

## SUPPLEMENTARY MATERIALS

For

### **Simulation of the actual absorbed solar power for the SWNTs in the cell\*\***

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To estimate the actual power absorption of SWNTs under the solar spectrum illumination, the high-frequency electromagnetic finite-element software HFSS is used to make a simulation. In the simulation, each SWNT bundle is modeled as a dielectric cylinder and the periodic boundary condition is used to deal with the array structure.

At first, we calculate the dielectric function of SWNTs with the method in Ref. 1. The chiral vector (9,4) is presumed for our SWNTs in the calculation. Figure 1a and 1b are respectively the calculated imaginary part of the SWNTs' dielectric function when the electric field of the incident light is parallel and perpendicular to the SWNT axis. The real part of the dielectric function can be derived from the imaginary part according to the Kramers-Kronig relation <sup>2</sup>.

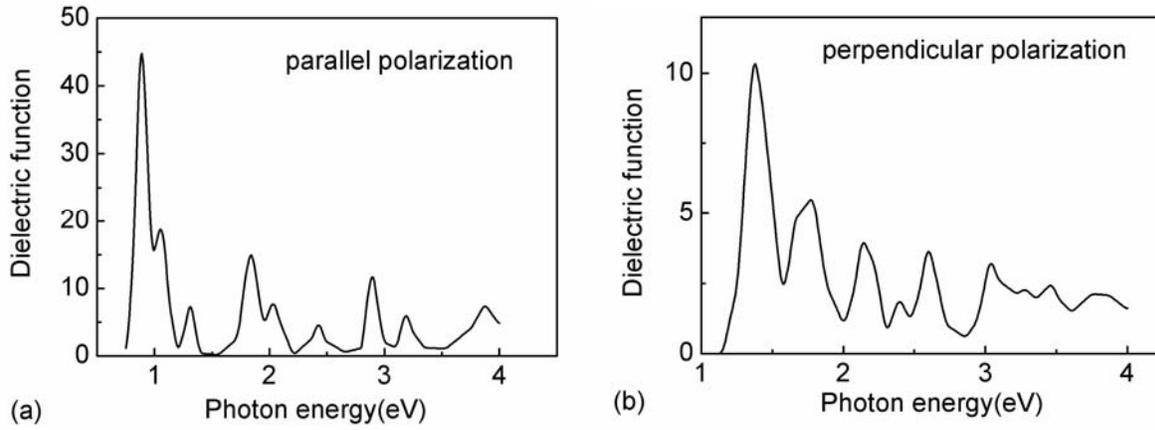


Figure 1 The imaginary part of dielectric function of the SWNT (9,4) for the electric field of the light parallel (a) and perpendicular (b) to the SWNT axis, respectively.

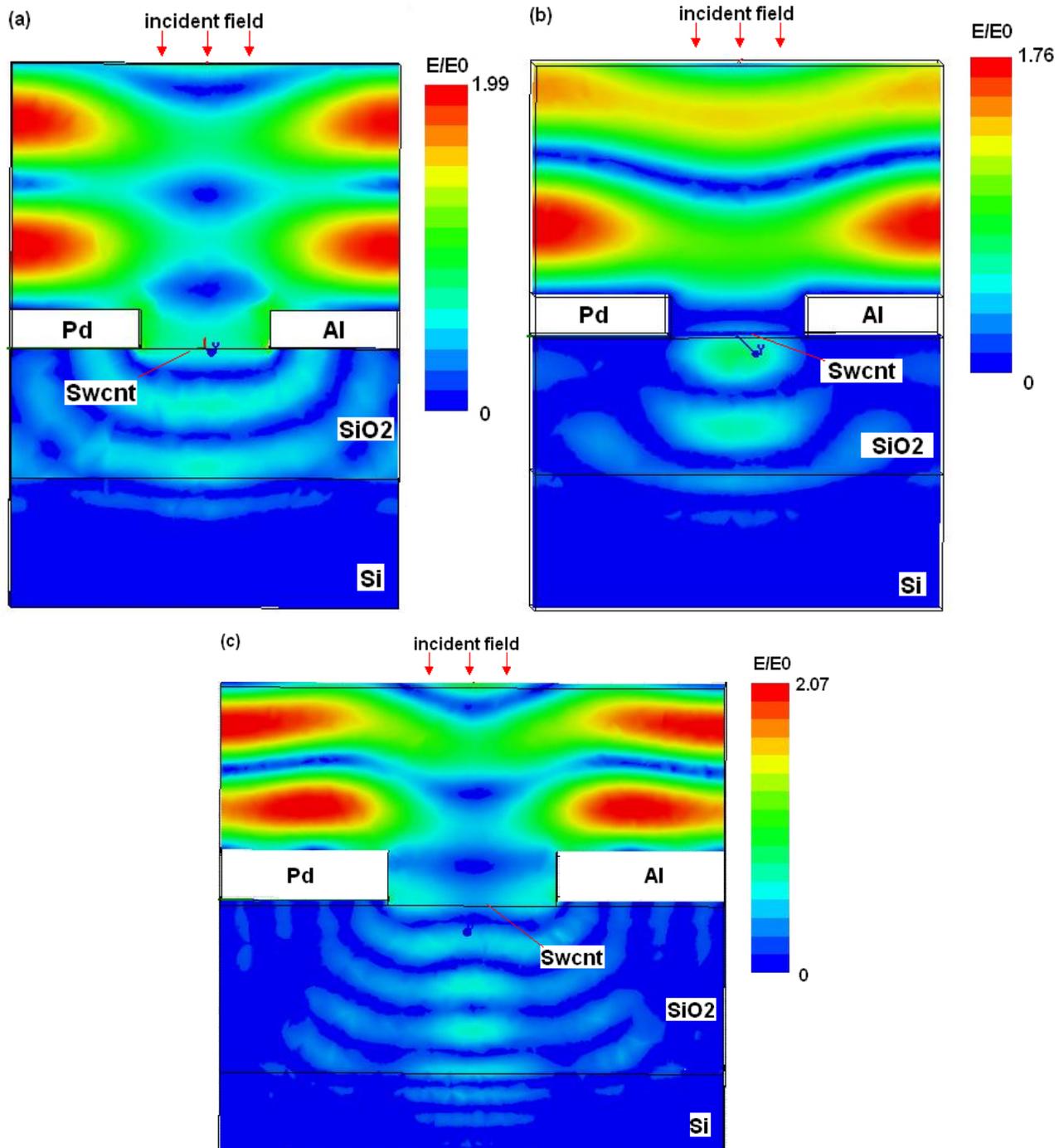
The system's response to the incident optical field is then simulated by the finite-element software HFSS. Considering that the solar light is circularly polarized, half of the incident power can be assigned along the SWNT's axis and another half is assigned perpendicular to its axis. For these two cases, we respectively calculated the monochromatic absorbed powers at various incident photon energies, which range from 0.5 eV to 4 eV with a step length of 0.01 eV. This range is enough to cover the solar spectrum. Figure 2 shows the simulated optical field distribution under the specific monochromatic illuminations of 1.4eV (a,b) and 2.5eV (c,d) for the electric field polarization of the light parallel and perpendicular to the tube axis. The absorbed powers per SWNT bundle as a function of the photon energy for these two polarization cases are shown in Figure 3a and 3b, respectively. The absorbed powers in the figure are normalized to the monochromatic incident power density of  $1 \text{ W/m}^2$ . It is indicated that the absorbed power for the electric field polarization of the light perpendicular to the tube axis is much smaller (about a magnitude smaller) than for the electric field polarization of the light parallel to the tube axis, which results from the smaller dielectric function in the former case and the depolarization effect (the anisotropy of the effective field) for one-dimensional SWNTs<sup>3</sup>.

By integrating the power absorption spectrum weighted by the power density component of the

used solar-simulated spectrum under different photon energies, we can obtain the total absorbed power under the solar-simulated light illumination, which can be expressed as

$$P = \int \frac{dP_s}{d(\hbar\omega)} \times P_a(\hbar\omega) d(\hbar\omega)$$

where  $\frac{dP_s}{d(\hbar\omega)}$  is the incident power density component distribution with the photon energy,  $P_a(\hbar\omega)$



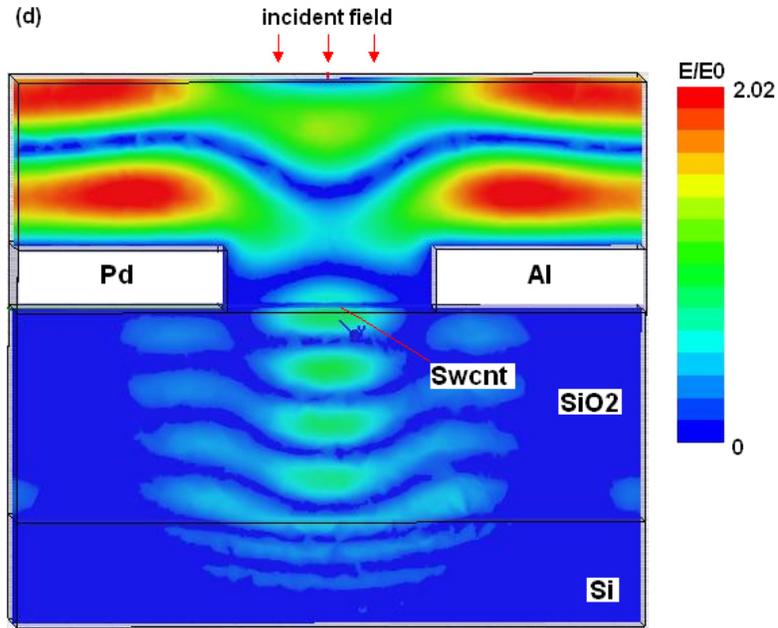
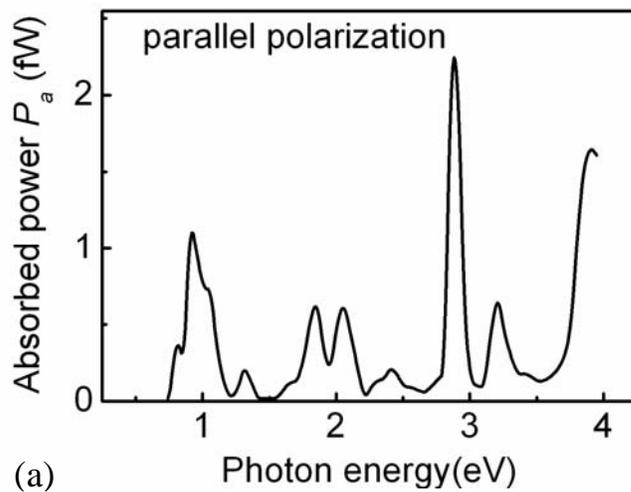


Figure 2 The optical field distribution under monochromatic illumination of 1.4eV for the parallel (a) and perpendicular (b) polarization case, and of 2.5eV for the parallel (c) and perpendicular (d) polarization case, respectively.  $E_0$  is the amplitude of the incident optical field.

is the absorbed power per unit monochromatic incident power density. The calculated total absorbed power per SWNT bundle is about  $1.41 \times 10^{-11}$  W for the incident power density of  $8.8 \text{ W/cm}^2$ . For the 146 SWNT bundle array, a total absorbed power of 2.06 nW is obtained. Similarly, the total absorbed powers under other incident power densities can also be calculated.



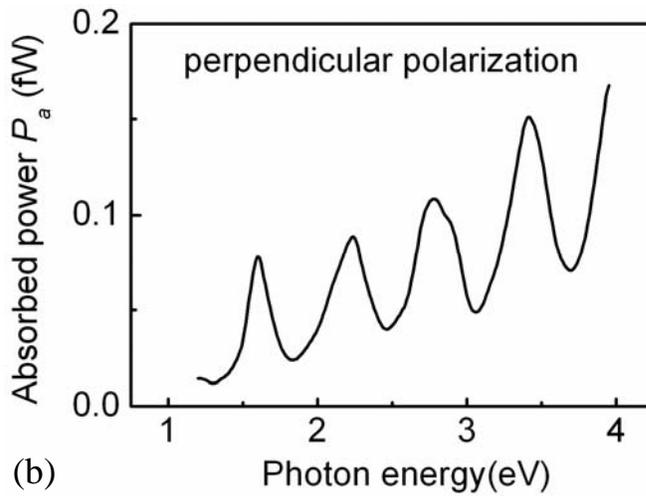


Figure 3 The power absorption spectra per SWNT bundle as a function of the photon energy for the parallel (a) and perpendicular (b) polarization case. The absorbed power under different photon energy is normalized to unity monochromatic incident power density.

### Supplementary Materials References

1. Zhao, G. L., Bagayoko, D. & Yang, L. Optical properties of aligned carbon nanotube mats for photonic applications. *Journal of applied physics* **99**,114311 (2006).
2. Yu, P. Y. & Cardona, M. *Fundamentals of Semiconductors* (Springer-Verlag Berlin Heidelberg, 2001).
3. Tasaki, S., Maekawa, K. & Yamabe, T. Pi-band contribution to the optical properties of carbon nanotubes: Effects of chirality. *Physical review B* **57**,9301-9318 (1998).

## Animation captions

Animation 1.gif

Optical field animation around the device under monochromatic illumination of 1.4eV (wave length: 914.6nm). The electric field of the light is parallel to the axis of SWNTs. The propagation direction of the light is normal to the plane of SWNT bundle array.

Animation 2.gif

Optical field animation around the device under monochromatic illumination of 2.5 eV (wave length: 505.1nm). The electric field of the light is parallel to the axis of SWNTs. The propagation direction of the light is normal to the plane of SWNT bundle array.

Note: The animation files can be viewed with the softwares *Windows picture and fax viewer* or *ACDSee photo manager*.