Quality Assessment of 2D Materials: continuity, uniformity and accuracy of mobility measurements

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As the availability of large area graphene and other 2D materials increases, the ability to accurately assess uniformity and quality has become critically important. Assessment of the spatial variability in carrier density and carrier mobility (μ) can be difficult and time consuming, but variations must be identified and minimized. We present a simple framework for assessing the homogeneity of devices based on 2D-materials. The field effect in large-scale graphene CVD devices [1] (Fig. 1a) and devices of exfoliated graphene encapsulated in hexagonal boron nitride [2] (Fig. 1c) were measured in dual configurations (Fig. 1b inset). A gate-dependent effective homogeneity factor, *ß* is then derived (see Fig. 1b/d). Finite element simulations were carried out and suggest that inhomogeneity in spatial doping (as low as 10^{10} cm^{-2}) rather than inhomogeneity in *μ* is the significant cause of variations in inhomogeneity in the case of graphene. Such doping variations lead to systematic errors when calculating *μ*, which are hidden if the inhomogeneity factor is ignored. In addition, we find that for certain devices Raman mapping (Fig. 2a) can be used as input for finite element simulations and reasonable agreement is found between simulated and experimental gate-dependent data (Fig. 2b). We also present data which illustrates the usefulness of the inhomogeneity factor in semiconducting 2D materials *e.g.* MoS_2 [3] and ReS_2[4]. A recent comprehensive study can be found here [5].

References

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Figures

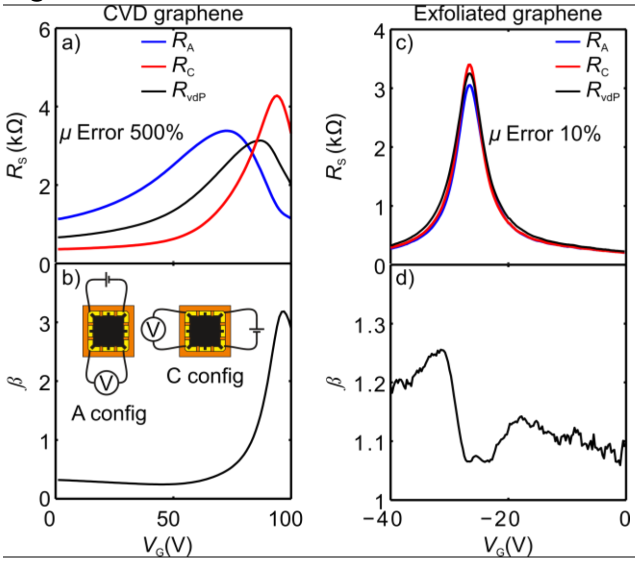

Figure 1:) CVD graphene device characteristics measured in the A config R_A, C config R_C, and calculated van der Pauw config R_{vdP}. b) Gate dependent device shape *ß* = R_A/R_C for data from Fig 1.a. Inset: Configs A and C. c/d) Measurements for exfoliated graphene encapsulated in hexagonal boron nitride.

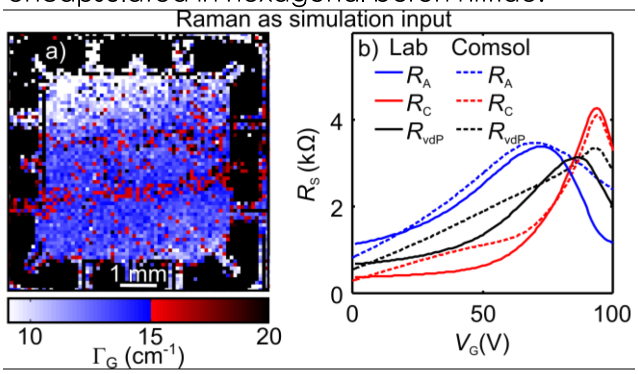

Figure 2: a) Raman map of 5625 spectra showing the FWHM of the G-peak (Γ_G). b) Comparison of electrical measurements (solid lines) and simulated gate data (dashed lines) using Raman maps as locations for isolating defects and doping.