**Controlled Growth of Single-Walled Carbon Nanotubes for Application to Solar Cells**

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We found the reversible and repeatable modification of diameter of vertical array of SWNTs by adding acetonitrile (AcN) in ethanol (EtOH) as feedstock of CVD [1-3]. When the nitrogen (N) is involved, the SWNT mean diameter was dramatically reduced from approximately 2.1 nm to less than 1 nm. Surprisingly, the main nitrogen configuration was found to be encapsulated diatomic $N_2$ molecules interior of SWNTs with the content of 1 at %. We address that the nitrogen atoms on the surface of the catalyst particle result in a change from the 'Octopus' to the 'VLS' growth mode predicted by molecular dynamics simulations. Another growth technique of small diameter vertically aligned SWNTs using Co-Cu catalyst are also discussed.

We proposed a water vapor treatment to build up SWNTs to a self-assembled micro-honeycomb network for the application of solar cells [4]. The micro-honeycomb network consists of vertical aggregated SWNT walls and a buckypaper bottom. This hierarchical structure is very efficient to collect holes from the interface of Si. 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. A recent record of highest PCE was more than 8 % without doping. The PCE remains stable for months in ambient condition. A PCE exceeding 10 % is achieved in the dry state after dilute nitric acid treatment. Coating with PMMA also is found to be efficient to increase the PCE up to 11%.

On the other hand, heterojunction solar cells using highly transparent-conductive SWNT films from controlled bundle-diameter and long bundle length are also promising [5]. Here, SWNTs were synthesized by the thermal decomposition of ferrocene vapor in a carbon monoxide atmosphere, with the average diameter of approx. 2 nm. Our preliminary test result shows the highest PCE of 11 % among such CNT-Si design without chemical doping. These solar cells are stable after 10 months [5].

References:

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