Constructing hexagonal copper-coin-shaped $NiCoSe_2@NiO@CoNi_2S_4@CoS_2$ hybrid nanoarray on nickel foam as a robust oxygen evolution reaction electrocatalyst

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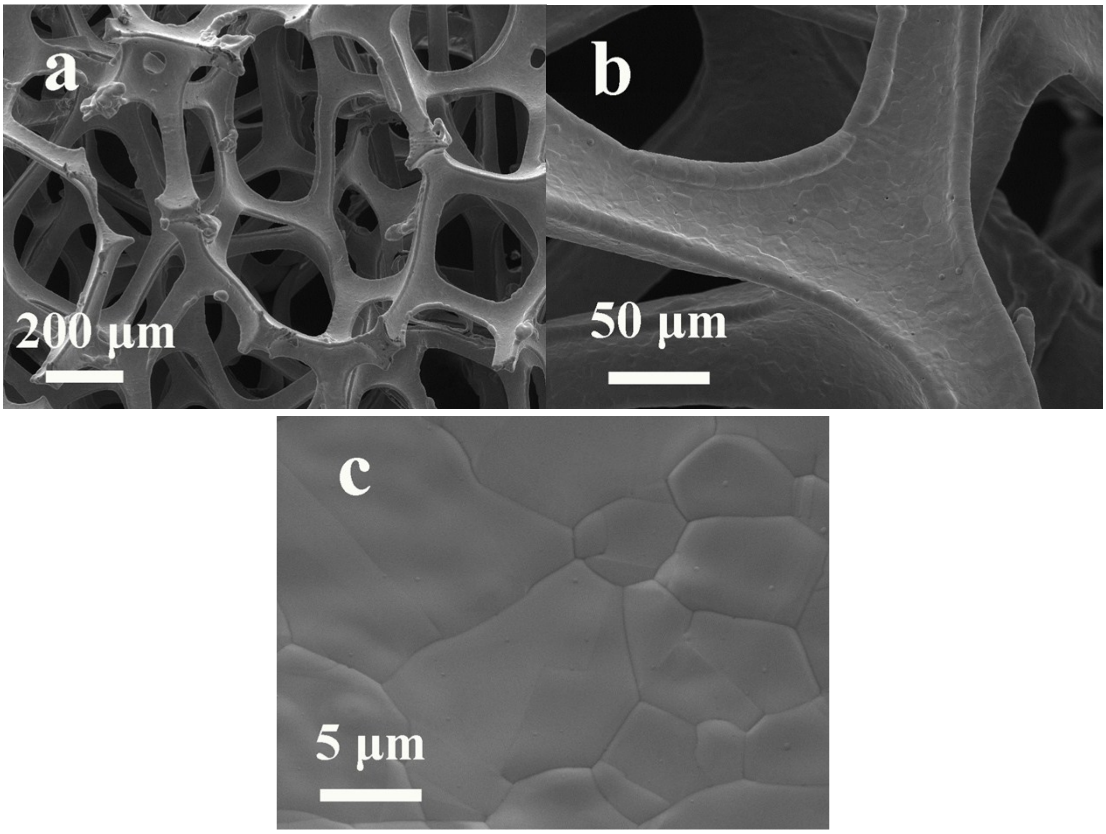


Fig. S1 SEM image of NF.

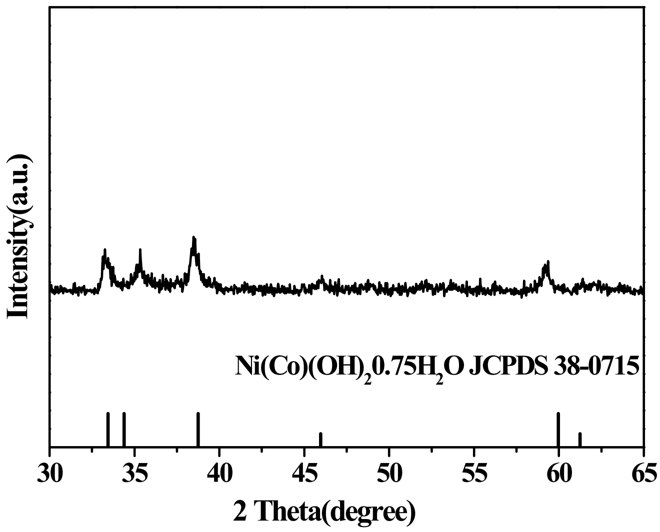


Fig. S2 The XRD spectra of NiCo-Precursor.

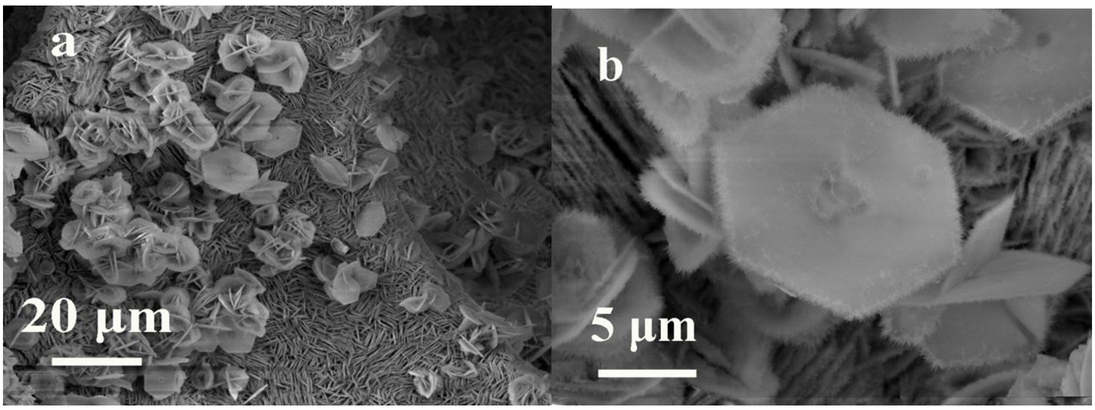
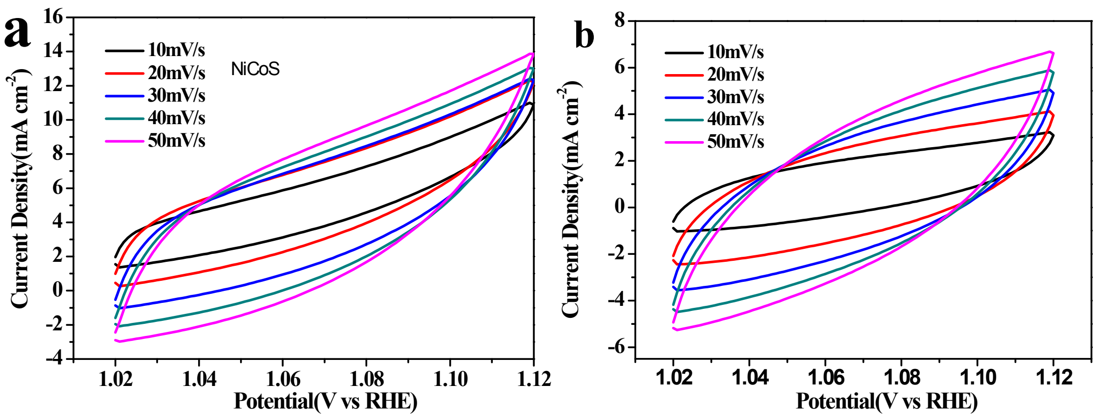


Fig. S3 SEM image of NiCo-Precursor.



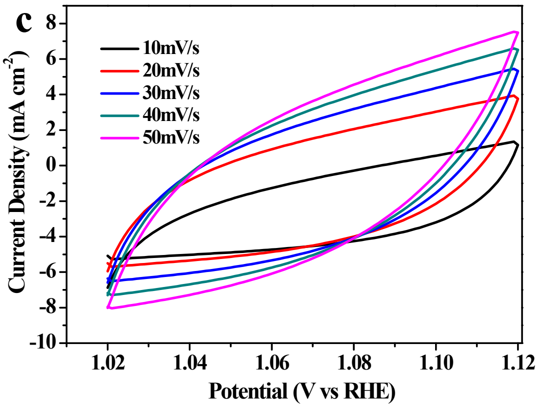


Fig. S4 Electrochemical double-layer capacitance measurements. The cyclic voltammograms (CVs) measurements with various scan rates for (a) $NiCoSe_2$@NiO@$CoNi_2S_4$@CoS_2/NF, (b) $NiCoSe_2$@NiO/NF, (c) $CoNi_2S_4$@CoS_2/NF in 1.0 M KOH.

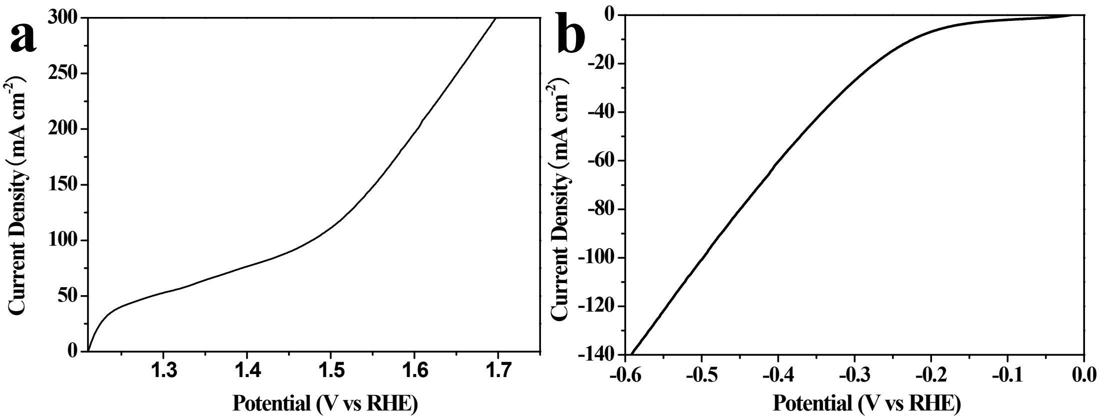


Fig. S5 (a) Polarization curves of $NiCoSe_2$@NiO@$CoNi_2S_4$@CoS_2/NF for OER in 30 wt% KOH solution, (b) LSV curve of $NiCoSe_2$@NiO@$CoNi_2S_4$@CoS_2/NF for HER in 1.0 KOH solution.

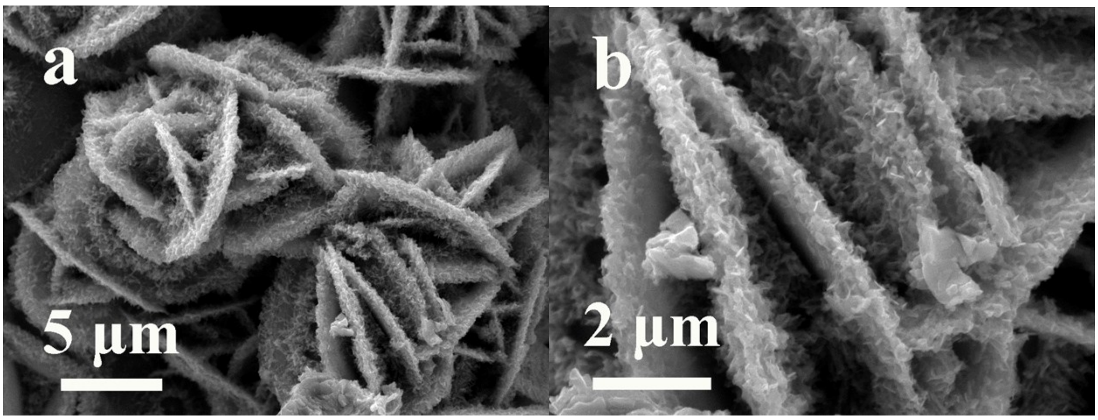


Fig. S6 SEM image of $NiCoSe_2$@NiO@$CoNi_2S_4$@CoS_2/NF after stability test for OER.

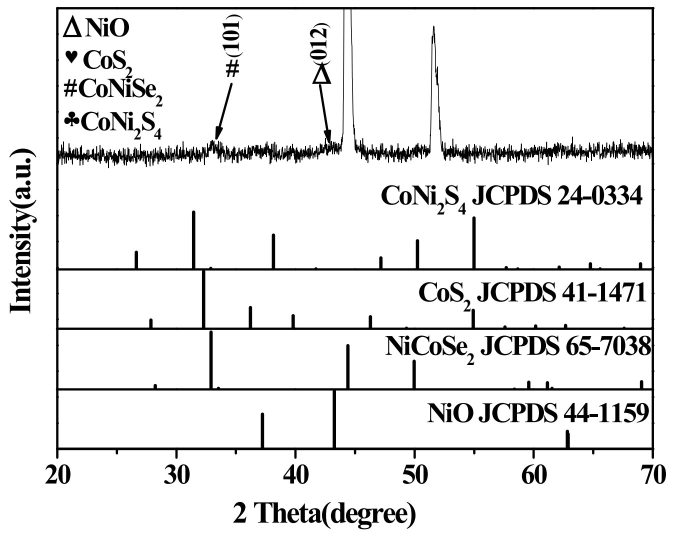


Fig. S7 XRD pattern of $NiCoSe_2$@NiO@$CoNi_2S_4$@CoS_2/NF after stability test for OER.

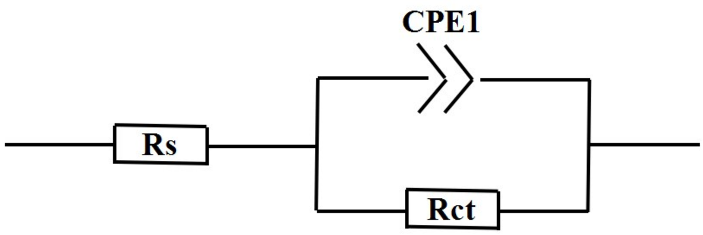


Fig. S8 The equivalent circuit for fitting the EIS results.

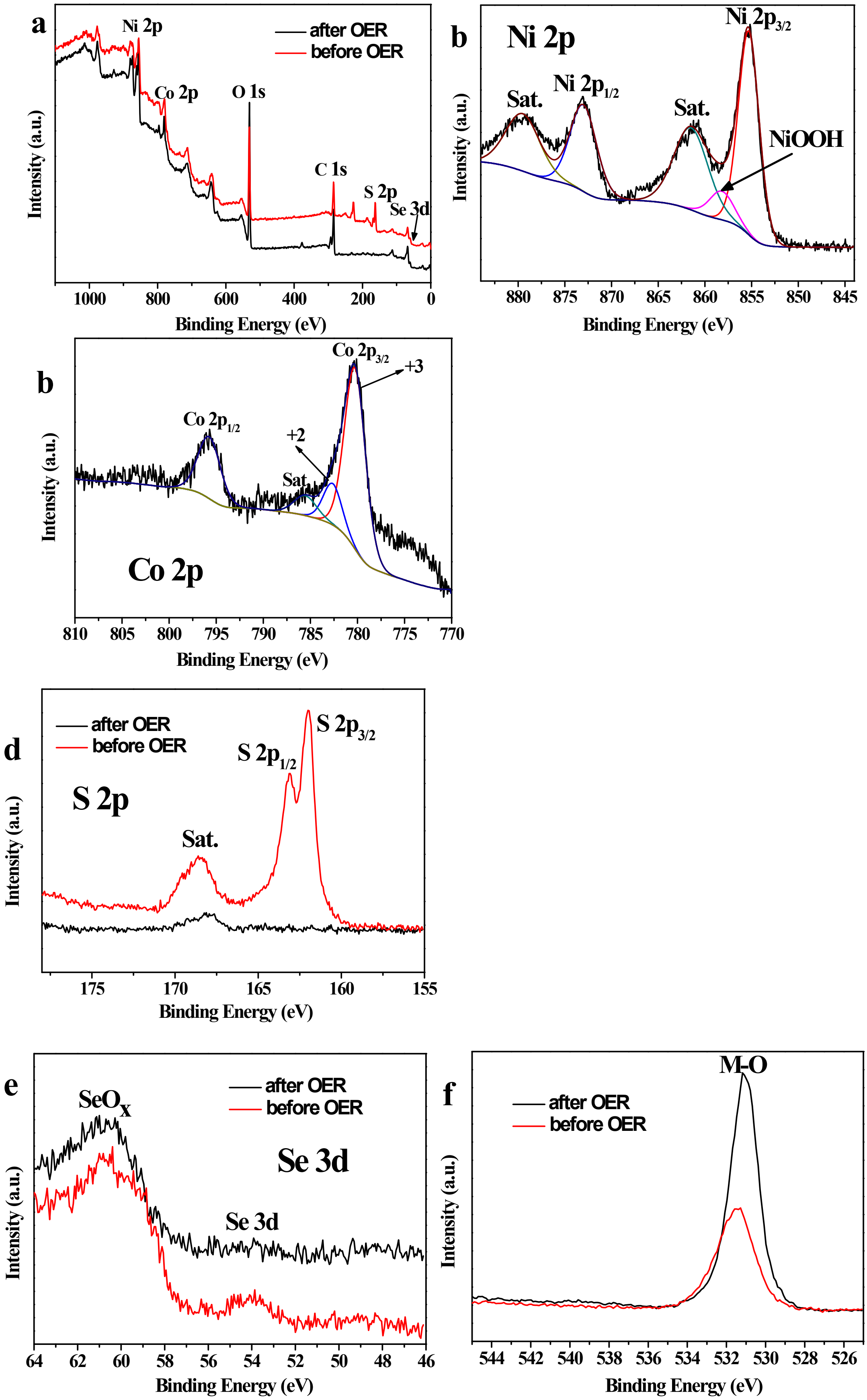


Fig. S9 The XPS spectra of $NiCoSe_2$@NiO@$CoNi_2S_4$@CoS_2/NF after OER stability test: (a) survey, (b) Ni 2p, (c) Co 2p, (d) S 2p and (f) Se 3d regions.

Table 1. Comparison of OER properties for catalysts of relevant catalytic materials

Catalyst	Electrolyte	Overpotential	Ref.
$NiCoSe_2$@NiO@ $CoNi_2S_4$@CoS_2/NF	1 M KOH	310@30 mA cm^{-2}	This work
$CoNi_2S_4$@CoS_2/NF	1 M KOH	365@30 mA cm^{-2}	
$NiCoSe_2$@NiO/NF	1 M KOH	369@30 mA cm^{-2}	
$MnO_2/NiCo_2O_4$/NF	1 M KOH	340@10 mA cm^{-2}	1
Ni_3S_2/NF	1 M KOH	340@10 mA cm^{-2}	2
NG/$NiSe_2$/NF	1 M KOH	307@20 mA cm^{-2}	3
Cu_3P/NF	1 M KOH	320@10 mA cm^{-2}	4
NiO/NF	1 M KOH	310@10 mA cm^{-2}	5
P-Co-Ni-S/NF	1 M KOH	296@100 mA cm^{-2}	6
NiCoFeP/NF	1 M KOH	271@200 mA cm^{-2}	7
S-$NiFe_2O_4$/Ni_3Fe/NW	1 M KOH	260@100 mA cm^{-2}	8
FeNiOH/NF	1 M KOH	271@20 mA cm^{-2}	9

Table 2. Comparison of two-electrode water-splitting for catalysts of relevant catalytic materials

Catalyst	Electrolyte	Overall voltage (10 mA cm^{-2})	Ref.
$NiCoSe_2$@NiO@ $CoNi_2S_4$@CoS_2/NF	1 M KOH	1.583 V	This work
$NiCo_2S_4$/NF	1 M KOH	1.63 V	10
NiFe/$NiCo_2O_4$/NF	1 M KOH	1.67 V	11
Ni_2P	1 M KOH	1.63 V	12
NiS/NF	1 M KOH	1.64 V	13
Ni_3Se_2	1 M KOH	1.65 V	14
CoP films	1 M KOH	1.63 V	15
Fe-Ni_3S_2/NF	1 M KOH	1.54 V	16
$F_{0.25}C_1$CH/NF	1 M KOH	1.45 V	17
P-$Ni(OH)_2$/$NiMoO_4$/NF	1 M KOH	1.55 V	18
NiFeP-SiO_2/NF	1 M KOH	1.57 V	19

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