Supporting Information for

Efficient energy conversion of nanotube/nanowire-based solar cells

Qinke Shu,[a] Jinquan Wei,[a] Kunlin Wang,*[a] Shuang Song,[b] Ning Guo,[a] Yi Jia,[a] Zhen Li,[a] Ying Xu,[b] Anyuan Cao,[c] Hongwei Zhu*[a] and Dehai Wu[a]

[a] Key Laboratory for Advanced Manufacturing by Material Processing Technology and Department of Mechanical Engineering, Tsinghua University, Beijing 100084, P. R. China

[b] Beijing Solar Energy Research Institute, Beijing 100083, P. R. China

[c] Department of Advanced Materials and Nanotechnology, College of Engineering, Peking University, Beijing 100871, P. R. China.

* To whom correspondence should be addressed. E-mails: hongweizhu@tsinghua.edu.cn; wangkl@tsinghua.edu.cn.

This PDF file includes:

Experimental methods, structural and photovoltaic characterizations of CNTs and SiNWs (Fig. S1~Fig. S4)

Experimental Methods

Synthesis of high quality carbon nanotube thin films: CNT thin films were prepared using a floating catalyst CVD method. A nickel mesh was placed at the front end of the quartz tube as a gas flow stabilizer. Liquid precursor (a mixture of xylene, 0.36M ferrocene and 0.036M sulfur) was pumped into the quartz tube through a capillary tube at a feeding rate of 2~4μL/min, then vaporized at a temperature of 200~220^{o}C. The vapor was carried to the reaction zone by a mixture flow of Ar (2500 mL/min) and H_2 (600 mL/min). Temperature for CNT growth was set to 1150~1170 ^{o}C. As-grown films were collected by arbitrary substrates (metals, plastics or papers) clinging to the inner wall of the quartz tube at the deposition zone (60~600^{o}C). Fig. S1a shows the photograph of the CNT thin film being peeled off the nickel substrate. Fig. S1b shows the SEM image of the CNT film. Based on the TEM measurement (Fig. S1c), the CNT film is composed of mainly single/double-walled CNTs and a small amount of triple-walled CNTs (less than 5%).

Preparation of silicon nanowire arrays: n-type (100) silicon wafer (with a sheet resistance of 2~4 Ω cm) was copiously cleaned and put into the etching solution (4.6 M HF and 0.02 M $AgNO_3$, 50 □) for 15 min. After removing the silver dendrite film which formed during the etching processing by HNO_3, the SiNW arrays were obtained. Fig. S2a-c show the side views of the SiNW arrays of different height (2 μm, 35 μm, 135 μm). Fig. S2d is a top view of a SiNW array. The diameters of the SiNWs vary from 30 nm to 150 nm, with an average value of 90 nm.

Assembly and characterization of CNTs/SiNWs solar cells: As-prepared SiNW array was cut into small pieces of 1.2×1.2 cm^2. As shown in Fig. 1, Ti/Pd/Ag back electrode was sputtered at the back side of the silicon substrate. An insulating tape (1.2×1.2 cm^2) with a round window (6 mm in diameter) was adhered on the top surface of the SiNW array. As-prepared CNT film was directly transferred to the top of the insulating tape, and coated on the SiNWs through the

window. Redox electrolyte containing 40% hydrobromic acid (HBr) and 3% bromine (Br_2) was dropped on the CNT film. A quartz plate was covered on the cell to avoid volatilization of the electrolyte. The upper electrode was connected to the CNT film by silver paint.

The devices were irradiated under a solar simulator (Thermo Oriel 91192-1000) at AM 1.5G (100 mW/cm^2), and the current-voltage data were recorded using a Keithley 4200 sourcemeter. Forward bias was defined as positive voltage applied to the CNT film.

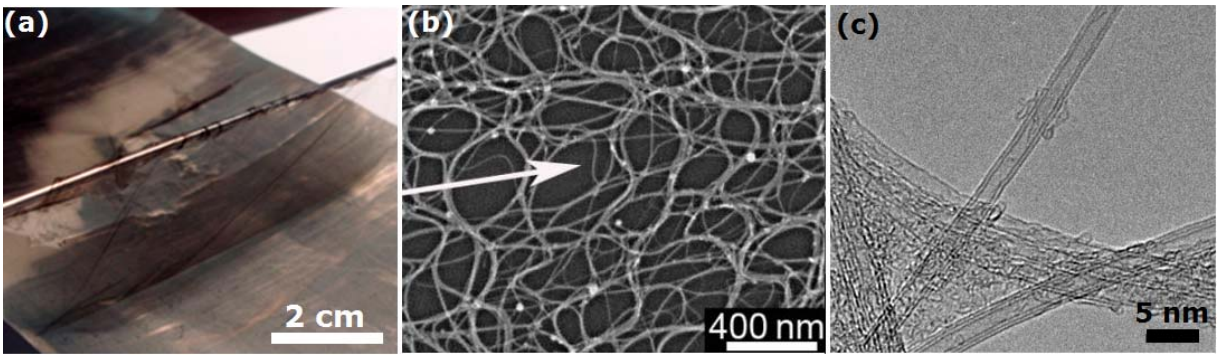

Fig. S1 (a) Photograph of a freestanding CNT film being peeled off the nickel foil. (b) SEM image. (c) TEM image.

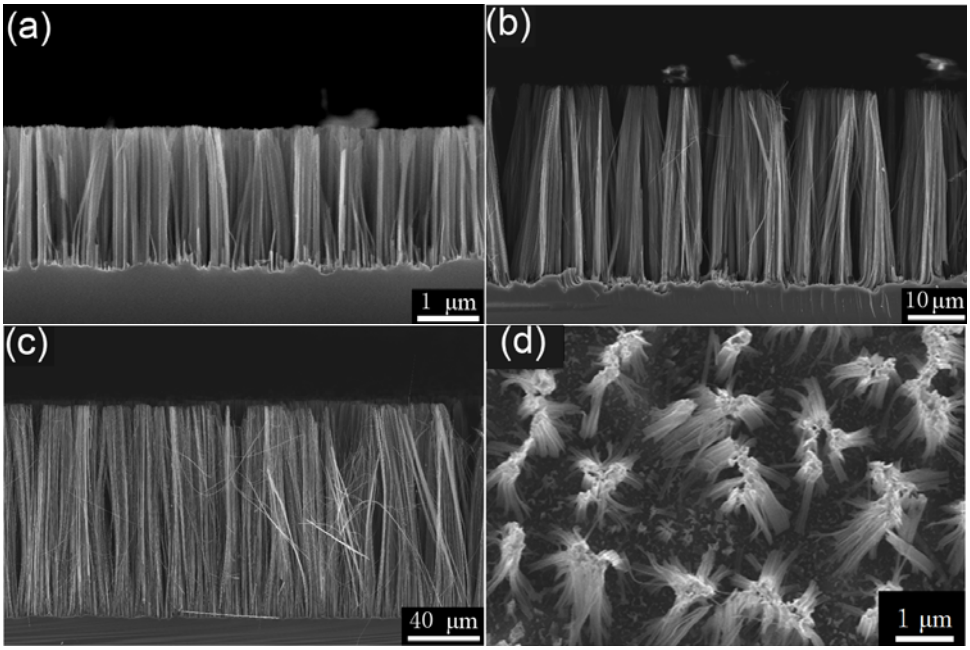

Fig. S2 SEM images of the SiNW arrays. (a) Height=2 μm. (b) Height=35 μm. (c) Height=135 μm. (d) Top view.

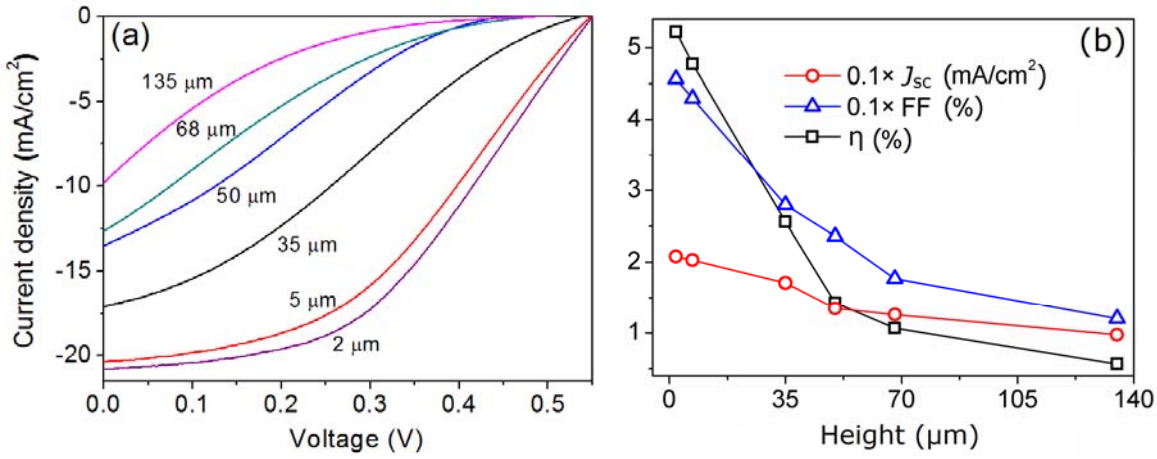

Fig. S3 (a) Light *J*-*V* curves of the hybrid solar cells made from SiNW arrays of different height. (b) Plots of J_{sc}, FF and η as a function of the array height. The transmittance at 550 nm of the CNT film is ~75 %.

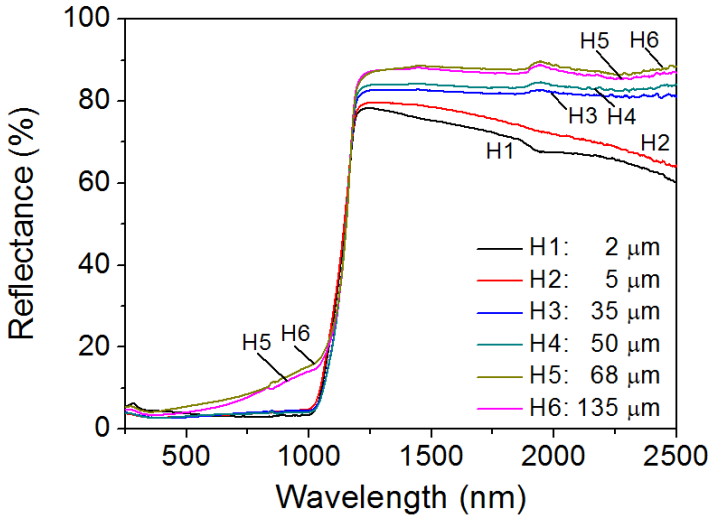

Fig. S4 Reflection spectra of SiNW arrays of different height.