

Contaminations and Doping in Defected Graphene by Raman Spectroscopy

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The determination and control of defects, doping and contaminations in graphene is crucial to optimize fabrication processes and device performance. Raman spectroscopy is a fast, non-destructive technique and ideal to characterize graphene as it can probe not only its electronic properties but also its structural properties [1-4]. We first consider the effect of doping and defects. We combine polymer-electrolyte top gating [3] and in-situ Hall effect measurements to investigate the doping dependence of D and D' for a fixed amount of defects [5]. $I(D)/I(G)$ and $I(D')/I(G)$ both decrease significantly for increasing doping, Fig 1a). We attribute this dependence to the additional effect of electron-electron scattering for increasing doping [5]. We also present a general equation that relates the D peak intensity with the amount of doping and defects for any Raman excitation energy[5]. We then investigate contaminations arising from the fabrication process of graphene based hetero-structures. Hexagonal boron nitride (h-BN) is considered an ideal substrate to optimize graphene's mobility [6-8], but this requires a clean graphene/BN interface. Contaminants are mainly trapped at the interface between graphene and h-BN. We use Raman spectroscopy to map these contaminants and identify them as tape residuals. Fig. 1b) plots a Raman map of the intensity ratio of a contaminant peak and the G peak of graphene. This relates to the atomic force microscopy (AFM) scan in Fig. 1c). We monitor the Raman peaks after successive steps of thermal annealing at 350°C and we find that the contamination Raman signal progressively decreases along with the height of trapped contaminants as confirmed by AFM scans. A systematic Raman and AFM study reveals that the contamination peaks only occur when acetone is used as an additional cleaning step after exfoliation. AFM scans confirm that avoiding this step enables us to produce atomically flat interfaces.

Figures

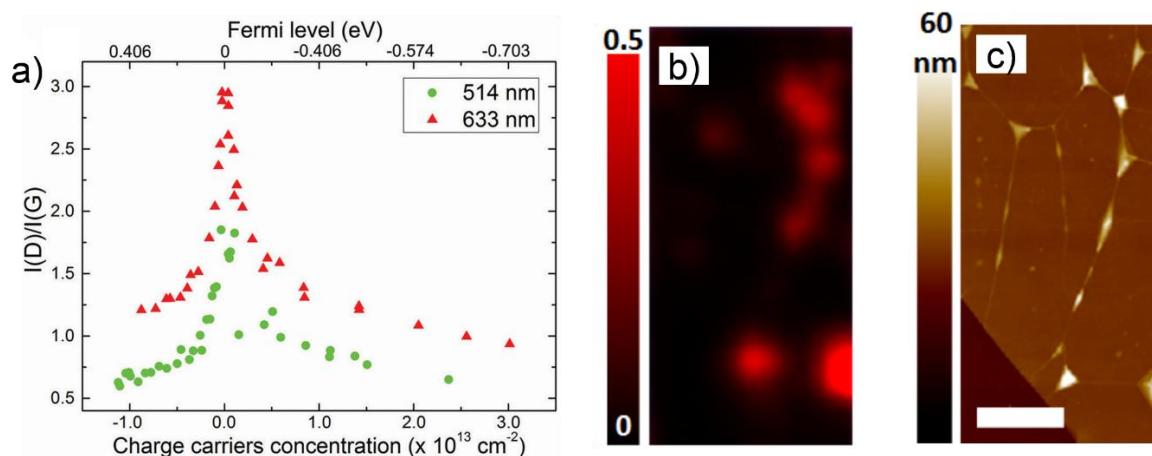


Figure 1: a) $I(D)/I(G)$ in dependence on charge carrier concentration and Fermi level. b) Raman map showing intensity ratio of polymer peak at 1530 cm^{-1} and G peak. c) Corresponding AFM image; scale bar is $2 \mu\text{m}$.

References

- [1] A. C. Ferrari and D. M. Basko. *Nature Nanotech.* **8**, 325 (2013).
- [2] A. C. Ferrari et al., *Phys. Rev. Lett.* **97**, 187401 (2006).
- [3] A. Das et al., *Nature Nanotech.* **3**, 210 (2008).
- [4] L. G. Cancado et al., *Nano Lett.* **11**, 3190 (2011).
- [5] M. Bruna et al., *ACS Nano* **8**, 7432 (2014).
- [6] C. R. Dean et al., *Nature Nanotech.* **5**, 722 (2010).
- [7] A. S. Mayorov et al., *Nano Lett.* **11**, 2396 (2011).
- [8] L. Wang et al., *Science* **342**, 614 (2013).