Electronic Supplementary Information

High Energy Density Hybrid Supercapacitor Derived by A Novel Ni_3Se_2 Nanowires In-situ Constructed on the Porous Nickel Foam

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Evaluation of the Ni_3Se_2 NWs@NF electrode and Ni_3Se_2 NWs@NF//AC hybrid supercapacitor

The AC electrode was fabricated by mixing the AC, acetylene black and binder (PVDF) in a weight ratio of 8:1:1, which was then pressed at 10 MPa into a square piece of 1 cm^2, and finally dried under vacuum at 100 ºC for 24 h.

The Ni_3Se_2 NWs@NF electrode was cut into a square piece of 1 cm^2, directly tested as a working electrode without the binder and conductive agent in a three-electrode cell. The electrochemical tests of the three-electrode system were conducted in 2M KOH aqueous electrolyte at room temperature, where the Pt foil serves as the counter electrode and the Ag/AgCl electrode as the reference electrode.

The specific capacity of the electrode and hybrid device can be calculated according to the following formulas, respectively:

$$C = \frac{I\Delta t}{m} \quad \text{or} \quad C = \frac{I\Delta t}{A} \tag{S1}$$

$$C_{HSC} = \frac{I\Delta t}{M} \quad \text{or} \quad C_{HSC} = \frac{I\Delta t}{A} \tag{S2}$$

Where the specific capacity (C_m, C g^{-1} or C cm^{-2}) is applicable to the single Ni_3Se_2 NWs@NF electrode in the three-electrode cell and the specific capacity (C_{HSC}, C g^{-1}; C cm^{-2}) is applicable to the HSC only. I is the discharge current (A), Δt is the discharge time (s), A is the area of the electrode (cm^2), m is the weight of the Ni-P@Ni NTs electroactive material loaded on the single electrode in the three-electrode cell, and M ($M=m_+ + m_-$) is the total mass of the electroactive materials on both the positive electrode and negative electrode in HSC.

The Ni_3Se_2 and AC were used as the positive electrode and the negative electrode, respectively. A 2M KOH aqueous electrolyte was used as electrolyte, and the hydrophilic porous cellulose membrane as the separator. The HSC (Hybrid Supercapacitor) was assembled. Prior to the fabrication of the HSC in the self-made Teflon mould, the masses of the positive electrode and negative electrode were balanced according to the following formula:

$$\frac{m_+}{m_-} = \frac{C_-}{C_+} \tag{S3}$$

Where m is the mass of the active material in electrode, C is the specific capacity, and ΔV is the voltage range for positive (+) and negative (-) electrodes, respectively. In this work, the optimum loading mass ratio of Ni_3Se_2 to AC is estimated to be 0.25, and the average loaded mass of the Ni_3Se_2 materials is around 2.3 mg cm^{-2}.

The energy density (E) and power density (P) of the Ni_3Se_2 NWs@NF//AC HSC could be calculated according to the following formula, based on the total weight of the two electrodes material.

$$E = \frac{I\int V dt_d}{M} \tag{S4}$$

$$P = \frac{E}{t_d} \tag{S5}$$

Where E is the energy density, P is the power density, t_d (s) is the discharge time obtained from the discharge curve, V is the voltage change during the discharge, M ($M=m_+ + m_-$) is the total mass of the electroactive materials include the Ni_3Se_2 material and AC material in HSC.

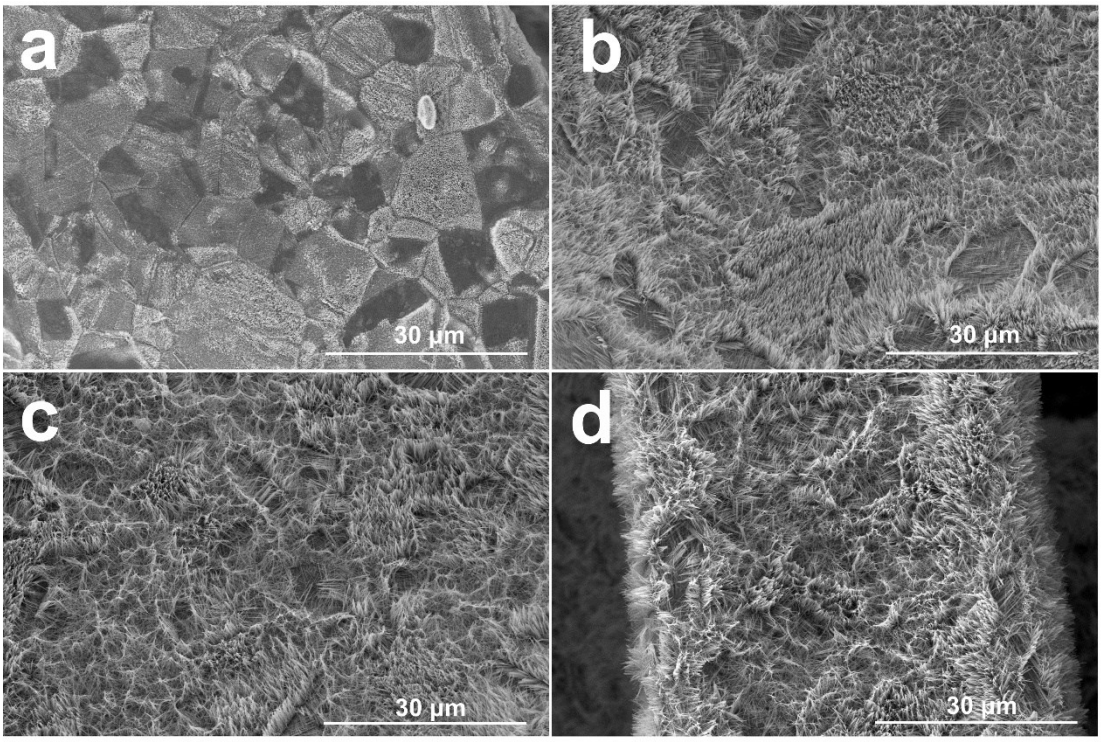

Fig. S1 SEM images of as-prepared NiSe NWs@NF with different reaction times at 120 ^{o}C: (a) 6h, (b) 12h, (c)18h, (d) 24h.

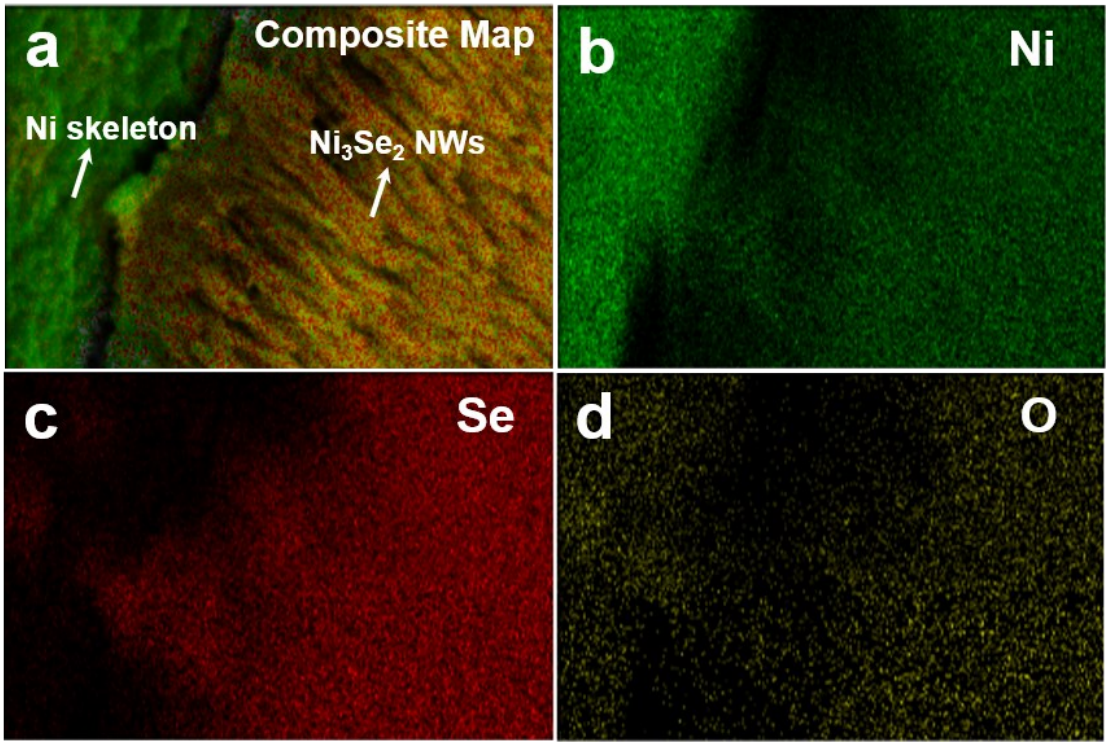

Fig. S2 EDX elemental mapping of Ni, Se and O elements for the fracture surface of the Ni_3Se_2 NWs@NF. (a) composite map; (b) Ni distribution; (c) Se distribution; (d) O distribution

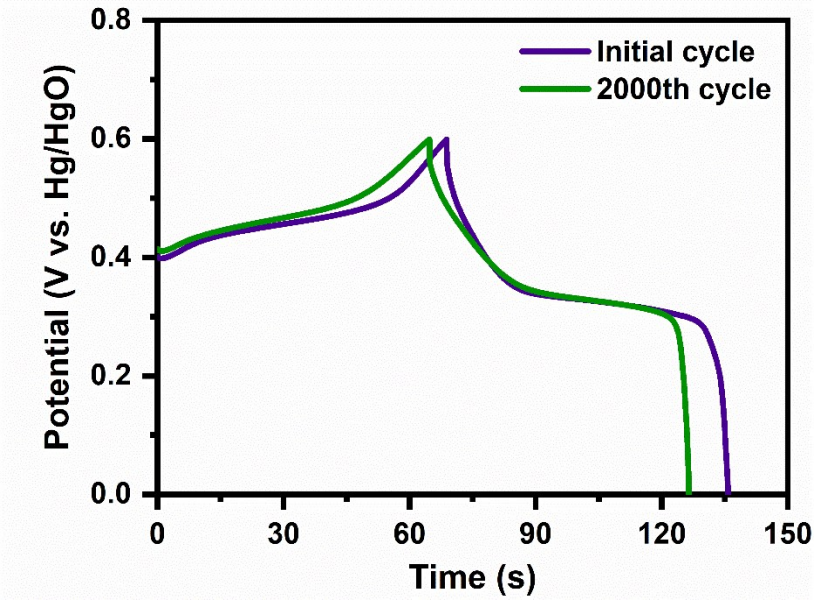

Fig. S3 Charge-discharge curve comparison before and after 2000 cycles

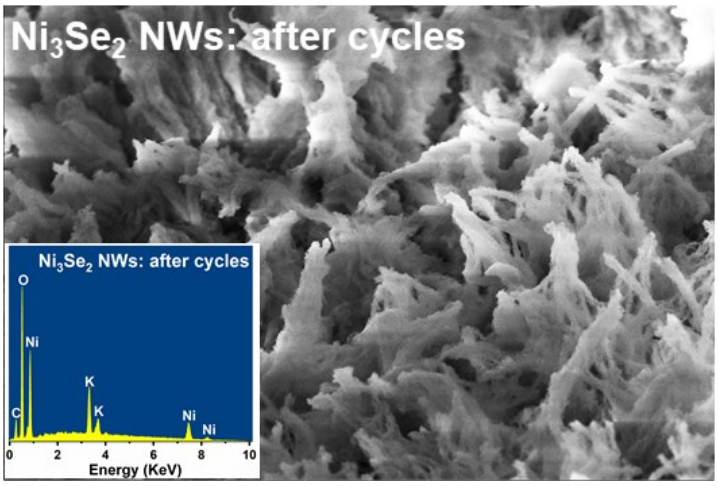

Fig. S4 SEM and EDX analysis of the NiSe NWs@NF electrode after 2000 cycles in a three-electrode cell.

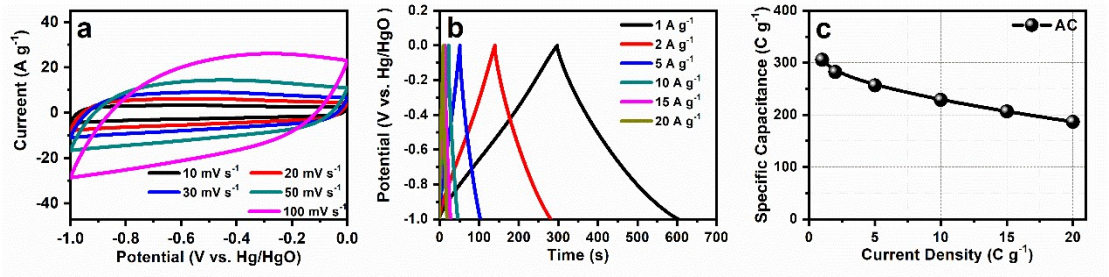

Fig. S5 Electrochemical performances of the AC electrode in the three-electrode cell. (a) CV curves within a voltage of 1.0V measured under different scan rates; (b) GCD curves recorded at various current densities; (c) Rate capability.