Electronic Supplementary Information

Electrodeposited CZTS solar cells from the electrolyte of Reline

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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\textsuperscript{1,2}

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

(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

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

(2)

$$ln\left( (J + J_L - GV) \right) = lnJ_o + \frac{q}{AKT}(V - RJ)$$

(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 $J_o$ according to the equation $ln(J+J_{sc}-GV) = lnJ_o + q (V-$
References
