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Tuning Microstructure and Nanostructure of Single-Walled Carbon Nanotubes for Solar Cells Applications

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1. Introduction

For solar cell applications SWNTs have superiorities in terms of the wide spectrum of absorption ranging from near-infrared to visible wavelength, high electrical conductivity at high transparency as well as the possibility multiple exciton generation. Combined with earth abundance and chemical stability, the SWNT is supposed to be a promising candidate for next-generation solar cells. In this study, we are trying to control the diameter of SWNTs and their microscale assembly for the applications of SWNT-Si solar cells.

2. Result and Discussion

Highly transparent-conductive SWNT films from controlled bundle-diameter and long bundle length were synthesized by the thermal decomposition of ferrocene vapor in a carbon monoxide atmosphere, with the average diameter of approx. 2 nm. The SWNT films with a sheet resistance of 117 Ω/sq. at the transmittance of 91 % over the AM1.5G spectrum were dry-transferred onto Si substrate to form a diode (Fig. 1). The power conversion efficiency of the solar cell is 11% and is stable after 1 year, which is attributed to the high purity pristine SWNTs. Moreover, the solar cell performance under different light intensities is investigated to evaluate both the series and shunt resistance of the device (Fig. 2). The interfacial oxide layer between the SWNT film and the Si substrate is also discussed [1].

A water-vapor treatment is proposed to build up SWNTs to a self-assembled microhoneycomb network for the application of solar cells [2]. The micro-honeycomb network consists of vertical aggregated SWNT walls and a buckypaper bottom. This hierarchical structure exhibits lower sheet resistance and higher optical transmittance compared with the buckypaper (Fig. 3). The heterojunction solar cell was fabricated by dry depositing the SWNT film to the 3 mm by 3 mm n-type silicon substrate. The pristine SWNT-Si heterojunction solar cell shows a record-high fill factor of 72 % as well as a power conversion efficiency (PCE) of 6 % without tuning the diameter or height of original vertically aligned SWNTs [2]. The PCE remains stable for months in ambient condition. A PCE exceeding 10 % is achieved in the dry state after dilute nitric acid treatment.

3. Conclusions

The full exploitation of the superior electrical, optical and chemical properties of SWNTs is very promising for the next generation photovoltaic devices.

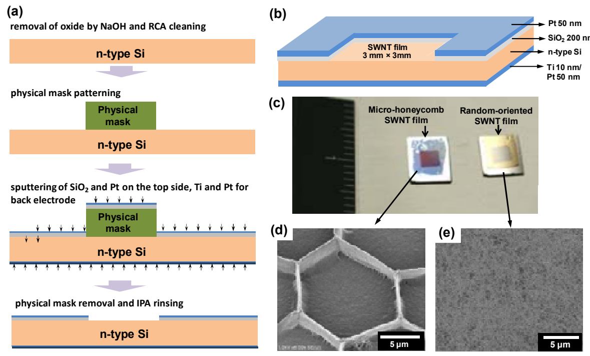

Figure 1 (a) Fabrication process of SWNT-Si solar cells

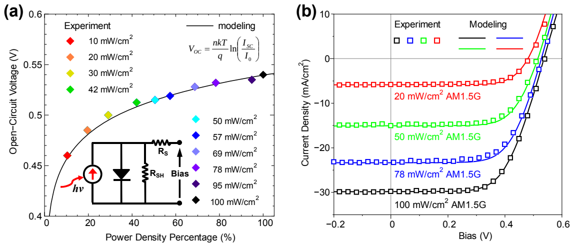

Figure 2 The performance of SWNT-Si solar cells under different light intensities.

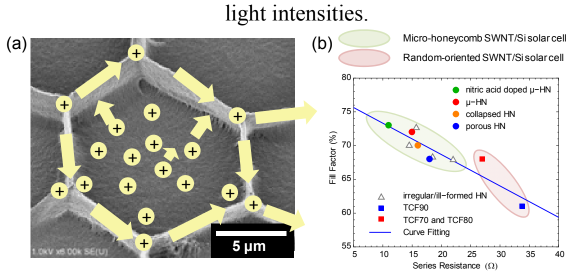

Figure 3 (a) Mechanisms of improvement by honeycomb structure and (b) comparison of FF and series resistance.

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References

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