Abstract

Graphene and 2D Materials: Fabrication and Applications

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Graphene and other 2D materials have unique properties and is expected for various applications. But there are challenges of how to realize large-scale fabrication of high-quality graphene and other 2D materials.

First, we developed a green electrochemical exfoliation process to produce graphene materials with high quality and in large quantity. Second, we developed an ambient pressure CVD to synthesize single crystal graphene grains and films. Moreover, we invented an electrochemical bubbling method to transfer these grains and films. Large area and continuous graphene transparent conductive films are produced by an integrated R2R process of CVD and bubbling transfer. Third, we have developed a template-directed CVD. With Ni foam as template, a 3D graphene macrostructure, so-called graphene foam (GF), has been synthesized.

Both CVD and exfoliation are also powerful methods to obtain other 2D materials such as transition metal disulfides and h-BN. For example, we developed a grinding exfoliation technology with the assistance of intermediaries for efficient exfoliation of layered materials. This method can be used for mass production of many 2D materials, such as h-BN, black phosphorus, and MoS\textsubscript{2}, with very high yield and high efficiency. By using CVD, we have grown high quality monolayer WS\textsubscript{2} and W\textsubscript{Se}2 single crystals and films, ultrathin carbide crystals, and a new 2D material of MoSi2N4, which show excellent physical properties.

Finally, these graphene and 2D materials can be used in energy storage, composites, thermal management, and opto/electronic applications.