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Ten-nm scale ballistic graphene channels connected with ballistic contacts

The possibility to make 10-nm-scale, and low-disorder, suspended graphene devices would open up many possibilities to study and make use of strongly coupled quantum electronics and quantum mechanics. We first present a versatile method, based on the electromigration of gold-on-carbon bow-tie bridges, to fabricate low-disorder suspended graphene ballistic transistors and quantum dots with lengths ranging from 6 nm up to 100 nm (Fig. 1a-b). We can controllably tear the width of suspended graphene channels from over 100 nm down to 27 nm and create high-quality suspended quantum dots. In wider graphene devices, we explore the ballistic transport of Dirac fermions.

After electromigration (annealing) of the gold, graphene located under the suspended gold junction (Fig. 1 a-b) act as ballistic graphene contacts for the central (exposed) graphene channel. We measure Fabry-Pérot oscillations (Fig. 1c) in the charge transport corresponding to the two lengths of the cavities formed respectively by the graphene channel and the suspended graphene contacts. We discuss how annealed gold directly deposited on graphene can be used as a local gate and allows the formation of few-nm long graphene p-n junctions. We present initial data showing extremely high frequency electromechanical resonances in these short graphene resonators.

We briefly mention progress on ongoing projects to use these ultra-short transistors in quantum strain-engineering experiments, and studying the electromechanics of bilayer graphene.

References

[1] V. Tayari, A. C. McRae, S. Yigen, J. O. Island, J. M. Porter, and A. R. Champagne, Nano. Lett., 15 (2015).

Figures

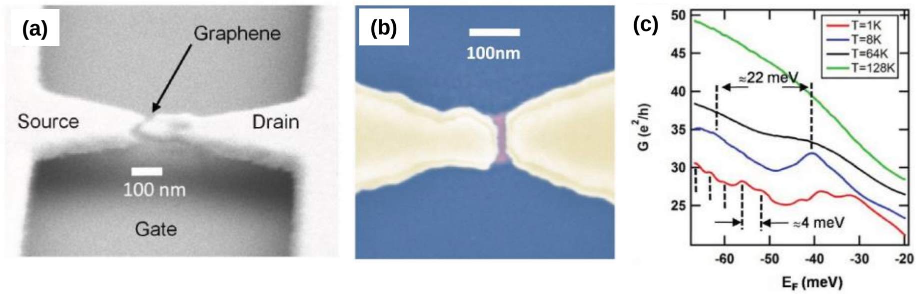

Figure 1: Ten-nm scale ballistic graphene channels. (a) Tilted SEM image of a gold-on-graphene breakjunction after electromigration of the gold to expose a short graphene channel. (b) Top view of a similar graphene channel (purple). (c) Transport data showing Fabry-Pérot oscillations whose two frequencies correspond to the length of the exposed graphene channel and length of the suspended graphene contacts.