# Electronic Supplementary Information

## *In-situ* formation of zinc ferrite modified Al-doped ZnO nanowire arrays for solar water splitting

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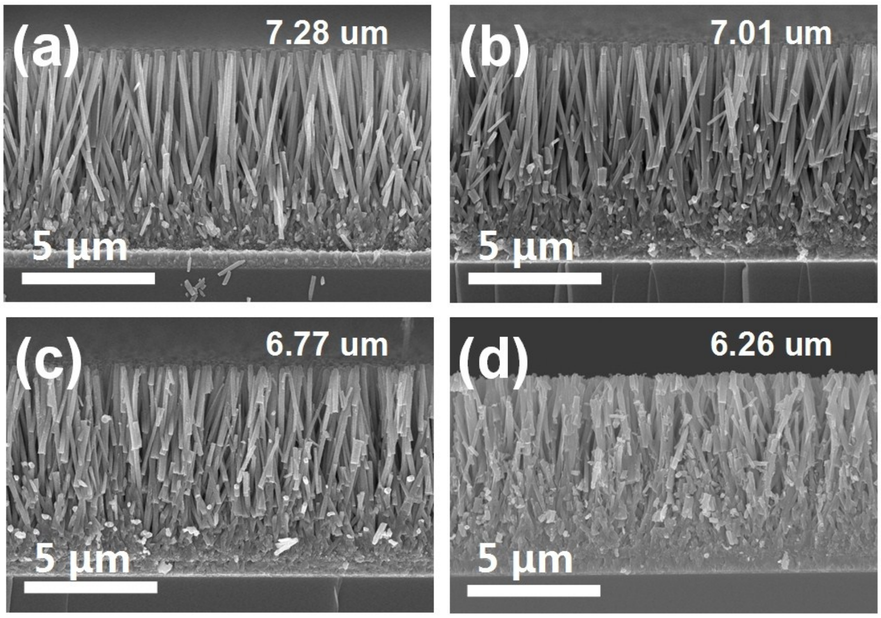


**Fig. S1** The cross-section views of the (a) AZO photoanode and AZO-ZFO photoanodes with different treating time: (b) 1 min, (c) 3 min, (d) 7 min.

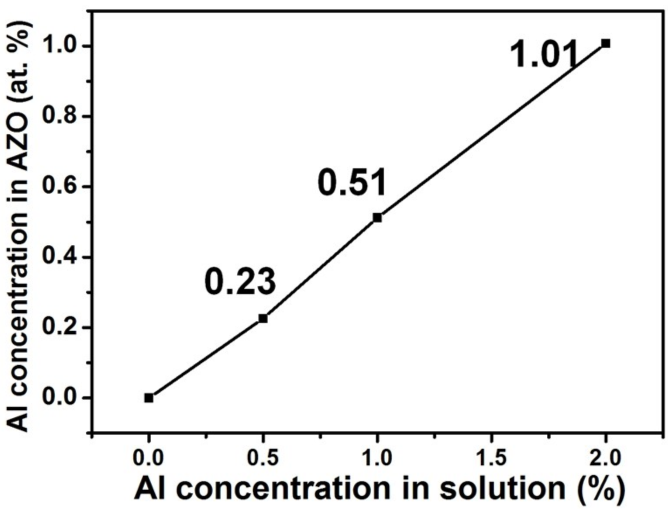


**Fig. S2** Al concentration in hydrothermal deposition solution *vs* Al concentration in the AZO as determined by EDS. It can be concluded that the Al concentration in AZO film is approximate half of that in solution.

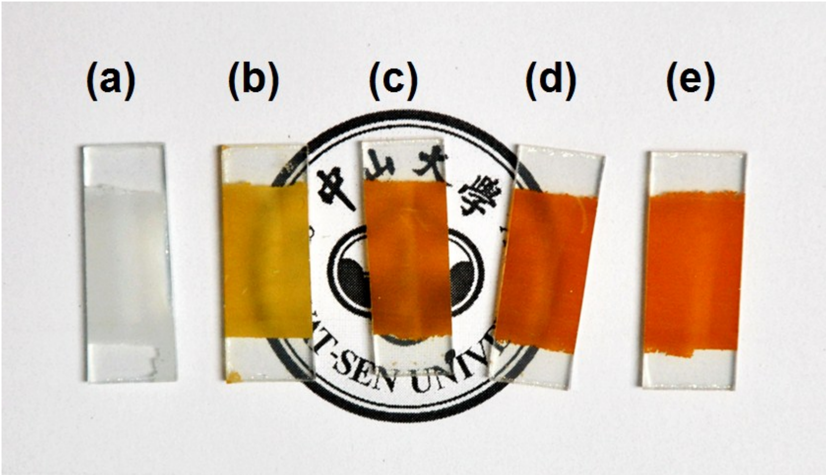


**Fig. S3** The digital photographs of the (a) AZO photoelectrode and AZO-ZFO photoelectrodes with different treating time: (b) 1 min, (c) 3 min, (d) 5 min, (e) 7 min.

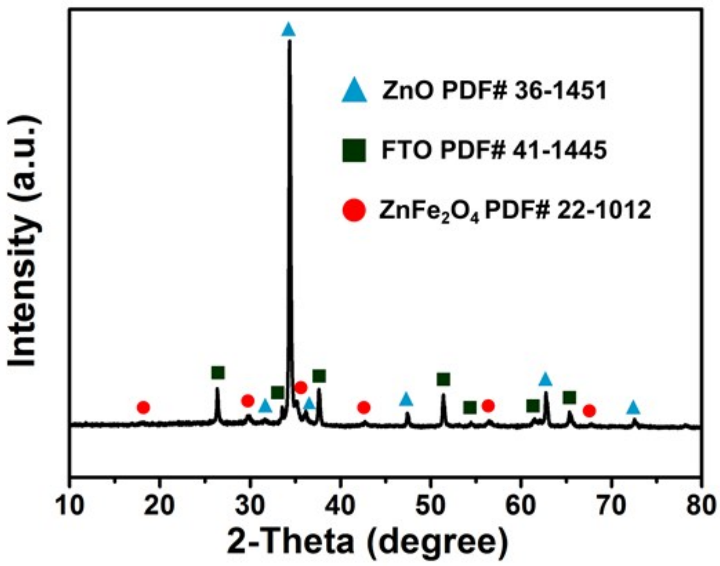


**Fig. S4** XRD pattern of the AZO-ZFO-3 min.

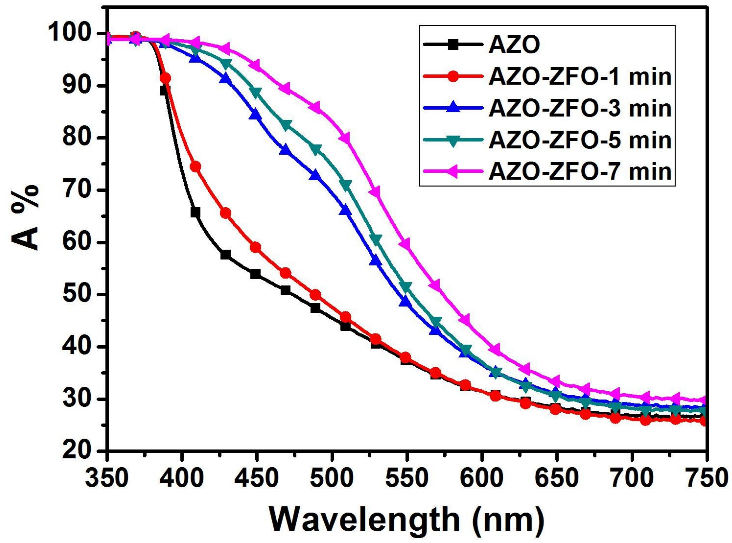


**Fig. S5** The absorption spectra of AZO and AZO-ZFO photoelectrodes. Notably, A%= 1-T%-R%.

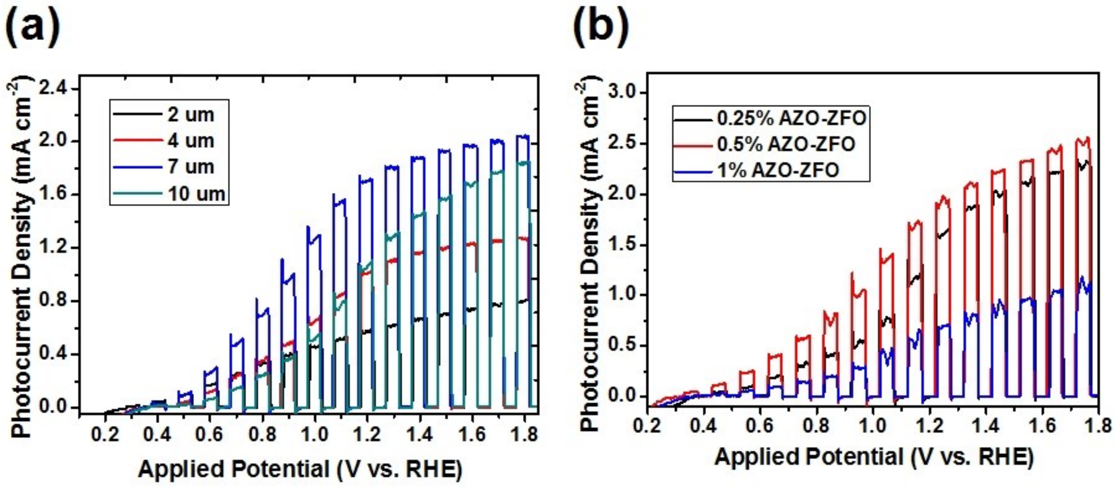


**Fig. S6** The LSV curves under chopped illumination of photoelectrodes with (a) various film thickness and (b) Al dopant concentrations.

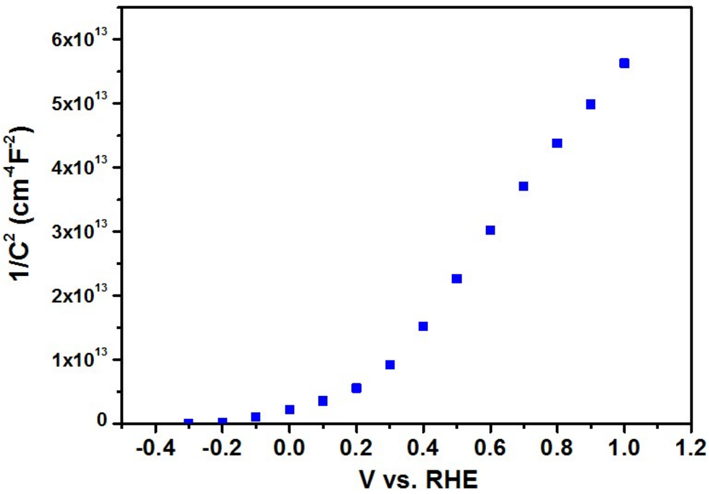


**Fig. S7** Mott-Schottky plots of the AZO-ZFO-3 min sample measured in dark at 1 KHz, in 0.1 M $Na_2SO_4$ solution.

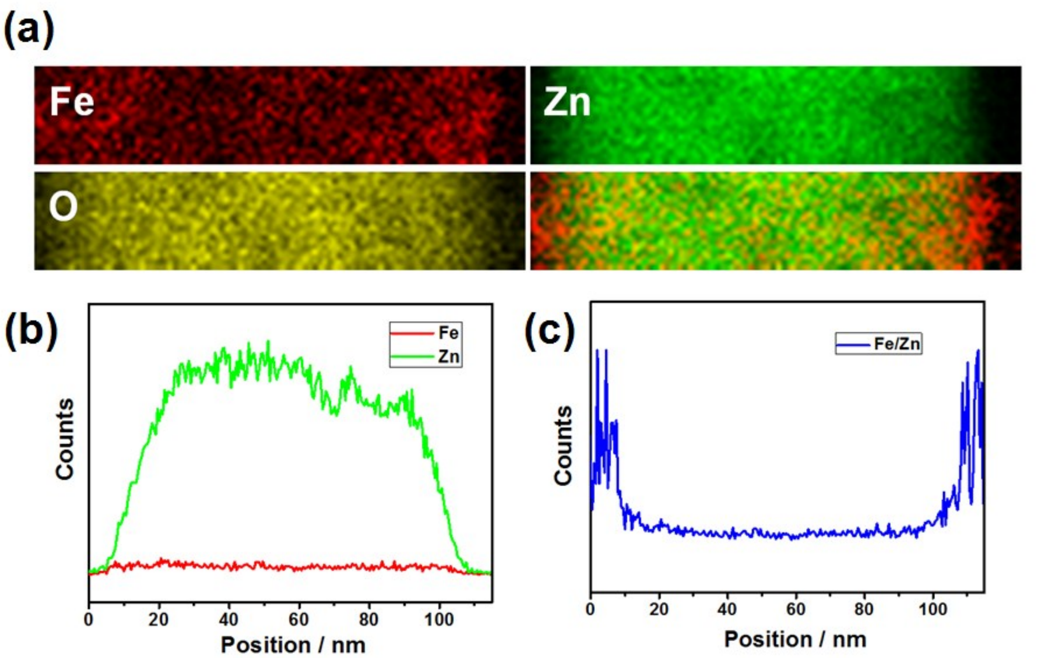


**Fig. S8** The EDX mappings of AZO-ZFO-1min (a) and the corresponding line scanning data (b). To clearly illustrate the Fe distribution, the Fe/Zn plots as a function of scan position were processed according to the line scanning results.

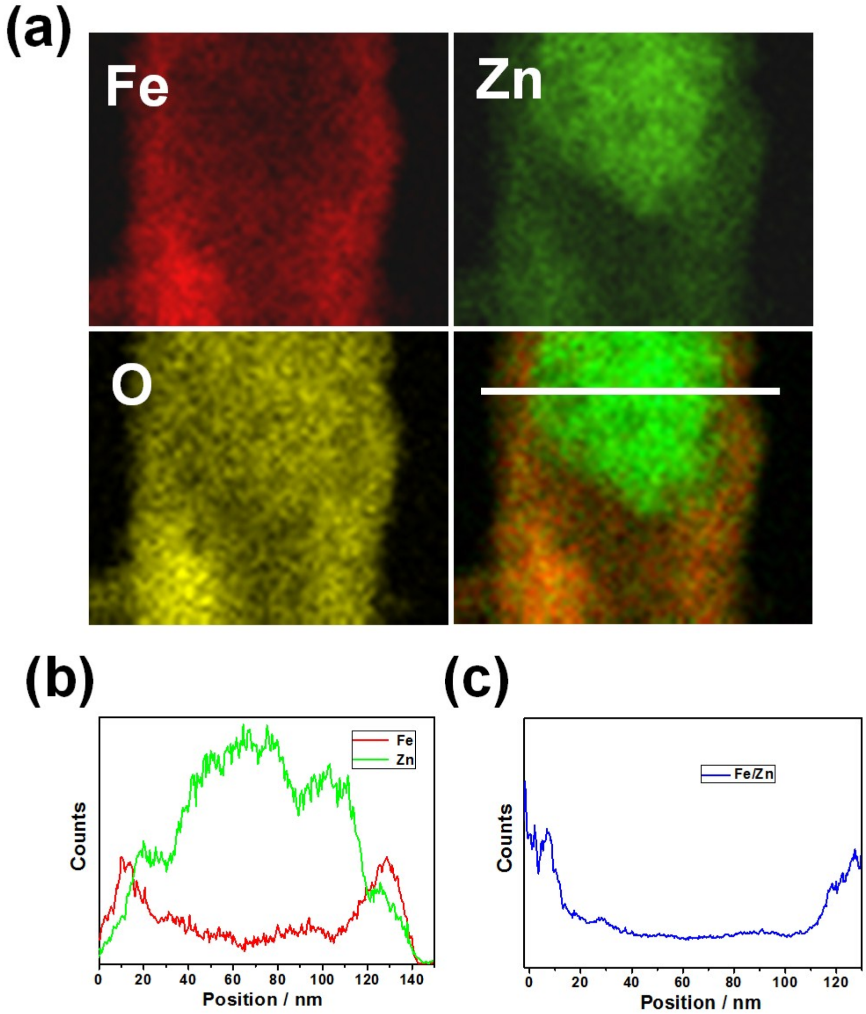


**Fig. S9** (a) The EDX mappings (b) the line scanning data and (c) the corresponding the Fe/Zn plots as a function of scan position (withe bar) of AZO-ZFO-3min.

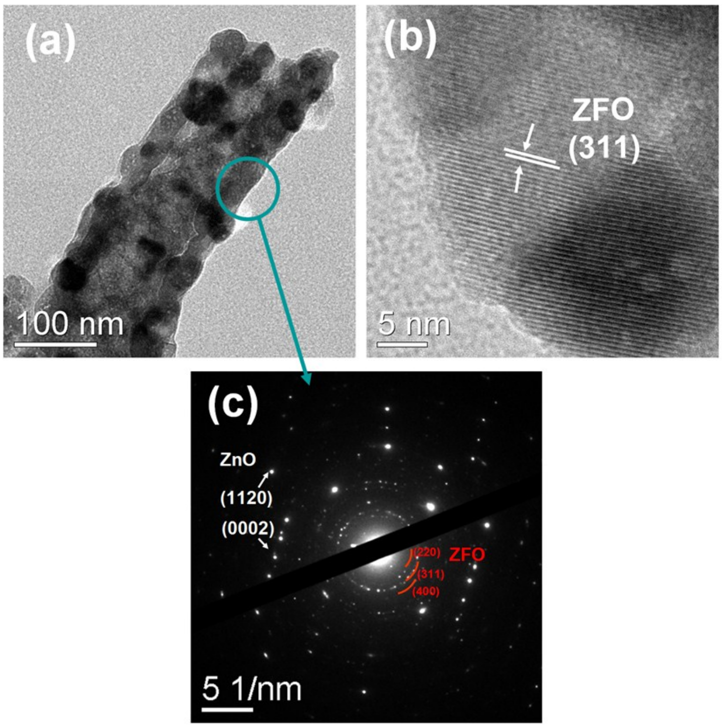


**Fig. S10** (a) TEM image and (b) the corresponding HRTEM image of 0.5% AZO-ZFO-7 min. (c) The selected area electron diffraction (SAED) pattern, which can index to the single-phase AZO and the multi-phase ZFO.

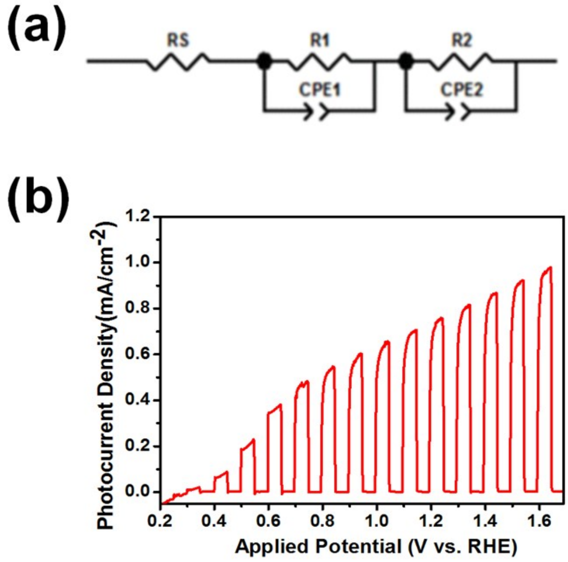


**Fig. S11** (a) Equivalent circuit model used to fit the EIS data. (b) The LSV curve of the ZnO-ZFO-3min sample.

**Table S1** Comparison of photoelectrochemical water oxidation performances for zinc ferrite involved photoanodes.

| Sample | Test Condition | Photocurrent density (mA $cm^{-2}$) | Ref. |
|---|---|---|---|
| Al:ZnO nanorod array/ $ZnFe_2O_4$ | 100 mW $cm^{-2}$, 0.1 M $Na_2SO_4$ | 1.72 @ 1.23 $V_{RHE}$ | This work |
| ZnO nanorod / $ZnFe_2O_4$ | 100 mW $cm^{-2}$, 0.1 M $Na_2SO_4$ | 0.57 @ 0.8 $V_{Ag/AgCl}$ (~1.4 $V_{RHE}$) | 1 |
| $TiO_2$ nanotube / $ZnFe_2O_4$ | 100 mW $cm^{-2}$, 0.01 M $Na_2SO_4$ | ~0.55 @ 0.60 $V_{SCE}$ (~1.23 $V_{RHE}$) | 2 |
| ZnO nanorod / $ZnFe_2O_4$ | 100 mW $cm^{-2}$, 0.1 M $Na_2SO_4$ | ~0.045 @ 0.6 $V_{Ag/AgCl}$ (~1.2 $V_{RHE}$) | 3 |
| $ZnFe_2O_4$ nanorod array | 100 mW $cm^{-2}$, 1 M NaOH | 0.24 @ 1.23 $V_{RHE}$ | 4 |
| $ZnFe_2O_4$ nanorods array | 100 mW $cm^{-2}$, 1 M NaOH | 0.32 @ 1.23 $V_{RHE}$ | 5 |
| $ZnFe_2O_4$ thin films | 100 mW $cm^{-2}$, 1 M NaOH | 0.35 @ 0.23 $V_{Ag/AgCl}$ (~1.23 $V_{RHE}$) | 6 |
| α-$Fe_2O_3$ / $ZnFe_2O_4$ | 100 mW $cm^{-2}$, 1 M NaOH | 0.80 @ 1.23 $V_{RHE}$ | 7 |
| Al-treated α-$Fe_2O_3$/ $ZnFe_2O_4$ | 100 mW $cm^{-2}$, 1 M NaOH | ~0.42 @ 0.40 $V_{Ag/AgCl}$ (~1.4 $V_{RHE}$) | 8 |
| α-$Fe_2O_3$ nanorod / $ZnFe_2O_4$ | 100 mW $cm^{-2}$, 0.1 M glucose +0.5 M NaOH | ~0.30 @ 0.20 $V_{Ag/AgCl}$ (~1.2 $V_{RHE}$) | 9 |

## References:


1. A. Sheikh, A. Yengantiwar, M. Deo, S. Kelkar, S. Ogale, *Small* **2013**, *9*, 2091-2096.

2. X. Li, Y. Hou, Q. Zhao, G. Chen, *Langmuir* **2011**, *27*, 3113-3120.

3. D. D. Qin, C. L. Tao, *RSC Adv.* **2014**, *4*, 16968-16972.

4. J. H. Kim, J. H. Kim, J.-W. Jang, J. Y. Kim, S. H. Choi, G. Magesh, J. Lee, J. S. Lee, *Adv. Energy Mater.* **2015**, *5*, 20140193.

5. J. H. Kim, Y. J. Jang, J. H. Kim, J. W. Jang, S. H. Choi, J. S. Lee, *Nanoscale* **2015**, *7*, 19144-19151

6. A. A. Tahir, K. G. U. Wijayantha, *J. Photochem. Photobio. A* **2010**, *216*, 119-125.

7. Z. Luo, C. Li, D. Zhang, T. Wang, J. Gong, *Chem. Commun.* **2015**, DOI: 10.1039/C5CC09321J.

8. K. J. McDonald, K. S. Choi, *Chem. Mater.* **2011**, *23*, 4863-4869.

9. Y. H. Guo, Y. M. Fu, Y. Liu, S. H. Shen, *RSC Adv.* **2014**, *4*, 36967-36972.