Ballistic transport in CVD graphene

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Chemical vapor deposition (CVD) synthesis of graphene is a scalable and controllable method for the production of single layer graphene (SLG). This has been intensively studied during last few years with a strong focus on improving its electronic and structural quality in order to match that of exfoliated graphene.

Here we report the synthesis of SLG by CVD that has the electronic quality of exfoliated graphene, which shows ballistic quantum transport. The synthesis is done with well-defined conditions in a home-made ultra clean furnace. This is ultimately necessary to allow fine tuning of the growth parameters. While doing that, we have achieved a nucleation density down to ~ 1 mm^2, which in turn leads to large (~ 0.5 mm) single crystals. We have developed a dry transfer method that minimizes the contamination (i.e. from water in case of wet transfer methods). With this method we transferred SLG crystals onto hexagonal boron nitride substrates (hBN). The hBN was exfoliated onto SiO_2/Si substrates and acts as an ultra-clean and atomically flat substrate for graphene [1].

Transport measurements were done on Hall bar shaped geometries in a liquid He cryostat. At room temperature we measured a field effect mobility of 17.000 cm^2/Vs which increased to 50.000 cm^2/Vs at 4K. For the first time, ballistic transport over 1 µm in CVD graphene was observed by transverse magnetic focusing between neighboring contacts [2]. Atomic force microscopy confirms that wrinkles in CVD graphene breaks down ballistic transport. By reducing or even eliminating them the quality could be improved even further.

We conclude that CVD graphene that has been grown and transferred with our method maintains its high electronic quality that matches (or potentially exceeds) that of exfoliated graphene. With this growth and transfer method it is now possible to grow mm sized crystals that show ballistic transport on a micron scale, and can replace exfoliated graphene in both fundamental research and future devices..

[1] C. R. Dean et al., Nature Nanotechnol. **5**, 722-726 (2010).
[2] T. Taychatanapat et al., Nature Phys. **AOP**, (2013).

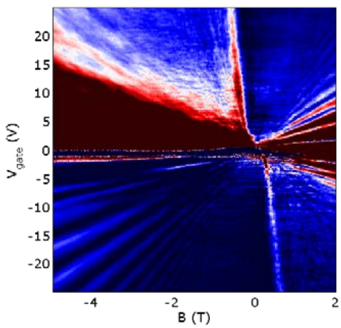

Fig. 1: Resistance between neighboring contacts in CVD graphene plotted as function of gate voltage and magnetic field. The square root line is due to transverse magnetic focusing, which is the evidence of ballistic transport.