

Supporting Information

A new family of cation-disordered Zn(Cu)-Si-P compounds as high-performance anodes for next-generation Li-ion batteries

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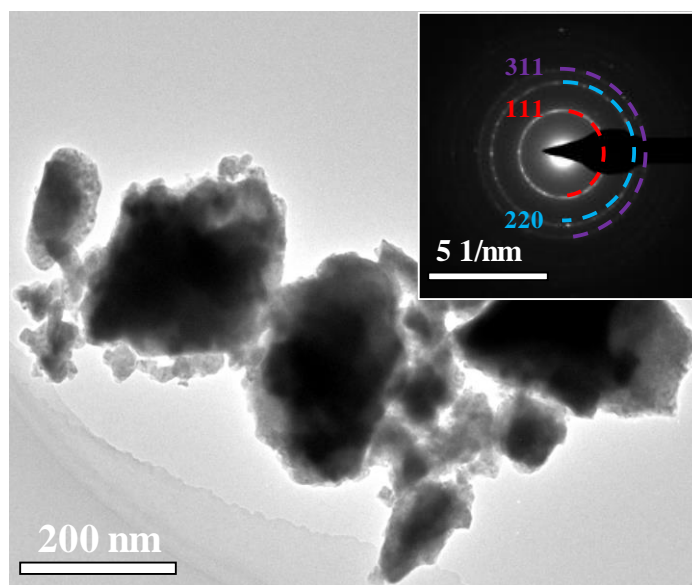
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Table S1. Crystallographic parameters and reliability factors for the cation-disordered ZnSiP₂ sample from XRD refinement.

Compound	ZnSiP ₂
Sp.Gr.	<i>F-43m</i>
<i>a</i> , Å	5.34025
<i>V</i> , Å ³	152.3
<i>2θ</i> -interval, °	5-120
Number of reflections	13
Rwp, %	7.23
Rp, %	8.9
Rexp, %	2.67
χ^2	1.62
RB, %	1.77

Table S2. Fractional atomic coordinates and isotropic displacement parameters (Å²) of ZnSiP₂.

	x	y	z	<i>B</i> _{iso}	Occ.
P	0.25	0.25	0.25	1	1
Si	0	0	0	1	0.5
Zn	0	0	0	1	0.5

**Figure S1.** TEM image and the selected area electron diffraction (SAED) pattern of the cation-disordered ZnSiP₂ powder.

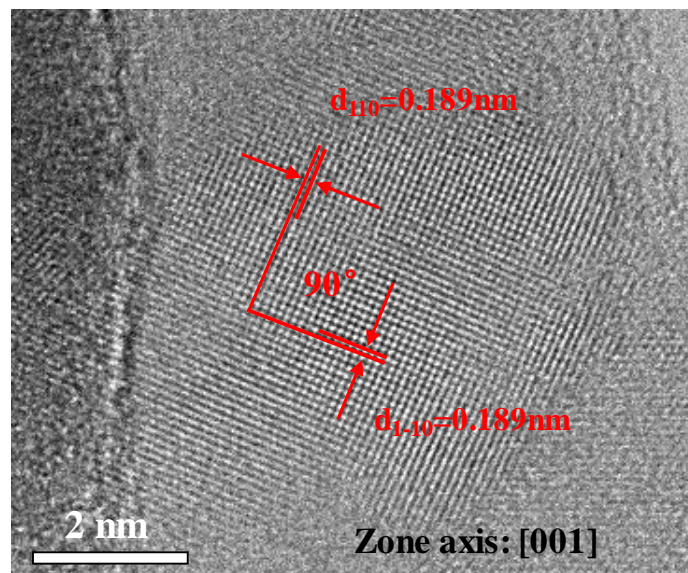


Figure S2. High-resolution TEM image of the cation-disordered ZnSiP_2 .

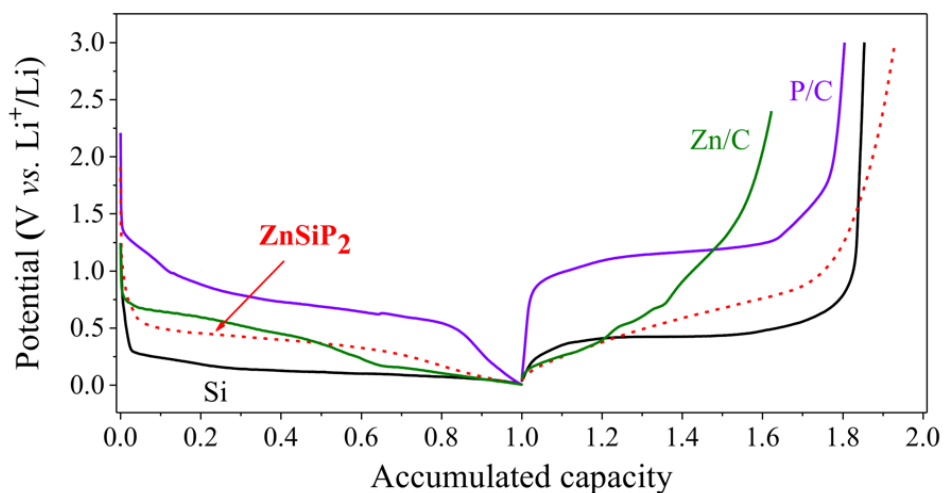


Figure S3. Discharge/charge profiles of the cation-disordered ZnSiP_2 , Zn/C, Si/C and P/C electrodes at a current density of 200 mA g^{-1} .

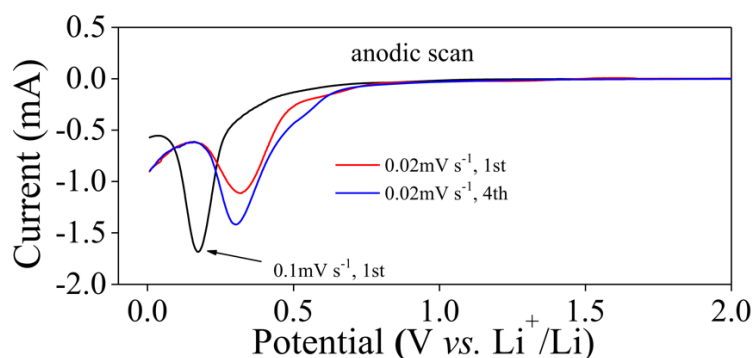


Figure S4. The initial anodic scan at different scan rates of the cation-disordered ZnSiP_2 anodes: black (Electrode 1), the initial anodic scan at a scan rate of 0.1 mV s^{-1} . Red (Electrode 2), the initial anodic scan at a scan rate of 0.02 mV s^{-1} ; blue (Electrode 2), the 4th anodic scan at a scan rate of 0.02 mV s^{-1} .

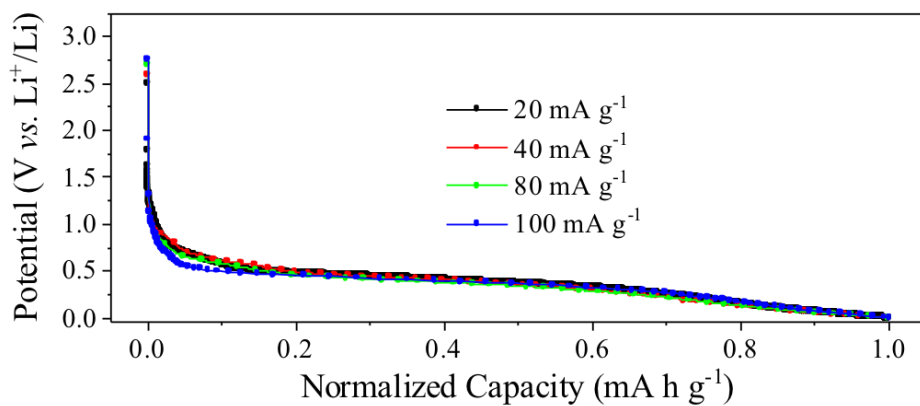


Figure S5. The initial discharge profiles of the ZnSiP₂ anodes cycled at ultralow current density of 20, 40, 80, and 100 mA g⁻¹.

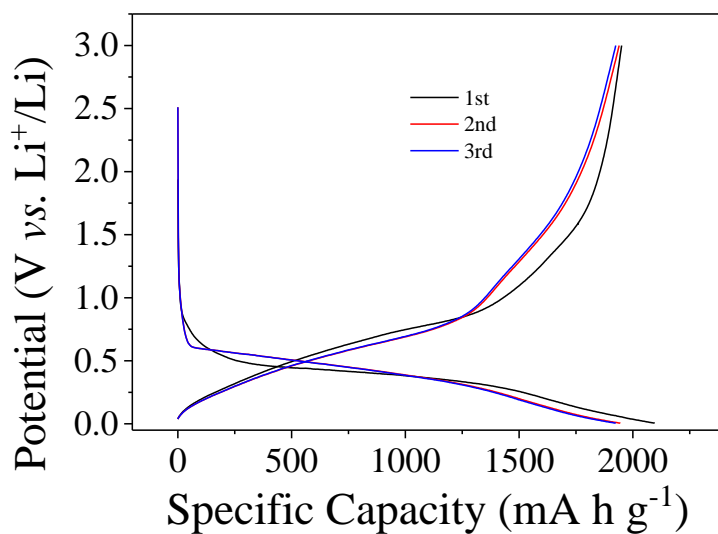


Figure S6. Initial three discharge/charge profiles of the cation-disordered ZnSiP₂ electrode at a current density of 200 mA g⁻¹

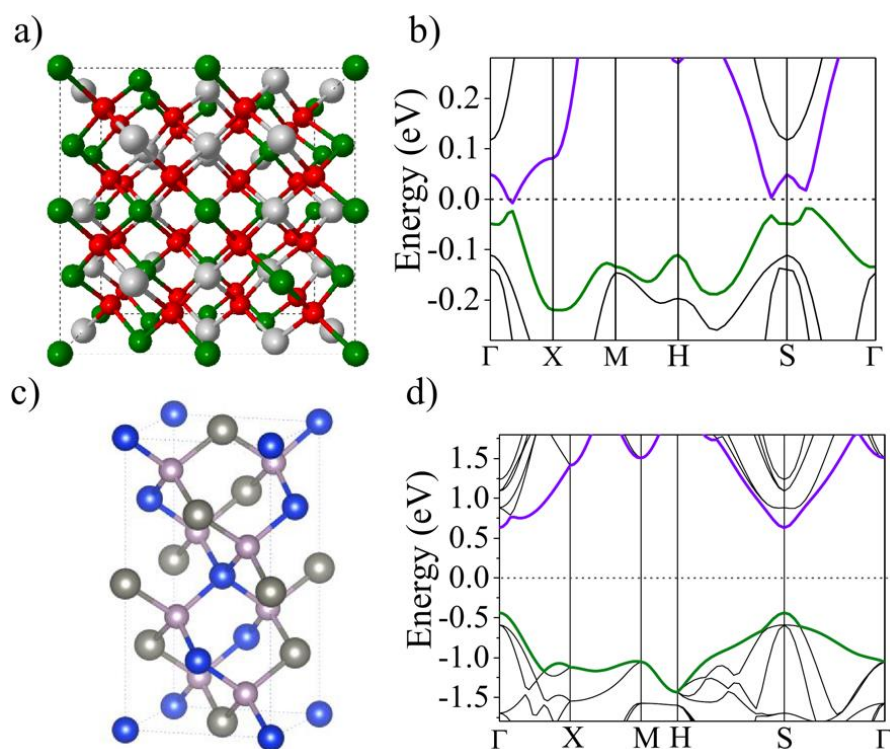


Figure S7. a) Schematic of the cation-disordered ZnSiP₂ crystal structure (red ball: P atom, gray white ball: Zn atom); b) the electronic structure based on the above model. c) the crystal structure model of the cation-ordered ZnSiP₂; d) the electronic structure of the cation-ordered ZnSiP₂.

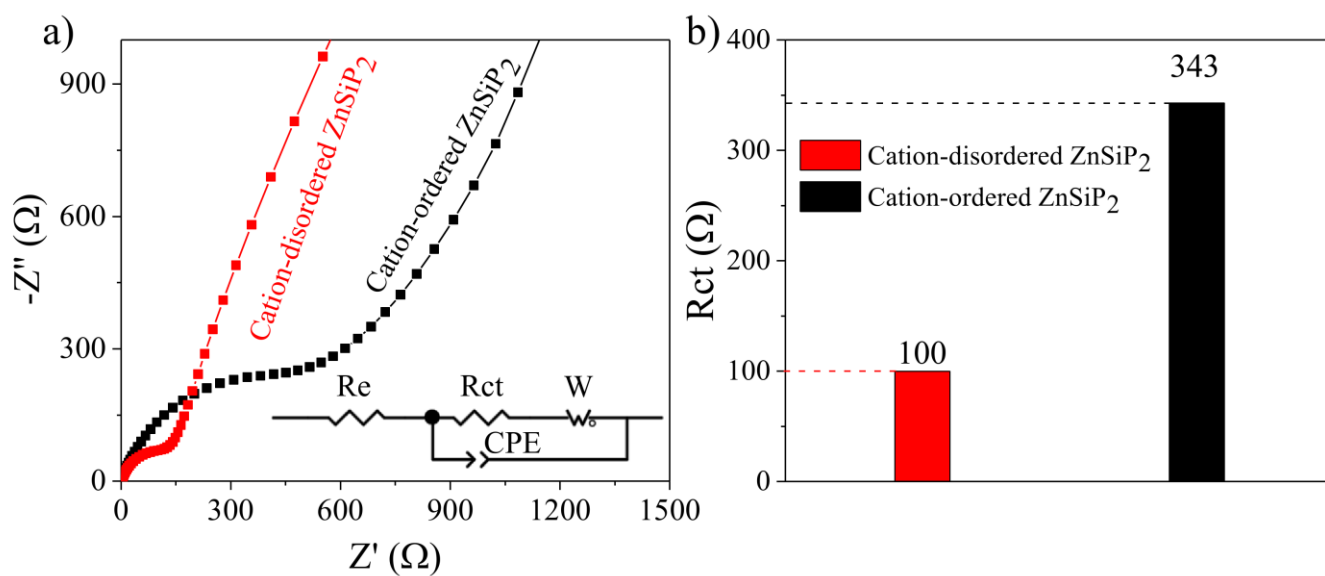


Figure S8. Electrochemical impedance spectroscopy study of a cation-disordered ZnSiP₂ electrode and a cation-ordered ZnSiP₂ electrode: a) impedance spectrum of a cell with a cation-disordered ZnSiP₂ electrode and that with a cation-ordered ZnSiP₂ electrode acquired under identical conditions, and b) charge transfer resistance (R_{ct}) determined from the impedance spectra shown in part a).

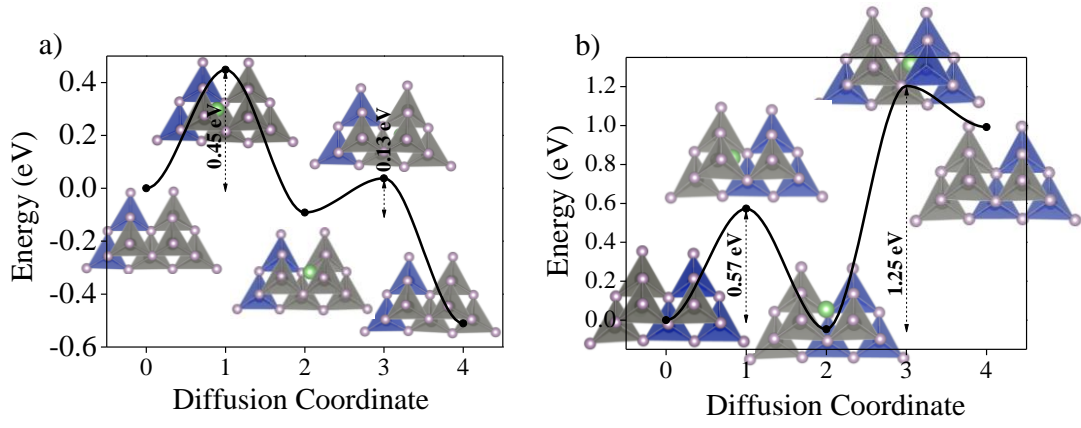


Figure S9. Li-ion diffusion barrier energy and its corresponding diffusion paths calculated based on the simulated model as shown in Figure S5a.

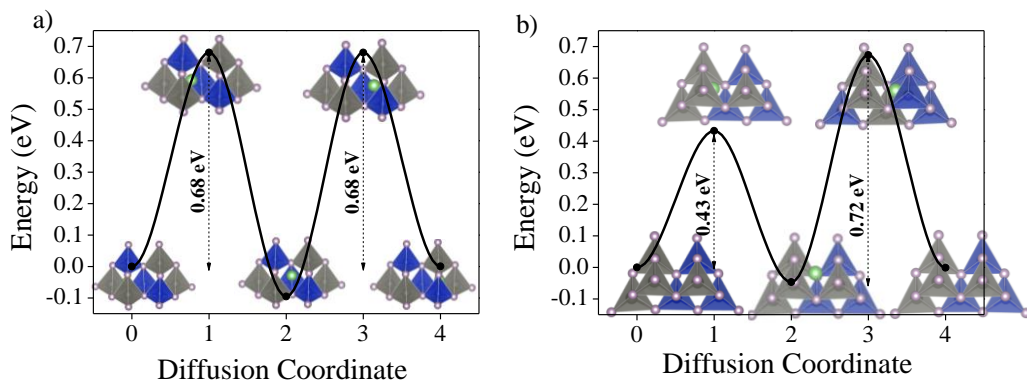


Figure S10. Li-ion diffusion barrier energy and its corresponding diffusion paths calculated based on the simulated model as shown in Figure S5c.

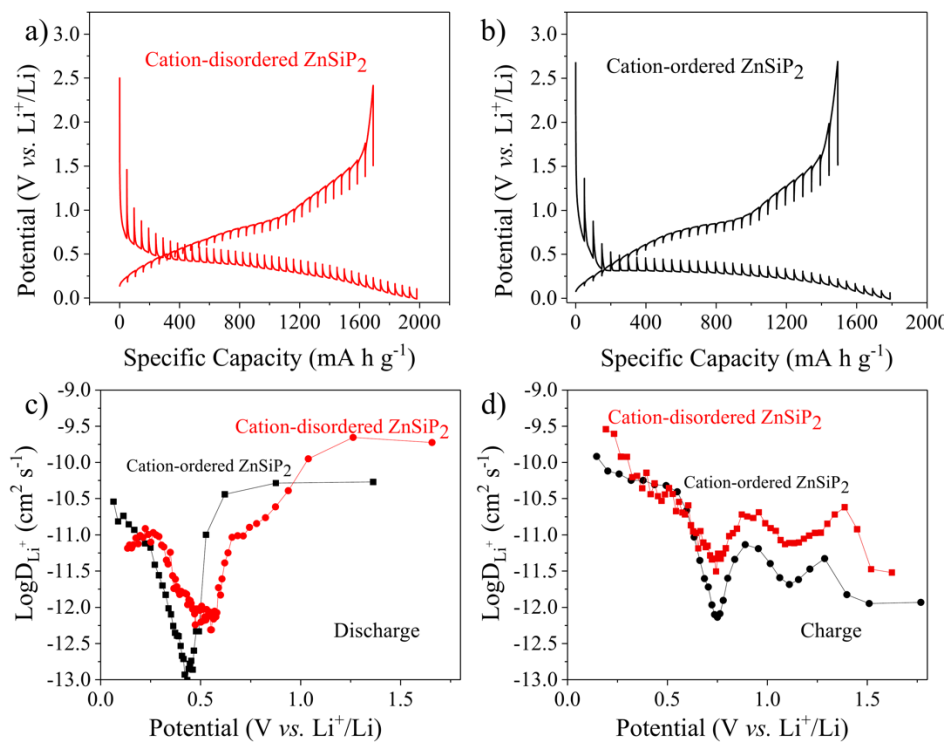


Figure S11. The cells were executed with a constant pulse for 30 min and then rest for 10 h: a) the initial discharge/charge profile of the cation-disordered ZnSiP₂ and b) the initial discharge/charge profile of the cation-ordered ZnSiP₂. Li-ion diffusion coefficients of the cation-disordered ZnSiP₂ and cation-ordered ZnSiP₂ anodes during discharge (c) and charge (d) processes.

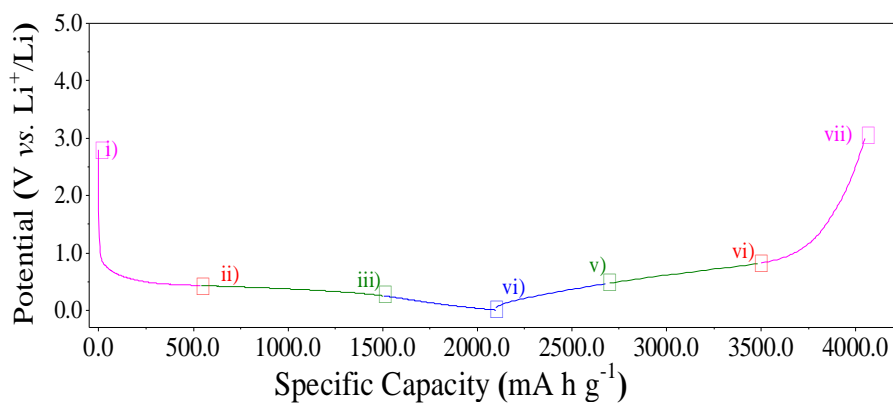


Figure S12. Discharge/charge profiles of the cation-disordered ZnSiP₂ used for ex-situ characterizations.

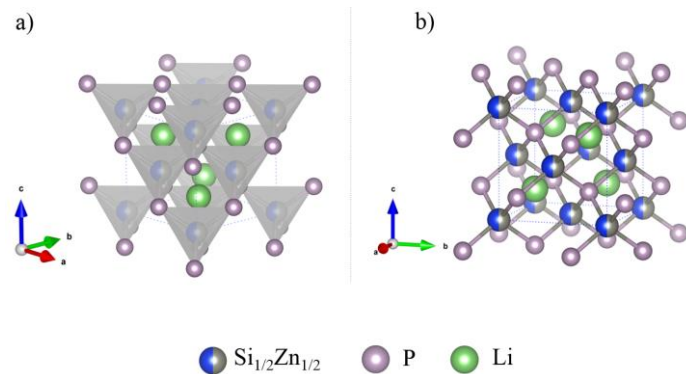


Figure S13. Schematic illustration of the voids suitable for Li-ion accommodation within the crystal structure of the cation-disordered $\text{Zn}_2\text{Si}_2\text{P}_4$ (one unit cell).

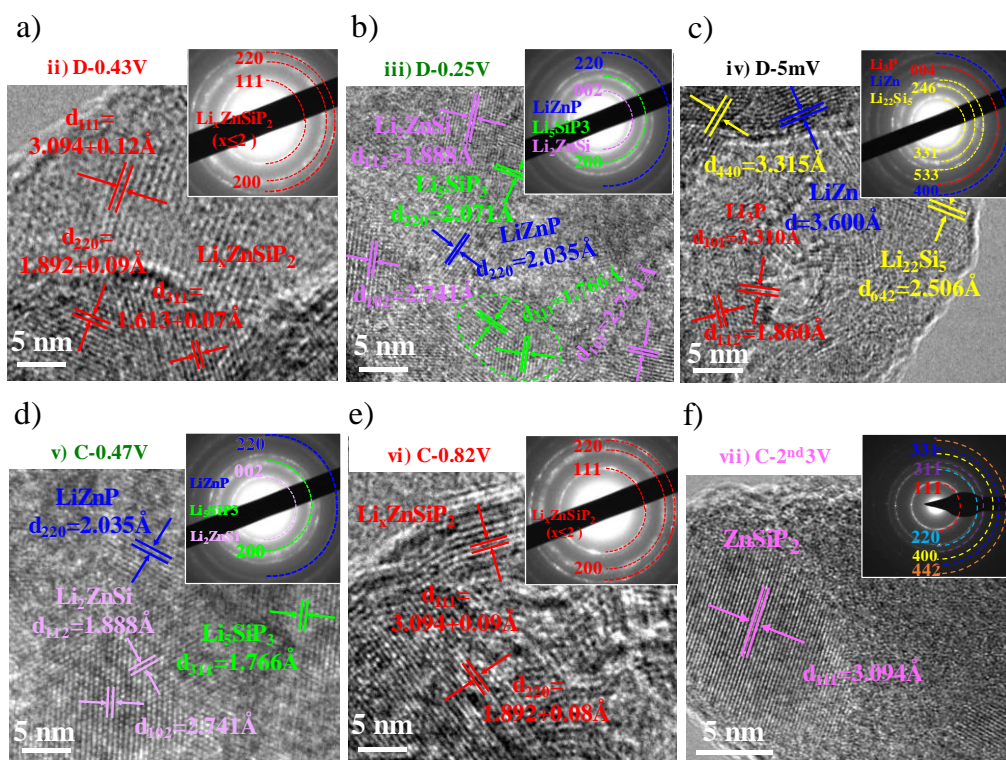


Figure S14. Ex-situ HRTEM and SAED patterns at the elected working potentials corresponding to Figure S9.

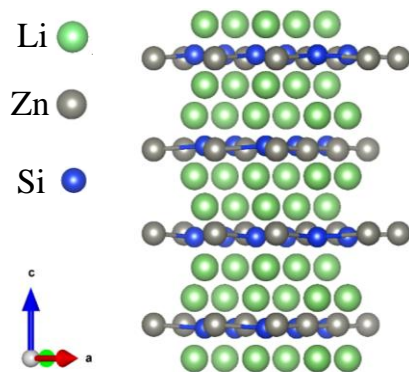


Figure S15. Schematic of the Li_2ZnSi crystal structure.

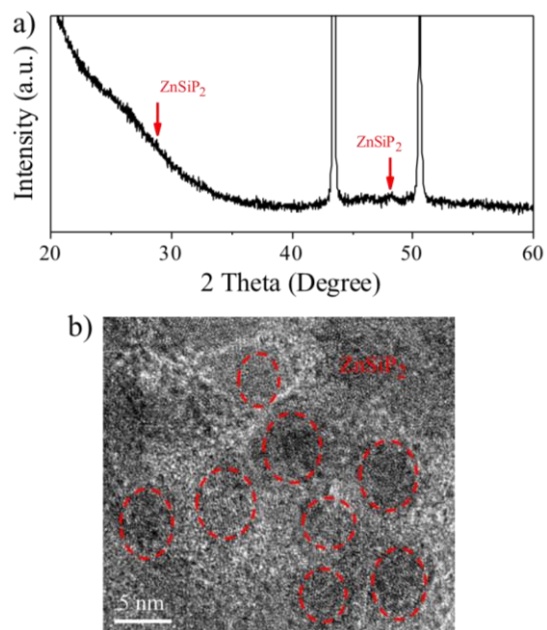


Figure S16. The ex-situ XRD (a) and HRTEM image (b) of the $ZnSiP_2$ electrode after 30 cycles.

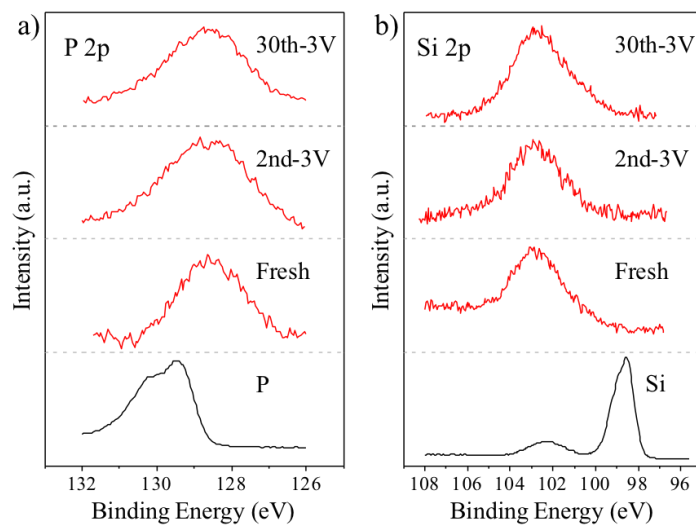


Figure S17. The ex-situ XPS of the $ZnSiP_2$ electrode after 30 cycles: a) high-resolution survey of P 2p; b) high-resolution survey of Si 2p.

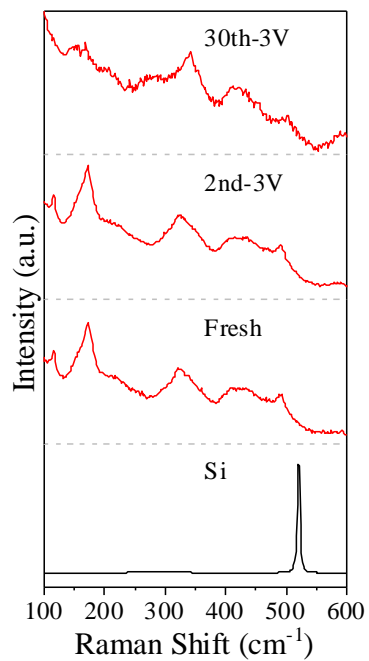


Figure S18. The ex-situ Raman of the ZnSiP₂ electrode after 30 cycles.

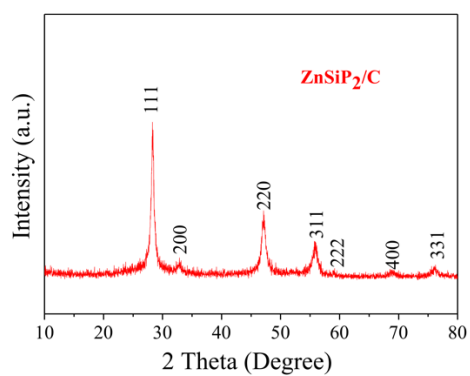


Figure S19. XRD pattern of the cation-disordered ZnSiP₂/C composite.

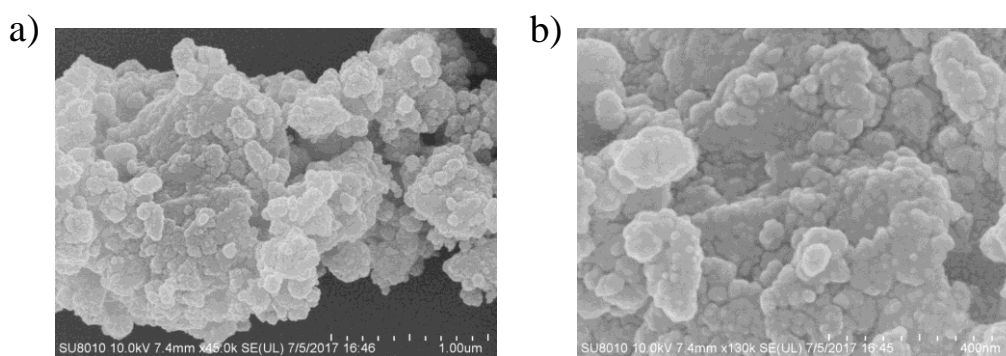


Figure S20. FSEM images of the cation-disordered ZnSiP₂ carbon composite: a) low-magnitude, b) high-magnitude.

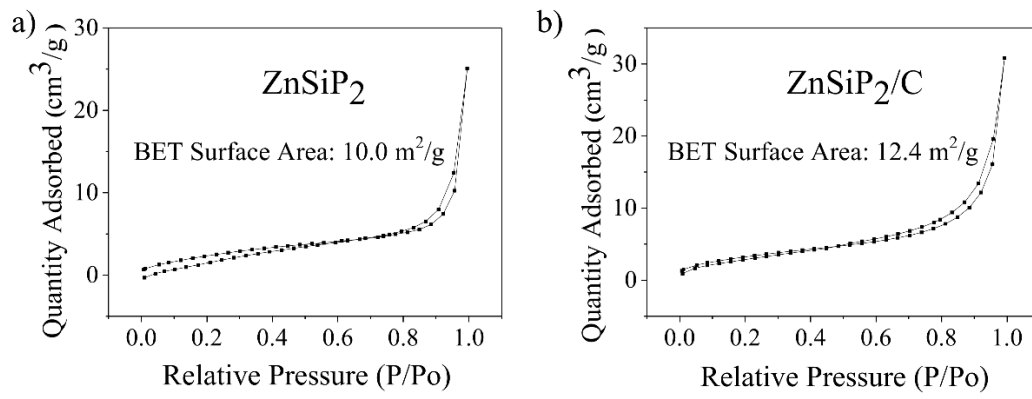


Figure S21. N_2 adsorption-desorption isotherms of a) the cation-disordered $ZnSiP_2$, and b) its carbon composite.

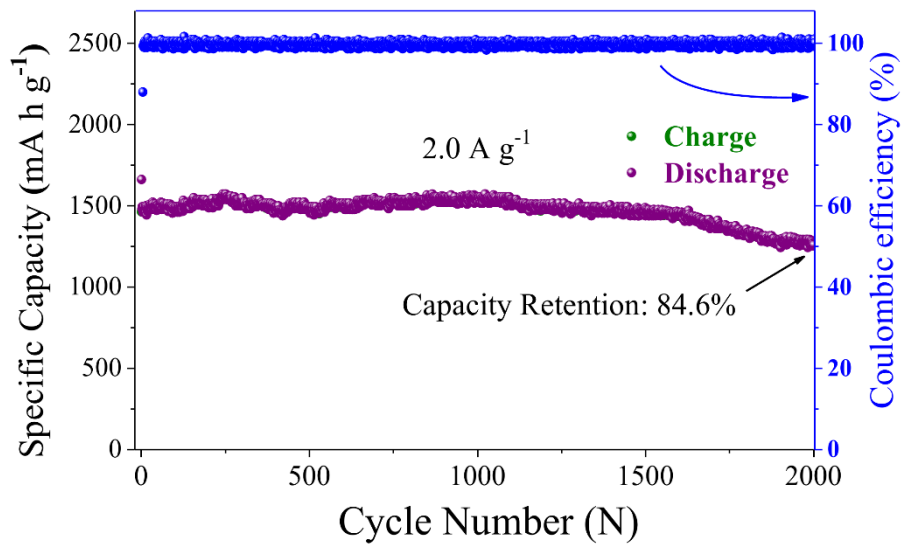


Figure S22. Cycle stability of the cation-disordered $ZnSiP_2/C$ anode at the current density of 2000 mA g^{-1} .