PREFACE

Bulk heterojunction (BHJ) based organic solar cells (OSCs) are gaining greater attention for clean energy production due to various features, namely low-cost, easy fabrication process, the feasibility of solution process, mechanical flexibility, non-toxicity, and biodegradability. Recently, the low bandgap polymer, poly[N-9′-heptadecanyl-2,7-carbazole-alt-5,5-(4′,7′-di-2-thienyl-2′,1′,3′-benzothiadiazole)] (PCDTBT) has been considered to be more suitable p-type donor polymer for the OSC. The PCDTBT is blended with the commonly used acceptor polymer $PC_{61}BM$ for the fabrication of OSC and provides better stability as well as improved photovoltaic parameters. Considering the above aspects, the present thesis is focused to fabricate and characterize the PCDTBT:$PC_{61}BM$ active layer based BHJ OSC by modifying the interface layer, transport layers, and the photoactive layer. The works of the thesis are intended to enhance the photovoltaic parameters through thin film engineering. The thesis consists of five chapters which are briefly outlined in the following sentences.

Chapter-1 introduces the inorganic and organic semiconductors and charge conduction mechanism through them. A brief discussion on solar cells is included. Further, various types of organic solar cells, including the BHJ OSC, are discussed along with working principles and important photovoltaic parameters. A detailed literature survey followed by the scope of the present thesis has been finally outlined in this chapter.

Chapter-2 reports the PQT-12 polymer-based interface layer (IL) effect for the improvement in the photovoltaic parameters of the BHJ OSC. The floating film transfer method (FTM) is adopted for the deposition of PQT-12 thin film. Two distinct BHJ

OSCs have been fabricated in the device structure of ITO/ZnO QDs/PCDTBT:$PC_{61}BM$/PEDOT:PSS/Ag and ITO/ZnO QDs/PCDTBT:$PC_{61}BM$/PQT-12/PEDOT:PSS/Ag for the comparative study. The effect of PQT-12 IL has been investigated by several characterizations, namely current-voltage characteristics, absorbance, photoluminescence (PL), impedance spectroscopy, and external quantum efficiency. The OSC with the PQT-12 based IL has shown improved photovoltaic parameters.

Chapter-3 investigates the effect of thickness variations of the electron transport layer (ETL) as well as hole transport layer (HTL) on the performance of PCDTBT:$PC_{61}BM$ based BHJ OSCs. The BHJ OSCs are fabricated in ITO/ZnO QDs/PCDTBT:$PC_{61}BM$/PQT-12/Ag structure, where ZnO QDs and PQT-12 are used as ETL and HTL, respectively. ZnO QDs ETL has been deposited by a solution-processed spin coating method, whereas PQT-12 HTL has been deposited using the FTM technique. The best OSC device performance has been obtained with the 35 nm ZnO QDs and 20 nm PQT-12 thicknesses.

Chapter-4 deals with the fabrication and characterization of two distinct BHJ OSCs in the device structures, ITO/ZnO QDs/PCDTBT:$PC_{61}BM$/MoO_3/Ag and ITO/ZnO QDs/PCDTBT:$PC_{61}BM$:CdSe QDs/MoO_3/Ag. The synergistic effect of CdSe QDs and $PC_{61}BM$ is investigated in the ternary OSC device, where ZnO QDs and MoO_3 are used as ETL and HTL, respectively. The device structure, ITO/ZnO QDs/PCDTBT:$PC_{61}BM$:CdSe QDs/MoO_3/Ag has shown the improved photovoltaic parameters compared to other OSCs described in Chapter-2 and Chapter-3. The maximum efficiency of 5.02% is achieved due to the synergistic effect of CdSe QDs and $PC_{61}BM$.

Chapter-5 includes the major findings of the thesis along with a brief outline for the future scope of research related to the present thesis.

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