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Supporting Information

Nickel enhanced catalytic activities of amorphous copper for oxygen evolution reaction

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Experimental details

1. Materials

Copper sulfate ($CuSO_4$•$5H_2O$ 99 %), Nickel sulfate ($NiSO_4$•$6H_2O$ 98.5 %), Sodium carbonate (Na_2CO_3), Sodium hydroxide (NaOH 98 %), ethyl alcohol were purchased from Chengdu Kelong Chemical Reagent Company and used without further purification. ITO coated glass slides were purchased from Shenzhen Huananxiangcheng Technology Company. All solutions were prepared with ultrapure water.

2. Electrodepotion of CuO_x, NiO_x, and $NiCuO_x$ films

All electrochemical experiments were performed on a CHI660E electrochemical station with a three electrode system at room temperature. A saturated Ag/AgCl electrode and Pt plate were selected as the reference electrode and auxiliary electrode, respectively. Prior to the electrodeposition, ITO electrodes were cleaned by sonication in sodium hydroxide, ethyl alcohol and ultrapure water for 10 min successively, and dried at 60 °C oven for 30 min. Electrodeposition was carried out by potentionstatic method at 1.1 V vs. Ag/AgCl for 40 min in an aqueous mixture of $CuSO_4$, $NiSO_4$ and 1 M Na_2CO_3 (pH = 11.8). For comparison, the concentration of $CuSO_4$ was fixed at 3 mM, and the concentration of $NiSO_4$ varied from 0 to 24 mM. Single CuO_x and NiO_x films were prepared by the same methods in a carbonate electrolyte containing 3 mM $CuSO_4$ or 3 mM $NiSO_4$, respectively. The as-prepared catalysts were then rinsed with deionized water and dried under room temperature.

3. Materials characterizations

The crystalline structures of as-prepared samples on ITO were investigated by powder X-ray diffraction (PANalytical B.V.) using Cu-Kα as radiation source. The morphology and elemental compositions were analyzed using ZEISS EV0 MA15 scanning electron microscope (SEM) coupled with energy-dispersive X-ray spectroscopy (EDS, CARL ZEISS). The surface chemical state of materials was studied using an X-ray photoelectron spectrometer (ESCALAB 250, ThermoFisher Scientific USA).

4. Electrochemical OER activity test

All OER activity tests were performed in 1 M Na_2CO_3 electrolyte (pH=11.8) at room temperature, using the same equipment and electrode as the electrodeposition. The OER activities of the as-deposited samples were measured by linear sweep voltammetry (LSV) from - 0.2 to 1.1 V vs. Ag/AgCl at a scan rate of 20 mV s^{-1}. The long-term stability was tested galvanostatically (5 mA cm^{-2}) for 10 h.

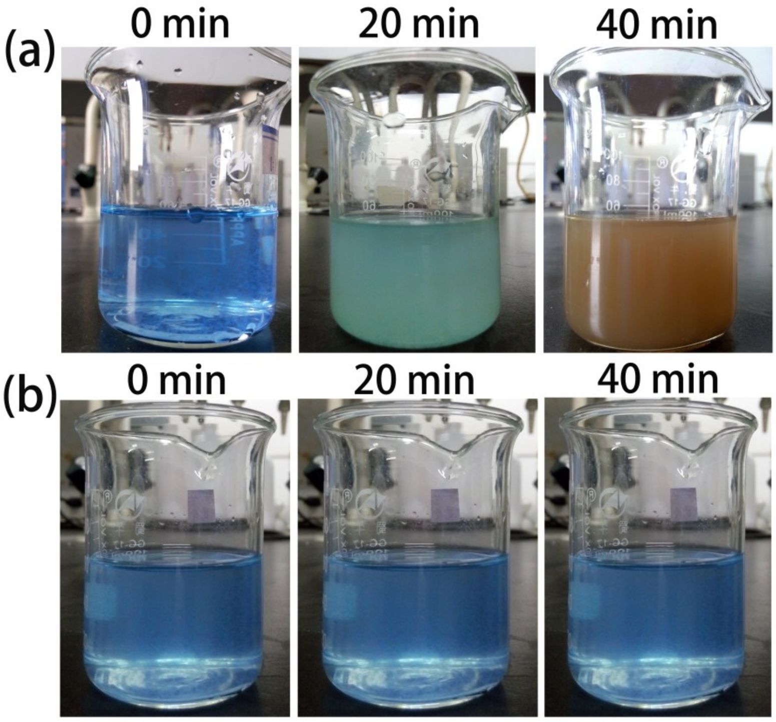

Fig. S1. The change of the deposition electrolyte for CuO_x (a) and $NiCuO_x$ (b) films during the deposition process.

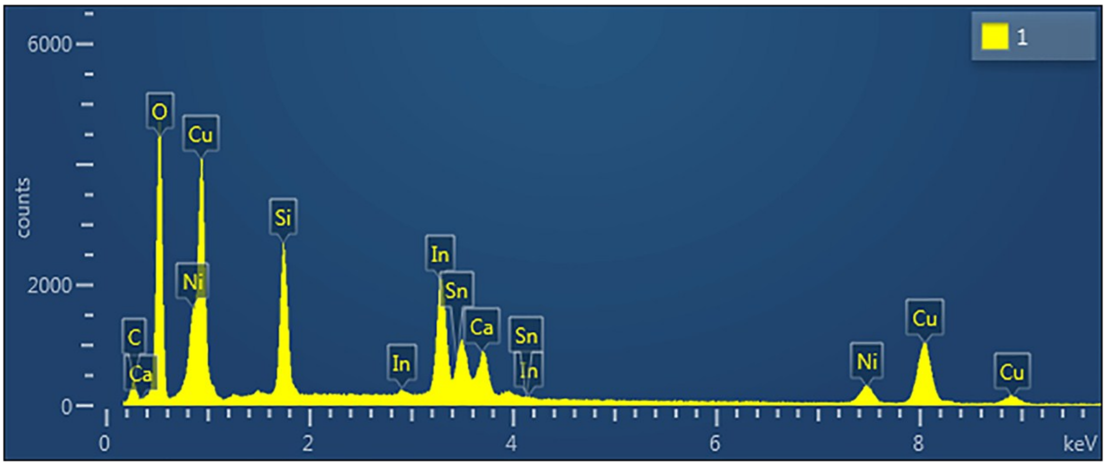

Fig. S2. The energy dispersive spectra of NiCuO$_x$ sample with the precursor ratio of Cu/Ni = 4:1.

Table S1. EDS results of NiCuO$_x$ sample with the precursor ratio of Cu/Ni = 4:1.

Element	Wt%	Atomic %
C	**6.14**	**13.36**
O	**38.69**	**63.20**
Ni	**4.71**	**2.10**
Cu	**21.56**	**8.87**