Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supplementary information

Direct Storage of Holes in Ultrathin $Ni(OH)_2$ on Fe_2O_3 Photoelectrodes for Integrated Solar Charging Battery-type Supercapacitors

Kaijian Zhu [a], Guoxiang Zhu [b], Jun Wang [b], Jixin Zhu [a], Gengzhi Sun [a], Yao Zhang [a], Ping Li [a], Yongfa Zhu [b], Wenjun Luo* [a,c], Zhigang Zou [c], Wei Huang [a]

[a] Key Laboratory of Flexible Electronics (KLOFE) & Institute of Advanced Materials (IAM), Jiangsu National Synergetic Innovation Center for Advanced Materials (SICAM), Nanjing Tech University (NanjingTech), 30 South Puzhu Road, Nanjing 211816, P. R. China

[b] Department of Chemistry, Tsinghua University, Beijing 100084, P. R. China

[c] Eco-materials and Renewable Energy Research Center (ERERC), National Laboratory of Solid State Microstructures and College of Engineering and Applied Science, Nanjing University, Nanjing 210093, P. R. China

*E-mail: iamwjluo@njtech.edu.cn

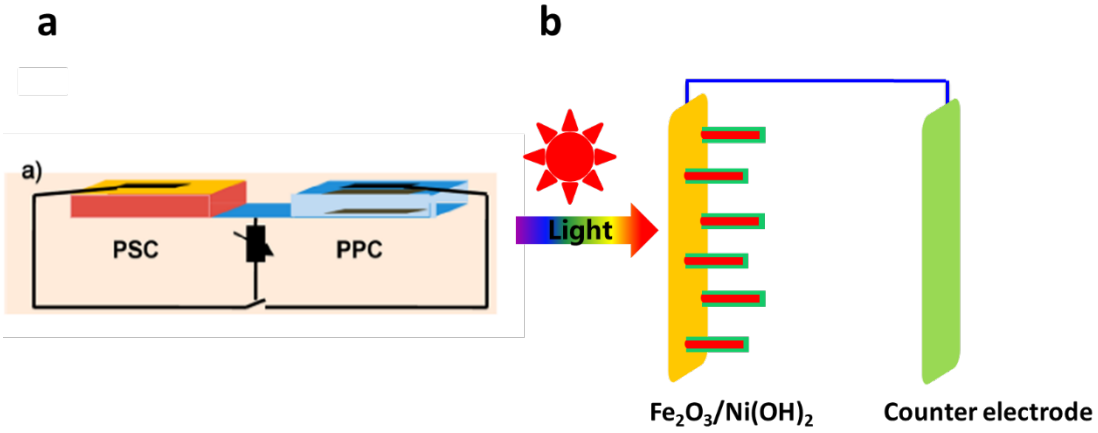

Fig. S1 Diagrammatic sketches of (a) a solar cell + supercapacitor[1] and (b) a photoelectrochemical supercapacitor

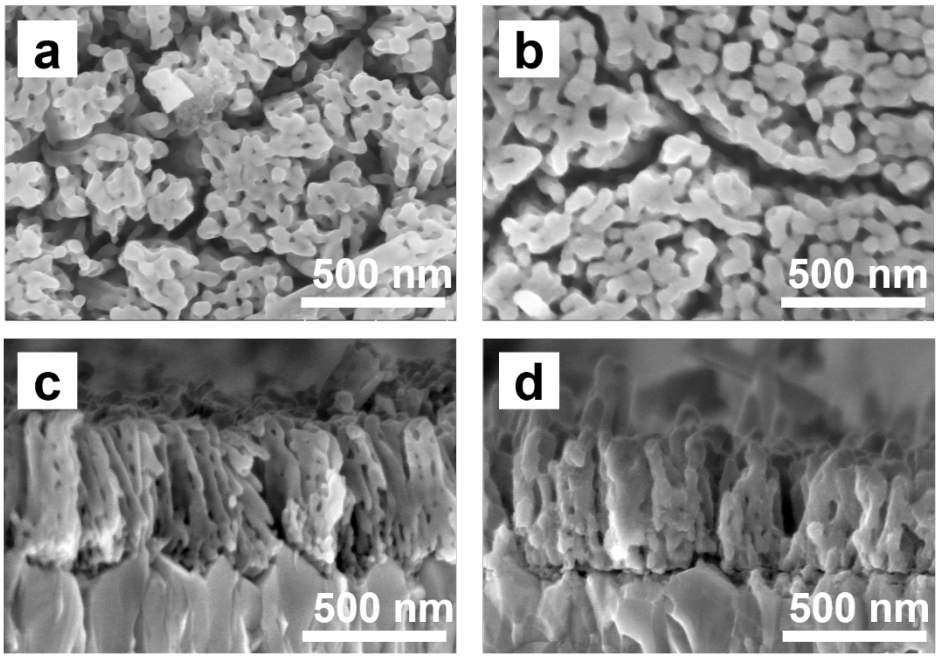

Fig. S2 Surface and cross-section SEM images of bare Fe_2O_3 (a, c) and Fe_2O_3@ $Ni(OH)_2$ with deposition time of $Ni(OH)_2$ for 10 min (b, d)

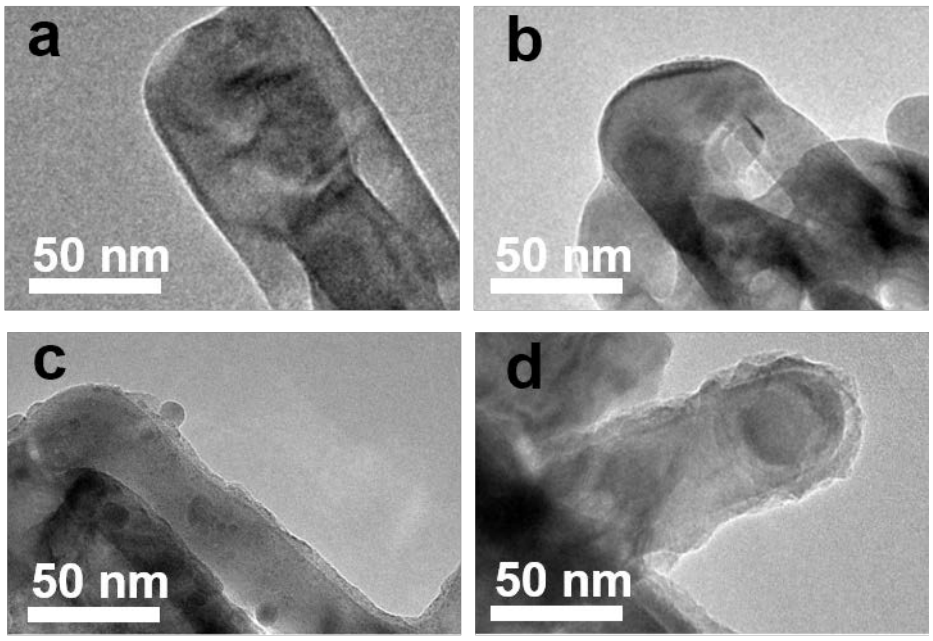

Fig. S3 TEM images of bare Fe_2O_3 (a) and Fe_2O_3@$Ni(OH)_2$ with different deposition time of $Ni(OH)_2$ for 3 min (b), 5 min (c) and 10 min (d).

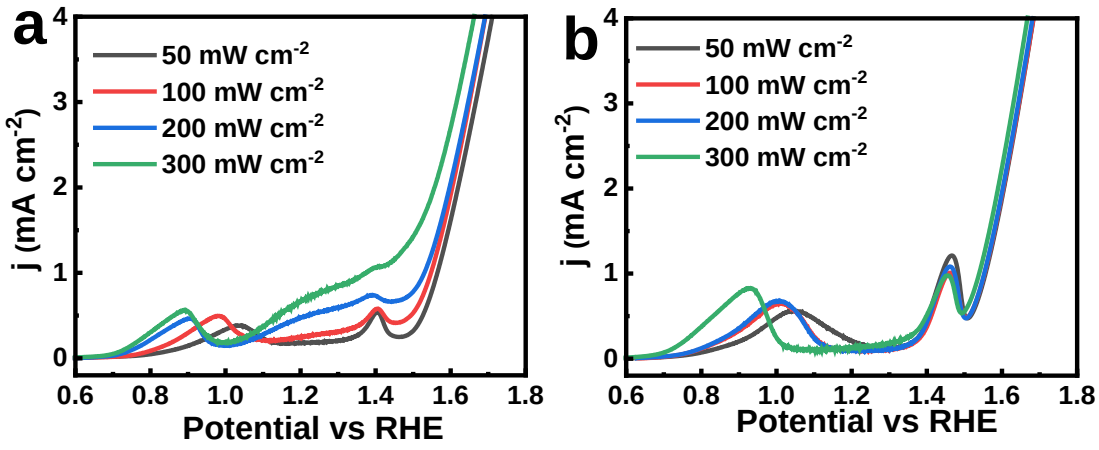

Fig. S4 Photocurrent-potential curves of Fe_2O_3@$Ni(OH)_2$ with deposition time of $Ni(OH)_2$ for 5 min (a) and 10 min (b) under illumination with different light intensities.

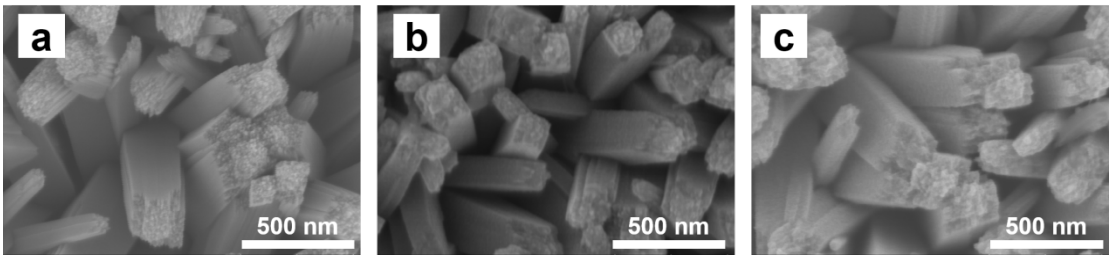

Fig. S5 Surface SEM images of bare TiO_2 (a) and TiO_2@$Ni(OH)_2$ with deposition time of $Ni(OH)_2$ for 5 min (b) and 10 min (c).

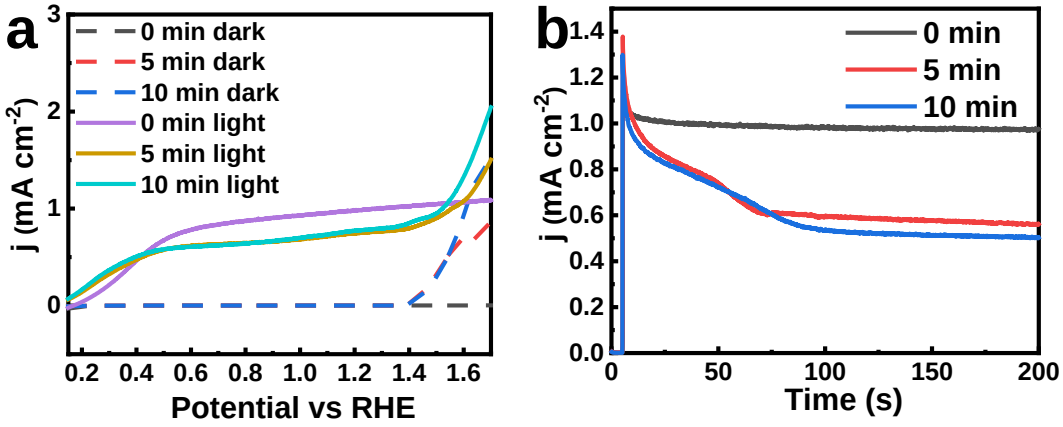

Fig. S6 (a) Dark current-potential and photocurrent-potential curves of bare TiO_2 and TiO_2@$Ni(OH)_2$ with deposition time of $Ni(OH)_2$ for 5 min and 10 min; (b) I-t curves at 1.1 V_{RHE} of TiO_2@$Ni(OH)_2$ with deposition time of $Ni(OH)_2$ for 10 min under illumination with different light intensities. Electrolyte: 1M KOH aqueous solution.

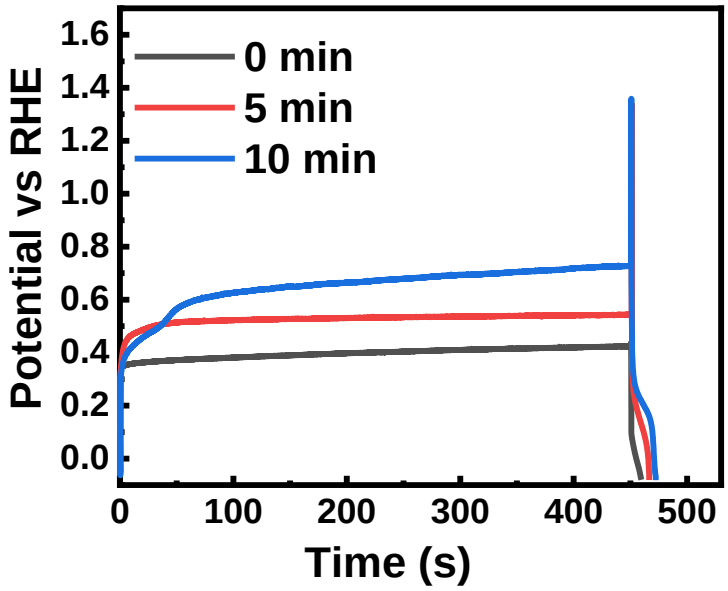

Fig. S7 Galvanostatic photo-charge at 0.6 mA cm^{-2} and dark-discharge curves of bare TiO_2 and TiO_2@ $Ni(OH)_2$ with depositon time of $Ni(OH)_2$ for 5 min and 10 min

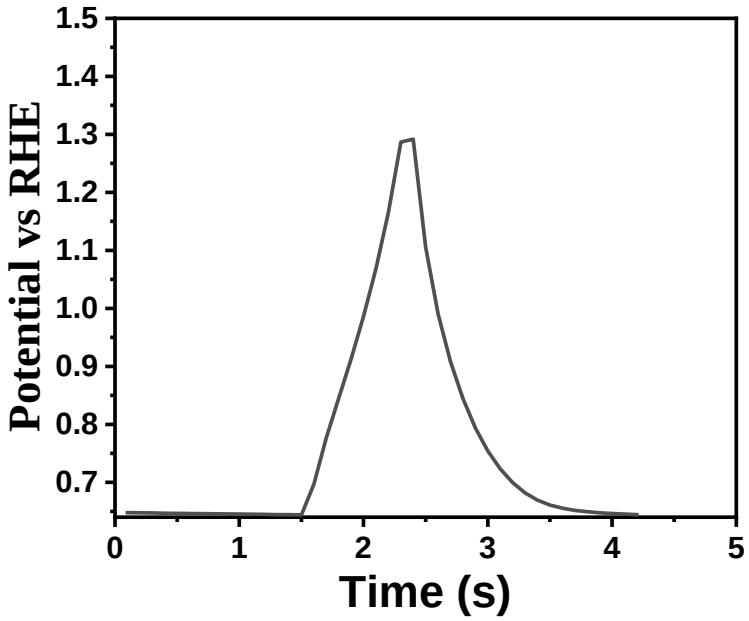

Fig. S8 Galvanostatic dark charge and discharge curves of Fe_2O_3@$Ni(OH)_2$ with depositon time of $Ni(OH)_2$ for 10 min.

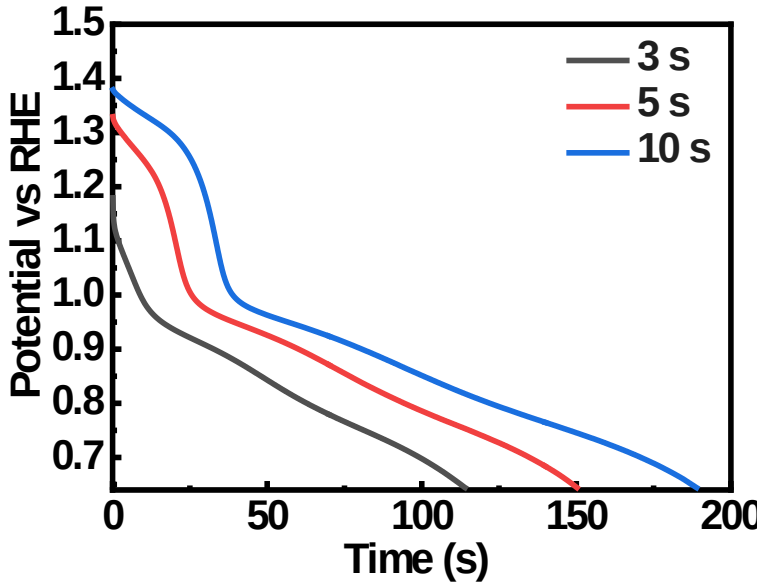

Fig. S9 Discharge curves at current density of 0.1 mA cm^{-2} of Fe_2O_3@$Ni(OH)_2$ with deposition time of $Ni(OH)_2$ for 10 min after photo-charge at 1.35 V_{RHE} for different times.

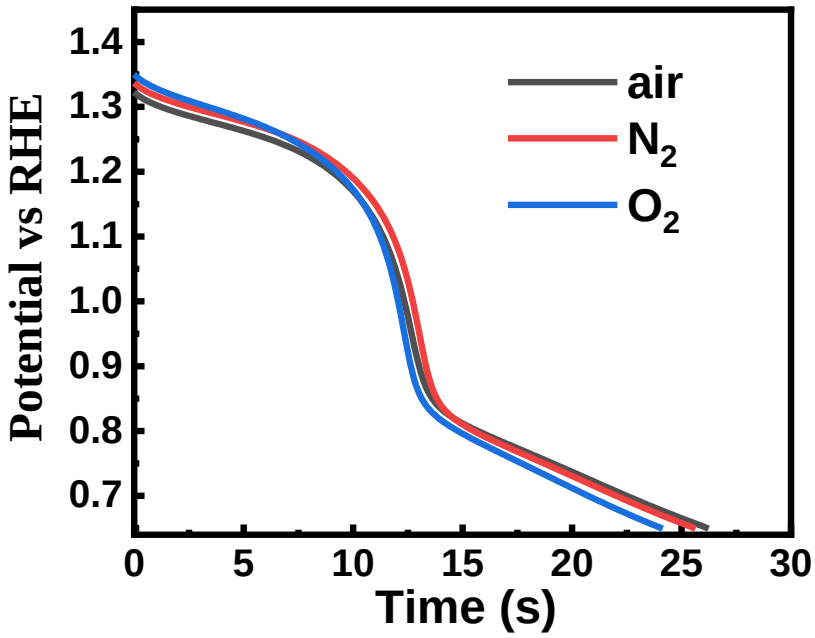

Fig. S10 Discharge curves (0.6 mA cm^{-2}) of Fe_2O_3@$Ni(OH)_2$ with depositon time of $Ni(OH)_2$ for 10 min at different atmosphere.

Table S1 The performances of different photo-capacitors in this study and literatures

Photoelectrochemical	Specific capacitance	Reference

supercapacitors		
Fe_2O_3@ $Ni(OH)_2$	20.6 mF cm^{-2}	This work
$BiVO_4/PbO_x$	4.5 mF cm^{-2}	2
PV+ Supercapacitors		
$DSSC/TiO_2$/SC	1.1 mF cm^{-2}	3
PSC/ PEDOT-carbon/SC	11.5 mF cm^{-2}	4
DSSC-SC	3.3 mF cm^{-2}	5
DSSC-fiber SC	41 mF cm^{-2}	6
PSC-SC	28.7 mF cm^{-2}	7

Note: PV: Photovoltaics PSC: Perovskite Solar Cell

SC: Supercapacitor DSSC: Dye Sensitized Solar Cells

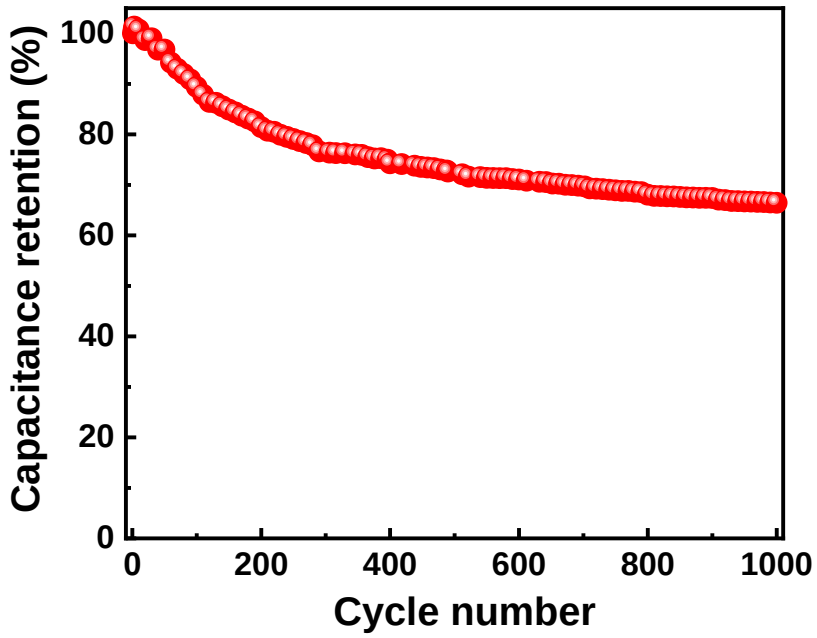

Fig. S11 Cycling capability of Fe_2O_3@$Ni(OH)_2$ with depositon time of $Ni(OH)_2$ for 10 min at 50 mV s^{-1}.

References

1. X. Xu, S. Li, H. Zhang, Y. Shen, S. M. Zakeeruddin, M. Graetzel, Y. Cheng and M. Wang. *ACS Nano* 2015, 9, 1782-1787.
2. S. Safshekan, I. Herraiz-Cardona, D. Cardenas-Morcoso, R. Ojani, M.Haro, S. Gimenez. *ACS Energy. Lett.* 2017, **2**, 469-475.
3. J. Xu, H. Wu, L. Lu, S. Leung, D. Chen, X. Chen, Z. Fan, G. Shen and D. Li. *Adv. Funct. Mater.* 2014, 24, 1840-1846
4. J. Xu, Z. Ku, Y. Zhang, D. Chao and H. J. Fan. *Adv. Mater. Technol*. 2016, 1, 1600074
5. X. Chen, H. Sun, Z. Yang, G. Guan, Z. Zhang, L. Qiu and H. Peng. *J. Mater. Chem. A*, 2014, 2, 1897-1902
6. Y. Fu, H. Wu, S. Ye, X. Cai, X. Yu, S. Hou, H. Kafafy and D. Zou. *Energy Environ. Sci.* 2013, 6, 805-812.
7. F. Zhou, Z. Ren, Y. Zhao, X. Shen, A. Wang, Y. Y. Li, C. Surya and Y. Chai. *ACS Nano* 2016, 10, 5900-5908