Semiconducting and Metallic nanosheets: Two dimensional electronic and mechanical materials

Informe

Información del proyecto

SEMANTICS

Identificador del acuerdo de subvención: 258616

Proyecto cerrado

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€ 1 405 632,60

Coordinado por
THE PROVOST, FELLOWS, FOUNDATION SCHOLARS & THE OTHER MEMBERS OF BOARD, OF THE COLLEGE OF THE HOLY & UNDIVIDED TRINITY OF QUEEN ELIZABETH NEAR DUBLIN
Ireland

Final Report Summary - SEMANTICS (Semiconducting and Metallic nanosheets: Two dimensional electronic and mechanical materials)

In 2009, graphene was the king of the nano-materials world. This single atom thick, 2-dimensional (2D) material was known to have unique electrical and mechanical properties and was the most exciting nano-material around. For five years researchers had studied it in great detail, learned to make it a number of ways and were beginning to demonstrate its potential in real applications. Some researchers were aware that other 2D materials existed but most didn't pursue this alternative line of research, perhaps because such materials couldn't be made in large quantities. In any case, graphene was the only game in town, wasn't it?

Around this time, Jonathan Coleman, a professor in Trinity College Dublin, had developed a method for producing good quality graphene in reasonably large quantities. This method, called liquid phase exfoliation (LPE), worked well but was just one of many graphene production methods. However, Coleman knew that there was nothing about LPE that was particular to graphene. In fact, in theory it should exfoliate any layered material. Could theory be put into practise?

This was the context of the ERC-funded SEMANTICS proposal which Coleman applied for in 2009 and was granted in 2010. The aim of this project was to develop methods to use LPE to exfoliate some of the hundreds of inorganic layered materials which are known to exist to generate a broad spectrum of 2D materials beyond graphene. This work was particularly promising from an applied science standpoint as each 2D material was expected to have different properties giving a palate of materials which could potentially be useful in a range of applications. As a result, the project also aimed to develop methods to form the nanosheets into useful structures and to test them in a number of applications.

SEMANTICS was one of the first projects to systematically study 2D materials beyond graphene and has been extremely successful. It has met all its goals, demonstrating the exfoliation of a wide range of new 2D materials, as well as testing methods to process these materials into structures and proving their worth in applications from battery electrodes to photodetectors.

The first paper published under SEMANTICS demonstrated proof of concept that inorganic nanosheets could be produced by LPE and appeared in the high impact international journal, Science. This was followed by a host of papers describing the exfoliation of exotic compounds with names like WSe_2, MoO_3 and black phosphorous. Importantly, the SEMANTICS team were able to demonstrate good degree of control over the nanosheets they produced, enabled by methodologies to easily measure the properties of the nanosheets. This ability to control what they were producing allowed the team to develop methods such as inkjet printing to deposit nanosheets into films and structures on demand. This in turn allows the production of printed photocells from combinations of graphene and MoS_2, the first all-printed, all nanosheet electronic device. In addition, the researchers found they could mix BN nanosheets with polymers to give composites that were strong, stiff and impermeable to gasses. In addition, by mixing nanosheets and another well-known nanomaterial, carbon nanotubes, Coleman's group could produce

functional composites which performed extremely well as battery electrodes.

Although SEMANTICS has now come to an end, it has left an indelible legacy. It has paved the way for researchers around the world to produce nanosheets, cheaply and easily in their own labs. With new types of nanosheets and new applications appearing monthly, who says graphene is king?

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