Supporting Information

Enhanced Broadband Photoresponse of a Self-Powered Photodetector Based on Vertically Grown SnS layers via the Pyro-Phototronic Effect

Mohit Kumar[a,b], Malkeshkumar Patel[a,b] , Joondong Kim[a,b,*], and Donggun Lim[c,*]

[a]*Department of Electrical Engineering, Incheon National University, 119 Academy Rd. Yeonsu, Incheon, 406772, Republic of Korea*

[b]*Photoelectric and Energy Device Application Lab (PEDAL), Multidisciplinary Core Institute for Future Energies (MCIFE), Incheon National University, 119 Academy Rd. Yeonsu, Incheon, 406772, Republic of Korea.*

[c]Department of IT Convergence, Korea National University of Transportation, 50 Daehak-ro, Chungju, Chungbuk 380702, Republic of Korea

* E-mails: joonkim@incheon.ac.kr (J. Kim) and dglim@ut.ac.kr (D. Lim)

†Electronic supplementary information (ESI) available

The electrical properties of SnS samples were characterized by a Hall measurement system (Hall measurement system, AHT5573R, Ecopia) using the van der Pauw contact method. The vertically grown SnS layers were investigated by Hall measurement and revealed *p*-type characteristics with an acceptor carrier concentration (NA) of 10^{17} cm^{-3} and a Hall mobility of 15 $cm^2\ V^{-1}\ s^{-1}$ at room temperature. More accurate data can be achieved by a field effect transistor to reach the high mobility values of 4200 $cm^2\ V^{-1}\ s^{-1}$.[1]

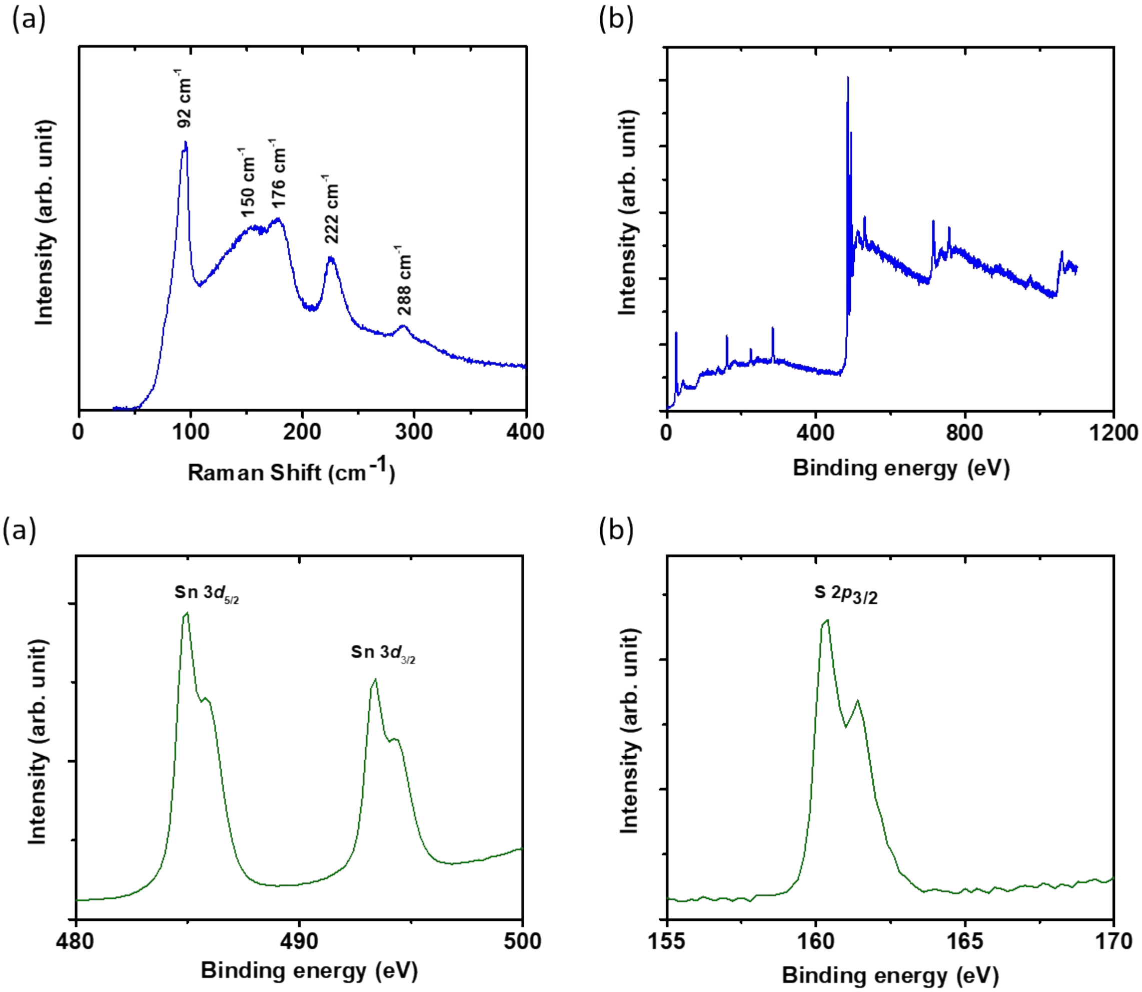

Fig. S1. Elemental analysis. (a) Raman spectra of tin sulphide, examined by spectroscopy (confocal Raman imaging, WITec alpha300) with an excitation wavelength of 532 nm (Laser: helium–neon) with a spatial resolution of <0.3 μm and spectral resolution of <0.01 nm. X-ray photoelectron spectroscopy. (b) Survey spectra of SnS layers, (c) and (d) represent the XPS peaks of Sn and S, respectively.

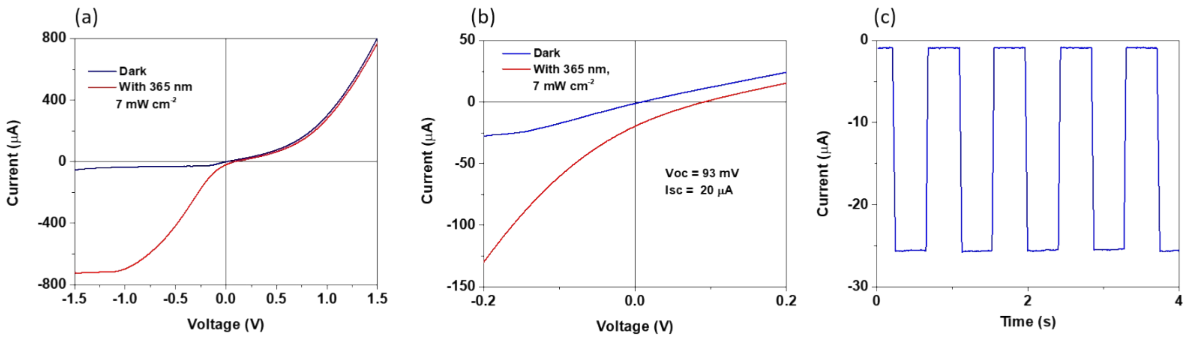

Fig. S2. Charge transport properties of ITO/*n*-Si heterojunction (without SnS layers). (a) Dark and UV current-voltage characteristics, depicting a significant change with light. (b) Shows a magnified view of (a), confirming its self-biased behavior. (c) Current-time behavior of the ITO/Si device under zero bias condition. Absence of peak can be clearly observed. In addition, response does show relatively slow response time in comparison to SnS-based device.

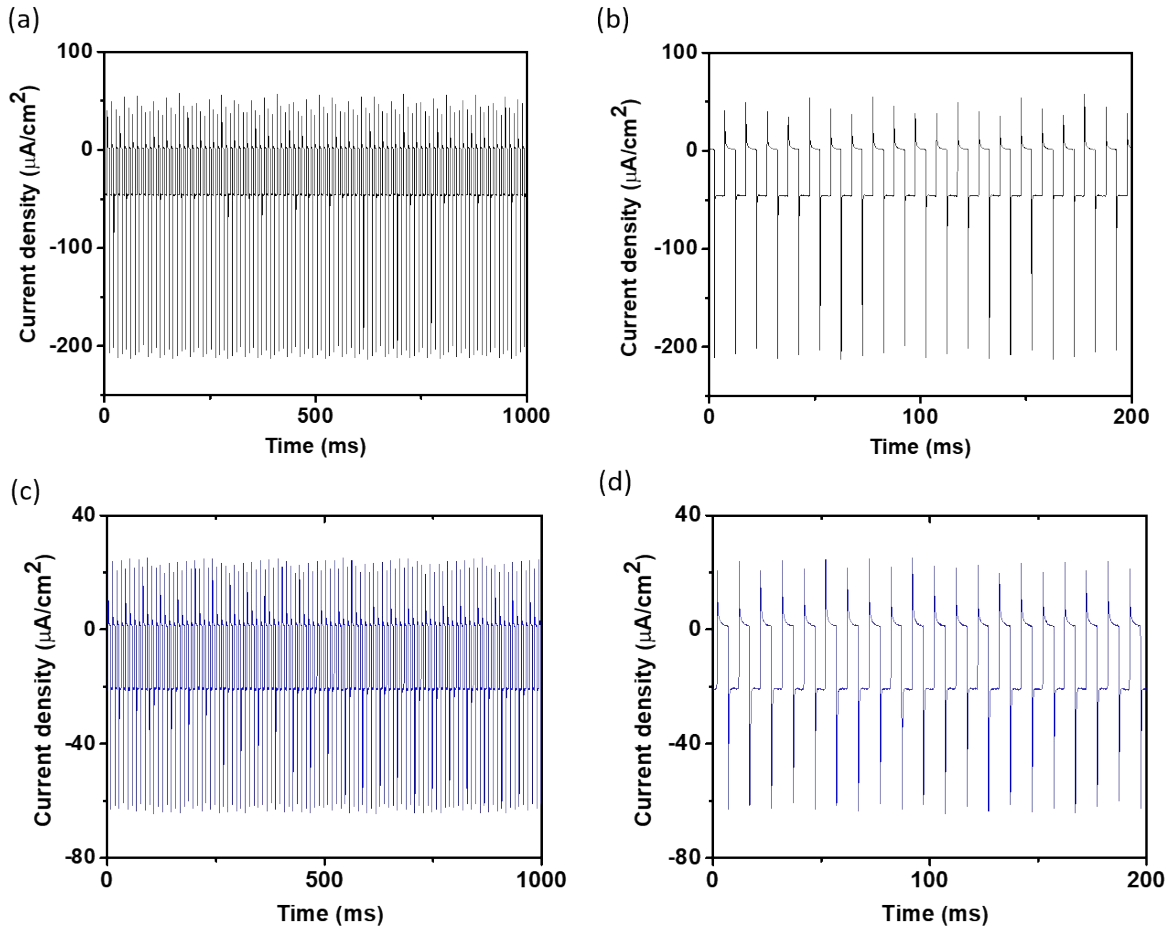

Fig. S3. Stability and durability. (a) Current-time behavior of ITO/SnS/Si/Al device under 660 nm at 3 mW cm^{-2} for 100 cycles, showing high reproducing behavior of the device. A magnified view of the same is depicted in (b). (c) Shows the current-time response of ITO/SnS/Si/Al device under 850 nm at 1 mW cm^{-2} for 100 cycles. A magnified view of the same is depicted in (d). These plots confirm that the presence of pyro-phototronic effect in vertically grown SnS layers is highly reproducible.

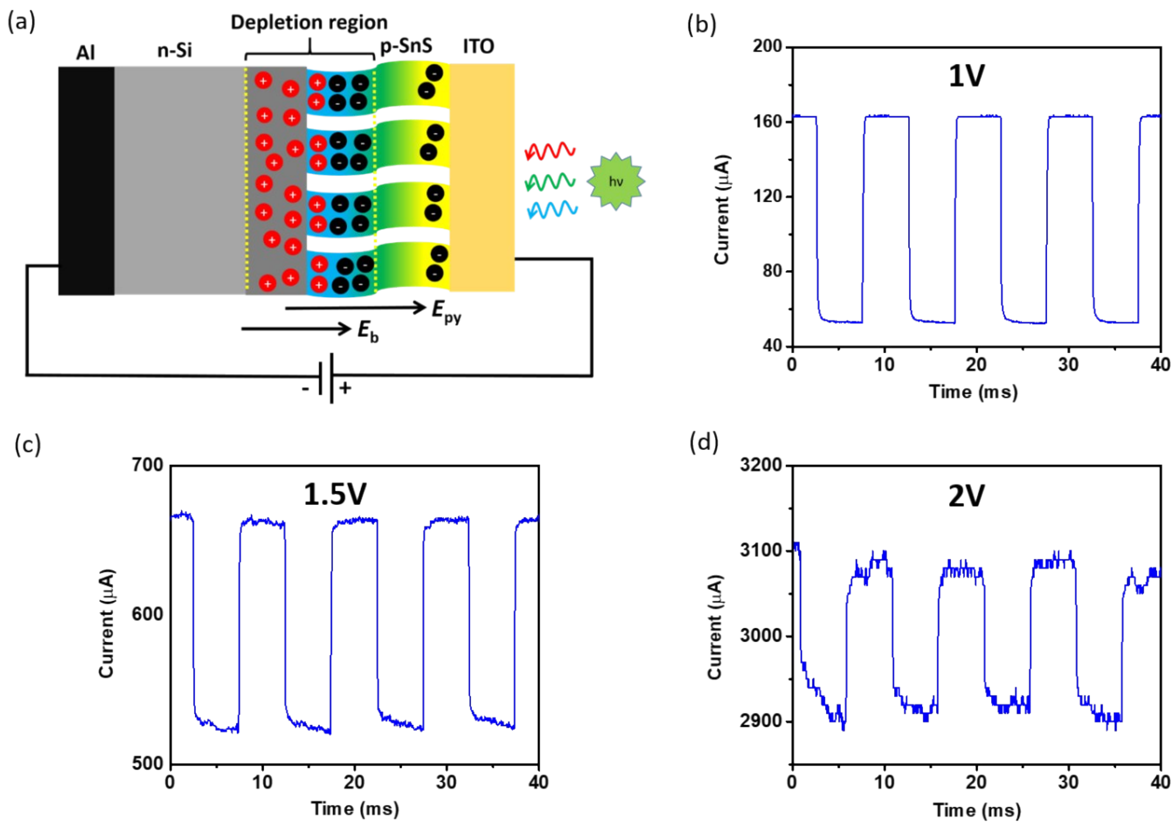

Fig. S4. Collapsing behavior of device. (a) Schematics diagram of ITO/SnS/Si/Al device with an applied external biased. (b) Current-time behavior of the device with applied +1V. Interestingly, no peak was observed, confirming the collapsing nature of the pyro-phototronic effect. (c) and (d) show the current response of the device, confirming that the rise and fall times are increasing with increasing applied external voltage.[2]

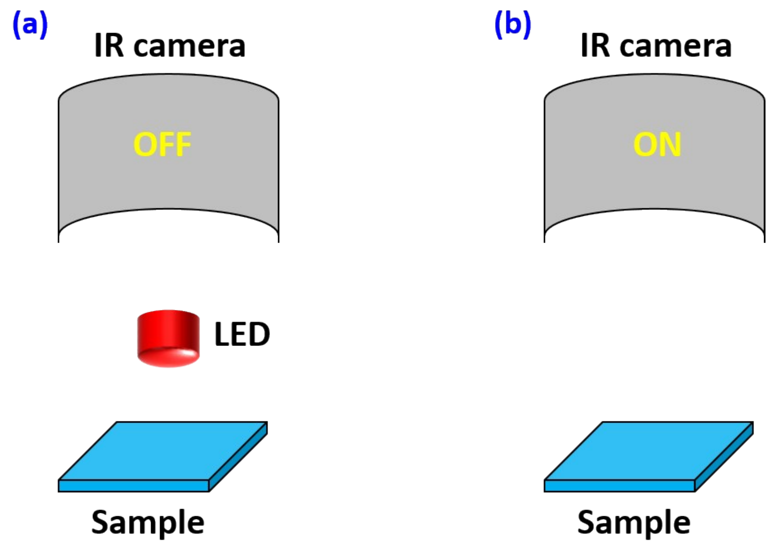

Figure S5: Schematic diagrams for the light-induced pyro-electric potential: (a) LED-induced surface heating and (b) image capturing after removing LED.

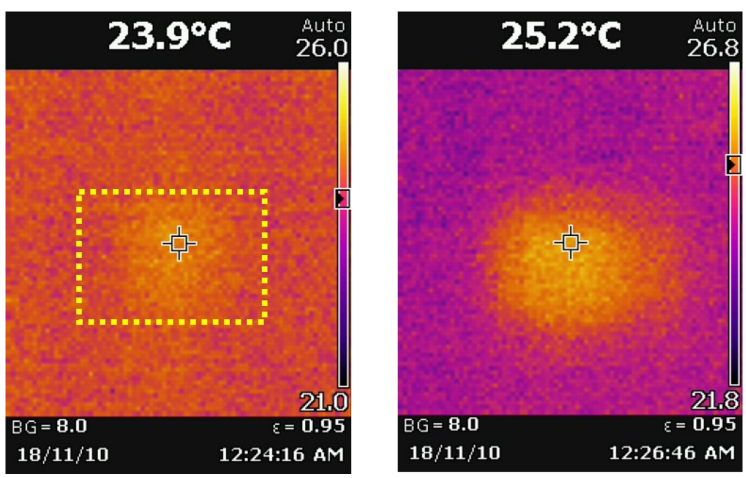

Figure S6: Change in the surface temperature due to pulsed (1k Hz) 650 nm illumination, 7 mW cm^{-2} for different times. To avoid the direct light reflection from the surface, these images are collected after the illumination [dotted yellow line shows the sample size, 1×1 cm^{-2}]. It is also mentioned here that observed nonuniformity of the measurements could be due to used cylindrical LED light source and large area.

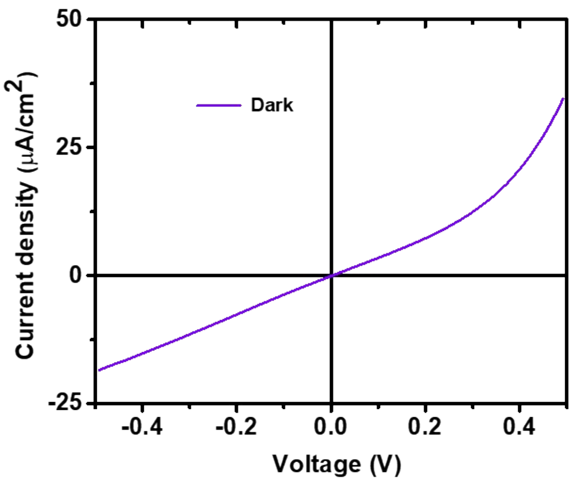

Figure S7: Dark *I-V* characteristic of SnS/Si junction.

Notes and references

1. M. Patel, H.-S. Kim, and J. Kim, 2017, DOI:10.1039/C7NR03370B.

2. Z. Wang, R. Yu, C. Pan, Z. Li, J. Yang, F. Yi, Z. L. Wang, *Nat. Commun*. 2015, 6, 9401.