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Charge transport mechanisms in GRM thin films: interplay between different length scales

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The processability and tunability of graphene 2-dimensional nanosheets make them an ideal test bed to study charge transport (CT) in systems with low dimensionality [1]. Here, we study CT in graphene-based materials with varying morphology at the atomic and mesoscopic scale, at temperatures from 2 to 300 K. We compare continuous layers of reduced graphene oxide (RGO, featuring higher sp^2 carbon content, high conductivity of the nanosheets but loose packing) with layers of exfoliated graphene oxide (EGO, featuring lower sp^2 carbon content but a better nanosheets packing).
We observe standard Variable Range Hopping (VRH) transport in RGO; conversely, EGO shows a power-law CT where the resistivity neither follows metallic nor insulating behavior. Such PL behavior is observed for EGO down to 10 K, and mimics CT in highly doped semiconductors near the metal-insulator transition. While the VRH mechanism was known for RGO networks [2], the PL behavior observed in EGO at low temperature is unique, and is attributed to the presence of an effective interaction between stacked nanosheets which, despite the low intrinsic conductivity of the single nanosheet, allow the resistivity to increase less than an order of magnitude in EGO as T approaches 0 K. Further insights in CT are given by magnetoresistance and electrical noise measurements. The striking differences in CT observed between RGO and EGO show how fascinating and complex such materials, that combines features of 1D, 2D and 3D systems, can be.

[1] Kovtun A. *et al*, ACS Nano, 15 (2021) 2654.
[2] Joung D. *et al*, Phys. Rev. B, 86 (2012) 235423; Vianelli A. *et al.*, Carbon, 89 (2015) 188.

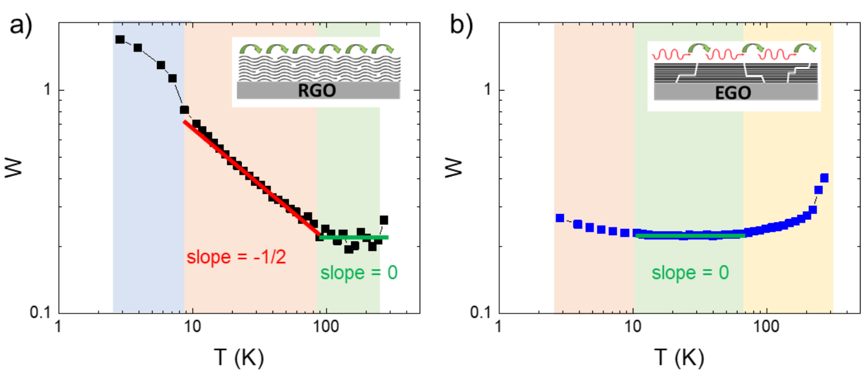

Figure 1: Reduced activation energy W as a function of temperature for the two systems compared in the study: a) RGO and b) EGO. The insets show a sketch of the charge carrier transport in the GRM network structure.