Supporting Information

Piezotronic effect on the Output Voltage of P3HT/ZnO Micro/Nanowire Heterojunction Solar Cells

*Ya Yang, Wenxi Guo, Yan Zhang, Yong Ding, Xue Wang, and Zhong Lin Wang**

School of Material Science and Engineering, Georgia Institute of Technology, Atlanta, Georgia 30332-0245, United States

To whom correspondence should be addressed: Email: zlwang@gatech.edu

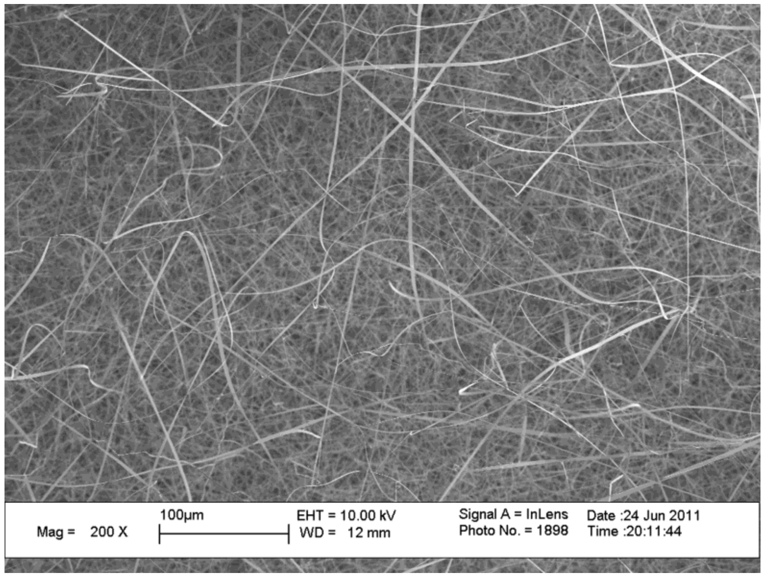

Figure S1 SEM image of as-grown ZnO micro/nanowires with [0001] growth direction.

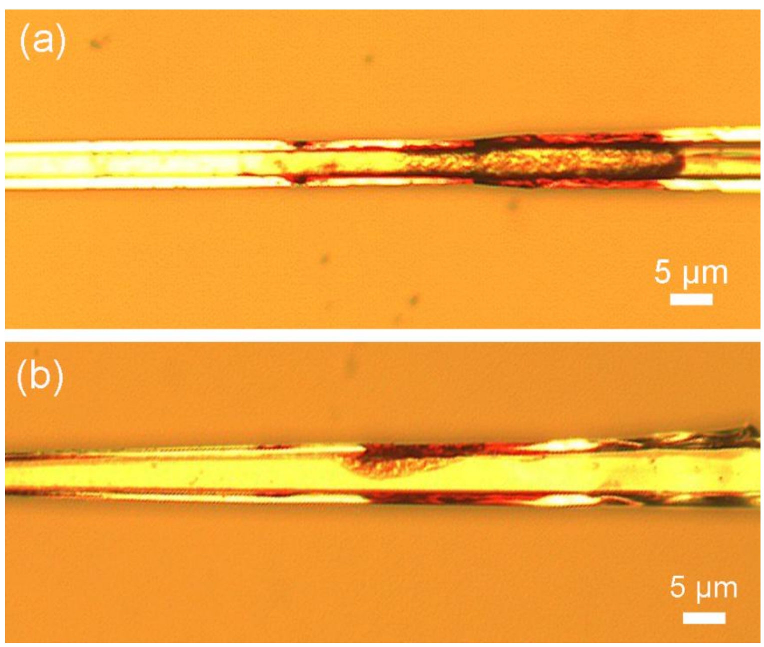

Figure S2 (a) Optical face image of a single ZnO wire after the P3HT was dropped on it. The substrate is the flexible polystyrene material. (b) Optical image taken from the bottom side of the ZnO wire after the P3HT was dropped on it. Owing to the large viscosity of the P3HT, it contacts only the top surface of the microwire. This is important for our proposed model in Figures 3 and 4.

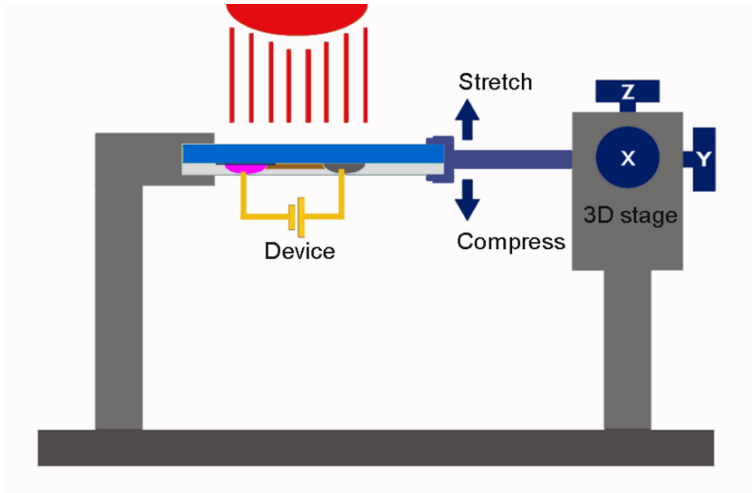

Figure S3 Schematic of the measuring system to characterize the performance of solar cell devices

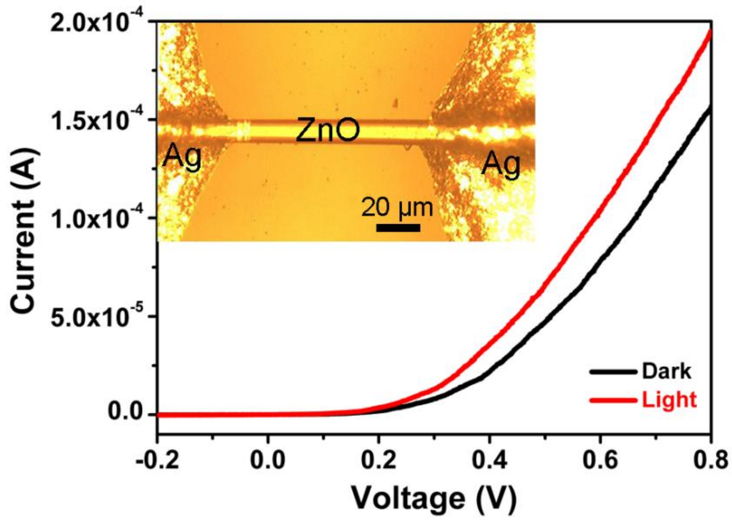

Figure S4 *I-V* characteristics of an Ag-ZnO-Ag device under the dark and sunlight illumination. The inset shows an optical image of the Ag-ZnO-Ag device.

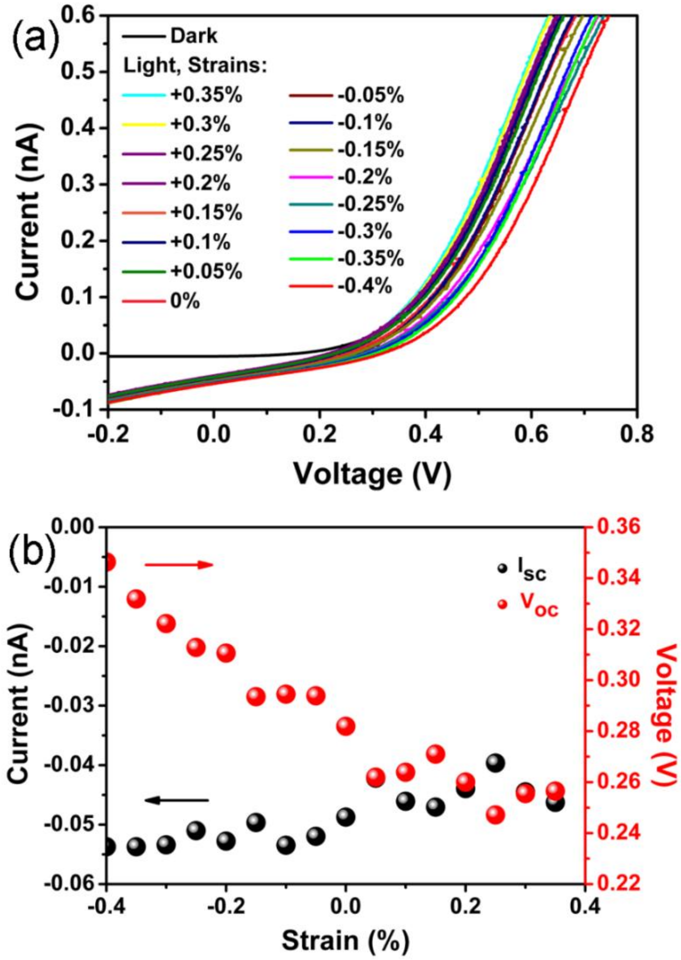

Figure S5 (a) *I-V* characteristics of another device under the different strains. (b) Dependence of short-circuit current I_{sc} and the open-circuit voltage V_{oc} on applied strains.

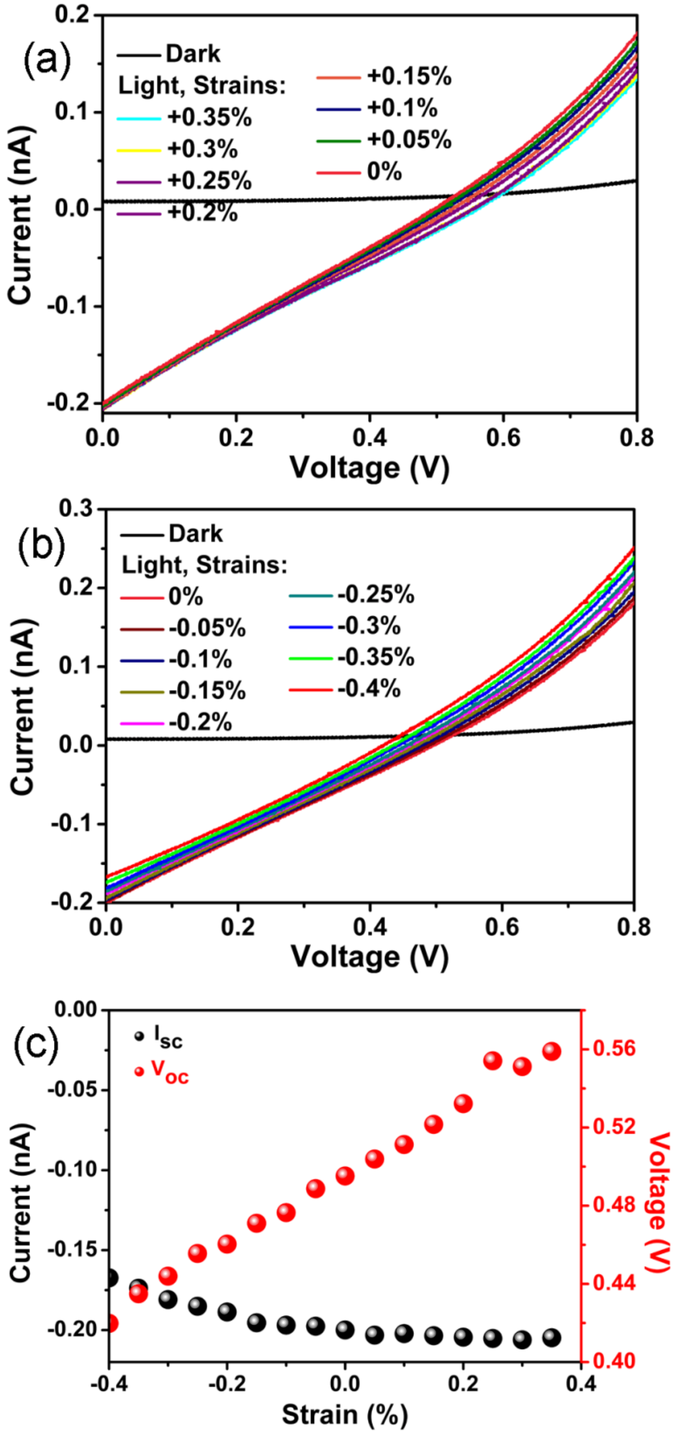

Figure S6 (a,b) *I-V* characteristics of another device under the tensile and compressive strains. (c) Dependence of I_{sc} and V_{oc} on applied strains.

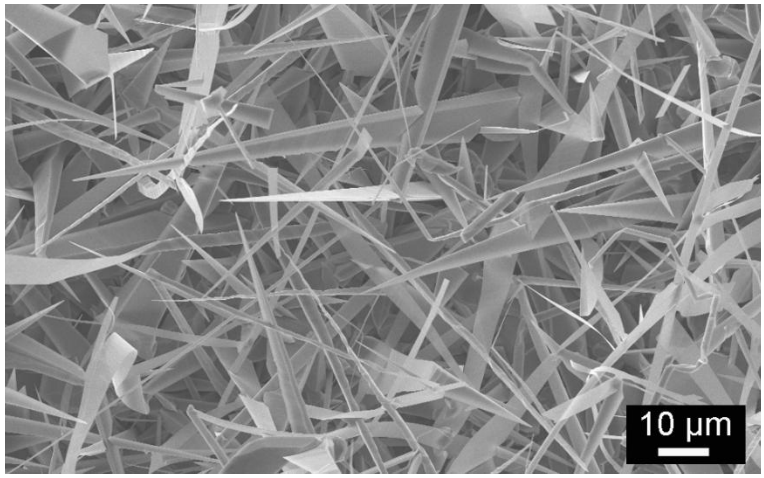

Figure S7 SEM image of the triangular ZnO micro/nanowires with growth direction of [01-10].

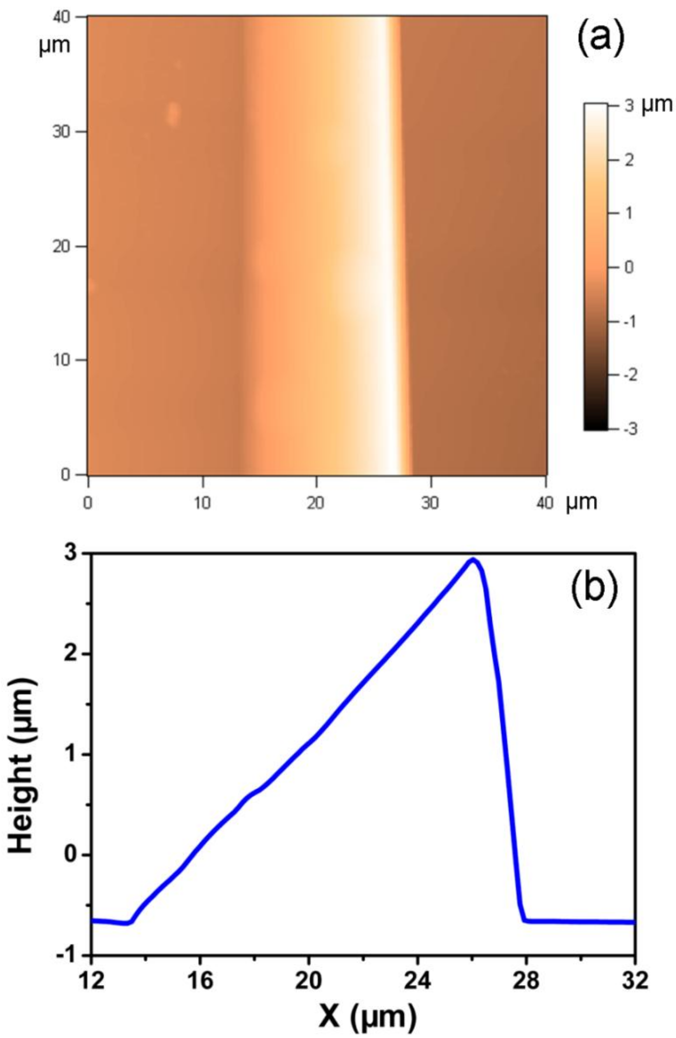

Figure S8 (a) AFM image of a triangular ZnO wire. (b) The corresponding cross section of the ZnO wire.

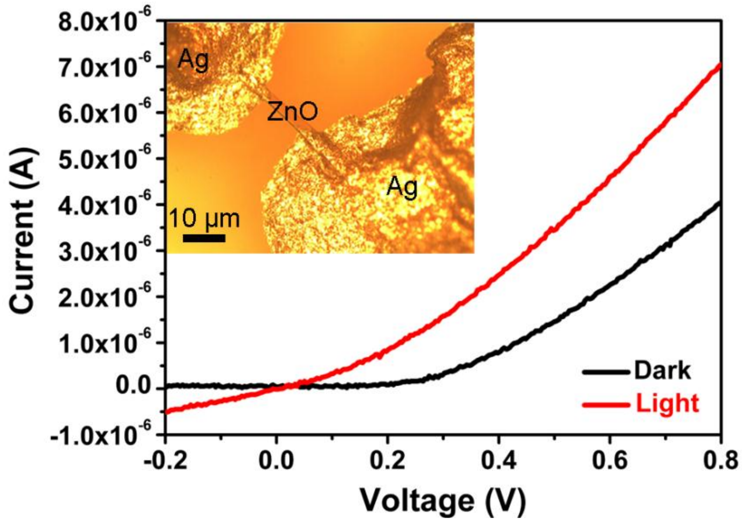

Figure S9 *I-V* characteristics of an Ag-triangle ZnO-Ag device under the dark and sunlight illumination. The inset shows an optical image of Ag-triangle ZnO-Ag device.

Calculation of strains for the fabricted devices

Since the ZnO wires have much smaller dimensions than the polystyrene (PS) substrate, the mechanical behavior of the PS substrate is not affected by the ZnO wire. The strains induced in the ZnO wire can be calculated by using the Saint-Venant theory for small deflections (s1). The strain ε along the length direction of the ZnO wire can be given by

$$\varepsilon = 3\frac{a}{l}\frac{D_{\max}}{l}(1-\frac{z}{l}) \qquad \text{(s1)}$$

where a is half-thickness of the PS substrate, l is the length of PS substrate from the fixed end to the free end, z is the distance between the fixed end of the PS substrate and the middle point of the ZnO wire where the z axis is parallel to the length l (assuming that the length of the ZnO wire is much smaller than the length of the substrate), $D_{\max}$ is the maximum displacement of the free end of the PS substrate, which has a positive or negative value depending upon whether the ZnO wire is under tensile or compressive strain, respectively (s2-s5). According to the equation s1 and the measuring system of devices in Figure S3, the corresponding strains under the different displacements can be obtained.

References

(s1) Soutas-Little, R. W. *Elasticity* (Dover Publications, Mineolar, NY, 1999).

(s2) Zhou, J.; Gu, Y.; Fei, P.; Mai, W.; Gao, Y.; Yang, R.; Bao, G.; Wang, Z. L. *Nano Lett.* **2008**, 8, 3035.

(s3) Wu, W.; Wang, Z. L. *Nano Lett.* **2011**, 11, 2779.

(s4) Yang, Q.; Guo, X.; Wang, W.; Zhang, Y.; Xu, S.; Lien, D. H.; Wang, Z. L. *ACS nano* **2010**, 4, 6285.

(s5) Wu, W.; Wei, Y.; Wang, Z. L. *Adv. Mater.* **2010**, 22, 4711.