Electrical Transport in Partially Reduced 3D Graphene Aerogels

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Abstract

This work investigates the electrical transport of partially reduced 3D graphene aerogels (rGAs) over the temperature range 80–473 K. The aerogels were synthesized via a solution-based route using graphene oxide (GO) flakes crosslinked with ethylenediamine (EDA), and subsequently, one set was also thermally reduced at 200 °C. Electrical transport studies reaffirmed the semiconductive nature of the 3D rGA network. Low-temperature electrical transport studies were used to calculate hopping exponents for both kinds of aerogels (with and without annealing). All the annealed samples, along with one of the unannealed samples, showed disordered metallic behaviour with a hopping exponent near 0.006. However, unannealed samples lie in a 3D VRH regime with a hopping exponent close to 0.25. The resistance ratio is also stable after thermal annealing at 8-11, but for as-prepared samples, it varies with EDA content from 25 to 50. This clearly suggests that the EDA-treatment and thermal annealing that remove functional groups also improve the electrical pathways, resulting in lower hopping exponents and resistance ratios. In the case of high temperature (up to 200◦C), the annealed samples showed much more stable electrical conductivity than the counterparts. Comparing two annealed samples with different oxidative states, we found nearly stable resistance ratios (R_{80K}/R_{300K} ~8 and R_{300K}/R_{473K} ~ 2), indicating that the binder's initial effect is overridden by annealing. Impedance spectroscopy reveals a broadened frequency-independent plateau < 100 KHz, corresponding to ohmic transport through a well-connected 3D network. Low density and improved electrical conductivity make these rGAs ideal for lightweight interconnects, temperature sensors, EMI shielding, and thermal insulation for robotic skin and space applications.

References

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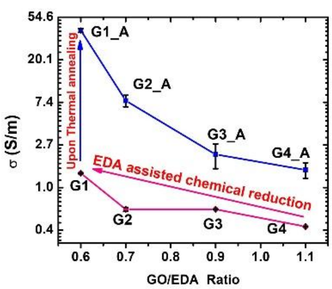
Figures



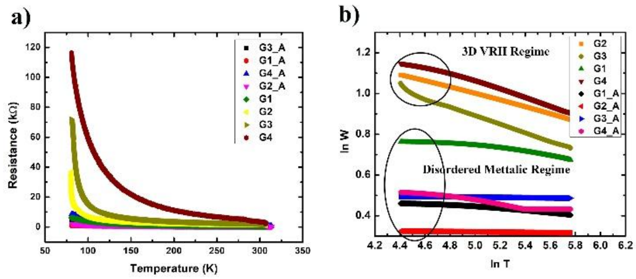


Figure 1. Electrical conductivity of partially reduced graphene aerogel as a function of GO/EDA ratio.

Figure 2. Resistance vs. temperature profile for (a) Unannealed and their annealed counterparts (b) ln W vs. ln T of unannealed and their annealed counterparts G1 A to G4 A.