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Characterization of Solution Processable Graphene for Electronic Applications

Many of the envisaged applications of graphene (i.e. printed electronics, batteries, composite materials) require few layer graphene flakes or graphene nanoplates that can be dispersed in solution. A variety of powders and dispersions purporting to contain graphene are now commercially available, However, the variable quality of these materials and lack of standardized protocols for their assessment is hampering the development of applications. Here we will describe ongoing work at the NRC aimed at developing characterization methods and standard protocols to characterize graphene powders and dispersions. We employ a variety of experimental techniques including scanned probe microscopies (AFM and STM), Raman spectroscopy, X-ray diffraction, X-ray photoelectron spectroscopy and dynamic light scattering in order to characterize the structure and chemical composition of these materials. These methods allow us to measure key parameters to assess the quality of these materials such as flake thickness and lateral size, carbon to oxygen ratio and impurity content.

Solution processable routes to graphene can be grouped into three approaches- a) bottom-up growth of flakes in the gas phase, b) exfoliation of graphite without oxidation and c) exfoliation via oxidation to graphene oxide (GO) followed by reduction. While the fabrication of GO produces a large fraction of large single layer flakes that are readily dispersed in water, reduction is usually incomplete and results in defective graphene which will reduce electrical conductivity. On the other hand, methods to produce graphene without oxidation typically result in few layer graphene nanoplatelets that are rather difficult to disperse, Properties of films made from these dispersions are dependent on both the quality of the individual flakes and details of how the flakes assemble into films. The preferred route for obtaining a graphene film will depend on the required properties and process constraints for a given application. Transparent conductive films have been fabricated from different in-house and commercially available GO and graphene containing dispersions and processed by various routes. The performance of these films can be characterized by a figure of merit based on the optical transmission and conductivity of the film. Performance of films made via reduction of GO will be compared with those based on directly exfoliated graphene.