Electronic Supplementary Information

Electrodeposited CZTS solar cells from the electrolyte of Reline

Hao Chen, Qinyan Ye, XuLin He, Jingjing Ding, Yongzheng Zhang, Junfeng Han, Jiang Liu *, **Cheng Liao** *, **Jun Mei, WoonMing Lau**

Chengdu Green Energy and Green Manufacturing Technology R&D Centre, Southwest Airport Economic Development Zone, Shuangliu, Chengdu, 610207, P. R. China

* Corresponding author: Tel: +86-28-67076209, Fax: +86-28-67070129

E-mail address: 546jiang@163.com (J. Liu); cliao315@hotmail.com (C. Liao).

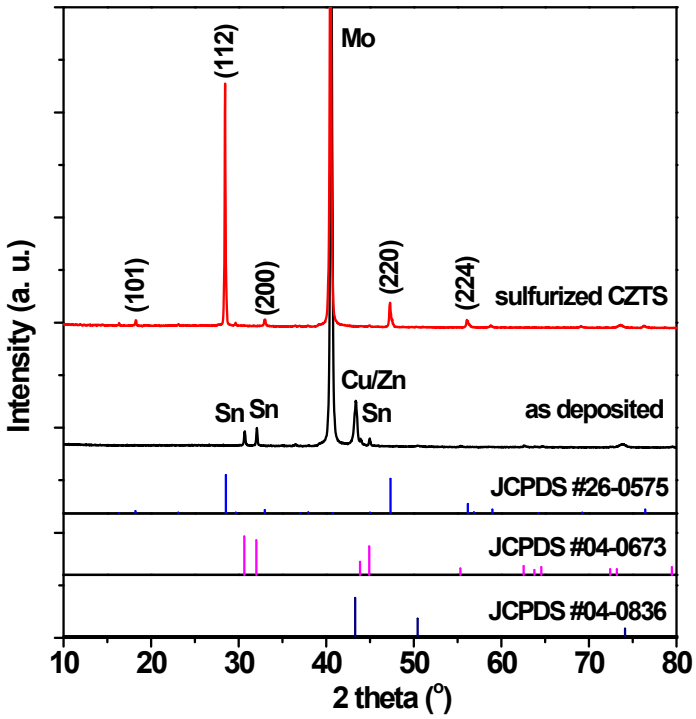

Figure S1 X-ray diffraction patterns of the co-electroplated CuZnSn precursor film and the sulfurized CZTS film. For reference, the standard XRD patterns of kesterite CZTS (JCPDS 26-0575), metal Sn (JCPDS 04-0673) and Cu (JCPDS 04-0836) are

shown below. The sulfurized CZTS XRD pattern compared with JCPDS 26-0575 suggests a basic kesterite crystal structure with a preferred orientation of (112). The peaks for CuZnSn precursor film correspond to elemental Cu, Zn and Sn phases.

The *J-V* characteristic of a single heterojunction solar cell can be described as[1, 2]

$$J = -J_L + J_o exp\left[\frac{q}{AkT}(V - RJ)\right] + GV \quad (1)$$

where G is the shunt conductance, R is the series resistance, A is the ideality factor, k is the Boltzmann constant, J_o is the saturation current density, q is the elementary charge, J_L is the light induced constant current density. From the equation (1), it can be deduced

$$\frac{dV}{dJ} = R + \frac{AkT}{q}(J + J_L)^{-1} \quad (2)$$

$$ln(J + J_L - GV) = lnJ_o + \frac{q}{AkT}(V - RJ) \quad (3)$$

Assuming that G=0 and $J_L = J_{sc}$, the series resistance R and the ideality factor A can be obtained by plotting dV/dJ against $(J+J_{sc}-GV)^{-1}$ to find the slope and intercept, respectively. Similarly, the saturation current density J_o can be obtained from the semilogarithmic plot of $(V-RJ)$ against $\ln(J+J_{sc}-GV)$.

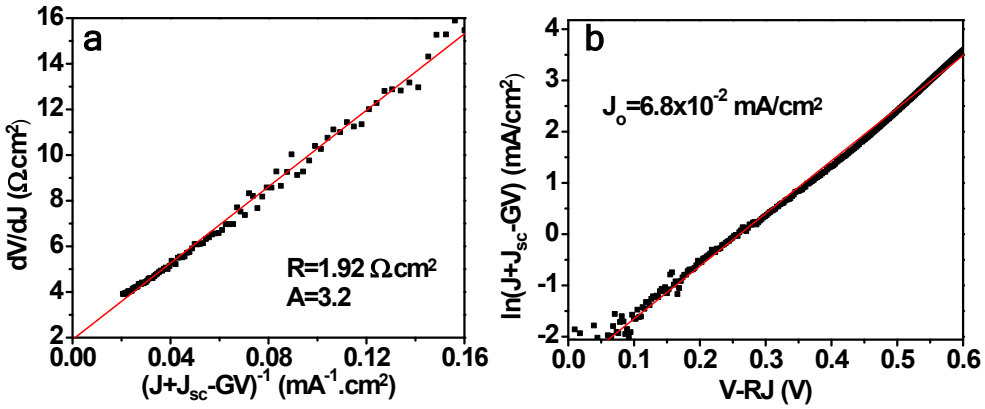

Figure S2. (a) dV/dJ versus $(J+J_{sc}-GV)^{-1}$ with fit used to determine R and A according to the equation dV/dJ =R+AkT $(J+J_{sc}-GV)^{-1}$ /q. (b) $(V-RJ)$ versus $\ln(J+J_{sc}-GV)$ with fit used to determine to determine Jo according to the equation $\ln(J+J_{sc}-GV) = \ln J_o$+q $(V$-

RJ) /*AkT*.

References

1. S. S. Hegedus and W. N. Shafarman, *Progress in Photovoltaics: Research and Applications*, 2004, **12**, 155-176.
2. J. Shi, J. Dong, S. Lv, Y. Xu, L. Zhu, J. Xiao, X. Xu, H. Wu, D. Li, Y. Luo and Q. Meng, *Applied Physics Letters*, 2014, **104**, 063901.