ELECTRIC FIELD EFFECT OF QUANTUM OSCILLATIONS IN A FEW-LAYER GRAPHENE

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Introduction

Graphene is a terminology for a single layer of carbon atoms densely packed into a benzene-ring structure. This term is widely used for carbon-based materials, including graphite, carbon nanotubes, etc (e.g. carbon nanotubes are graphene sheets rolled up into nanometer sized cylinders). The transport properties of low dimensional graphite systems have been fully studied in carbon nanotubes. The recent study of electric field modulation in mesoscopic graphite at low field (up to 9 T) [1] has motivated the investigation of the quantum oscillations in a few-layer graphene (FLG) at high field (up to 33 T). Moreover, the purpose of this work is to examine the effect of electric field on the charge density wave (CDW) that has been observed in bulk graphite at field and temperature of 27 T and 1.7 K, respectively [2].

Experimental, Results, and Discussion

In the present work we have measured the in-plane resistance in high magnetic field of FLG of Kish Graphite samples, as shown in Fig. 1 (left). The Kish Graphite samples were cleaved with adhesive tape and transferred onto a SiO_2/Si substrate by pressing mechanically with fingers. The typical samples with lateral size of ~ 20 μm and thickness between 5 to 50 nm can be obtained. Once the samples are on the substrate the Cr/Au electrodes with the thickness of 5/25 nm are fabricated by photolithography, as shown in the inset of Fig. 1 (right). In addition, a doped silicon substrate is used as a gate electrode with 100 nm of silicon oxide acting as the gate dielectric. To obtain both longitudinal R_{xx} and transverse Hall R_{xy} resistance, the total voltage signal of the current-voltage was measured by applying forward and reverse magnetic fields perpendicular to the graphite layers at constant temperature vs. field for different gate voltage, R_{xx} and R_{xy} signals were derived from the sum and difference of the forward-reverse field sweeps, as shown in Fig. 1 (right). The preliminary result of the frequency of the quantum oscillations is ~ 5T at 0 V bias and changes as the gate voltage increases or decreases. The arrows in the inset of Fig. 1 (left) indicate the field induced CDW transition H_{CDW}, which also changes with the gate voltage. Significant changes in the resistivity and Hall effect vaules are also seen with gate voltage. A further analysis of these results is still in progress. The systematic study of different samples, such as HOPG (highly oriented pyrolitic graphite) and Kish graphite are also needed.

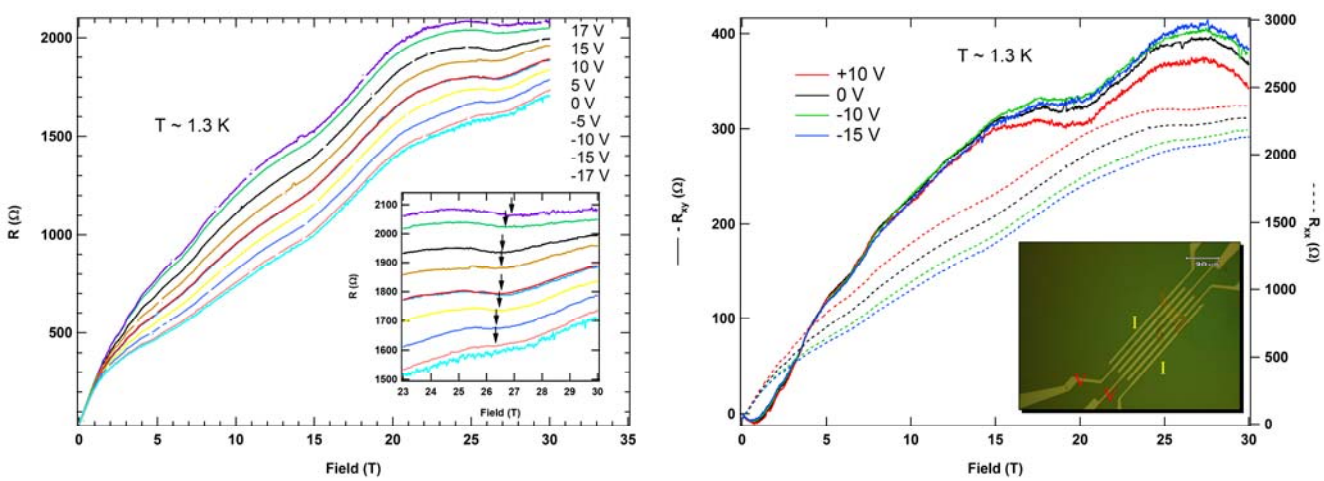

Fig. 1. Left: The resistance of FLG versus magnetic field for different gate voltage at temperature of 1.3K. Inset: The magnetoresistance at high field and the arrows indicate the H_{CDW} (see text). Right: The R_{xy} and R_{xx} signals versus magnetic field for different gate voltage. Inset: The optical microscope image of the FLG. The gap between two leads is 2 μm.

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References

[1] Zhang, Y., *et al*., Phys. Rev. Lett., **94**, 176803 (2005).
[2] Uji, S., *et al*., Physica B, **246-247**, 299-302 (1998).