Characterising Graphene and 2D Materials by Confocal Raman and Photoluminescence Microscopy

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Analysis of graphene and transition metal dichalcogenides (TMDCs) is crucial for understanding the characteristics and quality of samples and thus the effectiveness of different growth methods. Confocal Raman and photoluminescence (PL) microscopy is a non-destructive technique used to determine number of layers, defects, strain, and functionalisation. This work details the analysis of 2D materials, such as graphene and MoS_2, via mapping the same sample areas using Raman, PL, and PL lifetime microscopy.

Subtle changes in the Raman spectra aid in detecting the number of layers present and locate defects in graphene samples. Three main bands of interest are studied by Raman spectroscopy; the G-band, which is used for layer and strain analysis, the 2D-band, used for layer analysis, and the D-band, studied to detect defects. A confocal Raman microscope can be used to precisely map and plot where defects occur on the sample, Figure 1(a), of graphene.

Using Raman and photoluminescence techniques on the same sample can also provide extremely useful information in the study of 2D materials. In TMDCs, for example, the position of two Raman bands is indicative of the number of layers present, as the number of layers increase these bands move farther apart due to interlayer vibrations. Mapping TMDC samples allows plotting of these two peak positions to see distribution of layer thickness. PL mapping is also used in the search for monolayer TMDCs, the PL peak, for example at ~ 680 nm for MoS_2 (Figure 1(b)), will significantly decrease as layers increase due to the direct bandgap that is only present in mono-layer TMCDs. Additionally, as the layer thickness increased the PL peak position will shift to the red. TMDCs PL lifetimes also show important sample information, as the number of layers increase the lifetime will become shorter. Analysing single flake by lifetime mapping allows for grain boundaries and structural defects to be investigated.

Figures

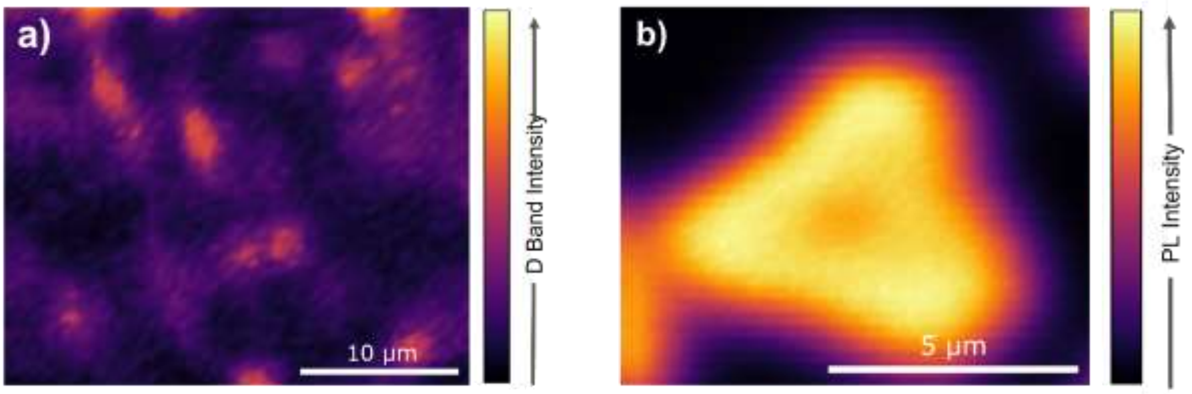

Figure 1: (a) Raman map highlighting defects in a sample of graphene, (b) PL intensity map of MoS_2