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Efficient and stable planar perovskite solar cells with a PEDOT:PSS/SrGO hole interfacial layer

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ABSTRACT

An efficient planar perovskite solar cell (PSC) was fabricated with a bi-layer consisting of the poly (3,4-ethylenedioxythiophne):poly (styrene sulfonate) (PEDOT:PSS) and sulfonic acid functionalized graphene oxide (SrGO) as a hole interfacial layer. The low temperature and solution processed PEDOT:PSS/SrGO interlayer produced better power conversion efficiency (PCE) of 16.01% than other single layers. Comprehensive investigations reveal that the increased PCE is mostly due to the decreased recombination and the increased built in potential for better charge transport and extraction. In addition, the device with PEDOT:PSS/SrGO showed excellent long-term stability in ambient air conditions. Consequently, these results support that the introduction of graphene materials into interlayers can be a promising approach for high performance and cost-efficient solar devices.

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1. Introduction

Hybrid lead halide-based perovskite solar cells (PSCs) have been focused as a promising next-generation solar cell technology due to the superior optical and electrical properties, simple manufacturing processes, and low-cost production [1–3]. In the last few years, the PSC efficiency has been achieved up to 23.7% due to the rapid development and improvement in the key materials, process, and device research fields [4–7]. In perovskite solar cells, mostly two types of cell structures were used: mesoporous and inverted planar structures [8]. Mesoporous structure PSC generally consisted of a front electrode/compact TiO_2/mesoporous TiO_2/perovskite/hole transport layer (HTL)/a rear electrode. However, this device could consume high energy due to the mesoporous TiO_2 as it required a high temperature sintering procedure of 500 °C. Hence, this material cannot be augmented in flexible device applications [9]. Nowadays, p-i-n type inverted structure solar cells have gained considerable attention because of their simple fabrication methods with low temperature and negligible photocurrent density-voltage (J-V) hysteresis [10–12]. The inverted planar structure usually consists of poly (3,4-ethylenedioxythiophne):poly (styrene sulfonate) (PEDOT:PSS) as HTL and [6,6] phentyl-C_{61}-butyric acid methyl ester (PCBM) as electron transport layer (ETL). Specially, the PEDOT:PSS could be the most popular HTL in solar devices, because it involves low temperature processability and simple solution-process ability [13–15]. However, the device stability and the relatively low efficiency of the PEDOT:PSS as a HTL material still remain a problem [16–18].

Recently, for the better HTL fabrication, many trials have been conducted on the use of two different materials to provide synergetic effect on the hole transporting ability [19–25]. Specially, the effectiveness of graphene derivatives (graphene oxide (GO) or reduced graphene oxide (rGO)) for composite or bilayer interlayers has been recently reported [23–26]. In fact, with their excellent features including low temperature solution-processability, simple conductivity controllability, and high material stability [18,27], graphene material based composite or bilayer HTLs improved the device-efficiency and stability compared to the single layer HTL [23–25]. However, GO has an insulating property with low conductivity, and the conventional and commercial rGO could have poor dispersion-ability and aggregation problems due to highly limited hydrophilic functional groups [26].

In this work, we report the effects of the PEDOT:PSS/SrGO double HTL on the device-performance and stability, and this double layer was investigated in planar p-i-n structure perovskite

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