Modulation and engineering of MOF-derived transition metal selenides/NiFe LDH for the application in electrocatalytic hydrogen evolution

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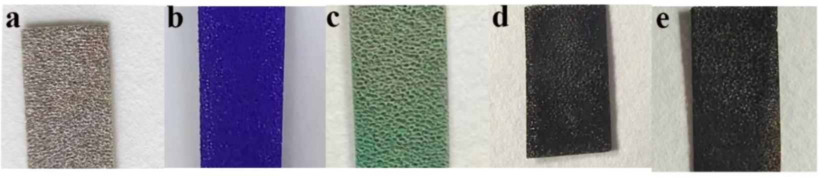

Fig. S1 The photograph of (a) NF, (b) ZIF-67/NF, (c) NiCo LDH/NF, (d) Ni-Co-Se/NF, (e) Ni-Co-Se@NiFe LDH/NF.

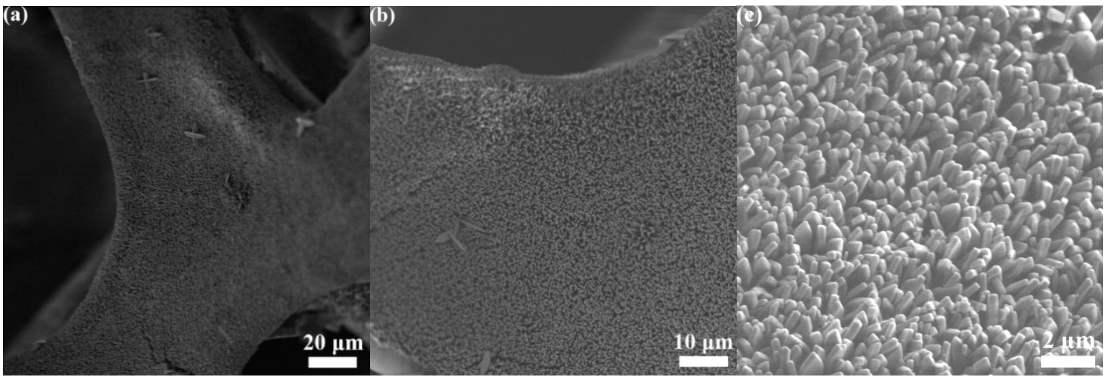

Fig. S2 SEM images of (a-c) ZIF-67/NF.

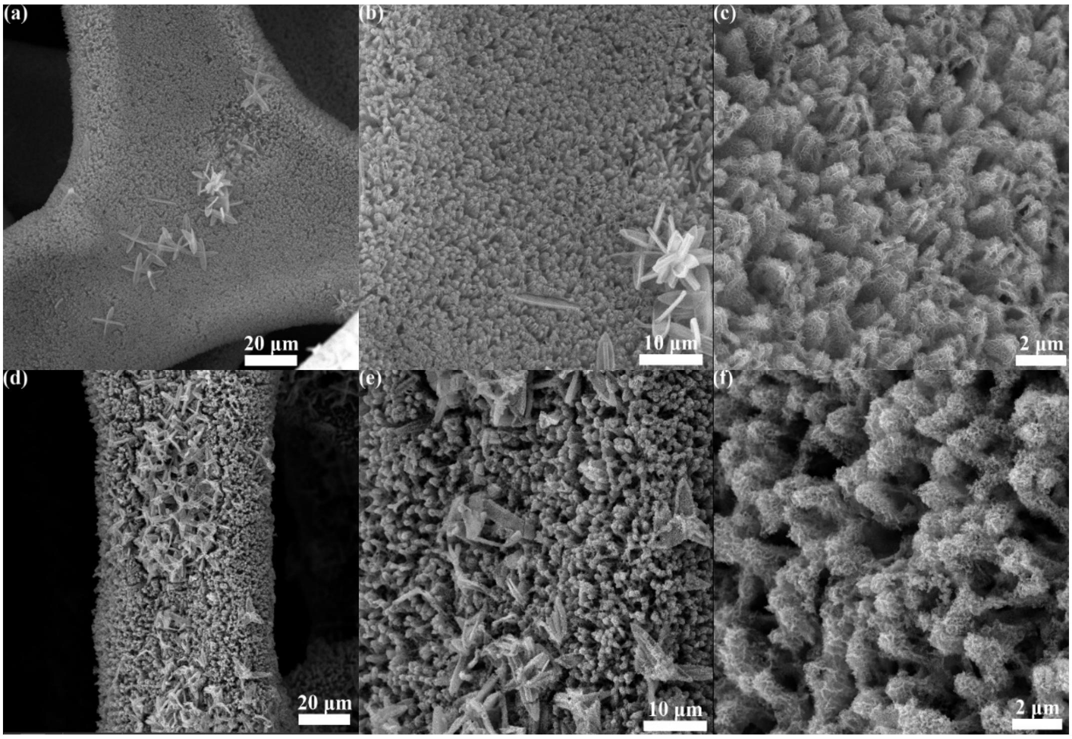

Fig. S3 SEM images of (a-c) NiCo LDH/NF, (d-f) Ni-Co-Se/NF.

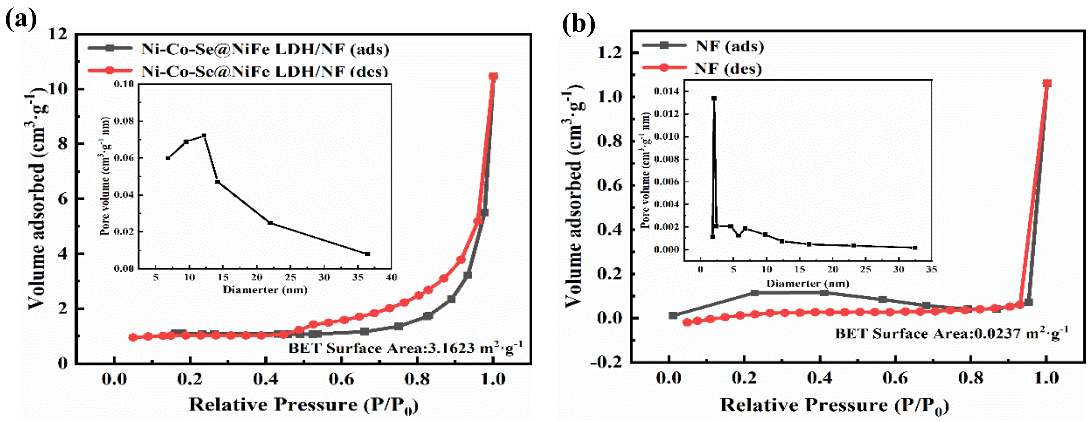

Fig. S4 Nitrogen adsorption-desorption isotherms and corresponding pore size distributions (inside) of (a) Ni-Co-Se@NiFe LDH/NF, (b) NF.

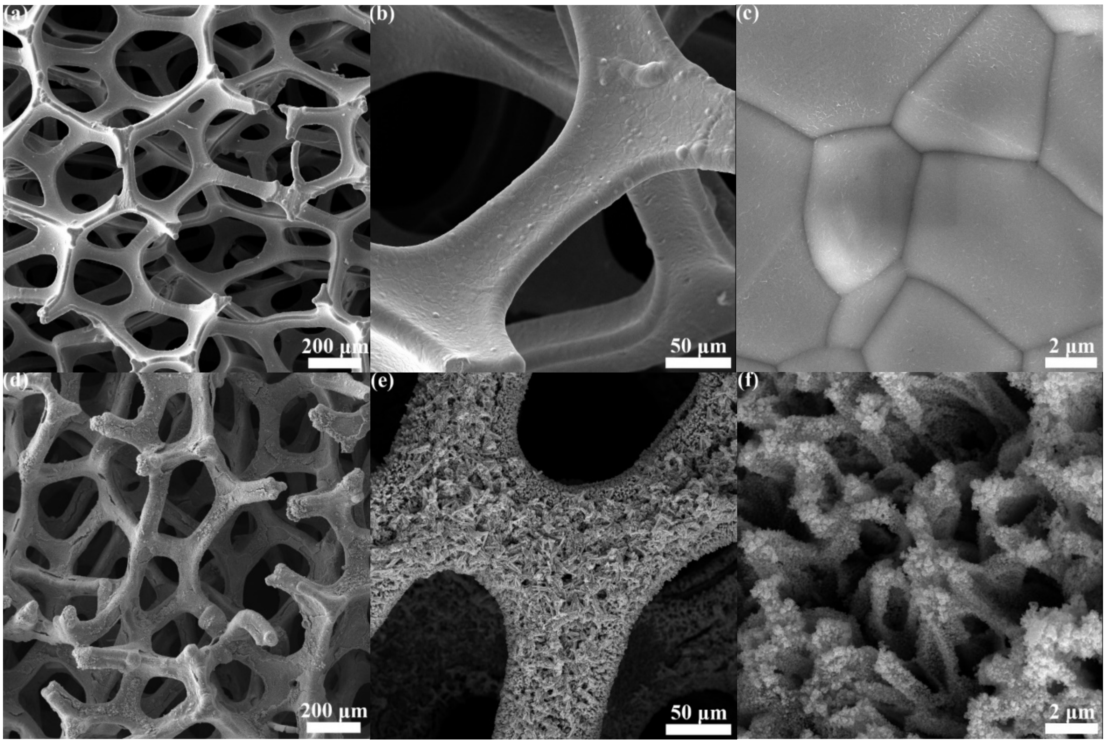

Fig. S5 SEM images of (a-c) NF, (d-f) Ni-Co-Se@NiFe LDH/NF.

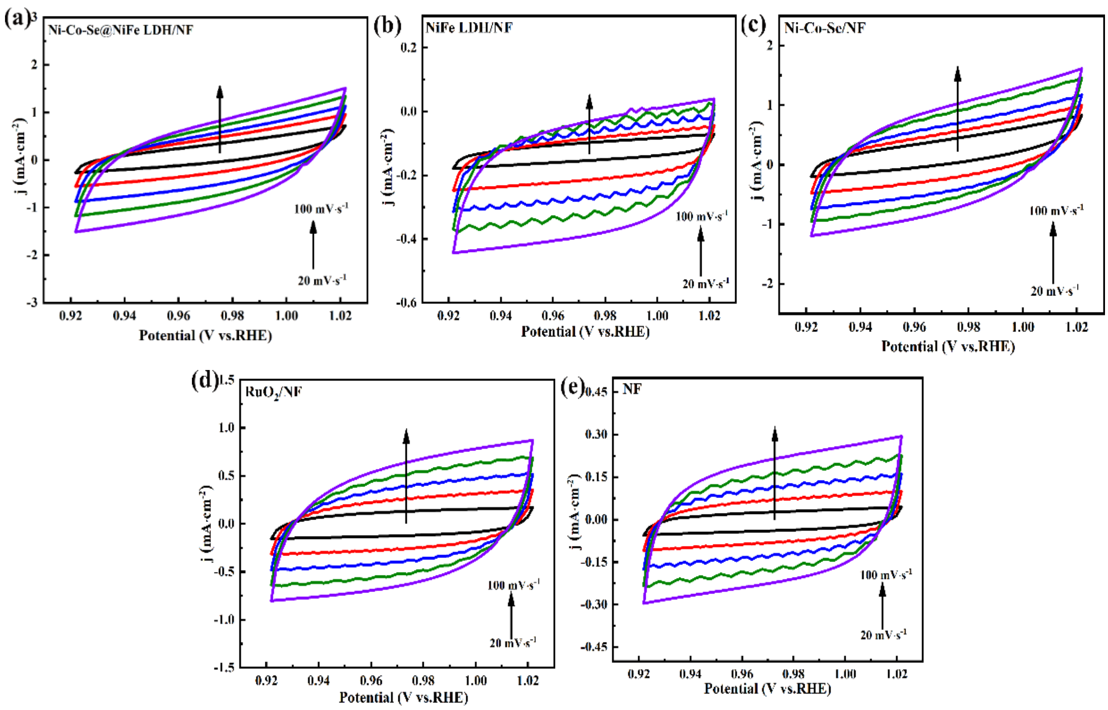

Fig. S6 CV curves of (a-e) Ni-Co-Se@NiFe LDH/NF, NiFe LDH/NF, NI-Co-Se/NF, RuO_2/NF and NF at increasing scan rates.

ECSA can be calculated from the C_{dl} by using the specific capacitance value for a flat standard with 1 cm^2 of real surface area. For the estimates of surface area, general specific capacitances of $C_s = 0.040\ mF\cdot cm^{-2}$ based on typical reported values were used. ECSA was calculated as following:

$$A_{ECSA}^{catalyst} = \frac{C_{dl}^{catalyst}(mF\cdot cm^{-2})}{C_s(mF\cdot cm^{-2})\ per\ cm_{ECSA}^2}$$

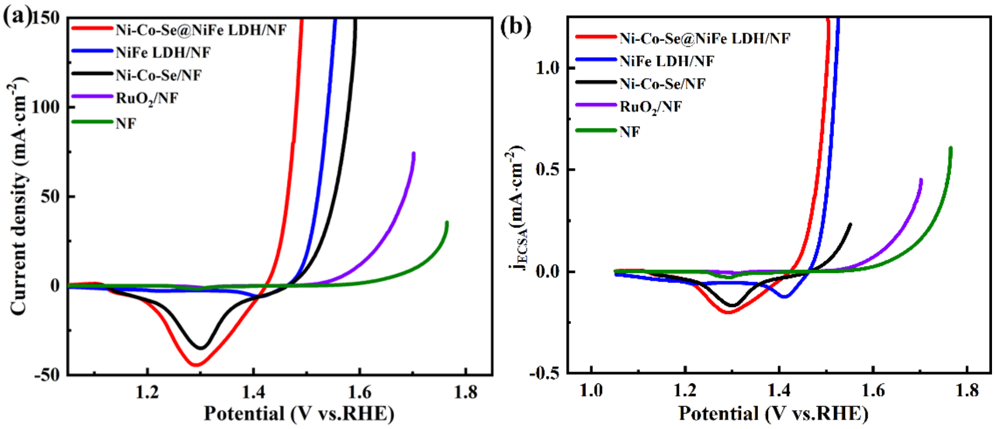

Fig. S7 OER performance of Ni-Co-Se@NiFe LDH/NF, NiFe LDH/NF, Ni-Co-Se/NF, RuO_2/NF and NF: (a) LSV curves, (b) ECSA-corrected LSV curves

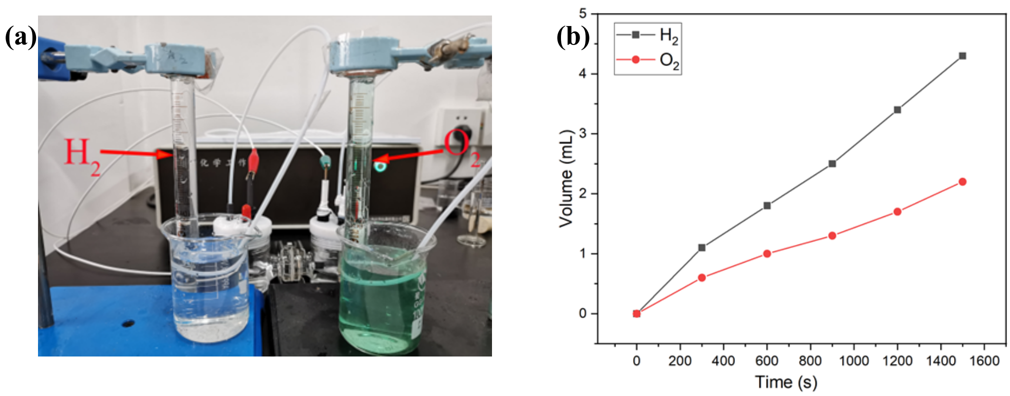

Fig. S8 (a) Gas collection of H_2 and O_2. (b) Gas volume versus time.

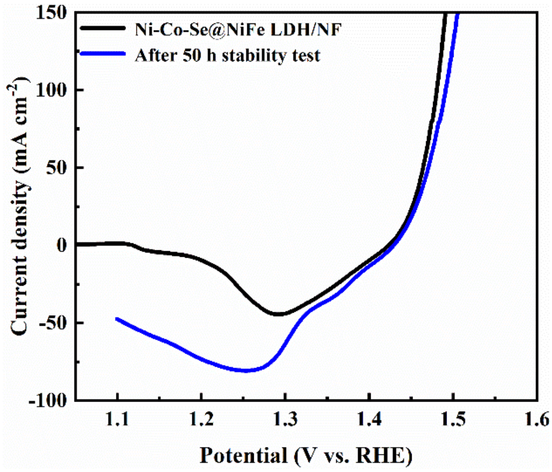

Fig. S9 LSV curves of Ni-Co-Se@NiFe LDH/NF before and after 50 h OER stability test.

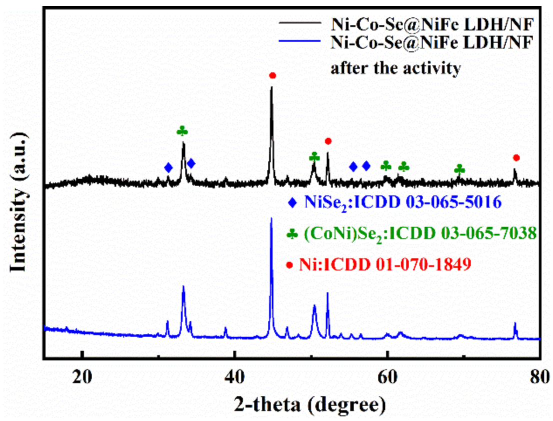

Fig. S10 X-ray diffraction pattern depicting the Ni-Co-Se@NiFe LDH/NF before and after activity test

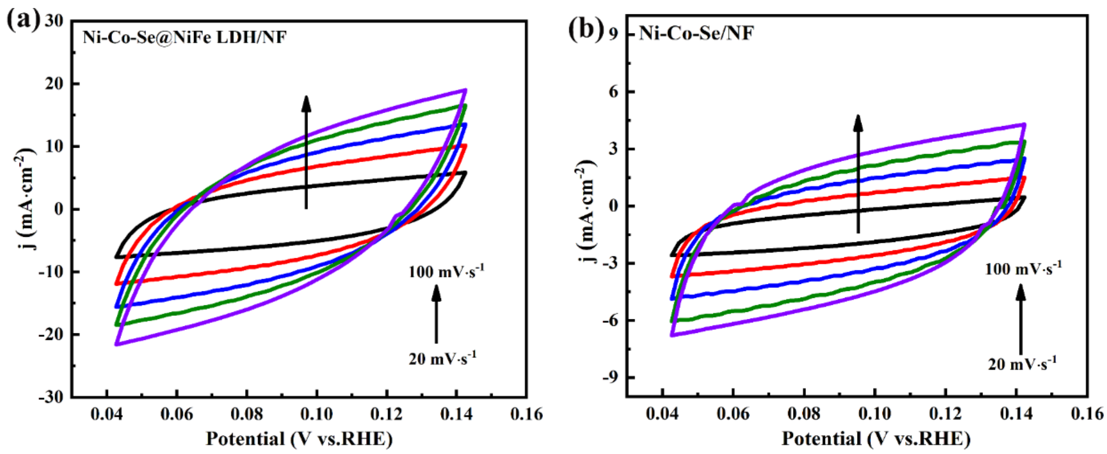

Fig. S11 CV curves of (a) Ni-Co-Se@NiFe LDH/NF, (b) Ni-Co-Se/NF at different scan rates.

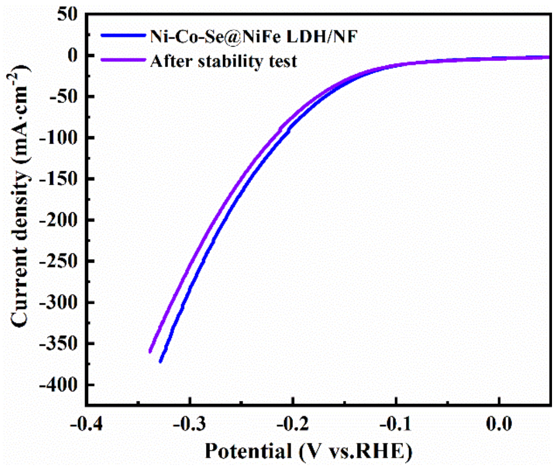

Fig. S12 LSV curves of Ni-Co-Se@NiFe LDH/NF before and after 50 h HER stability test.

Table S1 Map Sum Spectrum

Element	At. %
Ni	50.2
Se	34.4
O	11.0
Co	4.2
Fe	0.2

Table S2 Summary of EIS fitting results for OER

Catalysts	R_s (Ω)	R_{ct} (Ω)
Ni-Co-Se@NiFe LDH/NF	0.95	0.19
NiFe-LDH/NF	1.57	0.56
Ni-Co-Se/NF	1.29	1.56
RuO_2/NF	1.43	8.83
NF	1.12	58.88

Table S3 Summary of LDH-based non-noble metal electrocatalysts for OER

Catalysts	Overpotential (mV)	Electrolyte	Tafel slope ($mV \cdot dec^{-1}$)	Reference
This work	209@10 $mA \cdot cm^{-2}$ 234@50 $mA \cdot cm^{-2}$	1.0 M KOH	38.6	/
Co_3O_4@NiFe-LDH/NF	215@10 $mA \cdot cm^{-2}$	1.0 M KOH	40.4	1
s-EPS@FeNi LDH	220@10 $mA \cdot cm^{-2}$	1.0 M KOH	34.34	2
NiFe LDH@SnO_2/NF	234@10 $mA \cdot cm^{-2}$	1.0 M KOH	37	3
Cr-FeNi LDH/MXene	232@10 $mA \cdot cm^{-2}$	1.0 M KOH	54.4	4
NiFe-LDH/Ni_3S_4	223@10 $mA \cdot cm^{-2}$	1.0 M KOH	49	5
$FeCo_2O_4$@NiMn LDH	232@10 $mA \cdot cm^{-2}$	1.0 M KOH	31.85	6
NiFe-LDH@γ-MnOOH/NF	226@10 $mA \cdot cm^{-2}$	1.0 M KOH	88	7
NiCu-LDH@CoS/g-C_3N_4	290@10 $mA \cdot cm^{-2}$	1.0 M KOH	75	8
SSFF@NiFe LDH	180@10 $mA \cdot cm^{-2}$	1.0 M KOH	31.6	9

Table S4 Summary of EIS fitting results for HER

Catalysts	R_s (Ω)	R_{ct} (Ω)
Ni-Co-Se@NiFe LDH/NF	1.17	0.39
NiFe-LDH/NF	1.16	4.92
Ni-Co-Se/NF	1.29	1.32
Pt-C/NF	1.73	0.48
NF	1.49	4.63

Table S5 Summary of non-noble metal electrocatalysts for HER

Catalysts	Overpotential (mV)	Electrolyte	Tafel slope ($mV\cdot dec^{-1}$)	Reference
This work	78@10 $mA\cdot cm^{-2}$	1.0 M KOH	88.7	/
NiCoP@NiFe LDH/NF	119@10 $mA\cdot cm^{-2}$	1.0 M KOH	149.42	10
NiCoP-Ni_3S_2-MoS_2	140@10 $mA\cdot cm^{-2}$	1.0 M KOH	91.3	11
NiFe LDH@CoS_x/NF	136@10 $mA\cdot cm^{-2}$	1.0 M KOH	/	12
NiCo-LDH@CdS-N	133@20 $mA\cdot cm^{-2}$	1.0 M KOH	76	13
Ni_3Se_2@NiFe-LDH/NF	68@10 $mA\cdot cm^{-2}$	1.0 M KOH	106.2	14
Co-Ni-P@Ce_2O/NF	120@20 $mA\cdot cm^{-2}$	1.0 M KOH	176.7	15
Zn-Co-Ni-P/NF	94@10 $mA\cdot cm^{-2}$	1.0 M KOH	39.4	16
CoSe/$MoSe_2$	110@10 $mA\cdot cm^{-2}$	1.0 M KOH	54.24	17
NCSe@MGA	78@10 $mA\cdot cm^{-2}$	1.0 M KOH	55	18

Table S6 Summary of EIS fitting results for overall water splitting

Catalysts	R_s (Ω)	R_{ct} (Ω)
Ni-Co-Se@NiFe LDH/NF‖ Ni-Co-Se@NiFe LDH/NF	2.113	88.83
RuO_2/NF‖Pt-C/NF	2.599	852.8
NF‖NF	2.482	1144

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