Fabrication and applications of 3D graphene materials

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There are great challenges of how to realize large-scale fabrication of high-quality graphene structures and large-size single crystal graphene domains, which are essential for mass applications and device applications. In recent two years, in order to obtain graphene in a relatively large quantity by chemical vapor deposition, we tried to use Ni particles [1] and Ni foams [2] as substrates. Interestingly, with a Ni foam as template, a three-dimensional (3D) graphene macrostructure, which we called graphene foam (GF), has been synthesized [2]. This porous graphene bulk material consists of an interconnected network of graphene, is flexible, and has outstanding electrical and mechanical properties. And it can be used in elastic conductors [2], sensors [3], flexible lithium ion batteries [4], and electromagnetic interference fielding materials [5]. Using this unique network structure and the outstanding electrical and mechanical properties of GFs, we demonstrate the great potential of GF/PDMS composites for flexible, foldable and stretchable conductors, and parts-per-million level detection of NH_3 and NO_2 in air at room-temperature by this GF, which can also rival the durability and affordability of traditional sensors. By using GF as a current collector, loaded with $Li_4Ti_5O_{12}$ and $LiFePO_4$, for use as anode and cathode, respectively, we fabricated a thin, lightweight, and flexible full lithium ion battery, with a high-rate performance and energy density that can be repeatedly bent to a radius of 5 mm without structural failure and performance loss. Finally, we prepared an ultra-lightweight and graphene-based foam composite with high EMI shielding performance and the graphene/PDMS foam composite shows excellent flexibility, and its shielding effectiveness is almost unchanged after repeatedly being bent to a radius of ~2.5 mm for 10,000 times.

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1. Z. P. Chen, et al, Bulk growth of mono- to few-layer graphene on nickel particles by chemical vapor deposition from methane, ***Carbon*** 48 (12), 2010, p.3543-3550.
2. Z. P. Chen, et al, Three-dimensional flexible and conductive interconnected graphene networks grown by chemical vapour deposition, ***Nature Materials*** 10, 2011, p. 424-428.
3. F. Yavari, Z. P. Chen, et al, High senstitivity gas dection using a macroscopic three-dimensional graphene network, ***Scientific Reports*** 1 166 2011, DOI: 10.1038/srep00166.
4. N. Li, et al, Lightweight and flexible graphene-based lithium ion batteries with ultrafast charge and discharge rates, ***PNAS***, 109 (43), 2012, 17360-17365.
5. Z. P. Chen, et al, Lightweight and flexible graphene foam composites for high-performance electromagnetic interference shielding, ***Adv Mater*** 2013, in press.