Single-Walled Carbon Nanotube Films as Electron-Blocking-Layer and Transparent Electrode for Various Solar Cells

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1. CNT-Si and graphene-Si solar cells

It was found that a film of single-walled carbon nanotubes (SWNTs) can be dual-functional as electron-blocking-layer and transparent electrode through studies of nanotube-silicon heterojunction solar cells [1-3]. We have demonstrated efficient SWNT/Si solar cells using dry-deposited high-quality SWNTs [1] and honeycomb-structured SWNTs [2]. The SWNT/Si solar cells using the dry deposited SWNT film demonstrated the air-stable power conversion efficiency (PCE) of 11.6 % before any intentional doping process. With the stable copper oxide based doping, the PCE can be more than 13.5 %. Another long-term air-stable doping using boron-based molecular super Lewis acid is also introduced [4]. Adequately doped mm scale single crystal graphene [5] also exhibited the similar performance [3]. Even though the film of SWNTs composed of mixture of semiconducting and metallic tubes should be naively metallic, however, it can behave as an electron blocking layer.

2. Organic thin film and Perovskite solar cells

The dual functionality is also demonstrated for organic thin film and perovskite-type solar cells. For organic thin film solar cells, the SWNT/MoOx/PEDOT:PSS layer (normal structure) was demonstrated as a dual functional layer replacing ITO and organic electron-blocking-layer. Using PTB7/PC71BM mixture as active materials, the PCE of 6 % was obtained for glass substrate and 3.9 % on flexible PET substrate [6]. Window-like semi-transparent solar cells are demonstrated by replacing the electron blocking layer and metal electrode in inverted structure organic solar cell.

The SWNT film was also applied to normal and inverted organic-inorganic hybrid perovskite ($CH_3NH_3PbI_3$) solar cells. The dual-functional feature was demonstrated in double-sided illumination perovskite solar cells using SWNT film instead of electron-blocking-layer and gold electrode (shown in Figure 1) with over 9 % PCE [7]. Another perovskite solar cell structure using SWNTs instead of ITO is also proposed [8].

3. Acknowledgments

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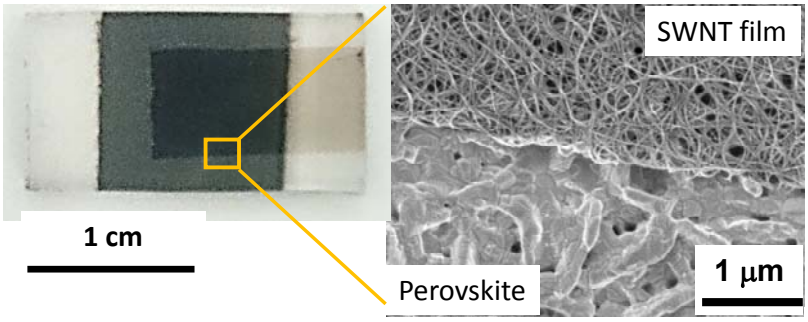

Fig. 1. Photograph and SEM image of a perovskite solar cell using SWNT film as electron-blocking-layer and transparent electrode.

4. References

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