Scientists synthesize 3D graphene films with high-energy E-beam

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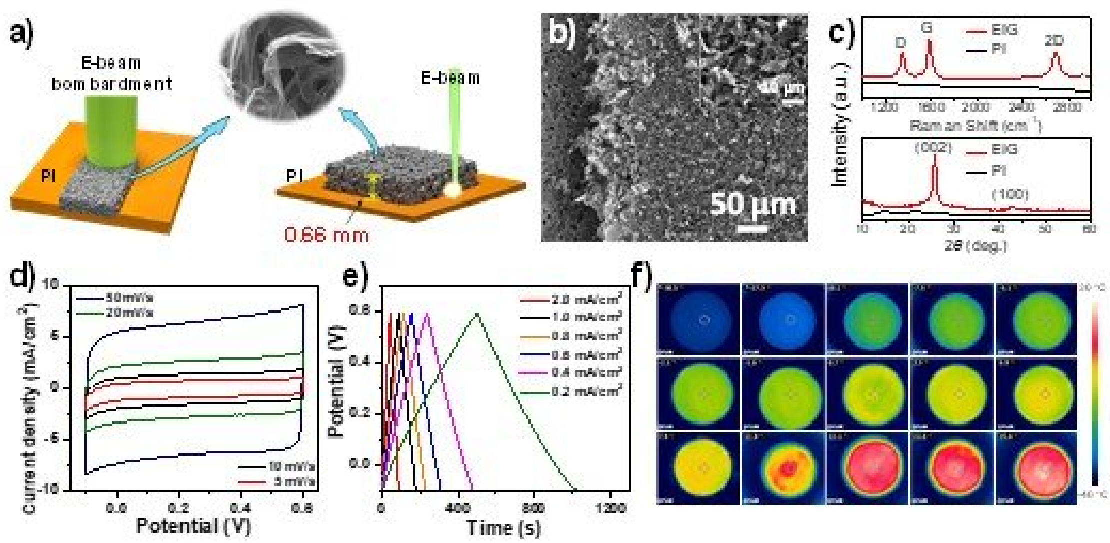

(a) A schematic diagram of the process of e-beam bombardment to induce graphene on polyimide; (b) SEM image of EIG; (c) Raman spectra (above) and XRD spectra (below) of EIG and polyimide film. (d) The CV curves at different scan rates of EIG electrode; (e) The GCD diagrams at different current densities of EIG electrode; (f) Photothermal performance of EIG materials at -40 °C. Credit: Li Nian

Recently, Prof. Wang Zhenyang's research group from the Hefei Institutes of Physical Science (HFIPS) of the Chinese Academy of Sciences (CAS) has prepared macroscopic thick three-dimensional (3D) porous graphene films.

Using a high-energy electron beam as the energy source and taking advantages of the high kinetic energy and low reflection characteristics of e-beam, the researchers directly induced polyimide precursor into a 3D porous graphene crystal film with a thickness of up to 0.66 mm. Related research results were published in the journal *Carbon*.

Graphene has proven to be a new strategic material owing to its numerous exceptional chemical and physical properties. Integrating a dimensional (3D) porous graphene network can prevent restacking of graphene sheets and enables easy access and diffusion of ions. However, efficient synthesis of macroscopic thick 3D porous graphene films is still a challenge.

The high instantaneous energy of a laser can induce the direct carbonization of the carbon-containing matrix to form high crystalline quality graphene. But the penetration depth of the laser into the carbon-containing matrix is quite low, resulting in insufficient thickness of the prepared graphene film, which limits its application in actual devices. Therefore, exploring a more effective energy source is a key problem that needs to be solved urgently for the industrial application of high-energy beam-induced graphene.

In this research, the researchers used a high-energy e-beam as a new energy source to realize efficient preparation of macroscopic thick 3D porous graphene crystal films on the polyimide precursor.

Compared with lasers, high-energy e-beams possess lots of advantages including zero reflection, high kinetic energy, injection effect, and simple focus control, making the e-beam a better energy source to quickly induce carbonization of polyimide precursors to produce graphene.

Hydrogen, oxygen and some other components in polyimide can rapidly escape in the form of gas, resulting in an abundant 3D pore structure of graphene.

This study exhibits that the thickness of e-beam-induced graphene (EIG) film is as high as 0.66 mm, and the synthesis rate is 84 cm^2/min, which is significantly larger than that offered by a laser. Furthermore, EIG has been successfully applied to the field of supercapacitor electrodes, which shows excellent electrochemical storage capacity.

With prominent photothermal performance, EIG can also be applied to the field of solar photothermal anti-icing and deicing. The temperatures can be -40 °C, which is considered ultra-low.

More information: Shuai Han et al, E-beam direct synthesis of macroscopic thick 3D porous graphene films, *Carbon* (2021). DOI: 10.1016/j.carbon.2021.06.035

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