Supplementary Information

For

Free-sustaining Three-dimensional S235 Steel-based Porous Electrocatalyst for Highly Efficient and Durable Oxygen Evolution

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Figure S1

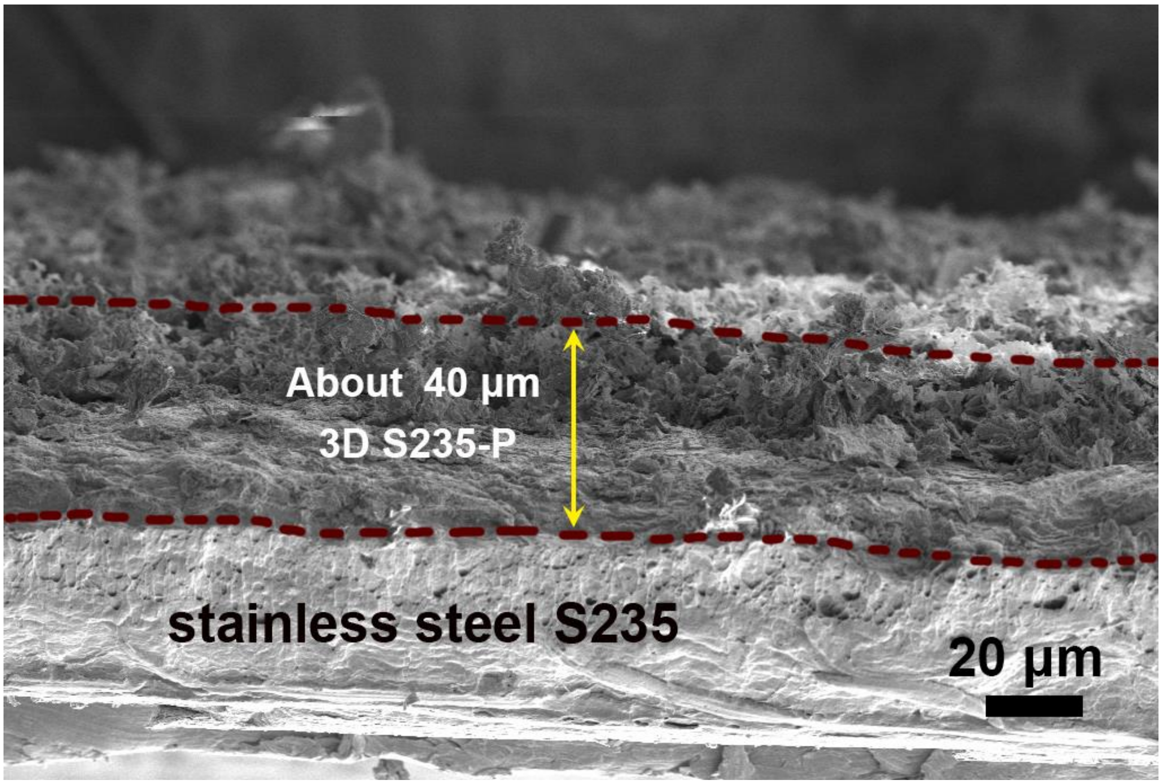


Figure S1. The cross-section SEM of 3D S235-P steel. The average phosphorized layer is about 40 μm.

Figure S2

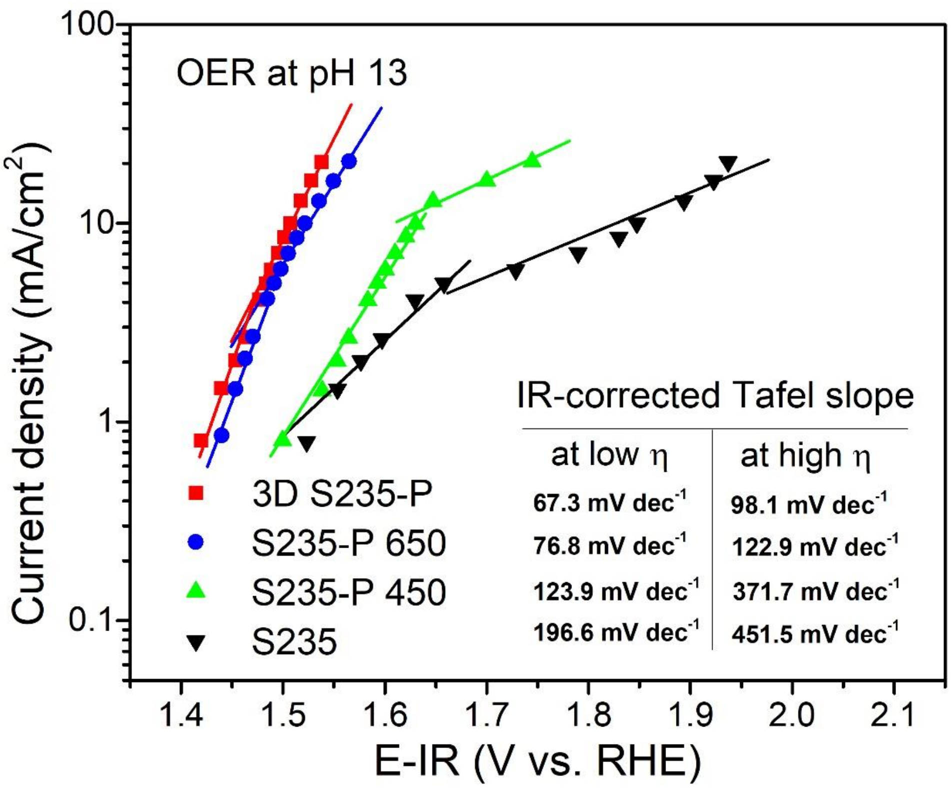
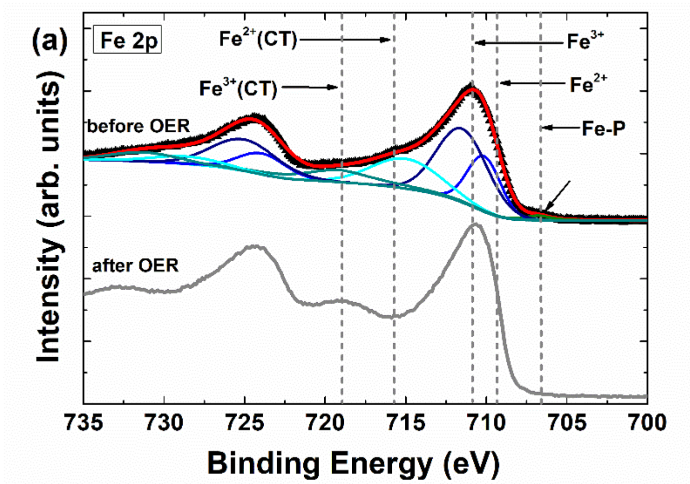
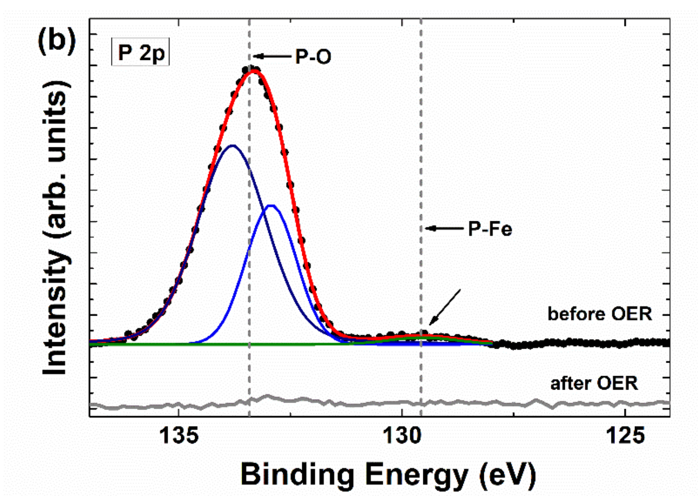


Figure S2. IR-corrected Tafel plots of 3D S235-P steel, S235-P-650 steel, S235-P-450 steel, and untreated S235 steel determined in 0.1 M KOH. Average voltage values for the Tafel plots were derived from 200 second chronopotentiometry scans at current densities 0.80, 1.48, 2.03, 2.67, 4.12, 4.98, 5.82, 7.07, 8.50, 9.98, 12.93, 16.36, and 20.34 mA cm^{-2}. IR compensation was performed by taking in account the electrolyte resistance from EIS measurements (Figure 5).

Figure S3


(a)
Fe 2p
Fe2+(CT)
Fe3+(CT)
Fe3+
Fe2+
Fe-P
before OER
after OER
Intensity (arb. units)
735 730 725 720 715 710 705 700
Binding Energy (eV)


(b)
P 2p
P-O
P-Fe
before OER
after OER
Intensity (arb. units)
135 130 125
Binding Energy (eV)

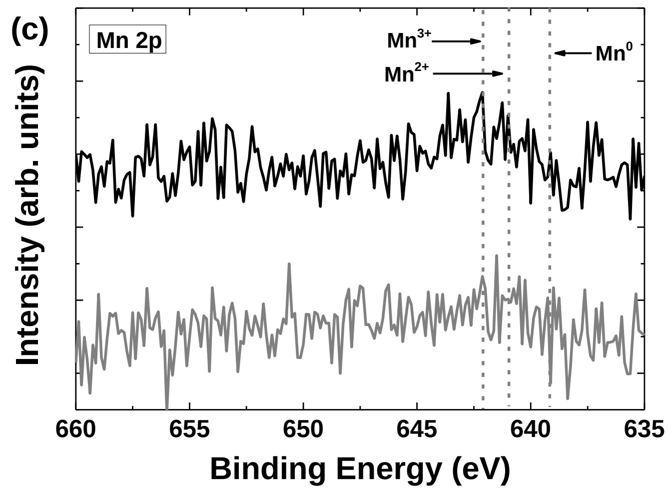
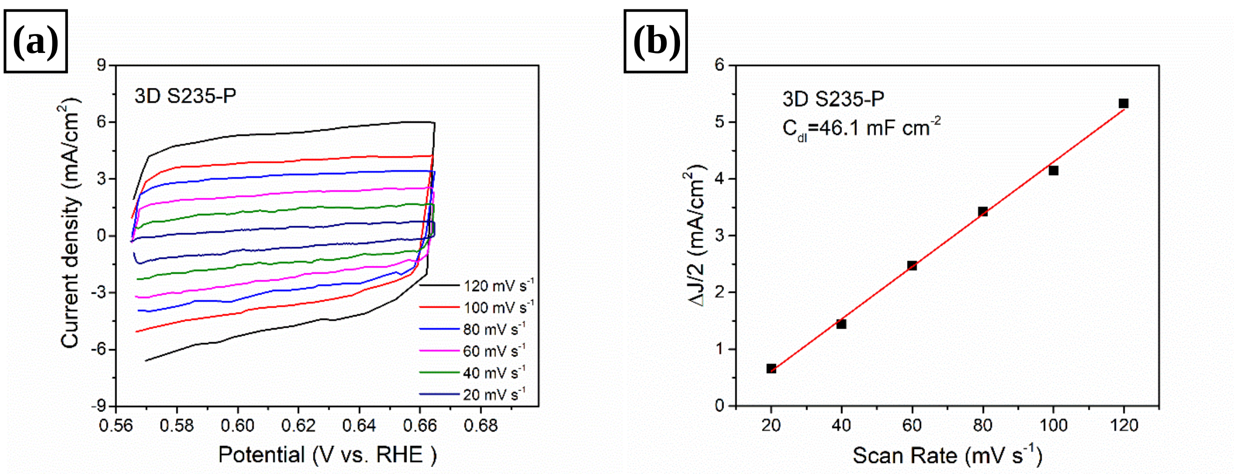


Figure S3. High-resolution XPS patterns for 3D S235-P steel before and after electrolysis for 2000 s: Fe 2p, P 2p, and Mn 2p.

Figure S4



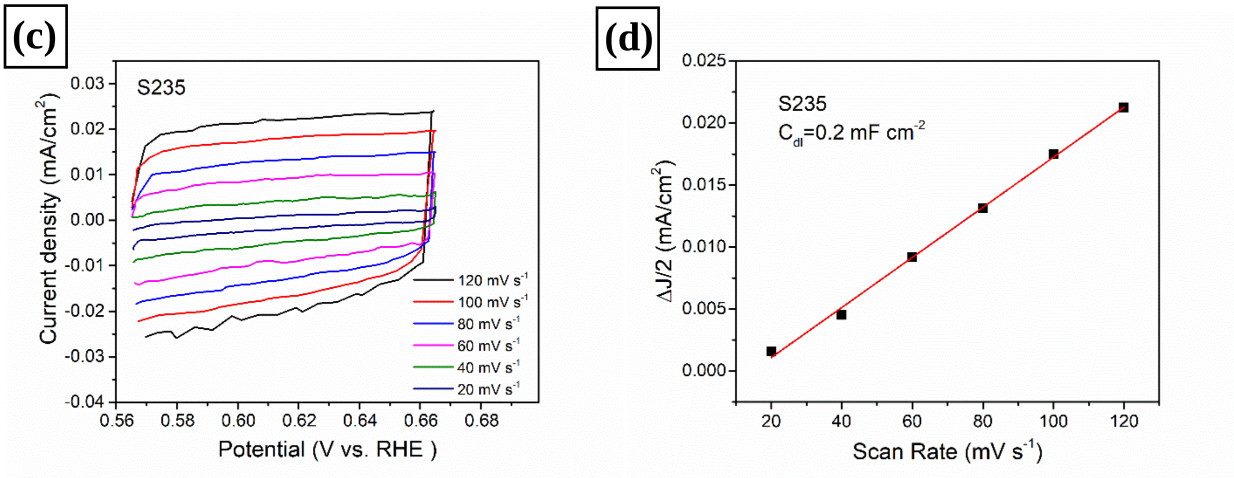


Figure S4. Cyclic voltammograms in the region of 0-0.10 V vs. RHE at various scan rates and the corresponding linear fitting of the capacitive currents vs. scan rates to estimate the C_{dl} (a) and (b) for 3D S235-P and (c) and (d) for S235; and the calculated C_{dl} values are shown in the insets.

Figure S5

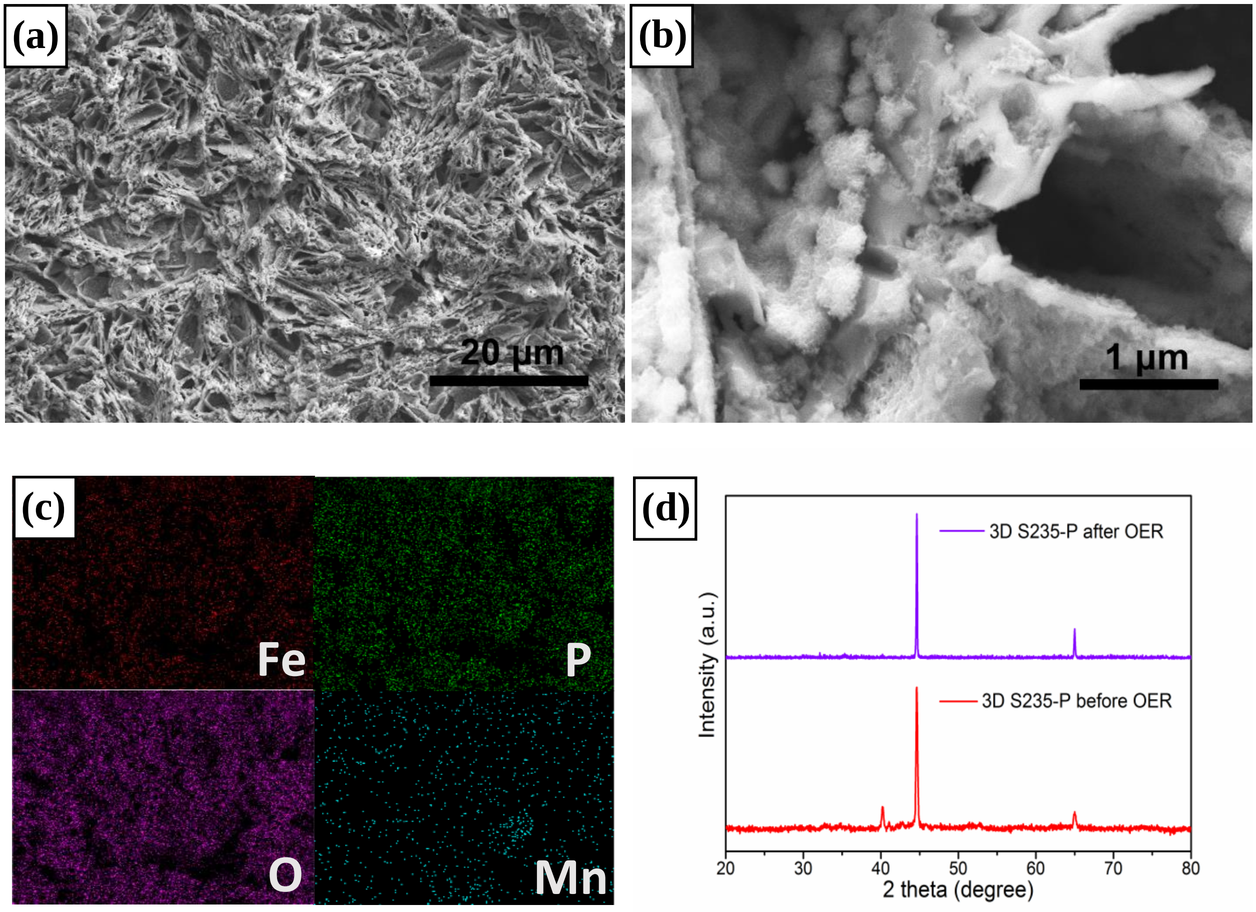


Figure S5. SEM images (a, b) of the 3D S235-P steel after long-term chronopotentiometric measurement, (c) the corresponding elemental mapping images and (d) XRD patterns.

Figure S6

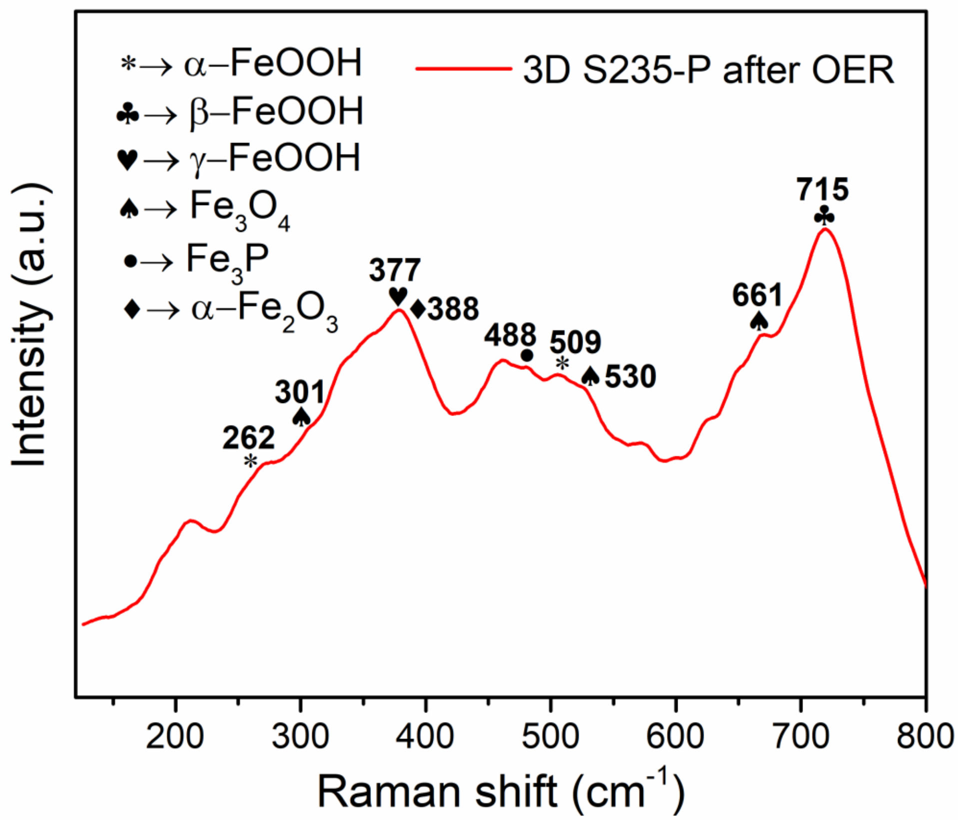


Figure S6. Raman spectrum of 3D S235-P steel after usage in OER testing.

Table S1. OER activities of the 3D S235-P steel and reported catalysts in alkaline condition.

Catalysts	Electrolyte	η_{onset} (mV)	Tafel slope (mV dec^{-1})	J_{geo} (mA cm^{-2})	Loading mass (mg cm^{-2})	Ref.
3D S235-P	**0.1 M KOH**	**180**	**76.3**	**10@ η = 295 mV**	**0.68**	**This work**
RuO_2	0.1 M KOH	-	-	10@ η = 298 mV	-	J. Phys. Chem. Lett. 2012, 3, 399
IrO_2		-	-	10@ η = 288 mV	-	
FeP NRs on CP	1.0 M KOH	290	63.6	10@ η = 350 mV	0.7	Chem. Commun., 2016, 52, 8711
$NiFeO_x$ film	1.0 M NaOH	-	-	10@η > 350 mV	-	J. Am. Chem. Soc. 2013, 135, 16977
sea-urchin-like $(Co_{0.54}Fe_{0.46})_2P$	0.1 M KOH	-	-	10@ η = 370 mV	0.2	Angew. Chem. Int. Ed. 2015, 127, 9778
$Fe_{1.1}Mn_{0.9}P$ nanoparticles	1.0 M KOH	-	39	10@ η = 350 mV	0.28	Chem. Mater. 2017, 29, 3048
NiFe LDHs Nanosheets	1.0 M KOH	-	40	10@η = 300 mV	0.07	Nat. Commun. 2014, 5, 4477
$Ni_{30}Fe_7Co_{20}Ce_{43}O_x$	1.0 M NaOH	270	70	10@η = 310 mV	-	Energy Environ. Sci. 2014,7, 682
Ni doped FeOOH	0.1 M KOH	-	-	10@ η > 340 mV	-	J. Mater. Chem. A, 2014, 2, 14957
amorphous FeNi oxides nanospheres	1.0 M KOH	-	48	10@η = 286 mV	0.1	Angew. Chem. Int. Ed. 2014, 53, 7547
FeP@Au	1.0 M KOH	250	56.8	10@η = 320 mV	-	J. Mater. Chem. A, 2016, 4, 9750
iron phosphide nanotube	1.0 M KOH	250	43	10@η = 288 mV	1.6	Chem. Eur.J. 2015, 21,18062
Fe-Ni oxides	1.0 M KOH	-	51	10@ η > 375 mV	1	ACS Catal. 2012, 2, 1793
Nickel Phosphide nanoparticles	1.0 M KOH	-	59	10@ η = 290 mV	0.14	Energy Environ. Sci., 2015, 8, 2347
$NiCo_{2.7}(OH)_X$ Amorphous nanocages	1.0 M KOH	250	67	10@ η = 350 mV	0.2	Adv. Energy Mater. 2015, 5, 1401880

I	II	III	VI	VII
Mass loss [mg]	**V (pH 7 buffer) [ml]**	**Ion concentration (Electrolyte) [mg/l]**	**∑detected ions [mg]**	**∑detected material [mg]**
0.10	400	0.16 (Fe) 0.01 (Mn)	0.064 (Fe) 0.004 (Mn)	0.068

Table S2. ICP OES analysis of the pH 7 electrolyte used for the long term chronopotentiometry measurements carried out for 40000 s at 2 mA/cm^2. The values in column III and IV are **averaged values** representing the results from three test runs. Column I represents the average mass loss of the steel samples while carrying out the long term chronopotentiometry measurement.