

Electronic Supplementary Information

Simple and scalable synthesis of CuS as an ultrafast and long-cycling anode for sodium ion batteries

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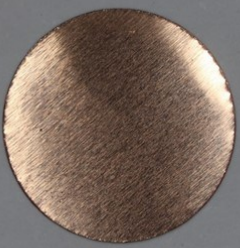
	Original Cu current collector	Sulfur powder with Cu current collector	(After heats at 80 °C) CuS electrode With Cu current collector
Sample image	a 	b 	c 

Fig. S1 a) Cu current collector, b) S powder with the Cu current collector, and c) CuS electrode with the Cu current collector.

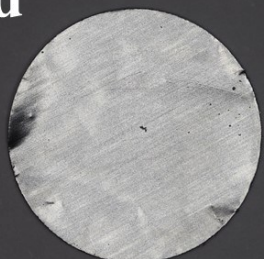
	Al foil	Sn foil	Ni foil
Original samples	a 	b 	c 
After reaction with sulfur	d 	e 	f 

Fig. S2 a) and d) Al foil, b) and e) Sn foil, and c) and f) Ni foil before/after reaction with S.

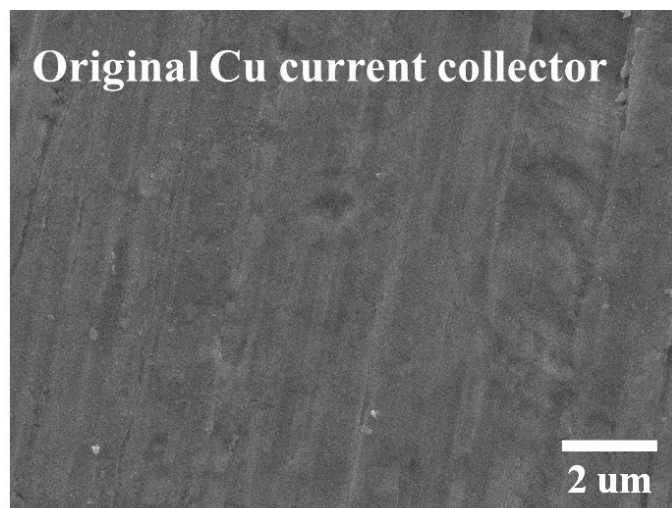


Fig. S3 Scanning electron microscopy (SEM) image of the original Cu current collector.

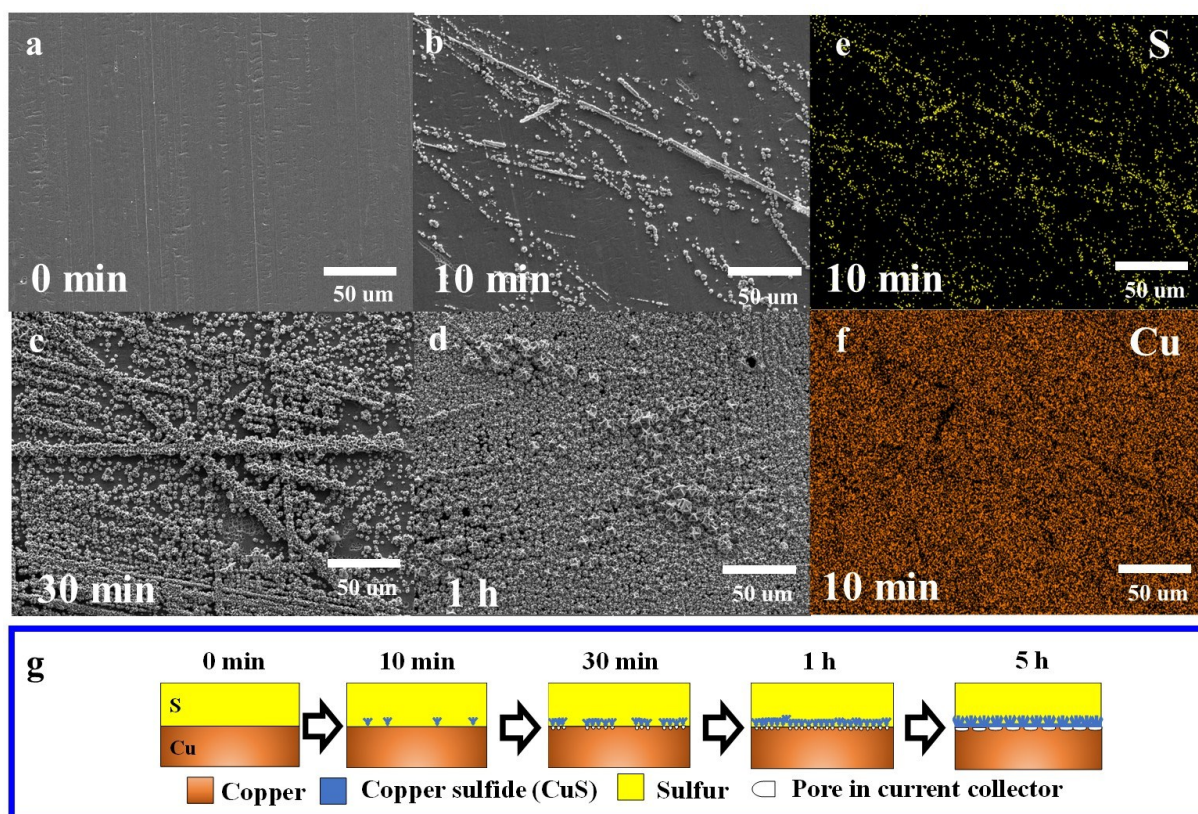


Fig. S4 SEM images of the Cu current collector with increasing reaction time with sulfur powder: a) 0 min, b) 10 min, c) 30 min, and d) 1 h. e, f) Energy-dispersive X-ray spectroscopy (EDS) results after 10 min of reaction. g) Schematic diagram of the CuS formation on Cu current collectors with increasing reaction time.

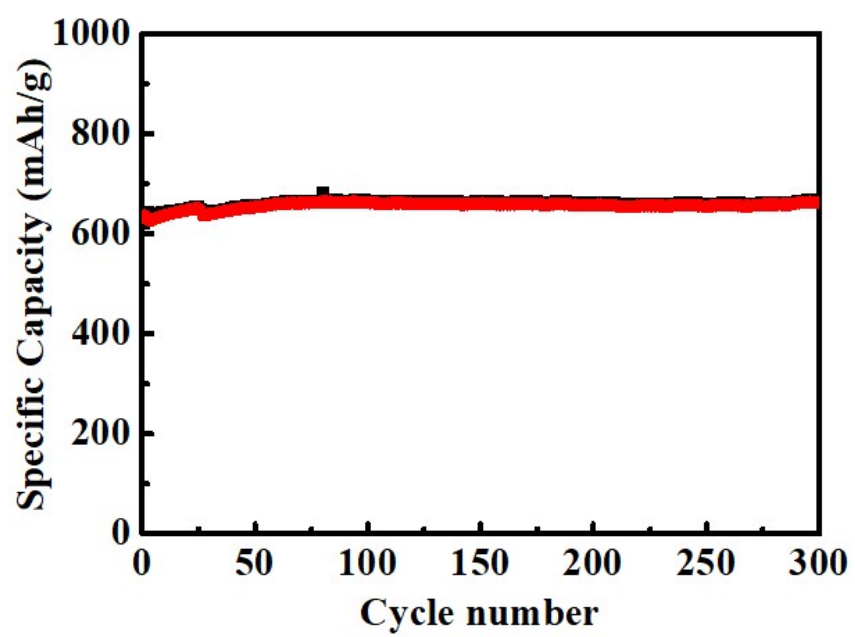


Fig. S5 Cycle properties of the CuS electrode at a current density of 1 A g^{-1} .

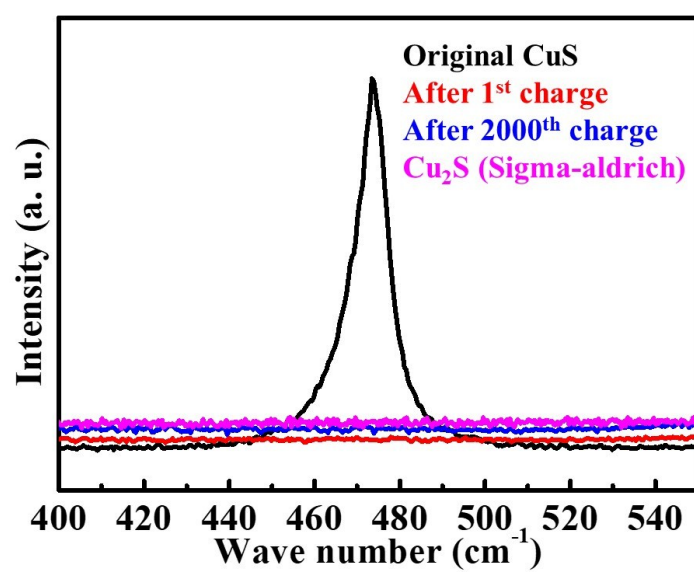


Fig. S6 Raman spectra of the CuS electrode during cycles.

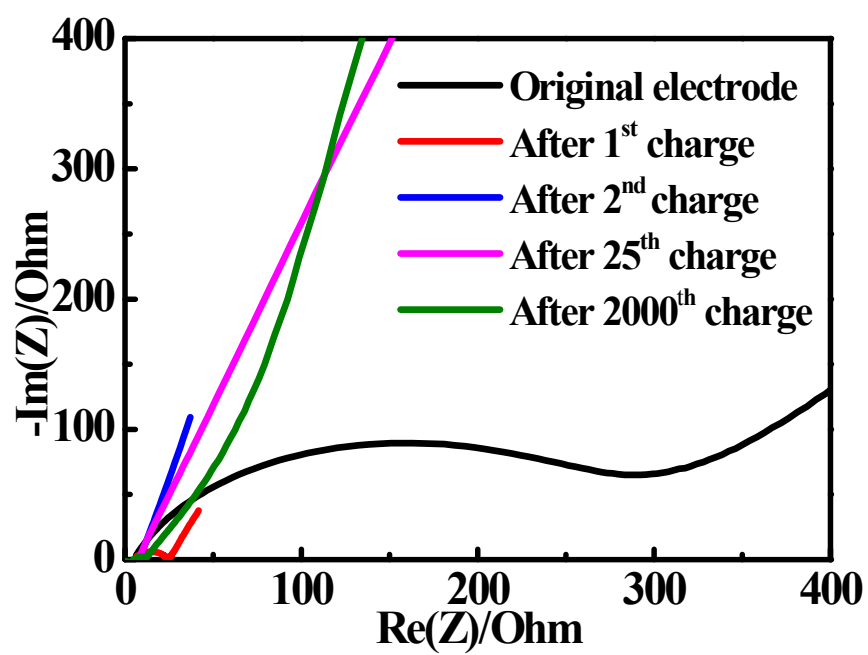


Fig. S7 Enlarged Nyquist plots of the CuS electrode during the cycles

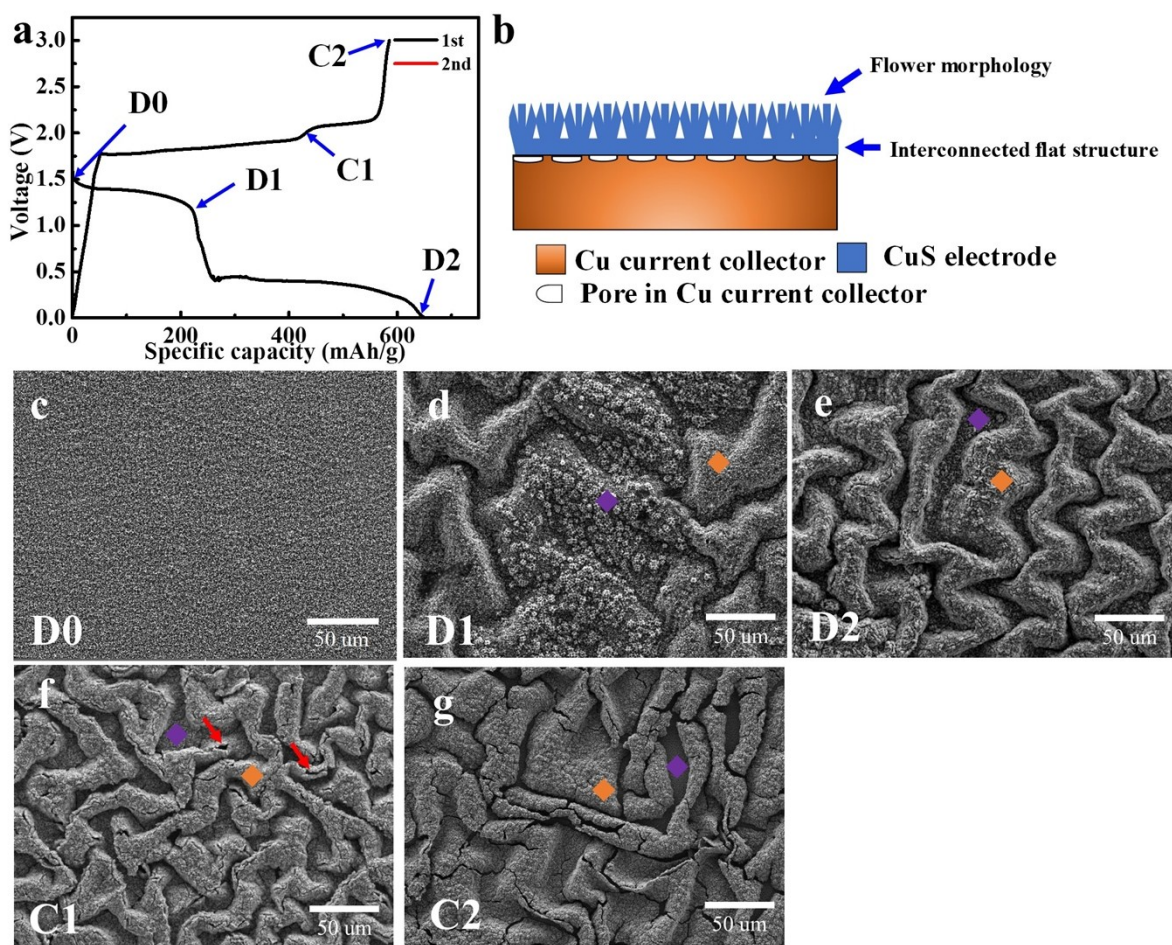


Fig. S8 a) 1st charge-discharge curves of the CuS electrode. b) Schematic of the CuS electrode with the Cu current collector. c-g) SEM images of the CuS electrode at various charge-discharge steps (orange marks: top of valley, purple marks: bottom of valley)

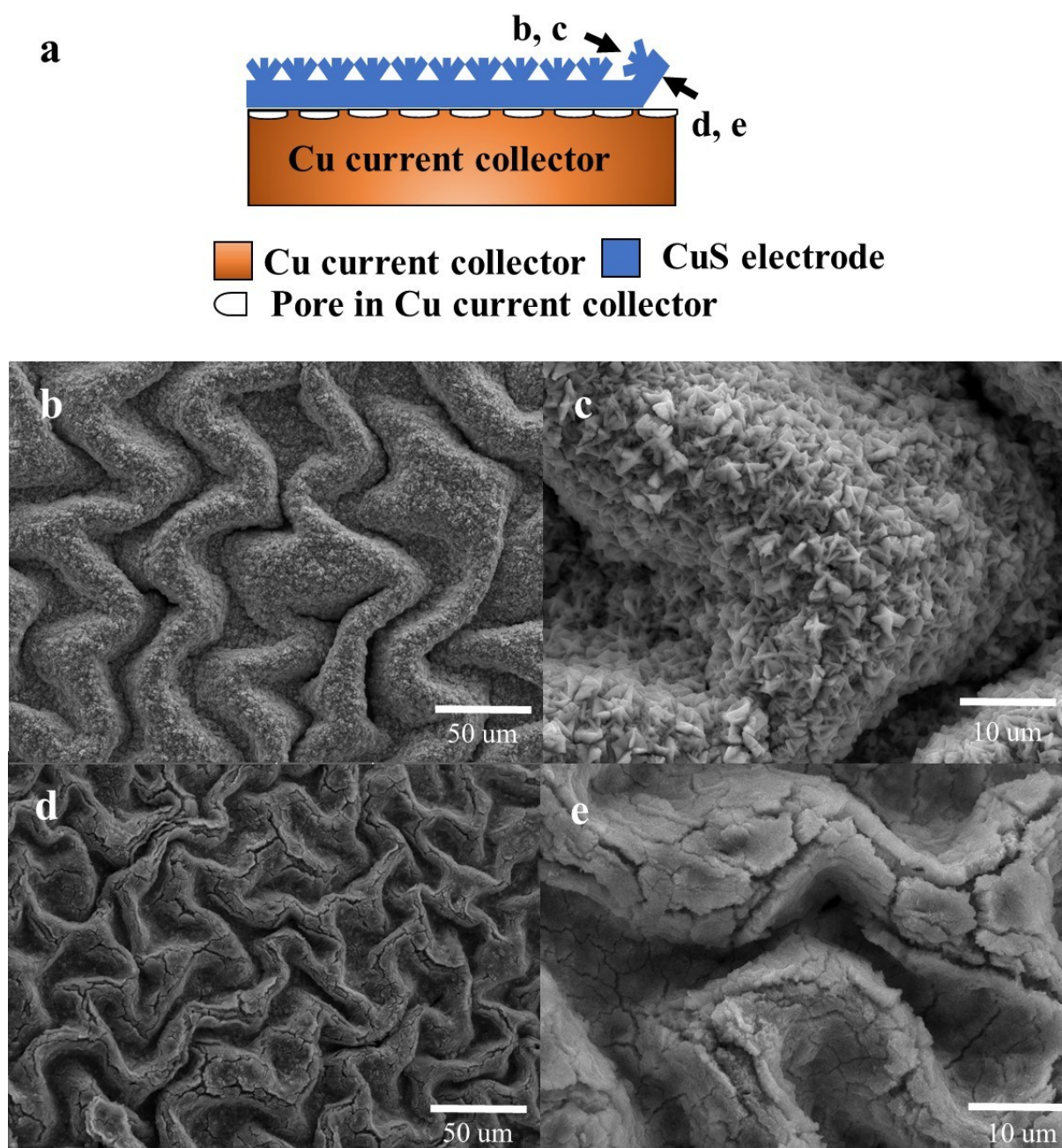


Fig. S9 a) Schematic of the CuS electrode with the Cu current collector. SEM images of the CuS electrode after 1st discharge: b) low magnification and c) high magnification images of the upper side and d) low magnification and e) high magnification images of the Cu current collector side.

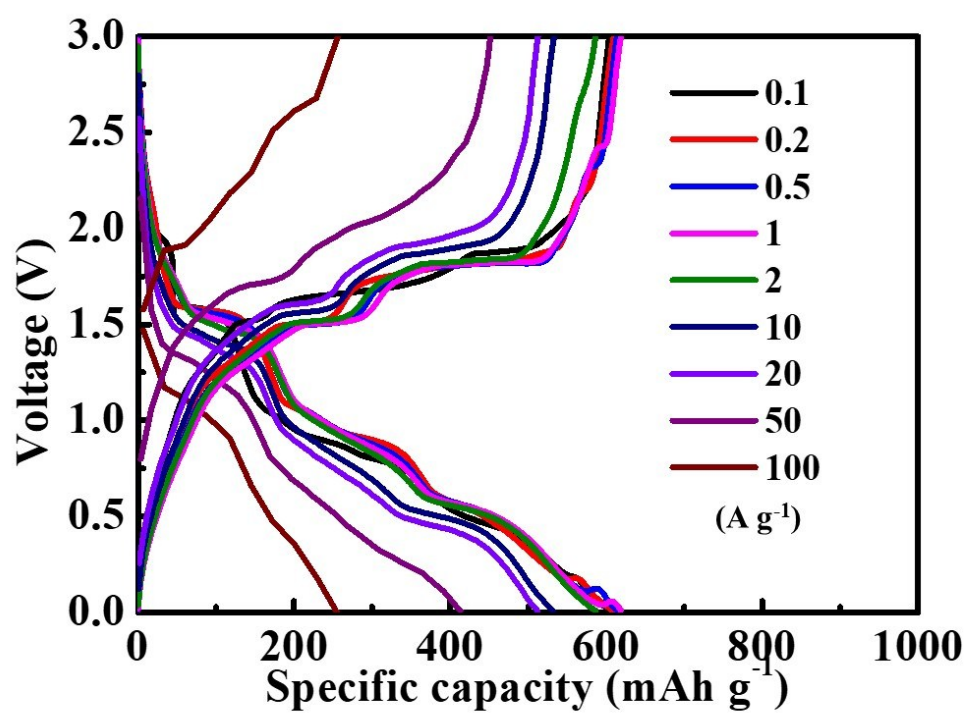


Fig. S10 Discharge-charge curves of the CuS electrode for various current rates.

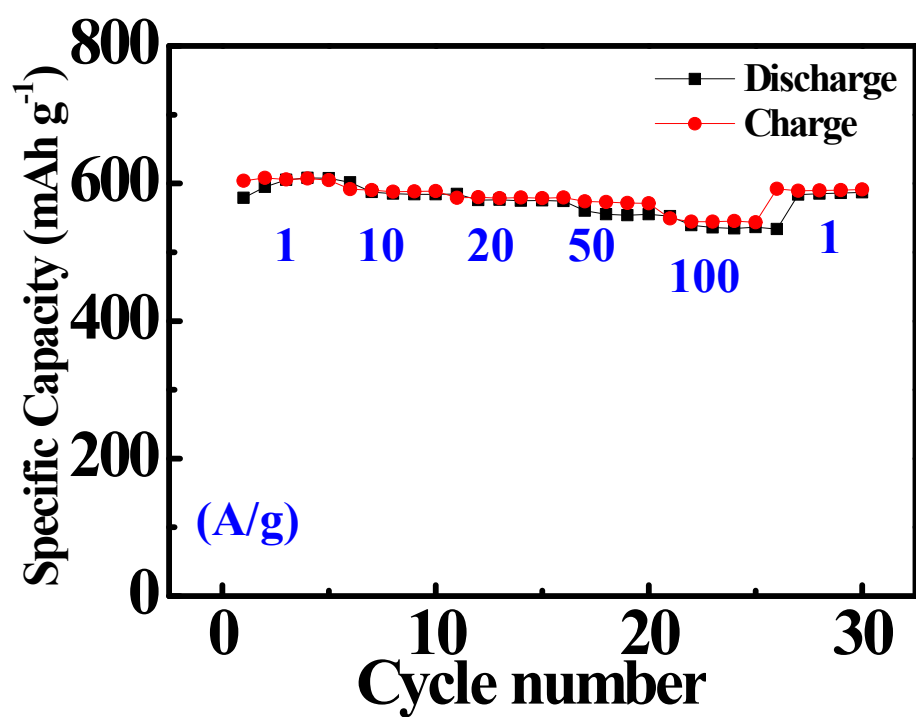


Fig. S11 Rate capability of the CuS electrode at various current rates with a constant discharge current density of 1 A g⁻¹.

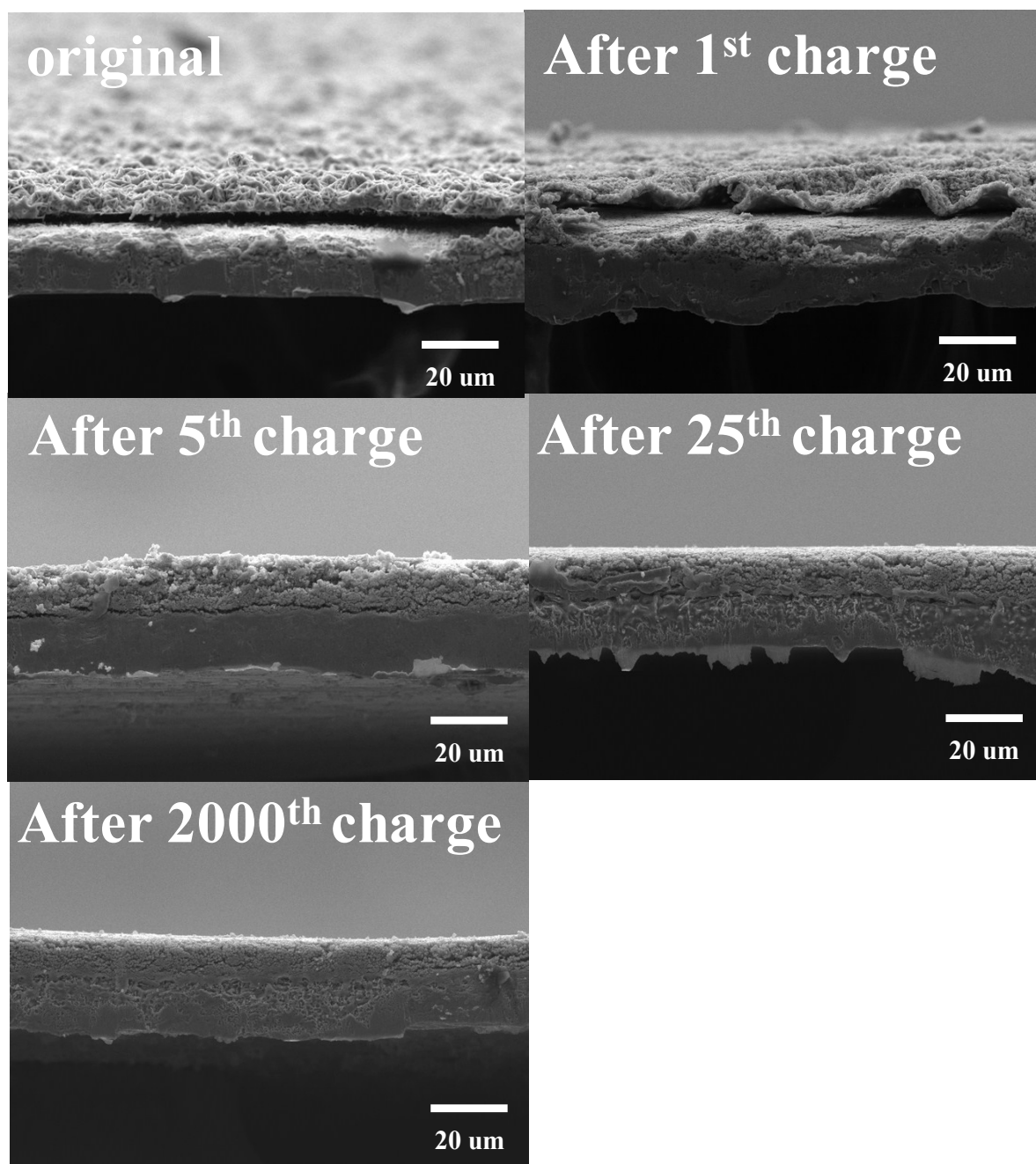


Fig. S12 SEM images of a cross section of a CuS electrode during the cycles.

Table S1. Comparison of prepared CuS electrode properties with those reported in previous studies on SIBs.

Substance	Electrode			Electrolyte (current collector)	Capacity@current density (cycle numbers) (mAh g ⁻¹ @A g ⁻¹ (n))	Highest rate (A g ⁻¹) Cut-off voltage	Ref.
	Synthesis method	Precursor	Electrode composition				
CuS	Hydrothermal	CuSO ₄ ·5H ₂ O Sulfur CTAB	CuS:PVPF:Super P 80:10:10	0.9 M NaPF ₆ DME (Al foil)	350@0.031 (1 st) 240@0.031 (2 nd) 50@0.031 (100 th)	0.031 1 – 3 V	1
CuS-rGO	Hydrothermal	CuSO ₄ ·5H ₂ O Thioacetamide rGO	CuS-rGO:PVPF:Super P 80:10:10	1 M NaPF ₆ /SO ₃ DEGDME (Cu foil)	530@0.1 (1 st) 450@0.1 (2 nd) 400@0.1 (50 th) 300@1 (450 th)	1 360 mAh g ⁻¹ 0.4-2.6 V	2
CuS-SWCNT	One-pot, template- solution 2steps	Sulfur CuCl SWCNT	CuS:SWCNT 60:40	1 M NaPF ₆ DEGDME (carbon)	700@0.1 (1 st) 450@0.1 (2 nd) 300@0.1 (500 th)	3 300 mAh g ⁻¹ 0.01-2.7 V	3
CuS	Solvothermal	Cu(NO ₃) ₂ ·3H ₂ O CTAB CS ₂	CuS:PVPF:AB 80:10:10	1 M NaPF ₆ DEGMDE (Cu foil)	680@0.112 (1 st) 100@0.112 (2 nd) 570@0.112 (150 th)	0.112 0.05-2.6 V	4
CuS-CTAB	Solvothermal	Cu(NO ₃) ₂ ·3H ₂ O CTAB Thiourea	CuS-CTAB:PVPF:Super P 80:10:10	1 M NaCF ₃ SO ₃ DEGDME (Cu foil)	720@0.1 (1 st) 700@0.1 (2 nd) 300@10 (1100 th)	40 21.1 mAh g ⁻¹ 0.01-3 V	5
CuS	3 neck bottle heating	Ti ₆₀ Cu ₄₀ H ₂ SO ₄	CuS:methylcellulose:AB 70:10:20	0.5 M NaClO ₄ DME (Cu foil)	490@0.1 (1 st) =irreversible capacity 340@0.1 (2 nd) 130@5 (5000 th)	2 135 mAh g ⁻¹ 0.25-2.25 V	6
CuS	Microwave irradiation	Cu(NO ₃) ₂ ·H ₂ O Na ₂ S ₂ O ₃ ·5H ₂ O	CuS:PVPF:AB 70:15:15	1 M NaClO ₄ TEGDME (Cu foil)	480@0.05 (1 st) 450@0.05 (2 nd) 150@0.2 (200 th)	1.6 80 mAh g ⁻¹ 0.5-3 V	7
Our work	Solid reaction	Cu foil Sulfur	CuS 100	1 M NaPF₆ DME (Cu foil)	648@0.1 (1st) 521@5 (2nd) 517@5 (2000th)	100 268 mAh g⁻¹ 0.01- 3 V	-

Table S2. Energy-dispersive X-ray spectroscopy (EDS) results for the CuS electrode after detaching from the Cu current collector.

Element	Original electrode (at %)	After 1st charge (at %)
S	55.52	33.6
Cu	44.48	66.4
Total:	100.00	100.00

Reference

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