Supporting Information

Ruthenium Nanoparticles Anchored on Graphene Hollow Nanospheres Superior to Platinum for the Hydrogen Evolution Reaction in Alkaline Media

Ji-Sen Li,[†,] Meng-Jie Huang,[†] Ling-Xin Kong,[†] Xiao-Nan Chen,[†] Yu-Wei Zhou,[†] Jun-Lei Li,[†] and Ming-Yu Wang[†]*

[†]Key Laboratory of Inorganic Chemistry in Universities of Shandong, Department of Chemistry and Chemical Engineering, Jining University, Shandong 273155, China

E-mail: senjili@sina.com

S1. Figures in Supporting Information

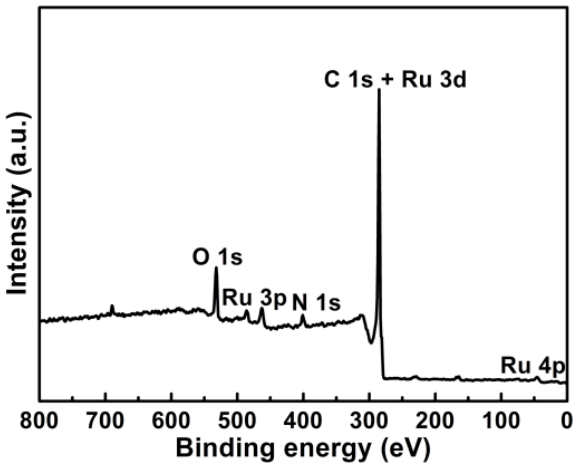

Figure S1. XPS survey full scan of Ru/GHSs.

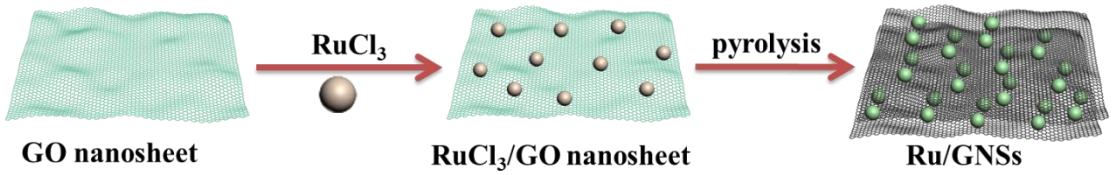

Figure S2. Schematic illustration of the fabrication of Ru/GNSs.

For comparision, the Ru/GNSs were also prepared under the identical conditions without adding the SiO_2 nanospheres, described in **Figure S2**. In brief, Ru^{3+} ions can be adsorbed on the surface of GO nanosheets owing to the electrostatic attraction forces, to form the $RuCl_3$/GO nanosheets. Subsequently, the resultant $RuCl_3$/GO hybrid is transformed into Ru/rGO nanosheets (termed Ru/GNSs) after pyrolysis in Ar.

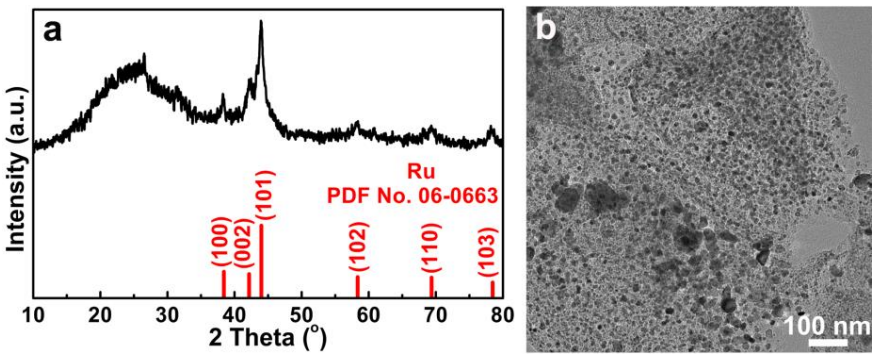

Figure S3. (a) PXRD and (b) TEM image of Ru/GNSs.

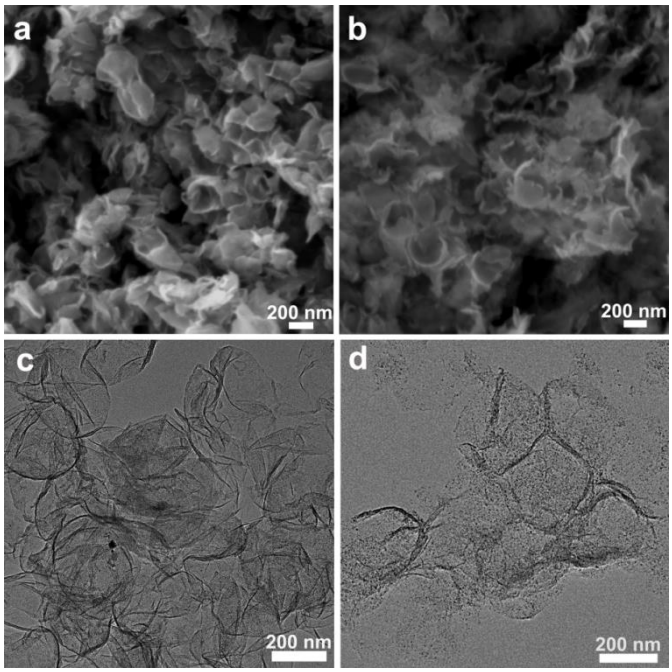

Figure S4. SEM and TEM images of the obtained catalysts annealed at 700 (a, c) and 900 °C (b, d).

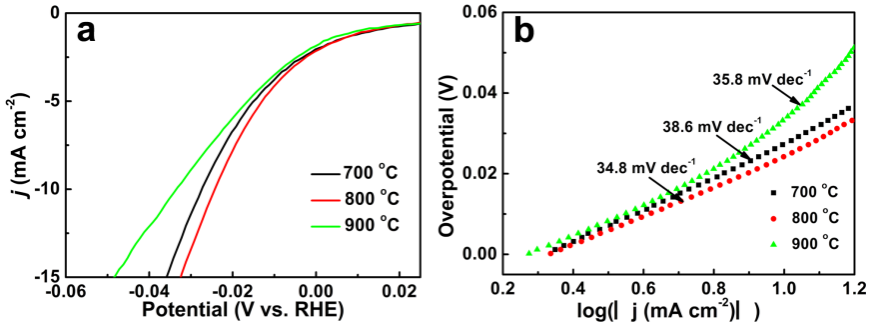

Figure S5. (a) Polarization curves and (b) Tafel plots of Ru/GHSs at different carbonization temperature.

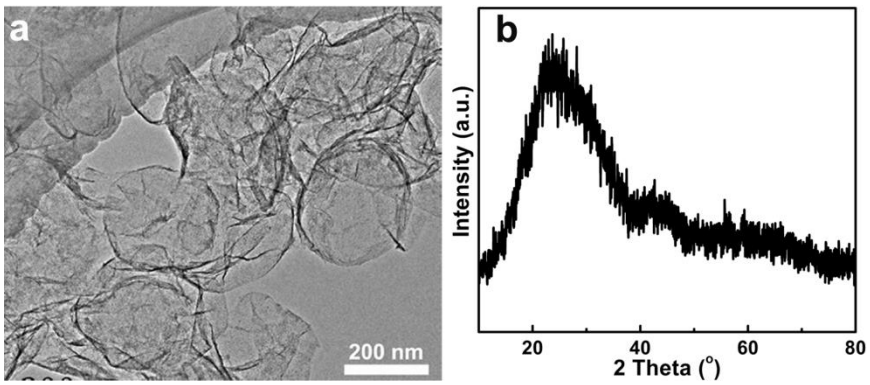

Figure S6. TEM (a) and PXRD pattern (b) of Ru/GHSs after the durability test.

S2. Table in Supporting Information

Table S1. Comparison of electrocatalytic performance of with other HER elecrocatalysts

Catalysts	Tafel slope [mV dec^{-1}]	η_{10} (mV)	Reference
Ru/GHSs	**34.8**	**24.4**	**This work**
Co_1/PCN	52	89	*Nat. Catal.*, 2019, **2**, 134.
IrP_2@NC	50	28	*Energy Environ. Sci.*, 2019, **12**, 952.
Ru-MoS_2/CC	114	41	*Appl.Catal. B: Environ.*, 2019, **249**, 91.
Ru/C-H_2O/ CH_3CH_2OH	47	53	*Appl.Catal. B: Environ.*, 2019, **258**, 117952.
N-Co_2P/CC	51	34	*ACS Catal.* 2019, **9**, 3744.
Ru-NGC	40	65	*Chem. Commun.*, 2019, **55**, 965.
Mo_2C@NC@Pt	57	47	*ACS Appl. Mater. Interfaces*, 2019, **11**, 4047.
Ru@GnP	28	22	*Adv. Mater.*, 2018, **30**, 1803676.
Ru@CQDs	47	20	*Adv. Mater.*, 2018, **30**, 1800676.
RuCoP	37	23	*Energy Environ. Sci.*, 2018, **11**, 1819.
Mo_2N–Mo_2C/HGr	152	154	*Adv. Mater.*, 2018, **30**, 1704156.
MoP/CNTs-700	73	86	*Adv. Funct. Mater.*, 2018, **28**, 1706523.
V-doped CoP	67.6	71	*Chem. Sci.*, 2018, **9**, 1970.
Ni_2P@NPCNFs/CC	80	104	*Angew. Chem. Int. Ed.*, 2018, **130**, 1981.
Ru@C_2N	38	17	*Nat. Nanotechnol.*, 2017, **12**, 441.
Ru powder	79	84	*J. Mater. Chem. A*, 2017, **5**, 5475.