Supporting Information

Rapid synthesis of sea urchin-like $Ni(OH)_2$@Ni(Fe)OOH electrocatalysts for the oxygen evolution reaction

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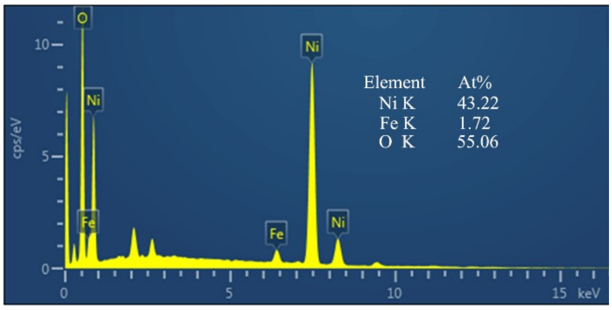

Fig. S1 SEM-EDX spectrum of $Ni(OH)_2$@Ni(Fe)OOH-100.

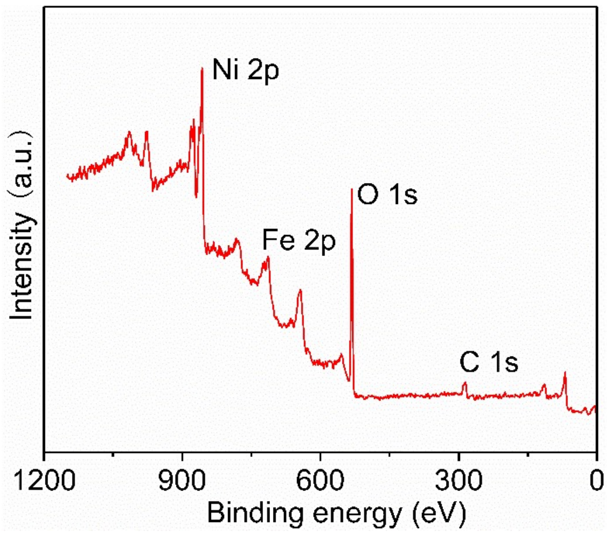

Fig. S2 XPS survey spectrum of $Ni(OH)_2$@Ni(Fe)OOH-100.

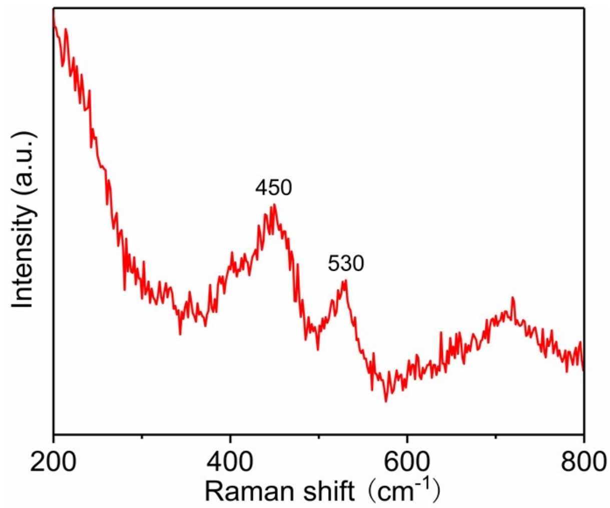

Fig. S3 Raman spectrum of $Ni(OH)_2$@Ni(Fe)OOH-100.

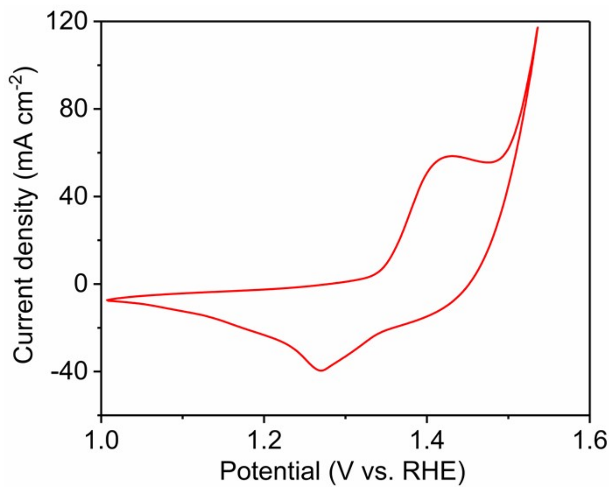

Fig. S4 The cycling voltammetry curve (the 20th cycle) of $Ni(OH)_2$@Ni(Fe)OOH-100 in 1 M KOH at the scan rate of 5 mV s^{-1} after iR-correction.

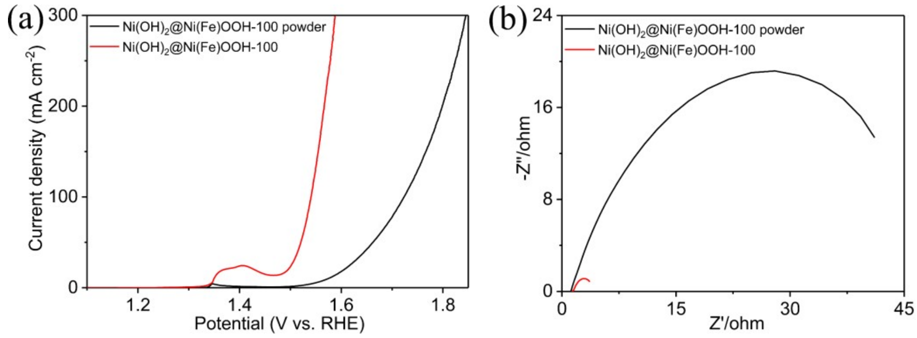

Fig. S5 (a) Polarization curves and (b) EIS spectra of Ni(OH)$_2$@Ni(Fe)OOH-100 and Ni(OH)$_2$@Ni(Fe)OOH-100 powder.

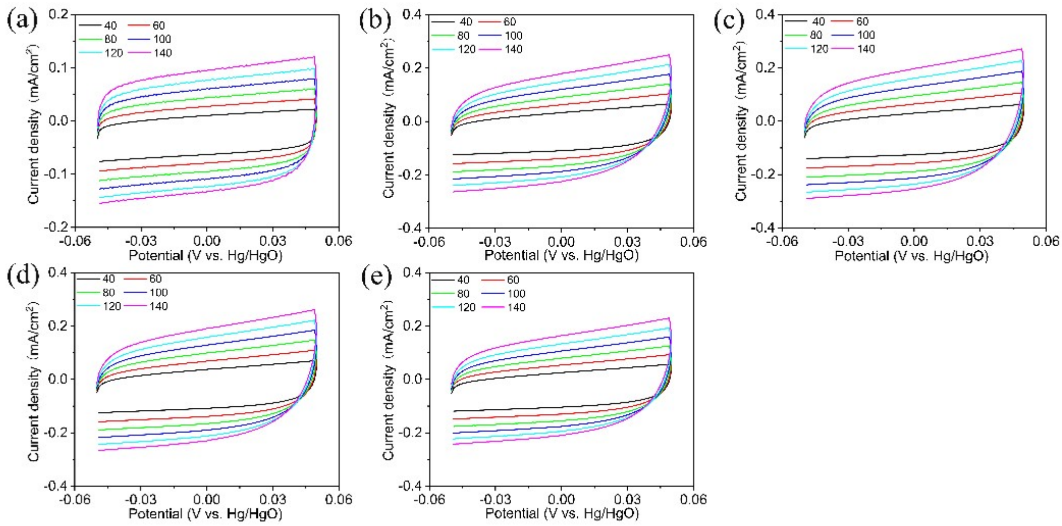

Fig. S6 The CV curves of (a) Ni(OH)$_2$, (b) Ni(OH)$_2$@Ni(Fe)OOH-25, (c) Ni(OH)$_2$@Ni(Fe)OOH-50, (d) Ni(OH)$_2$@Ni(Fe)OOH-75 and (e) Ni(OH)$_2$@Ni(Fe)OOH-100 with different scan rates to evalute the ECSA for OER process.

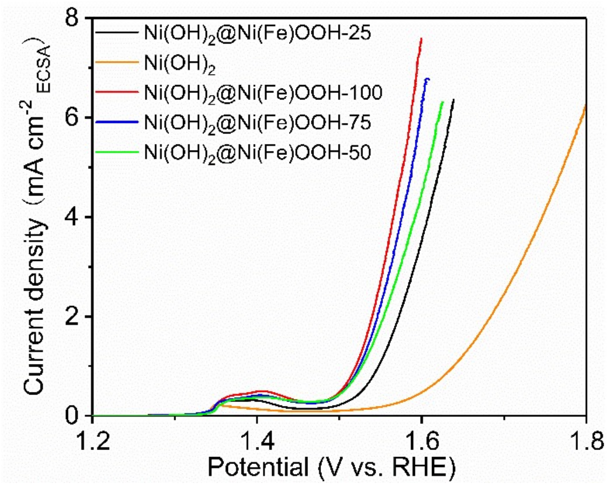

Fig. S7 ECSA-normalized polarization curves for $Ni(OH)_2$, (b) $Ni(OH)_2$@Ni(Fe)OOH-25, (c) $Ni(OH)_2$@Ni(Fe)OOH-50, (d) $Ni(OH)_2$@Ni(Fe)OOH-75 and (e) $Ni(OH)_2$@Ni(Fe)OOH-100.

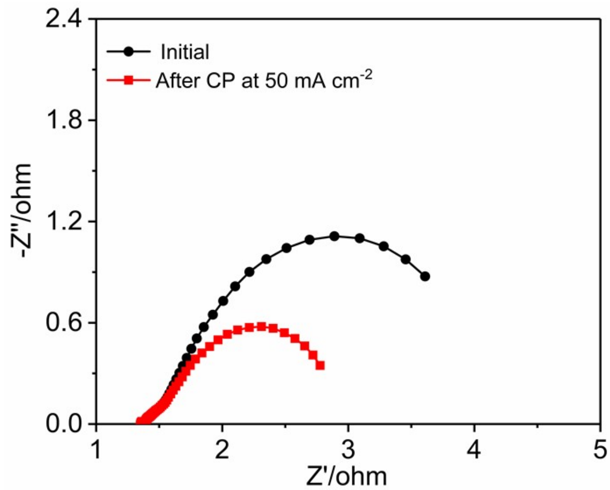

Fig. S8 EIS spectra of $Ni(OH)_2$@Ni(Fe)OOH-100 before and after stability test for 15 h.

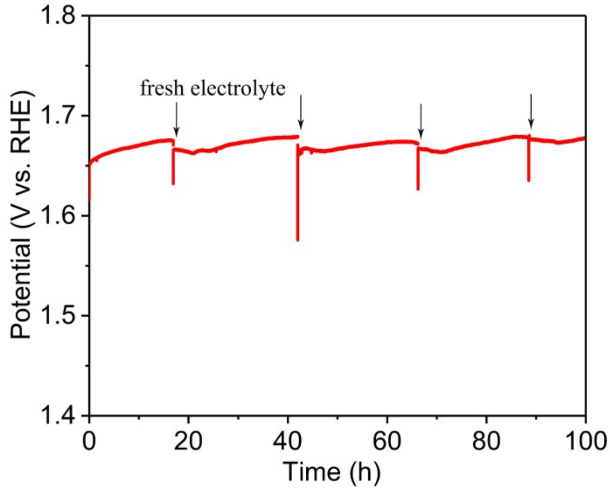

Fig. S9 Stability test of $Ni(OH)_2$@Ni(Fe)OOH-100 at 100 mA cm^{-2} for 100 hours.

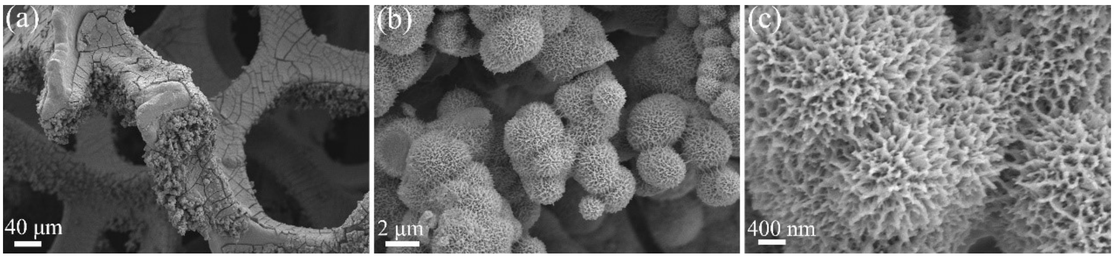

Fig. S10 SEM images of $Ni(OH)_2$@Ni(Fe)OOH-100 after stability test for 15 h.

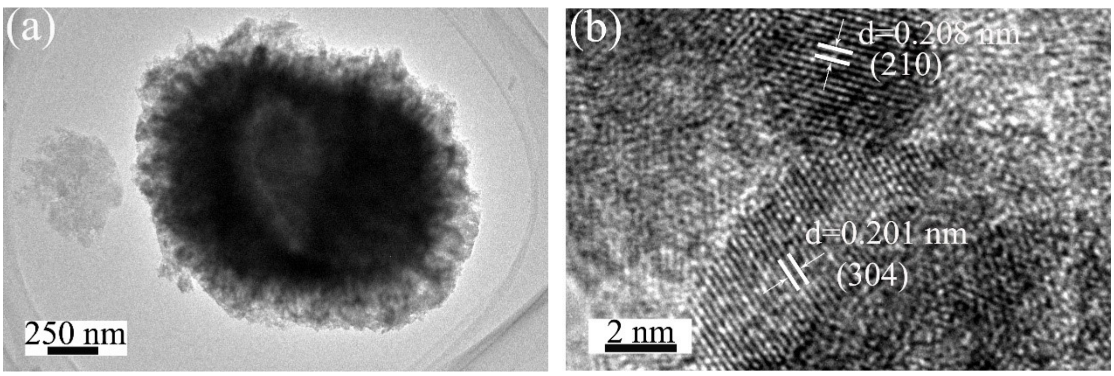

Fig. S11 (a) TEM and (b) HRTEM images of $Ni(OH)_2$@Ni(Fe)OOH-100 after stability test for 15 h.

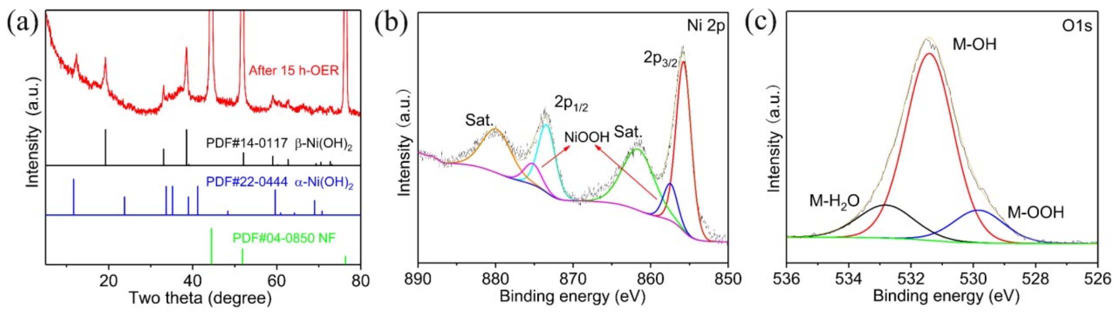

Fig. S12 (a) XRD pattern of $Ni(OH)_2$@Ni(Fe)OOH-100 after stability test. High-resolution XPS spectra of (b) Ni 2p and (c) O 1s of $Ni(OH)_2$@Ni(Fe)OOH-100 after stability test for 15 h.

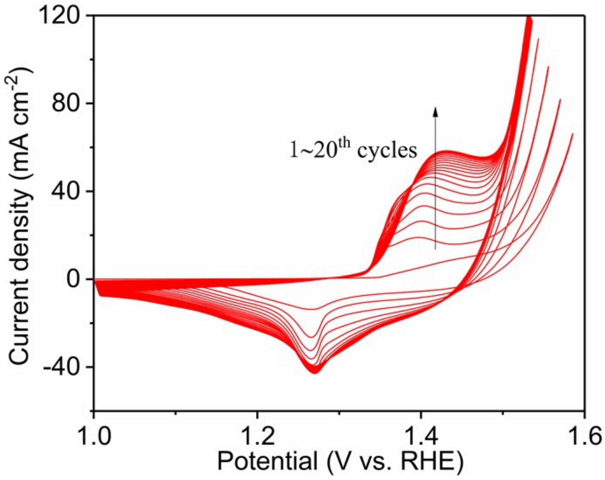

Fig. S13 20 CV cycles in the potential range of 1.0−1.6 V versus RHE at the scan rate of 5 mV s^{-1} after iR-correction.

Table S1. Comparison of OER performance of $Ni(OH)_2$@Ni(Fe)OOH-100 with some Ni or Fe-based electrocatalysts in 1 M KOH.

Catalysts	η@ 10 mA cm^{-2} (mV)	η@ 100 mA cm^{-2} (mV)	Tafel slope (mV dec^{-1})	*References*
$Ni(OH)_2$@Ni(Fe)OOH-100	245	310	40.7	This work
Fe-doped-$Ni(OH)_2$-40 min	248		61	[1]
Fe-NiTe-$Ni_{12}P_5$		340	66	[2]
NiFe-LDH	247		37	[3]
$Ni_{18}Fe_{12}Al_{70}$	255	345	37	[4]
$CoFe_2O_4$	287		43	[5]
Co_2P-Ni_3S_2/NF		331.7	31.6	[6]
CoNiLDH/FeOOH	250		60	[7]
$FeNi_3$@NCNT	264		58.5	[8]
$ZnFe_2O_4$@Ni_3S_2	254		39.29	[9]
$NiCo_2O_4$@MoS_2/TM	313	380	66.8	[10]
NiO-Ni_3Se_4/MXene	260		39.6	[11]
C-$NiFe_2O_4$@A-S-$NiFe_2O_4$	275		76.1	[12]

Table S2. The values of R_s and R_{ct} obtained from fitted plots using equivalent circuit.

Samples	*Solution resistance* R_s (Ω)	*Charge transfer resistance* R_{ct} (Ω)
$Ni(OH)_2$	1.41	7.29
$Ni(OH)_2$@Ni(Fe)OOH-25	1.47	7.37
$Ni(OH)_2$@Ni(Fe)OOH-50	1.45	4.24
$Ni(OH)_2$@Ni(Fe)OOH-75	1.45	3.83
$Ni(OH)_2$@Ni(Fe)OOH-100	1.40	3.66
RuO_2	1.31	17.88
$Ni(OH)_2$@Ni(Fe)OOH-100 powder@NF	1.15	57.12
NF	1.52	382.1
Post-$Ni(OH)_2$@Ni(Fe)OOH-100 (15 h)	1.38	2.04

Table S3. Comparison of overall water splitting performance with some reported electrocatalysts in 1 M KOH.

Catalysts	*Voltage* @10 mA cm^{-2} (V)	*References*
$Ni(OH)_2$@Ni(Fe)OOH-100‖Pt/C	1.54	This work
Co/CoO/NC/CC‖Co/CoO/NC/CC	1.66	[13]
Ni_2P-Fe_2P/NF‖Ni_2P-Fe_2P/NF	1.561	[14]
W_2N/WC‖W_2N/WC	1.58	[15]
V-$Co_2P_4O_{12}$/CC‖V-$Co_2P_4O_{12}$/CC	1.60	[16]
Co_3S_4@NiFe-200/NF‖Co_3S_4@NiFe-200/NF	1.595	[17]
ZnCoS-NSCNT/NP‖ZnCoS-NSCNT/NP	1.59	[18]
MoS_2/NiFe-LDH‖MoS_2/NiFe-LDH	1.61	[19]
$Co_2Mo_3O_8$@NC-800/NF‖Pt/C	1.67	[20]
RuO_2/NF‖Pt/C@NF	1.56	[21]
Mn-$NiCo_2S_4$/NF‖Pt/C	1.59	[22]

Supplementary references

[S1] C.-F. Li, H.-B. Tang, J.-W. Zhao, G.-R. L, *J. Mater. Chem. A*, 2023, **11**, 5841-5850.
[S2] Y.-J. Tang, Y. Zou, D. Zhu, *J. Mater. Chem. A*, 2022, **10**, 12438-12446.
[S3] H. Koshikawa, H. Murase, T. Hayashi, K. Nakajima, H. Mashiko, S. Shiraishi, Y. Tsuji, *ACS Catal.*, 2020, **10**, 1886-1893.
[S4] X. Liu, H. Lu, S. Zhu, Z. Cui, Z. Li, S. Wu, W. Xu, Y. Liang, G. Long, H. Jiang, *Angew. Chem. Int. Ed.*, 2023, **62**, e202300800.
[S5] G. Lee, M. Jeong, H. R. Kim, M. Kwon, S. Baek, S. Oh, M. Lee, D. Lee, J. H. Joo, *ACS Appl. Mater. Interfaces*, 2022, **14**, 48598-48608.
[S6] H. Li, X. Gao, G. Li, *Small*, 2023, **19**, 2304081.
[S7] P. Zhao, S. Fu, Y. Luo, C. Peng, L. Cheng, Z. Jiao, *Small*, 2023, **19**, 2305241.
[S8] D. Chen, Q. Sun, C. Han, Y. Guo, Q. Huang, W. A. Goddard, J. Qian, *J. Mater. Chem. A*, 2022, **10**, 16007-16015.
[S9] H. Liu, J. Miao, Y. Wang, S. Chen, Y. Tang, D. Zhu, *Chem. Commun.*, 2024, **60**, 4443-4446.

[S10] W. Bao, Y. Li, J. Zhang, T. Ai, C. Yang, L. Feng, *Int. J. Hydrogen Energy*, 2023, **48**, 12176-12184.
[S11] L. Yan, J. Liang, D. Song, X. Li, H. Li, *Adv. Funct. Mater.*, 2024, **34**, 2308345.
[S12] X. Li, M. Wang, J. Fu, F. Lu, Z. Li, G. Wang, *Small*, 2024, **20**, 2310040.
[S13] K. Dai, N. Zhang, L. Zhang, L. Yin, Y. Zhao, B. Zhang, *Chem. Eng. J.*, 2021, **414**, 128804.
[S14] L. Wu, L. Yu, F. Zhang, B. McElhenny, D. Luo, A. Karim, S. Chen, Z. Ren, *Adv. Funct. Mater.*, 2021, **31**, 2006484.
[S15] J. Diao, Y. Qiu, S. Liu, W. Wang, K. Chen, H. Li, W. Yuan, Y. Qu, X. Guo, *Adv. Mater.*, 2020, **32**, 1905679.
[S16] X.-W. Chang, S. Li, L. Wang, L. Dai, Y.-P, Wu, X.-Q. Wu, Y. Tian, S. Zhang, D.-S. Li, *Adv. Funct. Mater.*, 2024, **34**, 2313974.
[S17] L. Chen, H. Chen, L. Wu, G. Li, K. Tao, L. Han, *ACS Appl. Mater. Interfaces*, 2024, **16**, 8751-8762.
[S18] Z. Yu, Y. Bai, S. Zhang, Y. Liu, N. Zhang, K. Sun, *J. Mater. Chem. A*, 2018, **6**, 10441-10446.
[S19] X.-P. Li, L.-R. Zheng, S.-J. Liu, T. Ouyang, S. Ye, Z.-Q. Liu, *Chinese Chem. Lett.*, 2022, **33**, 4761-4765.
[S20] T. Ouyang, X.-T. Wang, X.-Q. Mai, A.-N. Chen, Z.-Y. Tang, Z.-Q. Liu, *Angew. Chem. Int. Ed.*, 2020, **59**, 11948-11957.
[S21] H. Yan, Y. Xie, A. Wu, Z. Cai, L. Wang, C. Tian, X. Zhang, H. Fu, *Adv. Mater.*, 2019, **31**, 1901174.
[S22] Y. Chen, H. Wu, N. Tang, Y. Zhang, Y. Wang, *Chem. Commun.*, 2024, **60**, 1751-1753.