# Graphene mapping 50 times faster

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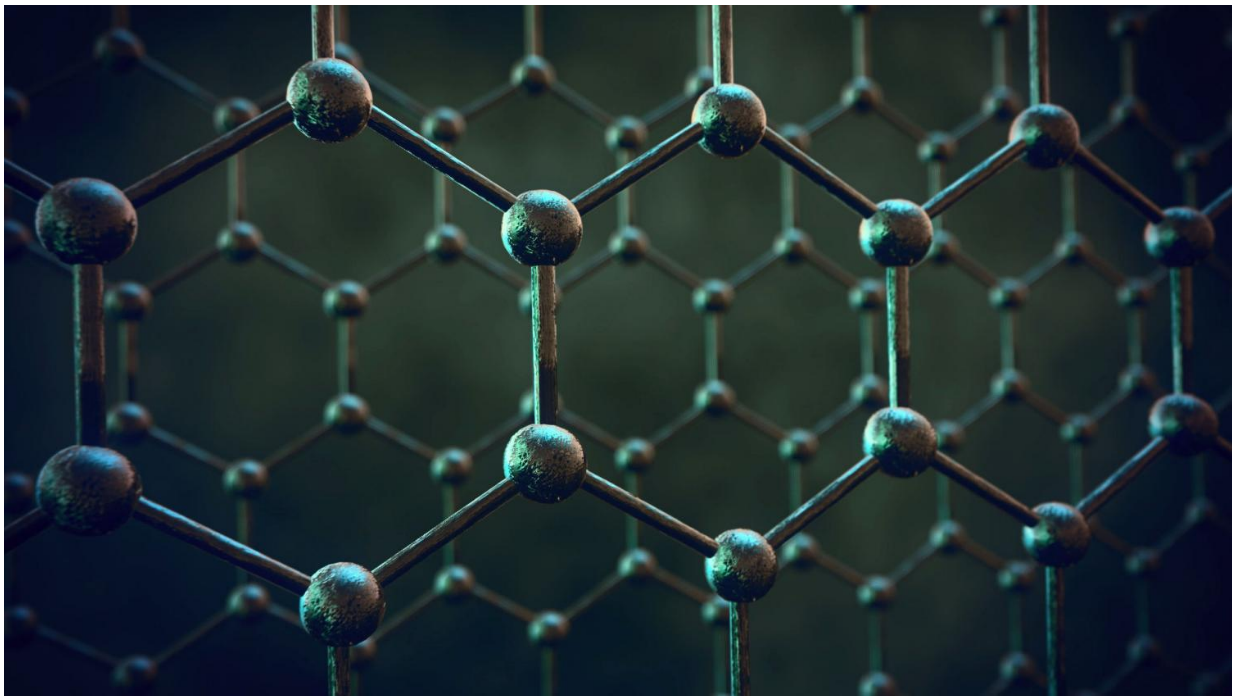


This visualisation shows layers of graphene used for membranes. Credit: University of Manchester

Graphene has created high expectations, as a strong, ultrathin, two-dimensional material that could also be the basis for new components in information technology. There is hence a huge need for characterization of graphene devices. This can be done using Raman spectroscopy. Laser light is sent to the material sample, and scattered photons tell us about the rotations and vibrations of the molecules inside, and thus about the crystal structure. On average, only around 1 in 10 million photons is scattered in this way. This not only makes it hard to detect the right information, it is also very slow: it may take half a second to image one single pixel. The question is whether Raman still remains the best option, or if there are better alternatives. Researchers Sachin Nair and Jun Gao keep Raman spectroscopy as a starting point, but manage to improve the speed drastically: not by changing the technique itself, but by adding an algorithm.

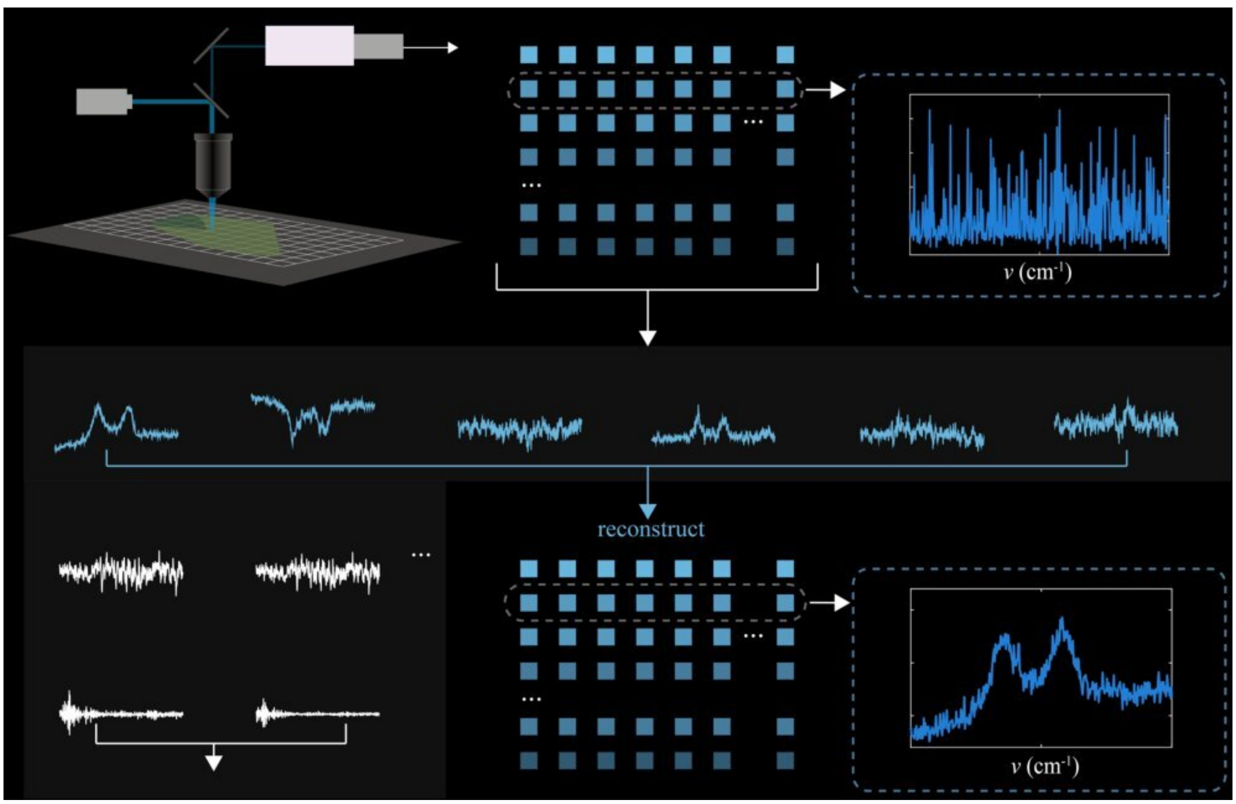
## Noise reduction

This algorithm is not unknown in the world of signal processing and it is called Principal Component Analysis. It is used to improve the signal-to-noise ratio. PCA determines the characteristics of noise and those of the 'real' signal. The larger the dataset, the more reliable this recognition is, and the clearer the actual signal can be distinguished. Apart from that, modern Raman instruments have a detector called electron-multiplying charge-coupled device (EMCCD) that improves the signal-to-noise-ratio. The net result of this work is that processing one pixel doesn't take half a second, but just 10 milliseconds or less. Mapping a single sample doesn't take hours anymore. An important feature for vulnerable materials like graphene oxide is that the intensity of the laser can be lowered two or three orders of magnitude. These are major steps ahead for getting a fast grip on materials' properties.

## Multi-purpose

Except for graphene, the improved Raman technique can also be used for other two dimensional materials like germanene, silicene, molybdenum disulfide, tungsten disulfide and boron nitride. Use of the algorithm is not limited to Raman spectroscopy; techniques like Atomic Force Microscopy and other hyperspectral techniques could also benefit from it.

The research has been done in the group Physics of Complex Fluids of Prof Frieder Mugele, part of UT's MESA+ Institute. The researchers collaborated with the Medical Cell BioPhysics group and the Physics of Interfaces and Nanomaterials group, both of the University of Twente as well.




Denoising algorithm improves Raman scanning speed. Credit: ©Science China Press

**More information:** Sachin Nair et al, Algorithm-improved high speed and non-invasive confocal Raman imaging of two-dimensional materials, *National Science Review* (2019). DOI: 10.1093/nsr/nwz177

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