Raman spectroscopy probes stress transfer efficiency in monolayer graphene/polymer systems

G. Anagnostopoulos[1], C. Androulidakis[1], G. Tsoukleri[1], J. Parthenios[1,2], I. Polyzos[1], K. Papagelis[1,3], C. Galiotis[1,2,3*]

[1]*Institute of Chemical Engineering and High Temperature Chemical Processes, Foundation for Research and Technology – Hellas (FORTH), P.O. BOX 1414, Patras 265 04, Greece*

[2] *Interdeparmental Programme in Polymer Science & Technology, University of Patras, Patras 26504, Greece*

[3]*Department of Materials Science, University of Patras, Patras 26504, Greece*

In this work, we investigate the stress/strain transfer mechanism in simply-supported and embedded graphene flakes on polymer substrates using the 4-point bending approach in tandem with Raman spectroscopy. At each strain level, a mapping (ω_{2D} & ω_G profiles) across specific lines on 1LG flakes is made. As seen (Fig.1), systematic shifts of the ω_{2D} are obtained as one move at steps of 100 nm from the edge of the flake towards the middle. These systematic shifts are evident at all strain levels but also in the as-received material. At 0.00% applied strain, there is almost a constant distribution of ω_{2D} Raman wavenumbers starting from ~2600 cm^{-1} for both edges. For the left side and up to 1.5 μm there is no significant shift of ω_{2D} line, while for the right side a similar trend is appeared up to 2.5 μm from the edges but at ~2605 cm^{-1}. Within the bulk of the flake, the ω_{2D} line varies up to 5 cm^{-1}. It is a shift, which cannot only be attributed to strains induced by the exfoliation procedure. According to Das et al. [1], the ω_{2D} phonon frequencies are sensitive to electrostatic interactions (in our case probably emanating from the substrate) causing its shifting to higher or lower values depending on doping. The above mentioned fluctuations at the edges, which are more intense at lower levels, are present in all applied strain levels, implying the presence of additional influences, such as doping that occurs via contact with the substrate.

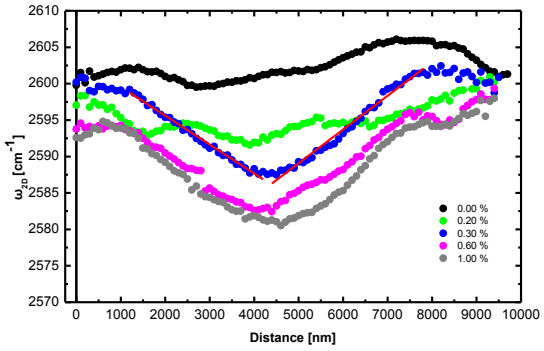

Fig.1: The ω_{2D} distributions for various levels of strain are shown along a sampling line in the simply-supported flake

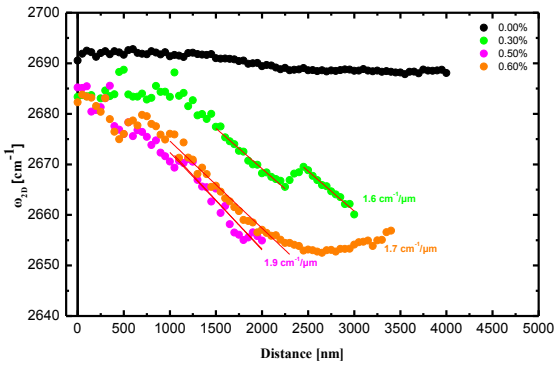

Fig.2 : The ω_{2D} distributions for various levels of strain are shown along a sampling line in the embedded flake

In the embedded case (Fig.2), the ω_{2D} shifts clearly to lower wavenumbers as one move from the edge towards the middle of the flake, indicating axial stress transfer through shear at the interface [2]. As in the case of the simply supported specimen some fluctuations of the ω_{2D} values are observed close to edges (< 1.0 μm) particularly at low strain levels.

References

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*Whom all correspondence should be sent to: c.galiotis@iceht.forth.gr