Electronic Supplementary Information

High Efficiency Hybrid PEDOT:PSS/Nanostructured Si Schottky Junction Solar Cell by Doping-Free Rear Contact

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Method for Extraction of Contact Resistance

The value of the specific contact resistance, ρ_c, for Al deposited on n-type Si (with and without Cs_2CO_3/PEI) was extracted by a transmission line model (TLM) method.[1] The detailed process is described as follows. The current-voltage (IV) curves between two contacts (length d and width W) were measured using a probing station, as shown in Fig. S5. Then the resistances (R_1, R_2 and R_3) were derived from the IV curve. The relationship between R_T and I were determined according to following equations. When $I = 0$, the relationship of R_T (the total resistance) and R_C (the contact resistance) was found to be $R_T = 2R_C$. According to the equation (1) and (2), the value of L_T was obtained.

$$R_E = \frac{1}{2}\left(R_1 + R_2 - R_3\right) \quad (1)$$

$$\frac{R_C}{R_E} = \cosh\left(\frac{d}{L_T}\right) \quad (2)$$

Where R_E is the contact end resistance; L_T is transfer length; d is the length of electrode measured by a optical microscope). Finally, ρ_c was extracted according to the equation (3):

$$\rho_c = R_E \cdot L_T \cdot W \cdot \sinh\left(\frac{d}{L_T}\right) \quad (3)$$

Where W was measured by an optical microscope. The contact resistances were 3.97×10^{-1} $\Omega\cdot cm^2$ and 6.18×10^{-2} $\Omega.cm^2$ for the Al/Si and Si/Cs_2CO_3/Al contact, respectively.

Method for Extracting Series Resistance

When taking into account series resistance (R_s) through which current flows, the J–V relationship can be expressed by: [2]

$$J = J_s \exp\left(\frac{q(V - JR_s)}{nkT} - 1\right), \qquad (4)$$

Where J_s is the reversed saturation current, T is the absolute temperature, and $V - JR_s$ is the voltage applied across the Schottky solar cell.

For $V - JR_s > \frac{3kT}{q}$, equation (4) becomes

$$J = J_s \exp\left(\frac{q(V - JR_s)}{nkT}\right) \qquad (5)$$

After differentiating and rearranging, equation (4) becomes

$$\frac{dV}{d(\ln J)} = R_s A_{eff} J + \frac{n}{\beta} \qquad (6)$$

Where $\beta = \frac{q}{kT}$, A_{eff} is the effective area of the Schottky solar cell.

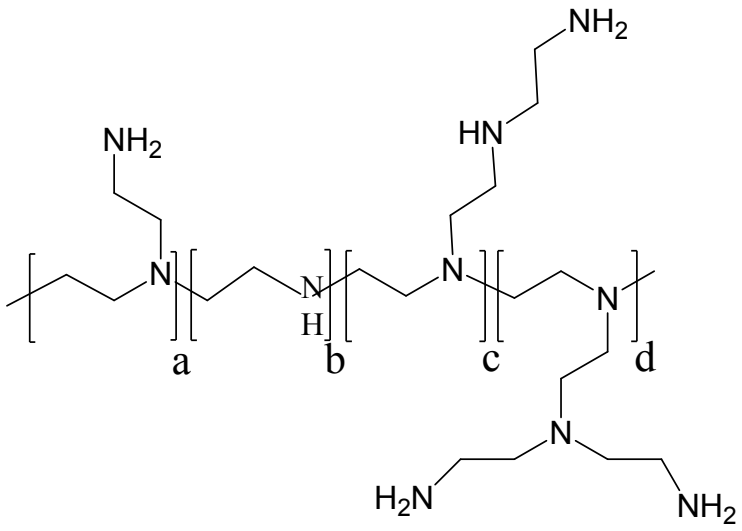

Figure S1. Chemical structure of polyethylenimine (PEI).

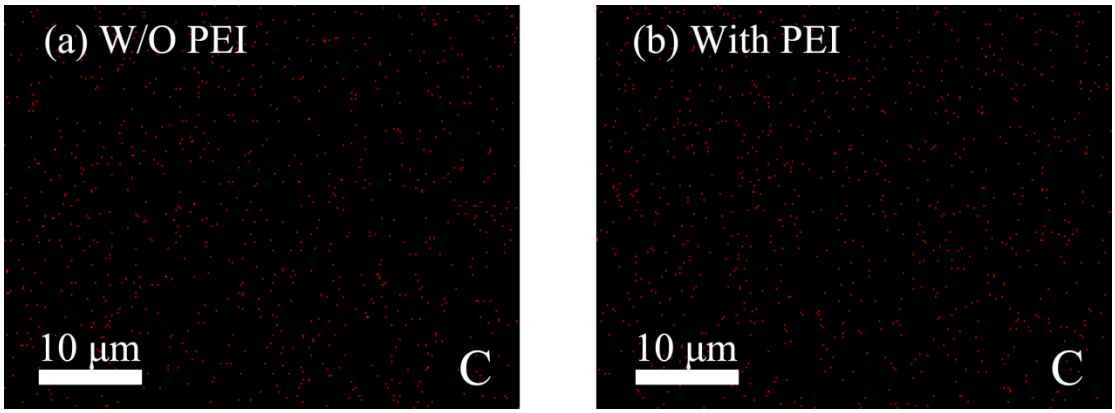

Figure S2. Element mapping images by energy-dispersive X-ray spectroscopy of carbon (a) without PEI and (b) with PEI.

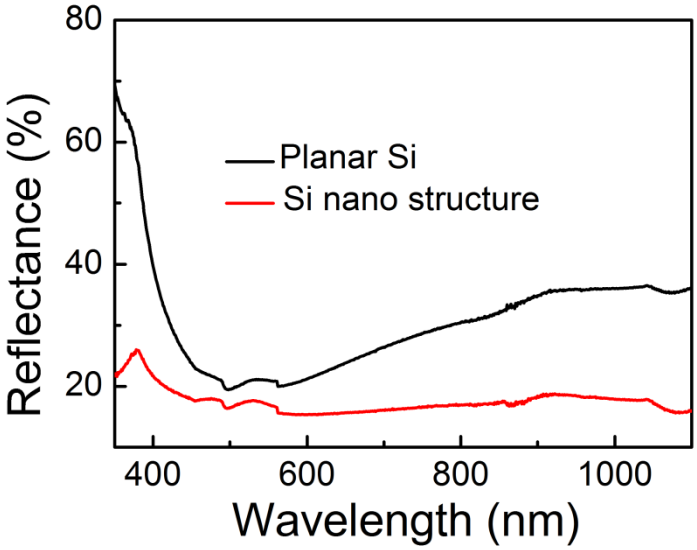

Figure S3. Reflectance of planar Si and nanostructured Si coated with PEDOT:PSS.

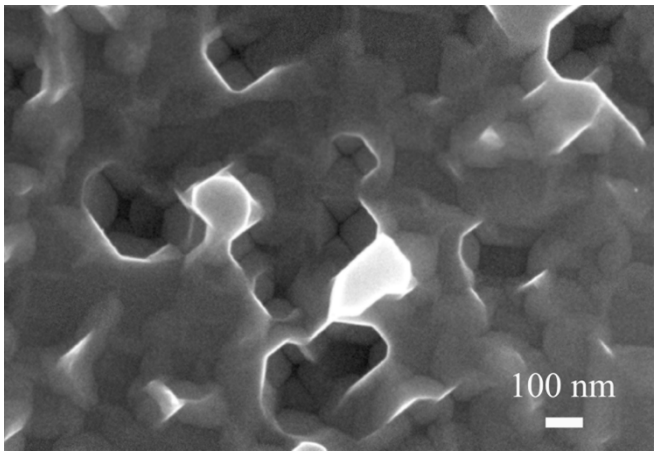

Figure S4 Plan-view SEM image of the nanostructured silicon.

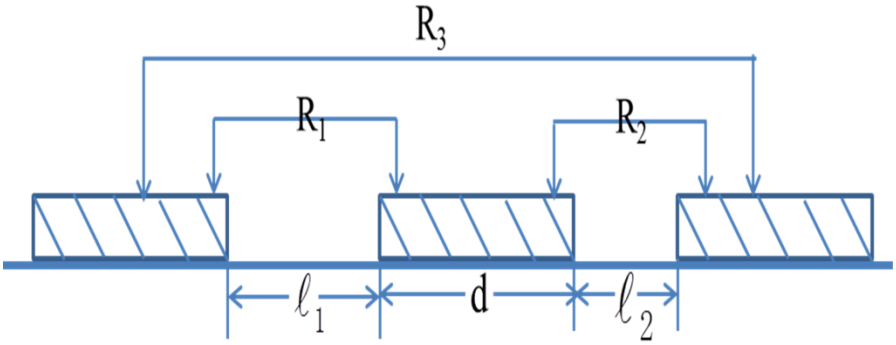

Figure S5. Schematic diagram for measuring the contact resistance value.

References

1. Reeves, G.; Harrison, H. *Electron Dev. Lett., IEEE,* 1982, **3**, 111-113.
2. Cheung, S. K.; Cheung, N. W. *Appl. Phys. Lett.,* 1986, **49**, 85-87.