Biaxial compressive strain in 2D systems in high pressure experiments

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Pressure is a 3-dimensional variable which losses significance if spatial dimensionality is reduced. We have investigated the high-pressure behaviour of supported graphene [1] and MoS_2 [2] and shown that the substrate volume reduction leads to the in-plane biaxial strain of the 2D-system up to values as high as -0.9 %.

We have probed the in-plane compression of supported graphene through the Raman optical modes pressure evolution [2,3] and evidence a significant dependence on the nature of the substrate. In fact, for 4 different substrates, the graphene G-band pressure coefficient ($\Delta\omega_G/\Delta P$) varies from 4.0 to 10.5 cm^{-1}/GPa from the less compressive to the more compressive substrates respectively (see Fig. 1). We have defined a *strain-transfer coefficient*, α, which has been found to vary in our experiments from α=1 (100 % strain transfer from the substrate) to α=0.2 (20 % strain transfer). The strain-transfer coefficient can depend on surface roughness and adhesion, but the main parameter governing it appears to be the difference of compressibility between the 2D-system and the substrate. The physical mechanism allowing for the needed dissipation of surface strain when α<1, should manifest as a local field of buckled graphene.

In the case of MoS_2, our measurements allowed to show that the adhesion on a SiO_2/Si substrate is bimodal, i.e., with a distribution of zones in close conformation with the substrate (good adhesion) and other zones with low conformation (detached).
These findings should contribute to the better understanding of the mechanics of NEMS or nanocomposites based on 2D systems [4].

References

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Figures

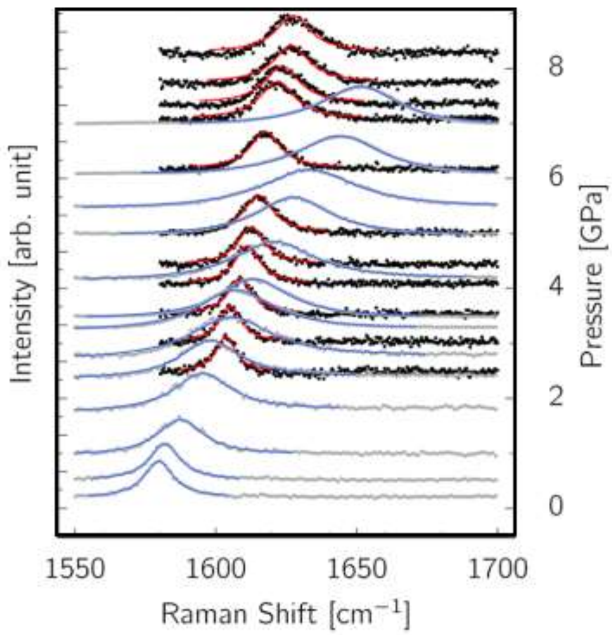

Figure 1: Evolution with pressure of the G-band of graphene supported by diamond (black points, red line) and by Si/SiO_2 (grey points, blue line). Fits (lines) are done with Lorentzian functions. The pressure (right scale) corresponds to the spectra base line. The corresponding values of the strain-transfer coefficients, α, are 1.0 (diamond) and 0.2 (SiO_2/Si).