Self-Assembled Micro-Honeycomb Network of Single-Walled Carbon Nanotubes for Heterojunction Solar Cell

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Various forms of nano-carbon films such as random network of single-walled carbon nanotubes (SWNTs), vertically aligned SWNT (VA-SWNTs) and graphene have been examined for SWNT/Si heterojunction solar cells. Here, we propose a self-organized micro-honeycomb network structure of SWNTs obtained by water or ethanol vapor treatment of as-synthesized VA-SWNTs for such devices with higher performance. VA-SWNTs were synthesized by the standard alcohol-catalytic CVD (ACCVD) method with Co/Mo dip-coated on Si/SiO2 substrates [1]. The VA-SWNT film was then exposed to water vapor by hanging over heated water. By drying the film, quasi-regular honeycomb cell structure was obtained. Honeycomb cell walls consist of capillary-aggregated vertically aligned SWNTs with heavily bundled top part. Within each cell, collapsed spaghetti-like SWNTs make contact to the substrate.

The SWNT/n-Si heterojunction solar cell was built by placing the micro-honeycomb SWNT network film on top of the substrate which had a 3 mm x 3 mm bare n-type silicon contact window in the center. Our preliminary test showed that the photovoltaic conversion efficiency (PCE) under AM1.5 was over 6 %, with the fill factor of 72% without any doping. The fill factor of 72 % is the highest record for such SWNT/n-Si heterojuction solar cells without doping. The PCE should be further increased by adjusting the transparency of the SWNT film, reducing contact resistances and reducing the sheet resistance of film. A PCE beyond 10% is achieved in the dry state after dilute nitric acid treatment. Furthermore, by modifying the vapor treatment condition, micro-honeycomb skeleton structure without the collapsed spaghetti-like SWNTs can be made. This structure is ideal for transparent and conductive film.

[1] Y. Murakami, S. Chiashi, Y. Miyauchi, M. Hu, M. Ogura, T. Okubo, S. Maruyama, Chem. Phys. Lett., 385 (2004) 298.