Quantification of Defects in Bilayer Graphene by Raman spectroscopy

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Quantification of defects in carbon nanostructures is crucial for both fundamental science and practical applications. Raman spectroscopy is widely used to determine the number of defects in these materials, because it is non-destructive, fast and relatively easy to interpret.

Here we used oxygen plasma to induce specific amount of defects in graphene samples composed of monolayer, bilayer with Bernal stacked layers and bilayer with randomly stacked (turbostratic) layers. We applied isotopic labelling of graphene layers by ^{13}C, which allowed us to address the Raman bands from the top and bottom graphene layers. Our results suggest that the phonons of the AB stacked bottom graphene layer are scattered by defects in the top graphene layer. Considering this effect we found that monolayer graphene and the top layer of turbostratic bilayer contains similar number of defects, while the top graphene layer of AB stacked bilayer contains fewer defects after a given time of oxygen plasma treatment. This result confirms that the behaviour of the top layer of turbostratic graphene is almost independent on the bottom layer, while the reactivity of the top layer in AB stacked graphene is significantly reduced by interactions with the bottom layer.

Moreover, the phonon 'scattering efficiency' by the defects in neighbouring graphene layer seems to be dependent on the interactions between graphene layers, which results in the variation of the intensity of the D mode. While in the case of the turbostratic graphene samples this effect leads only to slight increase of the D mode intensity, for the AB stacked bilayer is the intensity of the D mode increased by almost 100%. Consequently, the relation between the Raman signatures of defects and the actual amount of defects in graphene is significantly influenced by a presence of defects in another graphene layer and by the stacking order of these graphene layers.

References

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