Production and Applications of High Quality Graphene Flakes and 2D Monolayers

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Abstract

Single- and few-layer graphene films are promising for immediate applications such as heat dissipation for electronic devices. One of the most urgent issues is to develop a scalable method for producing high quality graphene flakes. A highly efficient method to produce high quality graphene flakes based on electrochemical method has been developed.[1] This technology produces a new class of graphene with very active electrochemical performance, which is very different from those obtained by other methods such as mechanical or chemical exfoliation.[2] This type of graphene is perfect as a conducting support for catalytic reaction as well as the heat conduction components.

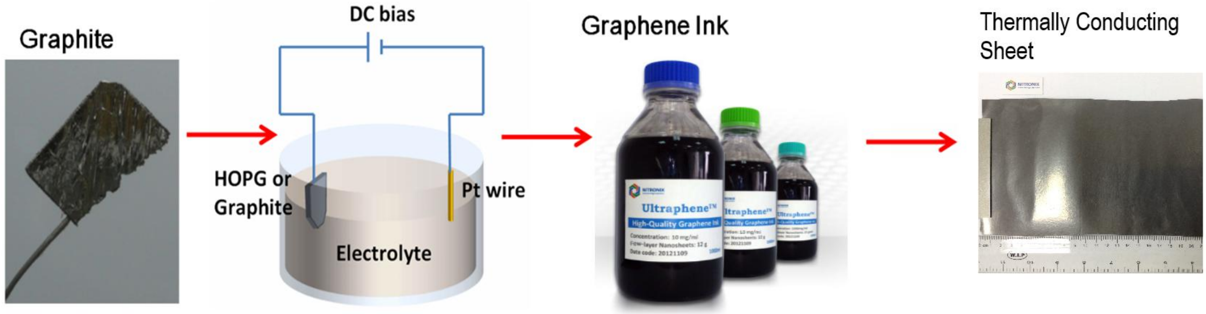

Figure 1. Schematic illustration of graphene flake and ink production. The electrically and thermally conducting films can be made by graphene inks.

Although graphene films may be are promising for post-silicon electronics due to their high carrier mobility and excellent stability, the lack of energy band gap issue still hinders their applications in electronics. Hence, other 2D materials such as MoS2 and WSe2 with a direct-gap are attractive for optoelectronics, energy harvesting and even for transistors.[3] Here I would like to discuss the synthetic approach to obtain MoS_2 (WSe_2, $MoSe_2$ and WS_2) monolayers directly on arbitrary insulating substrates using vapor phase reaction between metal oxides and S or Se powders.[4,5] The bandgap tunable monolayer alloy such as MoS_xSe_y or WS_xSe_y can be successfully obtained by the replacement reaction between Se and S. These layer materials can be transferred to desired substrates, making them suitable building blocks for constructing multilayer stacking structures, which never exist in nature and may exhibit unique and unexplored physical properties.

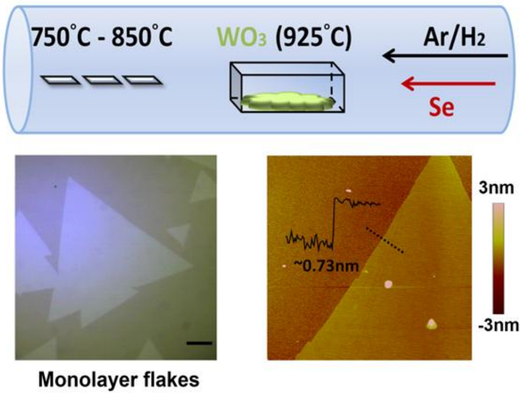

Figure 2. Schematic illustration of the growth of WSe_2 single crystalline flakes using chemical vapor deposition methods.

The 2D emiconducting material molybdenum disulfide (MoS_2) is also known as light- sensitive. Here we show that a large-area and continuous MoS_2 monolayer is achievable using a chemical vapor deposition method and graphene is transferable onto MoS_2. The significance of charge movement in the emerging field of 2D heterostructures, and the charge distribution strongly affects the properties of the 2D heterostructures. We demonstrate that a photodetector based on the graphene/MoS_2 heterostructure is able to provide a high photogain greater than 10^8.

References

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