Developing the measurement tools and international standards to enable the graphene industry

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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 end-users 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 discussed. The current state of international measurement standards within ISO/IEC, covering the material properties of the graphene family, will be detailed.

A key part of developing international measurement standards is the validation of protocols through international interlaboratory comparisons. As examples, the results of interlaboratory studies for Raman spectroscopy[1] and transmission electron microscopy[2] of chemical vapour deposition (CVD) grown graphene will be reported, which gathered data from more than a dozen participants across academia, industry (including instrument manufacturers) and National laboratories for each study, revealing key metrology issues in both the measurement and data analysis that must be considered.

Alongside international standards, industry also require 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.

References

[1] Turner, P. et al. 2D Mater. **9** (2022) 035010
[2] Tillotson, E. *et al.* 2D Mater. **13** (2026) 025007
[3] Marchesini, S., et al., Nanoscale, (2021) **13**(34) 14518-14524.
[4] Marchesini, S., et al., Nanoscale, (2021) **13**(13) 6389-6393.