Encapsulation of TiO_2(B) Nanowire Cores into SnO_2/Carbon Nanoparticle Shells and Their High Performance in Lithium Storage

Zunxian Yang,[1*] Guodong Du,[2] Zaiping Guo,[2,3*] Xuebin Yu,[4*] Zhixin Chen,[3] Tailiang Guo,[1] Rong Zeng[2]

[1]Engineering Research Center for Field Emission Display Technology of the Ministry of Education, Fuzhou University, Fuzhou 350002, P. R. China

[2]Institute for Superconducting & Electronic Materials, University of Wollongong, NSW 2522, Australia

[3]School of Mechanical, Materials & Mechatronics Engineering, University of Wollongong, NSW 2522, Australia

[4]Department of Materials Science, Fudan University, Shanghai 200433, P. R. China

Supporting Information

Captions

Fig. S1 the TGA results on **(a) TSC1**, **(b) TSC2**.

Fig. S2 X-ray diffraction patterns of as-prepared $H_2Ti_3O_7$ nanowires and **TS1** sample.

Fig. S3 Low and high magnification FE-SEM images of the hybrid nanowires: **(a)**

* Corresponding author should be addressed. Tel.: +61 2 4221 5225; Fax: +61 2 4221 5731

E-mail: zguo@uow.edu.au (Z. Guo)

yangzunxian@hotmail.com (Z. Yang)

yuxuebin@fudan.edu.cn (X. Yu)

low magnification FE-SEM image of **TSC1** and higher magnification (**inset**); **(b)** low magnification FE-SEM image of **TS1** and higher magnification (**inset**); **(c)** low magnification FE-SEM image of **TSC2** and higher magnification (**inset**); **(d)** low magnification FE-SEM image of **TS2** and higher magnification (**inset**). (The hybrid nanowires of **TSC1** and **TSC2** are much smoother than those of **TS1** and **TS2** because of the many SnO_2 nanocrystals growing on the surface of the **TS1** and **TS2** nanowires.)

Fig. S4 (a) TEM image of single **TSC2** nanowire, indicating that SnO_2 nanocrystals are encapsulated in carbonaceous material surrounding the TiO_2(B) nanowire. **(b)** High-magnification TEM image of **TS2** nanowire, indicating that SnO_2 nanocrystals surround the TiO_2(B) nanowire.

Fig. S5 Energy dispersive X-ray (EDX) spectra and corresponding content tables for the samples (**insets**): **(a) TSC1; (b)TS1; (c)TSC2; (d) TS2.** (The signals of Carbon result from the tape used for SEM observations, while those of Aluminum may be due to the Al stage used during SEM.)

Scheme S1 Charge diffusion and conducting mechanism of composite nanowires during charge/discharge processes: **(a)** TSC1 and TSC2; **(b)** TS1 and TS2.

Fig. S6 (a) Cyclic voltammograms of **TS1** electrode from the first cycle to the fifth cycle at a scan rate of 0.1 mVs^{-1} in the voltage range of 0.01–3.0 V. **(b)** Capacity–cycle number curves from the first cycle to the 66th cycle of composite electrodes cycled between 1.0 and 3.0 V vs. Li^+/Li at the current density of 60 mAg^{-1}.

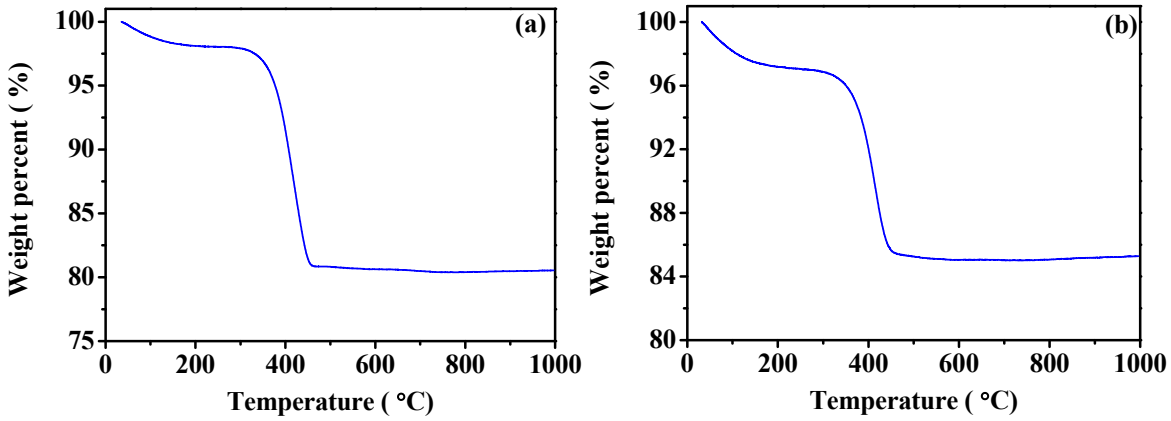

(a)
Weight percent (%)
100
95
90
85
80
75
0
200
400
600
800
1000
Temperature (°C)
(b)
Weight percent (%)
100
96
92
88
84
80
0
200
400
600
800
1000
Temperature (°C)

Fig. S1

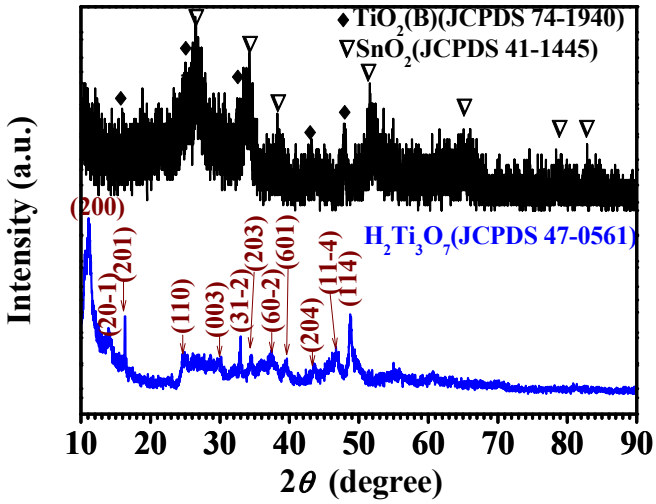

♦TiO2(B)(JCPDS 74-1940)
∇SnO2(JCPDS 41-1445)
H2Ti3O7(JCPDS 47-0561)
(200)
(20-1)
(201)
(110)
(003)
(31-2)
(203)
(60-2)
(601)
(204)
(11-4)
(114)
Intensity (a.u.)
10
20
30
40
50
60
70
80
90
2θ (degree)

Fig. S2

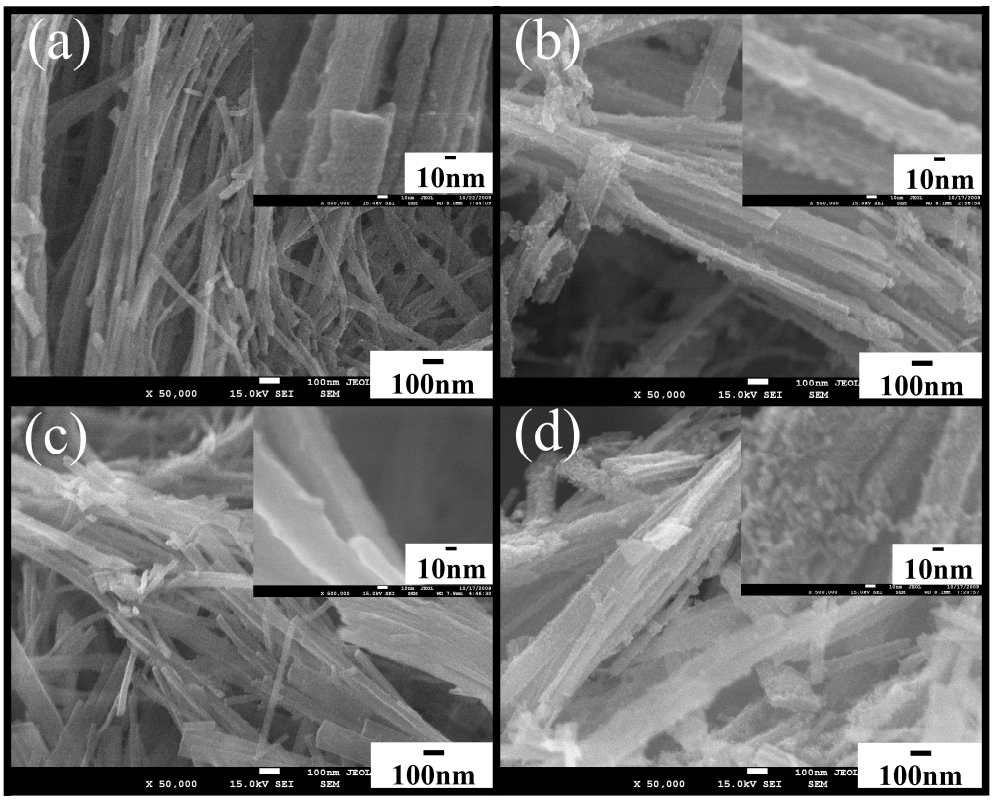

(a)
10nm
100nm
X 50,000 15.0kV SEI SEM
(b)
10nm
100nm
X 50,000 15.0kV SEI SEM
(c)
10nm
100nm
X 50,000 15.0kV SEI SEM
(d)
10nm
100nm
X 50,000 15.0kV SEI SEM

Fig. S3

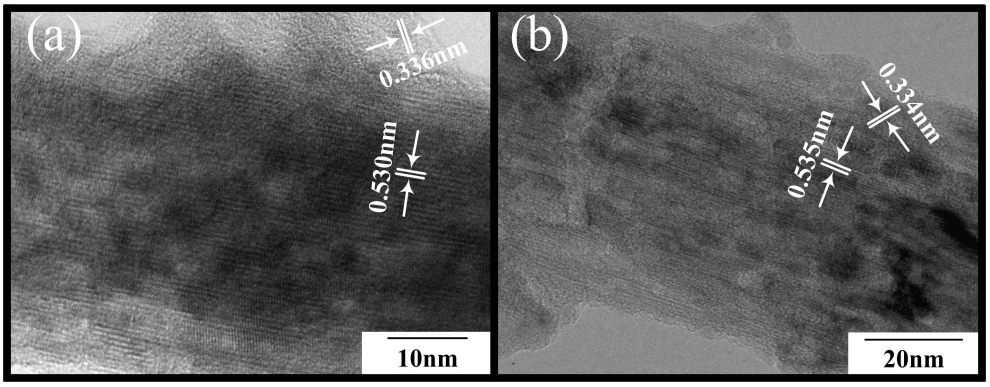


Fig. S4

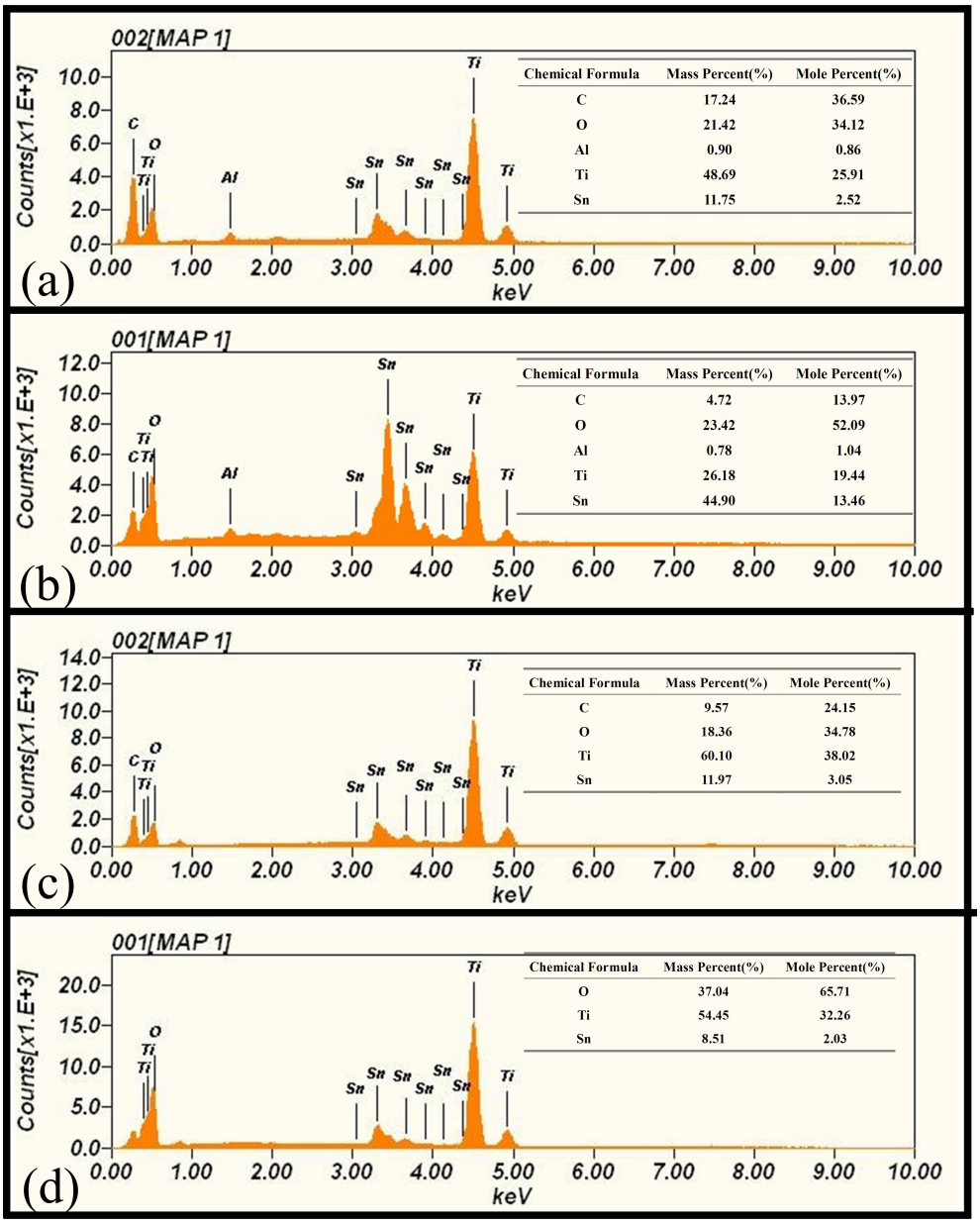
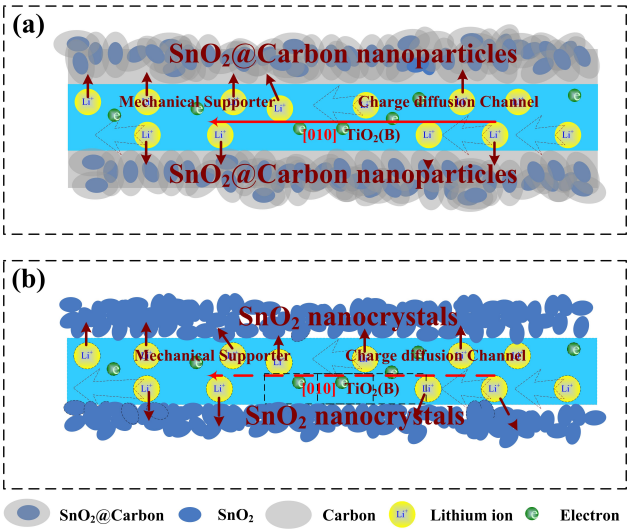

002[MAP 1]
Counts[x1.E+3]
keV
(a)
Chemical Formula | Mass Percent(%) | Mole Percent(%)
C | 17.24 | 36.59
O | 21.42 | 34.12
Al | 0.90 | 0.86
Ti | 48.69 | 25.91
Sn | 11.75 | 2.52
001[MAP 1]
(b)
Chemical Formula | Mass Percent(%) | Mole Percent(%)
C | 4.72 | 13.97
O | 23.42 | 52.09
Al | 0.78 | 1.04
Ti | 26.18 | 19.44
Sn | 44.90 | 13.46
002[MAP 1]
(c)
Chemical Formula | Mass Percent(%) | Mole Percent(%)
C | 9.57 | 24.15
O | 18.36 | 34.78
Ti | 60.10 | 38.02
Sn | 11.97 | 3.05
001[MAP 1]
(d)
Chemical Formula | Mass Percent(%) | Mole Percent(%)
O | 37.04 | 65.71
Ti | 54.45 | 32.26
Sn | 8.51 | 2.03

Fig. S5


(a)
SnO2@Carbon nanoparticles
Mechanical Supporter
Charge diffusion Channel
[010] TiO2(B)
SnO2@Carbon nanoparticles
(b)
SnO2 nanocrystals
Mechanical Supporter
Charge diffusion Channel
[010] TiO2(B)
SnO2 nanocrystals
SnO2@Carbon
SnO2
Carbon
Lithium ion
Electron

Scheme S1

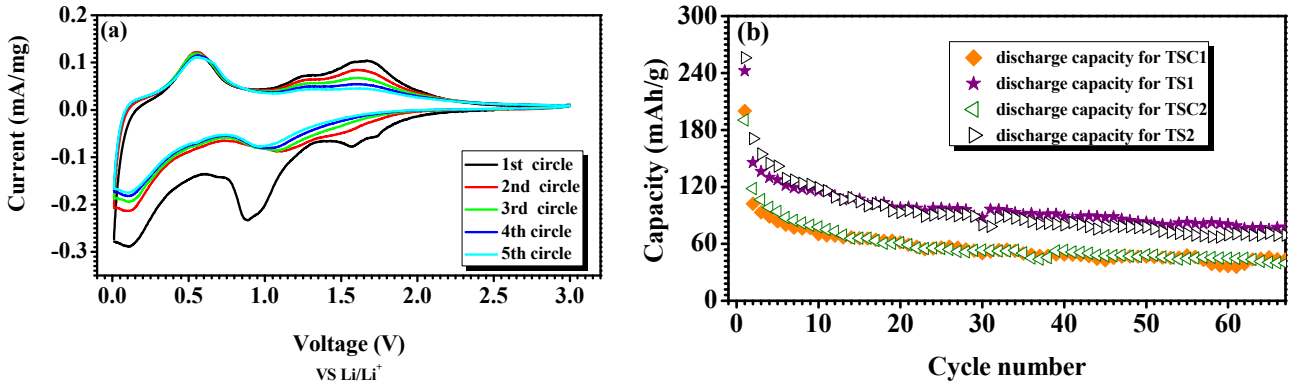

(a)
Current (mA/mg)
Voltage (V)
VS Li/Li+
1st circle
2nd circle
3rd circle
4th circle
5th circle
(b)
Capacity (mAh/g)
Cycle number
discharge capacity for TSC1
discharge capacity for TS1
discharge capacity for TSC2
discharge capacity for TS2

Fig. S6