Visualizing Graphene Properties at Highest Performance and Resolution Using Confocal Raman, AFM, SNOM and SEM

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Graphene is used in a multitude of macroscopic and microscopic devices. The combination of various analytical techniques often leads to the most appropriate understanding of graphene.
The aim of this contribution is to illustrate the various fields of application of combined confocal Raman, AFM, SNOM and/or SEM measurements with a focus on graphene.

New microscopic techniques are developed continuously to improve resolution but also to increase the amount of information obtainable from the samples. The confocal Raman microscope, a combination of a confocal microscope with high sensitivity Raman spectroscopy, provides chemical imaging with diffraction-limited resolution [1].
For graphene a combination of the confocal Raman microscope with AFM and SNOM leads to their more comprehensive characterization. AFM provides information about the geometric dimensions of graphene, whereas SNOM enables optical resolution beyond the diffraction limit while maintaining all optical contrast methods. Furthermore, by combining these two methods with Raman spectroscopy, the resolution of molecular imaging can be improved tremendously.

The Raman image presented in Fig. 1a is the integrated intensity of the G band which reveals the presence of a graphene sheet consisting of a monolayer, a double layer and a multilayered graphene (brightest areas). Furthermore, from the intensity distribution of the D band, it is possible to determine the chirality of graphene based on a diffraction limited optical method [2]. Fig. 1b highlights the same sample area, but this time measured in SNOM mode, revealing the transparency of the graphene layers as a function of number of layers (Fig. 1c).

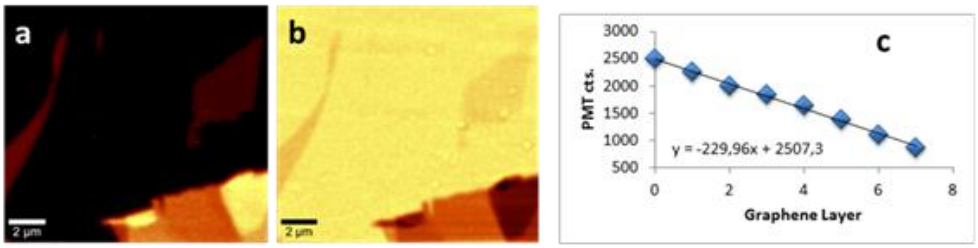

Fig. 1: Raman SNOM study of graphene: intensity of Raman G band (a), SNOM image (b), and decrease of transparency of graphene as a function of number of layers.

Additionally RISE Microscopy is a novel correlative microscopy technique that combines confocal Raman Imaging and Scanning Electron (RISE) Microscopy within one integrated microscope system. A new dimension in imaging: ultra-structural SEM complemented with chemical compound information and molecular Raman imaging (fig. 2).

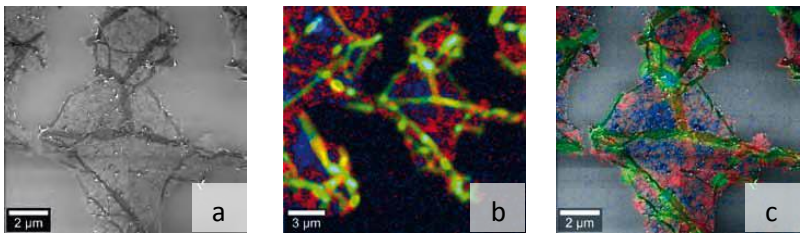

Fig. 2 - (a) SEM image of a graphene sample. (b) Color-coded confocal Raman image. (c) SEM image overlaid with the confocal Raman image.

References

[1] T. Dieng, O. Hollricher, and J. Toporski `Confocal Raman Microscopy´ Springer Series in Optical Sciences 158, 2010.
[2] Y. M. You, ZhenHua Ni, Ting Yu, and ZeXiang Shen, 'Edge Chirality Determination of Graphene by Raman Spectroscopy', Applied Physics Letters, 93 (2008), 163112