Supporting information

A new method of synthesis Sb_2Se_3/rGO as a high-rate and low-temperature anode for sodium-ion batteries

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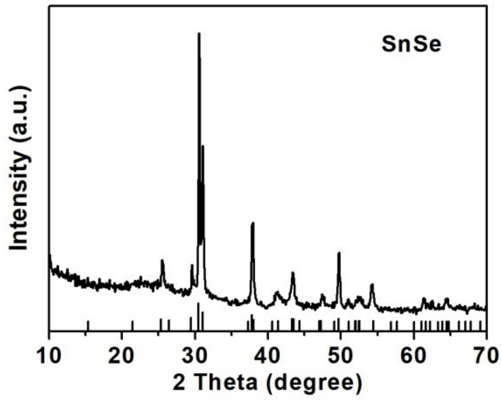

Figure S1. XRD pattern of SnSe.

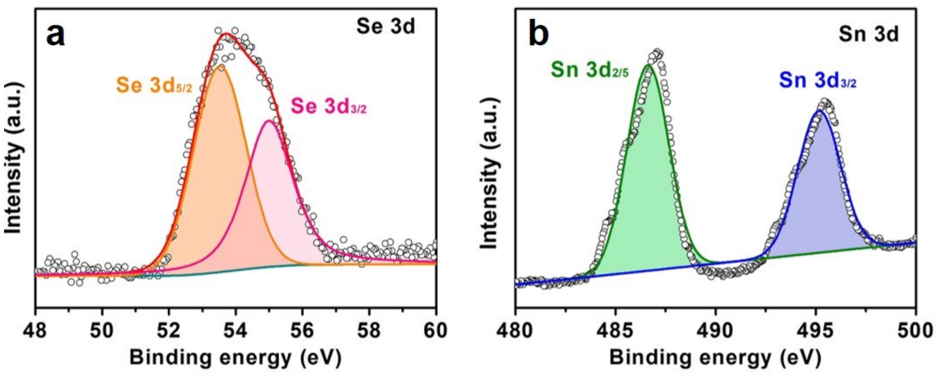

Figure S2. XPS spectra of (a) Se 3d, (b) Sn 3d of SnSe.

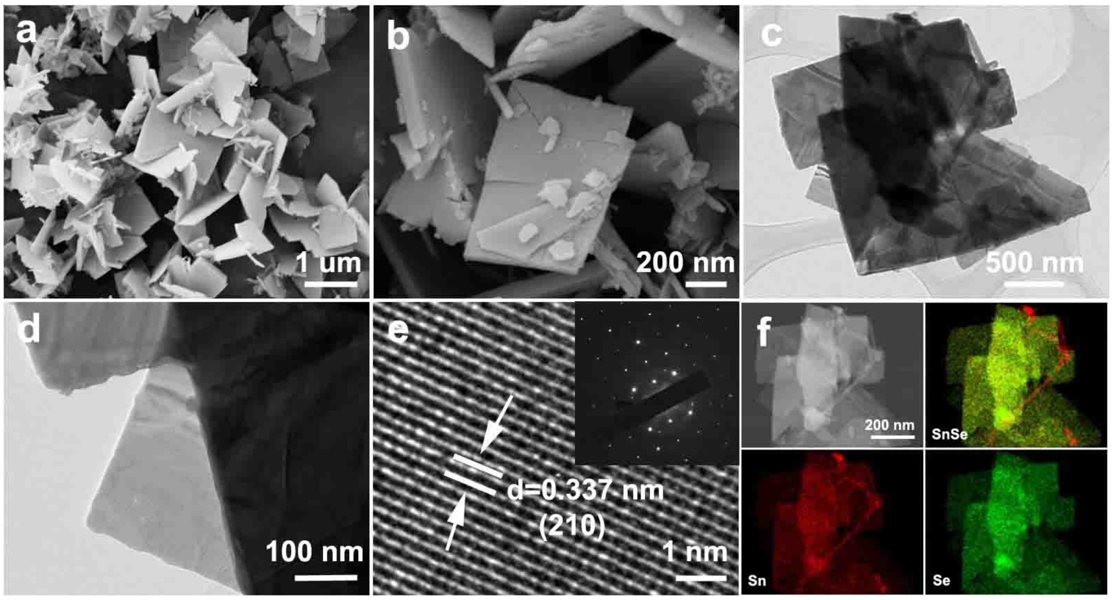

Figure S3. (a,b) SEM images, (c,d) TEM images, (e) HRTEM image, (f) elemental mapping of SnSe.

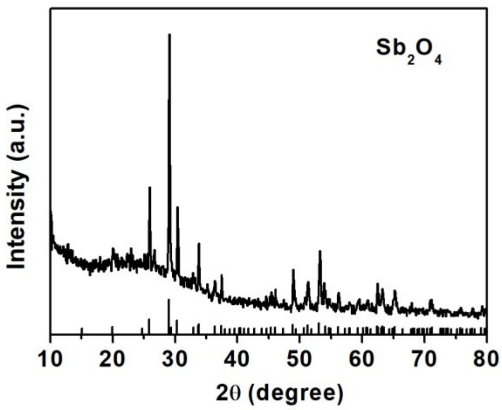

Figure S4. XRD pattern of Sb_2O_4.

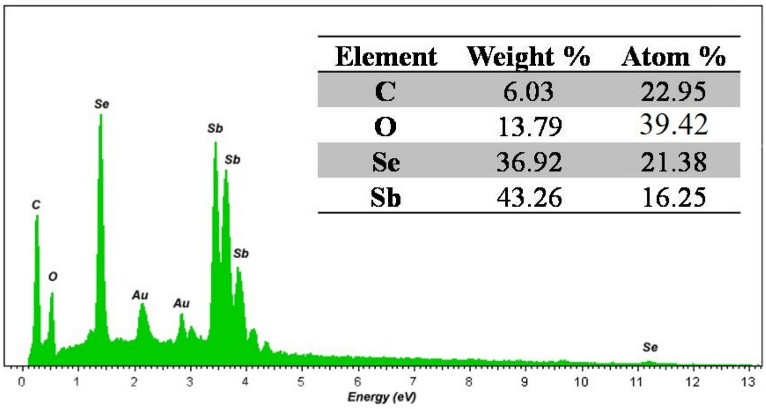

Figure S5. EDS of Sb_2Se_3/rGO.

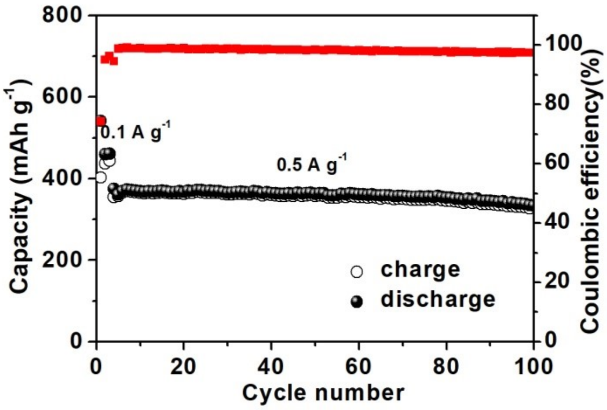

Figure S6. Cycling performance of SnSe.

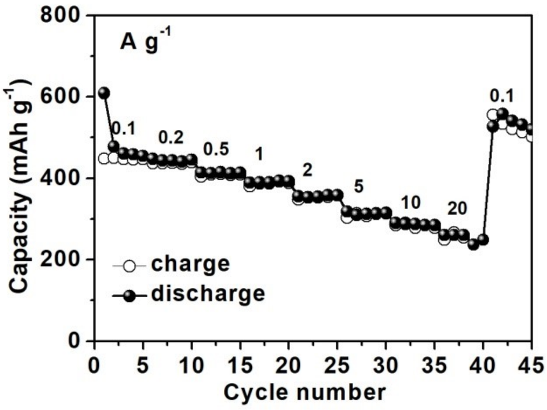

Figure S7. Rate performance of SnSe.

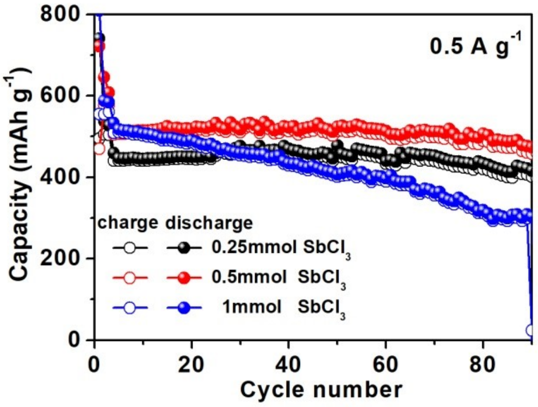

Figure S8. Cycling performance of Sb_2Se_3/rGO with different content of $SbCl_3$.

Insufficient amount of $SbCl_3$ causes incomplete SnSe conversion, resulting in low capacity of Sb_2Se_3/rGO. On the other hand, excessive amount of $SbCl_3$ leads to the hydrolysis of $SbCl_3$ and the production of by-products, resulting in the decrease of cycle stability of Sb_2Se_3/rGO.

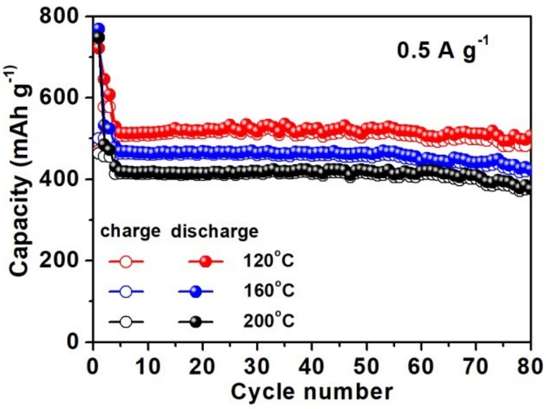

Figure S9. Cycling performance of Sb_2Se_3/rGO in different temperatures of hydrothermal reaction.

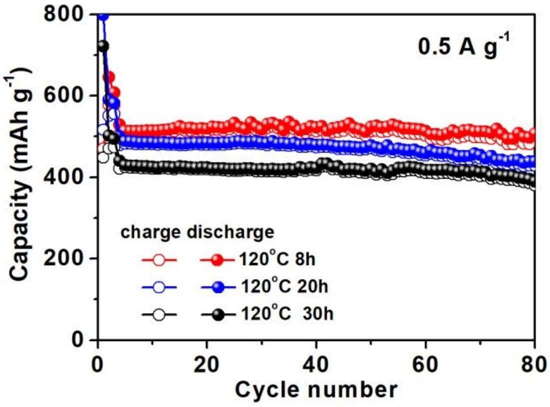

Figure S10. Cycling performance of Sb_2Se_3/rGO with different hydrothermal reaction time.

With the increase of reaction temperature and the reaction time, the Sb_2Se_3 nanoparticles agglomerate heavily, which is bad for the sodiation/desodiation, resulting the slowly reaction kinetics of sodium ion diffusion and storage, and leading to the low capacity and poor cycle stability of Sb_2Se_3/rGO.

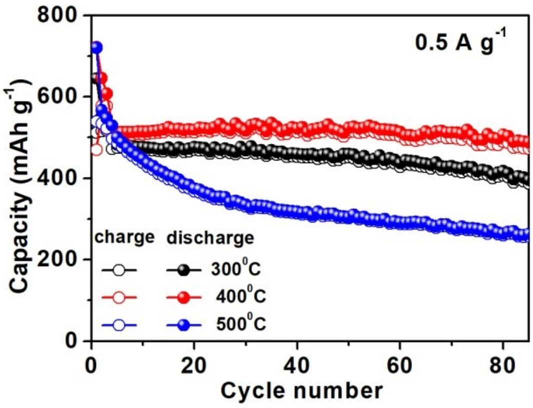

Figure S11. Cycling performance of Sb_2Se_3/rGO with different calcination temperatures.

If the calcination temperature is not high enough, the crystallization of Sb_2Se_3 and the reduction of graphene are not sufficient, causing the low capacity of Sb_2Se_3/rGO. On the other hand, if the calcination temperature is too high, it can cause the loss and the agglomeration of Sb_2Se_3 nanoparticles, leading to the poor cycle stability.

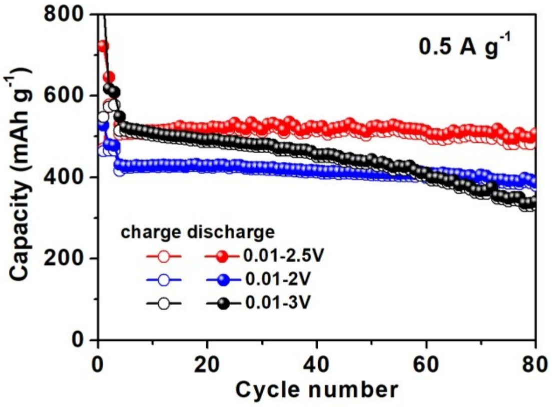

Figure S12. Cycling performance of Sb_2Se_3/rGO with different cut-off voltages.

In the larger voltage range of 0.01-3V, some side reactions such as the decomposition of the electrolyte will occur, resulting in deterioration of the cycle stability of Sb_2Se_3/rGO. Under the relatively small voltage range of 0.01-2V, part of the transformation mechanism is not included, resulting in the reduction of capacity of Sb_2Se_3/rGO.

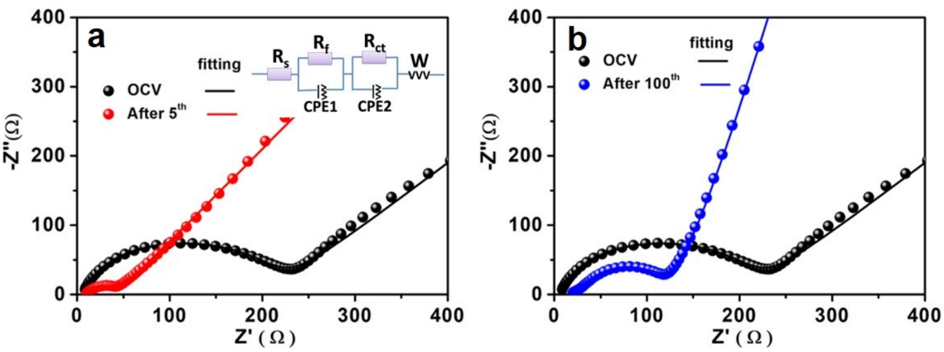

Figure S13. Nyquist plots of Sb_2Se_3/rGO at a current density of 0.5 A g^{-1}. (a) After 5 cycles. (b) After 100 cycles

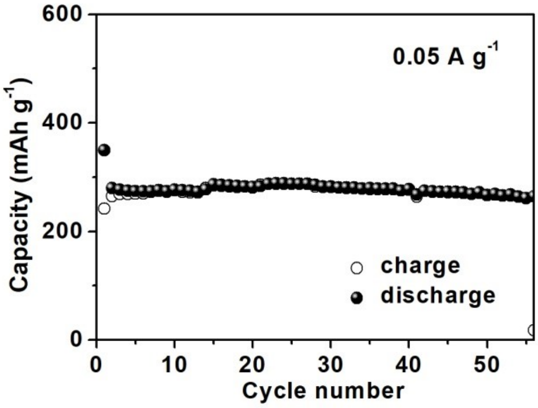

Figure S14. Cycling performance of SnSe under -15°C at the current density of 0.05 A g^{-1}.

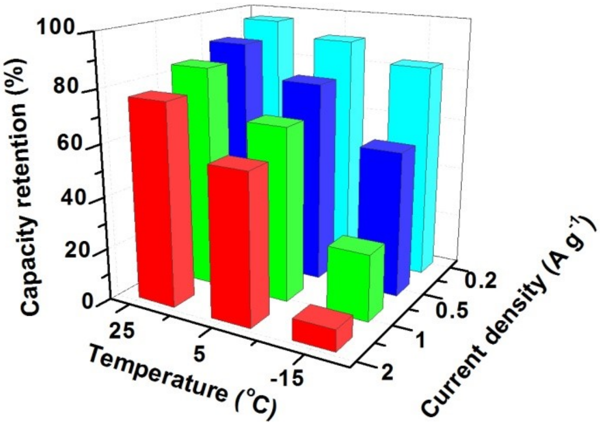

Figure S15. The capacity retentions of SnSe along with temperature variations between 25 and -15 °C at various current density of 0.2, 0.5, 1, 2 A g^{-1}.

Table S1. Fitting data of components in equivalent circuit

	R_s (Ω)	R_{ct} (Ω)	R_f (Ω)
Before cycling	11.3	157	45.9
After cycling	10	30.1	11