Evaluation and Study of Mobility in GFETs by geometrical magnetoresistance

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The low-field mobility in graphene field-effect transistors (GFETs) is usually evaluated by fitting the drain resistance model to transfer characteristics [1]. This approach has several limitations reducing accuracy. In particular, it requires knowledge of the total concentration of the charge carriers and assumption that mobility is constant. However, the mobility is constant only in the limited range of scattering by charged impurities [2]. The carrier concentration can be significantly modified by the interfacial capacitance [3]. As a result, the mobility found using the drain resistance model can be up to 3 times lower than that found e.g. in the delay time analysis [4]. In this work, we present a method of accurate evaluation and study of mobility in GFETs using geometrical magnetoresistance (GMR) [5]. The method is free from limitations of the drain resistance model, since it does not require knowledge of the carrier concentration and assumption of constant mobility, while maintaining a simple experimental set-up. The GFETs, with gate length of 1 µm and gate width of 15 µm were measured without and with magnetic field of 0.5 T obtained in a standard Hall measurement setup. Fig. 1 shows typical drain resistance of a GFET with and without magnetic field versus gate voltage (V_g) at drain voltage V_d=-0.1 V. Under magnetic field, the drain resistance is higher due to the GMR effect. Fig. 2 shows corresponding GMR mobility (μ_{GMR}) versus V_g. The μ_{GMR} decreases with V_g modulus due to contribution of the phonon scattering [2], and decreases significantly near Dirac voltage. The deepening at $V_g \approx V_d$ can be explained by formation of a region with residual concentration of the charge carriers at the drain side [6]. For comparison, the mobility calculated using the drain resistance model is 1400 cm^2/Vs, which is more than 2 times lower than the highest μ_{GMR}.

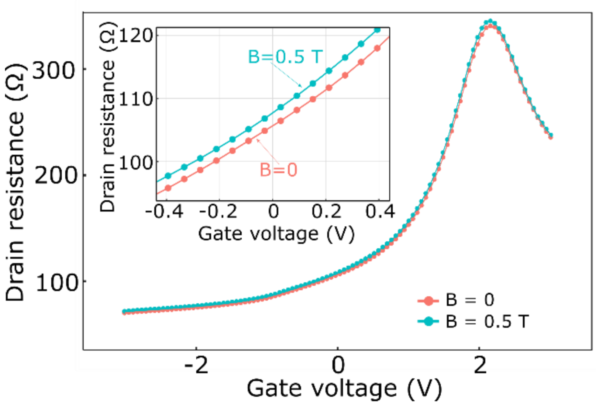

Fig. 1. The drain resistance vs the gate voltage with and without magnetic field. Insert shows the dependences in a narrow range of the gate voltage.

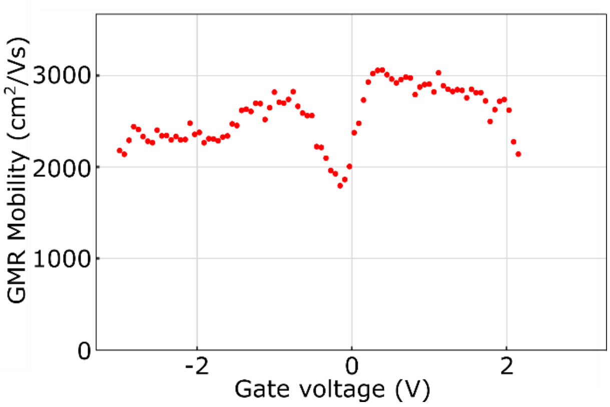

Fig. 2. The GMR mobility vs the gate voltage calculated using data from Fig. 1.

References

[1] S. Kim et al. *Appl. Phys. Lett*. 94, 062107, (2009).
[2] F. Giannazzo et al. *Nano Lett.* 2011, 11, 11, 4612–4618, (2011)
[3] M. Bonmann et al. *J. Vac. Sci. Technol. B*, Vol. 35, No. 1, (2017)
[4] M. Bonmann et al. *Appl. Phys. Lett.* 111, 233505 (2017)
[5] D. K. Schroder, Semiconductor Material and Device, Third Edition, p.480 (2006)
[6] I. Meric et al. *Nature Nanotechnology,* vol. 3, p. 654–659 (2008)