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Enhanced performance of perovskite solar cells using p-type doped PFB:F4TCNQ composite as hole transport layer

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ABSTRACT
Conjugated polymers have been widely used as hole transport materials (HTM) in the preparation of mesoscopic perovskite solar cells (PSCs). In this work, we employed p-type doped conducting polymer known as poly(9,9-dioctylfluorene-co-bis-N,N-(-4-butyl phenyl)-bis-N,N-phenyl-1,4-phenylenediamine) (PFB) as a hole transport material (HTM) in perovskite based solar cell. The effect of dopant concentration on the optical and electrical properties of PEB was investigated to optimize the electrical properties of the material for the best function of the solar cell. The highest power conversion efficiency of mesoscopic perovskite solar cells (PSCs), fabricated in this investigation, was found to be 14.04 % which is 57 % higher than that of pristine PFB hole transport layer. The UV-Vis absorption and Raman spectroscopy measurements confirm the occurrence of oxidation in a p-type doped PFB hole transport layer. This is attributed to the transfer of electrons from the highest occupied molecular orbital (HOMO) of PEB to the lowest unoccupied molecular orbital (LUMO) of F4TCNQ. The solar cells produced using p-type doped PFB:F4TCNQ composite not only improves device performances but also shows superior long-term stability. The optical, morphological and electrical properties of the doped composite PFB: F4TCNQ and newly fabricated devices are presented and discussed in this paper.

Keywords: Perovskite; Solar cell; P-type PFB; Hole transport material; Device stability.

1. Introduction

More than ever before, today the world needs a renewable energy source to save the planet earth from recurring natural disaster caused by global warming due to the high carbon dioxide emission into the atmosphere. Solar energy is one of the possible renewable energy sources which have a vast potential to satisfy the ever-increasing energy demand of our society. Solution processable perovskite based solar cell has become the most popular thin film solar cell technology at present. Therefore, the most important requirements of this technology is needed to reduce the cost of device preparation with high performance and long-term stability[1]. The general chemical formula structure of perovskite-based organo-metal halide as light absorbing materials is ABX_3, where A is a mono monovalent cation such as methylammonium (MA), formamidinium (FA), and Cs, or Rb), B is lead (Pb) or tin (Sn), and X is a halide such as Cl or Br or I, which offers several attractive photovoltaic properties [2–10]. The power conversion efficiency (PCE) of the perovskite based solar cell has steadily grown from less than 3.8 % in 2009 to well over 22.1 % at present [2, 10–15]. Until now, the highest recorded efficiency of a perovskite solar cell by the National Renewable Energy Laboratory (NREL) was 22.7 % [2].
Perovskite-based organo-metal halide has attractive features as the most encouraging materials for next-generation solar cells due to their potential properties for solar cell application such as long carrier diffusion length, high charge carrier mobility, high absorption coefficient, direct band gap, broad spectral absorption, and high crystallinity [2, 14, 16]. Furthermore, the processing of perovskite solar cells is compatible with a roll to roll device fabrication which certainly reduces the cost of device production and ease fabrication thin film solar cells [16, 17]. One of the main challenges in the realization of perovskite solar cell is the instability of the film under ambient condition. Hence, appropriate choice of hole and electron transport materials plays a critical role in addressing the challenges of poor device stability and improving power conversion efficiency [2, 8, 9]. The hole transport materials (HTMs) are designed to facilitate the extraction and transportation of photo-generated holes from perovskite solar absorber to metal electrodes, by way of reducing the losses that occur mainly through recombination at the active layer/electrode interfaces. Both organic and inorganic

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