Electronic Supplementary Material (ESI) for Energy & Environmental Science

Supporting Information

Improved Efficiency of Smooth and Aligned Single Walled Carbon Nanotube/Silicon Hybrid Solar Cells

By Xiaokai Li, Yeonwoong Jung, Kelsey Sakimoto, Teng-Hooi Goh, Mark A. Reed, *and* André D. Taylor*

Mayer rod coating method: 10 mg of SWNTs were mixed with 300 mg of sodium carboxymethyl cellulose (90 000 MW, Sigma Aldrich) and 10 mL of deionized water. Solutions were sonicated for 15 min, using a 1/4 in. probe sonicator operated at 225W (Cole Parmer Model CPX 750, 20 kHz), and then, centrifuged at 8500 rpm for 2 h. The final dispersions were obtained by decanting the top 60% of the supernatant. To deposit a SWNT film, 300 μL of the SWNT dispersion was dropped on a piranha-cleaned glass substrate. Subsequently, a Mayer rod (RD Specialist Inc.) was rolled over the solution, leaving a uniform, thin layer of the SWNT dispersion on the substrate. The wet coating of the SWNT on glass was carefully dried using a lamp. The samples were placed in 9 M HNO_3 overnight to remove surfactants.

Power conversion efficiency values were determined from *J*–*V* curve measurements (using a Keithley 2400 source meter) under a 1 sun, AM 1.5G spectrum from a solar simulator (PV measurement, Small-Area Class-BBA Solar Simulator, 100 mW/cm^2). Solar simulator illumination intensity was determined using a monocrystal silicon reference cell (Hamamatsu S1133). For water droplet effect and intensity dependence studies, the intensity of the solar irradiance is adjusted using a filter wheel holding neutral density filters.

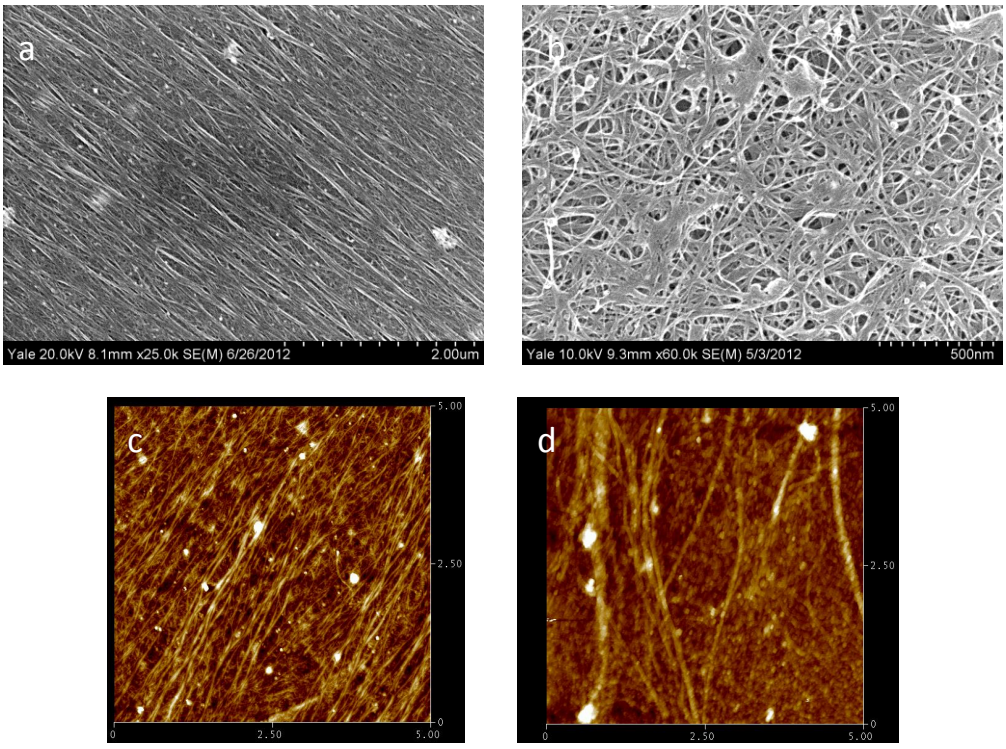

Figure S1. SEM image of (a) superacid SWNTs looking from bottom side (side in contact with silicon in final device). Carbon nanotubes are aligned in the shearing direction. (b) Mayer rod coated thin films. AFM image on the top side of superacid film (c) slowly dried in anhydrous air with roughness of 4.12 nm (d) coagulated in water with roughness of 9.99 nm.

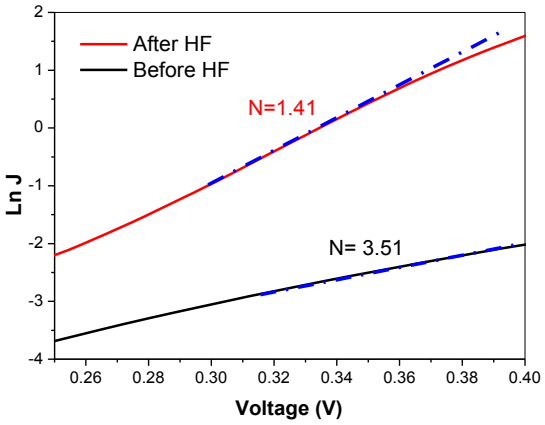

Figure S2. *ln (J)-V* under small forward bias assesses the quality of the solar cell devices: Mayer rod fabricated SWNT/Si device before and after HF treatment.

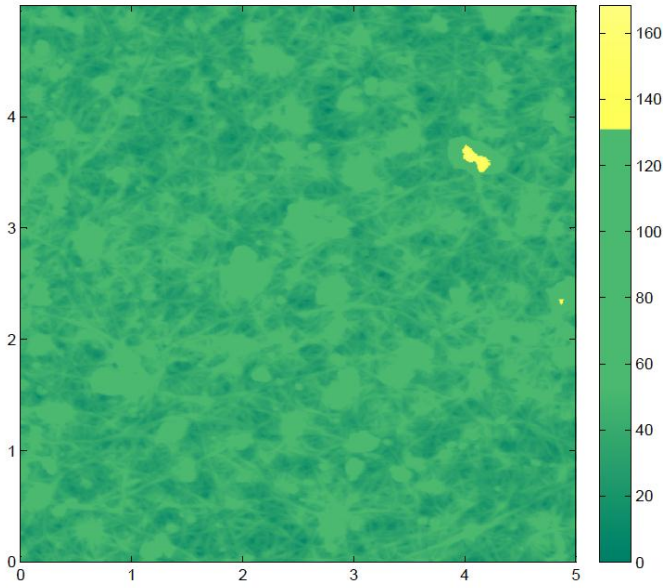

Figure S3. Visualization of the SWNTs in contact with Si (yellow) and not in contact with Si (green) for a Mayer rod SWNT film assuming a depth of 37.88 nm.

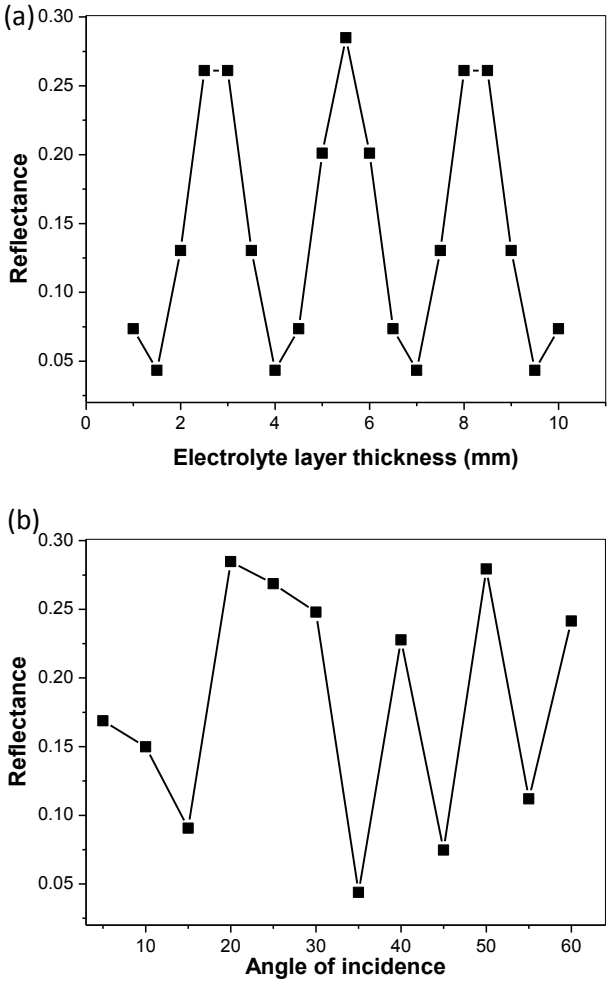

Figure S4. Dependence of reflectance at air/electrolyte/Si interface on (a) electrolyte layer thickness assuming incident light normal to Si surface and (b) angle of incidence assuming electrolyte layer thickness of 7 mm. All data care calculated using Frensel equation. The following parameters are used in the calculation: the wavelength of incident light is 550 nm; the electrolyte layer on the Si is flat with uniform thickness; The refractive index for air, electrolyte and silicon are 1, 1.333 and 3.96, respectively. From calculation, the reflectance (incident light normal to Si surface) at the air/Si interface without electrolyte/water is 35.61 %.

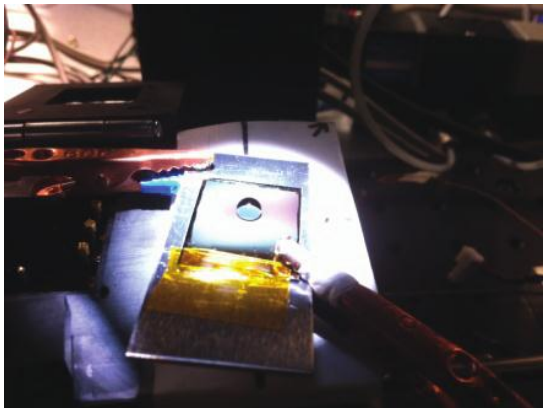

Figure S5. Photograph of a hemispherical water droplet on an operating device.

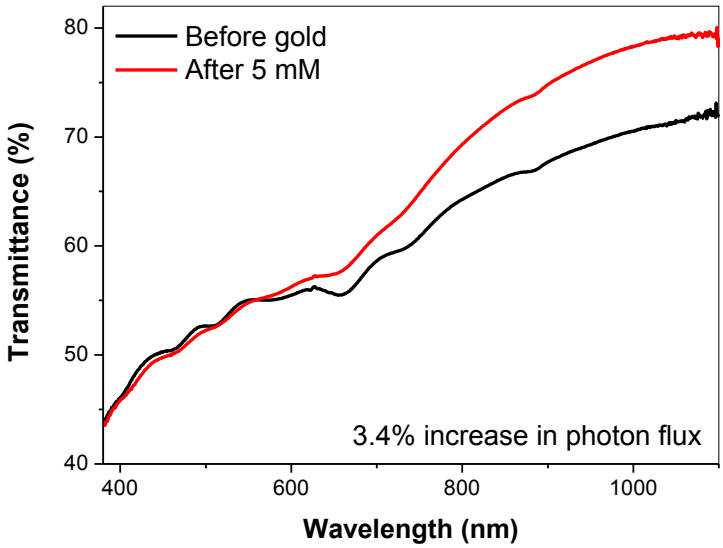

Figure S6. Transmittance of the super acid SWNT films change with the doping of gold salt.

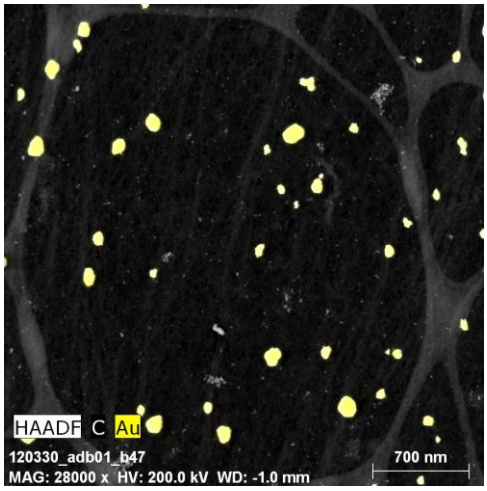

Figure S7. Energy-dispersive x-ray spectroscopy elemental mapping of gold doped SWNT films.

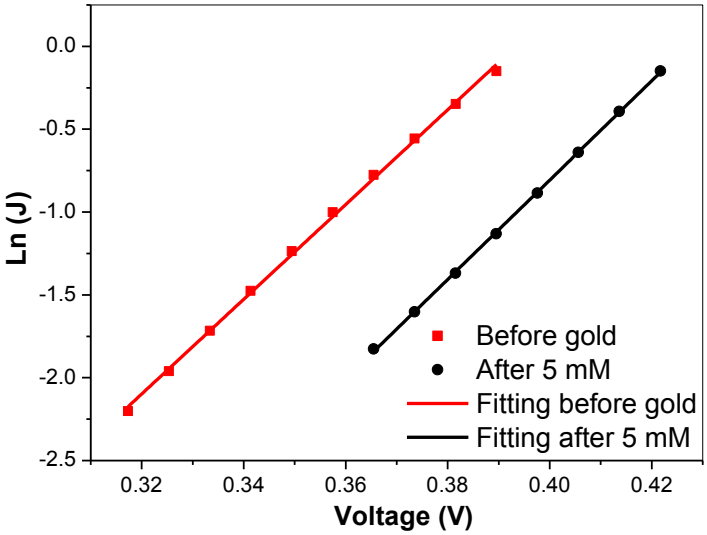

Figure S8. $J-V$ characteristics in the semi-logarithmic scale at the forward linear region.

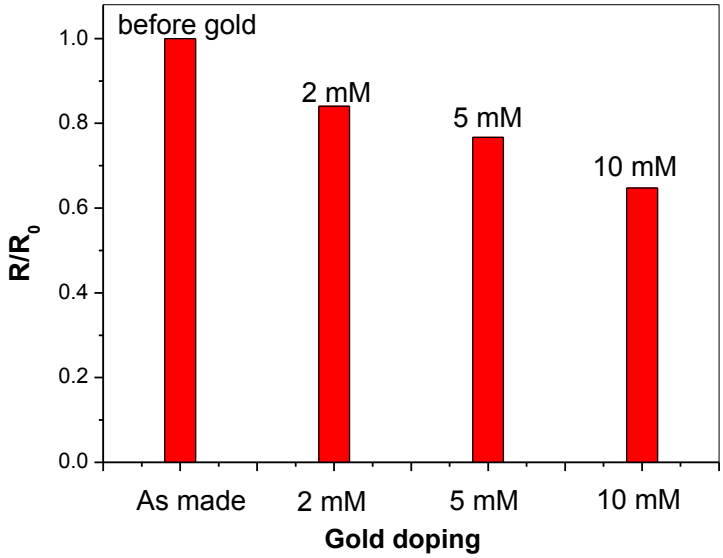

Figure S9. Sheet resistance of the super acid SWNT films change with the gold salt doping.

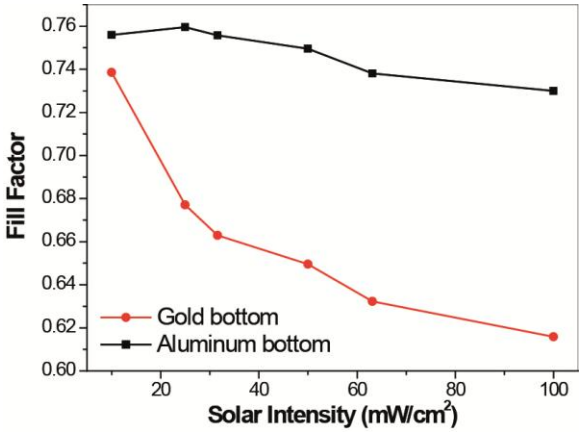

Figure S10. Solar intensity dependent variation of fill factor (FF) with back contacts of Au and Al.