Supporting information for

# Influence of Sodium Diffusion from Substrates on Performance of SnS/CdS Thin-film Solar Cells

*Jae Yu Cho, Kyeongrok Shin, Hyo Seok Lee, KrishnaRao Eswar Neerugatti,*

*and Jaeyeong Heo**

Department of Materials Science and Engineering, and Optoelectronics Convergence Research Center, Chonnam National University, Gwangju 61186, Republic of Korea

*Corresponding author email: jheo@jnu.ac.kr

Table S1. Device performance of SnS-based TFSCs with efficiencies over 1% since 2017.

| Author | Year | p-n junction | Solar cell properties | | | | Ref. |
|---|---|---|---|---|---|---|---|
| | | | $V_{OC}$ (V) | $J_{SC}$ (mA cm$^{-2}$) | FF (%) | $\eta$ (%) | |
| Kang et al. | 2017 | SnS/CdS | 0.269 | 13.28 | 45.07 | 1.61 | 1 |
| Takano et al. | 2018 | SnS/MgSnO | 0.313 | 21 | 33 | 2.1 | 2 |
| Lim et al. | 2018 | SnS/CdS | 0.291 | 17.76 | 56.8 | 2.938 | 3 |
| D. Ding et al. | 2018 | SnS/$TiO_2$ | 0.313 | 24.8 | 39 | 3.0 | 4 |
| Flores et al. | 2019 | SnS/CdS | 0.488 | 6.96 | 41 | 1.38 | 5 |
| Gedi et al. | 2019 | SnS/CdS | 0.283 | 13.9 | 41.1 | 1.62 | 6 |
| Chua et al. | 2019 | SnS/(Sn,Ge)$O_2$:N | 0.40 | 12.2 | 46 | 2.21 | 7 |
| Spalatu et al. | 2019 | SnS/CdS | 0.290 | 17.2 | 56 | 2.8 | 8 |
| Cho et al. | 2019 | SnS/CdS | 0.297 | 19.4 | 52.8 | 3.05 | 9 |
| Lee et al. | 2019 | SnS/CdS | 0.342 | 19.8 | 58.0 | 3.93 | 10 |

Table S2. The elemental analysis by EDX on SLG and Eagle XG substrates

| | SLG | | Eagle XG | |
|---|---|---|---|---|
| | wt% | at% | wt% | at% |
| Si | 41.58 | 32.20 | 38.24 | 29.19 |
| O | 38.08 | 51.77 | 42.70 | 57.22 |
| Na | 9.43 | 8.92 | 0.09 | 0.08 |
| Ca | 6.30 | 3.42 | 6.36 | 3.40 |
| Mg | 2.95 | 2.64 | 1.18 | 1.04 |
| Al | 0.99 | 0.80 | 11.37 | 9.04 |
| Fe | 0.29 | 0.11 | 0.05 | 0.02 |
| Ba | 0.19 | 0.03 | - | - |
| K | 0.10 | 0.06 | - | - |
| Ti | 0.09 | 0.04 | - | - |

Table S3. Detailed cell parameters for TFSCs with different substrates; the best cell for each sample is in red.

| Sample | Cell no. | Solar cell properties | | | |
|---|---|---|---|---|---|
| | | $V_{OC}$ (V) | $J_{SC}$ (mA cm$^{-2}$) | FF (%) | $\eta$ (%) |
| SLG | 1 | 0.290 | 16.77 | 49.66 | 2.418 |
| | 2 | 0.289 | 17.01 | 49.87 | 2.454 |
| | 3 | 0.297 | 16.33 | 50.24 | 2.435 |
| | 4 | 0.299 | 16.95 | 49.90 | 2.533 |
| | **5** | **0.301** | **17.30** | **51.08** | **2.662** |
| | Average | 0.295 | 16.87 | 50.15 | 2.500 |
| Eagle XG | 1 | 0.302 | 21.02 | 45.56 | 2.891 |
| | **2** | **0.302** | **20.93** | **46.39** | **2.931** |
| | 3 | - | - | - | - |
| | 4 | 0.305 | 20.68 | 42.85 | 2.706 |
| | 5 | 0.300 | 19.69 | 42.31 | 2.496 |
| | Average | 0.302 | 20.58 | 44.28 | 2.756 |

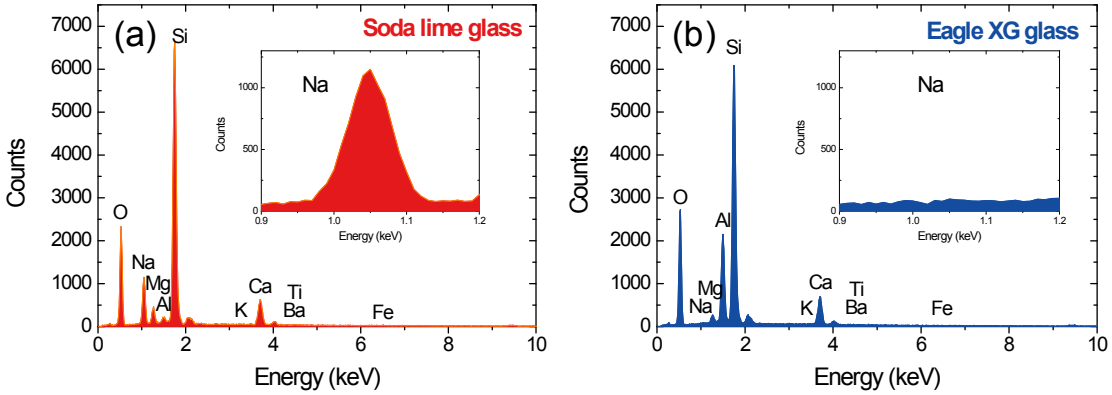


Fig. S1. Areal EDX spectrums for (a) SLG and (b) Eagle XG glass substrates, respectively. The inset shows the blow up of Na peaks for each substrate.

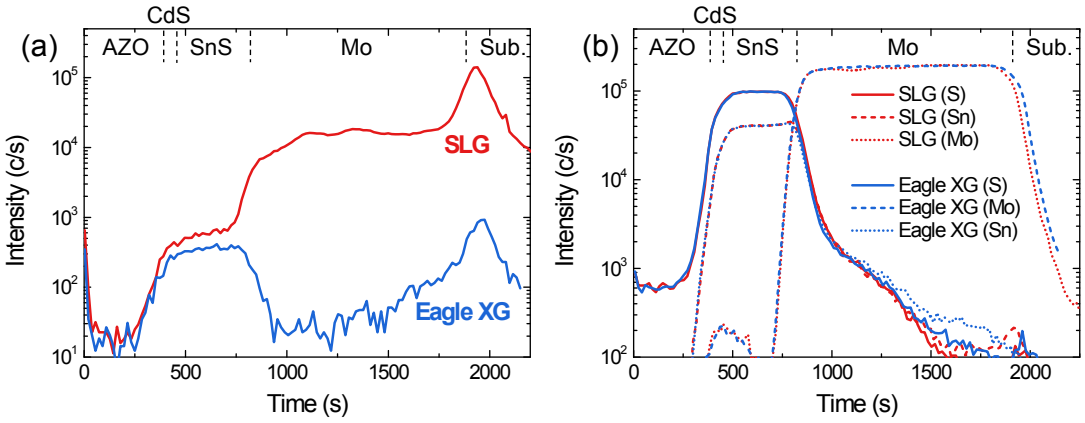


Fig. S2. (a) Na and (b) Sn, S, and Mo contents of each substrate from SIMS analysis.

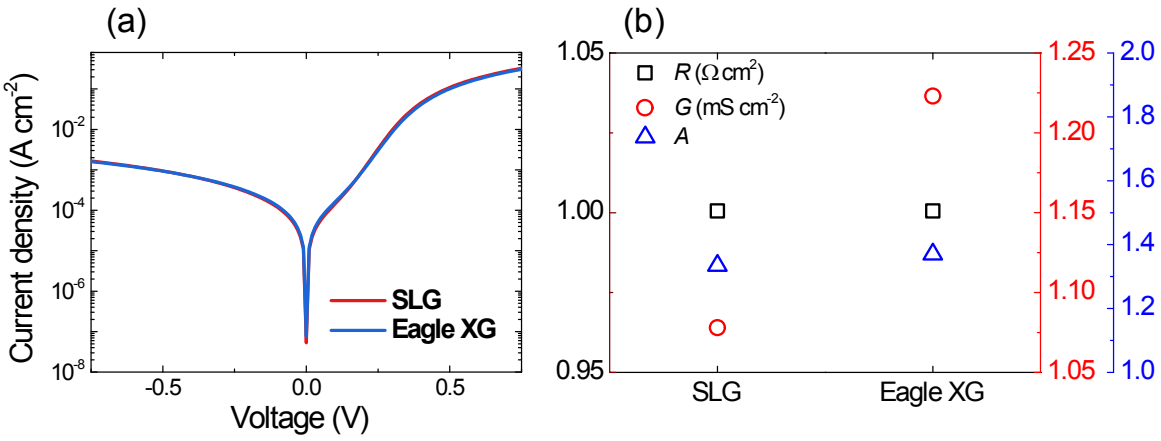


Fig. S3. (a) Dark *J*-*V* characteristics and (b) diode characteristics obtained from the best-performing SnS/CdS TFSCs.

**References**


1. J.-y. Kang, S.-M. Kwon, S. H. Yang, J.-H. Cha, J. A. Bae and C.-W. Jeon, *J. Alloys Compd.*, 2017, **711**, 294-299.
2. Y. Takano and K. Oyaizu, *Mater. Lett.*, 2018, **228**, 414-417.
3. D. Lim, H. Suh, M. Suryawanshi, G. Y. Song, J. Y. Cho, J. H. Kim, J. H. Jang, C.-W. Jeon, A. Cho, S. Ahn and J. Heo, *Adv. Energy Mater.*, 2018, **8**, 1702605.
4. D. Ding, T. Rath, L. Lanzetta, J. Manuel Marin-Beloqui and S. A. Haque, *ACS Appl. Energy Mater.*, 2018, **1**, 3042-3047.
5. V. E. González-Flores, R. N. Mohan, R. Ballinas-Morales, M. T. S. Nair and P. K. Nair, *Thin Solid Films*, 2019, **672**, 62-65.
6. S. Gedi, V. R. Minnam Reddy, T. R. R. Kotte, Y. Park and W. K. Kim, *Appl. Surf. Sci.*, 2019, **465**, 802-815.
7. D. Chua, S. B. Kim, P. Sinsermsuksakul and R. Gordon, *Appl. Phys. Lett.*, 2019, **114**, 213901.
8. N. Spalatu, J. Hiie, R. Kaupmees, O. Volobujeva, J. Krustok, I. Oja Acik and M. Krunks, *ACS Appl. Mater. Interfaces*, 2019, **11**, 17539-17554.
9. J. Y. Cho, S. Sinha, M. G. Gang and J. Heo, *J. Alloys Compd.*, 2019, **796**, 160-166.
10. D. Lee, J. Y. Cho, H.-S. Yun, D.-K. Lee, T. Kim, K. Bang, Y. S. Lee, H.-Y. Kim and J. Heo, *J. Mater. Chem. A*, 2019, **7**, 7186-7193.