Multimodal Correlative Microscopy of 2D Materials

Elena Bailo
Thomas Dieing
Ute Schmidt*

WITec GmbH, Lise-Meitner Str. 6, Ulm, Germany
www.witec.de

Elena.Bailo@witec.de

The characterization of 2D materials such as graphene or transition metal dichalogenides (TMDs) often require more than a single characterization technique to gather comprehensive information in order to understand and predict their behavior for specific applications. Graphene[1] and TMDs[2] have a layered structure in common, with significantly changes their properties when compared to in the bulk making them very attractive materials for electronic designs. The optimization of electronic device performance is strongly tied to the structure, degree of crystallinity and exciton dynamics of 2D materials. The scope of this contribution is to provide insight into how a combination of spectroscopic (Raman/Photoluminescence) and microscopy techniques (confocal/AFM/SEM) contribute to an ample characterization of such 2D materials.
Raman spectroscopy and more importantly still, Raman imaging proved to be of great value due to clearly different spectra obtained from single, double, triple and multi-layered 2D materials. Furthermore, Raman imaging is by now routinely used to determine strain, doping type and level, stacking, chirality and disorder in graphene. All these information can be extracted from Raman spectroscopy and imaging can well be complemented with other techniques such as various forms of atomic force microscopy (AFM), Scanning Nearfield Optical Microscopy (SNOM), Current sensing, scanning electron microscopy (SEM) or measurements at low temperatures (<10K) and under high magnetic fields (up to 9T).

The two dimensional forms of TMD materials are also often characterized using the same experimental methods. Fig. 1 shows an example of a correlative Raman-SEM measurement of CVD grown MoS2. For this group of 2D materials the information obtained through the combination of the techniques is even more valuable since the transition of indirect to direct semiconductor when going to a single layer gives rise to pronounced photoluminescence (PL)[3], which can easily be measured with exceptionally high resolution using SNOM-PL. In this contribution we illustrate the benefit of correlating the above mentioned techniques spatially applying confocal Raman imaging in order to deepen the understanding of the samples under investigation.

References

[1] K. S. Novoselov *et al.*, Science 306 (2014) 666
[2] M. Xu *et al.*, Chem. Rev. 113 (2013) 3766
[3] A. Steinhoff *et al.*, Nano Lett. 15 (2015) 6841

Figures

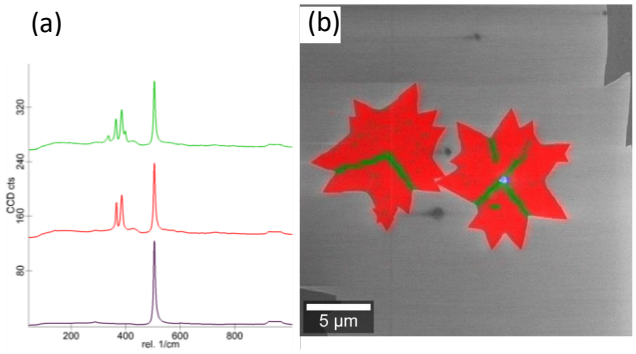

Figure 1: SEM-Raman imaging of CVD grown MoS2 on a Si-substrate: (a) Raman spectra evaluated from the 2D spectral array of a Raman image, and (b) RISE image, a combination of SEM and Raman image of the same sample area. The colors in the RISE image match the colors of the Raman spectra.