Electronic Supporting Information (ESI)

Comparative advantages of Zn-Cu-In-S alloy QDs in the construction of quantum dot-sensitized solar cells

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**Fig. S1** J-V curves of five cells in parallel for ZCIS QDSCs synthesized with a molar ratio (Zn/Cu-In = 0).

**Table S1** Photovoltaic parameters of CIS QDSCs under the illumination of 1 full sun intensity (AM 1.5 G, 100 mW cm\(^{-2}\)).

| \(V_{oc}\) (V) | \(J_{oc}\) (mA/cm\(^2\)) | FF  | PCE (%) |
|-----------------|--------------------------|-----|---------|
| 0.528           | 22.62                    | 0.545| 6.51    |
| 0.535           | 22.56                    | 0.550| 6.64    |
| 0.530           | 22.58                    | 0.553| 6.62    |
| 0.536           | 22.37                    | 0.555| 6.65    |
| 0.526           | 22.56                    | 0.545| 6.47    |
**Fig. S2** $J$-$V$ curves of five cells in parallel for ZCIS QDSCs synthesized with a molar ratio (Zn/Cu-In = 0.2).

**Table S2** Photovoltaic parameters of ZCIS QDSCs synthetized with a molar ratio (Zn/Cu-In = 0.2) under the illumination of 1 full sun intensity (AM 1.5 G, 100 mW cm$^{-2}$).

| Zn amount | $V_{oc}$ (V) | $J_{oc}$ (mA/cm$^2$) | FF  | PCE (%) |
|-----------|--------------|-----------------------|-----|---------|
| 0.2       | 0.572        | 23.55                 | 0.582 | 7.84    |
|           | 0.575        | 23.63                 | 0.585 | 7.95    |
|           | 0.576        | 22.87                 | 0.583 | 7.68    |
|           | 0.575        | 23.56                 | 0.578 | 7.83    |
|           | 0.578        | 23.61                 | 0.579 | 7.90    |
**Fig. S3** $J$-$V$ curves of five cells in parallel for ZCIS QDSCs synthesized with a molar ratio ($\text{Zn/Cu-In} = 0.4$).

**Table S3** Photovoltaic parameters of ZCIS QDSCs synthetized with a molar ratio ($\text{Zn/Cu-In} = 0.4$) under the illumination of 1 full sun intensity (AM 1.5 G, 100 mW cm$^{-2}$).

| Zn amount | $V_{oc}$ (V) | $J_{oc}$ (mA/cm$^2$) | FF | PCE (%) |
|-----------|--------------|-----------------------|----|---------|
| 0.4       | 0.611        | 22.74                 | 0.606 | 8.42 |
|           | 0.610        | 22.72                 | 0.608 | 8.43 |
|           | 0.602        | 22.68                 | 0.620 | 8.48 |
|           | 0.612        | 22.75                 | 0.605 | 8.43 |
|           | 0.600        | 22.59                 | 0.620 | 8.39 |
Fig. S4 J-V curves of five cells in parallel for ZCIS QDSCs synthesized with a molar ratio (Zn/Cu-In = 0.6).

Table S4 Photovoltaic parameters of ZCIS QDSCs synthetized with a molar ratio (Zn/Cu-In = 0.6) under the illumination of 1 full sun intensity (AM 1.5 G, 100 mW cm$^2$).

| Zn amount | $V_{oc}$ (V) | $J_{sc}$ (mA/cm$^2$) | FF | PCE (%) |
|-----------|-------------|-------------------|----|---------|
| 0.6       | 0.605       | 21.86             | 0.611 | 8.08   |
|           | 0.604       | 21.93             | 0.595 | 7.88   |
|           | 0.605       | 22.00             | 0.604 | 8.04   |
|           | 0.606       | 21.98             | 0.602 | 8.02   |
|           | 0.606       | 21.48             | 0.613 | 7.98   |
**Fig. S5** Cross section SEM image of the TiO$_2$ photoanode film.

**Fig. S6** UV-vis absorption spectra of CIS, CIS/ZnS and ZCIS QDs deposited on TiO$_2$ mesoporous film.
Fig. S7 $J-V$ curves of five cells in parallel for individual CIS, CIS/ZnS and ZCIS QDSCs based on Cu$_2$S counter electrodes.
Table S5 Individual and average photovoltaic parameters of CIS, CIS/ZnS and ZCIS based QDSCs under the illumination of 1 full sun intensity (AM 1.5 G, 100 mW cm\(^{-2}\)).

| Samples   | \(V_{oc}\) (V) | \(J_{sc}\) (mA/cm\(^2\)) | FF    | PCE (%) |
|-----------|-----------------|-----------------------------|-------|---------|
| CIS       | 0.566           | 15.30                       | 0.526 | 4.56    |
|           | 0.563           | 15.55                       | 0.541 | 4.73    |
|           | 0.569           | 15.52                       | 0.527 | 4.65    |
|           | 0.565           | 15.41                       | 0.531 | 4.62    |
|           | 0.563           | 15.62                       | 0.540 | 4.74    |
| Average   | 0.565 ± 0.003   | 15.48 ± 0.13                | 0.533 ± 0.007 | 4.66 ± 0.08 |
| CIS/ZnS   | 0.599           | 19.58                       | 0.586 | 6.87    |
|           | 0.603           | 19.72                       | 0.589 | 7.00    |
|           | 0.600           | 19.78                       | 0.597 | 7.09    |
|           | 0.602           | 19.83                       | 0.596 | 7.12    |
|           | 0.601           | 19.73                       | 0.564 | 6.68    |
| Average   | 0.601 ± 0.02    | 19.73 ± 0.09                | 0.586 ± 0.01 | 6.95 ± 0.18 |
| ZCIS      | 0.612           | 22.75                       | 0.605 | 8.43    |
|           | 0.614           | 22.41                       | 0.615 | 8.47    |
|           | 0.611           | 22.75                       | 0.606 | 8.42    |
|           | 0.612           | 22.70                       | 0.615 | 8.55    |
|           | 0.616           | 22.50                       | 0.611 | 8.48    |
| Average   | 0.613 ± 0.002   | 22.62 ± 0.14                | 0.610 ± 0.005 | 8.47 ± 0.05 |

Fig. S8 Nyquist curves for CIS (a); CIS/ZnS (b) and ZCIS (c) based QDSCs at different forward bias.