

Improvement of Single-Walled Carbon Nanotube Cathodes for Perovskite Solar Cells

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Perovskite solar cells [1] are attracting a lot of attention due to their high power conversion efficiency (PCE) with low-cost materials. The PCE was 3.8 % in 2009 [1] and has drastically increased to 22.1 % [2]. As cathodes, gold electrodes and Spiro-MeOTAD are used in conventional perovskite solar cells. Both gold and Spiro-MeOTAD are expensive, and the latter is unstable in ambient. Single-walled carbon nanotubes (SWNTs) have been reported to act as cathodes in perovskite solar cells by substituting gold and Spiro-MeOTAD [3]. However, PCEs of perovskite solar cells with SWNT cathodes have not yet attained those with conventional cathodes.

In this study, we developed a novel fabrication method of perovskite solar cells using SWNTs as cathodes to realize improved interface between perovskite crystals and SWNTs. Dry-deposited SWNT films [4] were employed, and solar cell structures were fabricated by deposition of TiO₂ layers, perovskite crystals, and SWNT films on FTO/glass substrates in ambient air. While SWNT films are usually transferred on perovskite crystals at the last step (type 1 cell), we inserted the transfer process of SWNT films between two-step spin coating of perovskite crystal precursors (type 2 cell). Figure 1 shows the *J-V* characteristics of the type 1 and the type 2 cells. The type 2 cell achieved better fill factor than the type 1 cell. This indicates the contact between SWNTs and perovskite crystals is considerably improved. We further increased the PCE of the type 2 cell by adding PMMA layers on top of the SWNT films (Fig. 2).

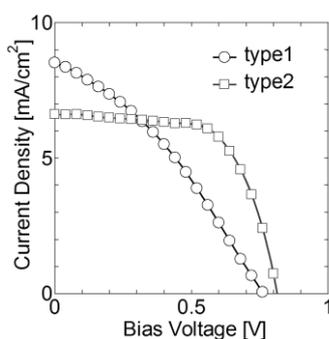


Fig. 1 *J-V* characteristics of type 1 and type 2 cells.

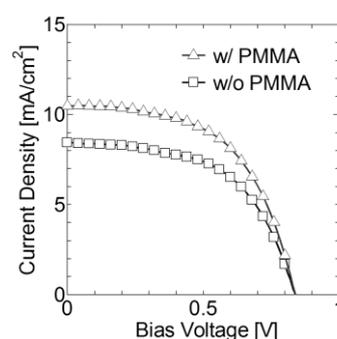


Fig. 2 *J-V* characteristics of w/ PMMA and w/o PMMA cells.

[1] A. Kojima *et al.*, *J. Am. Chem. Soc.*, **131**, 6050 (2009).

[2] http://www.nrel.gov/ncpv/images/efficiency_chart.jpg

[3] Z. Li *et al.*, *ACS Nano*, **8**, 6797 (2014).

[4] A. Kaskela *et al.*, *Nano Lett.*, **10**, 4349 (2010).

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