Electronic Supplementary Information (ESI†)

Facile synthesis of crystalline $RuSe_2$ nanoparticles as a novel pseudocapacitive electrode material for supercapacitors

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Part I: Experimental section

Materials synthesis

All chemicals used in our experiment were of analytical grade and utilized without further purification. The $RuSe_2$ nanoparticles were prepared by hydrothermal approach followed by thermal treatment under Ar atmosphere. Firstly, the 1 g $RuCl_3 \cdot xH_2O$ was dissolved in 250 mL of distilled water, and stirred for 10 min to obtain the homogeneous solution. Then, 25.93 mL of $RuCl_3 \cdot xH_2O$ aqueous solution and 78.96 mg of selenium powders were mixed together, and vigorously agitated for 20 min. Subsequently, 5 mL of hydrazine hydrate and 19.07 mL of distilled water were added to the above mixed solution. After continually stirring for another 20 min, the resulting mixture was transferred to Teflon-lined stainless steel autoclave (100 mL) and maintained at 180 °C for 12 h. The as-obtained amorphous product was centrifuged by alternately using distilled water and absolute ethanol for three times, respectively, and further dried in a vacuum oven at 70 °C overnight. Lastly, the as-resulted amorphous product was

annealed at 650 °C under Ar atmosphere to obtain the crystalline $RuSe_2$ nanoparticles.

Materials characterization

X-ray diffraction (XRD, Rigaku D/max 2550 VB^+) was undertaken to survey the structure of the $RuSe_2$ nanoparticles. Raman spectroscopy (Labram-010) and X-ray photoelectron spectroscopy (XPS, K-Alpha) were employed to characterize the crystal structure, composition and chemical states of the $RuSe_2$ nanoparticles. Field emission scanning electron microscopy (FESEM, MIRA3) and the corresponding energy-dispersive X-ray spectroscopy (EDS) and elemental mapping were conducted to study the morphology and composition of the $RuSe_2$ nanoparticles. Transmission electron microscopy (TEM, JEM-2100F), high resolution transmission electron microscopy (HRTEM, JEM-2100F) and the corresponding selected area electron diffraction (SAED) were executed to examine the morphology and microstructure of the $RuSe_2$ nanoparticles. The N_2 adsorption/desorption test (BET, Autosorb-iQ2-MP) was utilized to evaluate the BET specific surface area and pore size distribution of the $RuSe_2$ nanoparticles.

Electrochemical measurements

The working electrode was fabricated by mixing active materials, acetylene black, and polyvinylidene difluoride (PVDF) with a mass ratio of 80:10:10. A small amount of N-methyl-2-pyrrolidinone (NMP) was added to the above mixture and ground in a mortar to form the slurry. The as-resulted slurry was smeared onto the pretreated Platinum foil, and then vacuum-dried at 70 °C overnight. The mass loading of active material was about 2.0 mg cm^{-2}. The electrochemical tests of the as-obtained working electrode were conducted in a three-electrode configuration in 1 M H_2SO_4 aqueous solution, and the reference and counter electrodes were Hg/Hg_2Cl_2 and platinum electrodes, respectively. A CHI760E electrochemical workstation was used to measure

the electrochemical performances of the as-prepared working electrode via cyclic voltammetry (CV), galvanostatic current charge-discharge (GCD) and electrochemical impedance spectroscopy (EIS).

Part II: Supplementary figures

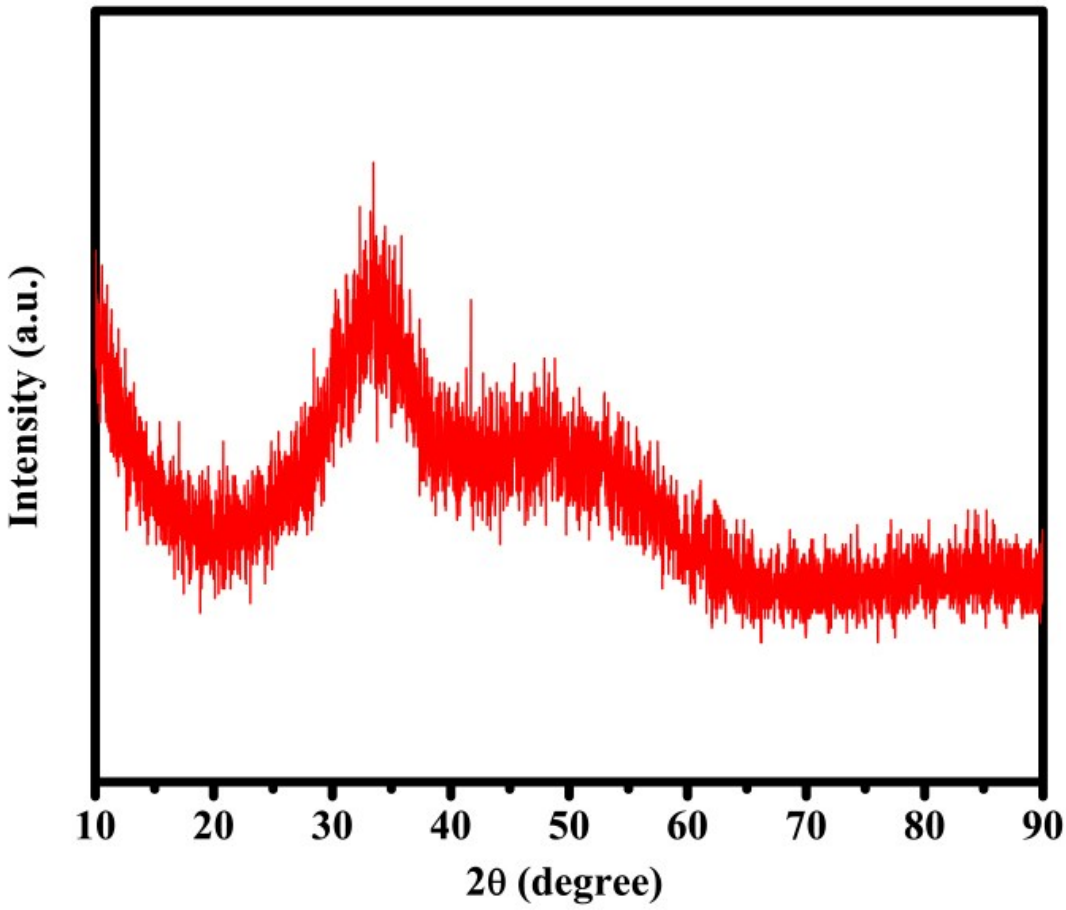

Fig.S1 XRD pattern of the $RuSe_2$ nanoparticles before thermal treatment

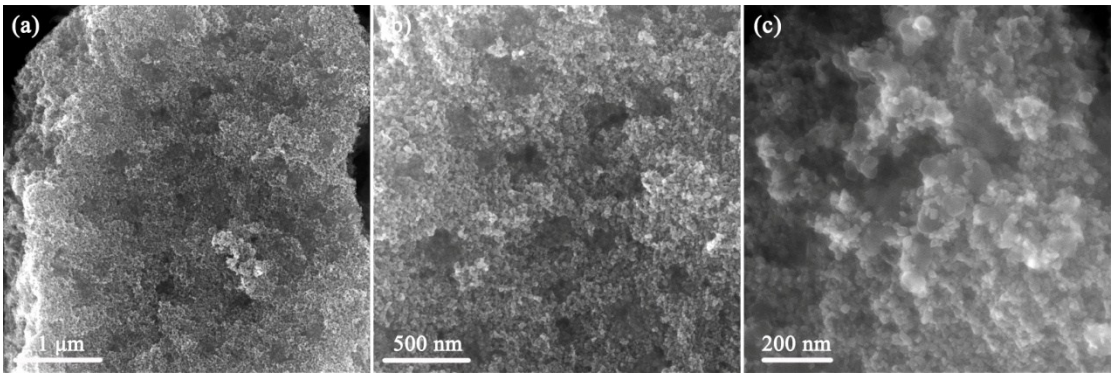

Fig.S2 FESEM images of the $RuSe_2$ nanoparticles after 1000 charge/discharge cycles

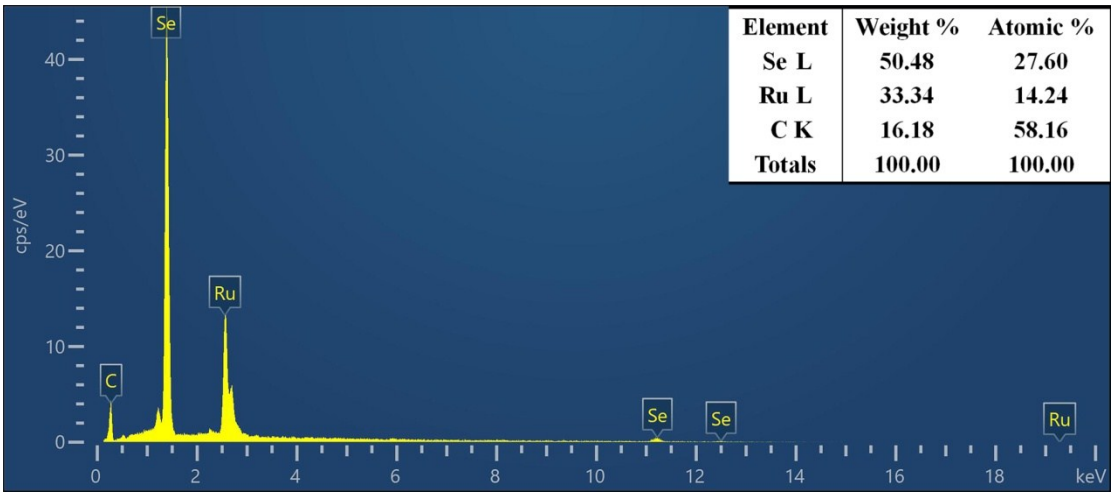

Fig.S3 EDS spectrum of the $RuSe_2$ nanoparticles after 1000 charge/discharge cycles