Structured SWNTs and Graphene for Photovoltaic devices

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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 or counter electrode of dye-sensitized 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/SiO_2 substrates. The VA-SWNT film was then exposed to water vapor by hanging over heated water. By dring the film, quasi-regular honeycomb cell structure was obtained as shown in Fig. 1 (a, b). Honeycomb cell walls consist of capillary-aggregaed vertically aligned SWNTs with heavily bundled top part. Within each cell, collapsed spaghetti-like SWNTs make contact to the substrate. As shown in the inset of Fig. 1(c), 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 5.91 %, 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. The graphene/n-Si heterojuction solar cell using graphene grown with ACCVD on copper foil shows reasonable performance. Furthermore, the superior performance of dye-sensitized solar cells using the micro-honeycomb SWNTs as counter electrode will be discussed.

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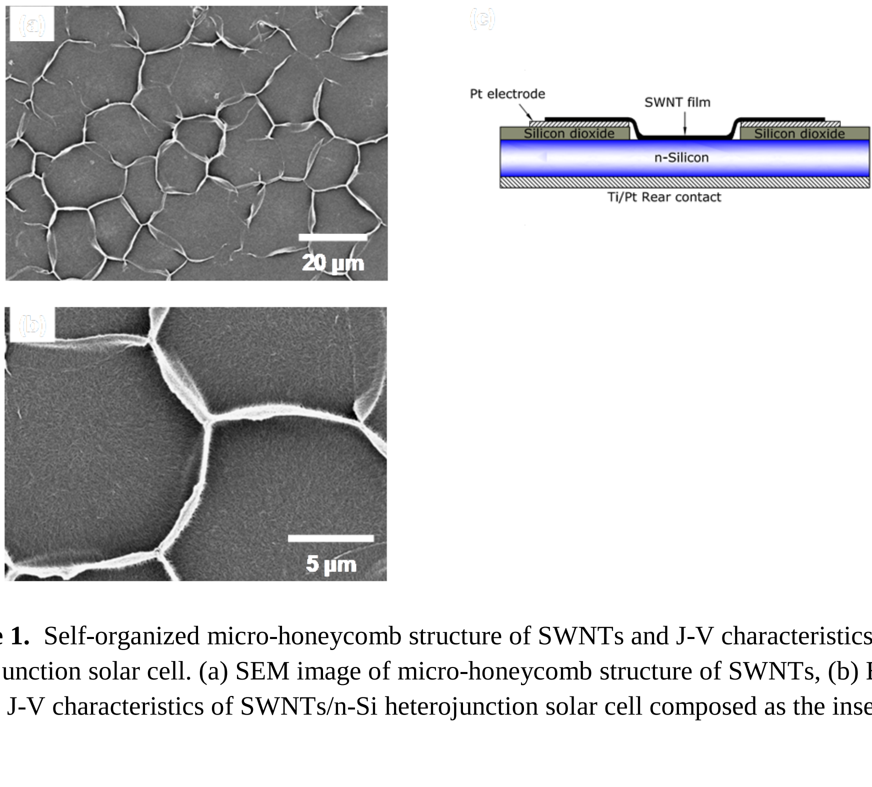

Figure 1. Self-organized micro-honeycomb structure of SWNTs and J-V characteristics of SWNT/n-Si heterojunction solar cell. (a) SEM image of micro-honeycomb structure of SWNTs, (b) Expanded image of (a), (c) J-V characteristics of SWNTs/n-Si heterojunction solar cell composed as the inset illustration.