Supporting information

Special layer structure WS₂ nanoflakes as high performances sodium ion storage materials

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Materials characterization: X-ray diffraction (XRD) data were recorded using a Rigaku D/MAX 2400 diffractometer (Japan) with Cu K α radiation ($\lambda = 1.5418$ Å) operated at 40 kV with the current of 60 mA to verify the crystalline structure of the obtained materials. The microstructure was depicted through transmission electron microscopy (TEM; JEOL, JEM-2010, Japan). The field-emission scanning electron microscopy (SEM; JEOL, JSM-6701F, Japan) was utilized to study the morphology and energy disperse spectroscopy (EDS). The elemental surface composition was analyzed through X-ray photoelectron spectroscopy (XPS, PHI 5700, ESCA).

Electrochemical characterization: To prepare the working electrodes, WS_2 (the active material), acetylene black (the conductive agent), polyvinylidene fluoride (the binder) were mixed in a weight ratio of 8:1:1 firstly, and then N-methyl-2-pyrrolidinone solvent (Aldrich, 99%) was added. After homogeneously mixing, the slurry was coated onto a copper foil by a coater, which was used as the current collector, and then dried under vacuum at 80 °C for 12 h. Finally, the working electrode was cut into wafers with diameters of 14 mm, and the mass loading of the active materials on one wafer was about 0.88-1.15 mg cm⁻². Coin-type LIR2032 half-cells were assembled in an argonfilled glovebox (water and oxygen content <1 ppm), using Na metal foils as counter electrodes, Whatman GF/D as separators, and 1M NaPF₆ in the mixture of ethylene carbonate (EC), dimethyl carbonate (DMC) and ethyl methyl carbonate (EMC) (in a volume ratio of 1:1:1) as electrolyte. The sodium ion hybrid button capacitors were assembled with the similar method of coin-type half-cells except the counter electrodes were no longer Na metal foils which were replaced with the active carbon (AC). Cyclic voltammetry (CV) data and electrochemical impedance spectroscopy (EIS) data were tested on an electrochemical workstation (CHI660d). The charge-discharge curve and cycle life was performed on a Land-CT2001A battery test system within the voltage range of 0.01-3.0 V (vs. Na⁺/Na). All the electrochemical tests were performed at room temperature.

The relevant specific capacitance of the assembled SIC was evaluated by using the following equation:

$$C_m = \frac{C}{m} = \frac{I\Delta t}{m\Delta V} \tag{S1}$$

The power density (P, W kg⁻¹) and energy density (E, Wh kg⁻¹) were calculated by the following equations:

$$E = \frac{1}{2} C V^2$$
(S2)
$$P = \frac{E}{\Delta t}$$
(S3)

Therein, *E* represents energy density, *P* represents power density, *C* represents the specific capacitance (F g⁻¹), *V* represents the working voltage window (V), Δt represents the discharge time (h).



Figure S1 XRD pattern of WO₃.



Figure S2 (a) AFM image, (b) height profile of WS_2 nanoflakes.



Figure S3 Nitrogen adsorption-desorption curve (a), pore size distribution (b).



Figure S4 Cycle performance of the SIB based on WS_2 at 0.5 A g⁻¹.



Figure S5 (a) Cycle performance, (b) rate performance of commercial WS_2 .



Figure S6 (a,b) SEM, (c,d) TEM of as-prepared WS₂ materials after 100 cycles.