Electronic Supplementary Material (ESI) for Nanoscale Advances.

Supporting Information

Zero-strain strategy incorporating TaC with Ta_2O_5 to enhance its rate capacity for long-term lithium storage

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Li^+ Diffusion coefficient (D_{2Li}) calculated by EIS:

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

where R is the gas constant, T is the absolute temperature, A is the surface area of the anode electrode, n is the number of electrons per molecule during oxidization, F is the Faraday constant, C is the ion concentration, σ is Warburg parameter.

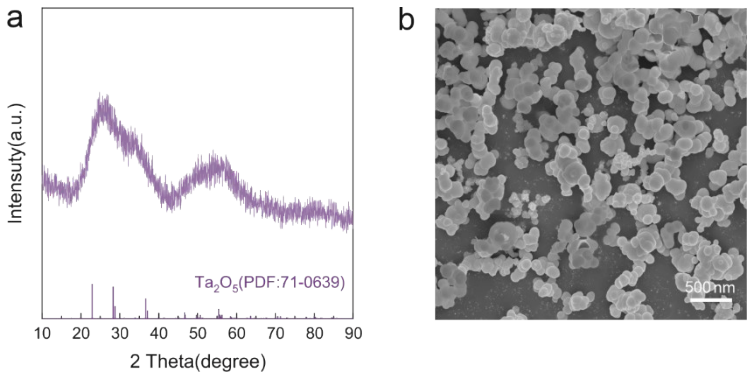

Fig. S1 (a) XRD pattern, and (b) SEM images of amorphous Ta_2O_5@PF hybrid nanospheres.

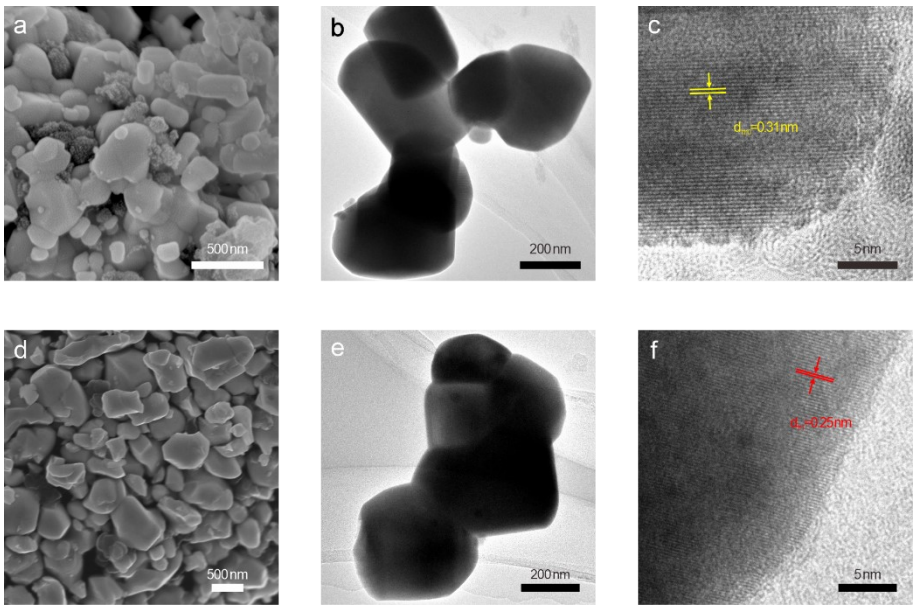

Fig. S2 (a) SEM, (b) TEM, and (c) HRTEM images of Ta_2O_5. (d) SEM, (e) TEM, and (f) HRTEM images of TaC.

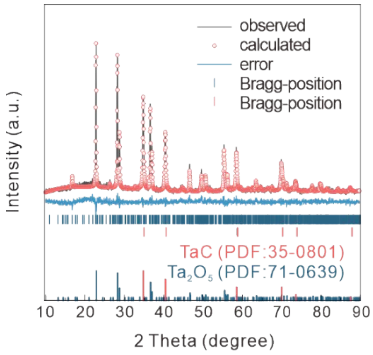

Fig. S3 a) XRD patterns of Ta_2O_5/TaC.

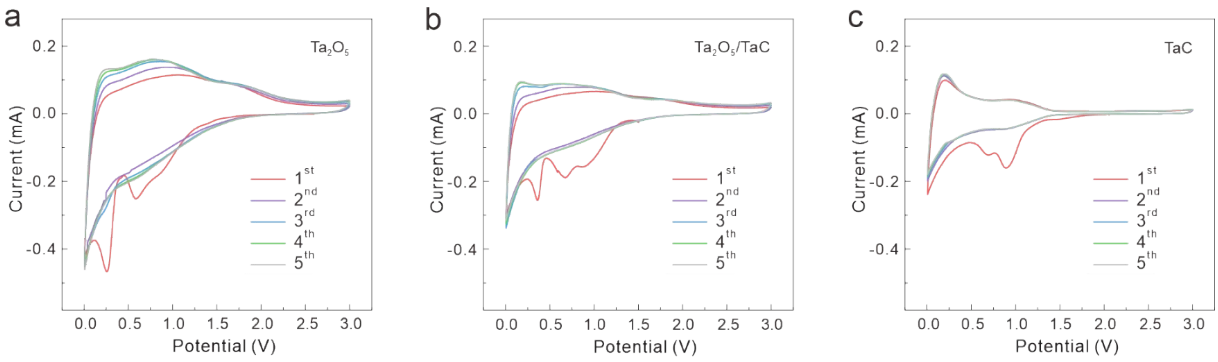

Fig. S4 CV curves of the a) Ta_2O_5, b) Ta_2O_5/TaC, and c) TaC anode at a scan speed of 0.2 mV s^{-1} for 5 consecutive cycles.

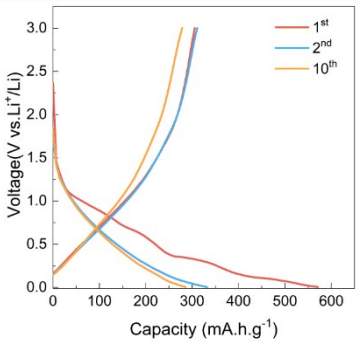

Fig. S5 The discharge/charge profiles of Ta_2O_5/TaC during the first ten cycles.

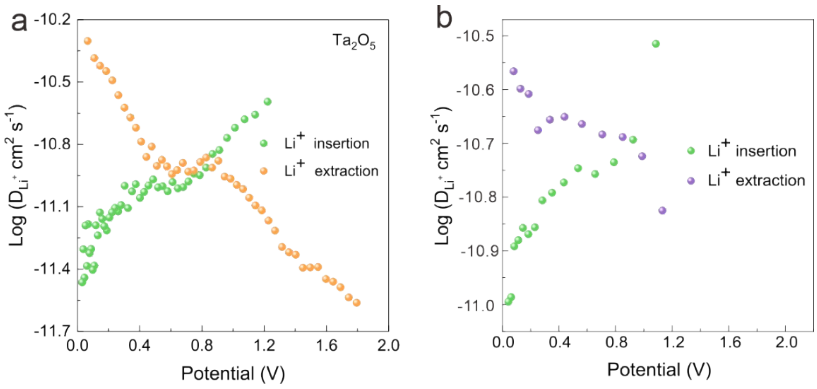

Fig. S6 The calculated D_{1Li+} from GITT curves of a) Ta_2O_5, b) TaC

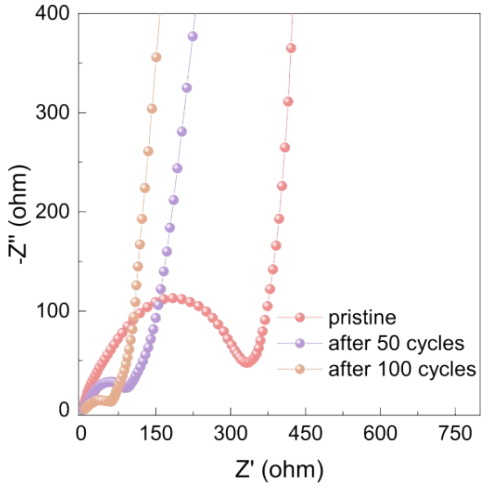

Fig. S7 Nyquist plots of Ta_2O_5/TaC anode in charging state for 50th and 100th cycles as well as before cycling.

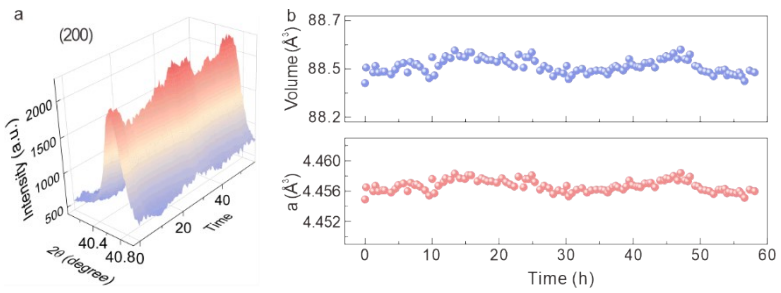

Fig. S8 a) 3D plot of selected in situ XRD patterns in the 2-theta range of 40.01 ~ 40.98˚. b) The change of lattice parameters for TaC during the initial two cycles.

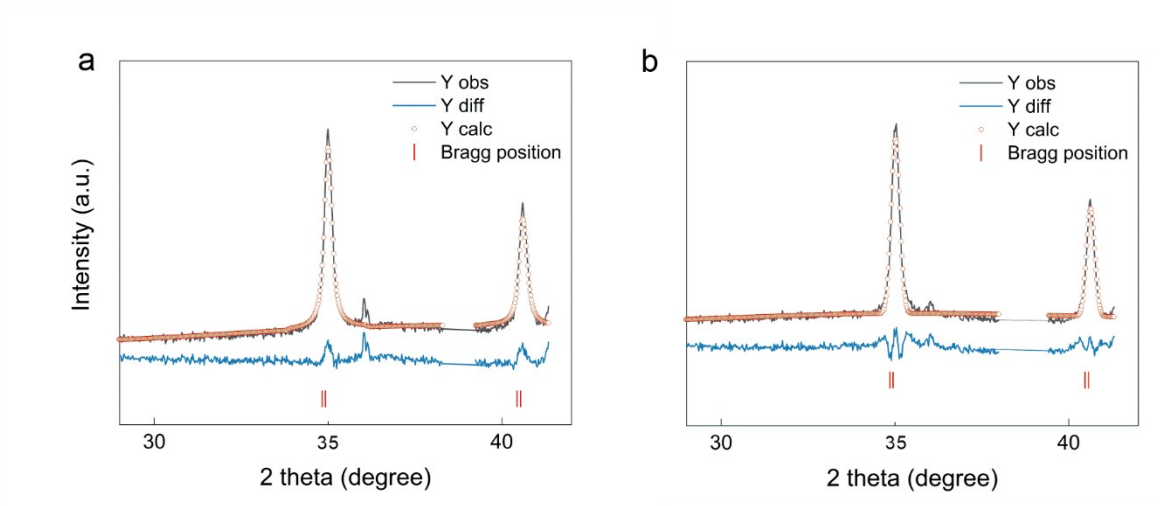

Fig. S9 Representative *in-situ* XRD patterns of Ta_2O_5/TaC in situ cell with Rietveld refinements at (a) 0.01 V (the end of second discharge) and (b) 3.0 V (the end of second charge). The peak at ~ 38.7˚originates from the Be window (see Fig. 5a), and was deleted during the refinement process.

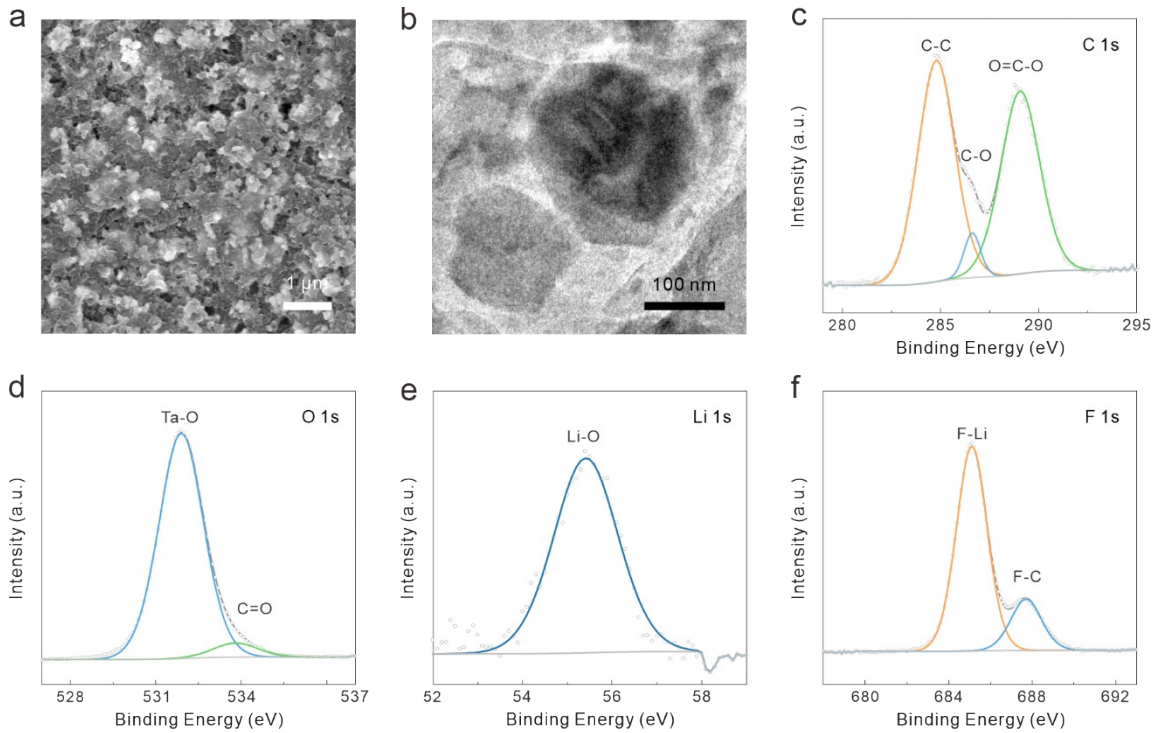

Fig. S10 (a) Low magnification FESEM image, and (b) TEM image of the Ta_2O_5/TaC electrode after 50 cycles. High-resolution XPS spectra of (c) C 1s, (d) O 1s (e) Li 1s, and (f) F 1s for Ta_2O_5/TaC electrode after being charged to 3 V.

Table. **S1** The calculated average D_{1Li} values

	Ta_2O_5	Ta_2O_5/TaC	TaC
Charge D_{1Li}	1.38×10^{-11}	2.26×10^{-11}	2.05×10^{-11}
Discharge D_{1Li}	9.54×10^{-12}	1.64×10^{-11}	1.61×10^{-11}

Table. **S2** Summary of R_s and R_{ct} calculated from EIS of Ta_2O_5, Ta_2O_5/TaC, and TaC anode.

	Ta_2O_5	Ta_2O_5/TaC	TaC
R_s (Ω)	8.2	3.7	7.2
R_{ct} (Ω)	400.0	351.8	255.4