Towards superlattices: Lateral bipolar multibarriers in graphene

Martin Drienovsky, Franz-Xaver Schrettenbrunner, Andreas Sandner, Dieter Weiss, Jonathan Eroms

Institute for Experimental and Applied Physics, University of Regensburg, Regensburg, Germany

Ming-Hao Liu, Fedor Tkatschenko, Klaus Richter

Institute for Theoretical Physics, University of Regensburg, Regensburg, Germany

Abstract

Superlattice effects in graphene are currently under active investigation. Unlike moiré superlattices, where a modulation of fixed strength and fixed lattice period is achieved by the interplay of graphene and a thin layer of hexagonal boron nitride, a tunable modulation of arbitrary period is highly desired. Here we report on a detailed experimental and theoretical study [1] of graphene samples with a global back gate and patterned top gate. The latter consists of a periodic stripe array with a lattice period between 100 nm and 200 nm. Tuning back and top gates independently, we can achieve both a unipolar transport regime, where carriers below and in between top gate stripes are of the same polarity, and a bipolar regime, with carriers of opposite types. In the latter, pronounced single and multibarrier Fabry-Pérot (FP) resonances occur. Our data on different devices with different numbers of top gate stripes and lattice spacings are compared to a detailed transport simulation based on a tight-binding model. The gate coupling of the modulated top gate is modeled accurately by taking into account both the geometric and the quantum capacitance. We can explain the resistance oscillations observed in the experiment by individual FP cavities stringed together, without invoking a superlattice effect. This is in contrast to a recent publication [2] where similar data on similar devices was ascribed to an artificial band structure, even though the mean free path did not exceed the superlattice period.

References

[1] M. Drienovsky, et al., arXiv:1401.1955
[2] S. Dubey, et al., Nano Lett. 13, (2013) 3990.

Figure

(a): Four-point resistance of a graphene sample with 3 top gate stripes, with 100 nm lattice period. In the bipolar regime (higher resistance) FP oscillations with 2 periods (dashed lines) are clearly visible. (b): Inverse transmission from the corresponding transport simulation. The calculation closely matches the experimental data.