Supplementary Information:

High-capacity and ultrastable lithium storage in $SnSe_2$-SnO_2@NC microbelts enabled by heterostructure

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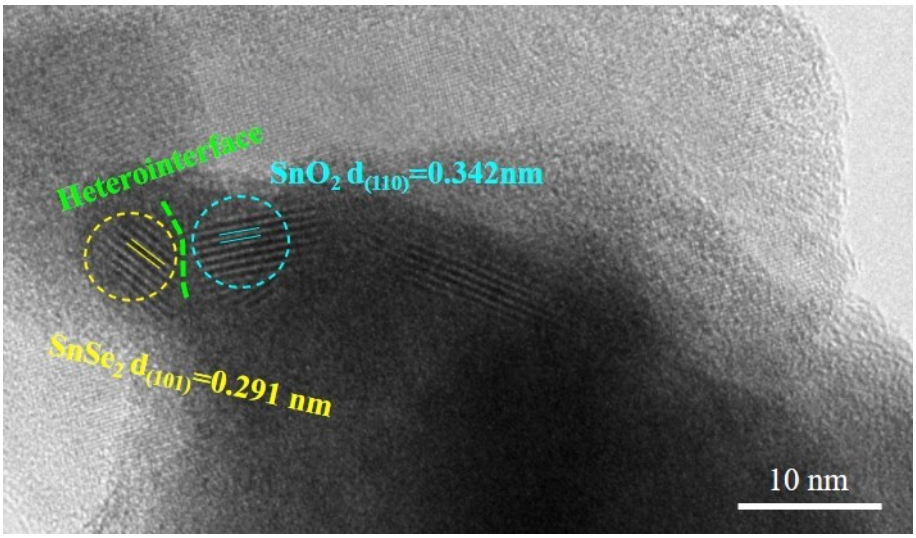


Fig. S1. High-resolution TEM image of $SnSe_2$-SnO_2@NC microbelts.

Analysis of carbon contents in all samples:

As shown in **Fig. 2c,** the TGA curve of $SnSe_2$-SnO_2@NC is mainly divided into two parts in the temperature range of 25 to 800 °C:

1. Evaporation of water below 200 °C (m_1 (H_2O)).

m_1(wt%) (record from the y-axis, 93.15 wt%) = m($SnSe_2$-SnO_2@NC) – m(H_2O)..... (S1)

2. The oxidation of $SnSe_2$-SnO_2@NC to SnO_2 in the temperature range of 250 –800 °C

and the gasification of carbon (m_c), also occurring in this temperature region. Accordingly, the chemical reaction should be depicted as Equations (S2 or S3):

$$SnSe_2+3O_2=SnO_2+2SeO_2\uparrow \quad \text{..... (S2)}$$

$$C+ O_2=CO_2\uparrow \quad \text{..... (S3)}$$

m_2(wt%) (record from the y-axis, 32.15 wt%) = m(SnO_2) =M(SnO_2)*n(SnO_2).....(S4)

When Only $SnSe_2$ in the material, the $SnSe_2$ content of $SnSe_2$-SnO_2@NC is estimated by

m ($SnSe_2$) = (n(SnO_2) × 1 × M(Sn))/m_1(wt%) × 100 wt% = (m_2(wt%)/M(SnO_2) × 1 × M($SnSe_2$)) / m_1(wt%) × 100 wt% = (m_2(wt%) / 150.7 × 1 × (276.62) / m_1(wt%)) × 100 wt%

The $SnSe_2$ loadings in the $SnSe_2$@NC and $SnSe_2$-SnO_2@NC are calculated to be 34.5 and 63.4 wt%, corresponding to 65.5 and 36.6 wt% for N-C, respectively.

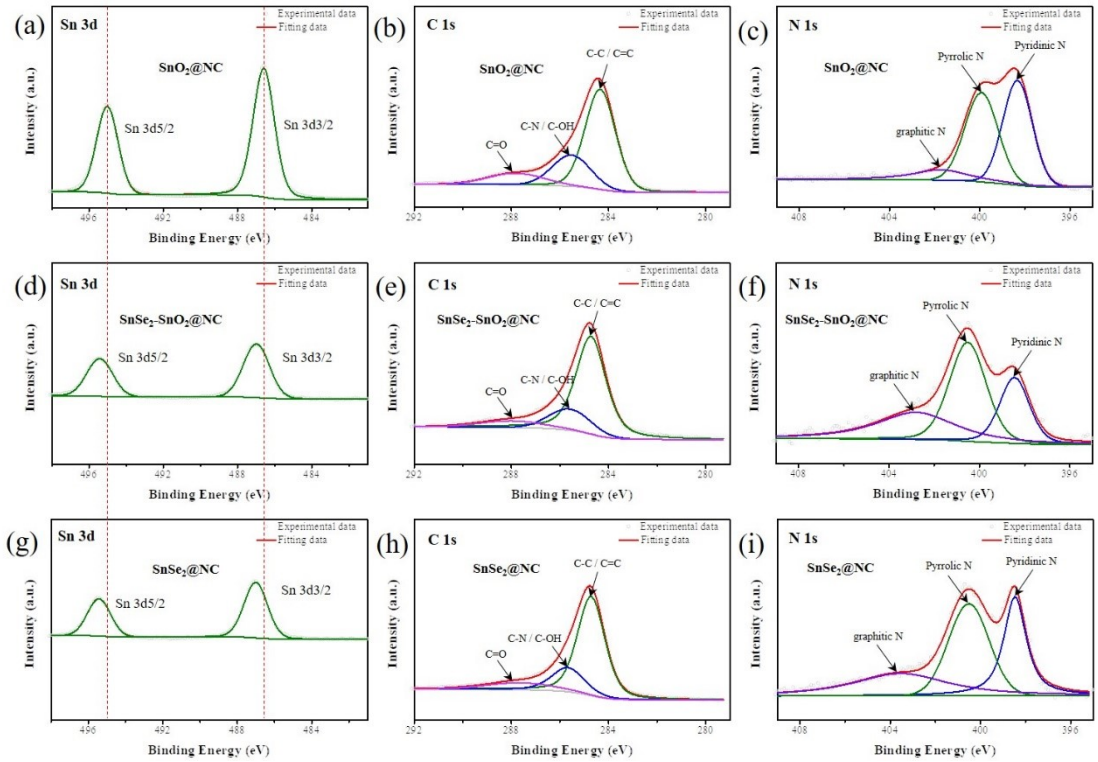
When Only the material of SnO_2 in the material, the SnO_2 content is estimated by

m (SnO_2) = m_2(wt%) / m_1(wt%) × 100 wt%

The SnO_2 loadings in the SnO_2@NC and $SnSe_2$-SnO_2@NC are calculated to be 58.3 and 34.5 wt%, corresponding to 31.7 and 35.5 wt% for N-C, respectively.

To sum up, the carbon content of $SnSe_2$-SnO_2@NC is between 35.5 wt% and 36.6 wt%. The carbon contents of SnO_2@NC, $SnSe_2$@NC is 31.7 and 65.5 wt%, respectively.

Fig. S2. High-resolution XPS spectra of (a), (d), (g) Sn 3d; (b), (e), (h) C 1s; and (c), (f), (i) N 1s for SnO_2@NC, $SnSe_2$@NC, and $SnSe_2$-SnO_2@NC microbelts, respectively.



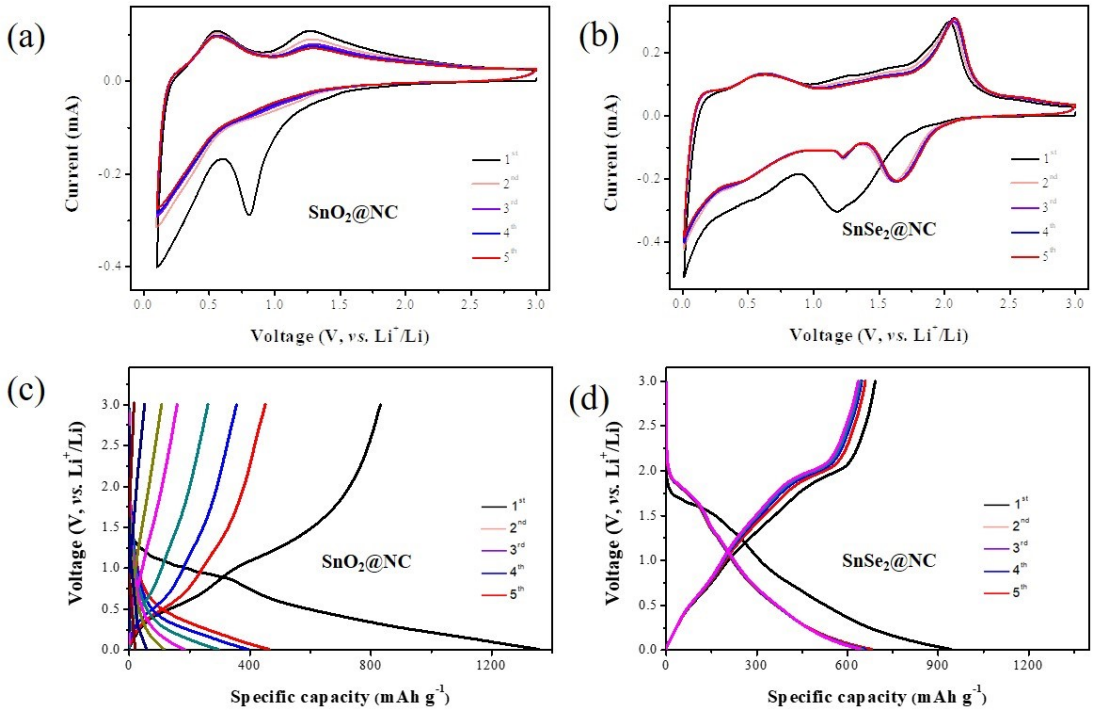


Fig. S3. (a,b) CV curves for the first five cycles of the SnO_2@NC and $SnSe_2$@NC electrodes at a scan rate of 0.2 mV s^{-1}. (c,d) Galvanostatic discharge-charge curves for selected cycles of the SnO_2@NC and $SnSe_2$@NC electrodes at a current density of 0.2 A g^{-1}.

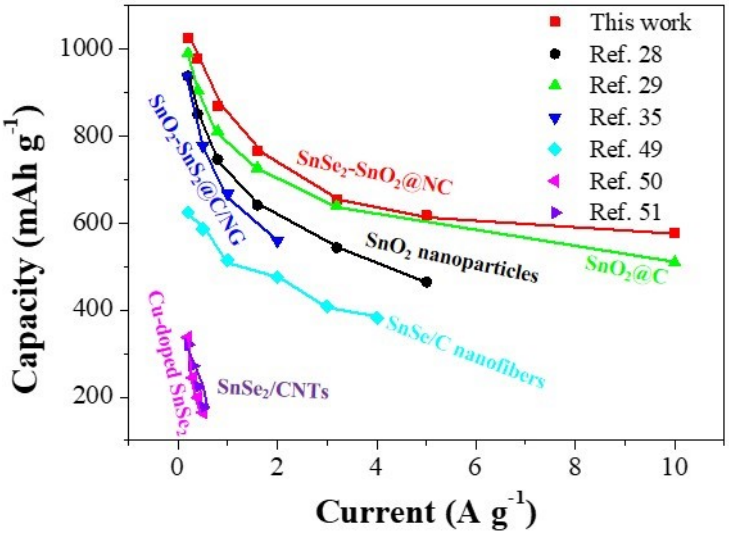


Fig. S4. Comparisons of the rate performance of the $SnSe_2$-SnO_2@NC with those of other similar reported anode materials.

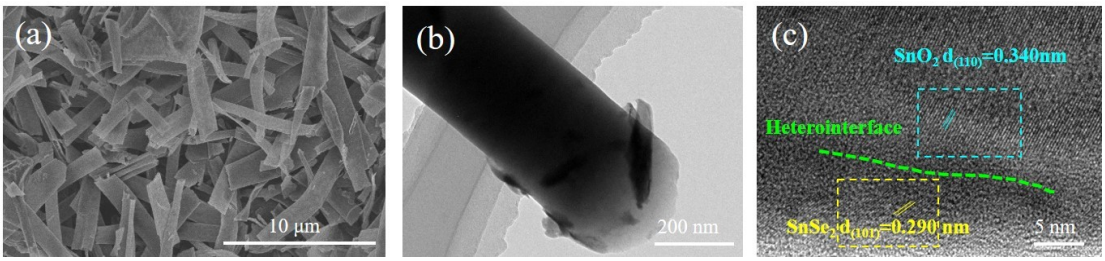


Fig. S5. SEM and High-resolution TEM images of the cycled $SnSe_2$-SnO_2@NC electrode.

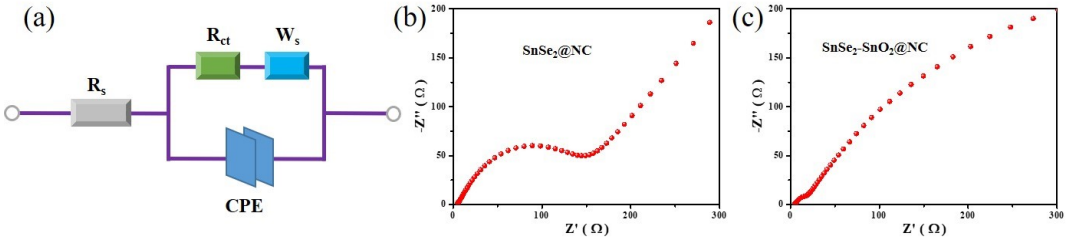


Fig. S6. (a) An equivalent circuit model for fitting of the Nyquist plots of the electrodes. (b,c) Nyquist plots of $SnSe_2$@NC and $SnSe_2$-SnO_2@NC electrodes.

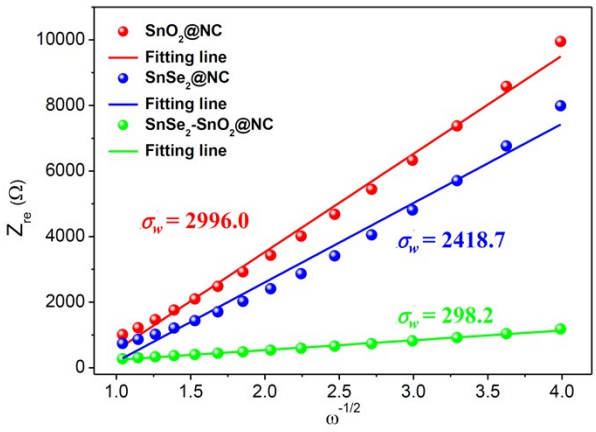


Fig. S7. Z'-$\omega^{-0.5}$ plots in the low frequency range for $SnSe_2$@NC and $SnSe_2$-SnO_2@NC electrodes

To further investigate the electrode kinetics, the Li^+ diffusion coefficient (D_{Li+}) is also calculated through the linear fitting of Z_{re} *vs.* $\omega^{-1/2}$ (Fig. S7). The detailed calculation is based on the following equation formulas:

$$Z' = R_s + R_{ct} + \sigma\omega^{-1/2} \qquad \text{(S5)}$$

$$D_{Li+} = \frac{R^2T^2}{2A^2n^4F^4C^2\sigma^2} \qquad \text{(S6)}$$

Where R, T, A, F, n and C are the gas constant (8.314 J K^{-1} mol^{-1}), absolute temperature (298 K), the area of electrode surface, Faraday constant (96500 C mol^{-1}), number of transferred electrons and concentration of the Li^+ (mol cm^{-3}), respectively. As a result, the $SnSe_2$-SnO_2@NC has a smaller σ value of 298.2 than $SnSe_2$@NC (2418.7) and SnO_2@NC (2996.0), once again indicating its stronger diffusion dynamics of Li^+.