Electronic Supplementary Material (ESI) for Nanoscale

Supplementary Information

Spray Deposition of Water-soluble Multiwall Carbon Nanotubes and $Cu_2ZnSnSe_4$ Nanoparticles Composites as Highly Efficient Counter Electrodes in Quantum dot-Sensitized Solar Cell System

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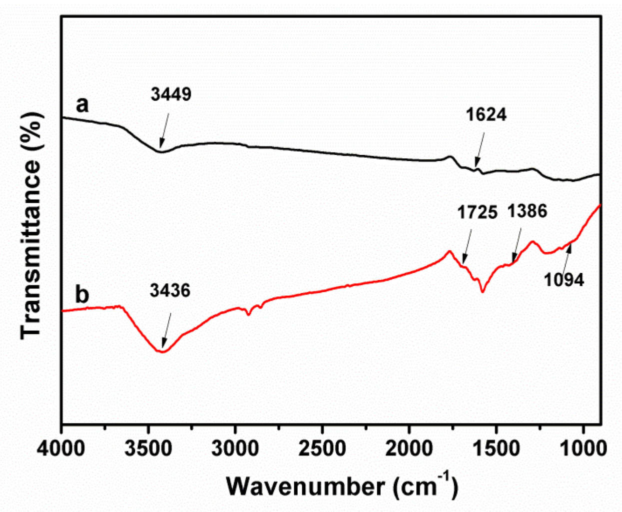

Fig. S1 FTIR spectra of (a) the raw-MWCNTs and (b) the modified MWCNTs.

It can be found that in comparison to the raw MWCNTs, there are several newly-presented peaks in the FTIR spectrum of the modified MWCNTs sample. These peaks located at 1725

cm^{-1}, 1386 cm^{-1}, 1094 cm^{-1} could be assigned to υ(C=O) stretching vibration, δ(O-H) bending vibration and υ(C-O) stretching vibration of the carboxylic groups (COOH) respectively. The results demonstrate clearly the surface of MTCNTs has been functionalized by the COOH groups.

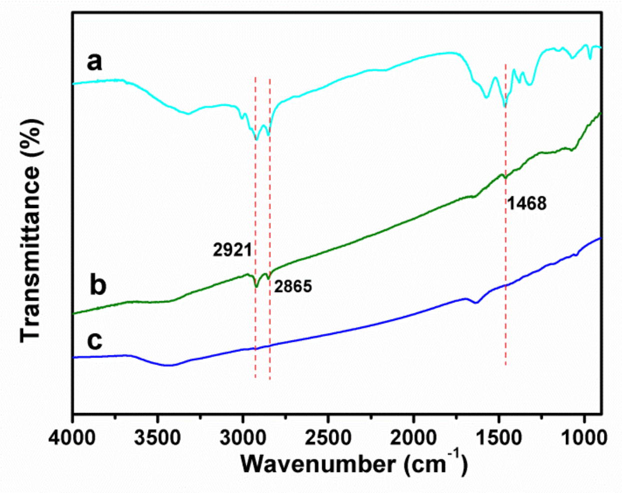

Fig. S2 FTIR spectra of (a) OLA, (b) OLA-capped CZTSe and (c) pyridine modified CZTSe. The peaks located at 2921 cm^{-1}, 2865 cm^{-1}, 1644 cm^{-1}, 1468 cm^{-1} are owing to OLA.

From FTIR spectrum of OLA-capped CZTSe nanocrystals, the peaks owing to OLA can be clearly observed, after reflux in pyridine, they disappear. The results also demonstrate the effectiveness of surface modification of CZTSe.

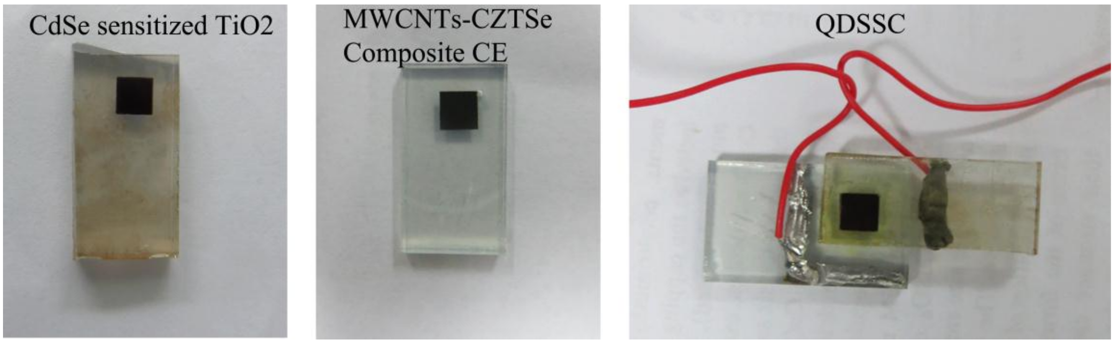

Fig. S3 Photographs of CdSe sensitized photoanode (the left image), spray deposited MWCNTs-CZTSe composite counter electrode (the middle image) and the completed solar cell (the right image).

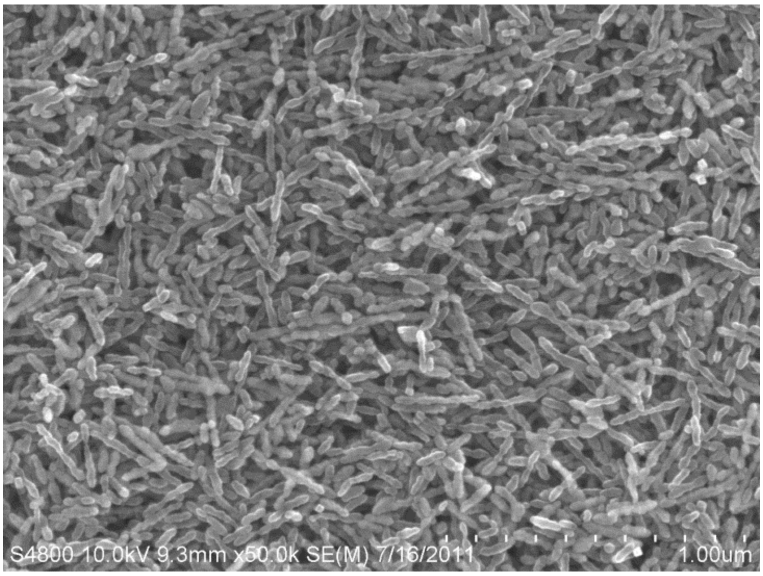

Fig. S4 SEM image of TiO_2 nanorods film used as the photoanode in QDSC.

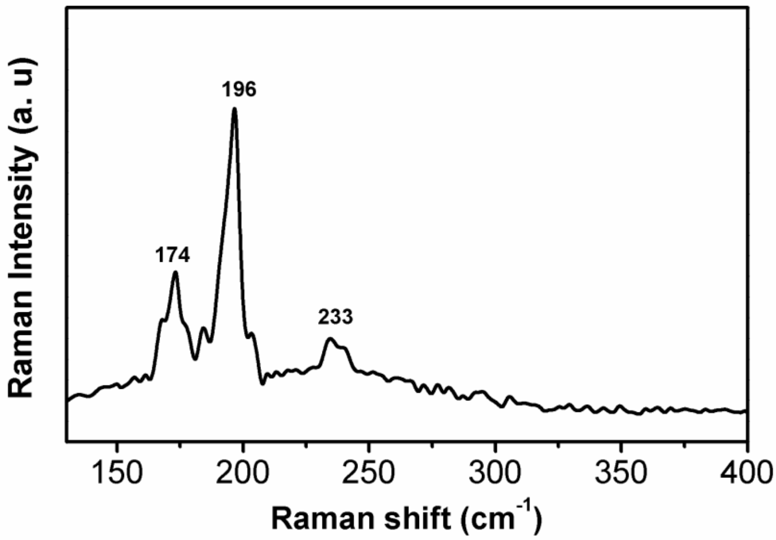

Fig. S5 Raman scattering spectrum of the freshly prepared CZTSe nanoparticles.

The peaks located at 174 cm^{-1}, 196 cm^{-1}, 233 cm^{-1} are corresponding to the signals of pure CZTSe product; no other by-products can be detected.

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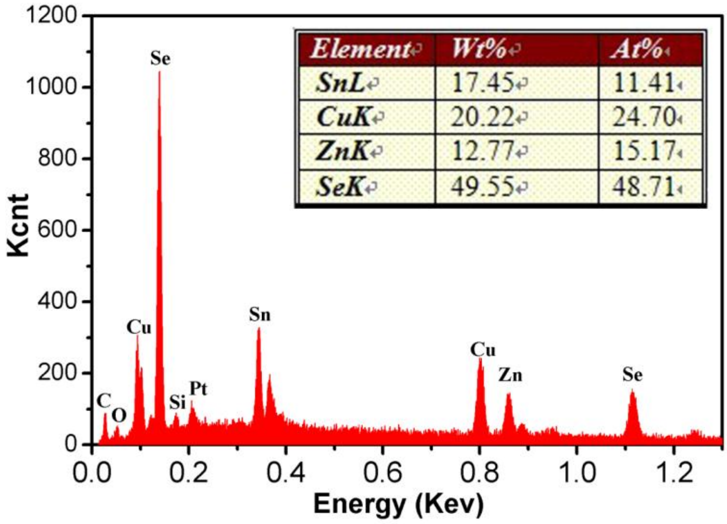

Fig. S6 EDX spectra of the as-synthesized CZTSe nanoparticles.

The composition of the as-synthesized CZTSe was determined to be $Cu_{1.98}Zn_{1.21}Sn_{0.92}Se_{3.89}$, very close to the ideal stoichiometric proportion of Cu: Zn: Sn: Se = 2: 1: 1: 4.

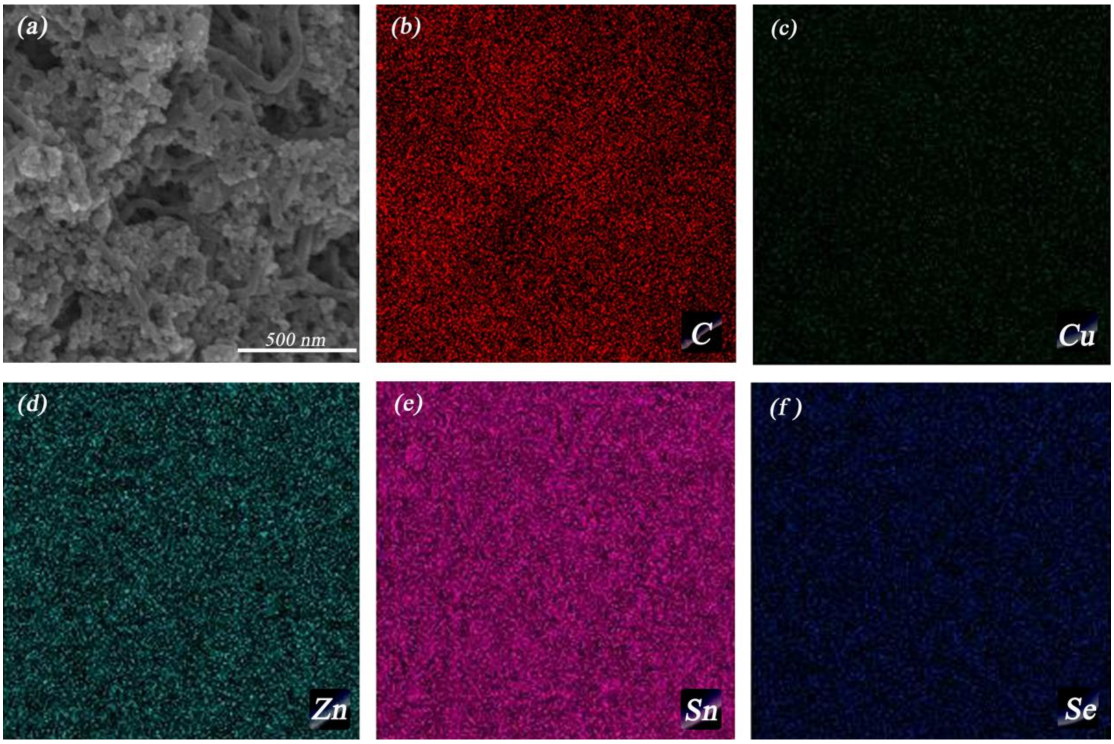

Fig. S7 SEM image and EDX elemental mapping of the MWCNTs-CZTSe composite film.