene foams are coated with a thin layer of polyelastomer (PDMS) to improve their flexibility and strain recoverability, so that they can be used in piesoresistive pressure sensors for real-time monitoring of body signals.

In addition, we propose that the functional potential of graphene foams can be further improved by reducing the pore size from the 200-400 μm range typical of commercially available metal foam templates. We demonstrate a new technique to reach a pore size range of 1-10 μm using networks of nanoparticles as the templates for graphene growth, which significantly increases the graphene surface area available in a given volume (Figure 2).

References
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Figures

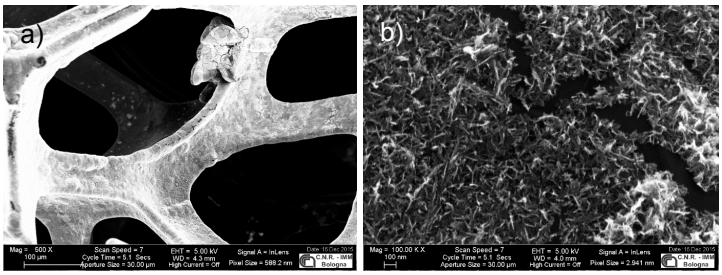

Figure 1. SEM images of functionalised graphene foams at increasing magnification, showing a) the porous structure and b) flower-like Fe_2O_3 nanocrystals on the surface

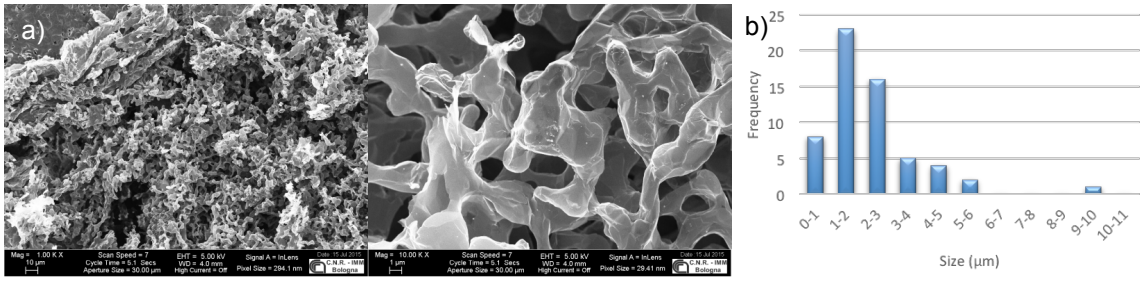

Figure 2. a) SEM images of graphene foams from sintered Ni nanoparticle templates at increasing magnification and b) corresponding pore size distribution