Functional Graphene-Polyelectrolyte Thin Films Formed By Hydrogen Bonding

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Abstract

This study focuses on incorporating surfactant assisted exfoliated pristine graphene nanoparticles into polyelectrolyte multilayers using hydrogen bonding to create functional thin films.

Electrically conducting thin films are essential for a variety of applications including solar cells, photonics and flexible electronics. Traditional inorganic thin film materials are reaching their technological limit. Organic based thin film systems that incorporate innovative materials are increasingly being studied in an effort to enhance electrical, thermal, optical and mechanical properties and provide added functionality. Recently, graphene, a carbon allotrope consisting of single layer macroscopic carbon sheets, has attracted considerable interest in a range of research fields due to its unique 2D structure [1]. As a consequence of this unique structure, graphene possesses remarkable electrical conductivity, tensile strength, flexibility and optical transmittance, making it ideal for integration into thin films.

Previous studies have formed thin films from the layer by layer addition of oppositely charged polymers and graphene sheets through strong electrostatic interactions [2]. This study focuses on incorporating graphene nanoparticles into polyelectrolyte multilayers using hydrogen bonding. First, dispersions of pristine graphene nanoparticles were created from synthetic graphite using a method of surfactant-assisted exfoliation [3]. Thin films containing the anionic polyelectrolyte, polyacrylic acid and graphene nanoparticles were then constructed using the layer by layer approach [4]. Films were prepared using dip coating at low pH and the Quartz Crystal Microbalance (QCM) apparatus was used to monitor the deposition kinetics and adsorbed amount.

A flow diagram of the process used to create and characterize graphene-polyelectrolyte thin films through hydrogen bonding is shown in Figure 1.

A range of analytical techniques were used to characterize the resultant film composition, surface features and mechanism of formation for the thin films. QCM measurements, Raman spectra and UV visible spectra indicate the successful formation of thin film multilayers incorporating polyacrylic acid and surfactant exfoliated graphene nanoparticles, suggesting hydrogen bonding facilitates film formation in such systems. However, atomic force microscopy imaging, in addition to optical microscopy indicated partial dewetting of the films from the silica substrates. It was also demonstrated that film growth proceeded exponentially during deposition of the first few bilayers, but became linear as significant numbers of bilayers were adsorbed. These results give an indication as to the quality and characteristics of thin films containing graphene nanoparticles, and formed through layer by layer deposition in addition to the mechanism of graphene multilayer thin film formation. These insights may guide further studies regarding graphene-based thin films.

References

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Figures

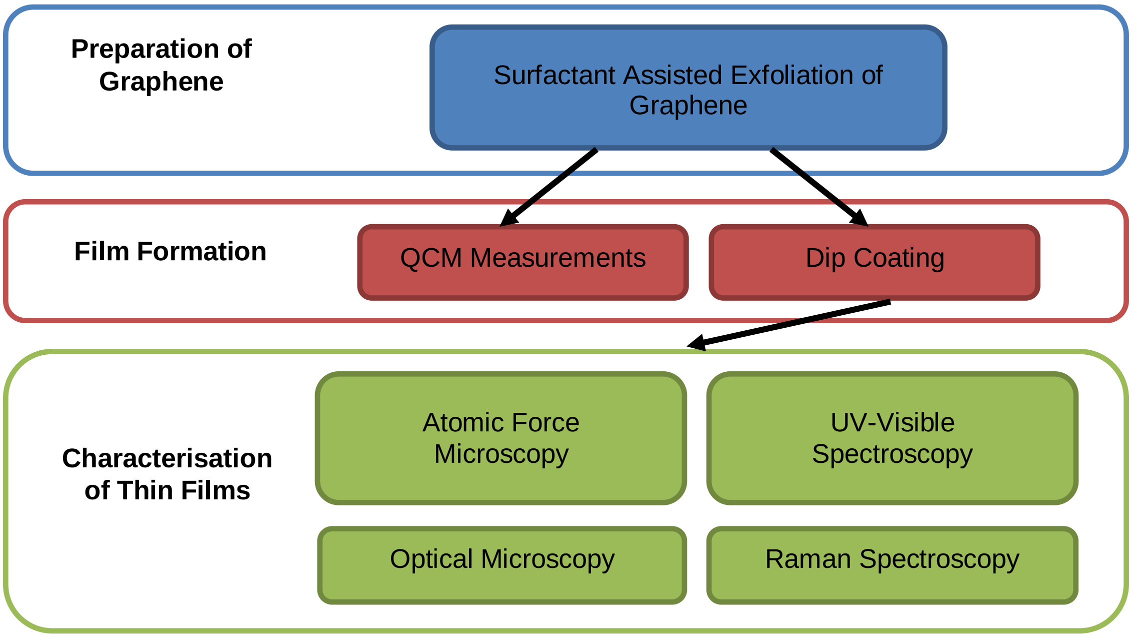

Figure 1: Flow diagram showing the techniques used in the preparation of graphene, film formation and characterization of thin films.