Supporting Information For :

$Na_2Ge_4O_9$ nanoparticles encapsulated in 3D carbon networks with long-term stability and superior rate capability in lithium ion batteries

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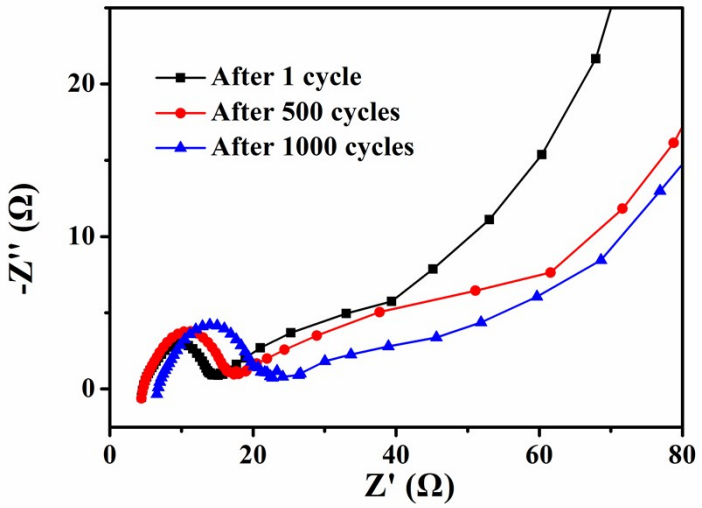

Figure S1.Nyquist plots of GEC-2 anode after initial, 500 and 1000 cycles at a current density of 1 A g^{-1} over the frequency ranging from 100 kHz to 0.01 Hz.

To further insight into the good electrochemical performance of GEC-2 anode, electrical impedance spectroscopy (EIS) measurements were performed after initial, 500 and 1000 cycles at 1A g^{-1} (Figure. 6). The semicircles in high frequency range

reflect the interface resistance of GEC-2 anode, which is associated with the SEI film and charge transfer resistance of Li-ions insertion. The charge transfer resistances of GEC-2 anode are 15, 18 and 22 Ω after initial, 500 and 1000 cycles, respectively. These similar values indicating no obvious change of the charge transfer resistance of Li ions from and into electrodes. The low charge transfer is derived from the high conductive 3D carbon network and strong interactions unique structure of active materials encapsulated into 3D carbon networks. Thus, good cycle and rate performances have been achieved for GEC-2 anode because the low charge transfer resistance is beneficial to the Li ion transfer at the interface of the electrolyte/electrode.

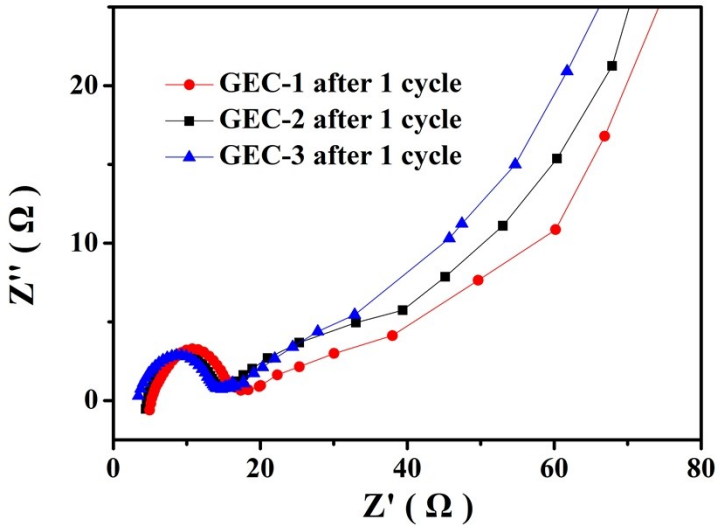

Figure S2. Nyquist plots of GEC-1, GEC-2 and GEC-3 anode after initial cycle at a current density of 1 A g^{-1} over the frequency ranging from 100 kHz to 0.01 Hz.

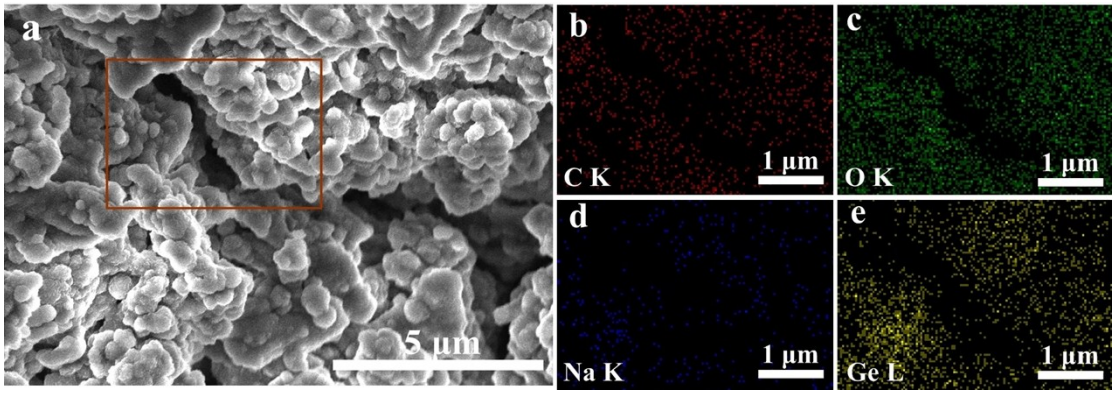

Figure S3. The images of elemental mapping of the electrodes after 1000 cycles.

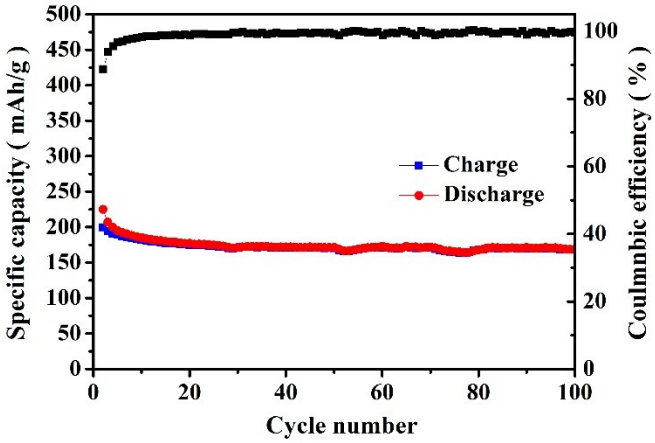

Figure S4. Discharge-charge performance of pure carbon anode at 1 A g^{-1}.

S5: Calculation of theoretical capacity of GEC-2 material:

The initial discharge and charge capacity of pure 3D carbon network is 611 and 211 mAh g^{-1}, respectively. The large irreversible capacity of pure 3D carbon network are derived from the inevitable formation of SEI film and decomposition of electrolyte[1]. And the initial theoretical capacity and reversible capacity of pure $Na_2Ge_4O_9$ is 1874.1 and 981.7 mAh g^{-1}, respectively. Thus the theoretical initial discharge capacity and theoretical initial charge capacity are calculated to 1611.4 and 821.4 mAh g^{-1} based on following equations:

Calculation of the initial discharge capacity (IDC, initial discharge capacity):

$$IDC\ (GEC\text{-}2) = IDC\ (Na_2Ge_4O_9) \times 79.2\% + IDC\ (C) \times 20.8\%$$

Calculation of the initial discharge capacity (ICC, initial charge capacity):

ICC (GEC-2) = ICC ($Na_2Ge_4O_9$)×79.2% + ICC (C) ×20.8%

References

1. X. Zhang, S. Han, X. Pingan, C. Fan and W. Zhang, *Carbon*, 2016.