3D graphene supercapacitor for energy applications

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Abstract

Due to its excellent mechanical, optical and electrical properties, graphene a 2D *sp* 2 -hybridized carbon sheet with one-atom thickness, has attracted increasing attention in recent years [1]. Its high theoretical surface area (2630 m^2 g^{-1}) and high electrical conductivity make it an attractive material for applications in energy-storage systems [2]. Considering this facts, the fabrication of a supercapacitor with graphene will provide an energy storage device with high power performance, long life cycle and low maintenance cost [3].

Graphene can be prepared by several techniques: mechanical exfoliation from graphite, precipitation on a silicon carbide surface, reduction of exfoliated graphene oxide, and chemical vapor deposition (CVD) growth on Cu or Ni. One of the most used is CVD, and the synthesized graphene is commonly grown on a flat metal foil or thin film. This method provides high quality graphene, but the amount of energy than can be stored in a monolayer is quite small. In order to solve that problem, it is necessary to use 3D graphene structures.

A commercial Ni foam was used as a catalytic metallic mesh to growth graphene by plasma-enhanced CVD (PECVD). Analyzing the sample by Raman spectroscopy, one can observe that the graphene has a few number of monolayers. In a posterior step, the Ni template was removed immersing the sample in HCl acid during several hours. The graphene foam obtained was characterized by scanning electron microscopy (SEM) showing similar morphology than the original foam. This graphene foam can be used as an electrode in a supercapacitor device.

A home-made supercapacitor cell was built in polypropylene with two stainless steel collectors (Fig. 1). Two 3D graphene foam discs were inserted inside the cell with a separator in the middle. This sandwich structure was dipped in a 1 mol L^{-1} KOH aqueous solution that acts as the electrolyte. The two collectors of the supercapacitor cell were connected to a potentiostat/galvanostat equipment. The electrochemical measurements are plotted in Figure 2. In this graph one can observe the charge and discharge of the 3D graphene supercapacitor. The specific capacitance of this device is 2 F g^{-1}, but further capacitance values can be reached by using several additives, like metal oxide nanoparticles or carbon nanotubes.

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References

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Figures

Figure 1. Picture of the graphene supercapacitor cell

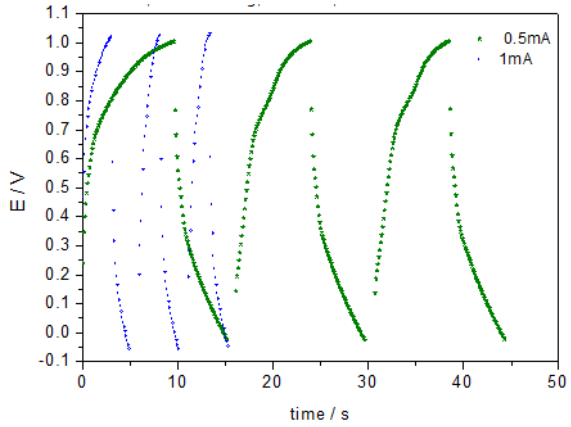

Figure 2. Charge/discharge cycles in the graphene supercapacitor cell at 0.5 mA and 1 mA.