SIMPLANT: Synthesis of few layered transition metal dichalcogenides by ion implantation

Main area: BSR01_Synthesis and characterization of LMs beyond graphene
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Abstract

The SIMPLANT project is dedicated to the controlled synthesis of transition metal dichalcogenide (TMDC) materials by ion implantation. This 24 months duration project brings together 4 academic laboratories and an industrial one, namely (i) CNRS-Ecole polytechnique from France, (ii) Instituut voor Kern- en Stralingsfysica (IKS) and (iii) Vaste-stoffysica en Magnetisme (VSM), both from KU Leuven, Belgium, (iv) Fritz Haber Institute from Germany, as well as (v) Thales Research & Technology, from France. The project will be coordinated by D. Pribat from CNRS-Ecole Polytechnique.The general objective of the project is to develop a large-scale technique for the uniform synthesis of TMDCs with a controlled number of unit layers (say from 1 to 5), using ion implantation, followed by an appropriate annealing at high temperature. Essentially 2 approaches will be studied, namely (i) the implantation of the chalcogen ion into epitaxial thin films of the transition metals and (ii) the co-implantation of both the chalcogen and metal ions into a neutral substrate, preferably monocrystalline (sapphire, MgO …), both followed by an annealing sequence in the 650-850 °C range. Two representative semiconductor TMDCs have been chosen for the project: MoS2 and WS2.Our preliminary experiments, using 10 nm-thick, small grain polycrystalline Mo films deposited on oxidized Si substrates and ion implanted with a fluence of 2.5 x 1015 sulfur atoms/cm2 have demonstrated the formation of MoS2 when the post-implantation annealing was performed in a vacuum-sealed quartz ampoule at 750 °C during 1 hour. However, even though the Raman signal was found uniform over the 1 cm2 sample, the crystalline orientation of the MoS2 layers was random, so that monocrystalline metal films and substrates will be needed in the future, in order to get epitaxial growth of the TMDC layers upon annealing.The project is built around 5 workpackages; WP1 for substrate preparation (including transition metal epitaxial deposition) and ion implantation; WP2 for the detailed study of post-implantation annealing, including in situ observations using x-ray photoelectron spectroscopy (XPS); WP3 for the physical characterizations of the synthesized TMDC materials, using Raman spectroscopy, angle resolved photoelectron spectroscopy (ARPES), XPS with different photon energies to measure depth profiles, photoluminescence (PL), high resolution transmission electron microscopy (HR-TEM), scanning tunnelling microscopy and spectroscopy (STM and STS); WP4 for the (opto)electronic characterizations using field-effect transistor structures and WP5 for the project management and the exploitation of the results.Because we have already made preliminary experiments showing the feasibility of the process that we propose, the risk should be low. The anticipated outcome of the project is a high throughput, uniform and large scale method for the synthesis of TMDCs with their thickness controlled between 1 and 5 unit layers.

Consortium

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