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Semiconducting Carbon Nanotubes applied to OPVs

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Introduction

The demand for new materials, to improve the power conversion efficiency of organic photovoltaic cells (OPVs), has triggered our interest to study semiconducting single wall carbon nanotubes (s-SWNTs).

The reasons are:

•s-SWNTs harvest sunlight in broad spectral range (typically 300~2000nm) [1],

•s-SWNTs exhibit relatively high carrier mobility (typically 1~10cm^2/V.s),

which have never been achieved with organic molecules and polymers.

Experimental

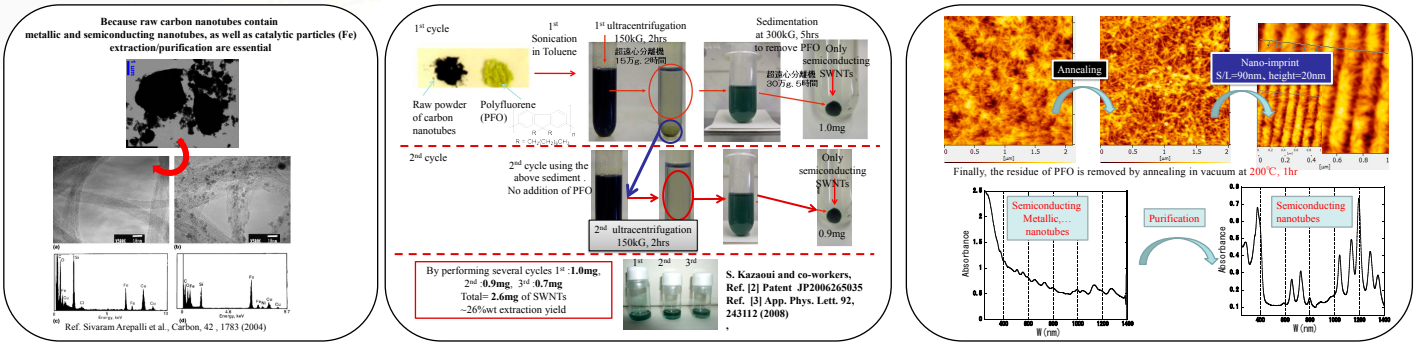
To carry out our study,

•First, we have developed a technique to selectively extracted s-SWNTs from raw carbon nanotubes (HiPco) dispersed in toluene solution using polyfluorene (PFO) as dispersant and extracting agent assisted by sonication and centrifugation techniques [2].

•Then, we have combined s-SWNTs with various materials (Fullerenes, Si nano-crystal [3], small organic molecules and polymers) to make bulk-heterojunction and layer-heterojunction OPVs.

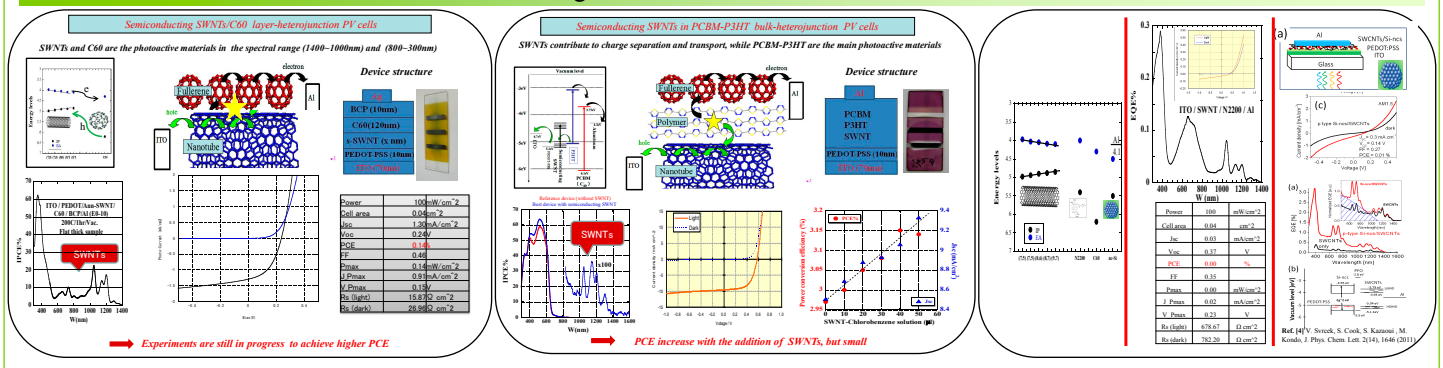
•Finally, we have characterized these OPVs by recording the I-V curves (at A.M. 1.5 100mW/cm^2) and the EQE spectra.

Extraction /Purification of s-SWNTs: Results and Discussions



s-SWNTs are obtained with an extraction yield 10~26% and a purity 95~99% , but this technique is still challenging for the mass-production.

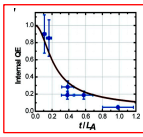
Fabrication and Characterization of OPVs consisting of s-SWNTS: Results and Discussions



s-SWNTs-based OPVs were made (proof-of-concept), but the power conversion efficiency (PCE) must be improved.

Conclusions / perspectives

Why the PCE is low?



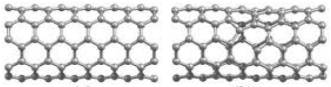
The exciton diffusion length is derived from the thickness dependence of the IQE

LD = 0.13 ± 0.04 *LA*.
If LA=21nm then LD=2.7nm

D. Bindl; Meng-Yin Wu; F. Prehn; M. Arnold *Nano Lett.* 2011, 11, 455-460 (University of Wisconsin, USA)

Exciton diffusion length is ~3nm, whereas carbon nanotubes are ~100nm

carbon nanotubes have defects, which are due to the growth and purification methods



semiconducting carbon nanotubes are of great interest in OPVs, but the problem is how to make semiconducting carbon nanotubes defects-free

References / Acknowledgements

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[2] S. Kazaoui and co-workers, Patent JP2006265035

[3] "Semiconductor-enriched single wall carbon nanotube networks applied to field-effect transistors", N. Izard, S. Kazaoui, K. Hata , T. Okazaki , T. Saito , S. Iijima , N. Minami , App. Phys. Lett. 92, 243112 (2008).

[4] "Silicon Nanocrystals and Semiconducting Single-Walled Carbon Nanotubes Applied to Photovoltaic Cells", V. Svrcek, S. Cook, S. Kazaoui , M. Kondo, J. Phys. Chem. Lett. 2(14), 1646 (2011).

Acknowledgments: this work is supported by NEDO
革新的太陽光発電技術研究開発（革新型太陽電池国際研究拠点整備事業）/
高度秩序構造を有する薄膜多接合太陽電池の研究開発
（平成20～26年度）