Supplementary Information

Bimetallic Doped RuO_2 with Manganese and Iron as Electrocatalyst for Favorable Oxygen Evolution Reaction Performance

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Experimental Section

Electrochemical Surface Areas (ECSAs)

The employed CV measurement helps evaluating electrochemical surface areas (ECSAs) of prepared catalysts by extracting double layer capacitance C_d. The calculation method of ECSA and C_d can be described as the equation: ECSA = C_d / C_s. A potential range of 0.25–0.45 V was selected with no faradic response when subjected under scan rates of 25 mV/s, 50 mV/s, 75 mV/s and 100 mV/s. C_s, the specific capacitance of electrode, was considered as 0.035 mF cm^{-2} based on previously reported value.[1]

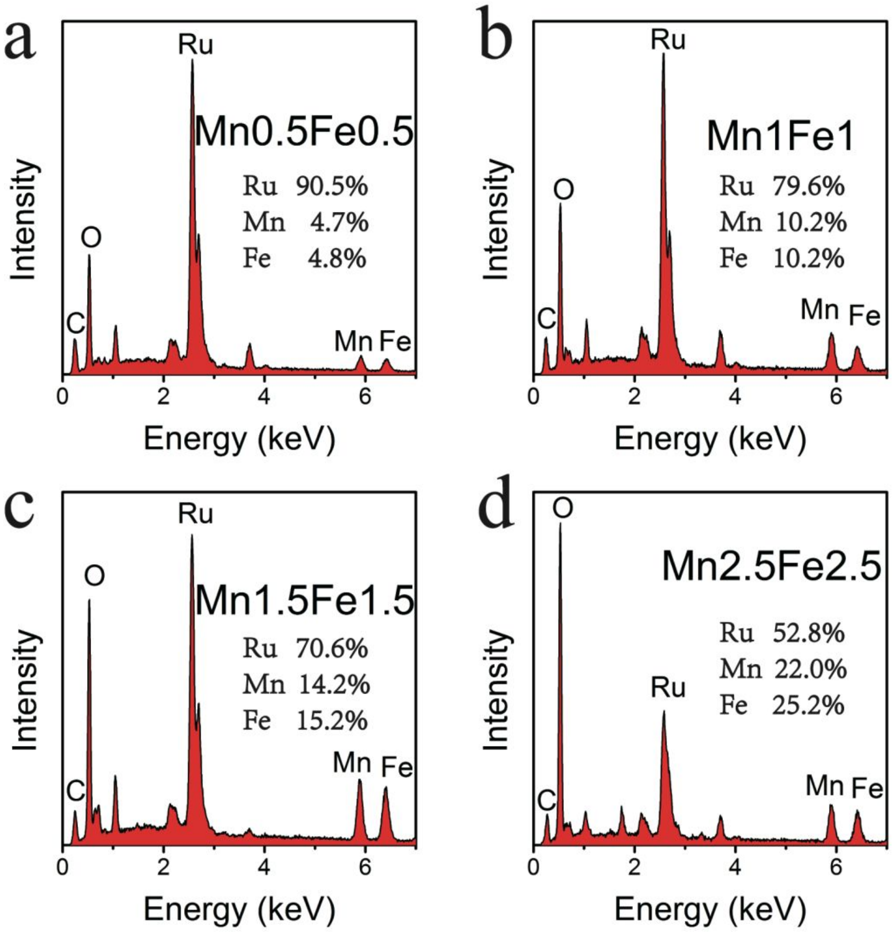

Figure S1 EDS spectra of (a) MnFeRu-90, (b) MnFeRu-80, (c) MnFeRu-70, (d) MnFeRu-50. Atomic percent of all elements tested by ICP are shown in the specific spectra.

Table S1 The electrochemical performance comparison of MnFeRu-90 against other Ru oxide-based catalysts.

Catalysts	Tafel slope / $mV*dec^{-1}$	Electrolyte	Reference
MnFeRu-90	41	0.1 M $HClO_4$	This work
RuO_2	64	0.1 M $HClO_4$	This work
$RuO_2(110)$	59	0.5 M H_2SO_4	Mechanism and Tafel Lines of Electro-Oxidation of Water to Oxygen on $RuO_2(110)$[2]
RuO_2 after laser treatment	50	0.5 M H_2SO_4	Surface modification of RuO_2 electrodes by laser irradiation and ion implantation: Evidence of electrocatalytic effects[3]
$RuO_2@IrO_2$	60	0.5 M H_2SO_4	Reaction mechanism for oxygen evolution on RuO_2, IrO_2, and $RuO_2@IrO_2$ core-shell nanocatalysts[4]
$RuO_2(100)$	60	0.1 M KOH	Orientation-Dependent Oxygen Evolution Activities of Rutile IrO_2 and RuO_2[5]
RuO_2/Co_3O_4	69	1 M KOH	MOF-derived RuO_2/Co_3O_4 heterojunctions as highly efficient bifunctional electrocatalysts for HER and OER in alkaline solutions[6]

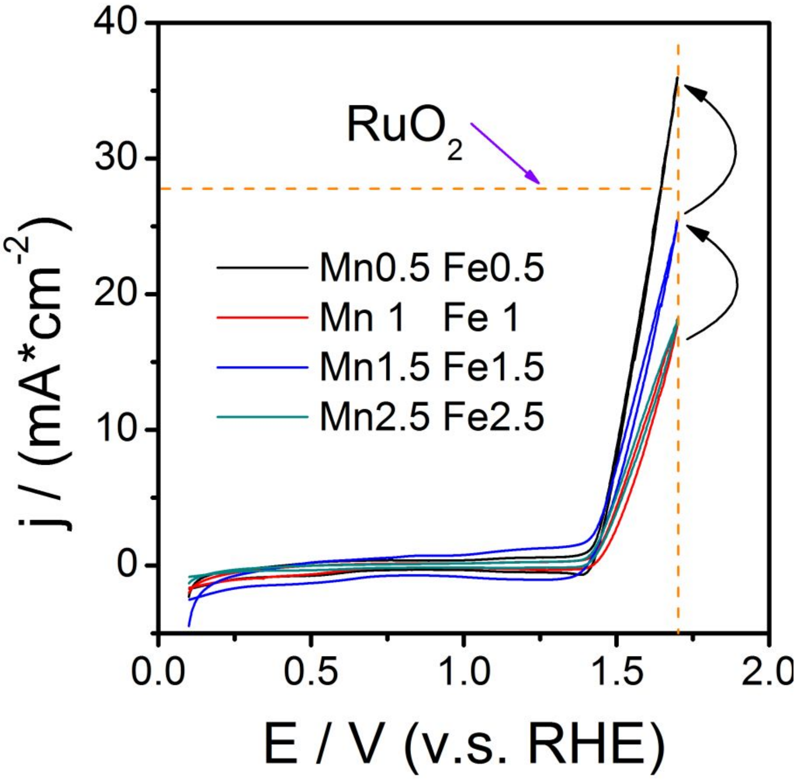

Figure S2 iR-uncorrected linear sweep voltammetery curves for the OER process of all codoped composites relative to RuO_2 in the acidic solution (0.1 M $HClO_4$).

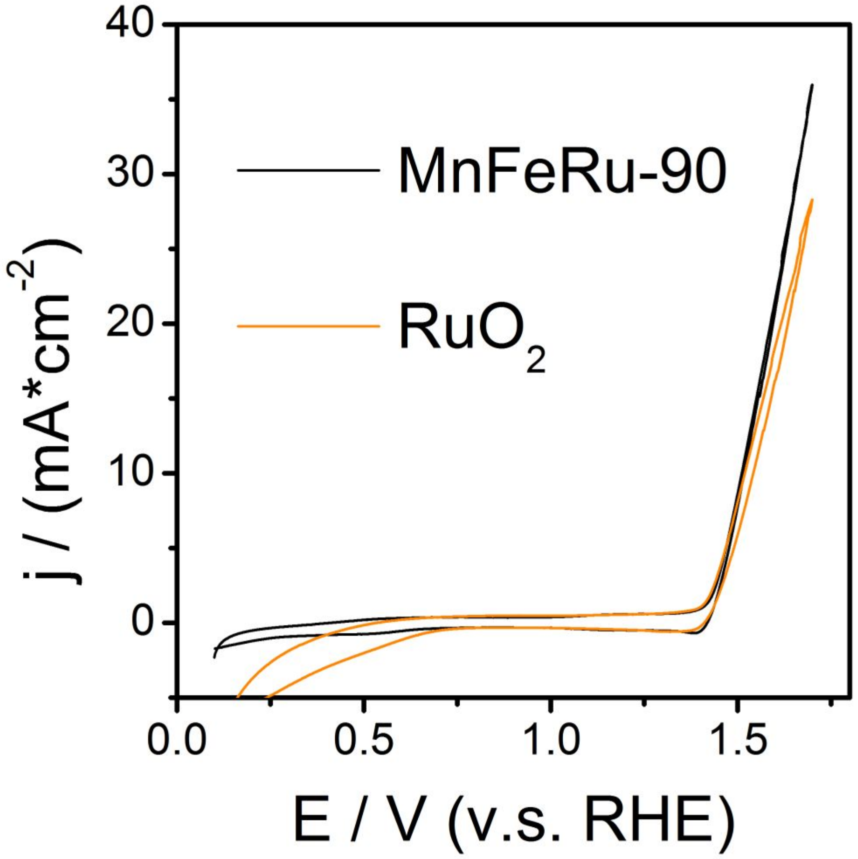

Figure S3 The polarization curves for the OER process of MnFeRu-90 relative to RuO_2 in the acidic solution (0.1 M $HClO_4$).

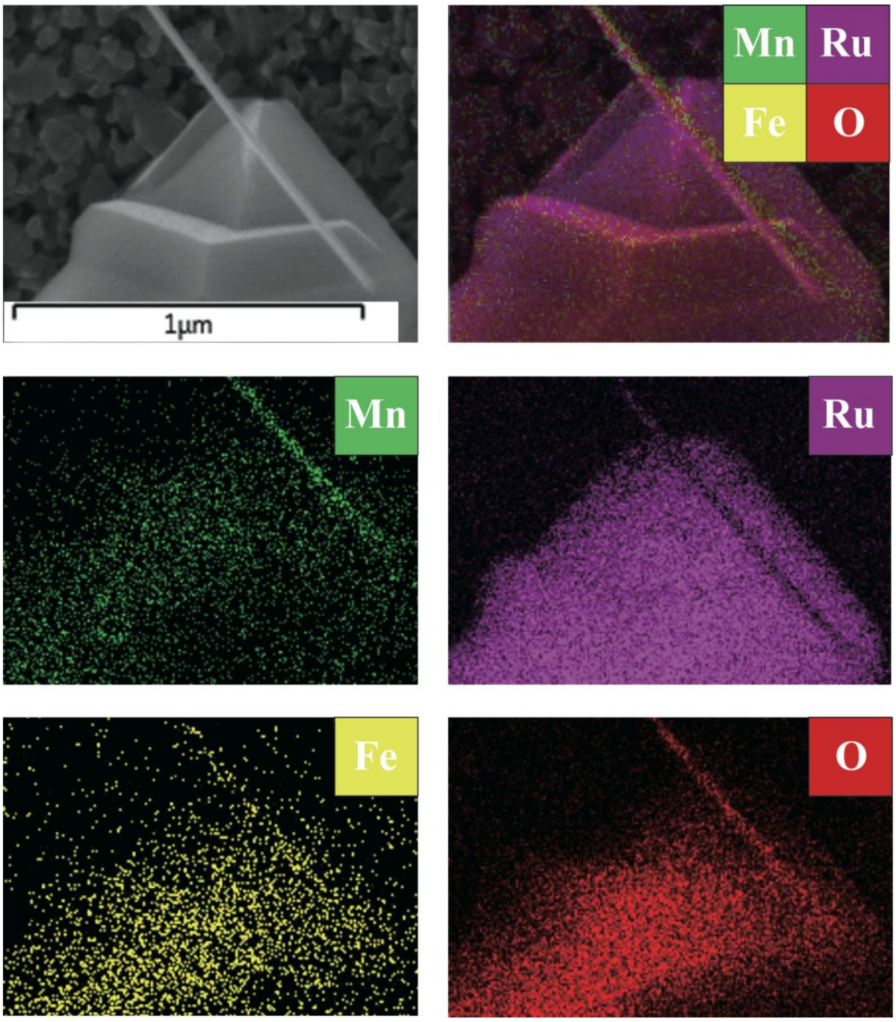

Figure S4 FESEM and EDX element mappings for MnFeRu-50. The needle shown in the spectra is mixture of manganese and iron oxides.

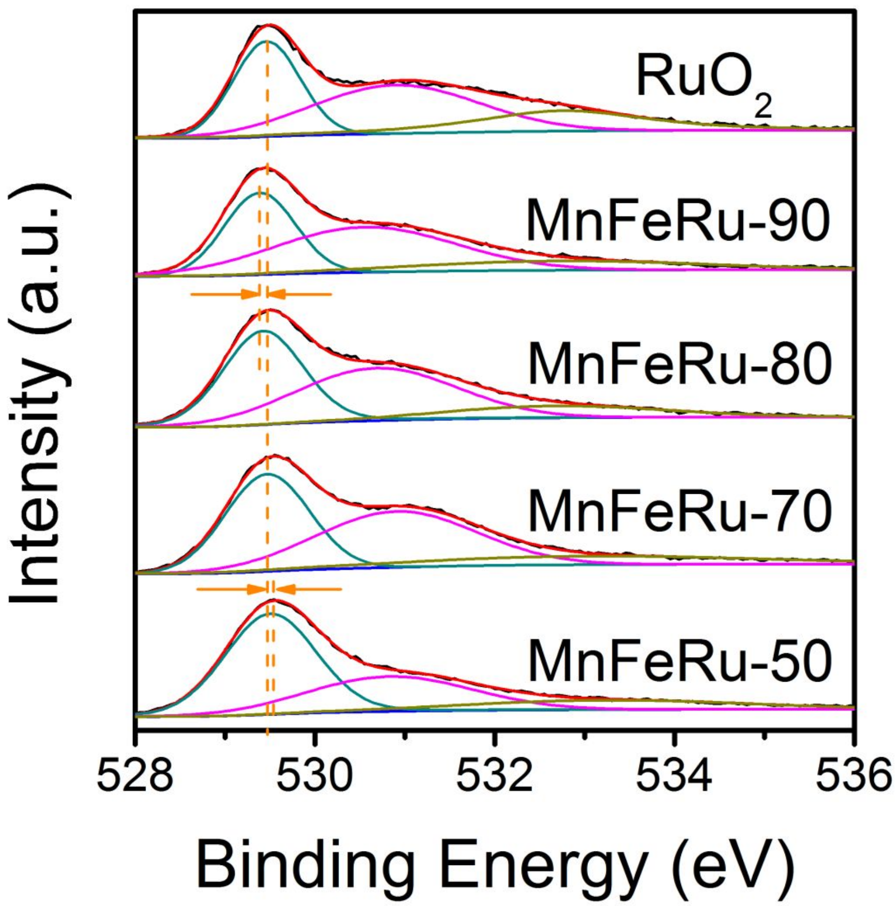

Figure S5 XPS spectra of O-1s in MnFeRu series with decreasing ruthenium up to 50% mol fraction.

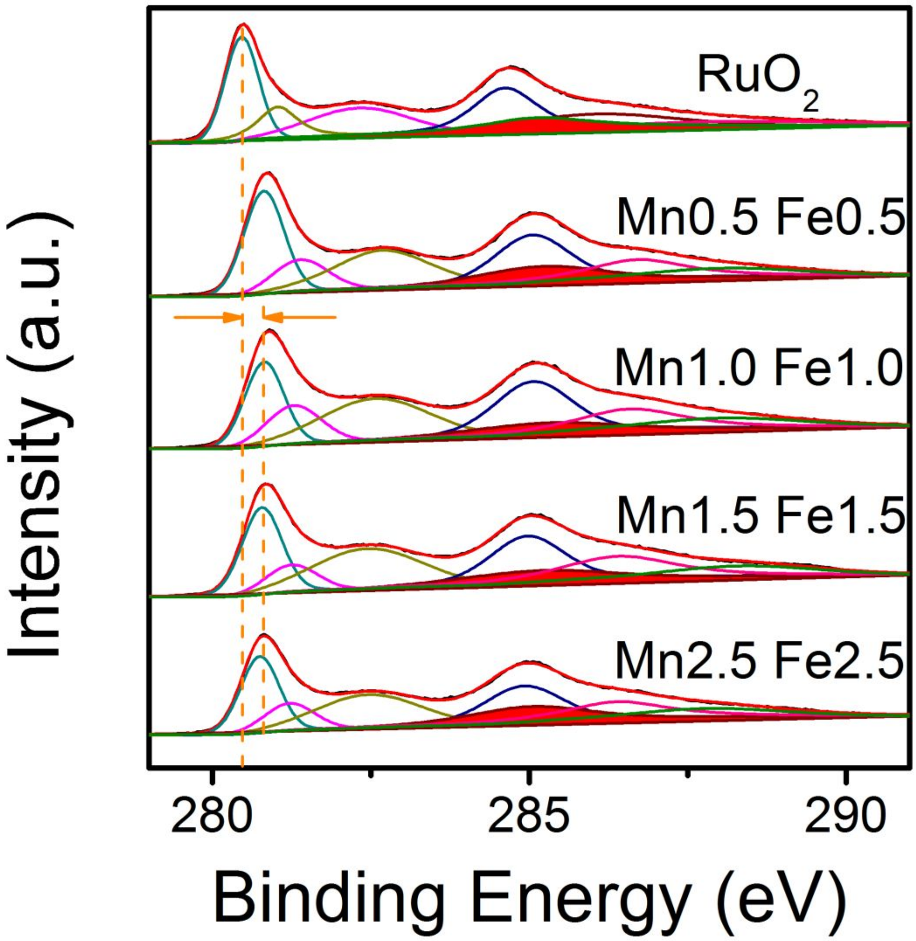

Figure S6 XPS spectra of Ru-3d in NiCoRu series with decreasing ruthenium up to 50% mol fraction. The red peaks correspond to C-1s for calibration.

References

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(3) Guerrini, E.; Colombo, A.; Trasatti, S. Surface modification of RuO2 electrodes by laser irradiation and ion implantation: Evidence of electrocatalytic effects. *Journal of Chemical Sciences* **2009,** *121* (5), 639, DOI: 10.1007/s12039-009-0077-9.

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