

Tuning the electronic properties of graphene nanoribbons by chemical functionalization

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Graphene presents remarkable properties, such as a high carrier mobility, optical transparency, and mechanical flexibility [1]. These properties potentially make graphene one of the most relevant materials in technology in the forthcoming years, but work still needs to be done to improve processing and production techniques of graphene for applications. Effort is being done in order to overcome the lack of a bandgap in graphene, which can be attained by the one-dimensional constraining into graphene nanoribbons (GNRs). We have recently developed a new method to produce highly aligned GNRs based on the controlled metal-assisted etching of single-layer graphene (Fig. 1a) [2,3]. Tuning of some other electrical properties, such as the carrier type and concentration, is also important for implementation of graphene nanoribbons in electronic applications.

In the present work we explored the chemical functionalization of our GNRs to tune the electronic properties. Two different molecules were employed for the functionalization, namely a diazonium salt

(4-NBD) [4], and diethylene triamine (DETA) [5] (see schematics in Fig.1b). The decrease of the 2D band relative intensity in Raman spectra following functionalization indicates the doping of the GNRs. Evolution of the shifts of the different bands after functionalization indicate that 4-NBD and DETA are producing hole- and electron-doping respectively, as the G band upshifts in both cases but the 2D band only does in the case of 4-NBD (Fig. 1b). Measurements in GNR field-effect transistors (FET) confirmed the Raman findings, with the charge neutrality point of the transfer curves shifting towards higher (4-NBD) or lower gate values (DETA) after functionalization (Fig. 1c). Moreover, it was observed that the doping effects are usually higher for the GNRs than for the graphene under the same conditions, pointing to an increase of the reactivity caused the presence of edges in the GNRs. This is also evidenced by the FET measurements, which do not show a large degradation in the current after the functionalization. Our results present a feasible way to modify the electronic properties of GNRs [6].

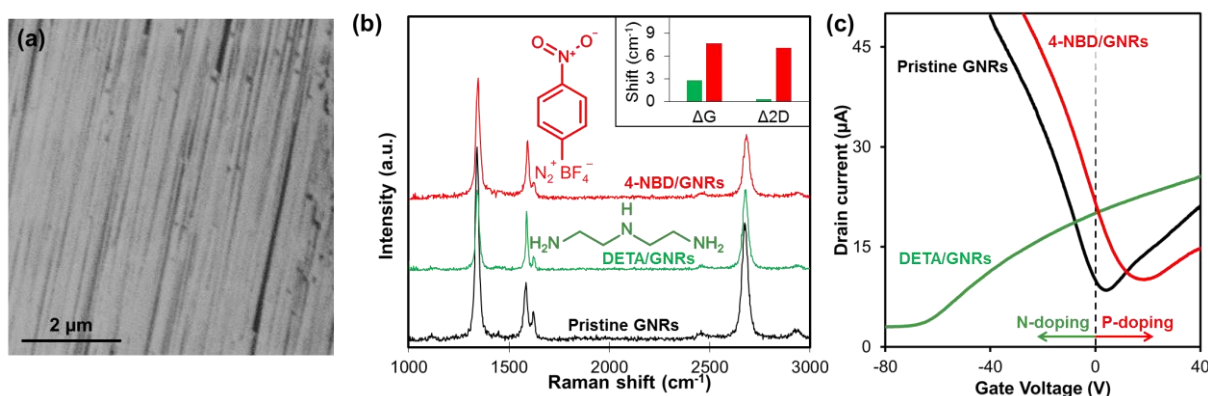


Figure 1. (a) SEM image of the GNRs (dark contrast). (b) Raman spectra of the GNRs before and after functionalization with DETA and 4-NBD. Next to each spectrum there is a schematic representation of the molecule employed for the functionalization. The inset represents the changes in the position of the G and 2D bands after the functionalization. (c) FET transfer characteristics of pristine and functionalized GNRs.

References:

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