On the mechanical deformation of single and multilayer graphene

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A key issue to most applications involving graphene is its mechanical response under various stress/ strain states. The electronic band structure of bi- and tri-layer graphene differs remarkably from that of a monolayer resulting in materials with different electronic properties, suitable for next-generation optoelectronics and post-silicon nanoelectronics. However, their mechanical properties that can significantly alter their electronic properties are not well documented so far. In this work, we present an experimental study on single, bi- and tri-layer graphene flakes under uniaxial tensile and compressive strain, for low levels of strain (up to 1.5%). Graphene layers were loaded by employing a polymeric cantilever beam assembly, where the graphene flakes are embedded into the polymer beam. The mechanical response of graphene is monitored by simultaneous Raman measurements by means of the frequency shift of the G and 2D optical phonons, and their strain rates are determined. The results can be used to quantify the amount of uniaxial strain, providing a fundamental tool for measuring load transfer in graphene based nanocomposites.

References

[1] O. Frank, M. Bouša, I. Riaz, R. Jalil, K. S. Novoselov, G. Tsoukleri, J. Parthenios, L. Kavan, K. Papagelis* and C. Galiotis, “Phonon and structural changes in deformed Bernal stacked bilayer graphene”, Nano Letters 12, 687-693 (2012).

[2] O. Frank G. Tsoukleri, I. Riaz, K. Papagelis J. Parthenios, A.C. Ferrari, A. K. Geim, K. S. Novoselov and C. Galiotis, “Development of a universal stress sensor for graphene and carbon fibres”, Nature Communications 2:255 doi: 10.1038/ncomms1247 (2011).

[3] O. Frank, M. Mohr, J. Maultzsch, C. Thomsen, I. Riaz, R. Jalil, K. S. Novoselov, G. Tsoukleri, J. Parthenios, K. Papagelis*, L. Kavan and C. Galiotis, “Raman 2D-band splitting in graphene: theory and experiment”, ACS-Nano 5, 2231-2239 (2011).

[4] O. Frank G. Tsoukleri, J. Parthenios, K. Papagelis, I. Riaz,R. Jalil, K. S. Novoselov and C.

[5] G. Tsoukleri, J. Parthenios, K. Papagelis, R. Jalil, A. C. Ferrari, A. K. Geim, K. S. Novoselov and C. Galiotis. “Subjecting a graphene monolayer to tension and compression”, Small 2, 2397-2402 (2009).