Electronic Supplementary Information

Three-dimensional Ni foam supported $NiCoO_2$@Co_3O_4 nanowire-on-nanosheet arrays with rich oxygen vacancies as superior bifunctional catalytic electrodes for overall water splitting

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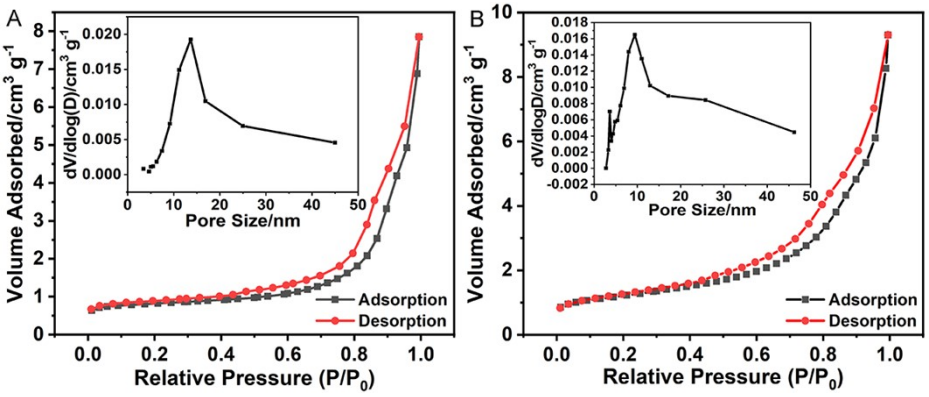

Figure S1. N_2 adsorption–desorption isotherm (A, B) and pore size distribution (A inset, B inset) of NF@$NiCoO_2$ NSA (A) and NF@$NiCoO_2$ NSA@Co_3O_4 NWA (B).

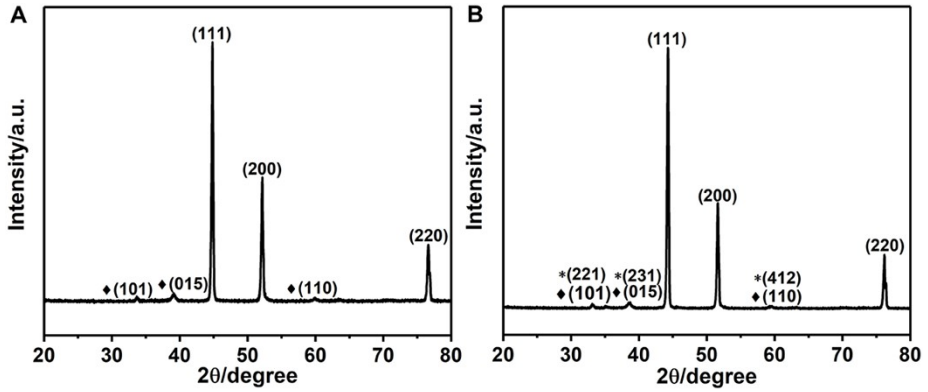

Figure S2. XRD patterns of NF@$NiCoO_2$ NSA (A) and NF@$NiCoO_2$ NSA@Co_3O_4 NWA (B) before calcination. The peaks without labeling are from cubic Ni (JCPDS No. 01-1258). ♦ and * represent characteristic peaks of rhombohedral cobalt nickel carbonate hydroxide (JCPDS card No. 33-0429) and orthorhombic cobalt carbonate hydroxide (JCPDS card no. 048-0083), respectively.

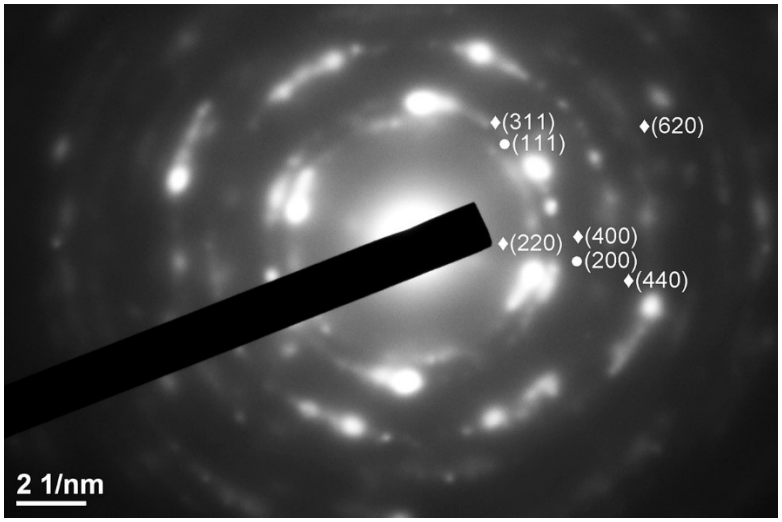

Figure S3. SAED pattern of NF@$NiCoO_2$ NSA@Co_3O_4 NWA. ● and ♦ represent characteristic peaks of cubic $NiCoO_2$ (JCPDS No. 10-0188) and cubic Co_3O_4 (JCPDS No. 42-1467), respectively.

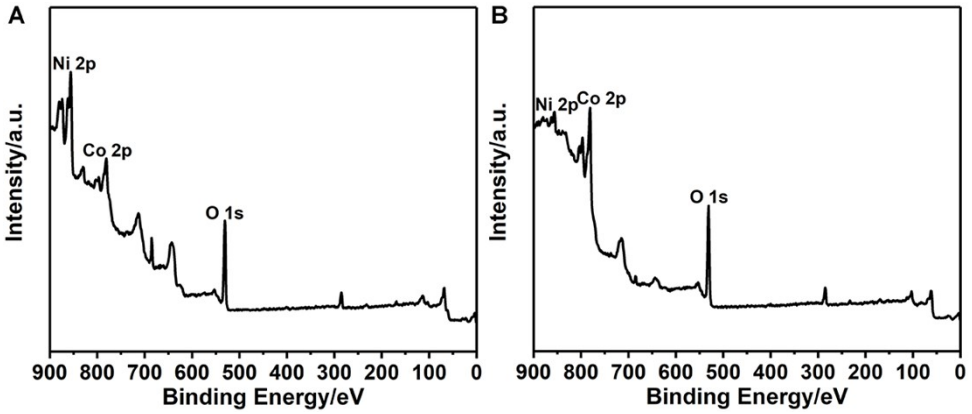

Figure S4. XPS survey spectra of NF@$NiCoO_2$ NSA (A) and NF@$NiCoO_2$ NSA@Co_3O_4 NWA (B).

Table S1. The performance of representative OER catalysts measured in 1.0 M KOH.

catalyst	overpotential@10 mA cm^{-2} (mV)	Tafel slope (mV dec^{-1})	reference[1-38]
α-Fe_2O_3	275	73.63	[1]
Mn_3O_4@$Cu(OH)_2$-2	314	97	[2]
Fe_2O_3–Mn_2O_3	350	70	[3]
$Fe_{0.5}Co_{0.5}MoO_{4-x}S_x$	263	87	[4]
$Co_2Mo_3O_8$@NC-800	331	87.5	[5]
NiO/$NiCo_2O_4$	357	130	[6]
Cu/Cu_2O/CuO	289	73.1	[7]
$NiCo_2O_4$-CN-180	383	53.5	[8]
$Cu_{0.5}Co_{2.5}O_4$	285	79.2	[9]
Ar-$NiCo_2O_4$|S	256	51.1	[10]

NiO/CN-2:1	261	58.92	[11]
$Ni_xCo_{3-x}O_4$/NF	287	88	[12]
CoO hexagrams	269	64.4	[13]
$Co_{0.708}Fe_{0.292}WO_4$	327	53	[14]
Ce-$MnCo_2O_4$-3%	390	125	[15]
NiS_2@GO	294	54	[16]
MoS_2-Co_9S_8-NC	230	77	[17]
Co_9S_8/Co-NCNT-0.05	450	115.6	[18]
NiP/NiFeP/C	250	58	[19]
Co-Ni_3S_2/NF	274	199	[20]
S, N-CNTs/CoS_2@Co	340	76.1	[21]
Se/Fe-Co_9S_8-0.14	288	51.29	[22]
Fe_3O_4/Co_3S_4	270	56	[23]
NH_4CoPO_4•H_2O/Co	254	64.4	[24]
$Fe_{2.95}(PO_4)_2(OH)_2$	281	46.48	[25]
Cu_xSNiMn LDH/NF	263	57.79	[26]
$Ni_{0.65}Fe_{0.35}P$	270	60	[27]
Ni_2P@NC	320	50	[28]
$CoMoN_x$-500 NSAs/NF	231	50.6	[29]
N–NiCo-LDH	250	75	[30]
D-Ni_3N QDs/VN	226	54	[31]
Mo_2N–MoS_2(1:1) MCNFs	270	57.2	[32]
Co_3FeN_x-10/NC LACC	270	52.5	[33]
Co_3O_4/NC	309	89	[34]
Fe-doped Co_9S_8@CoO	296	65	[35]
RuO_2	267	61	[36]
IrO_2/C	360	82	[37]
Ir/C	N.A.	77	[38]
NF@$NiCoO_2$ NSA@Co_3O_4 NWA	**221.8**	**46.2**	**This work**

Table S2. The performance of representative HER catalysts measured in 1.0 M KOH.

catalyst	overpotential@10 mA cm^{-2} (mV)	Tafel slope (mV dec^{-1})	reference[10, 15, 18, 29, 32, 39-61]
Ar-$NiCo_2O_4$|S	137	121.4	[10]
Ce-$MnCo_2O_4$-3%	389	96	[15]
Co_9S_8/Co-NCNT-0.05	196	84.94	[18]
$CoMoN_x$-600 NSAs/NF	160	127.2	[29]
Mo_2N–MoS_2(1:1) MCNFs	131	68.9	[32]
$CoMoO_4$/NF	242	132.4	[39]
C@CoO/CC	120	129	[40]
Ni-$NiFe_2O_4$@C	217	96	[41]
$NiMoO_4$	406	130	[42]
$BaMoO_3$	336	110	[43]
$NiTiO_3$	356	130	[44]
MoO_2	271	93.2	[45]
Co_3O_4@MoS_2	158	148	[46]
Amorphous Fe_2O_3	325	327.8	[47]
$NiCo_2O_4$@$CoMoO_4$/NF-7	121	77	[48]
$Fe_{1.89}Mo_{4.11}O_7/MoO_2$	197	79	[49]
NiP_2/NiO NRs	131	94	[50]
NiO NRs-m-Ov	110	100	[51]
N droped Ni_3S_2	155	113	[52]
Ni_3S_2/NF	288	120	[53]
$(Ni_{0.33}Co_{0.67})S_2$ NWs/CC	156	127	[54]

CoS_x/NCS	330	146	[55]
CoS_2 HNSs	193	100	[56]
CNT@NPC-900	304	105	[57]
FeP NPs@NPC	214	82	[58]
$FeNi_3N$-h	185	134.7	[59]
$Co(OH)_2$@P-NiCo-LDH	226	134	[60]
Am $FePO_4$/NF	123	104.49	[61]
NF@$NiCoO_2$ NSA@Co_3O_4 NWA	**122.7**	**72.2**	**This work**

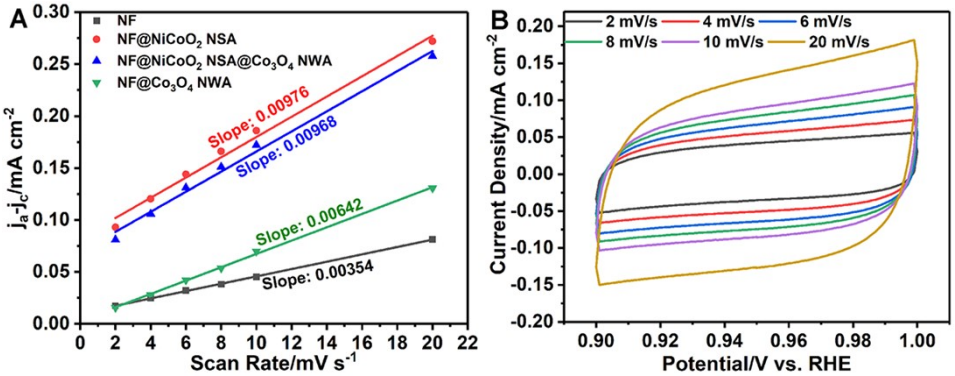

Figure S5. (A) Charging current density differences of NF, NF@$NiCoO_2$ NSA, NF@$NiCoO_2$ NSA@Co_3O_4 NWA and NF@Co_3O_4 NWA versus scan rates. (B) Typical CV curves at different scan rates for NF@$NiCoO_2$ NSA@Co_3O_4 NWA (CV curves at different scan rates for other samples are not shown for brevity).

Table S3. The performance of representative water splitting catalysts measured in 1.0 M KOH.

catalyst	voltage /V（10 mA cm^{-2}）	reference[10, 17, 21, 29, 30, 32, 41, 54, 59, 62-81]
Ar-$NiCo_2O_4$|S//Ar-$NiCo_2O_4$|S	1.63	[10]
MoS_2-Co_9S_8-NC//MoS_2-Co_9S_8-NC	1.63	[17]
S, N-CNTs/CoS_2@Co//S, N-CNTs/CoS_2@Co	1.633	[21]
$CoMoN_x$-500 NSAs/NF//$CoMoN_x$-500 NSAs/NF	1.55	[29]
N-NiCo-LDH//N-NiCo-LDH	1.55	[30]
Mo_2N–MoS_2(1:1) MCNFs//Mo_2N–MoS_2(1:1) MCNFs	1.63	[32]
Ni-$NiFe_2O_4$@C//Ni-$NiFe_2O_4$@C	1.57	[41]
$(Ni_{0.33}Co_{0.67})S_2$ NWs/CC//$(Ni_{0.33}Co_{0.67})S_2$ NWs/CC	1.57	[54]
$FeNi_3N$-h//$FeNi_3N$-h	1.63	[59]
RuO_2//Pt/C	1.57	[62]
$CoS_{0.46}P_{0.54}$//$CoS_{0.46}P_{0.54}$	1.62	[63]
Co_3S_4-MoS_2//Co_3S_4-MoS_2	1.61	[64]
IrO_2/NF//Pt/C/NF	1.66	[65]
Co@$CoMoO_x$-α-CrOOH//Co@$CoMoO_x$-α-CrOOH	1.57	[66]
NCGC//NCGC	1.68	[67]
Ni/Mo_2C(1:2)-NCNFs//Ni/Mo_2C(1:2)-NCNFs	1.64	[68]
mac-CoO@Co/NGC NSAs//mac-CoO@Co/NGC NSAs	1.62	[69]
Co_9S_8/HWS_2/CNFs//Co_9S_8/HWS_2/CNFs	1.60	[70]
N-Ni_3S_2@C/NF//N-Ni_3S_2@C/NF	1.57	[71]

C/NiFeP NSs//C/NiFeP NSs	1.63	[72]
NiFeP/NiP/PP//NiFeP/NiP/PP	1.613	[73]
Ni_3S_2–Ni_2P/NF//Ni_3S_2–Ni_2P/NF	1.58	[74]
NiFeP@N-CS//NiFeP@N-CS	1.57	[75]
NiFeP@NiP@NF//NiFeP@NiP@NF	1.56	[76]
$CoFeN_x$-500 HNAs/NF//$CoFeN_x$-500 HNAs/NF	1.592	[77]
CoP/CN@MoS_2//CoP/CN@MoS_2	1.61	[78]
Co-NCNTFs//NF//Co-NCNTFs//NF	1.62	[79]
CoFeP@NSOC//CoFeP@NSOC	1.62	[80]
a-$Ni_{0.65}Fe_{0.35}(OH)_2$//a-$Ni_{0.65}Fe_{0.35}(OH)_2$	1.60	[81]
NiCo-$NiCoO_2$@Cu_2O@CF	1.69	[82]
carbon-incorporated NiO/Co_3O_4 concave surface microcubes	1.63	[83]
CoO_x/CN_x	1.93	[84]
Mo_2C-CoO@N-CNFs	1.56	[85]
CoO/MoS_2/CC	1.65	[86]
NF-NiCo-Co//NF-NiCo-Co	**1.55**	**This work**

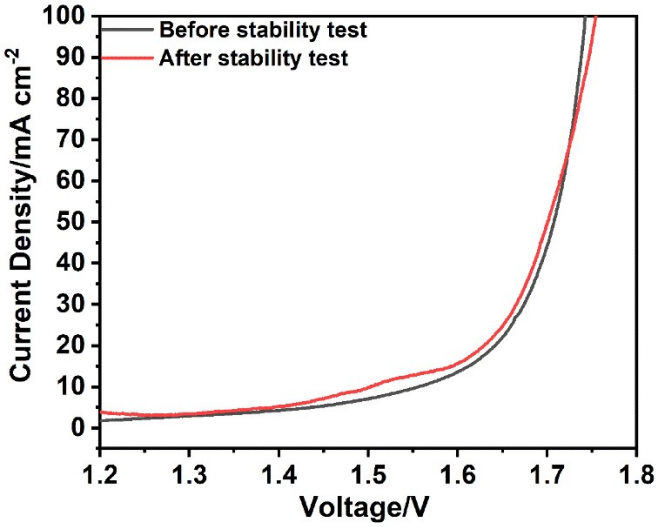

Figure S6. LSV curves of the water electrolyzer before and after the stability test.

Figure S7 FESEM image of NF@$NiCoO_2$ NSA@Co_3O_4 NWA after the stability test.

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