Electronic Supplementary Information

Ru doped WO_3 Enabling Efficient Hydrogen Oxidation Reaction in Alkaline Media

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Figures and Tables

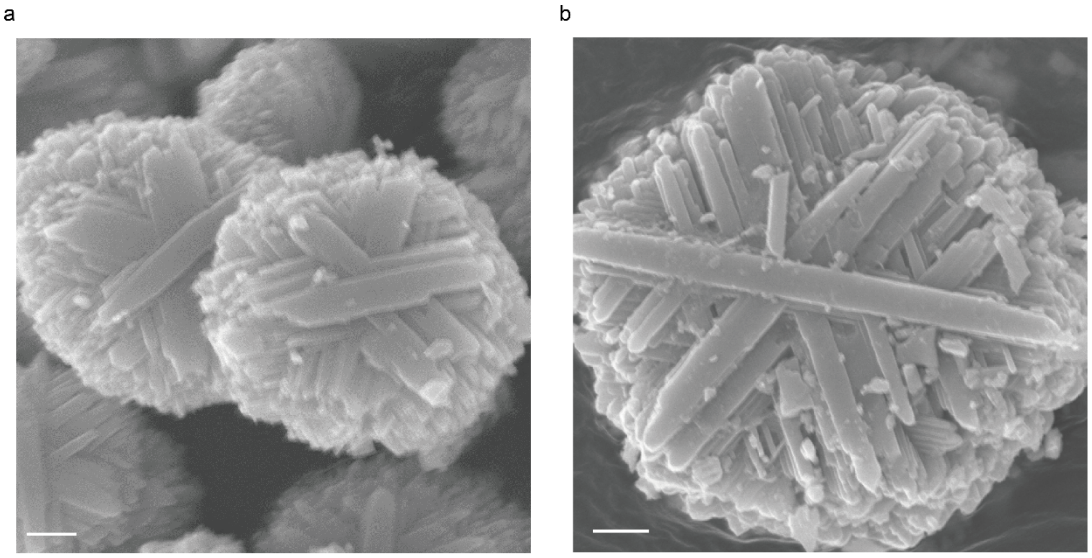

Figure S1. SEM images for Ru-WO_3 with different ratios at 200 nm scale. a) 5% Ru. b) 10% Ru.

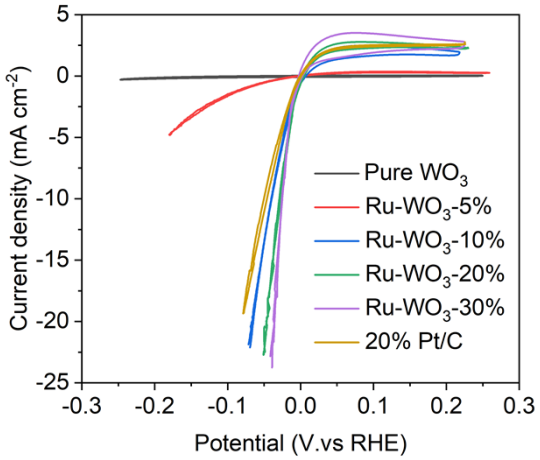

Figure S2. Corresponding cv curves for Ru-WO_3, pure WO_3 and 20% Pt/C measured in 0.1 M KOH with H_2.

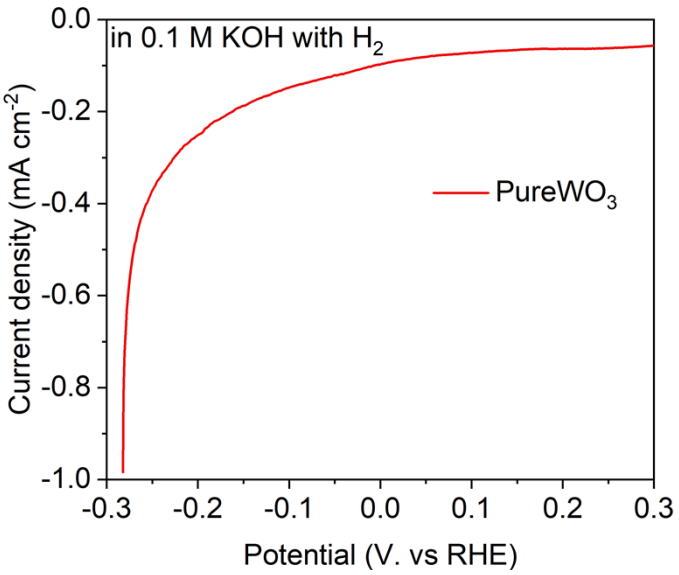

Figure S3. Polarization curve for pure WO_3 in 0.1 M KOH at a scan rate of 5 mV/s.

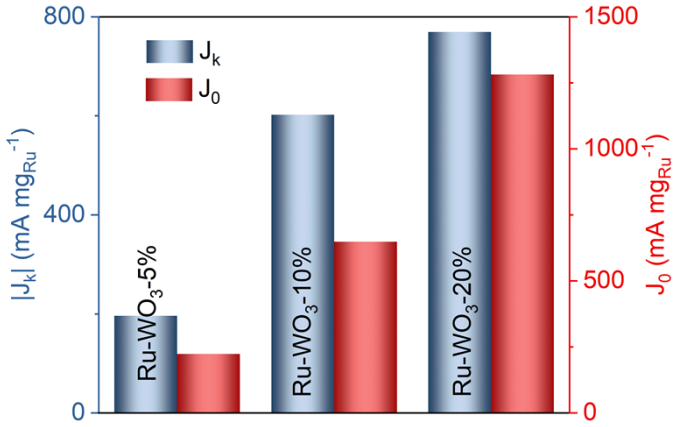

Figure S4. The kinetic current density and exchange current density normalized to the mass loading of Ru.

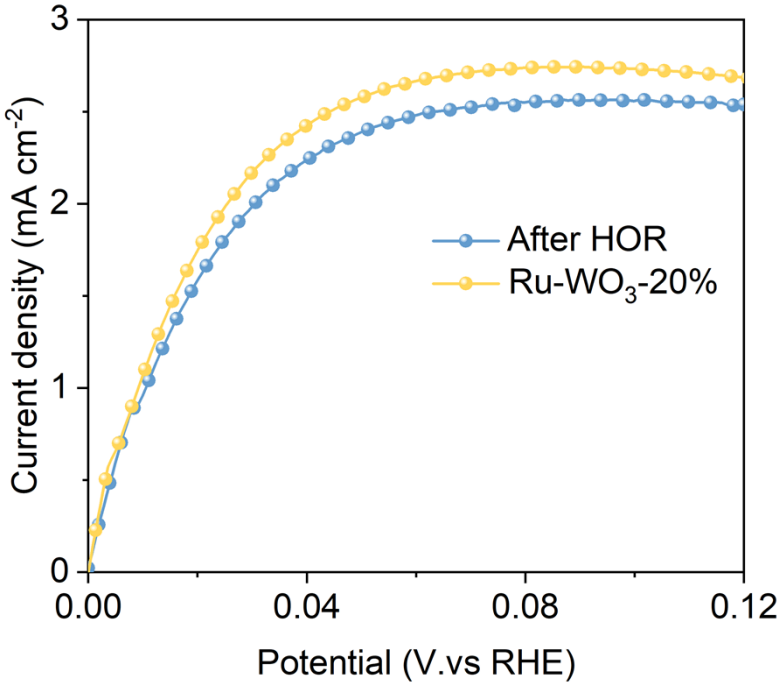

Figure S5. Polarization curves for Ru-WO_3-20% before and after durability test at 0.1 V vs. RHE.

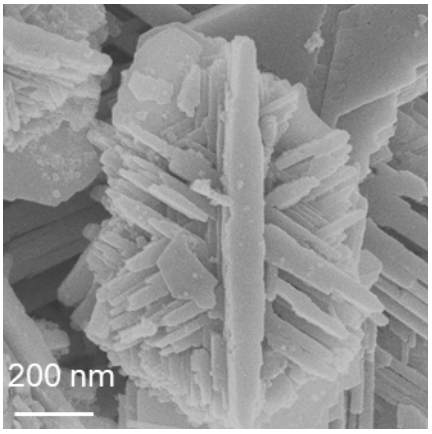

Figure S6. SEM image of Ru-WO_3-20% after chronoamperometry test

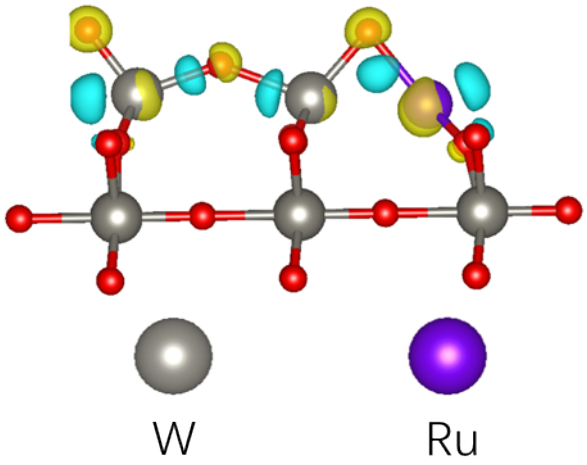

Figure S7. The electron density difference in Ru doped WO_3.

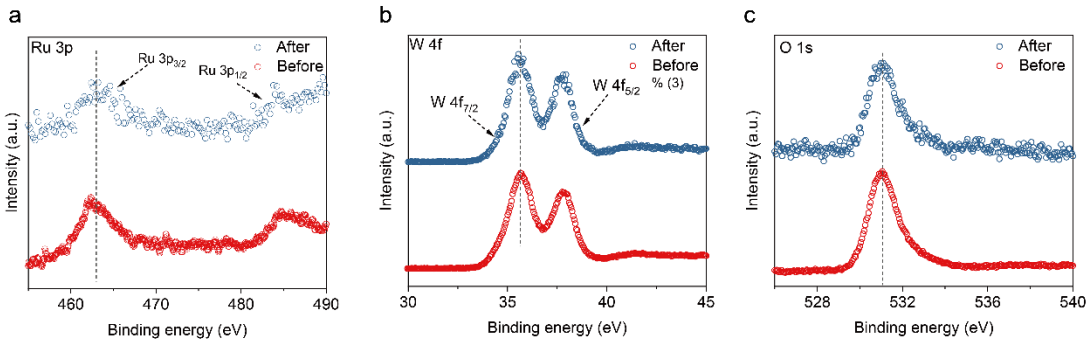

Figure S8. XPS spectra of Ru-WO_3-20% after chronoamperometry test. a) Ru 3p XPS spectra. b) W 4f XPS spectra. c) O 1s XPS spectra.

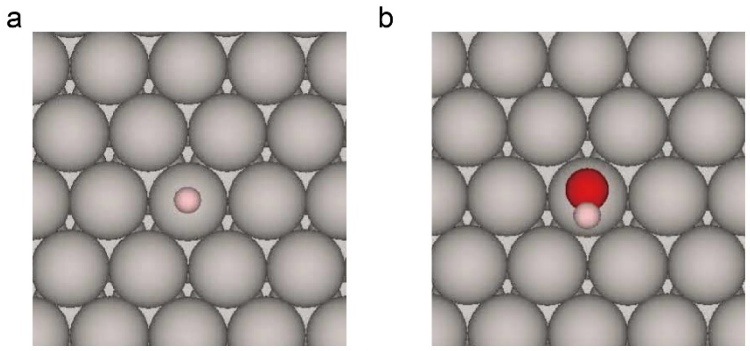

Figure S9. a) H* adsorption model on Pt (111) plane. b) OH* adsorption model on Pt (111) plane.

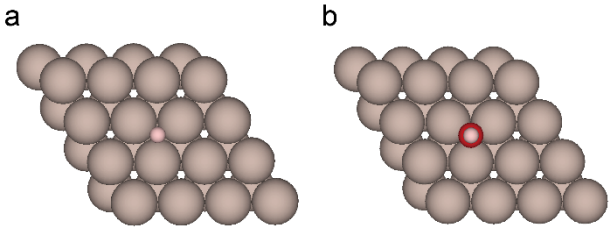

Figure S10. a) H* adsorption model on Ru (0001) plane. b) OH* adsorption model on Ru (0001) plane.

Table S1. EDS results for Ru-WO_3.

sample	W (at%)	Ru (at%)	Total
Ru-WO_3-5%	97.36%	2.74%	100%
Ru-WO_3-10%	94.76%	5.24%	100%
Ru-WO_3-20%	90.61%	9.39%	100%
Ru-WO_3-30%	89.24%	10.76%	100%

Table S2. Comparison of exchange current density (j_0) between this work and reported Ru-based HOR catalysts

Catalyst	**j_0 (mA cm^{-2})**	**Electrolyte**	**Ref**
Ru-WO_3	12.81	0.1 M KOH	This work
Ru Colloidosomes	2.86	0.1 M KOH	[1]
Ru_c/NHCS	1.74	0.1 M KOH	[2]
Ru-Cr_1(OH)-1.1	5.8	0.1 M KOH	[3]
O-RuNi@C-400	1.56	0.1 M KOH	[4]
HEA NSWs	6.42	0.1 M KOH	[5]
Ru/Ni-NiO@C	4.44	0.1 M KOH	[6]
Ru/Meso C	9.23	0.1 M KOH	[7]
Pt-Ru	2.98	0.1 M KOH	[8]
Ru modified Pt	5.52	0.1 M KOH	[9]
RuO_2-Pt/C	4.77	0.1 M KOH	[10]

Ru_7Ni_3/C	1.8	0.1 M KOH	[11]
Ru-Ni diatomic sites	2.69	0.1 M KOH	[12]
RuP@NOC	2.64	0.1 M KOH	[13]
Ru@Pt_{2MLE}	1.78	0.1 M KOH	[14]
RuRh-Co	1.91	0.1 M KOH	[15]

Table S3. Values of ΔG_{H^*}, E_{H^*}-E*, ΔEZPE and TΔS for H* adsorption.

Catalysts	ΔG_{H^*} (eV)	E_{H^*}-E* (eV)	ΔEZPE (eV)	TΔS (eV)
Ru-WO_3	-0.015	-0.297	0.077	-0.205
Pt (111)	-0.110	-0.342	0.047	-0.205
Ru (0001)	-0.296	-0.523	0.022	-0.205

Table S4. Values of ΔG_{H^*}, E_{H^*}-E*, ΔEZPE and TΔS for H* adsorption.

Catalysts	ΔG_{OH^*} (eV)	E_{OH^*}-E* (eV)	ΔEZPE (eV)	TΔS (eV)
Ru-WO_3	-0.582	-1.03	-0.020	-0.470
Pt (111)	1.450	1.038	-0.058	-0.470
Ru (0001)	0.230	-0.181	-0.058	-0.470

Reference

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