Electronic Supplementary Information (ESI) Porous Nickel Oxide Nanospindle Structures with Huge Specific Capacitance and Long-life Cycle

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1 Synthesis of Wang's NiO nanostructures

The Ni₃(btc)₂·12H₂O crystal was synthesized through a simple hydrothermal process. Firstly, a mixture of 0.25 g Ni(CH₃COO)₂·4H₂O, 0.20 g NH₄COOH (Shanghai Chemical Co. Ltd. , P. R. China), 0.15 g 1,3,5-benzenrtricarboxylic acid (H₃BTC, Alfa Aesar) and 20 mL H₂O was placed in a 30 mL Telflonlined stainless steel autoclave and heated at 200 °C for 24 h, followed by cooling to room temperature naturally. Then the precipitate was filtrated, washed with distilled water and dried at 45 °C. Finally, the precursor was heated in the solid state at 200 °C for 24 h with a temperature-increase rate of 3 °C min⁻¹ from room temperature, and the resulted black powder was the synthesized nickel oxide.

2 Electrode preparation

The working electrodes were prepared as follows. The electrode of NiO nanomaterials was prepared according to the following steps. The mixture containing 80 wt.% NiO, 15 wt.% acetylene black and 5 wt.% polytetrafluoroethylene (PTFE) was well mixed, and then was pressed onto nickel grid $(1.2 \times 10^7 \text{ Pa})$ that serves as a current collector (surface is 1 cm²). The typical mass load of electrode material is 5 mg. The four working electrodes were also named as P1, P2, P3 and M, which would be often used later.

3 Characterization

The morphology of the as-prepared samples was observed by a Hitachi S-4800 field-emission scanning electron microscope (FE-SEM) at an acceleration voltage of 10.0 kV. The phase analyses of the samples were performed by X-ray diffraction (XRD) on a SHIMADZU, XRD-6000 with Cu K_a radiation ($\lambda = 1.5418$ Å). Transmission electron microscopy (TEM) images and HRTEM image were captured on the JEM-2100 instrument microscopy at an acceleration voltage of 200 kV.

The electrochemical measurements were carried out by an electrochemical analyzer system, CHI660D (Chenhua, Shanghai, China) in a three-compartment cell with a platinum plate counter electrode, a saturated calomel electrode (SCE) reference electrode and a working electrode. The electrolyte was a 3 wt. % KOH aqueous solution.

4 Calculations

1. Specific capacitances derived from cyclic votalmmetry (CV) tests can be calculated from the

equation:
$$C = \frac{1}{m\upsilon(U_2 - U_1)} \int_{U_1}^{U_2} I(U) dU$$
(1)

where C (F/g), m (g), υ (V/s), U₁ and U₂, and I (A) are the specific capacitance, the mass of the active materials in the electrode, potential scan rate, low and high potential limit of the CV tests, and the instant current on CV curves, respectively.

2. Specific capacitances derived from galvanostatic (GV) tests can be calculated from the equation:

$$C = (I \Delta t)/(m \Delta U)$$

where C (F/g), I (A), Δt (s), m (g) and ΔU are the specific capacitance, the discharge current, the discharge time, the mass of the active materials in electrode, and the potential window, respectively.

(2)

3. Specific energy (E) and specific power (P) derived from GV tests can be calculated from the following equations:

$$E = 0.5 C (\Delta U)^{2}$$
(3)
$$P = E/\Delta t$$
(4)

where E (Wh/kg), C (F/g), ΔU (V), P (W/kg) and Δt (s) are the specific energy, specific capacitance, potential window, specific power and discharge time, respectively.



ESI Fig. 1 (a) SEM image of the precursor; (b) XRD pattern of the precursor.



ESI Fig. 2 SEM images of NiO electrode materials after 3000 cycles, a-P1, b-P2, c-P3, d-M



ESI Fig. 3 electrochemical impedance spectra (EIS) for the as-prepared materials electrode at room temperature, in inset of it-an equivalent circuit.