Development of highly efficient organic and perovskite solar cells

Abstract

With rapid industrial development and global population growth in 21st century, the search for renewable energy source becomes more important. Among various renewable energy sources, solar energy is the most plentiful one. Great efforts have been made to develop high efficient and low cost photovoltaic (PV) technologies. So far, the dominant PV technology is based on inorganic semiconductor materials, such as Silicon (Si) and Gallium arsenide (GaAs). Despite with the high solar energy conversion efficiency, these PV technologies require strict manufacturing processes and have very high materials and fabrication costs. To make the PV technology price cheaper, people have been searching for other types of solar cells using cheap materials and low-cost manufacturing processes. Organic solar cells (OSCs) and perovskite solar cells (PrSCs) have attracted lots of attentions as a new generation of PV technologies recently. They are attractive because of their low-cost fabrication process, mechanical flexibility, solution processability, etc. The objective of this work is to improve the performance and reduce the fabrication costs of the OSCs and PrSCs. First, a newly synthesized n-type conjugated polyelectrolyte (CPE), poly [9,9-bis((60-N,N,N-trimethylamino)hexyl)-fluorene-alt-cobenzoxadiazole dibromide] (PFBD), was applied into OSCs with an inverted structure as electron transporting material (ETM) to improve the OSCs' performance. The OSCs using PFBD as the ETM exhibited a better power conversion efficiency (PCE) and improved stability. Through study of the so-called light-soaking effect observed in our OSCs based on PFBD, we found that the change of work function of ITO electrodes modified by PFBD plays an important role in influencing the OSCs'

performance. Based on these findings, we proposed some guidelines for designing and developing highly efficient CPE materials for ETMs in OSCs. Second, we studied the factors that can influence the performance of PrSCs by applying a series of newly synthesized p-type polymers into PrSCs as hole transporting materials (HTMs). These polymer HTMs have almost the same band energy levels but different crystallinity, thus demonstrating different performance when applied into PrSCs. So except for band alignment between HTMs and photoactive layers, crystallization of the HTMs is also very important. The polymer HTM with the highest crystallinity has the best performance with a PCE of 14.02%. Last, we designed and fabricated fully printable OSCs and PrSCs by using a transfer printing technique to deposit electrodes. Compared with the traditional thermally or E-beam evaporating methods, our transfer printing method introduced less defects into organic layers and improved the performance and stability of OSCs and PrSCs. This transfer printing process is also compatible with the roll-to-roll manufacturing process and can significantly reduce the manufacturing costs of OSCs and PrSCs.