Magnetoconductance Crossover in Thermally Reduced Multi Layer Graphene Oxide

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Introduction

Reduced graphene oxide (rGO) flakes are important because cost-effective mass production of graphene can be achieved from thermal reduction of graphene oxide. However the reduction is not perfect to obtain high-quality graphene and the properties of rGO attracts great attention. We investigated source-drain bias current and temperature dependence of magnetoconductance (MC) in rGO and found out MC sign crossovers.

Experimental

We have performed MC and *I-V* characteristics measurements of multi layers of rGO. The multi layers of rGO were prepared by modified Hummer's method. 4 probe Ti/Au 10/50 nm electrodes were prepared on top of the sample. The MC was measured at different current levels (bias voltages) at different temperatures by using 2 or 4 probe configurations. The measurement was performed in cell 8, NHMFL using a 35 Tesla resistive magnet.

Results and Discussion

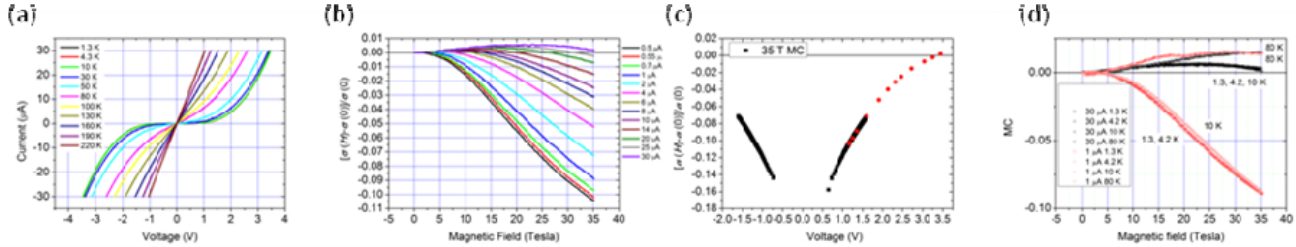

Fig. 1. Temperature dependence of *I-V* characteristics and electric field (Applied current, 4 probe) dependence of MC at 1.3 K of rGO (a) Temperature dependence of *I-V* characteristics of rGO (~ 9 layers) (b) Applied current dependence of MC at 1.3 K. The large negative MC moves to small positive MC as the applied current (Electric field) increases. (c) Electric field dependence of 35 T MC. Red dots represent 35 Tesla values of MC in (b). (d) Temperature dependence of MC at different bias currents of 1 μA and 30 μA (1 μA: Red, 30 μA: Black).

At 1.3 K, large negative MC was observed at low bias current (0.5 μA). As the applying current increased, the absolute value of the MC decreased and the sign changed to positive values. Similar sign shift has been reported in organic magnetoresistance (OMAR) systems, for example, in an ITO/polyfluorene/Ca device [1]. Temperature dependence of MC was investigated at different bias currents of 1 μA and 30 μA. The sign crossover was observed at 80 K to positive MC from negative MC when 1 μA was biased. However, the MC remained positive from 1.3 – 80 K when 30 μA was biased. The diminishing character is similar with that of polyacetylene nanofibers but the sign crossover is distinct from the diminishing MC of polyacetylene nanofibers [2].

Conclusions

We observed negative MC up to 35 Tesla in rGO flakes at 1.3 K at low bias currents. Interestingly the absolute value of the MC decreased as the source-drain electric field increased and eventually the MC became positive at high bias currents. The sign crossover was observed in temperature dependence of MC at low bias current. However it was not observed at high bias current.

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References

[1] Mermer, Ö., *et al*., Phys. Rev. B., **72**, 205202 (2005).

[2] Choi, A., *et al*., Phys. Rev. B. **86**, 155423 (2012).