

Surface Area Increase of Silicon Alloys in Li-Ion Full Cells Measured by Isothermal Heat Flow Calorimetry

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 $h \t h$ density of \mathbf{h} and \mathbf{h} are subject of \mathbf{h} and development. To date the full commercial input \mathbf{h} als technology has not been met owing to the different via the different with \mathbf{h} 3.16 3.16 3.16 h h3-267 h 7667. ((111221.627.)-0.4 () - 5)0.2 (containing h 3 main causes: 1) mechanical or electrical discon h allow particles in the composite electrode of the composite electrode owing to large h volume changes h and h [4](#page-5-2) 2) crystallization effects of h 5)0.2 (i) 1 2 2 3 5 ... 1 (i) 2 2 3 5 ... 1 (i) 2 3 3 ... 1 (i) 3 1 3 1 3 ... 1 (i) 3 1 3 1 3 ... 1 (i) 3 1 3 1 3 ... 1

 h_{15} h_{15} 4 h, h h h h ()-270 () 4 44

Current source.— h 2602
h h h h h h charge and discharge the cells. This equipment is capable to cells. This equipment is capable in h capable in h h 10 h 100 h range with an accurrent in the 100 h range w racy of ± 0.03% + 6 μA with a resolution of 200 nA. The voltage $\pm 0.015\% + 1$ h 10μ
h 6 $\pm 0.015\% + 1$ h μ $h \t 6$ range. This case $\langle 1 \t h \rangle$ is precision and h measurement of the coulombic efficiency to within $\pm 0.02\%$.

Isothermal heat flow calorimeter.— h h TAM III (Thermally Activated Module, TA Instruments) in which 12 $\begin{array}{ccc} \texttt{.} & \texttt{.} & \texttt{.} & \texttt{.} & \texttt{.} & \texttt{.} & \texttt{.} \\ & \texttt{.} \\ & \texttt{.} & \texttt{.} & \texttt{.} & \texttt{.} & \texttt{.} & \texttt{.} \end{array}$ $37°$. h $h \qquad \qquad 13 \qquad h$ $\qquad 13 \qquad h$ $\qquad 13 \qquad h$ method and modifications made to the TAM III to allow in-operandom in-operando calorimetry measurements on \mathbb{R}^n and \mathbb{R}^n adapting for adapting fo $h \t h$ is parasitic measurements with pouch cells with pouch cells with pouch cells h in h [14.](#page-5-10)

Cycling protocol.— h in the intervalue in the intervalue in the intervalue in the isothermal in the intervalue in the isothermal in the intervalue i heat flow calorimeter was follows: cells were cycled 10 times 10 h h h 3.0–3., 3.5–3., 3.7–3., 3.4, 3.7–3.8, 3.7–3.8, 3.7–3.9, 3.8–4.0, 3.7–3.9, 3.8–5. 4.0 4.25 \cdot h 11 $3.04.25$. voltage segment resulted in a nominally stabilizer $\mathcal{L}_\mathcal{S}$ and $\mathcal{L}_\mathcal{S}$ and $\mathcal{L}_\mathcal{S}$ h described in an earlier publication. In an earlier publication. In the last cycle of each voltage in \mathbb{R}^2

segment was then used to construct a plot of parasitic theorem ${\bf h}$ versus the segment of the segment of the segment of the method is the method of the method in the method in th we use here, coulombia efficiency, is simultaneously inefficient \mathbf{h} h h h h h h have reported on this cycling protocol protoco helectrolyte chemistry of $\ln (1/\ln \frac{1}{2})$ $\frac{13}{10}$ in the present work, h materials with distinctly different voltage versus capacity different voltage versus capacity h h $(. . . .)$ h and graphite), h and graphite lithiation delithiation does not occur uniformly for both materials uniformly for both materials uniformly for both materials under all $\mathbf h$

 \cdot h

Methods.— (a) Differentialcapacity(dQ/dVvs V) curves of Sialloy and electrolyte for t (disc15.4 (37 (t)-(we)-294..9 3.2 (4 (37 (t)-be1 (s..9 3.22 (i)-0.1 (n.9 3.22 (a)0.2 (n) (discdetail(n) (d56 (publica54 (is5.9776 0 0 5.9776 162.429 293.733oltag83 T)-33310.00011 Tc 8.966.111[a)0.2,.9776 0 0 5.97.7498 -1.111[a)0.24 09776 09664 0 0 8.9664 212.226 230.6971 (o2.5 160.2840.000)-249Tc .7498 -1.11126 (777W)80.7 (e)-237.(we)-2257363(a)20ata.1 (n63disc15e (n63d1enc)22(distinnt]TJ **Methods.—** (15.4(37()-(1)-2 4.. 3.2(4(37()-1(1). 3.22(1)-0.1(1). 3.22(1)0.2(1)(1)(56(1154(5. 776005. 0 sly7g2T46 0.391tFigure1. graphitehalf cells, Si alloy delithiation peaks are identified by diamonds.(b) Differential capacity curve of a Gr:Si-alloy//LCO full cell with the corre-sponding Sialloy delithiation peaksmarked by diamonds.

and contraction leads to the exposure of fresh non-passivated surfaces of \mathbf{h} $h h$ drive the additionally drive h drive consumption.

Summary

- $\frac{1}{2}$ induced cycle induced cycle induced cycle induced cycle $\frac{1}{2}$ cells was shown by caloring methods by caloring methods to be and precision cycling methods to be a shown by c and expansion of effective surface area where the formed SEI likely surface area where the formed SEI likely \mathbf{h} contains active electrochemical surfaces. FEC, used ubiquitously as and additive to improve the cycle life of \mathbf{h} h at the surface area expansion most likely through h are h $\mathbf h$ denser and more resilient $\mathbf h$ and more resilient $\mathbf h$ failure, observed after \mathbf{h} observed was also shown to be \mathbf{h}
- accompanied by surface area expansion.

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