Raman spectroscopy as a tool to study the doping of graphene

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Abstract

In this communication, we will illustrate how Raman spectroscopy can be used to study the doping of graphene. We will first report data recorded by in situ Raman experiments on single-layer (SLG) graphene during exposure to rubidium vapor. By this way, we have been able to follow continuously the changes of the G and 2D bands features over a broad doping range (up to about 10^{14} electrons/cm^2). Previous theoretical predictions have shown that the evolution of the G-mode in SLG results from the competition between adiabatic and non-adiabatic effects. We emphasize that a possible substrate pinning effect, which inhibits the charge-induced lattice expansion of graphene layer, can strongly influence the G band position [1].

In the second part, we will show that the charge carrier density of graphene exfoliated on a SiO_2/Si substrate can be finely and reversibly tuned between electron and hole doping with visible photons. This photo-induced doping happens under moderate laser power conditions but is significantly affected by the substrate cleaning method. In particular, it requires hydrophilic substrates and vanishes for suspended graphene. These findings also suggest that Raman spectroscopy is not always as non-invasive as generally assumed [2].

References

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[2] A. Tiberj, M. Rubio-Roy, M. Paillet, J.-R. Huntzinger, P. Landois, M. Mikolasek, S. Contreras, J.-L. Sauvajol, E. Dujardin, A.-A. Zahab, Scientific Reports, **3** (2013) 2355.

Figures

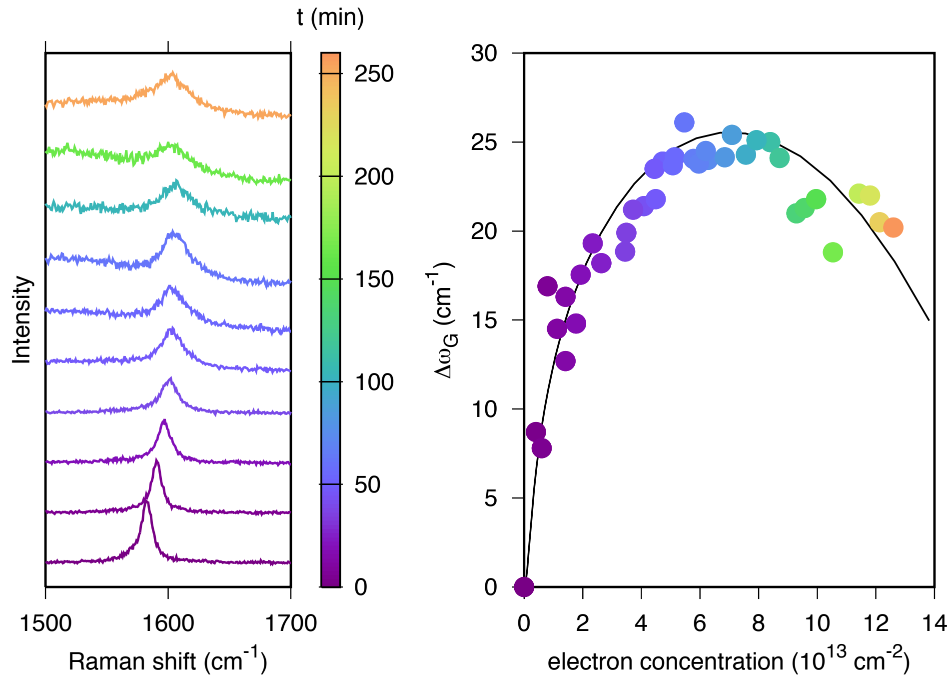

Figure 1 Raman spectra and frequency shifts (G band) of the graphene monolayer as a function of Rb doping time. Each spectrum and frequency color is coded with the corresponding doping time with the scale presented in the center part.

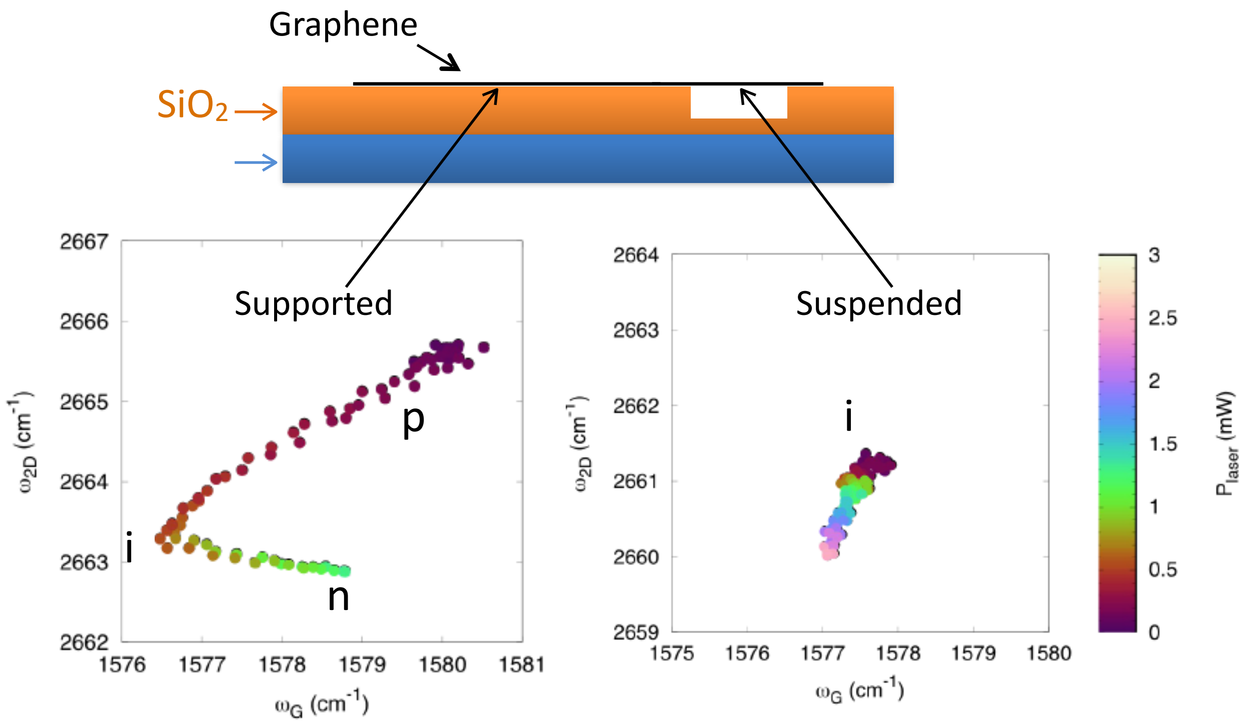

Figure 2 Comparison of the relative evolutions of the 2D band position (ω_{2D}) versus the G band position (ω_G) as a function of the laser power (P_{laser}) for supported and suspended graphene flakes. The color code of each point corresponds to the incident P_{laser} as displayed on the right hand side color bar. The supported flake is p-doped at low P_{laser}, it becomes quasi-neutral around 0.5 mW and n-doped for higher P_{laser}. The suspended graphene flake is neutral and stays neutral with the increasing P_{laser}. The measured shifts for the suspended flake are only due to laser heating effects. Each plot includes both increasing and decreasing power sweeps demonstrating the reversibility of this photodoping effect.