Supporting Information

Nickel enhanced catalytic activities of amorphous copper for oxygen evolution reaction

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Experimental details

1. Materials

Copper sulfate (CuSO₄•5H₂O 99 %), Nickel sulfate (NiSO₄•6H₂O 98.5 %), Sodium carbonate (Na₂CO₃), 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. Electrodeposition of CuOₓ, NiOₓ, and NiCuOₓ 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 CuSO₄, NiSO₄ and 1 M Na₂CO₃ (pH = 11.8). For comparison, the concentration of CuSO₄ was fixed at 3 mM, and the concentration of NiSO₄ varied from 0 to 24 mM. Single CuOₓ and NiOₓ films were prepared by the same methods in a carbonate electrolyte containing 3 mM CuSO₄ or 3 mM NiSO₄, 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 Na₂CO₃ 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 NiCuOₓ sample with the precursor ratio of Cu/Ni = 4:1.

**Table S1.** EDS results of NiCuOₓ sample with the precursor ratio of Cu/Ni = 4:1.

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<thead>
<tr>
<th>Element</th>
<th>Wt%</th>
<th>Atomic %</th>
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<tbody>
<tr>
<td>C</td>
<td>6.14</td>
<td>13.36</td>
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<tr>
<td>O</td>
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<td>Ni</td>
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<td>2.10</td>
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<tr>
<td>Cu</td>
<td>21.56</td>
<td>8.87</td>
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