

Supporting information

Synthesis of Stretchable Hybrid Copper Films via Nanoconfinement

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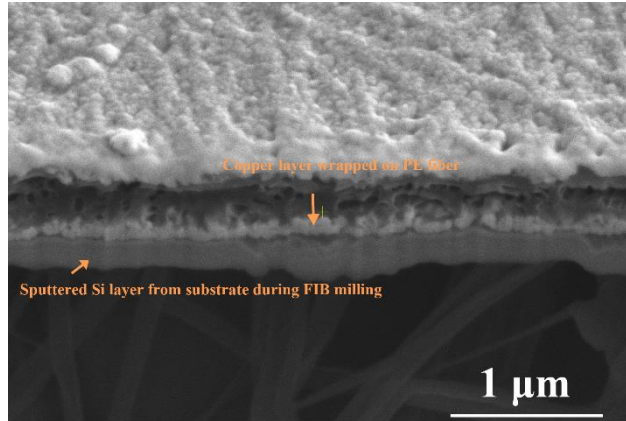


Fig. S1 Surface and cross section image of CuPE (150 nm Cu/350 nm PE/150 nm Cu)

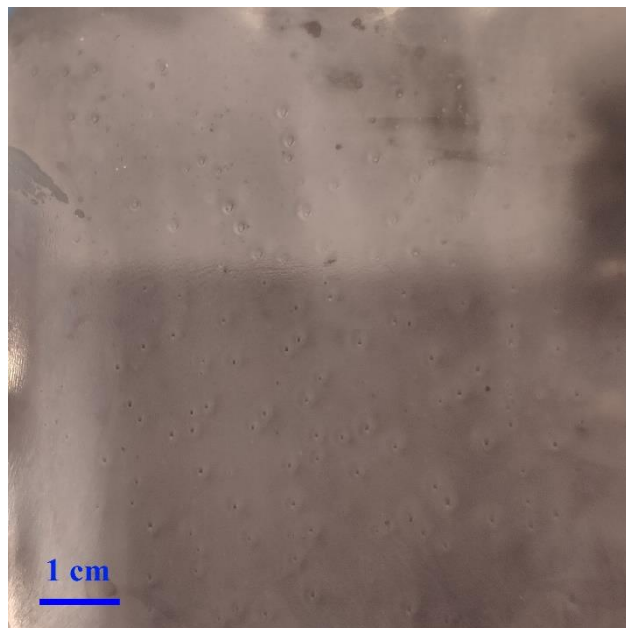


Fig. S2 21% Stretched CuPE film.

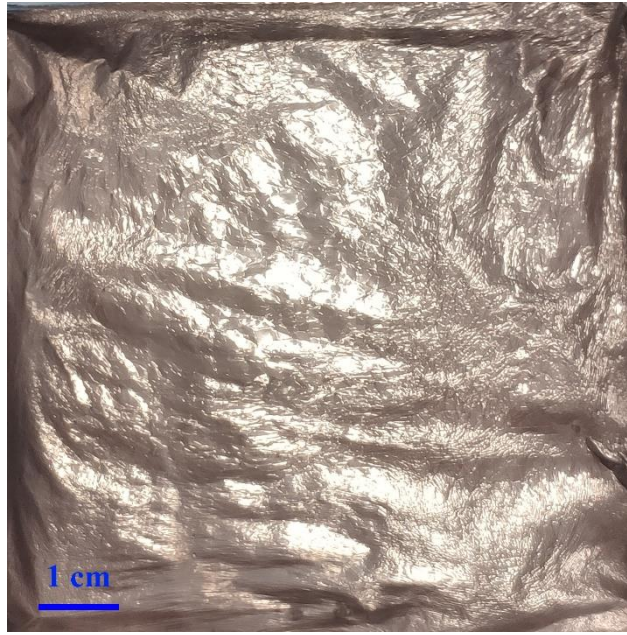


Fig. S3 Wrinkled CuPE when back to initial position after stretching.

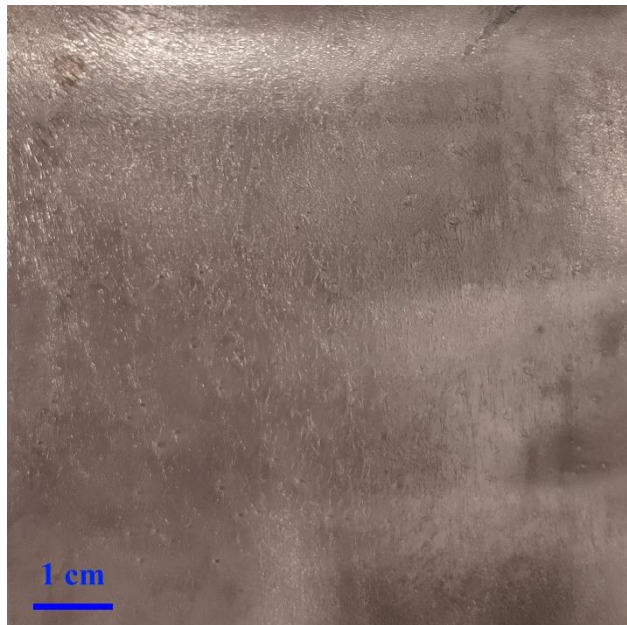


Fig. S4 Annealed CuPE from Figure S3

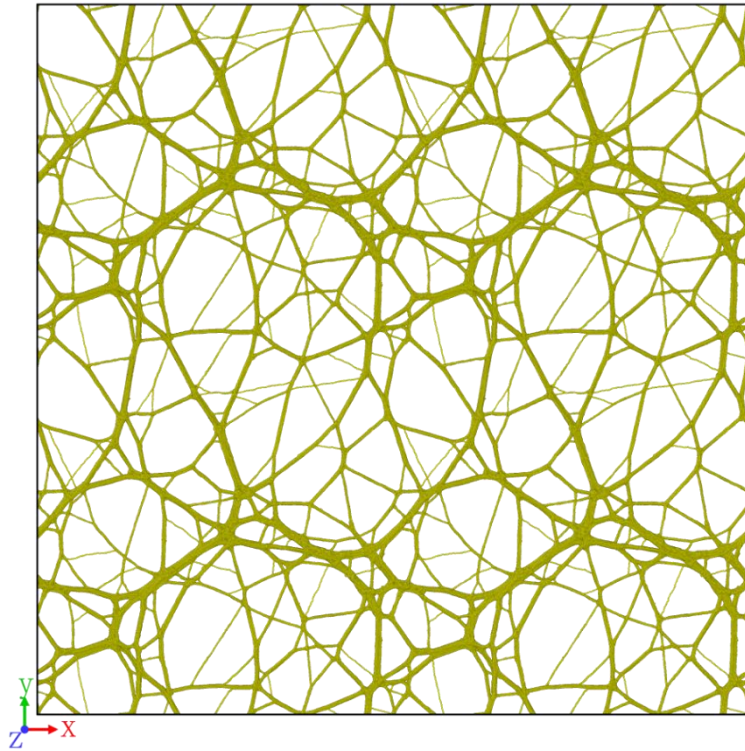


Fig. S5 Fiber distribution of stretched PE

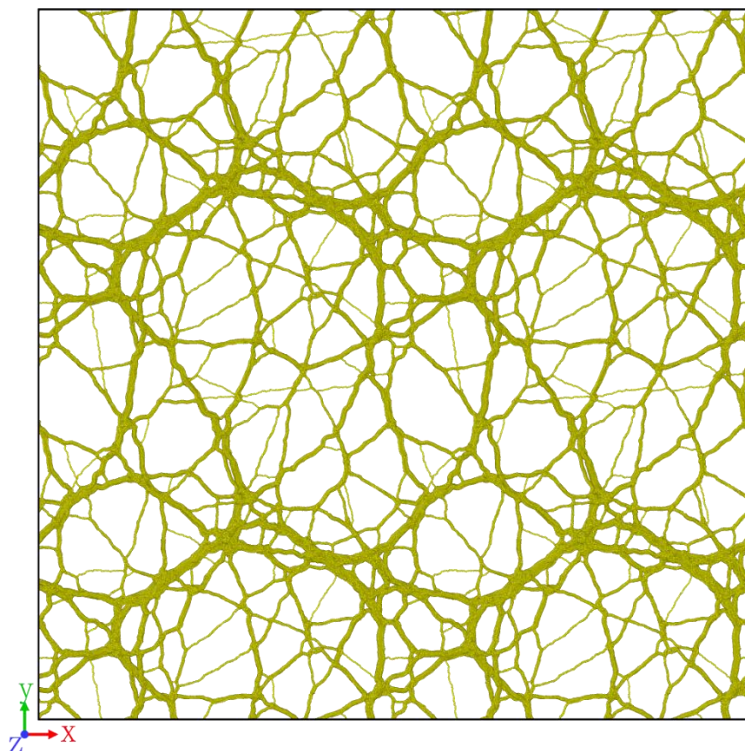


Fig. S6 Gauche conformations of PE fiber during retraction

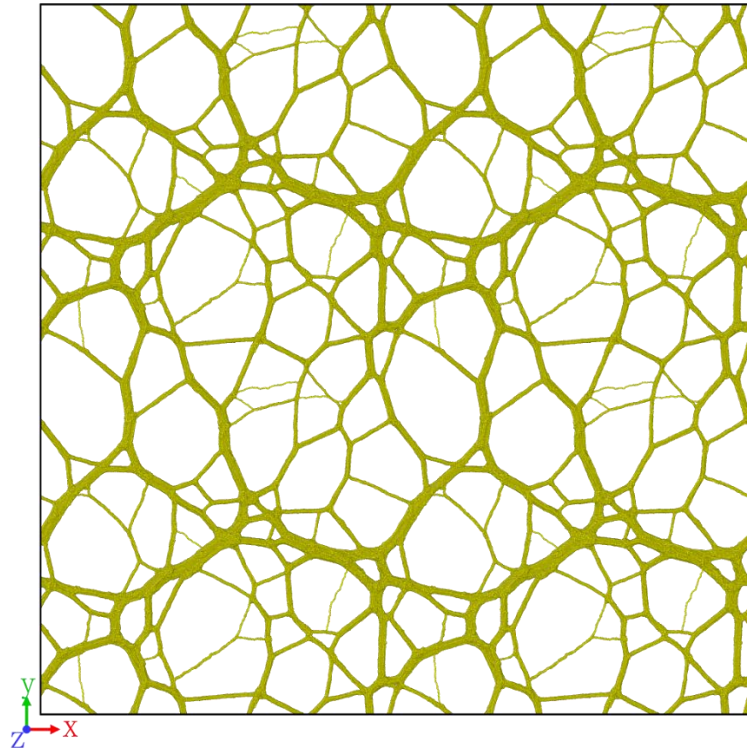


Fig. S7 Restoration of PE fiber

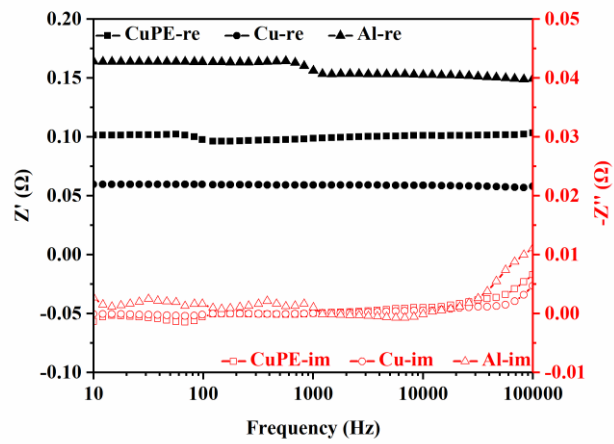


Fig. S8 Z' -re and Z' -im of commercial Cu, Al along with CuPE after subtract background.

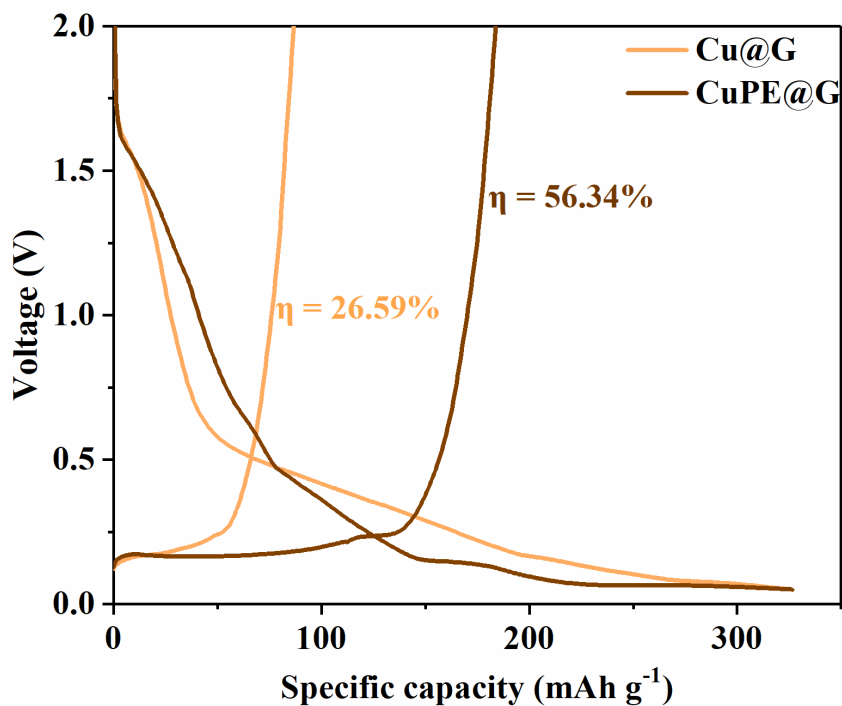


Fig. S9 Initial cycle charge and discharge curve of graphite/Cu and graphite/CuPE electrodes after mechanical distortions by folding, twisting and unfolding.

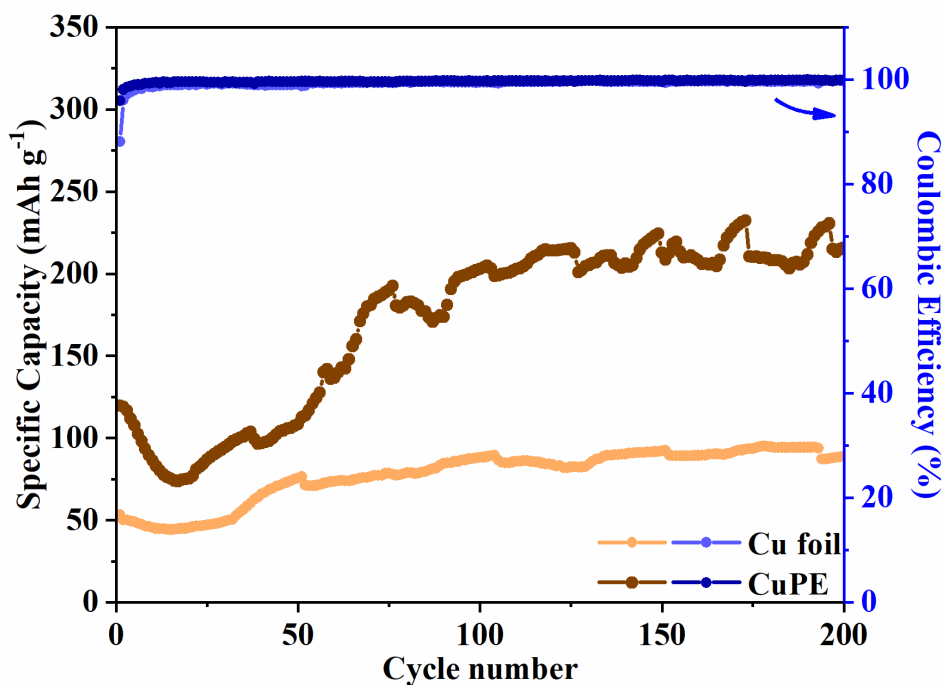


Fig. S10 Discharge capacity during long cycles of graphite/Cu and graphite/CuPE electrodes after mechanical distortions by folding, twisting and unfolding.

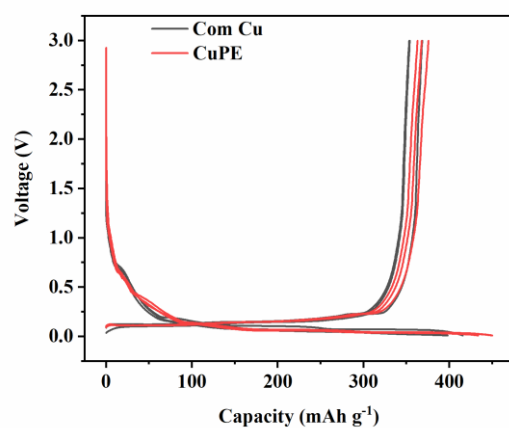


Fig. S11 Charge and discharge curve of graphite/Cu and graphite/CuPE electrodes

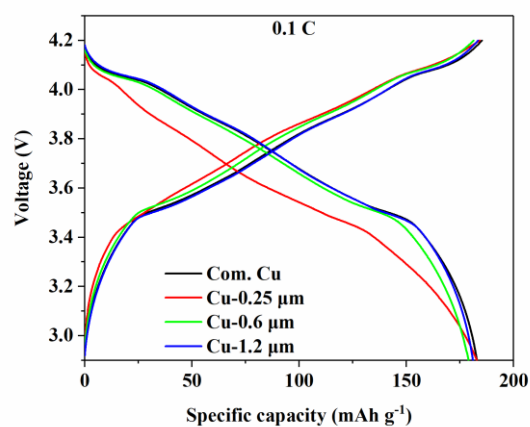


Fig. S12 Charge and discharge curves of rate test at 0.1 C corresponding to Figure 5b.

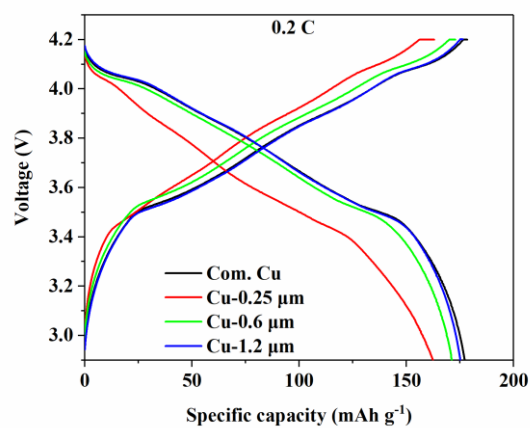


Fig. S13 Charge and discharge curves of rate test at 0.2 C corresponding to Figure 5b.

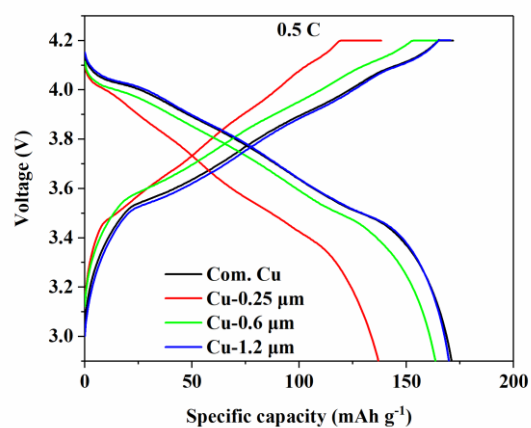


Fig. S14 Charge and discharge curves of rate test at 0.5 C corresponding to Figure 5b.

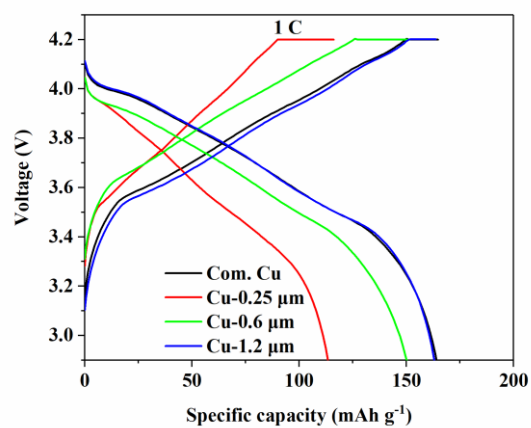


Fig. S15 Charge and discharge curves of rate test at 1 C corresponding to Figure 5b.

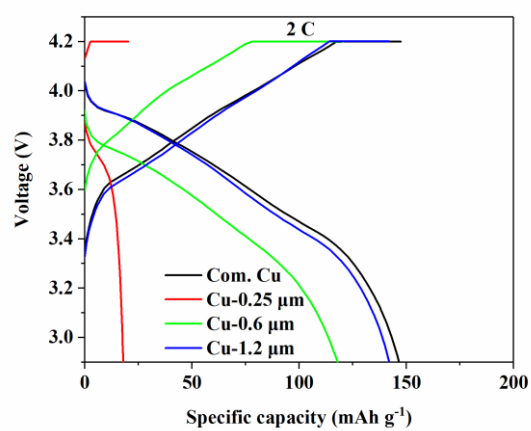


Fig. S16 Charge and discharge curves of rate test at 2 C corresponding to Figure 5b.

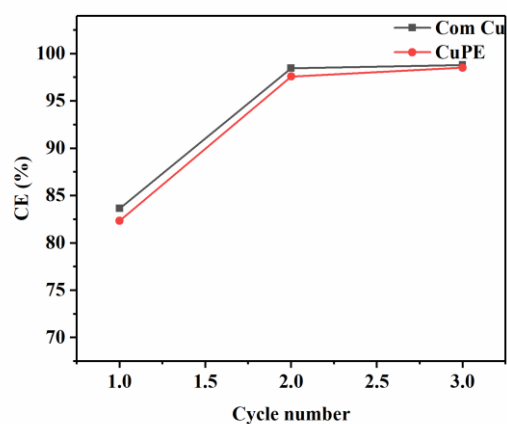


Fig. S17 Coulombic efficiency in initial 3-formation cycles of NMC 811//graphite pouch bags with commercial copper foil and CuPE (0.6 μm Cu at each side)

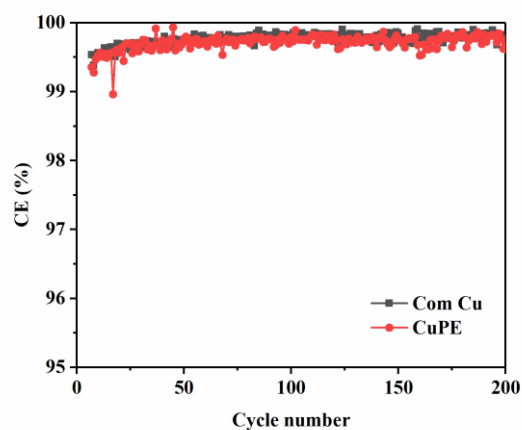


Fig. S18 Coulombic efficiency in 0.5 C long-cycle test of NMC 811//graphite pouch bags with commercial copper foil and CuPE (0.6 μm Cu at each side)

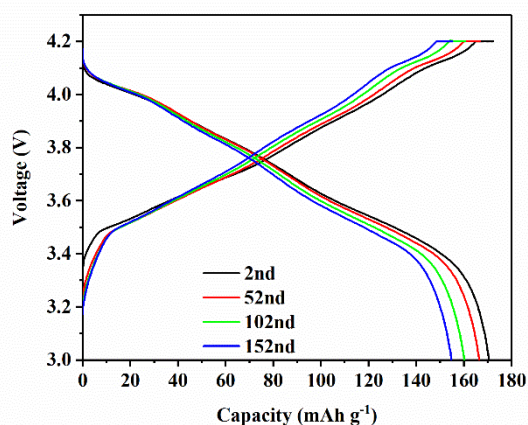


Fig. S19 Typical charge and discharge curve of NMC 811//graphite pouch bags with commercial copper foil during long cycles at 0.5 C.

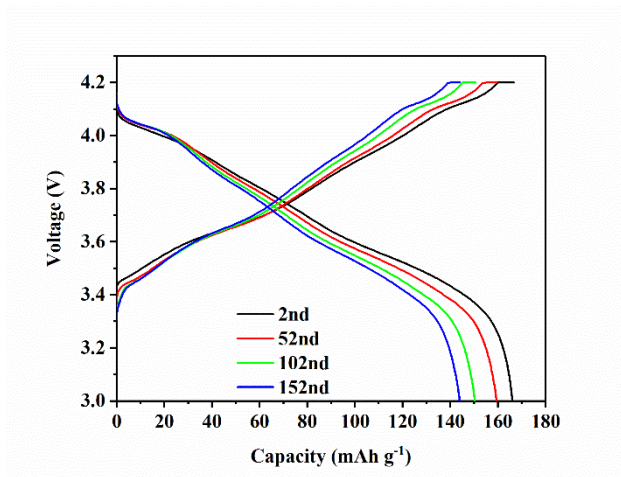


Fig. S20 Typical charge and discharge curve of NMC 811//graphite pouch bags with CuPE (0.6 μm Cu at each side) during long cycles at 0.5 C.

Table S1. Calculation of energy density of various cathodes in pouch bags. Here the commercial Cu foil is 9 μm and the CuPE is 0.6 μm Cu at each side.

Cathode materials	LCO	NMC 111	NMC 532	NMC 811	LFP	LLRO
Cathode area density at each side (mAh cm ⁻²)	2					
Cathode mass capacity (mAh g ⁻¹)	160	180	200	220	160	250
Average discharge voltage (mAh g ⁻¹)	3.9	3.7	3.8	3.9	3.4	4
Cathode material area mass (mg cm ⁻²)	25.00	22.22	20.00	18.18	25.00	16.00
Active material ratio	96%					
Cathode material area mass with binder and super P (mg cm ⁻²)	26.04	23.15	20.83	18.94	26.04	16.67
Area mass of Al foil (mg cm ⁻²)	3.6					
Cathode total area mass (mg cm ⁻²)	29.64	26.75	24.43	22.54	29.64	20.27
Negative/positive ratio	1.05					
Anode area density (mAh cm ⁻²)	4.2					
Anode mass capacity (mAh g ⁻¹)	320					
Active material ratio	95%					
Anode material area mass with binder and super P (mg cm ⁻²)	13.8					
Area mass of commercial Cu foil(mg cm ⁻²)	8.06					
Total area mass with commercial Cu (mg cm ⁻²)	21.88					
Separator and electrolyte (mg/cm ⁻²)	0.5+6					
Real capacity (mAh g ⁻¹)	66.10	69.42	72.32	74.89	66.10	78.21
Energy density (Wh kg ⁻¹)	257.78	256.84	274.82	292.05	224.73	312.85
Area mass of CuPE (mg cm ⁻²)	1.2					
Total area mass with CuPE (mg cm ⁻²)	15.02					
Real capacity (mAh g ⁻¹)	74.55	78.80	82.56	85.92	74.55	90.33
Energy density (Wh kg ⁻¹)	290.73	291.55	313.73	335.09	253.46	361.32
Improvement (%)	12.78	13.51	14.16	14.74	12.78	15.49