Fall 5-10-2015

Three-dimensional printing of graphene-based composite aerogels

Chen Zhu

Three-dimensional printing of graphene-based composite aerogels

Graphene-based composite materials have found wide applications in nanoelectronics, sensors, catalysis, energy storage, and biomedicine areas for their unique combination of low density, exceptional mechanical properties, large surface area, and excellent electrical conductivity. Recent progress has produced bulk 3D assemblies of graphene, such as graphene aerogels, by the self-assembly or gelation of the graphene oxide (GO) suspension via hydrothermal reduction, chemical reduction, or direct crosslinking of the GO sheets. Other templating methods like chemical vapor deposition (CVD) coatings and freeze-casting have already been employed to control over the pore morphology of 3D graphene monoliths. However, the architecture of these graphene networks remains largely random, precluding the ability to tailor transport and other physical properties of the material, which limit their performance compared to the potential of an engineered architecture. Here, we report the fabrication of periodic graphene aerogel mesostructures, possessing an engineered architecture via a 3D printing technique known as Direct Ink Writing. The 3D printed graphene aerogels are lightweight, highly conductive and exhibit super-compressibility (up to 90% compressive strain). Moreover, the Young's moduli of the 3D printed graphene aerogels show an order of magnitude improvement over bulk graphene materials with comparable geometric density and possess large surface areas. Adapting the 3D printing technique to graphene aerogels realizes the possibility of fabricating a myriad of complex aerogel architectures for a broad range of applications.

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

IM release number: LLNL-ABS-670331