Inter-laboratory comparisons in support of the development of standards for 2D materials

Malcolm A. Lawn, Åsa Jämting, Bakir Babic and Victoria A. Coleman

Nanometrology Section, National Measurement Institute,

36 Bradfield Road, Lindfield, New South Wales 2070, Australia.

Confidence in measurements and methods are essential to translate novel materials from the laboratory to successful products in the marketplace. Methods and material characteristics need to be reproducible to scale up and reproduce laboratory processes, whilst in the marketplace, products must comply with both national and international regulations, and consumers increasingly want to know what their products contain. Building this confidence around the commercial application of nanomaterials, including 2D materials like graphene, relies on the development of internationally accepted testing methodologies and reference materials. The Nanometrology Section at the National Measurement Institute Australia (NMIA) has played a role through participation in the development of documentary standards in The International Organisation for Standardisation's (ISO) technical committees on nanotechnology, and the development of material specific pre-normative standards in inter-laboratory comparisons (ILC's) run by organisations such as the Versailles Project on Advanced Materials (VAMAS, vamas.org).

With the potential for the widespread commercial application of graphene and related 2D materials, a technical work area dedicated especially to these materials has been established by VAMAS. This aims to validate methodologies of measurement, determine measurement uncertainties, and establish sample preparation and data analysis protocols, primarily through a series of ILCs. The capabilities and expertise of national measurement institutes, such as NMIA, are critical to support the reproducibility and repeatability of these ILCs, though participation from other research institutes and Universities is also welcomed. The results from this work will form the basis of future standardisation which should address problems with the commercial production and application of 2D materials such as differing routes to production and batch-to-batch consistency.

This presentation will focus on the technical highlights of NMI's participation in some of the recent VAMAS graphene and related 2D materials ILCs. One of the challenges of AFM measurements of the sub-nanometre thicknesses of graphene and other 2D materials with traceability to the SI metre is the lack of step-height calibration standards with sub-nanometre dimensions. We have used the measurement of monoatomic lattice steps on the surface of miscut crystalline silicon, to calibrate our AFM's vertical measurement axis thereby allowing traceable measurement of these 2D material thicknesses with higher accuracy.