Doping dependence of the Raman signatures of defects in graphene

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Abstract

Raman spectroscopy is a fast, non-destructive way to probe the structural and electronic properties of graphene [1,2]. Doping and structural defects can strongly affect the properties of graphene, therefore the ability to characterize them efficiently is of crucial importance in this phase of the development of graphene-based technology. While a significant effort was devoted to understand the effect of defects in samples with negligible doping[3], and the effect of doping in samples with negligible defects [4,5], the combined effect of doping and defects on the Raman spectrum of graphene has received little attention to date. But, most samples produced by either micromechanical exfoliation, or chemical vapour deposition or liquid phase exfoliation or carbon segregation from SiC or metal substrates are doped, and many of them have also defects, and defects may appear during processing for device integration. It is thus critical to understand if and how the defects can be detected and quantified by Raman spectroscopy in doped samples. Here, we report the dependence of the defect-related Raman peaks in graphene on the position of the Fermi level, by combining polymer electrolyte gating [4] with in situ Hall-effect measurements and Raman spectroscopy (see fig.1 a)) at different excitation wavelengths. We find that the intensity of the D and D' peaks varies strongly with the doping level, as shown in fig. 1 b). This highlights the importance of taking into account the doping level when determining the amount and the type of defects in graphene from the intensity of the D-peak. We interpret the doping-induced intensity variation as an arising from the increased broadening of the electronic states due to electron-electron interaction. We present a formula for the determination of the defect concentration for samples with non-negligible doping.

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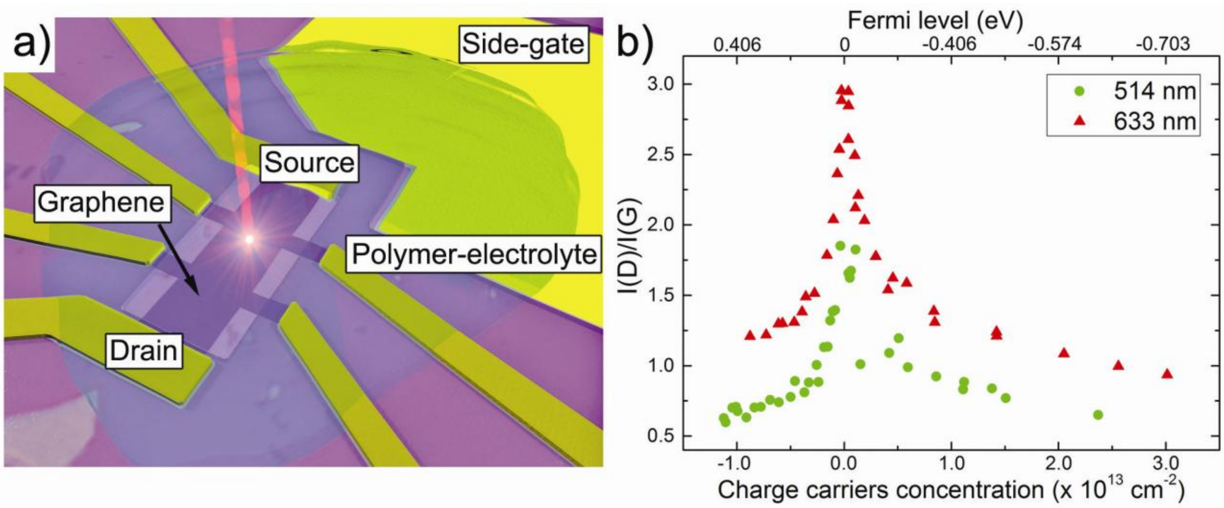

Fig. 1: a) Scheme of polymer electrolyte-gated graphene transistor. B) doping dependence of the intensity ratio between D and G peak, I(D)/I(G)