Supporting information

Porous silicon nano-aggregate from silica fume as anodes for high-energy lithium-ion battery

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Experimental section

Material Synthesis

Synthesis of Mg_2Si: Mg_2Si was prepared following a literature (*Chem. Commun.* 2015, 51, 7230). Typically, 2.0 g of Mg and 1.0 g of bulk Si were mixed and moved into a tube furnace. Subsequently, the tube furnace was maintained at 500 °C for 5 hours under an Ar atmosphere and cooled to room temperature to obtain the Mg_2Si.

Synthesis of SNC: the as- prepared Mg_2Si powder and silica fume (~96% SiO_2) with a molar ration of 1:1 were mixed and moved into a tube furnace. The tube furnace was heated to 650 °C with a heating rate of 5 °C min^{-1} under an Ar atmosphere. And then, the as-obtained sample was immersed in hydrochloric acid (2M) for several hours. Subsequently, the khaki precipitate was collected by centrifugation, washed with deionized water and ethanol and dried at 70 °C for 12 h in a vacuum oven.

Materials Characterization

The product morphology was examined using scanning electron microscopy (SEM, JEOL-JSM-6700F), Transmission electron microsocopy (TEM, Hitachi H7650 and HRTEM, JEOL 2010). Crystallographic information of the product was performed on a Philips X' Pert Super diffract meter with Cu Kα radiation (λ=1.54178 Å). The pore size and specific surface area of the sample were measured by Brunauer-Emmett-Teller analyzer (BET; Micromeritics ASAP 2020) at 77 K. The information of Raman spectrum was collected using a Spex 1403 Raman spectrometer. The surface composition of the sample was examined by X-ray photoelectron spectroscopy (XPS; ESCA-Lab

MKII X-ray photoelectron spectrometer), using Mg Kα X-ray as the excitation source. The conductivity of the PSNA is measured by voltammetry（Keithley 2410）.

Electrochemical measurements

The electrochemical properties of PSNA electrodes were measured under ambient temperature with coin-type half cells (CR2016) which were assembled under an argon-filled glove box (H_2O, O_2 < 1 ppm). The working electrode was prepared by mixing the PSNA material, Carboxyl Methyl Cellulose (CMC) and super P carbon black in a 6:2:2 weight ratio in water solvent. The mixture slurry was pasted onto a Cu foil and then dried at 80 °C for 10 h in a vacuum oven. The mass loading of nanosilicon active material for each electrode was determined to be 0.6-0.8 mg/cm^2. The counter electrode was metallic Li sheet, and the electrolyte used was 1 M LiPF6 in a mixture of ethylene carbonate and dimethylcarbonate (1:1 by Volume, Zhuhai Smoothway Electronic Materials Co., Ltd (China)). Cyclic voltammetry (CV) was performed on a electro-chemical workstation (CHI660D), with a scanning rate of 0.1 mV s^{-1} at room temperature. The charge-discharge measurements were performed using a LAND-CT2001A instrument at room temperature that was cycled between 0.005 V and 1.50 V (vs. Li$^+$/Li).
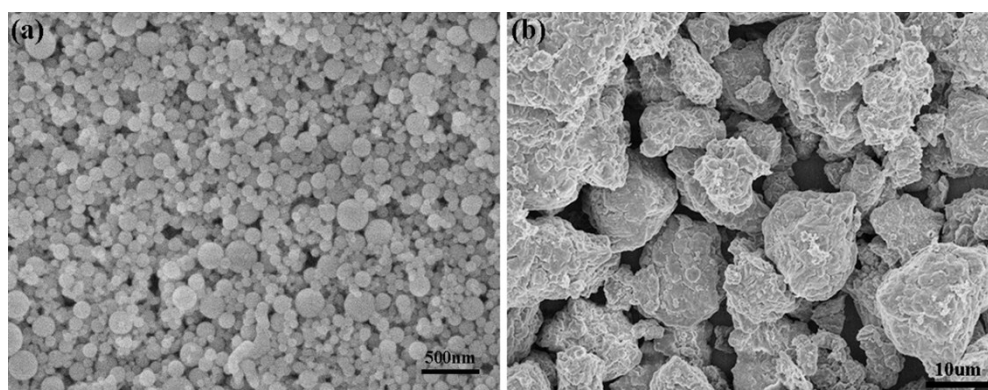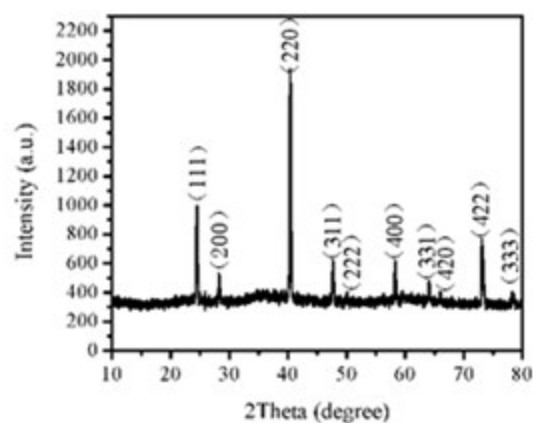

Figure S1. The SEM images of silica fume and Mg$_2$Si.

Figure S2. The XRD pattern of Mg$_2$Si.
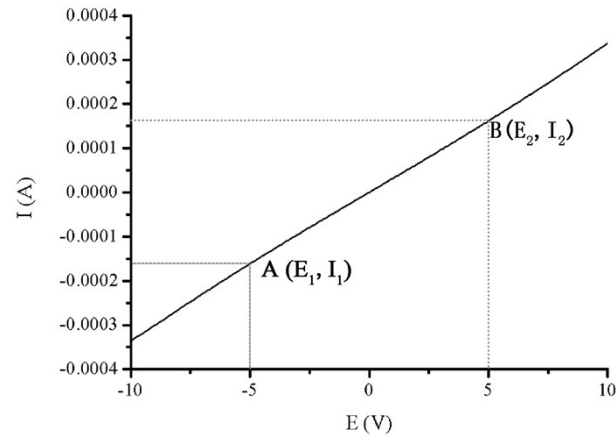
Figure S3. The voltammetric curve of the specimen.

$R = \Delta E / \Delta I$ (1)

$\rho = R A / b$ (2)

$\sigma = 1 / \rho$ (3)

$\sigma = \Delta I b / \Delta E A$ (4)

$E_1 = -5$ V, $I_1 = -1.61 \times 10^{-4}$ A; $E_2 = 5$ V, $I_2 = 1.62 \times 10^{-4}$ A;

$b = 1.02 \times 10^{-3}$ m; $A = 8.41 \times 10^{-6}$ m^2

R is the electrical resistance of a uniform specimen of the material (measured in ohms, Ω)

b is the thickness of the specimen (measured in metres, m)

A is the cross-sectional area of the specimen (measured in square metres, m^2).

ρ is the electrical resistivity

σ is the conductivity

The conductivity of the PSNA is as follows:

$\sigma = (1.62 \times 10^{-4}$ A $+ 1.61 \times 10^{-4}$ A$) \times 1.019 \times 10^{-3}$ m $/ (5$ V $+ 5$ V$) \times 8.41 \times 10^{-6}$ m^2

$= 3.92 \times 10^{-3}$ S / m