Improving the accuracy of international standards for graphene

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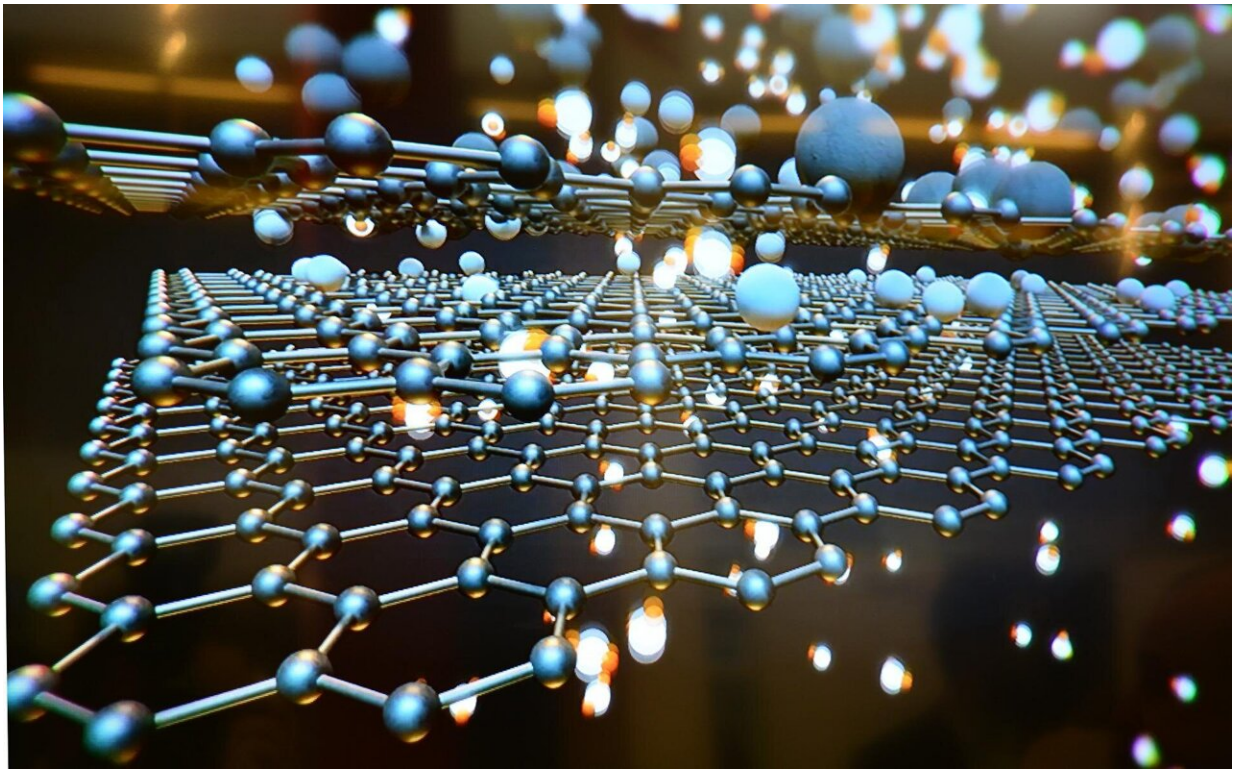

Made of a single sheet of carbon atoms, graphene can be spun at the fastest rate of any known macroscopic object. Credit: Pixabay/CC0 Public Domain

The results of the first international comparison of the measurement of graphene have been published in *2D Materials*, led by the National Physical Laboratory (NPL) in the U.K., through the Versailles Project

on Advanced Materials and Standards (VAMAS) and in collaboration with institutes from around the world.

The international interlaboratory comparison (ILC) outlined improvements that reduce measurement uncertainty, in some cases by a factor of 15, and which will be the basis for a new international standard that is currently under development within ISO/IEC for Raman spectroscopy. This will provide a verified source of data and ultimately provide more accurate and precise measurement standards for the global graphene industry.

Although a wonder material with many superlative properties set to disrupt industries ranging from electronics to construction, as a single layer of carbon atoms, graphene can be difficult to measure. There is a pressing need for reliable, reproducible and accurate measurements of graphene's properties, through international standards, to facilitate industrial growth.

Processes such as chemical vapor deposition (CVD) allow companies around the world to now produce graphene on the scale of meters, but a standardized measurement method to determine the quality of the material is still under development within the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC).

VAMAS was established in 1982 by the G7 group of nations to ensure best practice plus accurate and precise standardized measurement methods, in order to promote and grow world trade. More recently in 2016, a technical working area was established for "Graphene and Related 2D Materials," that now has 14 active projects.

The first of these projects is the measurement of CVD grown graphene using Raman spectroscopy, a go-to measurement technique for

understanding the structure of graphene related 2D materials. The Industrialisation Work Package (WP19) of the EU Graphene Flagship funded NPL's work to lead this international ILC consisting of 17 entities, including National Metrology Institutes, Universities and industry, with CVD grown graphene samples supplied by Graphenea Semiconductor, Spain.

Many of the measurements for these VAMAS ILCs have been completed, however there are several projects that have been recently initiated and looking for participants. These projects will also contribute to other international standards, ultimately improving the accuracy of the measurement of graphene and other 2D materials and, in doing so enabling industry around the world.

Dr. Andrew J Pollard, principal research scientist at NPL said: "Interlaboratory comparisons are vital if we are to provide a quantitative uncertainty alongside our measured values, as well as help us to improve standardized protocols to achieve the most accurate and precise values possible. These in-depth studies require both time and international collaboration but will help the whole community through reproducible and comparable measurements."

Prof. Cinzia Casiraghi, professor of nanoscience at the University of Manchester said: "Raman spectroscopy is one of the most used techniques for characterization of graphene because it can quickly provide a wide range of information on the quality of this material. Despite its simplicity, discrepancies in the Raman measurements and data were reported in the literature, hence affecting industrial production and the ability to compare graphene samples produced in different labs. The VAMAS project is a first crucial step in the development of a standardized protocol for the characterization of graphene using Raman spectroscopy."

Dr. Amaia Zurutuza, scientific director at Graphenea Semiconductor said: "This was our first time participating in an international interlaboratory comparison, we found the experience very positive and we would like to highlight the crucial importance of these type of studies. It was incredible that such disparate values were obtained on the same samples. We will definitely participate in another ILC in the near future."

More information: Piers Turner et al, International interlaboratory comparison of Raman spectroscopic analysis of CVD-grown graphene, *2D Materials* (2022). DOI: 10.1088/2053-1583/ac6cf3

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