

Supplementary Materials

High-Rate One-Dimensional α -MnO₂ Anode for Lithium-Ion Batteries: Impact of Polymorphic and Crystallographic Features on Lithium Storage

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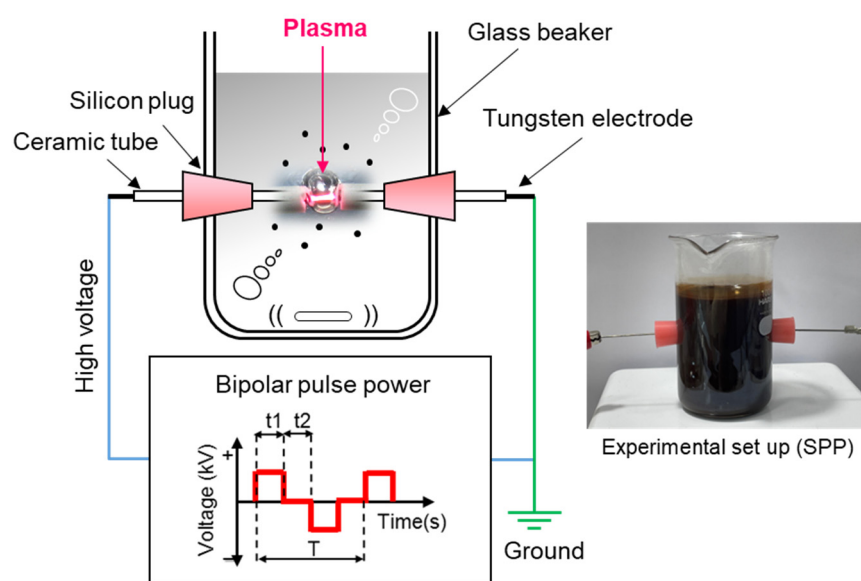


Figure S1 Experimental set-up of solution plasma process (SPP)

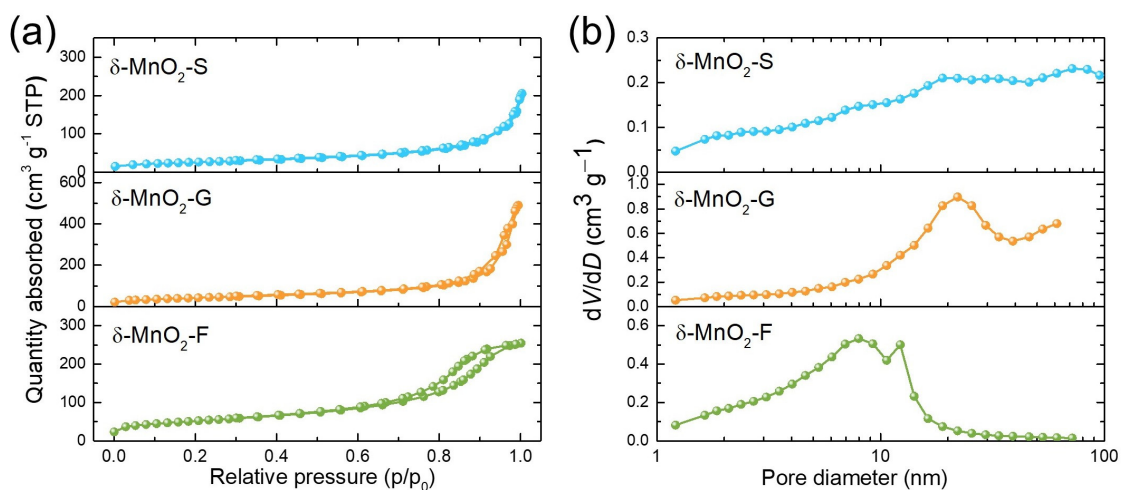


Figure S2 (a) Specific surface area and (b) pore size distribution of δ -MnO₂ particles.

Table S1 Summary of SSA, pore size and volume of δ -MnO₂ particles.

Sample	Specific surface area (m ² g ⁻¹)	Pore volume (cm ³ g ⁻¹)	Avg. pore size (nm)
δ -MnO ₂ -S	83.8	0.31	14.4
δ -MnO ₂ -G	139.4	0.75	20.9
δ -MnO ₂ -F	165.9	0.38	9.0

Table S2. Galvanostatic discharge/charge capacity for initial and second cycle for δ -MnO₂ electrodes.

		Specific discharge capacity (mAh g ⁻¹)		
		δ -MnO ₂ -S	δ -MnO ₂ -G	δ -MnO ₂ -F
Initial cycle	Dch.	1689	2050	1856
	Char.	1090	1160	556
	I.C.E (%)	64.5	56.6	30.0
Second cycle	Dch.	1131	1214	611
	Char.	1044	1089	517
	C.E (%)	92.3	89.7	84.6

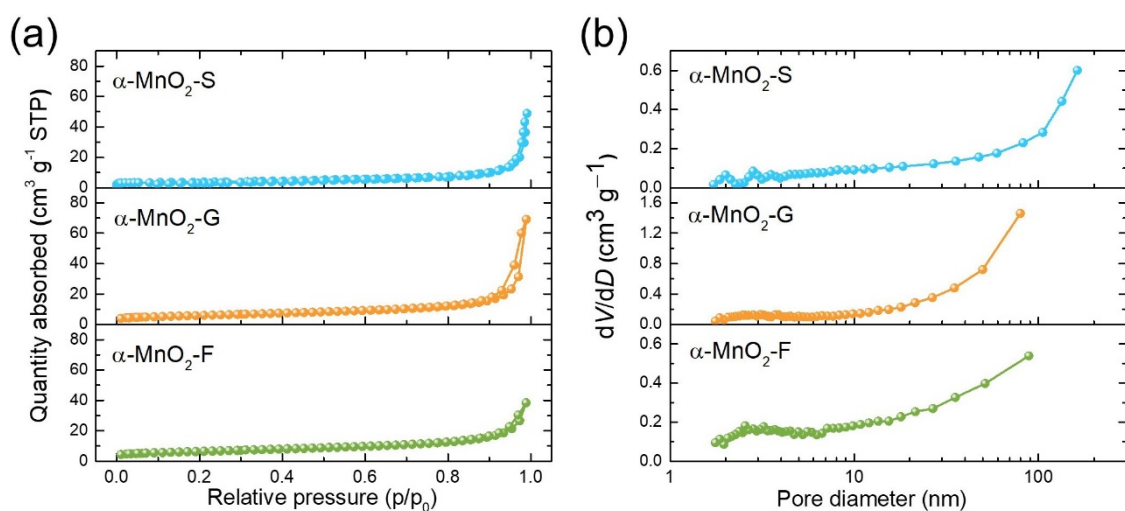


Figure S3 (a) Specific surface area and (b) pore size distribution of α -MnO₂ particles.

Table S3 Summary of SSA, pore size and volume of α -MnO₂ particles.

Sample	Specific surface area (m ² g ⁻¹)	Pore volume (cm ³ g ⁻¹)	Avg. pore size (nm)
α -MnO ₂ -S	21.3	0.18	33.1
α -MnO ₂ -G	20.6	0.11	20.8
α -MnO ₂ -F	21.7	0.06	10.9

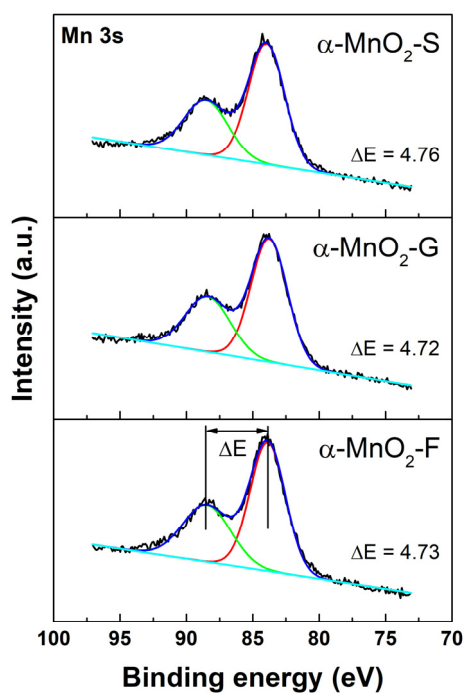


Figure S4 XPS spectrum of Mn 3s for α -MnO₂-S, α -MnO₂-G and α -MnO₂-F

Table S4. Galvanostatic discharge/charge capacity for initial, second and third cycle for α -MnO₂ electrodes.

		Specific discharge capacity (mAh g ⁻¹)		
		α -MnO ₂ -S	α -MnO ₂ -G	α -MnO ₂ -F
Initial cycle	Dch.	1744	1654	1626
	Char.	1260	1004	680
	I.C.E (%)	72.2	60.7	41.8
Second cycle	Dch.	1287	1026	709
	Char.	1251	997	638
	C.E (%)	97.2	97.2	90.0
Third cycle	Dch.	1294	1027	664
	Char.	1248	989	612
	C.E (%)	96.4	96.3	92.2

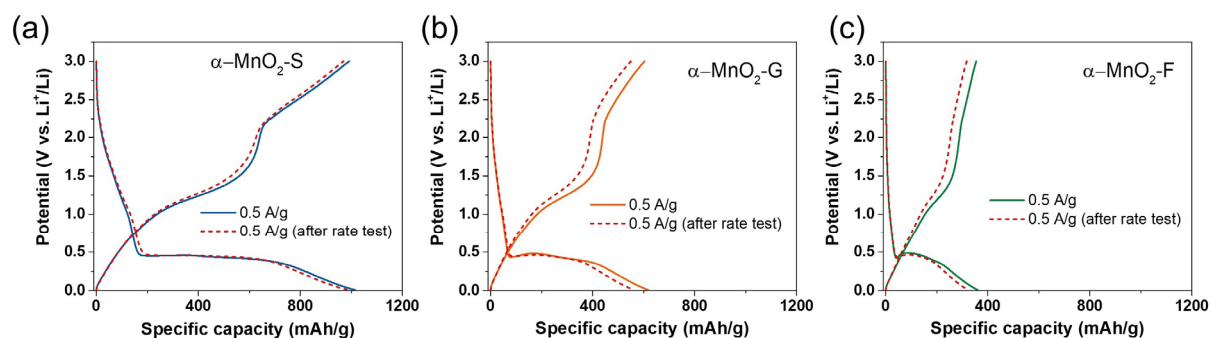


Figure S5 Comparison of galvanostatic discharge-charge curves for initial (solid line) and after rate test (dashed line) at current density of 0.5 A g^{-1} of (a) $\alpha\text{-MnO}_2\text{-S}$, (b) $\alpha\text{-MnO}_2\text{-G}$ and (c) $\alpha\text{-MnO}_2\text{-F}$.

Table S5 Specific discharge capacity in third cycle of $\alpha\text{-MnO}_2$ electrodes at various current density.

Current Density (A g^{-1})	Specific discharge capacity (mAh g^{-1})			Rate capability % (relative retention) (Rate/0.1 C)		
	$\alpha\text{-MnO}_2\text{-S}$	$\alpha\text{-MnO}_2\text{-G}$	$\alpha\text{-MnO}_2\text{-F}$	$\alpha\text{-MnO}_2\text{-S}$	$\alpha\text{-MnO}_2\text{-G}$	$\alpha\text{-MnO}_2\text{-F}$
0.1	1294	1027	664	100	100	100
0.2	1186	828	476	91.7	80.6	71.7
0.5	1014	618	361	78.4	60.2	54.4
1	845	470	283	65.3	45.8	42.6
2	673	353	215	52.0	34.4	32.4
0.5	987	556	321	76.3	54.1	48.3

Table S6. Summary of impedance parameters: Ohmic (R_s), charge transfer (R_{ct}) and Warburg coefficient (σ) of α -MnO₂ electrodes.

	R_s (ohm)	R_{ct} (ohm)	σ ($\Omega \text{ s}^{-1/2}$)
α -MnO ₂ -S	1.8	32.5	7.3
α -MnO ₂ -G	2.0	46.3	10.2
α -MnO ₂ -F	1.6	49.5	15.8

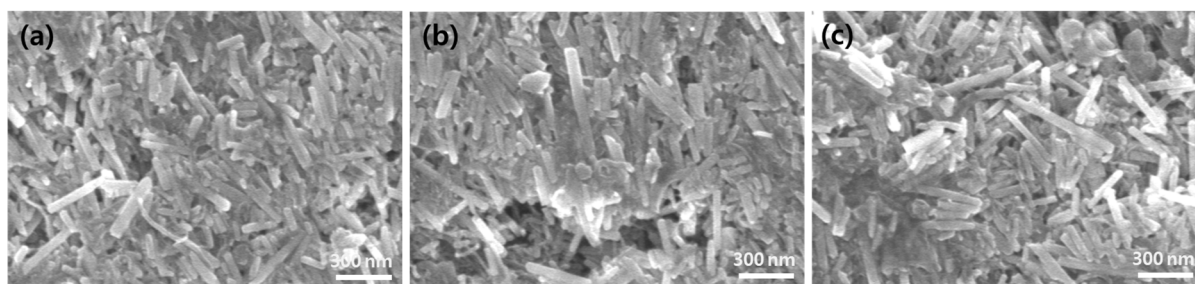


Figure S6 FE-SEM images of cycled electrodes for (a) α -MnO₂-S, (b) α -MnO₂-G and (c) α -MnO₂-F.

Table S7. Summary of cyclability and rate performance of MnO_x and carbon composites anodes for LIBs

Electrode materials	Rate performance (mAh g ⁻¹)	Ref.
MnO₂/3D-rGO	380 (1 A/g)	Ref 1
δ-MnO₂ nanoscrolls/RGO	226 (1A/g)	Ref 2
Nanostructured MnO₂	464 (2 A/g)	Ref 3
MnO₂-3D Porous	433 (1.6 A/g)	Ref 4
MCM-MnO₂	65 (2.4 A/g)	Ref 5
MnO₂/VACNTs (vertically aligned carbon nanotubes)	414 (2 A/g)	Ref 6
NiCo₂O₄@MnO₂	398 (1.6 A/g)	Ref 7
MnO₂@HCN (Hollow carbon nanosphere)	150 (2 A/g)	Ref 8
Mn₂O₃	528.4 (2 A/g)	Ref 9
α-MnO₂/graphene	340 (2 A/g)	Ref 10
MnO_x@C	670 (2A/g)	Ref 11
δ-MnO₂/C	212 (1.5 A/g)	Ref 12
SnO₂@MnO₂@graphite nanosheet	621.6 (2 A/g)	Ref 13
MnO₂-polypyrrole nanorods	475 (2 A/g)	Ref 14
MnO₂ nanosheets	576 (2 A/g)	Ref 15
Fe₃O₄@C@MnO₂	445 (2 A/g)	Ref 16
Mn₃O₄/NHC (N-doped honeycomb carbon)	472 (2 A/g)	Ref 17
MnO₂ nanorods	498.2 (1 A/g)	Ref 18
MnO₂@Fe₂O₃ composite	583.1 (1.6 A/g)	Ref 19
α-MnO₂-S	673 (2 A/g)	This work
α-MnO₂-G	353 (2 A/g)	This work
α-MnO₂-F	215 (2 A/g)	This work

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