Supporting Information

**Porous graphene/carbon nanowire hybrid with embedded SnO$_2$ nanocrystals for high performance lithium ion storage**

Jingjing Tang,$^a$ Juan Yang,$^b$ Xiangyang Zhou,$^b$ Haimin Yao$^a$ and Limin Zhou$^{a, *}$

$^a$ Department of Mechanical Engineering, The Hong Kong Polytechnic University, Hong Kong, China

$^b$ School of Metallurgy and Environment, Central South University, Changsha, China

Table S1 Comparison of the electrochemical performance and synthesis method of SnO$_2$/C.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Synthesis method</th>
<th>Discharge/Charge capacity in the first cycle (mAh g$^{-1}$)</th>
<th>Reversible capacity in n cycle (mAh g$^{-1}$)</th>
<th>Current density (mA g$^{-1}$)</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SnO$_2$@CNT</td>
<td>Solution-based method</td>
<td>1851/650</td>
<td>454 (100)</td>
<td>25</td>
<td>[1]</td>
</tr>
<tr>
<td>C/SnO$_2$/C</td>
<td>Electrosprinng, hydrothermal process and heat treatment</td>
<td>1050/961</td>
<td>837 (200)</td>
<td>52.2</td>
<td>[2]</td>
</tr>
<tr>
<td>SnO$_2$/C</td>
<td>Hydrothermal process and heat treatment</td>
<td>-/760</td>
<td>660 (100)</td>
<td>300</td>
<td>[3]</td>
</tr>
<tr>
<td>SnO$_2$/G/C</td>
<td>Two-step hydrothermal process and heat treatment</td>
<td>1310/958</td>
<td>757 (150)</td>
<td>200</td>
<td>[4]</td>
</tr>
<tr>
<td>SnO$_2$/G</td>
<td>Solution-based method</td>
<td>-/786</td>
<td>558 (50)</td>
<td>50</td>
<td>[5]</td>
</tr>
<tr>
<td>SnO$_2$/G</td>
<td>Hydrothermal process</td>
<td>1596/1107</td>
<td>847.5 (50)</td>
<td>78.2</td>
<td>[6]</td>
</tr>
<tr>
<td>SnO$_2$@C</td>
<td>Solution-based method and heat treatment</td>
<td>1772/1212</td>
<td>963 (100)</td>
<td>400</td>
<td>[7]</td>
</tr>
<tr>
<td>SnO$_2$-PG/CNWs</td>
<td>Vacuum assisted impregnation</td>
<td>1699/932</td>
<td>1200 (200)</td>
<td>200</td>
<td></td>
</tr>
</tbody>
</table>

This work
**Figure S1.** (a) FESEM and (b) FETEM images of GCNWs.

**Figure S2.** TGA curve of SnO$_2$-PG/CNWs under air atmosphere at a heating rate of 10 °C min$^{-1}$.
Figure S3. XPS survey spectrum (a) of GO/PPy. XPS C1s (b) and N1s (c) spectra of GO/PPy.

Figure S4. Cycling performance of SnO$_2$-PG/CNWs at 2 C for the first 465 cycles and 0.2 C for the following cycles.
Figure S5. The corresponding equivalent circuit of EIS curves.

Figure S6. Relationship between $Z'$ and $w^{-1/2}$.

Figure 7a shows the Nyquist plot in the open circuit state tested before and after cycling. And Figure S5 is the equivalent circuit model constructed to analyse the impedance spectra. $Re$ and $Rct$ are correspond to the ohmic resistance of the electrolyte and the charge transfer resistance, respectively. $Ws$ represents the Warburg impedance, which is associated with the lithium ion diffusion. After cycling, the $Re$ and $Rct$ are calculated to be 6.39 and 40.54 $\Omega$, respectively. The lithium diffusion coefficient can be calculated according to the following equation [8,9]:

$$D_{Li^+} = \frac{R^2T^2}{2A^2n^4F^4C^2} \sigma^2$$

(1)

Where, $R$ is the gas constant, $T$ is the absolute temperature, $A$ is the surface area of the electrode, $n$ is the number of electrons per molecule for the redox couple, $F$ is the Faraday constant, $C$ is the concentration of lithium ion, and $\sigma$ is Warburg factor, which is determined by the slope of the lines in Figure S6 based on the follow equation:
\[ Z' = R_d + R_f + \sigma w^{-1/2} \quad (2) \]

The lithium ion diffusion coefficient was calculated to be \(2.25 \times 10^{-13}\) m/s for SnO\(_2\)-PG/CNWs.

**References**


metal oxide-carbon microballs by continuous process for use as anode materials in Li-ion batteries, Nano Lett. 13 (2013) 5462-5466.