Graphene for energy storage

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Due to its excellent mechanical, thermal, optical and electrical properties, graphene has recently attracted increasing attention. It provides a huge surface area (2630 m^2 g^{-1}) and high electrical conductivity, making it an attractive material for applications in energy-storage systems. Graphene-based supercapacitors and batteries are expected to provide increased energy and power performance, long cycle life and low maintenance cost, and thus contribute to electric transport and portable electronics. In fact, the energy-storage market is the one in which graphene is expected to provide more benefits in the short term.

Graphene can be prepared by several techniques, aiming to improve the specific surface and the electrical properties. Chemical routes based on oxidation-reduction processes of graphite or other carbon sources are commonly used to obtain graphene oxide with controllable oxygen content. Also, plasma-enhanced chemical vapor deposition (PE-CVD) using metal foils or films, such as Cu or Ni, has demonstrated very good results for high quality few-layer 2D graphene, even at low growth temperatures. To fabricate electrodes for supercapacitors or batteries, however, 3D graphene structures are mandatory to increase the capacitance and thus the energy density. A Ni foam acts as a catalytic metallic mesh to grow the graphene coating. Raman spectroscopy indicates that the deposited graphene layer is several nm thick, which satisfies a trade-off between the mass and the electrical properties. Once the metal is removed, some functionalisation by polymers, oxide nanoparticles or other additives is required to increase the specific surface, and therefore the energy density.

Supercapacitor cells have been designed to increase the reliability of the electrochemical measurements, which are performed by means of a potentiostat / galvanostat equipment. State-of-the-art specific capacitances up to 900 Fg^{-1} have already been achieved. These results show the potential of graphene for the development of energy-storage devices and their application to hybrid, plug-in and full electric vehicles.

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