

## CHAPTER I

### INTRODUCTION

In recent years, development of flexible and bendable energy storage devices has received strong attention in order to meet the next-generation electronic equipment including rollup displays and wearable devices. The flexible electrodes also attracted a lot of interest among researchers and industries for various applications. Specially, the increasing demand for flexible touch screens has motivated the researchers for production of new and inexpensive electrodes. These electrodes should have easily production, good conductivity and good mechanical flexibility.

Not only flexible electrode but also polymer solar cells (PSCs) have received great interest due to many advantages over Si-based solar cells such as low cost, light weight, flexibility, ease of fabrication and compatibility with the roll-to-roll manufacturing. Bulk heterojunction (BHJ) polymer solar cells with an active layer adopted by blending of conjugated polymers (electron donor) and fullerene derivatives (electron acceptor) have been used to improve the performance of PSCs by providing a large number of sites for charge separation and bicontinuous pathways for efficient carrier transport. The power conversion efficiency (PCE) of BHJ polymer solar cells consisting of Poly[[4,8-bis[(2-ethylhexyl)oxy]benzo[1,2-b:4,5-b']dithiophene-2,6-diyl][3-fluoro-2-((2ethylhexyl) carbonyl) thieno[3,4-b]thiophenediyl]] (PTB7) and PC<sub>70</sub>BM - [6,6]-phenyl-C<sub>61</sub>-butyric acid methylester (PC<sub>61</sub>BM) can reach to 9.2 %.

For enhancing stability, an inverted structure has been developed in which an anode interfacial layer as hole transport layer (HTL) between high work function metal anode and the BHJ in order to decrease the sensitivity to oxygen and moisture in air and a cathode interfacial layer as electron transport layer (ETL) between the indium tin oxide (ITO) cathode and the BHJ for avoiding degradation performance from poly(3,4-ethylenedioxythiophene) : poly(styrenesulfonate) (PEDOT:PSS) at ITO interface because of the strong acid nature of PSS.<sup>8-10</sup> The most popular HTL is

PEDOT:PSS which have achieved the highest %PCE in PSCs. However, several drawbacks of PEDOT:PSS have been reported such as strong acidic nature of PSS<sup>10</sup>, high cost and low electrical conductivity.<sup>1</sup> Therefore, an interested and important topic is still to develop a new HTL material with superior properties composing of : (i) processing solvent should be orthogonal with active layer. (ii) the work function of HTL material should be more than 5.0 eV. (iii) the HTL should have very high transparency so that the more sunlight can pass through the active layer.

Graphene, which is a two-dimensional all-sp<sup>2</sup>-hybridized carbon nanostructure, has various properties such as high electrical conductivity and charge-carrier mobility, good transparency, high mechanical strength, inherent flexibility and large surface area so, it is expect to be an ideal material for electrode. Graphene can be obtained through various physical and chemical routes. Micromechanical cleavage of graphite was the initial approach to produce single layer graphene, but it is not suitable for large scale production due to its inefficient process and no control over the number of layer. Epitaxial grown of graphene and chemical vapor deposition (CVD) had been reported to fabricate large-area graphene film, however, these methods are limited for specific conditions of application, such as high temperature, ultrahigh vacuum, and capital equipment dependence. An alternative approach to cost-effectively large-scale produce graphene-based devices is to first produce graphite oxide (GO) and then reduce it to reduce graphene oxide (RGO). Graphene oxide (GO) consists of a two-dimensional (2D) sheet of covalently bonded carbon atoms bearing various oxygen functional group (e.g., hydroxyl, epoxide and carboxyl groups) on their basal plane and edges. which make GO facilitate to form film by solution-based fabrication process. Unfortunately, GO exhibits poor conductivity due to the interruption of conjugation by substituted oxygen functional groups. Chemical reduction has been used to restore the sp<sup>2</sup> network of highly conducting and converted it to RGO. In 2011, Wang et al. prepared RGO by simply heating a GO suspension under strongly alkaline conditions after ultrasonic process while Yun J.-M. et al. reported a newly conversion GO to RGO by using p-toluenesulfonyl hydrazide (p-TSH). Although, RGO is better electrical properties, it

also decrease in their hydrophilicity leads to their irreversible agglomeration and precipitation.

Layer-by-layer (LbL) self-assemble technology is one of the most effective synthesis tools to fabricate highly ordered nanoscale structures with extended functionalities and activities. Usually, the LbL assemble deposition is mainly controlled by a charge compensation mechanism, via the electrostatic interaction of positively charged poly diallyldimethylammonium (PDADMAC) or negatively charged components.

For intrinsic conducting polymers (ICPs), polyaniline (PANI) has been widely used in sensors, supercapacitors and organic light-emitting diodes because of their high conductivities high thermal stability and ease of synthesis. PANi can be synthesized by in-situ polymerization with PSS for soluble in water, and thus PANi-PSS can be used as HTL in inverted PSCs.

In this project, we divided into two parts, synthesis and application of graphene oxide. GO was synthesized by modified Hummer's method and converted to RGO under alkaline condition and p-TSH reduction with PSS. For applications part, we have developed flexible thin film electrode by using LbL technique of RGO/PDADMAC nanocomposite and improved interface between PTB7:PC<sub>71</sub>BM as active layer and poly(ethylene dioxythiophene) :poly(styrenesulfonate) (PEDOT:PSS) as HTL by RGO/PANI composite in water solution by spin-coating.