Carbon nanotube films for perovskite solar cells

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1. Introduction

A film of single-walled carbon nanotubes (SWNTs) can be flexible and stretchable transparent-conductive layer. At the same time, this film can be carrier-selective layers, i.e., electron-blocking-layers or hole-blocking-layers, by using adequate doping. We have demonstrated efficient SWNT/Si solar cells [1,2] and organic solar cells [3,4] using dry-deposited high-quality SWNTs and honey-comb-structured SWNTs. For organic solar cells, the SWNT doped by MoO_x and PEDOT:PSS demonstrated a dual function, which can replace both ITO and electron-blocking-layer [3]. Using this advantage of the SWNT film, flexible organic solar cells were fabricated with ease [3]. Also, it was possible to replace electron-blocking-layer and metal electrode for inverted-type organic solar cells [4]. The removal of metal electrode enabled flexible, the semi-transparent window-like solar cells, which was inexpensive in their production process [4]. Here we have extended the application of CNT films for organic-inorganic Perovskite solar cells.

2. SWNTs for Perovskite Solar Cells

We have demonstrated the replacement of ITO in inverted-type perovskite solar cells, SWNTs/PEDOT:PSS/$CH_3NH_3PbI_3$/PCBM/Al [5]. The flexible application on polyethylene terephthalate (PET) is also demonstrated [5].

Replacement of electron-blocking-layer and metal electrode in normal-type perovskite solar cells is demonstrated as well. They show high power conversion efficiency (PCE), cost-efficiency, and higher stability. Those devices can have comparable PCE as the conventional design with organic electron-blocking layer and top metal electrode [6].

The normal-type perovskite solar cell, composed of ITO/C_{60}/$CH_3NH_3PbI_3$/SWNTs as shown in Fig. 1, can achieve a PCE of 17 % with spiro-MeOTAD as dopant to SWNTs [7]. This structure with a perovskite layer sandwiched by C_{60} and SWNTs can lead to the solar cells without hysteresis and with much improved air-stability [7]. The effective passivation of the degradation of perovskite material by moisture can be achieved with C_{60} and SWNTs [7]. More recent configuration is using a film of SWNTs for both anode and cathode electrode. With adequate doping, we can fabricate Perovskite solar cells without ITO and metal electrode.

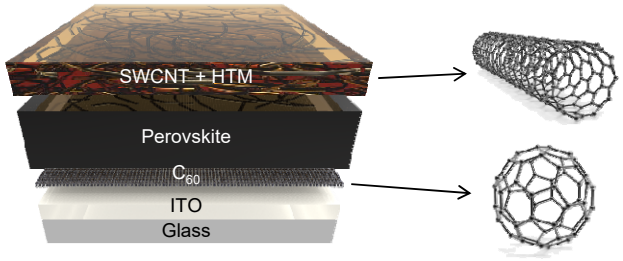

Figure 1. Structure of Perovskite solar cells sandwiched by SWNTs and C_{60}.

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