Synthesis of Transparent Conducting Hybrid Film of Metalliuc SWCNT and Graphene

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Abstract

Organic electronic devices are receiving growing interest because of their potential to employ lightweight, low-cost materials in a flexible architecture. These devices contain organic semiconductor materials that can be uniquely tuned to enable properties and performance which can be competitive with entrenched inorganic electronics, while facilitating other exciting niche applications. Organic electronic devices such as organic photovoltaics and organic light emitting diodes require the use of a transparent electrode to allow photons to enter or exit the devices efficiently and to simultaneously allow the extraction or injection of charge carriers. Typically, indium tin oxide (ITO) is utilized as the electrode due to its excellent transparency throughout the visible spectrum, its relatively low sheet resistance, and its work function, which is compatible with the injection and collection of charge carriers in organic semiconductors.

However, ITO may ultimately hinder the full market integration of organic electronics due to its increasing cost, lack of mechanical flexibility, chemical instability, and sustainability pertaining to the environment and material utilization. Therefore, alternatives for ITO in organic electronics are being pursued. Transparent electrodes comprised of carbon nanomaterials are an appealing choice as a surrogate for ITO in organic electronics because of the extraordinary electrical and mechanical properties these structures possess, and the demonstrated potential of state of the carbon nanomaterial films. As such, the research presented in this dissertation has been conducted to advance the goal of manufacturing SWCNT/graphene hybrid networks with transparent electrode properties that meet or exceed those of ITO.

In order to fully realize the potential of SWCNT networks as a transparent electrode, monodisperse networks that leverage the electronic homogeneity of the film were investigated and discussed. Metallic SWCNT films were found to have superior optoelectronic properties in comparison to similarly processed SWCNT films. Electrical sheet resistance evaluation, and optical spectroscopy combined with a theoretical understanding of metallic and semiconducting SWCNT were employed to clearly describe the impact of structure on these films.

In this dissertation, SWCNT films were characterized with regard to the collective and individual properties of the SWCNTs that comprise the network. The insight gained from evaluation of intrinsic SWCNT properties was effectively leveraged to expand the present understanding of SWCNT networks to facilitate future SWCNT-based electrode development.

References

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Figure: TEM image a) single layer of graphene, b) few layer of graphene.