Electronic Supplementary Information

High-Performance Quantum Dot-Sensitized Solar Cells Based on Sensitization with $CuInS_2$ Quantum Dots/CdS Heterostructure

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Fig. S1 The *J*–*V* curves of QDSSCs assembled with the TiO_2/$CuInS_2$-QDs/CdS/ZnS photoanode and Pt or Au counter electrodes under one-sun illumination

Fig. S2 Nyquist impedance plots of Au and Pt electrodes in the polysulfide electrolyte

Fig. S3 SEM images of the CuS nanocrystalline films deposited with varying SISCR cycles

Fig. S4 Cu 2p XPS spectra of the CuS film

Fig. S5 Nyquist impedance plots of the CuS electrodes in the polysulfile electrolyte

Fig. S6 The *J*–*V* curves of a QDSSC assembled with a $CuInS_2$-QDs/CdS-sensitized photoanode without ZnS coating, and the 4-cycle SISCR CuS counter electrode under one-sun illumination.

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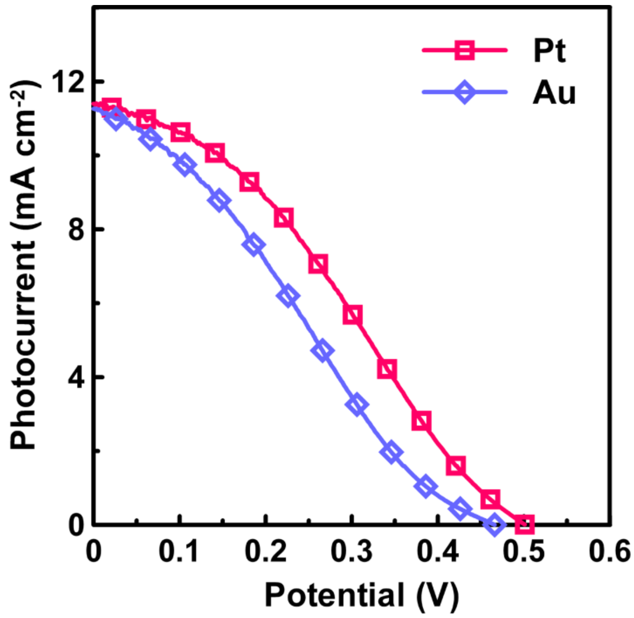

Fig. S1. Photocurrent–voltage characteristics of QDSSCs assembled with the TiO_2/$CuInS_2$-QDs/CdS/ZnS photoanode and Pt or Au counter electrodes under AM1.5-type solar illumination at 100 mW cm^{-2}. The $CuInS_2$-QDs/CdS co-sensitized cells have η values of 1.86 and 1.43% with the Pt and Au counter electrodes, respectively, and corresponding fill factor values of 0.33 and 0.27. A small fill factor is associated with the large resistance of a device.

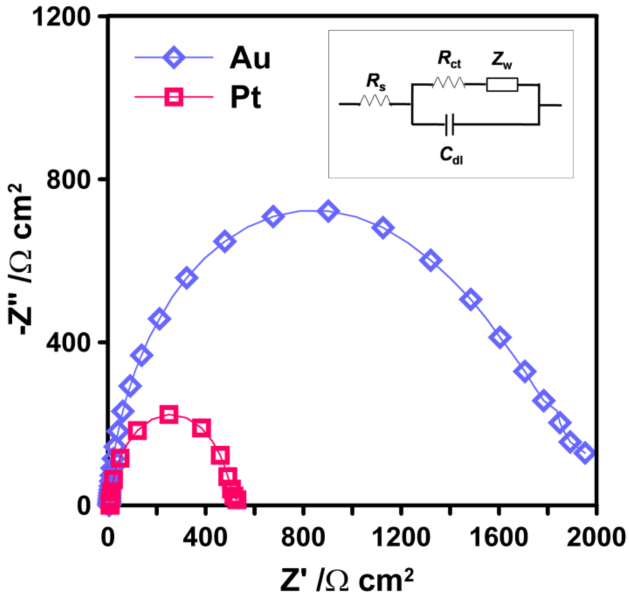

Fig. S2. Nyquist impedance plots of Au and Pt electrodes toward polysulfide electrolyte measured at zero bias in a symmetric two-electrode cell. Inset shows the equivalent circuit used for fitting the impedance data, where R_s is the equivalent series resistance, Z_w is the Nernst diffusion impedance of the electrolyte, R_{ct} is the charge transfer resistance, and C_{dl} is the electric double layer capacitance. The impedance tests employed a sandwich-type electrochemical cell, consisting of two identical electrodes that were separated by a distance of 60 μm, and a polysulfide electrolyte. By fitting the impedance data with an equivalent-circuit model, shown in the inset of Fig. S2, we obtained R_{ct} values of 520 and 1800 Ω cm^2 for the Pt and Au electrodes, respectively. The Pt and Au electrodes have a strong resistance toward interaction with the polysulfide electrolyte.

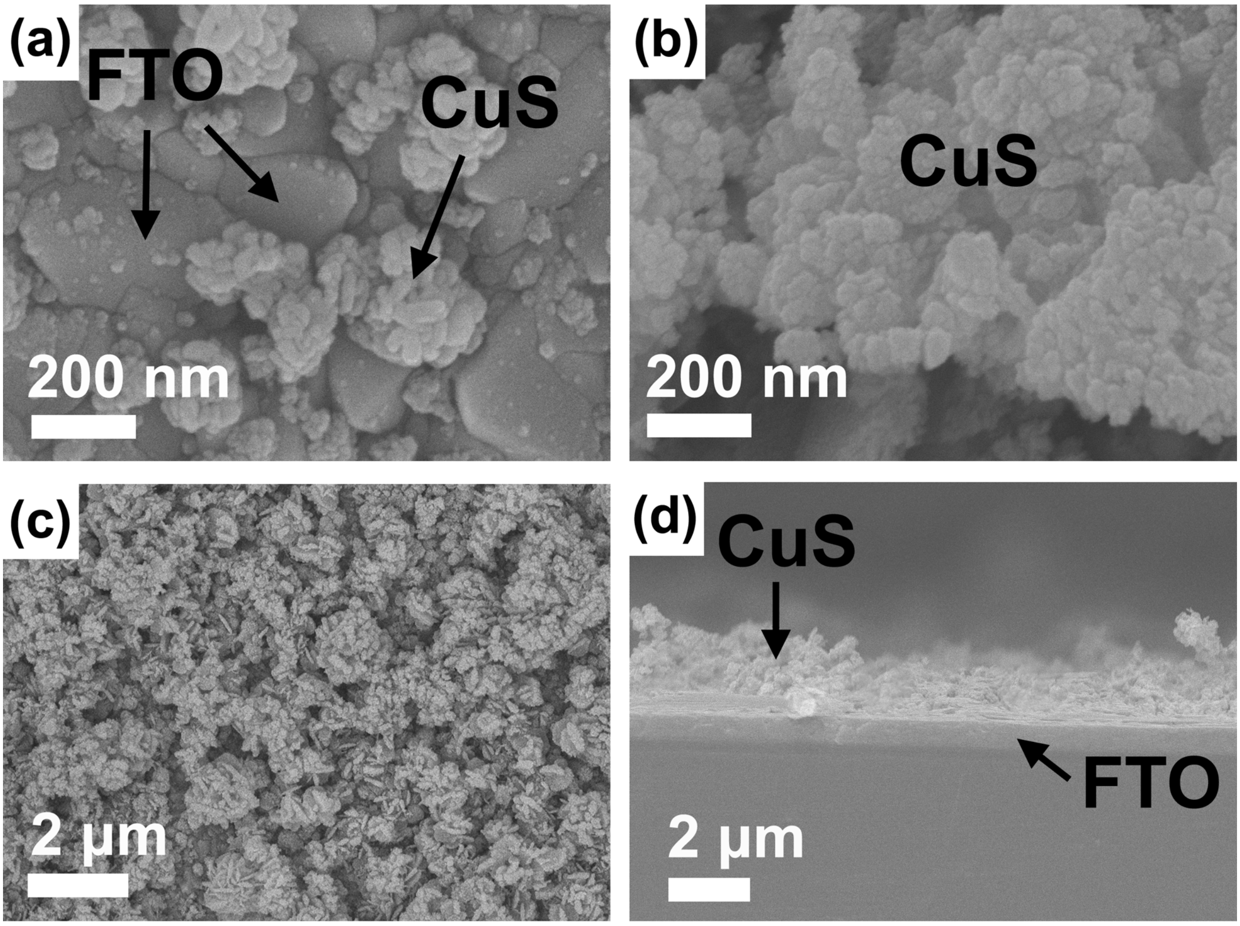

Fig. S3. Scanning electron microscopy (SEM) images of the CuS nanocrystalline films deposited with different successive ionic solution coating and reaction (SISCR) cycles: (a) 1 cycle and (b) 4 cycles. Panels (c) and (d) show the top-view and cross-section images of the 4-cycle SISCR CuS film at lower magnification. The density of the 1-cycle CuS deposit is low (panel (a)), and a significant proportion of surface FTO remains exposed. Complete coverage of the FTO substrate by a CuS layer can be observed by increasing the deposition cycle to 4 (panel (b)). Panels c and d demonstrates the long-range uniformity of the nanocrystalline CuS film, with a thickness of approximately 2 μm, from 4 cycle SISCR deposition by zooming out (i.e., lowering the magnification) to obtain the top and cross-section view images.

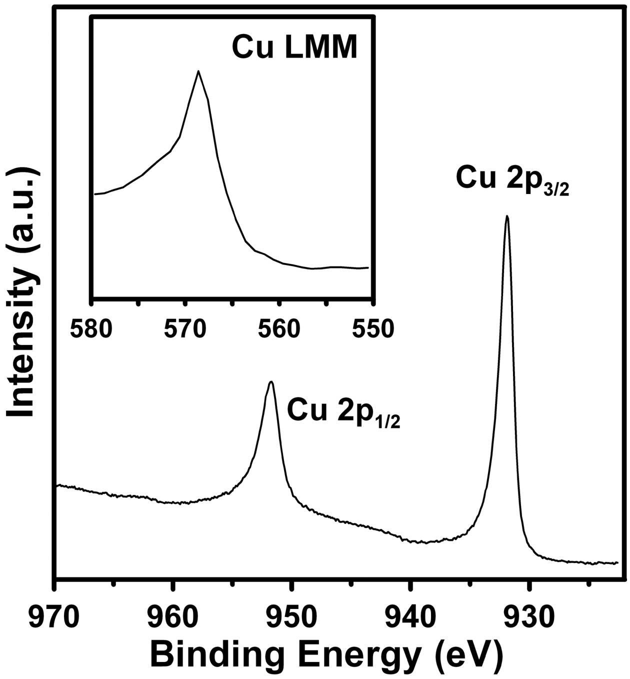

Fig. S4. High-resolution Cu 2p X-ray photoelectron spectroscopy (XPS) spectra of the CuS film, with inset showing the Auger Cu(LMM) spectrum. The XPS spectrum in the figure reveals that the Cu $2p_{3/2}$ peak has binding energy centered at 931.8 eV. The 931.8 eV peak is characteristic of CuS, and is 0.7 eV lower than that of the typical Cu_2S.[1,2] Copper ion in the CuS state can also be verified by the Auger Cu(LMM) spectrum, as shown in the inset of this figure, in which the Cu(LMM) line was centered at 568.6 eV, which was 0.6 eV lower than that of Cu_2S.[3,4]

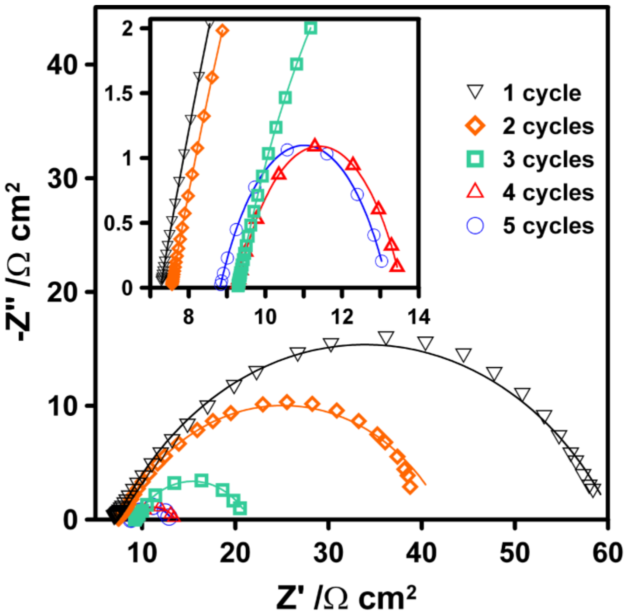

Fig. S5. Nyquist impedance plots of CuS electrodes, from varying SISCR cycles, toward the polysulfile electrolyte measured at zero bias in a symmetric two-electrode cell. Inset shows the magnification of the low *Z′* region of the impedance plots. Based on the data fitting with an equivalent-circuit model (inset of Fig. S2), the EIS measurements produced R_{ct} values of 53, 34, 12, 4.2, and 4.2 Ω cm^2 for the CuS electrodes from 1, 2, 3, 4 and 5 deposition cycles, respectively.

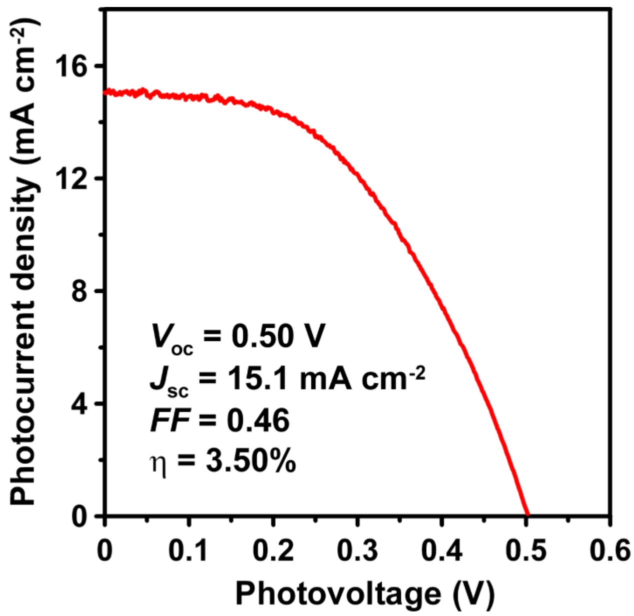

Fig. S6. Photocurrent–voltage characteristics of QDSSCs assembled with a $CuInS_2$-QDs/CdS-sensitized photoanode without ZnS coating, and the 4-cycle SISCR CuS counter electrode under AM1.5-type solar illumination at 100 mW cm^{-2}.

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