Room temperature ballistic graphene p-n junctions defined by Zn metal doping

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Creation of sharp lateral p–n junctions in graphene, with transition widths w well below the Fermi wavelength λ_F of graphene charge carriers ($\lambda_F \approx 10nm$) is vital for the fabrication of graphene electron optical devices. The use of a double local gating approach allows the formation of p-n junction in graphene, but the width of the formed junctions is limited by the thickness of the dielectric layer [1]. However, even if the formation of ballistic p-n junctions presenting Klein tunnelling and electron optics phenomena (such as negative refraction of Dirac fermions [2]) have already been shown in graphene at cryogenic temperatures (T<4K), on very clean substrate (hBN), the formation of sharp ballistic p-n junction at room temperature and on conventional SiO_2 substrate has not yet been reported. Very recently, Chaves et al [3] in a theoretical study of graphene-metal interface showed that sharp p-n junctions (w<10nm) can be induced on graphene even at room temperature using metallic nano-island. In this study, we report the formation of sharp ballistic p-n junctions using Zn metal contacts. At first, Raman mapping and vector analysis verifies the induced high p-type graphene doping through Zn. Additionally, transfer length measurements are used in order to extract charge carrier mobility in graphene as well as the actual induced doping underneath Zn metal contacts. The ballistic propagation of carriers through the formed junctions up to room temperature is demonstrated. Finally, numerical solutions, using Landauer formalism, also verify the fully ballistic propagation and Klein tunnelling of carriers in the formed p-n junctions indicating the formation of extremely sharp planar p-n junction (w<5nm) close to metal contacts.

References

[1] U. Chandni et al, Nano Lett., 15, 2015, 7329
[2] G.H. Lee et al, Nat. Phys., 11, 2015, 925
[3] F. A. Chaves et al, Nanoscale, 11, 2019, 10273

Figures

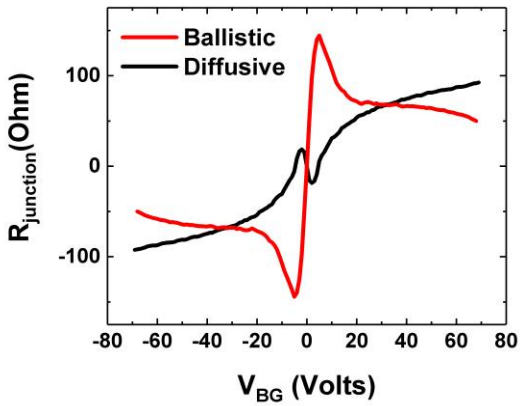

Figure 1: Resistance of graphene p-n junction ($R_{junction}$) versus the back gate voltage (V_{BG}) in ballistic (red line) and in diffusive regime (black line).