Linear Magnetoresistance in Random Network of Nanosheets

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Many practical applications of two-dimensional (2D) materials require them to be solution-processable [1,2]. However, due to their granular nature and inevitable defects and impurities, charge transport behaviour in randomly stacked 2D nanosheets is significantly different from that of their parent layered crystals. To fabricate high performance devices using these materials, it is crucial to understand the factors controlling charge conduction in such systems. Here, we report an anomalous linear magnetoresistance (LMR) at high magnetic fields in a series of laminates made from randomly stacked graphene nanosheets, Figure 1 [3]. We suggest that the local Hall voltage in graphene nanosheets mixes with the longitudinal voltage, resulting in the observed LMR. Our analysis shows the slope of the LMR scales with inverse of square root of junction resistance between graphene nanosheets. We further demonstrate that the conductivity of individual nanosheets is encoded in the global response of the laminate, and the temperature dependence of the LMR provides direct evidence of the electronic quality of the individual nanosheets. Based on these findings we optimized our graphene ink to produce flexible laminates showing room temperature carrier mobilities of 2990 $cm^2 \cdot V^{-1} \cdot s^{-1}$. Additionally, by controlled thermolysis of minute organic molecules that are physisorbed on the graphene sheets, we can fine-tune the doping level of the graphene laminates. This leads to the production of n-type, neutral, and p-type doping from the same starting materials, with thermoelectric power factors exceeding 350 $\mu W \cdot m^{-1}.K^{-1}$. Our findings offer new insights into engineering charge transport in disordered systems made from 2D crystals and provide a promising avenue for creating dispersions suitable for flexible electronics and beyond [1-4].

References

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[2] Z. Lin, Y. Huang and X. Duan, Nature Electronics 2 (2019) 378
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Figures

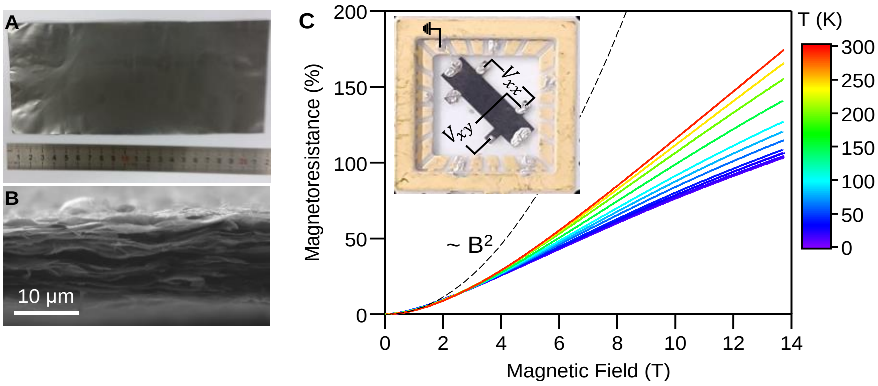

Figure 1: Charge transport in random network of graphene nanosheets: (A) Photograph of the laminate after solution casting, (B) and its SEM cross section micrograph. (C) Magnetoresistance of the laminates at various temperature showing linear response above 3 Tesla, deviating from quadratic response.