SUPPORTING INFORMATION

NiS Nanobelts as Cathode Materials for Al-ion Batteries

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Experimental section

Synthesis.

In a typical preparing process, 2mmol of $Ni(CH_3COO)_2 \cdot 4H_2O$ and 1mmol $Na_2S_2O_3 \cdot 5H_2O$ were dissolved in a 40mL of deionized water under continuously stirring for 10 min. Then the green solution was transferred into a 50mL Teflon-lined autoclave with stainless steel shell for hydrothermal reaction at 200℃ for 24 h. After the reaction, the autoclave was allowed to cool to room temperature naturally. The black precipitate were collected and washed with distilled water and anhydrous ethanol by a centrifuge. Finally, the precipitate was dried under vacuum at 60℃.

Characterization

The structure and thermogravimetric analysis (TGA) of the as-prepared samples were characterized by X-ray diffraction (XRD, Rigaku, D/max-RB) and TGA-2050 thermogravimeter (TA Corp.), respectively. Transmission electron microscopy (TEM, JEOL, JEM-2010) and high-resolution transmission electron spectroscopy (HRTEM) experiments were performed to characterize the morphology and microstructure of the as-prepared material. Compositional analysis was determined by X-ray diffractmeter (XRD, Rigaku, D/max-RB).

Electrochemical characterization

Cell Fabrication Al/NiS batteries were assembled in pouch cell made from laminated aluminum film. For electrochemical studies, high-purity Al foil was fabricated as counter and reference electrode, respectively. The working electrode was prepared by mixing active material (as-prepared nano NiS), acetylene black and teflon (poly(tetrafluoroethylene), PTFE) binder at a weight ratio of 45:45:10. The mixture was dissolved in absolute ethyl alcohol to form uniform viscous slurry after stirring. Then the resultant slurry was coated uniformly on tantalum-foil current collector and dried at 60℃ for 24 h. The ionic liquid electrolyte was made by mixing 1-ethyl-3-methylimidazolium chloride ([EMIm]Cl, 97%, Acros Chemicals) and anhydrous aluminium chloride ($AlCl_3$, 99.999%, Sigma Aldrich) with 1:1.3 molar ratio in an argon-atmosphere glove box ($[O_2] < 0.1$ ppm, $[H_2O] < 0.1$ ppm). A glass fiber (GF/D)

from Whatman were placed between the anode and cathode.

Electrochemical measurements The pouch cell was assembled in the glove box and galvanostatically cycled at different current densities in the voltage range of 0.1–2.0V using NEWARE battery testing system. Cyclic voltammetry (CV) measurements were performed at a voltage range between 2.0 and 0.1 V by CHI 1140A electrochemical workstation. Electrochemical impedance spectroscopy (EIS, CHI 1140A) measurement was tested at open potential with an amplitude of 5 mV over the frequency range from 100 kHz to 0.1 Hz.

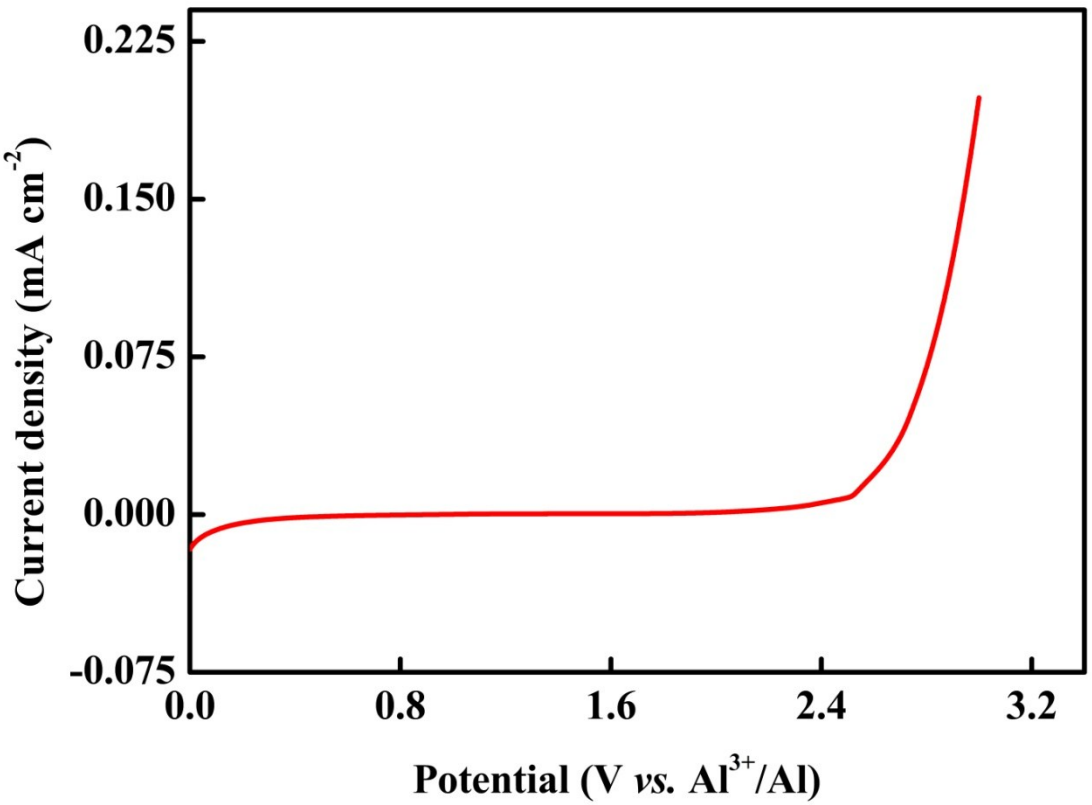

Figure S1 The polarization curve of tantalum current collector in the AlCl3/[EMIm]Cl ionic liquid electrolyte system.

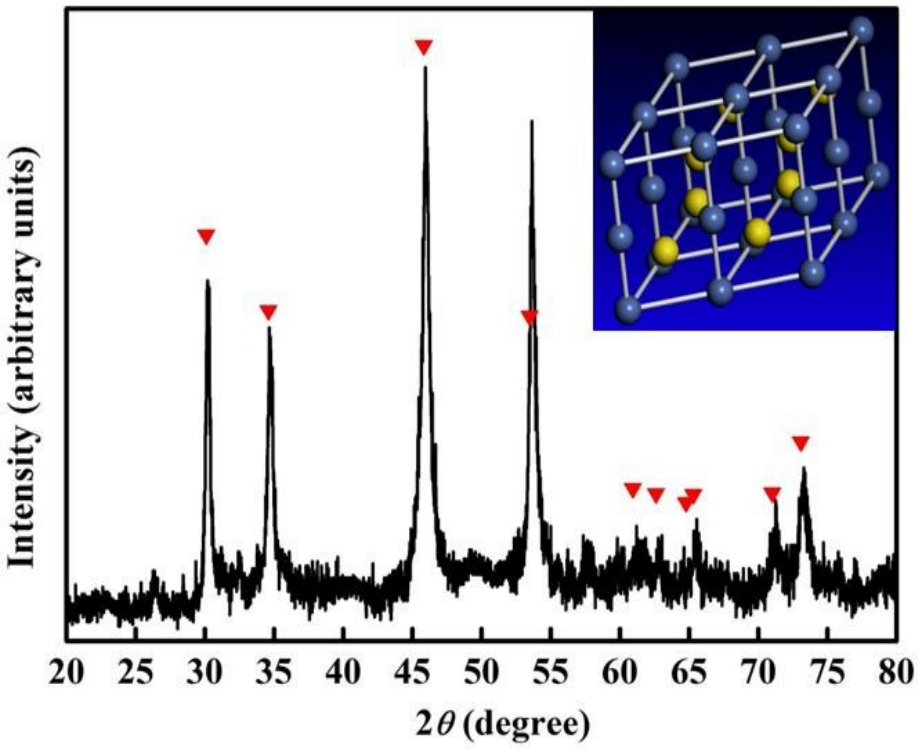

Fig. S2 XRD patterns and hexagonal unit-cell structure of NiS sample.

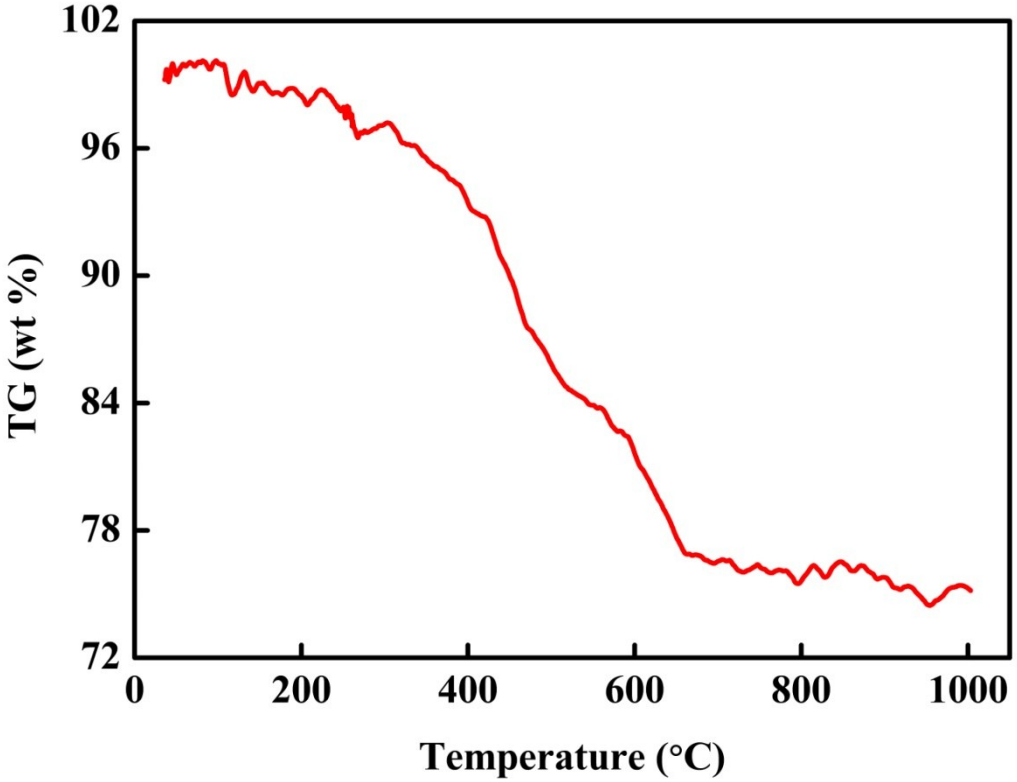

Fig S3 TGA diagram of the as-prepared NiS nanobelts.

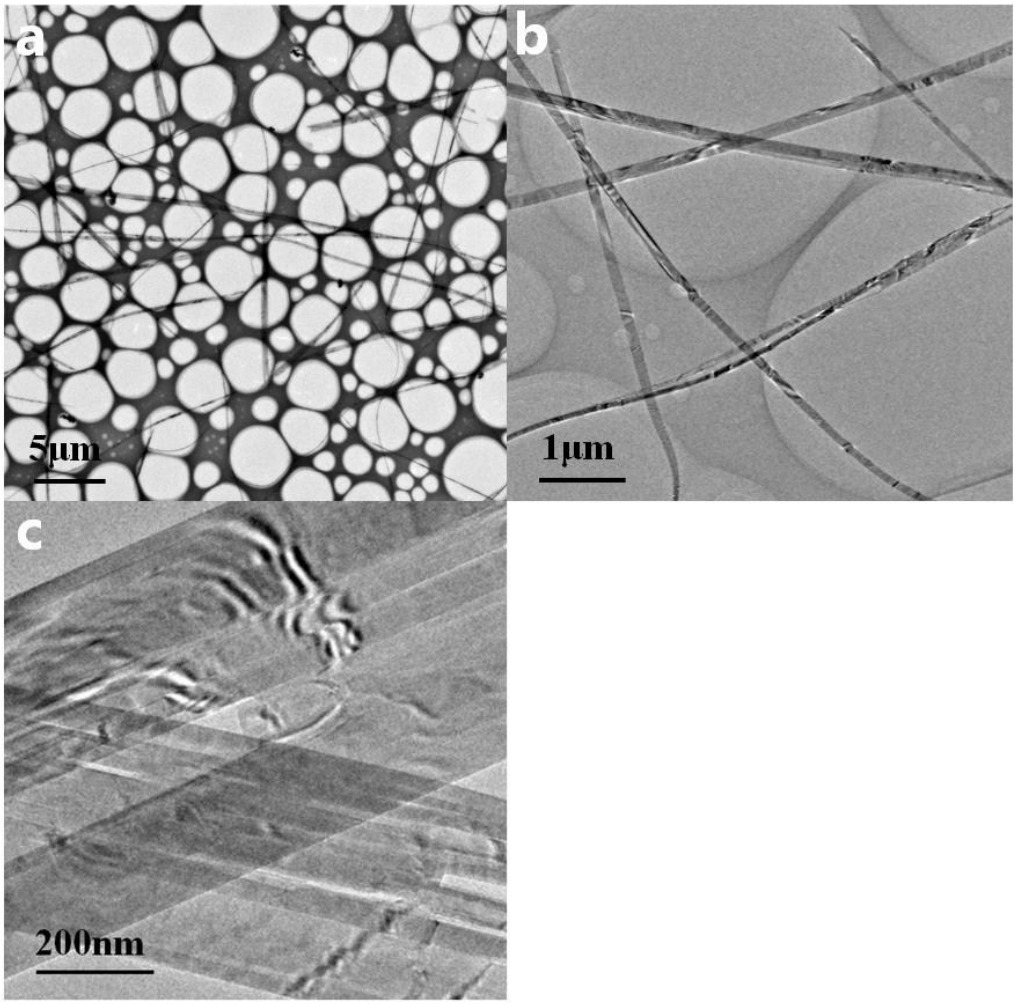

Fig S4 (a-c) TEM image of NiS nanobelts.

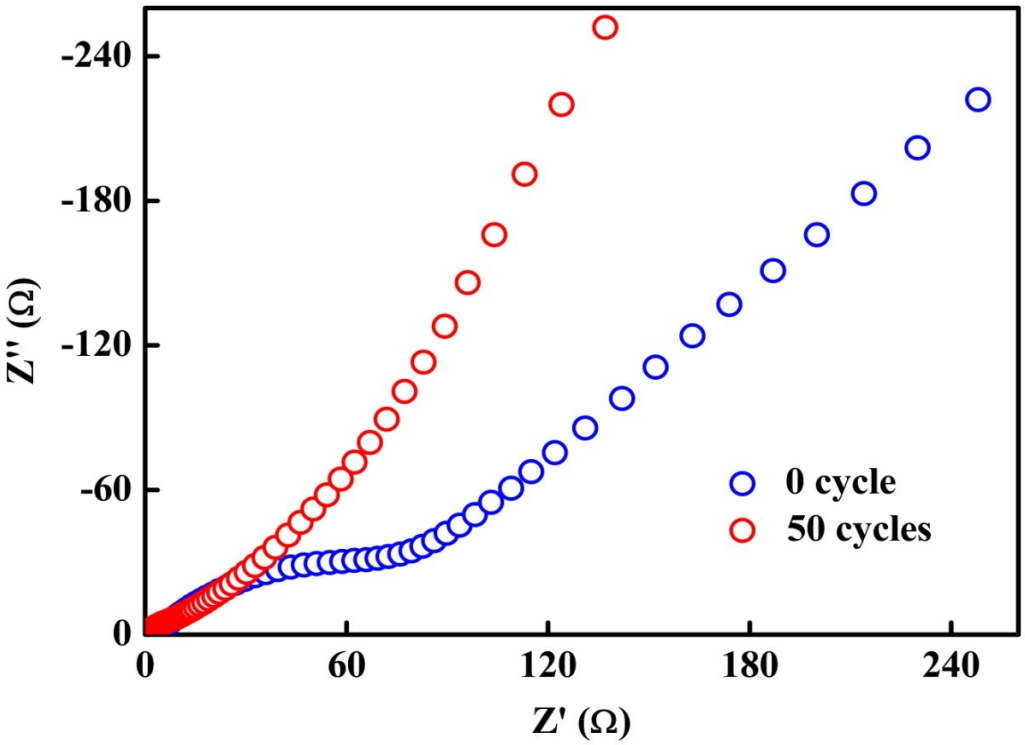

Fig. S5 AC impedance spectra of as-prepared NiS nanobelts for Al-ion batteries