Electronic Supplementary Information

Nanoscopically and uniformly distributed SnO_2@TiO_2/C composite with highly mesoporous structure and bichemical bonds for enhanced lithium ion storage performances†

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Table S1 The chemical composition of the TiO_2/C and SnO_2@TiO_2/C samples are from XPS results. The chemical composites of TOT and 0.2 g MO/1 g TOT are from molecule structure.

Samples	Ti (wt/at%)	Sn (wt/at%)	O (wt/at%)	C (wt/at%)	H (wt/at%)
TOT	19.8/2.6	0/0	21.5/8.8	49.5/27.2	9.2/61.4
TiO_2/C	36.0/13.6	0/0	25.5/28.7	38.5/57.7	0/0
MO/TOT	16.5/0.25	9.5/0.6	20.4/9.1	45.1/26.9	8.5/63.15
SnO_2@TiO_2/C	26.6/10.1	9.8/1.5	20.3/23.0	43.3/65.4	0/0

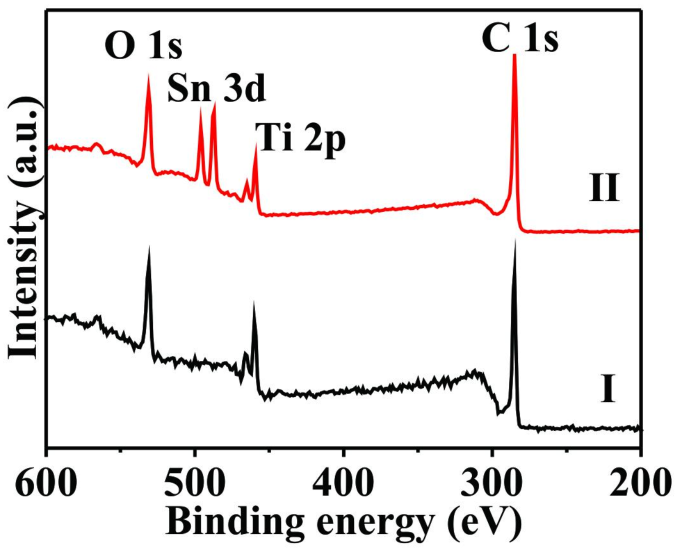

Fig. S1 XPS survey peaks of the obtained samples.

Table S2 The percentages of Ti-O-C and Sn-O-C bonds in the samples calculated by the XPS spectra of C 1s.

Samples	Ti-O-C (%)	C-O/Sn-O-C (%)
TiO_2/C	20.7	3.4 totally from C-O bonds due to absence of Sn
SnO_2@TiO_2/C	25.5	7.5

The percentages of Sn-O-C bonds in the SnO_2@TiO_2/C can be calculated by the total percentage minus C-O (2.9%) as 4.1%.

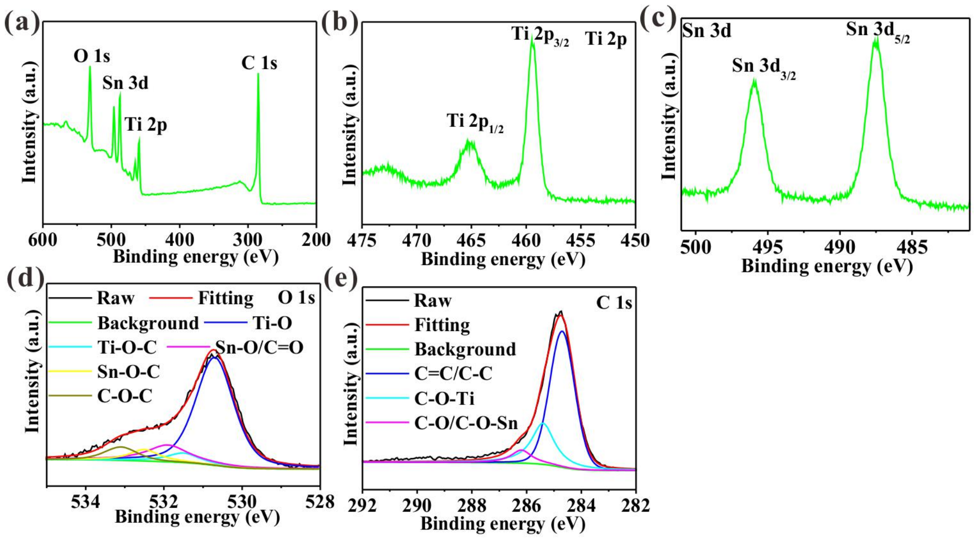

Fig. S2 (a) XPS survey peak, (b-e) XPS spectra of Ti 2p (b), Sn 3d (c), O 1s (d), and C 1s (e) of SnO_2@TiO_2/C.

The percentages of Ti-O-C bonds and C-O/Sn-O-C bonds are about 26.1% and 7.1%, which are similar with the results of SnO_2@TiO_2/C in Table S2, suggesting that the Ti-O-C and Sn-O-C bonds are uniformly distributed in the whole SnO_2@TiO_2/C.

Table S3 Chemical composition of the obtained samples. The mass percentages of Ti and Sn were obtained from ICP-AES. The mass percentage of O was calculated from TiO_2 and SnO_2 based on the mass of Ti and Sn. The mass percentages of C is calculated as a difference between 100wt% and mass percentages of Ti, Sn, and O.

Samples	Ti (wt%)	Sn (wt%)	O (wt%)	C (wt%)
TiO_2/C	50.3	0	33.6	16.1
SnO_2@TiO_2/C	36.8	10.2	27.3	25.7

Table S4 The electrical conductivity (EC, S/cm), carbon content (wt%) and chemical bond content of the samples.

Samples	EC	Carbon content	Sn-O-C	Ti-O-C
TiO_2/C	7.8x10^0	16.1	0	20.7
SnO_2@TiO_2/C	9.1x10^2	25.7	4.1	25.5

Table S5 The charge capacity (mAh g^{-1}) and charge capacity retention (%) after 100 cycles of the samples.

Samples	First capacity	Final capacity	Capacity retention
TiO_2/C	165.3	169.6	102.6
SnO_2@TiO_2/C	823.4	830.7	100.9

Table S6 Electrochemical performances of TiO_2-based materials for LIB anodes in open reports. C_C-charge capacity after cycling (mAh g^{-1}), C_R-capacity retention (%), M_L-mass loading (mg cm^{-2}), J-current density (C or A g^{-1}), N_C-cycle number, NA-not available. 1 C indicates the current density when the anodes are charged to the theoretical capacity in one hour.

Samples	C_C	C_R	M_L	J	N_C	References
SnO_2@TiO_2/C	**830.7**	**100.9**	**1.2**	**0.5 C**	**100**	**This work**
SnO_2@TiO_2/C	**438.5**	**96.0**	**1.2**	**10 C**	**1000**	**This work**
SnO_2@TiO_2/C	**217.7**	**NA**	**1.2**	**50 C**	**NA**	**This work**
2S-AB-TiO_2-HoMS	215.4	76.4	1.5-2	1 C	100	Adv. Mater. 31 (2019) 1805754
2S-AB-TiO_2-HoMS	125.7	70	1.5-2	20 C	1000	Adv. Mater. 31 (2019) 1805754
TiO_2-B nanowires	192.4	68.7	NA	10 C	3600	J. Mater. Chem. A 7 (2019) 3842-3847
CNF-S@TiO_2	607	90	NA	0.2 A g^{-1}	150	Small (2019) 1902201
N-doped carbon@ TiO_2 nanoparticles	223.1	94.5	0.5-0.8	1 C	200	J. Power Sources 420 (2019) 38–45
S-doped carbon@TiO_2	440	81.2	1.5	0.2 A g^{-1}	200	Energy Storage Mater. 13 (2018) 215–222
S-doped carbon@TiO_2	215	64.6	1.5	2 A g^{-1}	1000	Energy Storage Mater. 13 (2018) 215–222
TiO_2 films	254	76.9	NA	0.33 C	200	Adv. Funct. Mater. 28 (2018) 1801849
TiO_2 (A)/TiO_2 (B)	260.1	98	NA	1 C	500	Adv. Funct. Mater. 27 (2017) 1703270
$TiO_{2-\delta}$/Ti nanomembranes	135	~100	0.5	10 C	5000	ACS Nano 11 (2017) 821−830
N-doped a-TiO_2	100	NA	NA	10 C	NA	J. Mater. Chem. A 5 (2017) 20651-20657
TiO_2-CNT	215	~100	2-3	2 C	200	Nano Energy 35 (2017) 44–51
TiO_2 (B)-BH	186.6	~100	0.8-1	5 C	1000	Nano Energy 31 (2017) 1–8

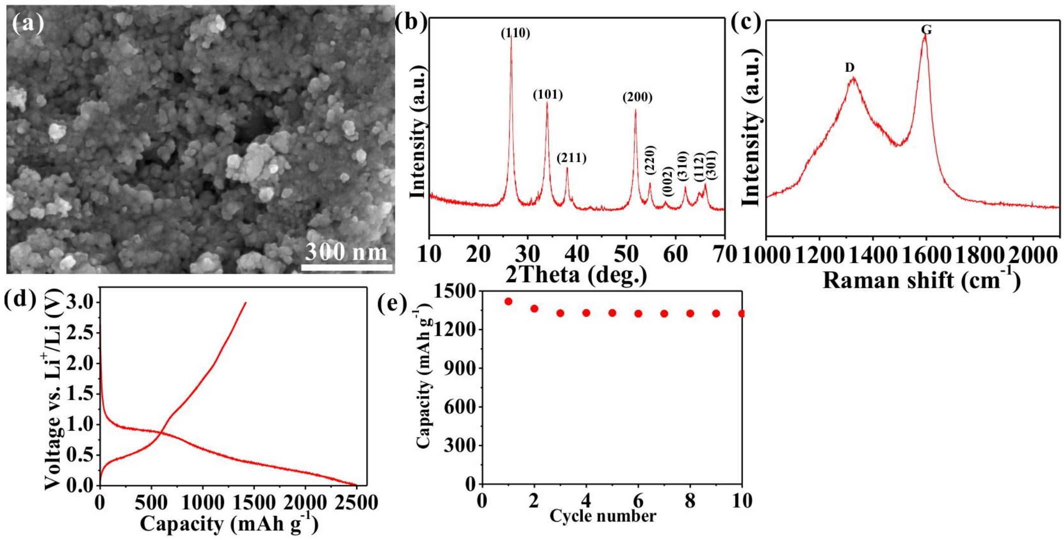

Fig. S3 (a) SEM image, (b) XRD pattern, (c) Raman spectrum, (d) First charge and discharge curves, and (e) Cycling performance of the sample obtained by pyrolysis of MO in the sealed vessel.

From SEM image (Fig. S3a), the sample is composed of nanoparticles with an average size of about 30 nm. From XRD pattern (Fig. S3b), the sample shows a series of diffraction peaks of SnO_2 (JCPDS No. 41-1445), indicating that the sample contains SnO_2 nanocrystals. From Raman spectrum (Fig. S3c), the sample shows typical D and G peaks of carbon material, indicating the presence of free carbon. The above results indicate the sample contains SnO_2 and C, labeled as SnO_2/C nanocomposite. Fig. S4d and e show the SnO_2/C nanocomposite has a high reversible capacity of 1419.5 mAh g^{-1}.

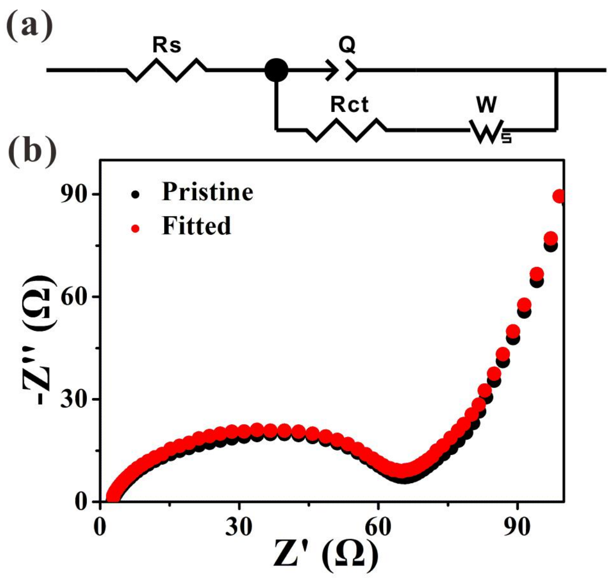

Fig. S4 Fitted equivalent circuit (a) and corresponding fitting spectra of EIS after the 100th cycle (b).

Table S7 The EIS parameters during cycling.

Cycling number	R_s (Ω)	R_{ct} (Ω)
before cycling	1.9	85.9
after the 1st cycle	2.2	103.4
after the 10th cycle	2.4	79.5
After the 100th cycle	2.7	64.7

Table S8 Rate capability of different kinds of materials for LIB anode in open reports. C_C-charge capacity (mAh g^{-1}), J-current density (C or A g^{-1}). 1 C indicates the current density when the anodes are charged to the theoretical capacity in one hour.

Samples	C_C	J	References
SnO_2@TiO_2/C	**516.8**	**5 C**	**This work**
SnO_2@TiO_2/C	**333.5**	**20 C**	**This work**
SnO_2@TiO_2/C	**217.7**	**50 C**	**This work**
Sn hybrid composite	150	20 C	Nano Lett. 18 (2018) 467-474.
$Nb_{18}W_{16}O_{93}$	70	100 C	Nature 559 (2018) 556-563.
Si-nanolayer-embedded graphite/carbon hybrids	222.3	5 C	Nat. Energy 1 (2016) 16113.
SiO_x/SiO_y nanomembrane	4	10 A g^{-1}	Adv. Mater. 26 (2014) 4527-4532.
Si nanotube	540	20 C	Nat. Nanotechnol. 7 (2012) 310-315.
$Li_4Ti_5O_{12}$ nanowire	119.4	30 C	Adv. Mater. 24 (2012) 6502-6506.

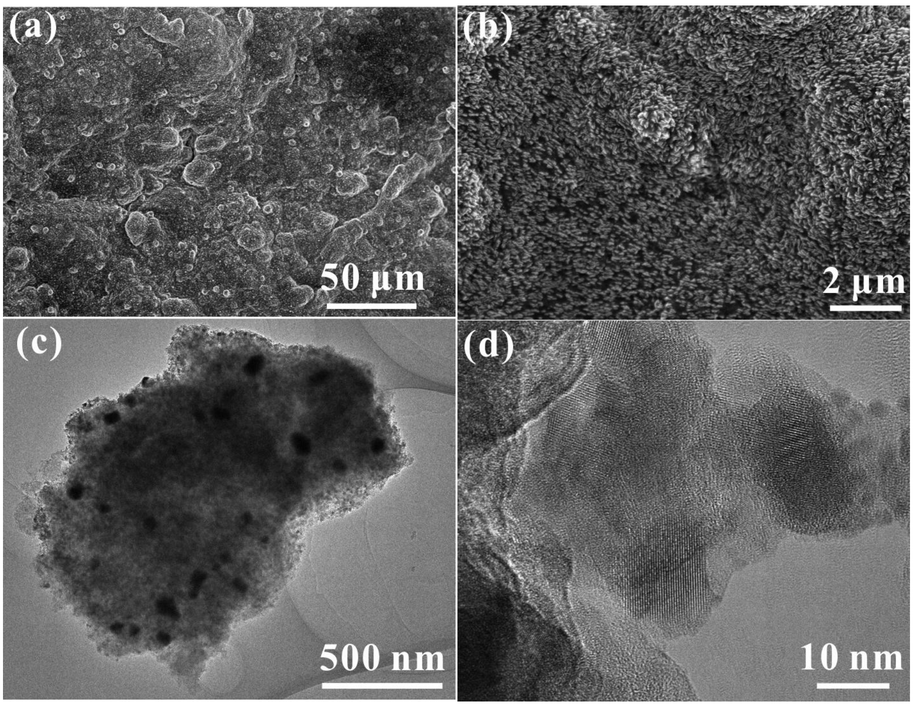

Fig. S5 (a,b) SEM images, (c) TEM images, and (d) HRTEM image of SnO_2@TiO_2/C nanocomposites.