ARTICLE

Utilization of Si/SiO_x/Al_2O_3 material from recycled solar cells for high-performance lithium-ion battery anode (Electronic Supplementary Information)

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Yi-Hung Liu*[a], Yen-Lin Chen[a], Yu-Sin Chen[a], Shih-Ming Huang[b], Hsu-Min Huang[b], Shih-Jen Lin[b] and Ching-Yi Yang[c]

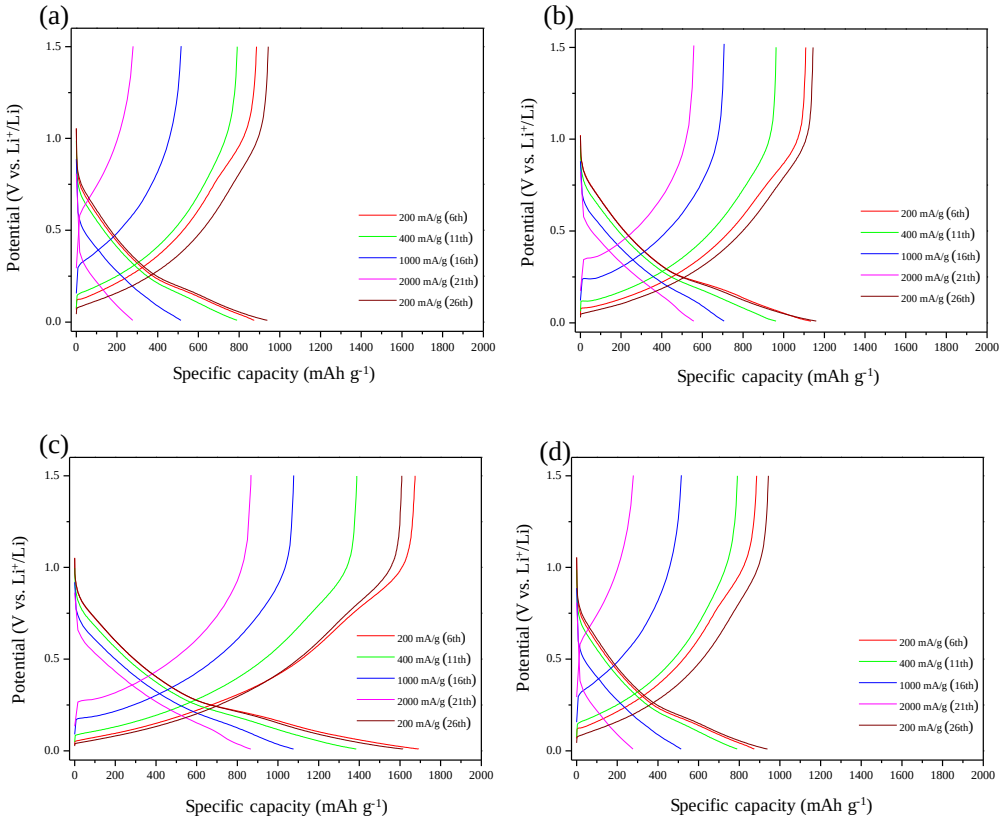

Fig. S1 Charge/discharge curves of cells comprising (a) Raw, (b) 500-1, (c) 500-2, and (d) 500-5 Si-based materials.

[a] Department of Chemical and Materials Engineering, National Central University. No. 300, Zhongda Rd., Zhongli Dist., Taoyuan City 32001, Taiwan (R.O.C.)
[b] ACON Greenergy Technology Co., Ltd. No. 28, Ln. 634, Zhongshan N. Rd., Yongkang Dist., Tainan City 71041, Taiwan (R.O.C.)
[c] Department of Mechanical Engineering, Chien Hsin University of Science and Technology. No.229, Jianxing Rd., Zhongli Dist., Taoyuan City 32097, Taiwan(R.O.C.)

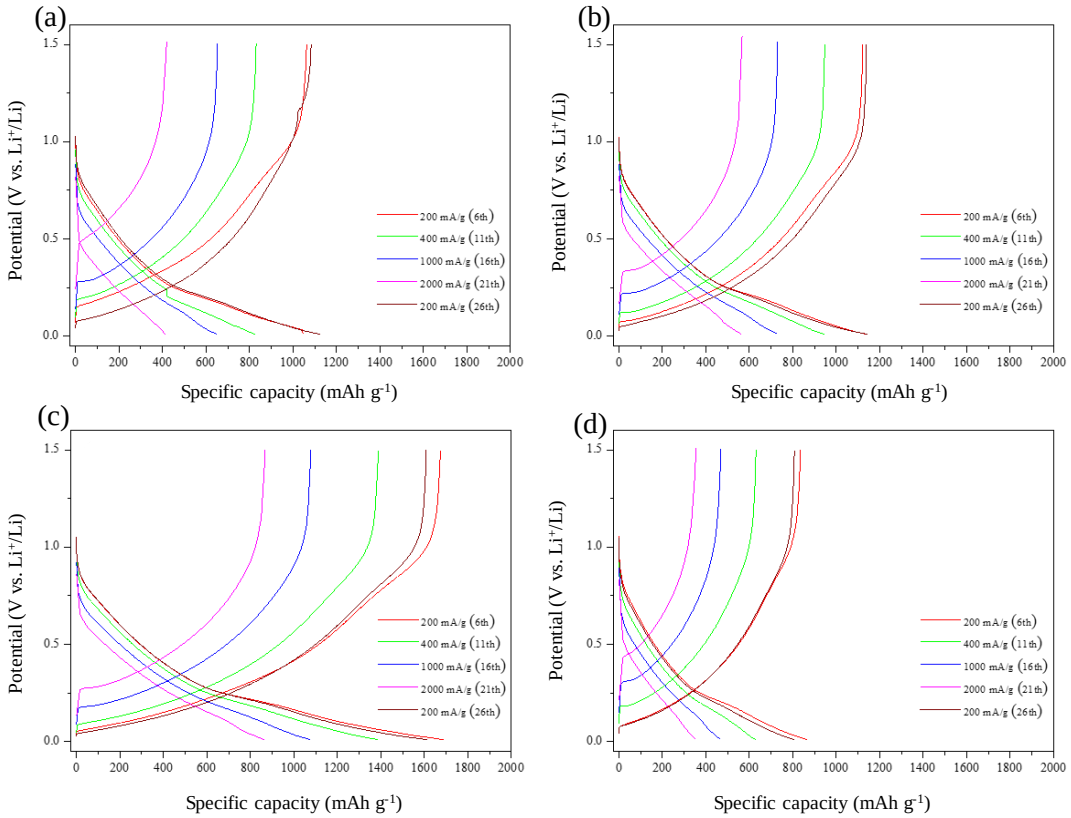

Fig. S2 Charge/discharge curves of cells comprising (a) 300-2, (b) 400-2, (c) 500-2, and (d) 600-2 Si-based materials.

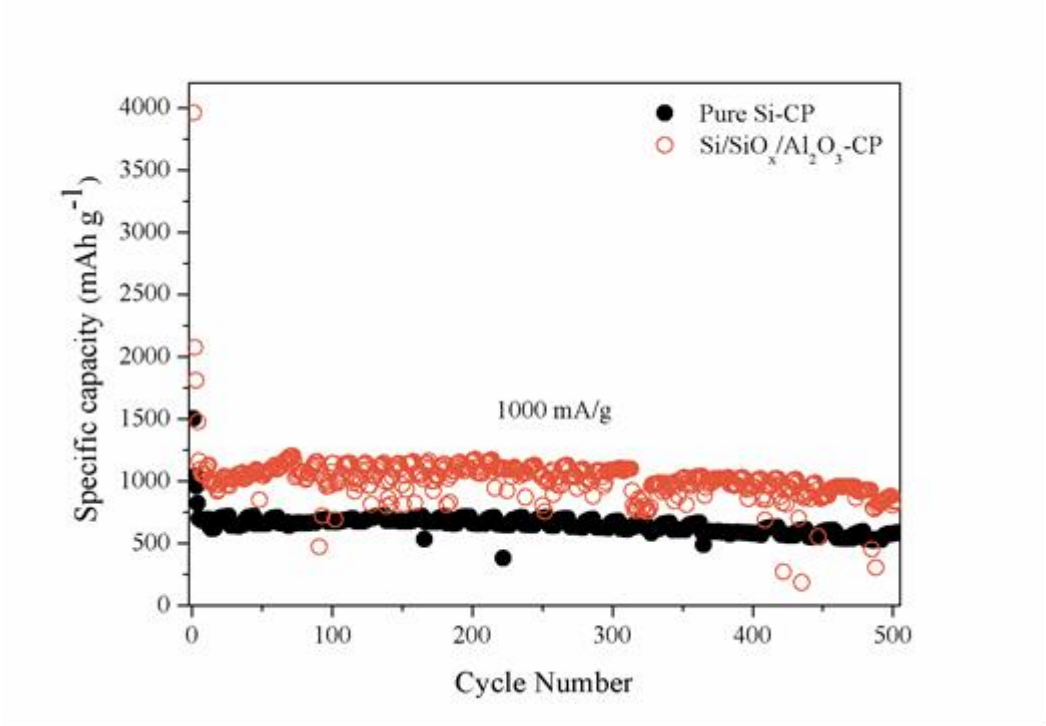

Fig. S3 Cycling performance of cells comprising commercial Si (pure Si) and typical recycled Si ($Si/SiO_x/Al_2O_3$, 500-2 sample).

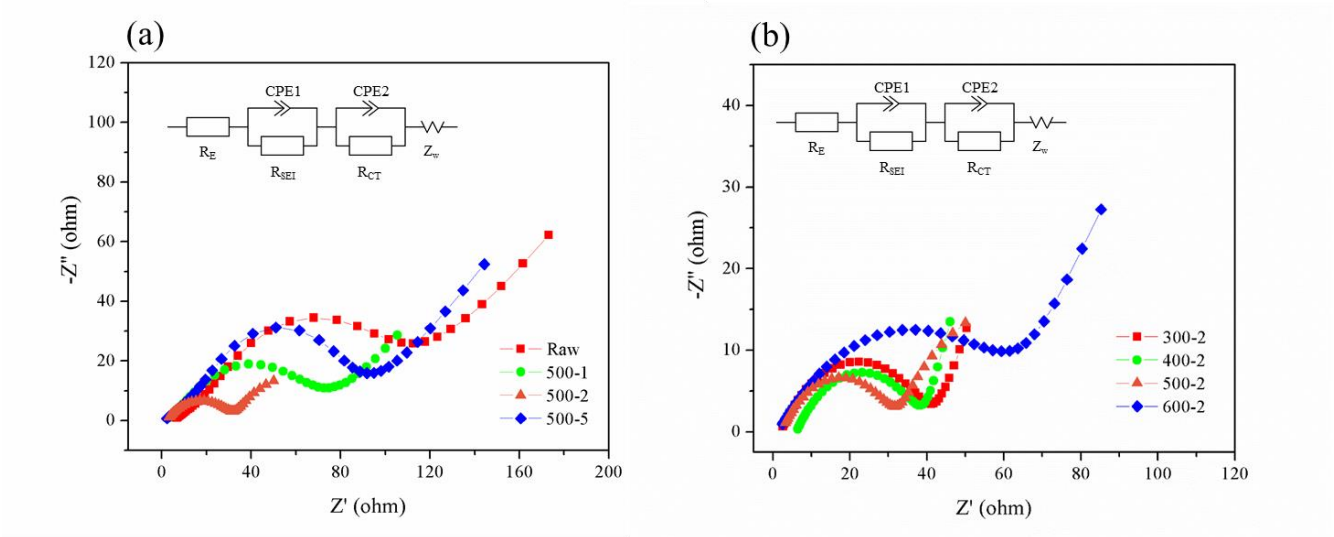

Fig. S4 EIS spectra of cells comprising recycled Si at different (a) milling times and (b) rotation speeds.

Table S1 Element composition of raw Si particles of waste solar cells

Element	Si	Al	Ag	B
Composition (wt%)	83.60	9.41	1.29	0.02
Composition (at%)	89.15	10.44	0.36	0.05

Table S2 Si oxidataion states of Raw-Si and recycled Si powders at different milling times. The ratios were estimated from Si 2p peak area obtained by XPS

Sample	Si^0	Si^{1+}	Si^{2+}	Si^{3+}	Si^{4+}
Raw	68.15%	15.09%	6.32%	4.71%	5.73%
500-1	26.64%	13.58%	8.03%	18.92%	32.83%
500-2	25.43%	20.94%	11.89%	17.71%	24.03%
500-5	22.92%	22.24%	11.42%	15.27%	28.15%

Table S3 Si oxidataion states of Raw-Si and recycled Si powders at different rotation speeds. The ratios were estimated from Si 2p peak area obtained by XPS

Sample	Si^0	Si^{1+}	Si^{2+}	Si^{3+}	Si^{4+}
300-2	40.76%	17.23%	7.55%	11.51%	22.95%
400-2	33.33%	13.79%	5.48%	14.07%	33.32%
500-2	25.43%	20.94%	11.89%	17.71%	24.03%
600-2	20.31%	17.31%	5.51%	21.18%	35.70%

Table S4 Al oxidataion states of Raw-Si and recycled Si powders at different rotation speeds

Sample	Al	Al_2O_3
Raw	17.94%	82.06%
500-2	14.42%	85.58%
600-2	8.70%	91.30%

Table S5 EIS fitting results of cells comprising recycled Si at different milling times

Sample	R_E (Ω)	R_{SEI} (Ω)	R_{CT} (Ω)
Raw	5.02	70.55	52.86
500-1	1.17	44.52	39.38
500-2	2.12	30.44	29.19
500-5	1.26	53.60	41.45

Table S6 EIS fitting results of cells comprising recycled Si at different rotation speeds

Sample	R_E (Ω)	R_{SEI} (Ω)	R_{CT} (Ω)
300-2	2.02	42.60	39.49
400-2	6.32	33.05	44.18
500-2	2.12	30.44	29.19
600-2	1.32	64.54	49.79

Table S7 N 1s deconvolution results of O-CP and H-CP substrates

Sample	Pyridinic nitrogen (N-6)	Pyrrolic nitrogen (N-5)	Quaternary nitrogen (N-Q)
O-CP	13.04%	43.51%	43.46%
H-CP	18.43%	43.16%	38.41%

Table S8 EIS fitting results of recycled Si-based cells comprising different substrates

Sample	R_E (Ω)	R_{SEI} (Ω)	R_{CT} (Ω)
Cu	3.19	584.90	253.20
Pristine CP	2.17	34.16	74.44
O-CP	2.80	40.36	72.95
H-CP	1.69	29.25	30.34

Table S9 Estimated lithium-ion diffusion coefficients of recycled Si-based cells comprising different substrates

Sample	Oxidation D_0 ($cm^2\ s^{-1}$)	Reduction D_0 ($cm^2\ s^{-1}$)
Cu	4.79×10^{-19}	4.36×10^{-18}
Pristine CP	7.10×10^{-16}	6.51×10^{-16}
O-CP	5.74×10^{-16}	1.07×10^{-15}
H-CP	1.08×10^{-15}	1.25×10^{-15}