Supplementary Information

Manipulation of oxygen evolution reaction kinetic of free-standing $CoSe_2$-$NiSe_2$ heterostructure electrode by interfacial Engineering

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1. EDX analysis

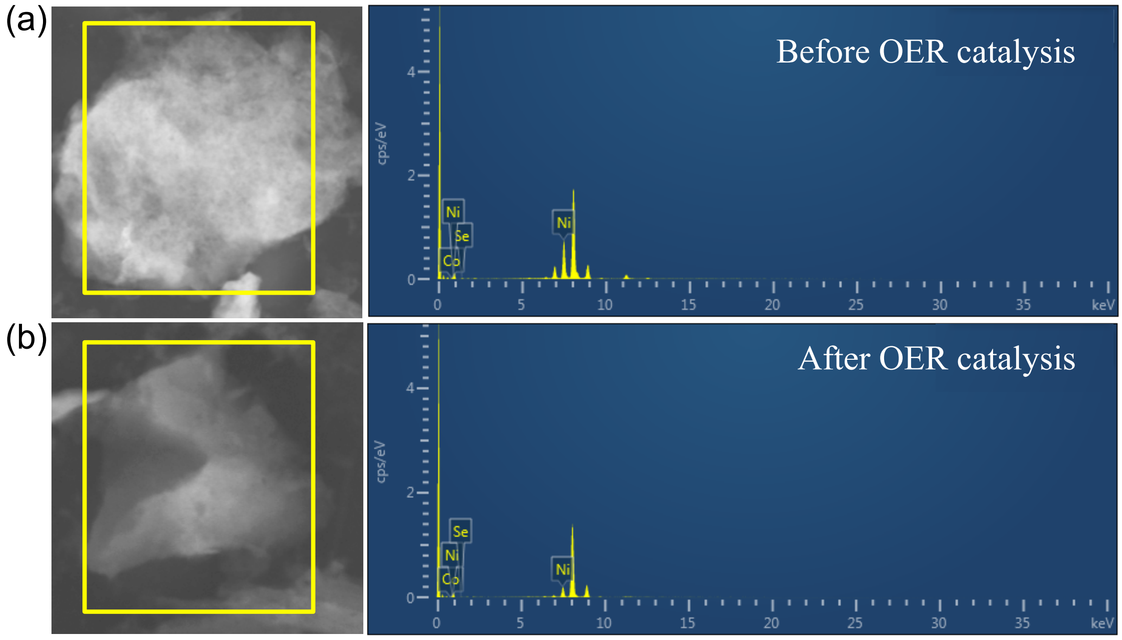

Fig. S1 EDX analysis of $CoSe_2$-$NiSe_2$/NF electrocatalyst before and after the OER catalysis in an alkaline solution.

Energy dispersive spectroscopy (EDS) has been used for component analysis to acquire spectral data and map elemental distributions within the sample. The EDS spectra revealed the presence of Ni, Co, and Se elements in the heterostructured $CoSe_2$-$NiSe_2$/NF electrocatalyst before (Fig. S1a) and after (Fig. S1b) OER catalysis. However, the relative wt. % of the Co (22%), Ni (63%), and Se (15%) elements were changed to 10%, 81%, and 9%, respectively, after OER catalysis due to the oxidation process.

2. SAED pattern

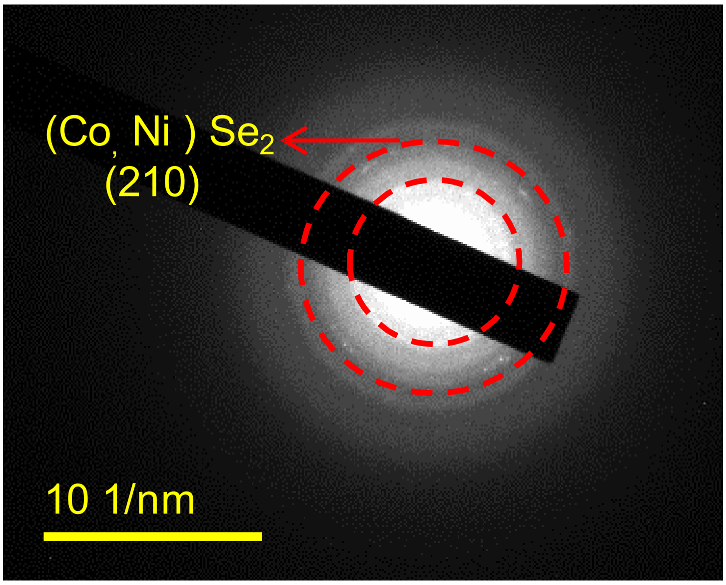

Fig. S2 SAED pattern of $CoSe_2$-$NiSe_2$/NF electrocatalyst.

3. Morphology analysis after OER catalysis

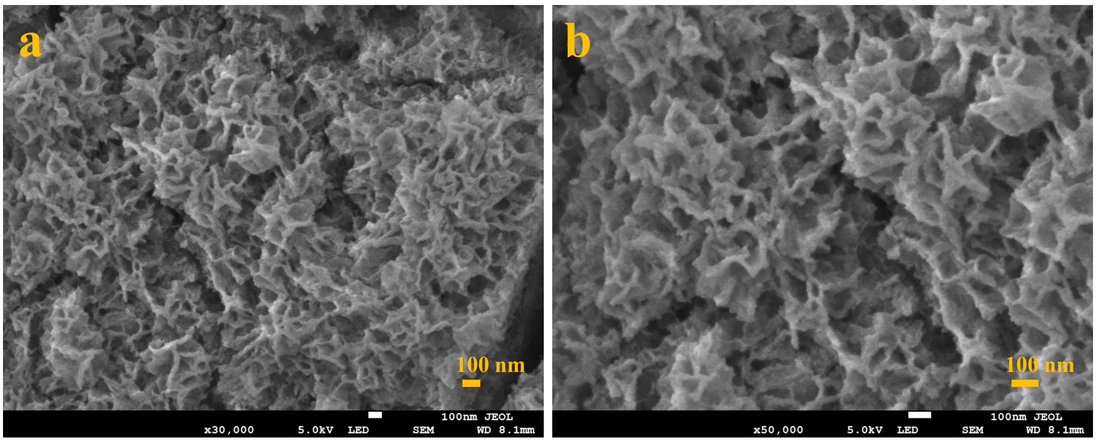

Fig. S3 FE-SEM images of $CoSe_2$-$NiSe_2$/NF electrocatalyst after the OER catalysis.

Table S1. Comparison of the OER catalytic activity of $CoSe_2$-$NiSe_2$/NF electrocatalyst with reported transition metal selenide-based electrocatalysts.

Electrocatalyst	OER(η(mV) j=10 mA cm^{-2})	Tafel slope (mV dec^{-1})	Reference
$CoSe_2$@$NiSe_2$	$235_{(\eta=20)}$	43.2	[1]
CoO*x*–CoSe	$298_{(\eta=20)}$	68	[2]
$NiSe_2$/NF	$274_{(\eta=20)}$	97	[3]
$CoSe_2$/Ni_3Se_4@NC/KB	260	68	[4]
$CoSe_2$/$FeSe_2$@C	291	62	[5]
$Ni_{0.26}Co_{0.74}Se$	$302_{(\eta=50)}$	110	[6]
$CoSe_2$-CoO/NCF	279	44.6	[7]
EG/(Co, Ni)Se_2–NC	258	73.3	[8]
Cu_3Se_2@$CoSe_2$–$NiSe_2$/PNCF	240	87	[9]
$CoSe_2$-$NiSe_2$/NF	160	44	**This work**

References:

[1] X. Zhang, Y. Ding, G. Wu, X. Du, $CoSe_2$@$NiSe_2$ nanoarray as better and efficient electrocatalyst for overall water splitting, International Journal of Hydrogen Energy, 45 (2020) 30611-30621.

[2] X. Xu, P. Du, Z. Chen, M. Huang, An electrodeposited cobalt–selenide-based film as an efficient bifunctional electrocatalyst for full water splitting, Journal of Materials Chemistry A, 4 (2016) 10933-10939.

[3] J. Zhu, Y. Ni, Phase-controlled synthesis and the phase-dependent HER and OER performances of nickel selenide nanosheets prepared by an electrochemical deposition route, Crystengcomm, 20 (2018) 3344-3352.

[4] G. Liu, Z. Zhang, J. Li, J. Liu, X. Long, H. Chen, H. Tong, Z. Liu, D. Qian,

Constructing heterostructured $CoSe_2/Ni_3Se_4$@N-doped carbon nanosheets/ketjen black carbon as a robust oxygen evolution electrocatalyst, International Journal of Hydrogen Energy, 45 (2020) 30666-30672.

[5] W. Li, Y. Niu, X. Wu, F. Wu, T. Li, W. Hu, Heterostructured $CoSe_2/FeSe_2$ nanoparticles with abundant vacancies and strong electronic coupling supported on carbon nanorods for oxygen evolution electrocatalysis, ACS Sustainable Chemistry & Engineering, 8 (2020) 4658-4666.

[6] J. Zhu, Z. Liu, M. Zhai, Y. Ni, $Ni_{1-x}Co_xSe$ nanostructures deposited on nickel foam by a facile potentiostatic route for enhanced OER performance, Journal of Physics and Chemistry of Solids, 148 (2021) 109658.

[7] T. Zhang, J. Yu, H. Guo, J. Liu, Q. Liu, D. Song, R. Chen, R. Li, P. Liu, J. Wang, Heterogeneous $CoSe_2$–CoO nanoparticles immobilized into N-doped carbon fibers for efficient overall water splitting, Electrochimica Acta, 356 (2020) 136822.

[8] J. Cao, K. Wang, J. Chen, C. Lei, B. Yang, Z. Li, L. Lei, Y. Hou, K. Ostrikov, Nitrogen-doped carbon-encased bimetallic selenide for high-performance water electrolysis, Nano-Micro Letters, 11 (2019) 67.

[9] G. Wang, J. Huang, G. Chen, W. Chen, C. Song, M. Li, X. Wang, D. Chen, H. Zhu, X. Zhang, K.K. Ostrikov, In-situ-engineered 3D Cu_3Se_2@$CoSe_2$–$NiSe_2$ nanostructures for highly efficient electrocatalytic water splitting, ACS Sustainable Chemistry & Engineering, 8 (2020) 17215-17224.