Fabrication of Graphene Materials and Their Composite Applications

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Graphene is a single-atom-thick sheet of hexagonally arranged, sp^2-bonded carbon atoms that is not an integral part of a carbon material but is freely suspended or adhered on a foreign substrate, and has excellent properties, such as high mechanical strength and modulus, high thermal and electrical conductivities, very stable thermal and chemical stabilities, and unique electronic properties. Graphene materials, overarching terms for the collection of two-dimensional materials that contain the word “graphene”, including multilayered materials (N less than about 10), chemically modified forms (graphene oxide, reduced graphene oxide), and materials made from graphene precursors, are expected for various applications, including making composite materials.

In order to use graphene materials in composite materials, synthesis of graphene materials in a large quantity at reasonable costs is very important. Chemical exfoliation of natural graphite and chemical vapor deposition of hydrocarbons are the most-popularly-used two methods. We have developed intercalation-expansion-liquid phase exfoliation and electrochemical exfoliation processes for producing graphene materials in suspension or powder states. The graphene materials obtained have wide applications in composites, anti-corrosion coatings, conductive inks, etc. CVD can be used to obtain graphene materials with high quality, and large-area graphene thin films can be easily prepared. In particular, we proposed to use Ni particles and Ni foams as templated substrates. For example, with Ni foam as a template, a 3D graphene macrostructure, which is called graphene foam (GF), can be synthesized. This porous graphene bulk material consists of an interconnected network of graphene, is flexible, and has outstanding electrical and mechanical properties.

By incorporating with various polymeric, ceramic or metallic matrixes, various composite materials with high mechanical performance and multi-functionalities can be fabricated. Graphene composite materials are promising structural and multifunctional materials with significantly improved tensile strength and elastic modulus, electrical and thermal conductivity, and thermal stability, etc. These graphene-based composite materials may have great potential for use in many fields, from electronics to energy field, and from transportation to space as low-weight structural materials, thermal interface materials, electrically conductive materials, flexible electric components, etc., due to their outstanding multiple properties and the availability of graphene materials in large quantity and at low cost.

Many factors, including the type of graphene materials used and their intrinsic properties, the dispersion state and alignment of graphene in matrixes, the interfacial interactions between graphene and matrixes, and the network structure and macroscopic morphologies of graphene materials in matrixes, can affect the properties and applications of graphene composite materials obtained. The critical challenges faced by graphene composite materials lie in (a) how to prepare structure-controlled graphene materials with identical geometry as well as consistent and dependable high performance, (b) how to fabricate composite materials with a uniformly dispersed and controlled spatial distribution of graphene, (c) how to achieve suitable interfacial interactions between graphene materials and matrixes.

Two-dimensional graphene materials have provided a wide range of alternatives for the production of light-weight, low-cost and high-performance composite materials for various applications, and bring significant opportunities and challenges to basic science to applied technologies in the composite field.

Biography

Dr. Hui-Ming Cheng is Professor and Director of both *Advanced Carbon Research Division* of Shenyang National Laboratory for Materials Science, Institute of Metal Research, the Chinese Academy of Sciences, and the *Low-Dimensional Material and Device Laboratory* of the Tsinghua-Berkeley Shenzhen Institute, Tsinghua Univ.. His research activities focus on carbon nanotubes, graphene, other low-dimensional materials, energy storage materials, photocatalytic semiconducting materials, and bulk carbon materials. He has published over 500 papers and is recognized as a Highly Cited Researcher in both materials science and chemistry fields by Thomson Reuters. He used to be the Editor of *Carbon* and Editor-in-Chief of *New Carbon Materials,* and is now the founding Editor-in-Chief of *Energy Storage Materials* and Associate Editor of *Science China Materials*.