An International Standard for Measuring the Flatness of Graphene

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Researchers from Graphene Flagship partner RWTH Aachen University and the Graphene Flagship Standardization Committee have pushed through a new IEC standard for assessing the strain uniformity of single-layer graphene using Raman spectroscopy.

Graphene is often portrayed as the ultimate conductor, thanks to its flexibility and to its excellent conductivity. However, research has shown that the electrical and the structural quality of graphene are intimately connected, and that nanoscale lattice deformations caused by surface corrugations limit the mobility of electrons in graphene. Therefore, controlling the flatness of a graphene sheet is fundamental for the fabrication of high-quality graphene layers for electronic devices – and the possibility of measuring this parameter with a simple and fast method is a major technological advantage. Furthermore, the new standard for detecting graphene flatness, pioneered by the Graphene Flagship and published by the International Electrotechnical Commission (IEC), will expedite the manufacture and implementation of single-layer graphene.

The method used to measure graphene's flatness is Raman spectroscopy, a standard tool of graphene research. This technique is fast, non-destructive and well understood, especially if the sample under evaluation consists of single-layer graphene. It allows distinguishing between single and few-layer graphene, and it helps to determine the doping of a graphene, the amount of mechanical strain and defects in the lattice. In 2015, Graphene Flagship researcher Christoph Stampfer at RWTH Aachen University, Germany, showed that Raman spectroscopy contains also unambiguous information on the amount of nanometer-scale strain variations in a graphene sheet, directly correlated to flatness.

This discovery came at a very appropriate time, as nanometer-scale strain variation had been pinpointed as the main source of electron scattering in defect-free graphene just the year before. "It was clear that this result had the potential for setting the basis of an internationally recognized standard for the strain uniformity of graphene", says Norbert

Fabricius, from International Standards Consulting GmbH & Co. KG.

At that time, Fabricius led the Graphene Flagship Standardization Committee, a team of experts dealing with the long process between scientific discovery and the establishment of an international standard. The results provide a well-defined recipe to use scanning confocal Raman mappings to produce a “strain uniformity parameter”. This measurement is based on statistical interpretations of the linewidth of the characteristic 2D-peak generated by single-layer graphene,

“The strain uniformity parameter is a figure of merit that quantify the influence of nanometer-scale strain variations on the electronic properties of the layer. It gives an upper limit on the electronic performance of the characterized graphene. It can therefore help manufacturers to classify their material and decide whether or not it is potentially suitable for various applications”, explains Fabricius.

The new standard was published by the EIC in October 2021, and represents a good example of the work supported by the Graphene Flagship Standardization Committee, currently chaired by Thurid Gspann from Graphene Flagship partner Karlsruhe Institute of Technology, Germany. “A standard must meet the different needs of different stakeholders: researchers, manufacturers, and buyers”, says Gspann. “In the Committee we mediate the discussion between different actors to find consensus on the specifications of the standard, we support the scientific work that forms the backbone of the standard, and we link to international organisations such as the International Organization for Standardization (ISO) or, in this case, the IEC.”

The pioneer of this new standard measurement technique, Christoph Stampfer, from Graphene Flagship partner RWTH Aachen, says: “In my view, the largest portion of merit in this story goes to two students from my group, Christoph Neumann, who realized the potential of Raman spectroscopy to measure nanometer-scale strain fluctuations and who initiated the work needed for the standard, and Jens Sonntag, who picked up that same work and pushed it until the very final stage.”

As appreciation for their work on standardisation, all three Graphene Flagship researchers – Stampfer, Neumann and Sonntag – have now received the “Standardisation Certificate” by the Graphene Flagship Standardisation Committee for authoring an international standard on

graphene.

“Established standards can increase efficiency, reduce risks and costs, and catalyze innovation. This particular standard will allow manufacturers to certify that their material is in principle suitable for applications that crucially depend on the electronic quality of graphene, such as high-frequency transistors and broad-band receivers. This can accelerate the appearance of this type of devices onto the market,” says Gspann.

Kari Hjelt, Head of Innovation of the Graphene Flagship, adds: “The Graphene Flagship devotes most of its resources to commercializing graphene-enabled products. That requires both reliable materials and solutions and industry trust, both of which are boosted by international standards, like the one just granted to Stampfer’s method to measure the flatness of graphene. I am convinced the work of our Graphene Flagship Standardisation Committee will keep bearing fruits and ultimately speeding up the early adoption of graphene and related materials.”

Read the original article on Graphene Flagship.