Application of Single Wall Carbon Nanotubes with Small Molecule Organic Solar Cells

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1. Introduction

Organic solar cells can convert electricity with an efficiency around 5% using cheap materials. They also have a great potential for fabricating flexible solar cells. However, organic solar cells generally use ITO (Indium Tin Oxide), an expensive inorganic semi-conductor, which is also brittle and not suitable for flexible solar cells.

On the other hand, single-walled carbon nanotubes (SWNTs) are a cheap, innovative and exceptional material which has excellent physical properties such as outstanding electron mobility, flexibility, optical properties. Therefore, the flexibility and extreme lightness of carbon nanotubes could enable a fast and easy fabrication of thin and flexible organic solar cells (processes as roll-to-roll printing are fast and avoid large space-consuming issues).

The improvement of SMOSCs mainly comes from the design of low molecular weight organic molecules that give higher absorption coefficients, fast charge transport, enhanced miscibility with the fullerene acceptor and better reproducibility.

In this study we fabricated some SMOSCs using a SWNT electrode instead of ITO for the first time. The bulk heterojunction layer was composed of a small donor molecule, diketopyrrolopyrrole (DPP(TBFu)$_2$) with [6,6]-phenyl-C$_{61}$-butyric acid methyl ester (PC$_{61}$BM) as acceptor material.

2. Composition of the organic solar cells

Structure of devices

The structure of devices is reported on Figure 1. We used either glass substrates for the dry deposited free-standing SWNT film or vertically aligned SWNTs grown on quartz substrate. Those films were doped with MoOx and annealed to improve their performances. As hole transport layer, poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS) was spin coated over the SWNT film. Active layer containing DPP(TBFu)$_2$ and PC$_{61}$BM was mixed in chloroform. LiF (the electron transport layer) and aluminum were deposited by thermal vacuum deposition.

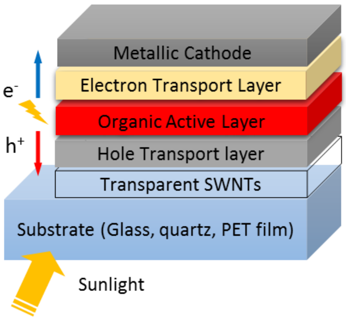

Figure 1. Structure of the organic solar cell using SWNTs

SWNT electrode

Two different structures of transparent SWNT films were used as shown as in Figure 2.

a) b)

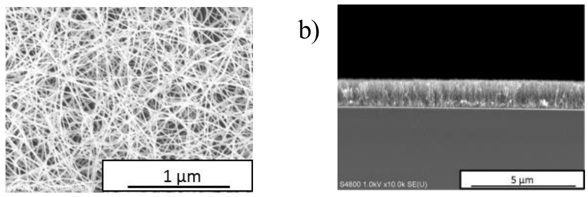

Figure 2. a) SEM picture of top view of dry deposited free-standing SWNT films on glass b) SEM picture of cross-section view of vertically aligned SWNTs grown by Alcohol Catalytic Chemical Vapor Deposition (ACCVD) on silicon substrate

Organic active layer

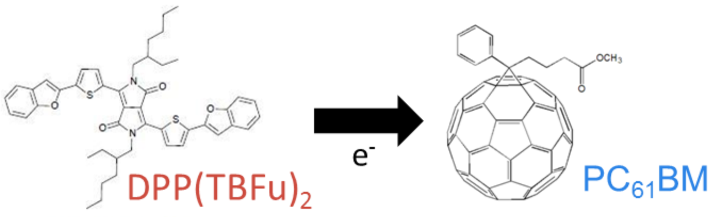

Figure 3. Donor molecule, diketopyrrolopyrrole (DPP(TBFu)$_2$) and acceptor molecule, [6,6]-phenyl-C$_{61}$-butyric acid methyl ester (PC$_{61}$BM)

3. Conclusions

We studied the integration of two different SWNT films used as electrode in SMOSCs and showed the comparison with same devices using ITO electrode as references. The use of hole transport materials over or inside the SWNT film, so as the doping of SWNT were also investigated in order to optimize the performances.

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Appendix

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