CENIDE & WIN Seminar Series on 2D-MATURE

DFG IRTG 2803 & NSERC CREATE

Andrew Pollard

National Physical Laboratory & University of Manchester

"Ensuring Accuracy for Graphene Applications through Measurement and Standardisation"

May 25th, 2023
10:00 a.m. ET / 16:00 p.m. CET

Andrew Pollard leads NPL's research into the structural and chemical characterisation of graphene and related 2D materials, with a focus on enabling industrial commercialisation in this area. This metrology research has allowed the development of several international standards addressing the measurement of 2D materials, either published or in progress within the ISO 'Nanotechnologies' Technical Committee (TC229).
Andrew is a Visiting Lecturer at the University of Manchester, the co-chair of the VAMAS Technical Working Area 'TWA 41: Graphene and Related 2D Materials', Metrologist-in-Residence at the Henry Royce Institute, the Secretary of the 'Materials and Characterisation' Group at the Institute of Physics (IOP)) and the recipient of the Royal Society of Chemistry's '2018 Rising Star in Industry Award'.

Although the global graphene industry is continuing to grow and deliver new real-world products, without an understanding of the properties of the materials available in the supply chain these new applications cannot be efficiently developed and improved. Thus, there is a need for reliable, accurate and precise measurements for material testing, which are standardised across the industry and therefore allow endusers to be able to compare commercially-available materials from around the world.
To this end, the underlying metrology (measurement science) enabling industry and directly leading to international standards will be detailed. The current state of international measurement standards covering the material properties of the graphene family will be discussed, in particular the ISO/IEC standard "TS 21356-1 Structural characterization of graphene: Graphene from powders and dispersions" [1], which uses a suite of techniques to understand the material under investigation, based on the NPL Good Practice Guide [2]. The development of the understanding of the techniques included in the standard, such as the Brunauer-Emmett-Teller (BET) method [3], will also be reported.
A key part of developing international measurement standards is the validation of protocols through international interlaboratory comparisons. As an example, the results of an interlaboratory study on Raman spectroscopy of chemical vapour deposition (CVD) grown graphene will be reported, which gathered data from 17 participants across academia, industry (including instrument manufacturers) and National laboratories, revealing key metrology issues in both the measurement and data analysis that must be considered [4].
Alongside international standards, industry also requires rapid, inexpensive and simple techniques to be used as quality control tools. These techniques need to be verified against more accurate and precise measurements, but at the same time do not need the same level of precision themselves. Several techniques and methods developed for industry will be described, such as Nuclear Magnetic Resonance Proton Relaxation [5]. Examples of how these techniques and others, such as Secondary Ion Mass Spectrometry (SIMS) and Tip enhanced Raman

Spectroscopy (TERS) have been used for commercially-available materials will be described, also demonstrating the direct impact that reliable and robust metrology can provide, aiding 2D materials to move from the laboratory to the factory floor.

[1] ISO/TS 21356-1:2021 “Nanotechnologies — Structural characterization of graphene — Part 1: Graphene from powders and dispersions”, https://www.iso.org/standard/70757.html
[2] A. J. Pollard, et al., Characterisation of the structural properties of graphene, NPL Good Practice Guide145 (2017)
[3] ISO/TS 80004-13:2017 “Nanotechnologies — Vocabulary — Part 13: Graphene and related twodimensional (2D) materials”, https://www.iso.org/standard/64741.html
[3] S. Marchesini et al., Gas physisorption measurements as a quality control tool for the properties of graphene/graphite powders, Carbon, 167, 585-595 (2020)
[4] P. Turner et al., International interlaboratory comparison of Raman spectroscopic analysis of CVDgrown graphene, 2D Mater. 9 035010 (2022)