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Magneto-transport Properties of Graphene Foam

Large area single crystal two dimensional (2D) graphene is not realized to the date, which is the biggest hurdle for the utilization of graphene in practical electronic gadgets.[1] According to the roadmap of Novoselov et al.[2], high-quality large area 2D graphene may be available in 2035, indicating unavailability of large area single crystal graphene in the present days. However, hierarchy of 3D structure of 2D graphene such as graphene foam (GF) for graphene-based practical devices could turn as an alternate.[3] To the best of our knowledge, magneto-transport properties of bulk GF have not been explored so far. Magneto-transport properties of GF could be different in comparison to 2D graphene due to the presence of different sizes of graphene flakes and more crucially the types of connection between these flakes, presence of edge boundaries,[5] geometry of graphene edges,[6] difference in the stacking of graphene layers and different number of graphene layers.[7-9] Therefore, graphene morphology may influence on the motion and trajectories of the charge carriers under the applied magnetic field, thus, interesting electro/magneto transport properties can be observed. However, metal electrode deposition on the top of GF is a big challenge for studying electro/magneto transport properties.[10]
Herein, we present the first observation of magneto-transport properties of GF composed of a few layers in a wide temperature range of 2 − 300 K. The multilayer polycrystalline GF was fabricated with the help of Chemical Vapor Deposition (CVD) (Fig. 1a-f). Large room temperature linear positive magnetoresistance (PMR ~ 171 % at B ~ 9 T) has been detected.[11] The largest PMR ~ 213 % has been achieved at 2 K under a magnetic field of 9 T, which can be tuned by the addition of poly-(methyl methacrylate) to the porous structure of the foam. The excellent magneto-transport properties of GF open a way towards three-dimensional graphene-based magnetoelectronic devices. Magnetoresistance (MR) of graphene is fixed under a particular magnetic field and temperature but can be further improved or controlled by introducing artificial defect states. These artificial defects can be introduced via fluorination that is a conventional method to control the magnitude of MR required for magnetoelectronic applications. One of the main benefits of fluorination is the de-fluorination, which takes place within few days resulting in doping-free defects. Herein, tunable and temperature-independent magnetotransport of GF is achieved by controlled fluorination process for the first time. The magnitude of MR decreases with the increasing fluorination time (i.e. 30, 60 and 90 min), indicating defects induced scattering plays a major role in magnetotransport properties of fluorinated GF (FGF). The magnitude of MR in FGF specimens at room temperature (under a magnetic field strength of 5 T) was observed for three months, a particular value of MR (FGF-30 ~ 59%, FGF-60 ~ 58%, FGF-90 ~ 37%) is observed that is higher in magnitude than the first day of fluorination. In this way, fluorination of GF can provide a pathway to tune magnetotransport properties being very useful for magnetoelectronics devices especially highly sensitive magnetic sensors.

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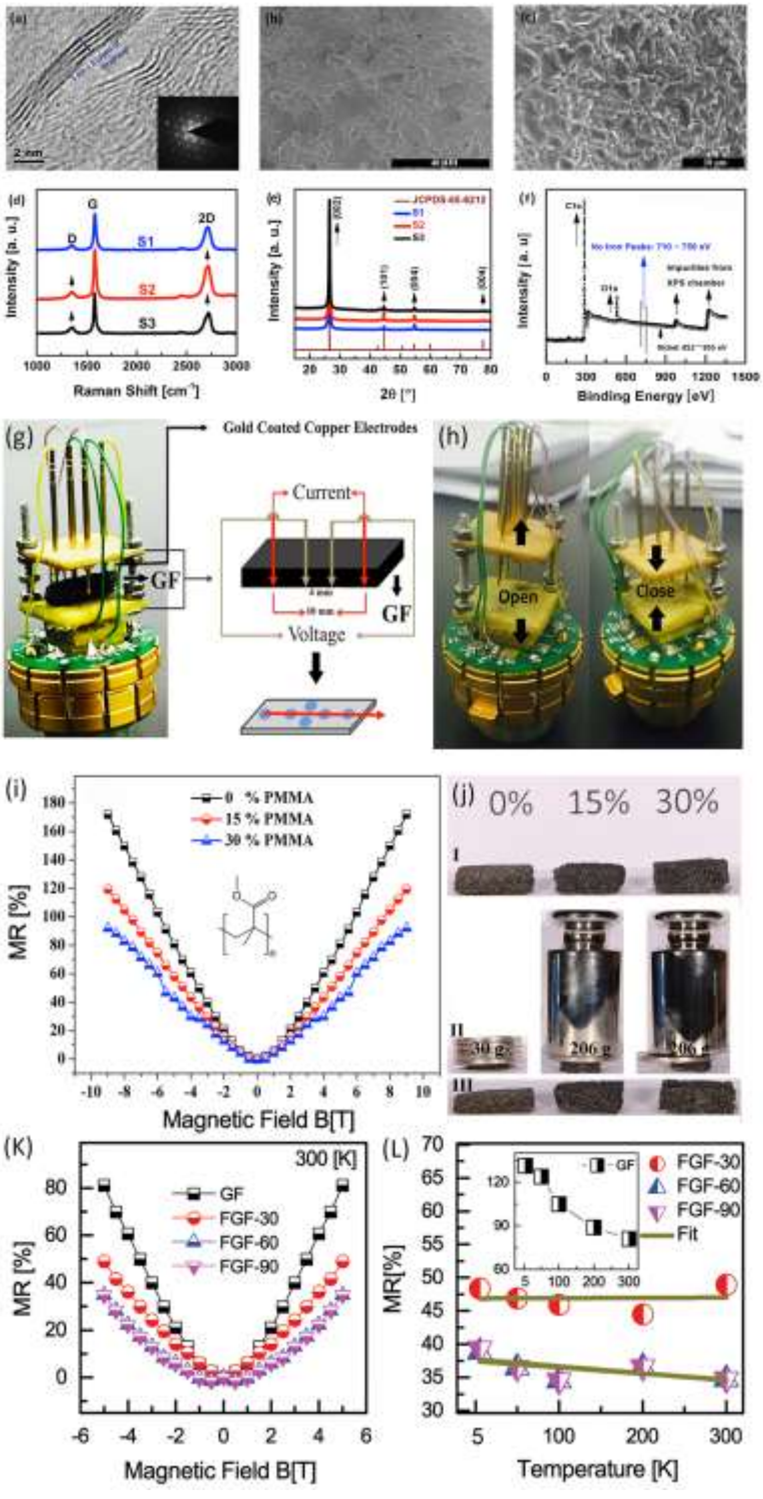

Figure 1: Characterization of Chemical Vapor Deposition (CVD) grown graphene foam (GF) (a-f). Electrode assembly for magnetotransport properties of GF (g-h). Magnetoresistance (MR) of GF and GF/Polymethyl-methacrylate (PMMA) specimen (i) Mechanical stability of GF *via* PMMA infiltration. MR of fluorinated GF (FGF) under 30, 60 and 90 mins.