GRAPH-EYE: In situ, non-invasive quality control of crystalline quality of GRMs via non-linear optical properties imaging

Main area: ARI01_In-situ and ex-situ quality control of GRMs
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Abstract

The emerging family of Graphene and related materials (GRMs), have provided researchers a fertile ground for exploring fundamental phenomena and developing innovative technology. However, GRMs can contain numerous structural defectswhich significantly alter their physico-chemical properties.1 This is certainly an undesirable characteristic towards emerging applications, for which large-scale production of high purity materials is essential. Therefore, it is timely to develop techniques to quickly monitor in-situ the quality of these materials and provide feedback for process control of material synthesis.In this project, we propose a fast, in-situ, super-resolution non-linear optical method for the quality control of as- grown GRMs and their heterostructures. Polarized Second Harmonic Generation (PSHG) imaging will reveal detailed information of the crystal orientation, thickness inhomogeneities and nanoscale defects. Pixel-by-pixel information of the atomic structure of 2D nanosheets will be extracted from PSHG data with a spatial resolution of ~50nm in two different ways; first, by measuring the SHG intensity, the number of layers for every pixel in the image will be determined. Second, the polarization of the SHG signal will reveal high-resolution details of the orientation of the crystallographic axis. Therefore, defects of the crystal structure will create a sharp contrast in the PSHG image. Theoretical models will also be developed to accurately predict and explain the PSHG data. The adjustment of the pixel-by-pixel PSHG results to the theoretical calculations will be utilized as a “second order filter” to enhance the optical contrast. Due to the small dimensions of the pixel (~50nm) compared to the diameter of the excited volume (~500nm), the extracted optical information goes beyond the diffraction limit. This technique is being developed at the Foundation for Research and Technology-Hellas (FORTH).The crystallographic orientation, specimen thickness, strain and doping/impurity levels, stacking sequence and twist, chemical composition, electric fields and charge densities will be also validated, in-situ via high resolution Raman spectroscopy at the Graphene Centre (CGC) of UCAM and ex-situ via atomic-resolution scanning transmission electron microscopy (STEM) imaging at the Electron Microscopy for Materials Science group of the University of Antwerp (UA). The CVD test-case samples will be provided by the CGC and the AIXTRON company.This project introduces for the first time a fast, high-resolution, non-invasive, in-situ, nonlinear optical technique that will evaluate in detail the crystal quality of as- grown GRMs and their heterostructures. The results will be validated and further supported by high resolution Raman spectroscopy and STEM. We envisage that this project will have a big impact in the field of GRMs’ growth and will prove useful towards the development of defect-free GRMs with excellent optoelectronic properties.

Consortium

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