Anomalous Electrical and Thermal Transport Properties of Pyrolytic Graphite Films at Near Room Temperatures

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The discovery of two-dimensional graphene leads to tremendous studies on its electrical, thermal, optical and mechanical properties, especially considering its unique honeycomb structure with strong sp2 carbon-carbon bonds. Among these, the high thermal conductivity of graphene has seen promising applications in thermal management in modern electronics. Actually, commercially available graphite or graphene films, which are claimed to have thermal conductivity as high as 1500 W/mK, has served as heat spreaders in CPUs of smartphones and laptops for years. However, the thermal transport properties in such graphene-based structure has not been fully understood, especially at temperatures largely deviate from room temperature. Here in the current work, we report a comprehensive study on the electrical and thermal transport properties in several commercially available graphite/graphene films from liquid nitrogen temperature up to around 500K. An unpredicted minimum electrical resistance was discovered at around room temperature in these graphite films produced from carbonization and graphitization of polyimide films. For comparison, the electrical resistance of the graphene films produced from exfoliated graphite decreases monotonously even up to 500K. Moreover, as the temperature increases and step across the transition temperature, the thermal diffusivity jumps down for nearly two folders. Further structure analysis shows that, the anomalous electrical and thermal transport properties in these graphite films but not in the graphene films is due to the unevenly distributed defects in such materials where thermally expansion or compression causes reversible separation of graphene flakes. This work provides crucial information for commercial application of such graphite films in thermal management of electronics in the 5G era.