Better than Hall? Increasing sensitivity of graphene magnetic sensor based on extraordinary magnetoresistance with peculiar effects

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Since its discovery, extraordinary magnetoresistance (EMR) has drawn a lot of attention to applications such as hard drive read heads and magnetic sensors. Recently, an extremely large magnetoresistance, $MR=(R(B)-R_0)/R_0\sim10^7\%$ are achieved in devices of graphene encapsulated in hexagonal boron nitride with a central metal shunt [1], exceeding that achieved in state-of-the-art semiconductor devices by one order of magnitude [2]. Encapsulated graphene is the most promising material for EMR devices among all reported to date [3]. We find the room-temperature sensitivity dR/dB of encapsulated graphene EMR devices to reach 102.2 kΩ/T at ~-0.2T [5], more than 3 times and 60 times larger than the previous records achieved in encapsulated graphene [1] and unencapsulated graphene [4], respectively. This sensitivity is comparable to recently reported in encapsulated graphene Hall sensor, however measured at 4.2K [6]. This suggests that graphene EMR sensors could outperform state-of-the-art sensors in room-temperature conditions, including graphene Hall sensors. We highlight that the room-temperature sensitivity in our EMR devices can reach 13 kΩ/T at B=-6.7 mT. We also demonstrate that the sensitivity can be enhanced by reducing the charge carrier density, lowering the temperature and increasing the charge carrier mobility. EMR devices also exhibit magnetic focusing, magnetic commensurability effects, weak localization and weak antilocalization [5], which may be employed to tune or improve the magnetic field sensing performance further. The appearance of these effects associated with cyclotron orbits, quantum coherence and device geometry suggests the EMR geometry as an interesting alternative to the Hall geometry for fundamental physics studies.

References

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Figures

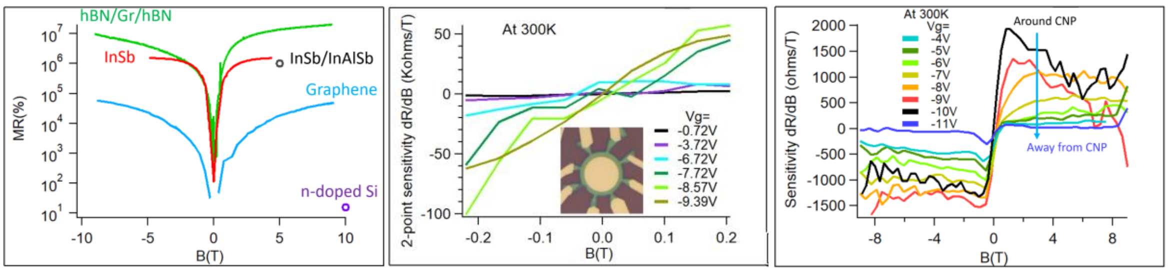

Figure 1: (a) The best magnetoresistance (MR) values reached in EMR devices made by different materials reported in literatures. (b) The largest room-temperature sensitivity dR/dB reached in encapsulated graphene EMR devices. (c) The sensitivity dR/dB of encapsulated graphene EMR devices increases with decreasing charge density (closer to charge neutral point (CNP)).