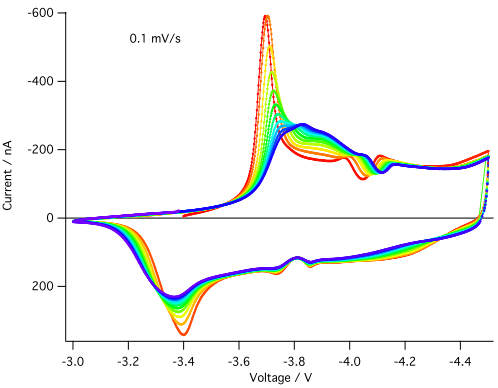

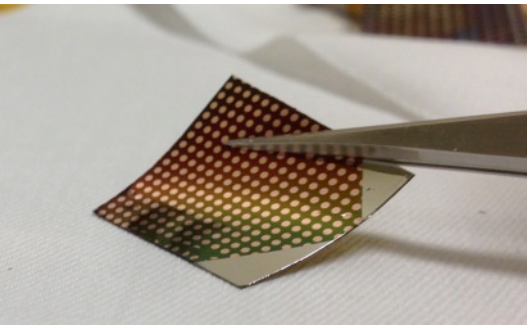

SAND2016-5018C

Solid-state rechargeable Li-ion batteries prepares at room-temperature over flexible substrates

Farid El Gabaly, N. Ware, E. Fuller, S. Vitale, F. Leonard, A. Talin

Sandia National Laboratories

Livermore, CA

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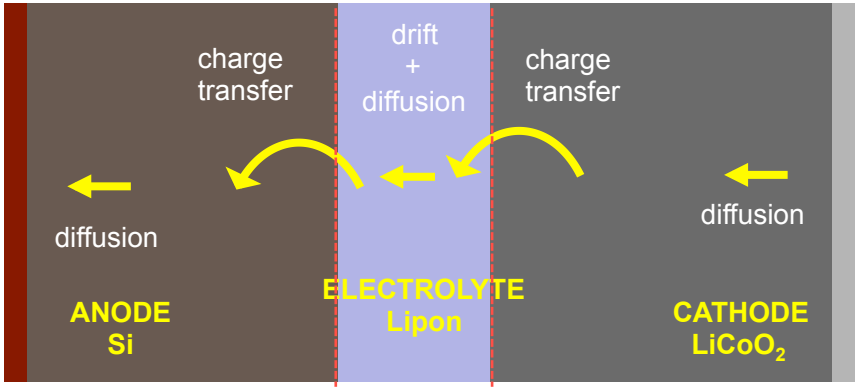
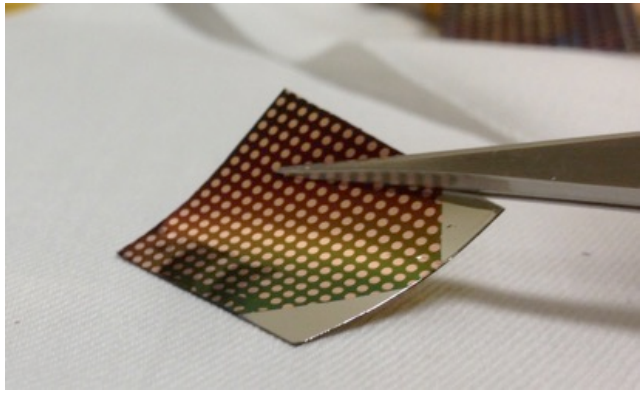
Thin-film Solid State Li-ion Batteries

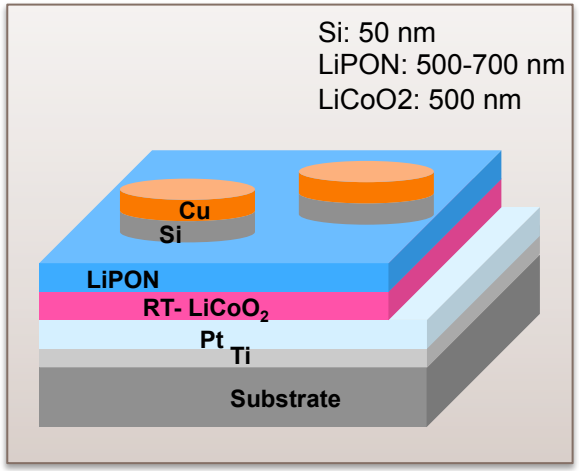
- Solid state Li-ion batteries (SS-LIBs) provide long cycle life, very low self-discharge rates, and integrability with a variety of materials
- One of the most stable thin-film SS-LIBs has $LiCoO_2$ cathode, LiPON solid state anode, and lithium or silicon anodes

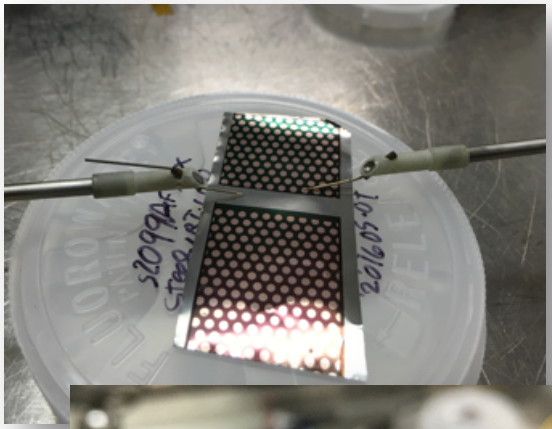


RT-LCO batteries

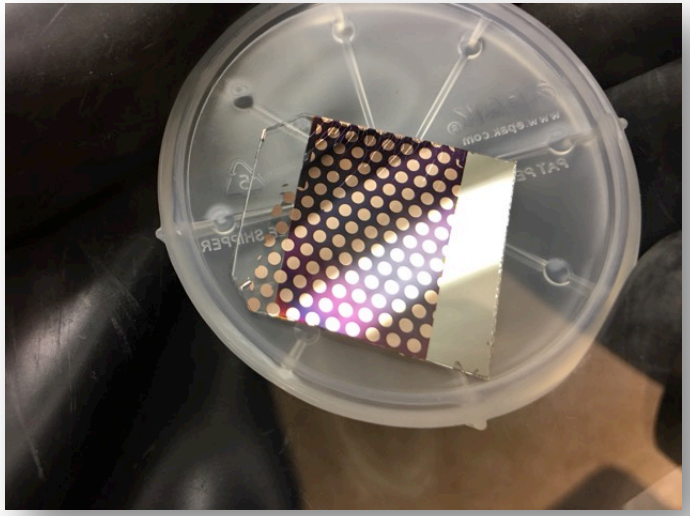
PMMA -Poly(methyl methacrylate), acrylic, 0.125 mm thick



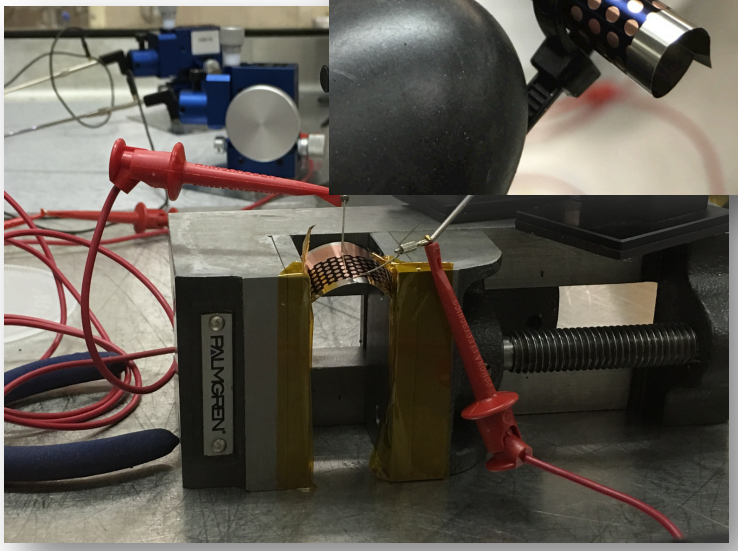




Polycarbonate, 0.5 mm thick



Thin stainless steel



AFM LCO's

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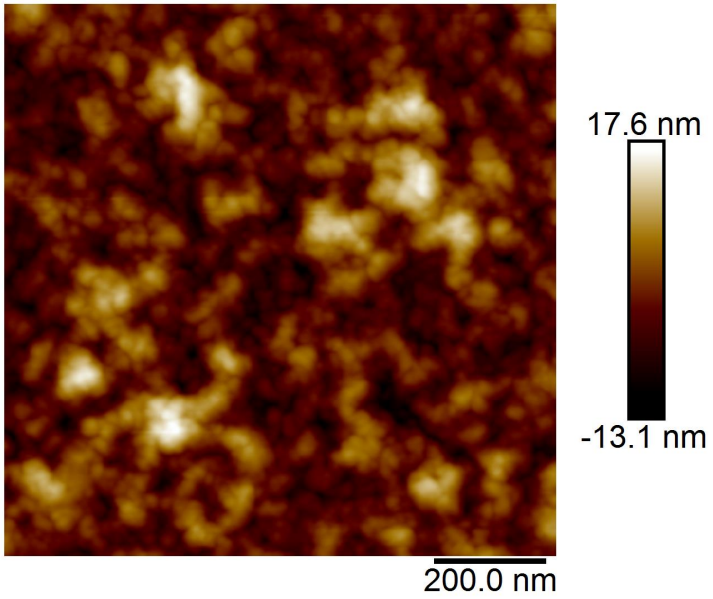
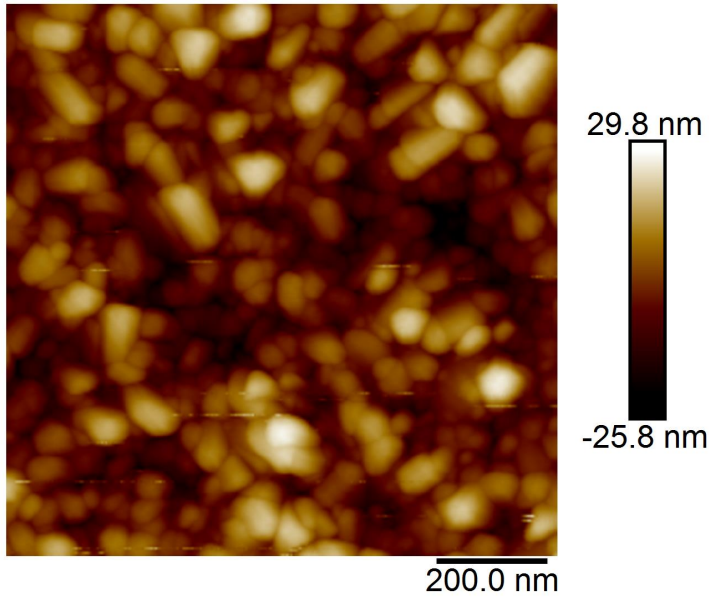
$LiCoO_2$ thin film annealing

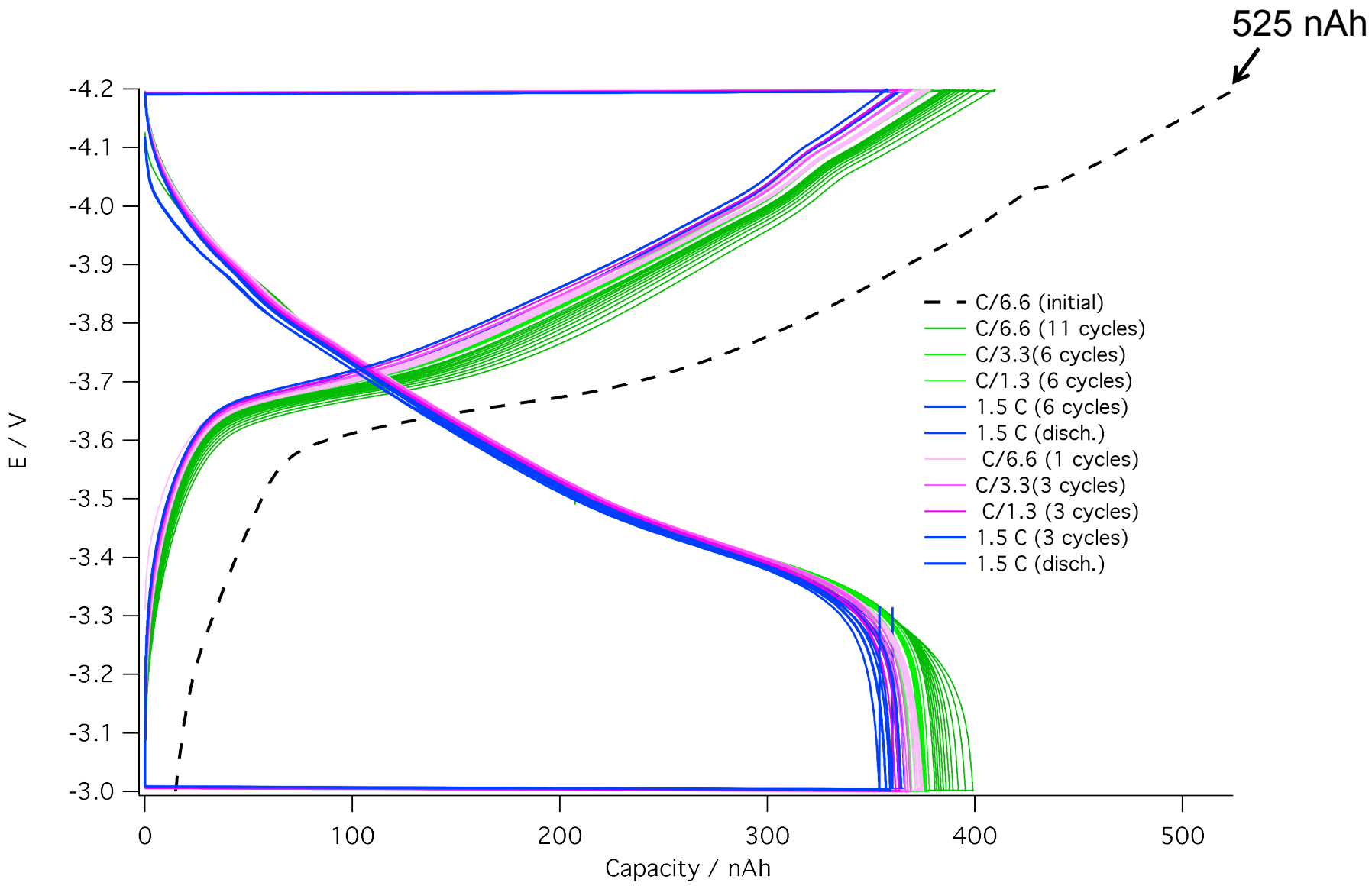


RT-LCO



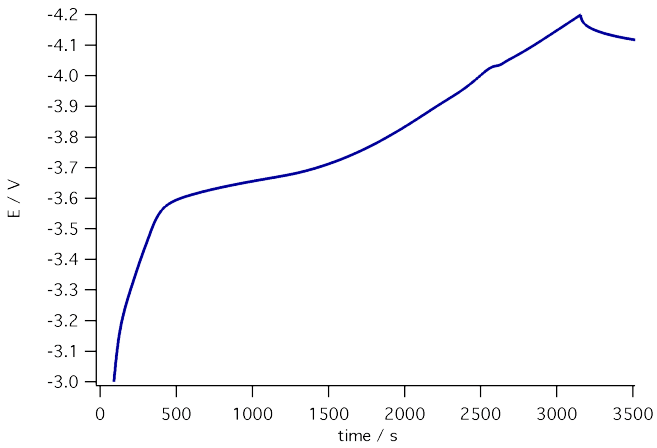
HT-LCO

Cycling test (41 cycles, 15 days)



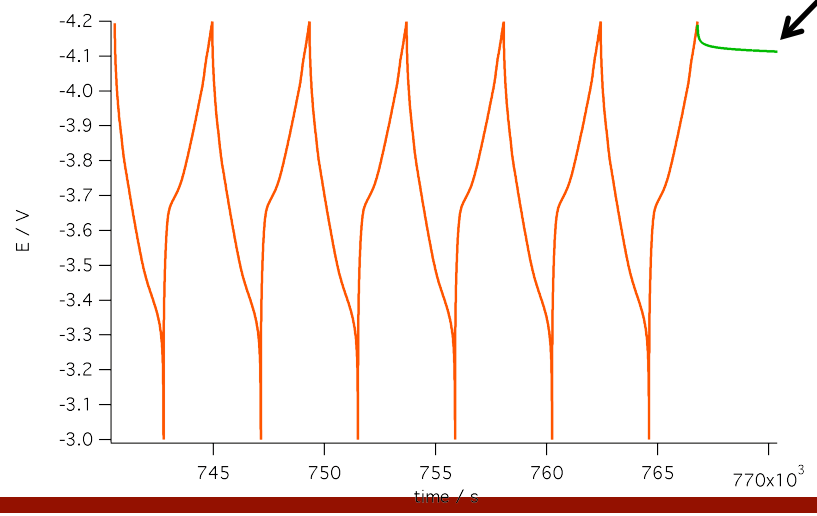
Theoretical capacity: 546 nAh

Maintaining the charge

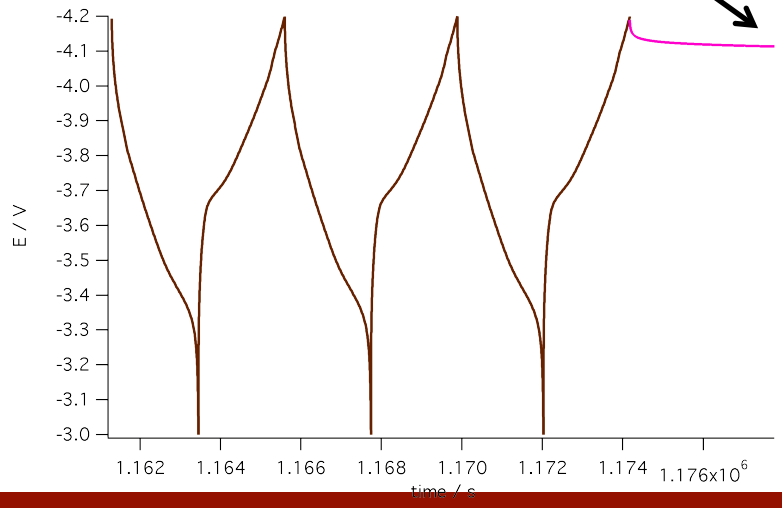


After the first charge at C/6.6:
4.12V after 1h

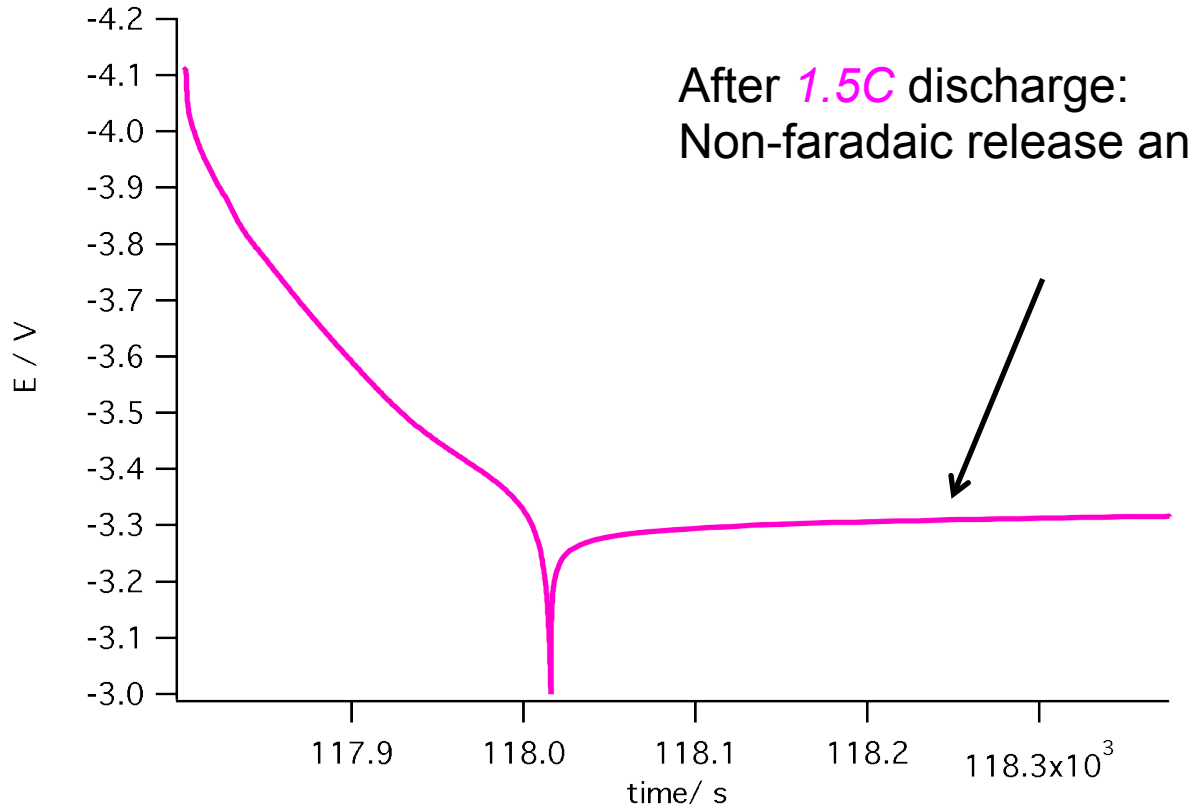
After 30 cycles ending at 1.5 C rate:
4.113V after 1h



After 40 cycles ending at 1.5 C rate:
4.114V after 1h

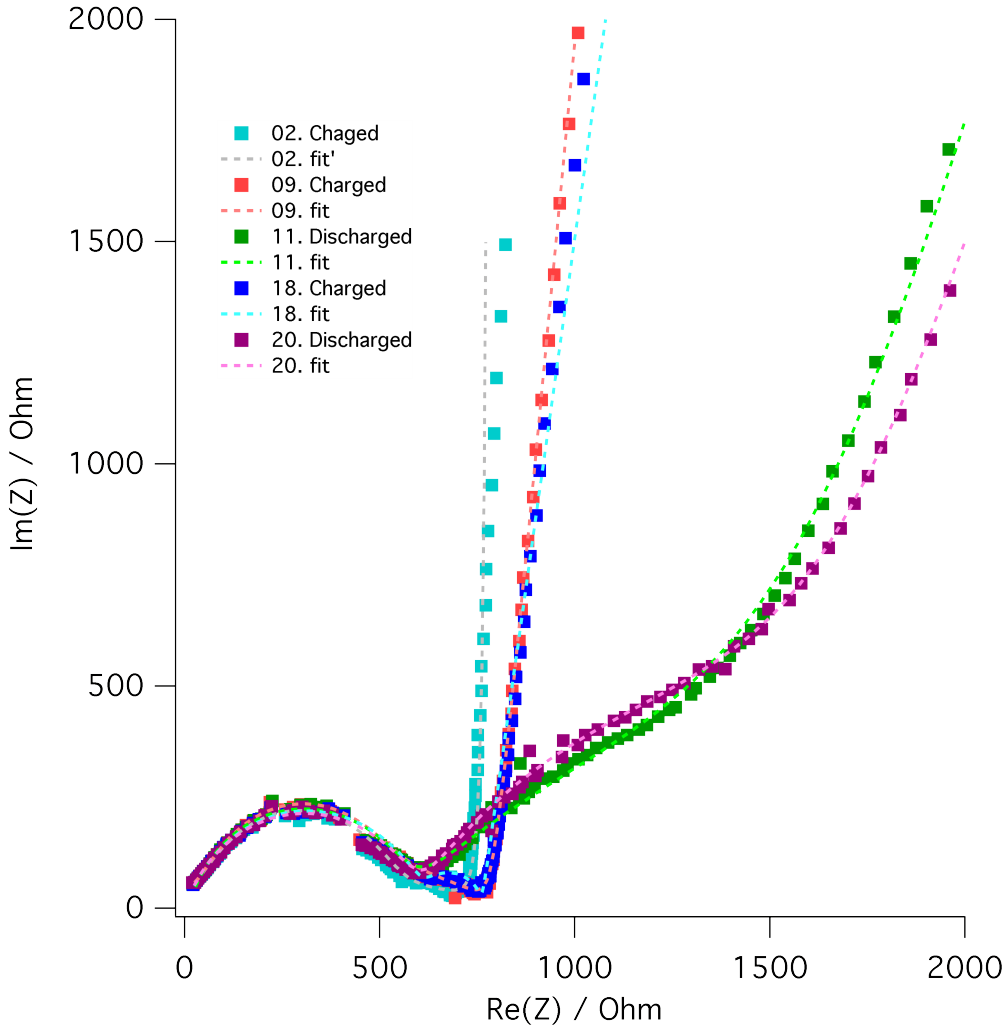


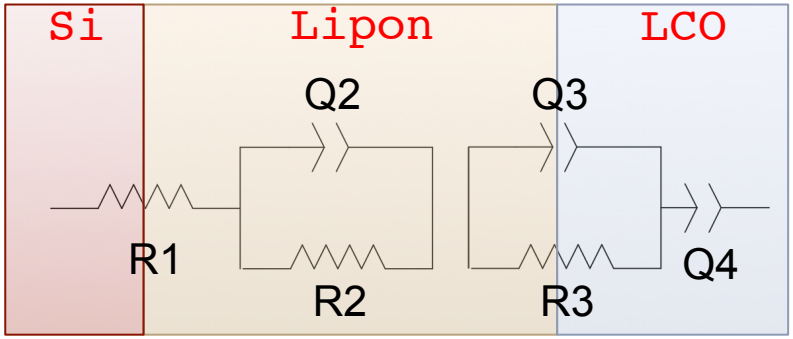
Maintaining the charge



After *1.5C* discharge:
Non-faradaic release and plateau at 3.32V after 1h

EIS equivalent circuit

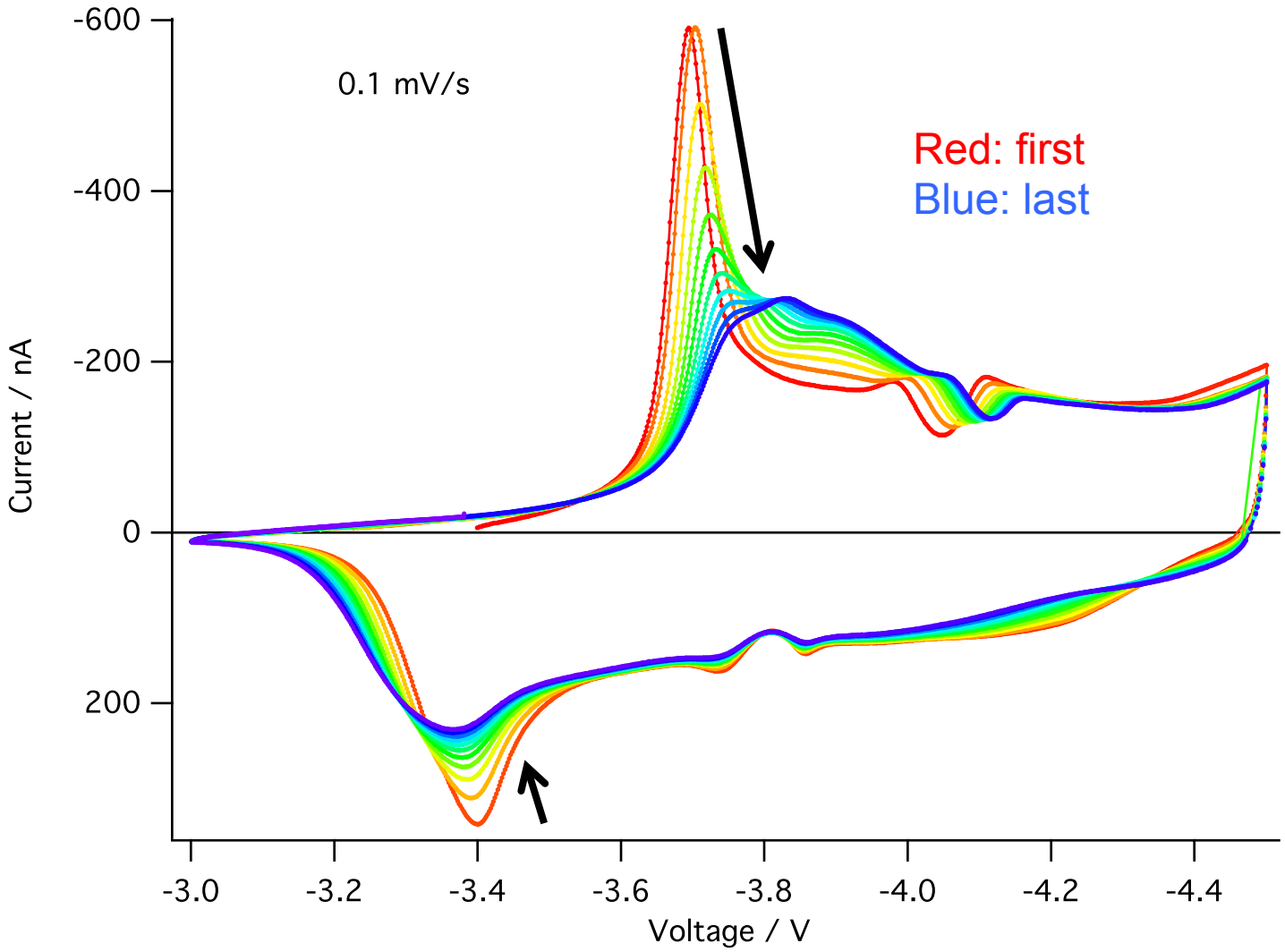




Seq.#	Cycles	R1 / Ohm	R2 / Ohm	R3 / Ohm
02.	1 (4.1 V)	84.43	5,866	1,146
09.	30 (4.1 V)	17.58	4,081	3,898
11.	31 (3.0 V)	22.96	6,078	8,957
18.	40 (4.1 V)	16.36	6,212	1,374
20.	41 (3.0 V)	10.8	5,928	10,973

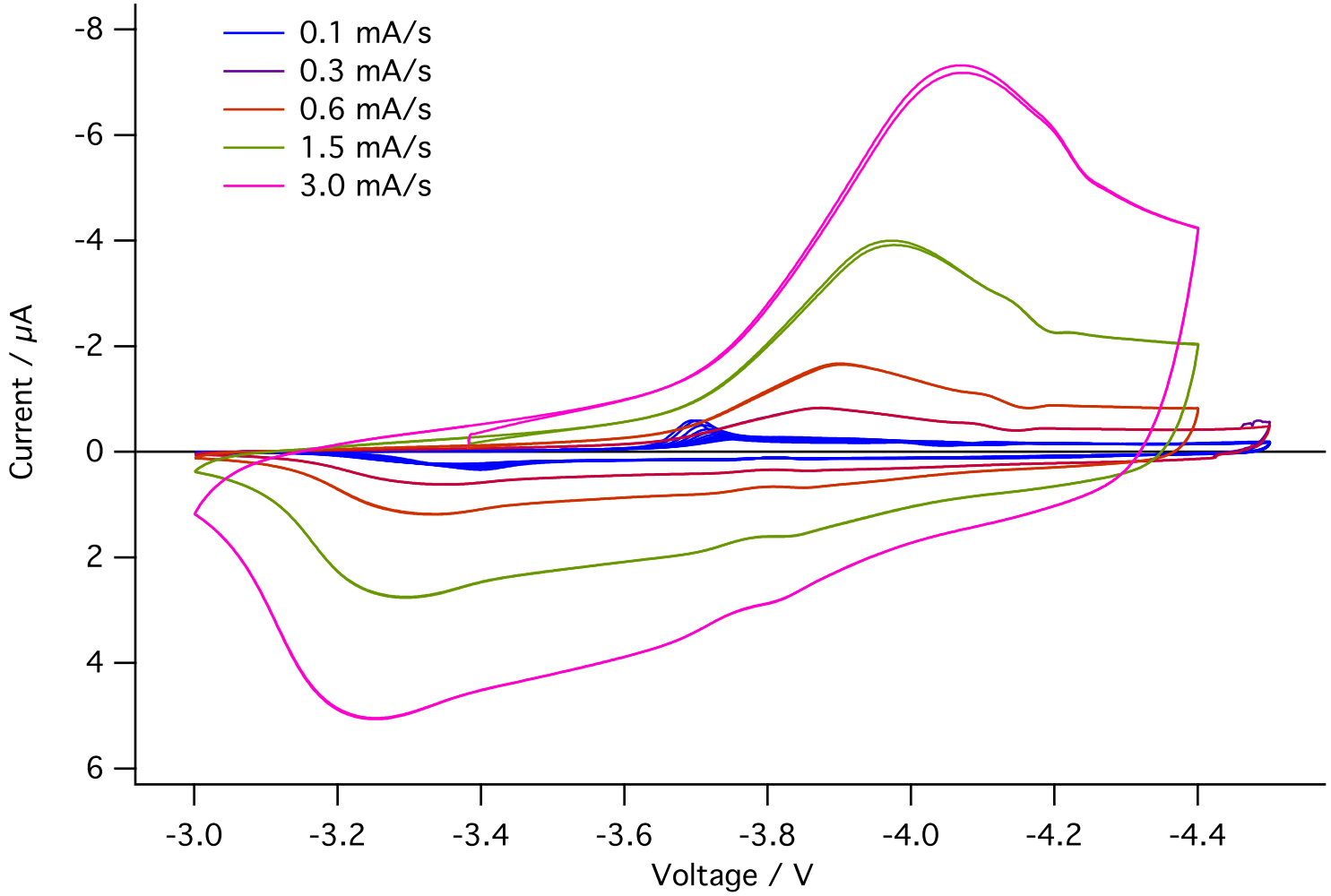
Y. Iriyama et al. Solid State Ionics 176 (2005) 2371–2376

SS Battery s1040A: CV 0.1 mV/s

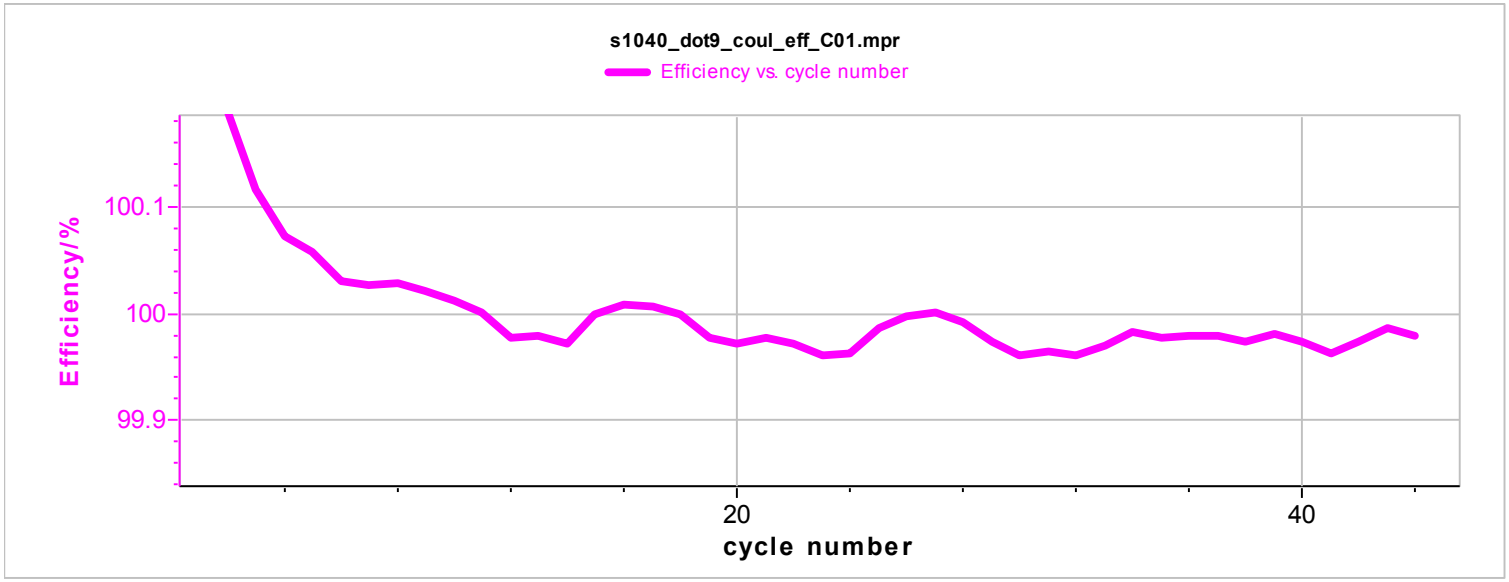


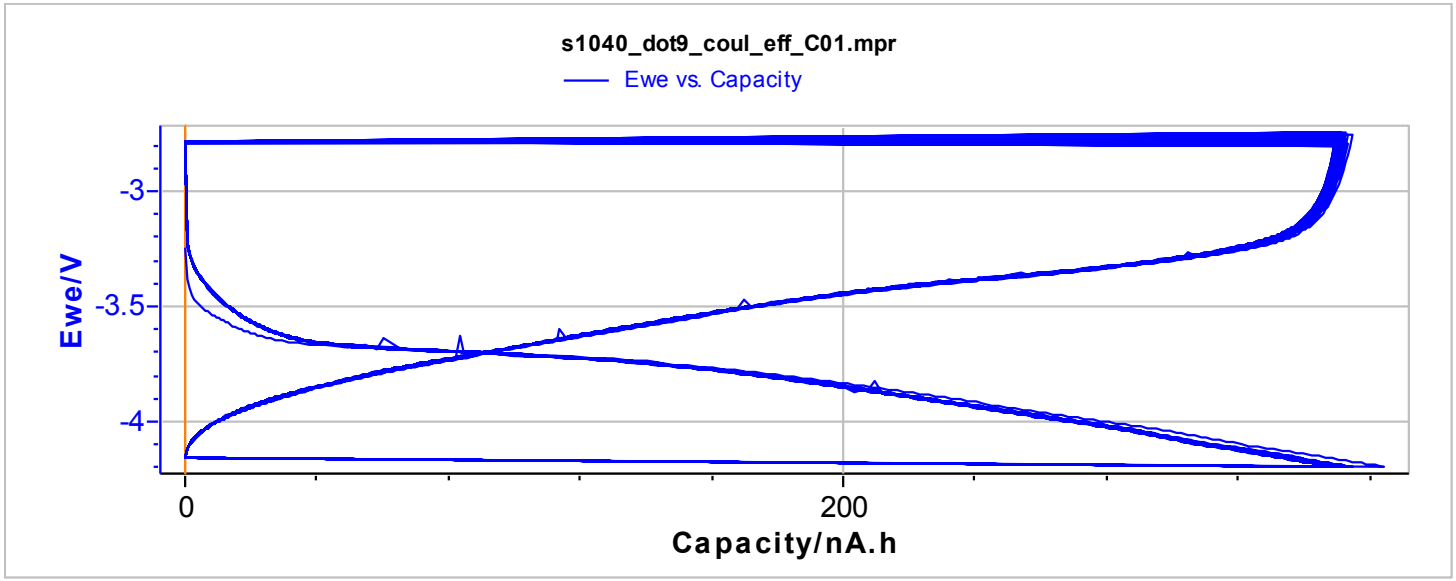
Starting with a fresh battery

SS Battery s1040A: CVs

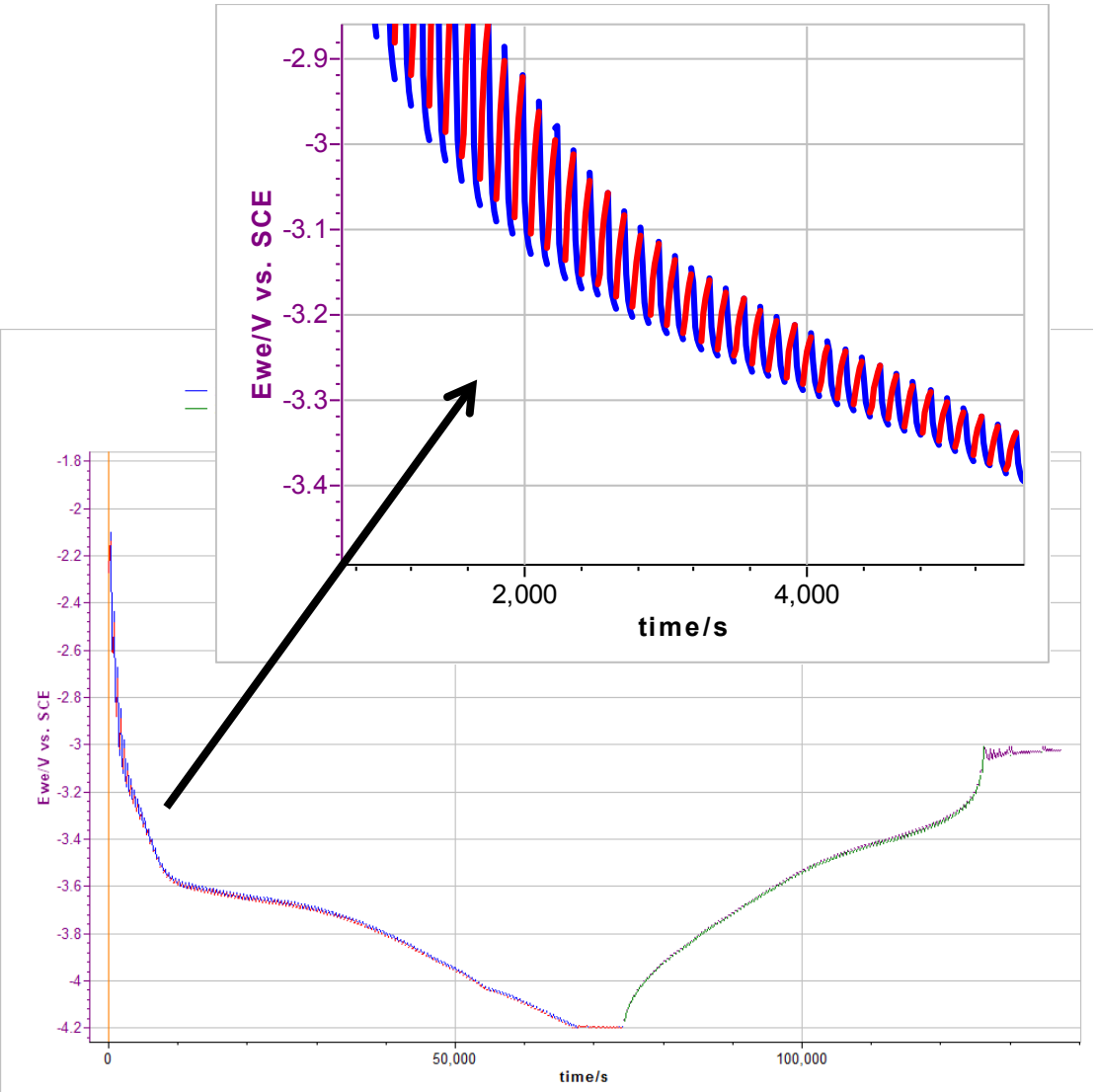


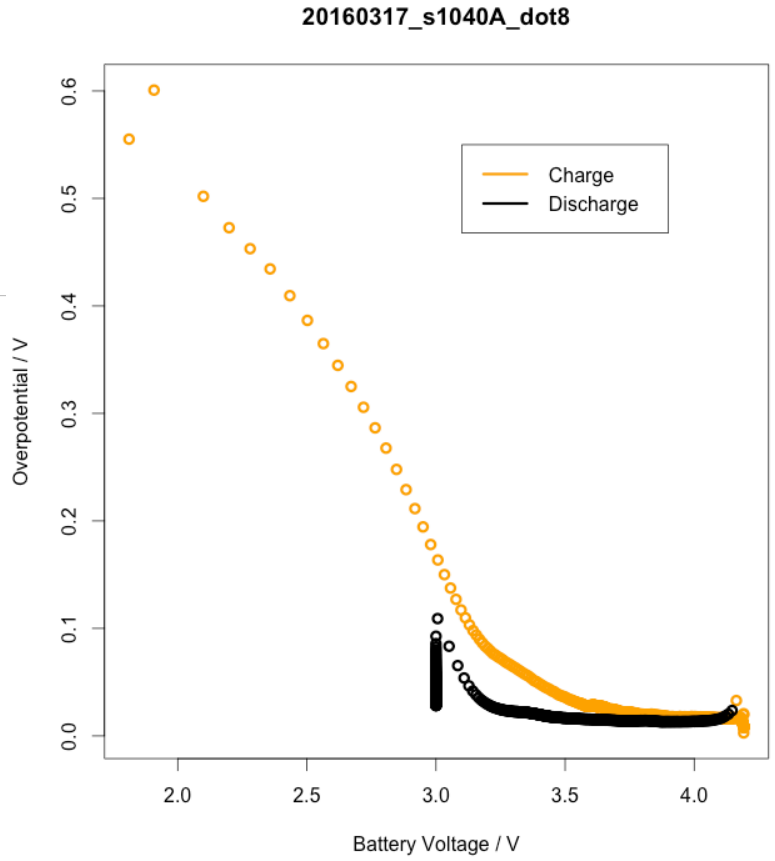
coulombic efficiency: 45 cycles





Current interrupt: Solid State Battery





FIB/SEM s1040B cross-section

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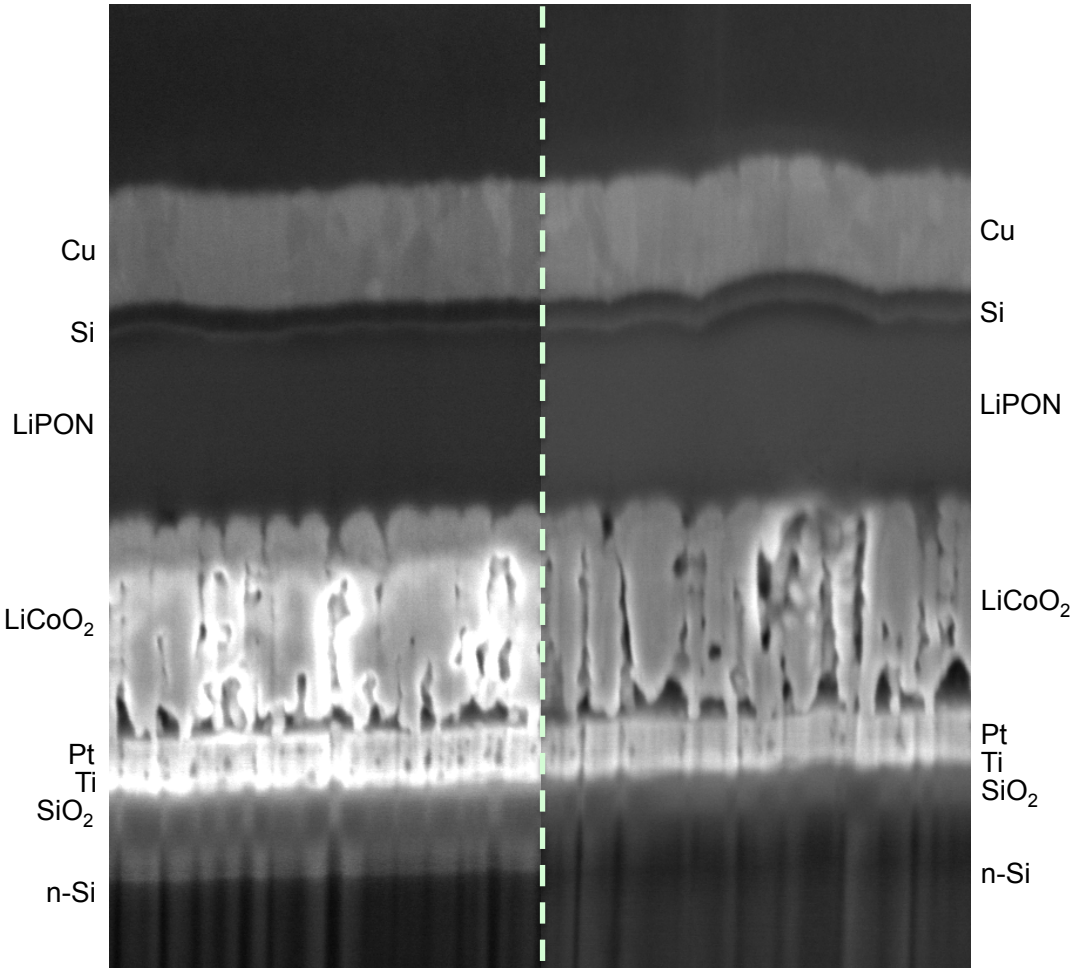
Cycled



Non cycled

Demanding power from SS-LIBs(1/3)

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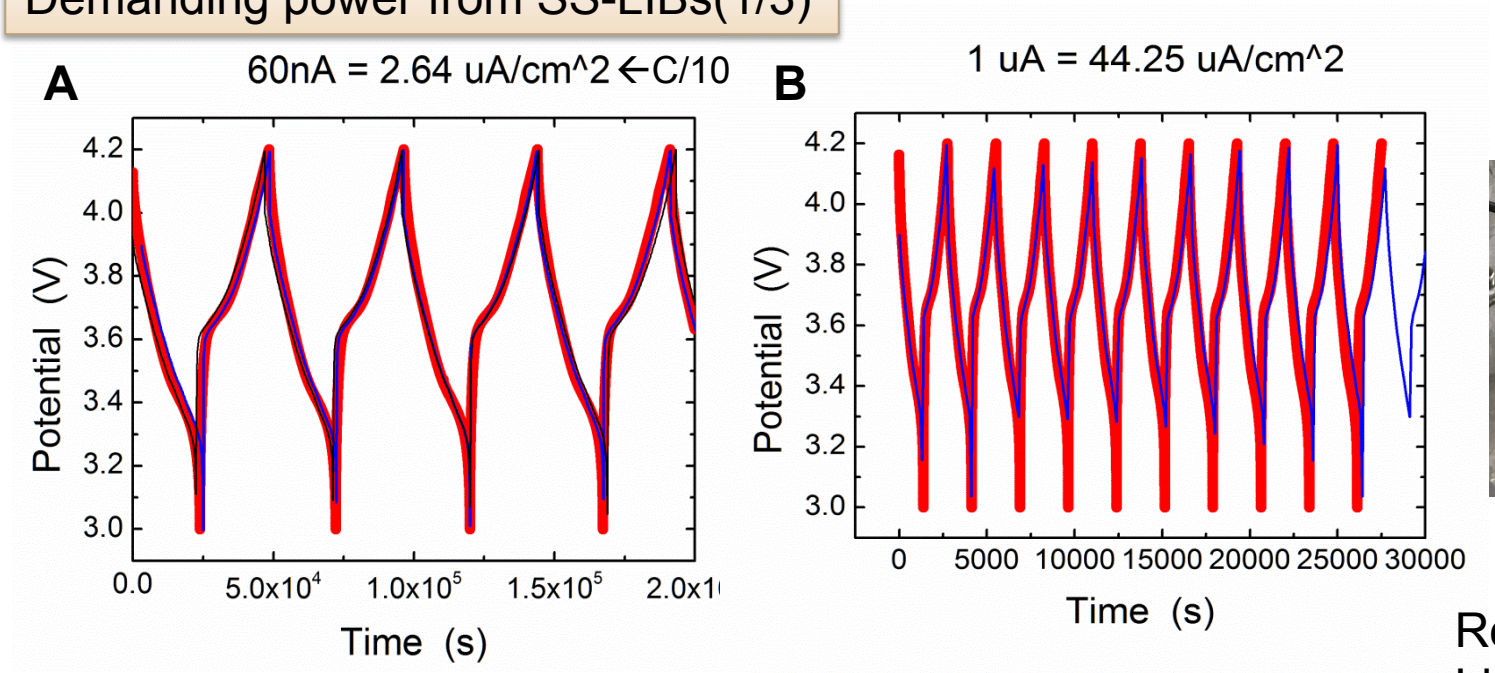

Red: experiment
Lines: model

←2mA, 90C rate!
But…
capacity is 1/4

What is happening inside the battery? (2/3)

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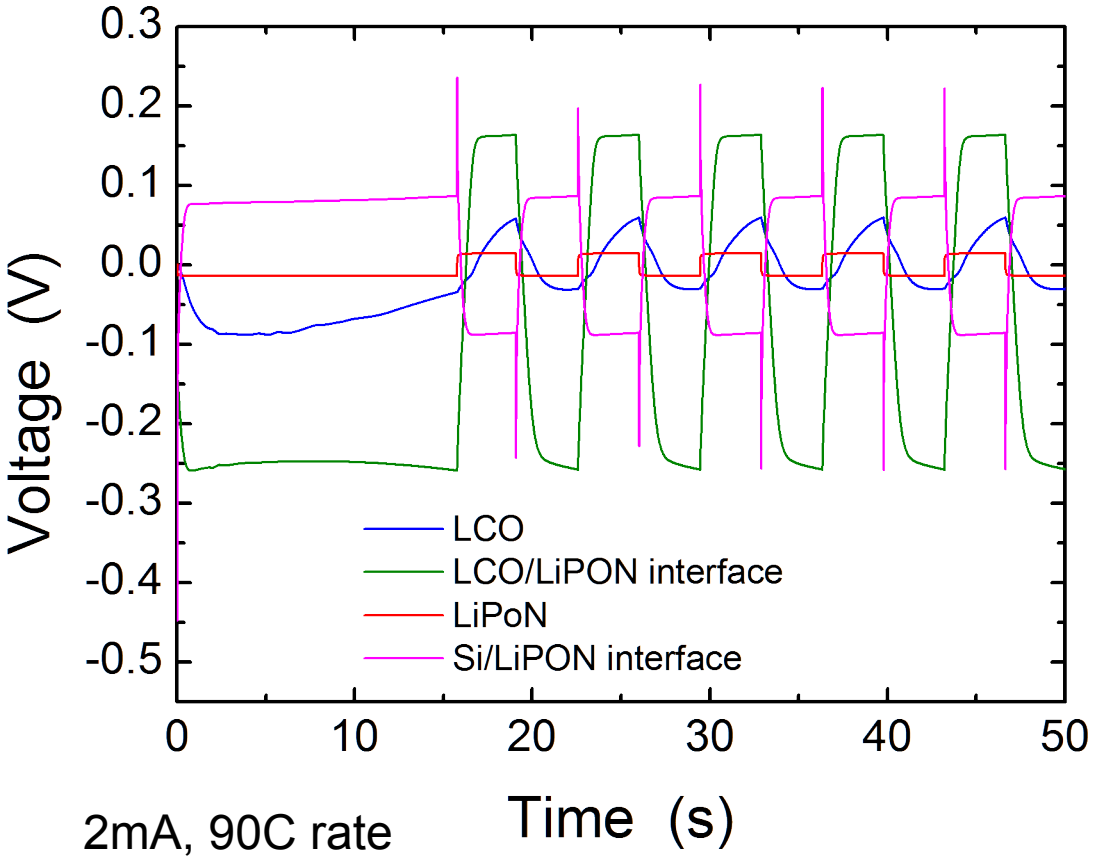
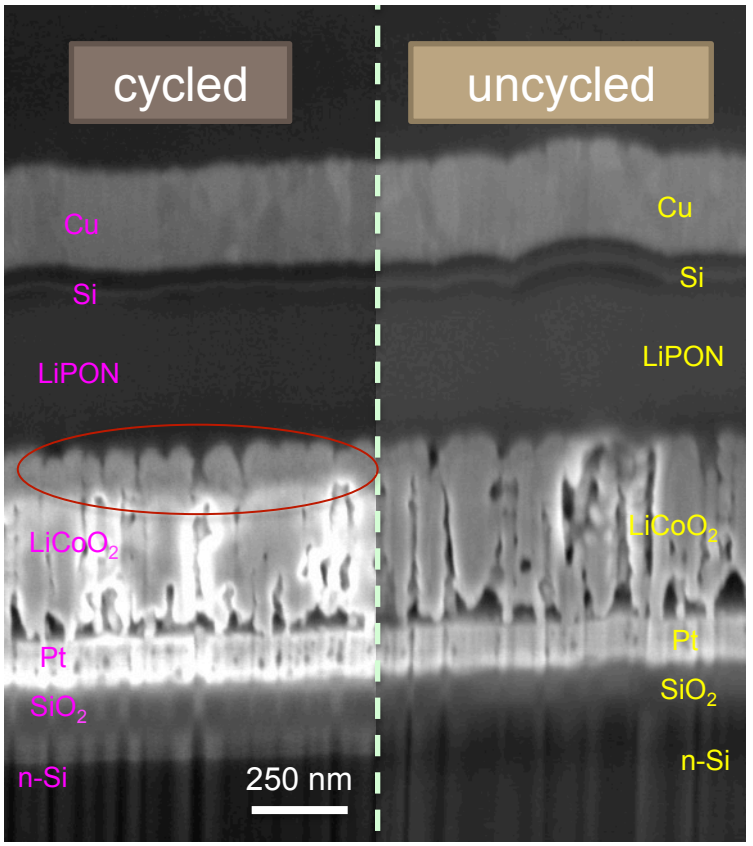
E Overpotentials extracted after fitting the experimental cycling curves with our model

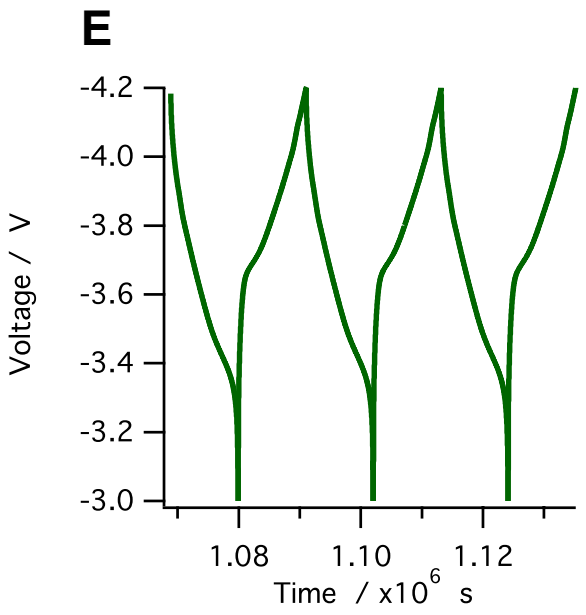


2mA, 90C rate

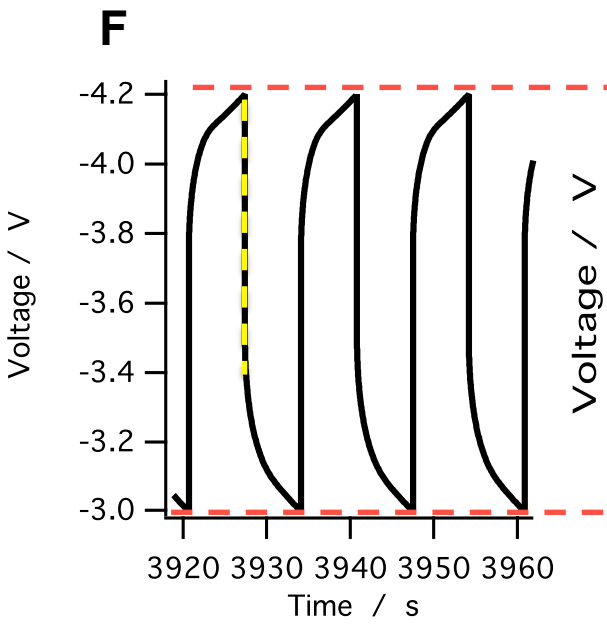
FIB/SEM cross section of the battery before and after cycling



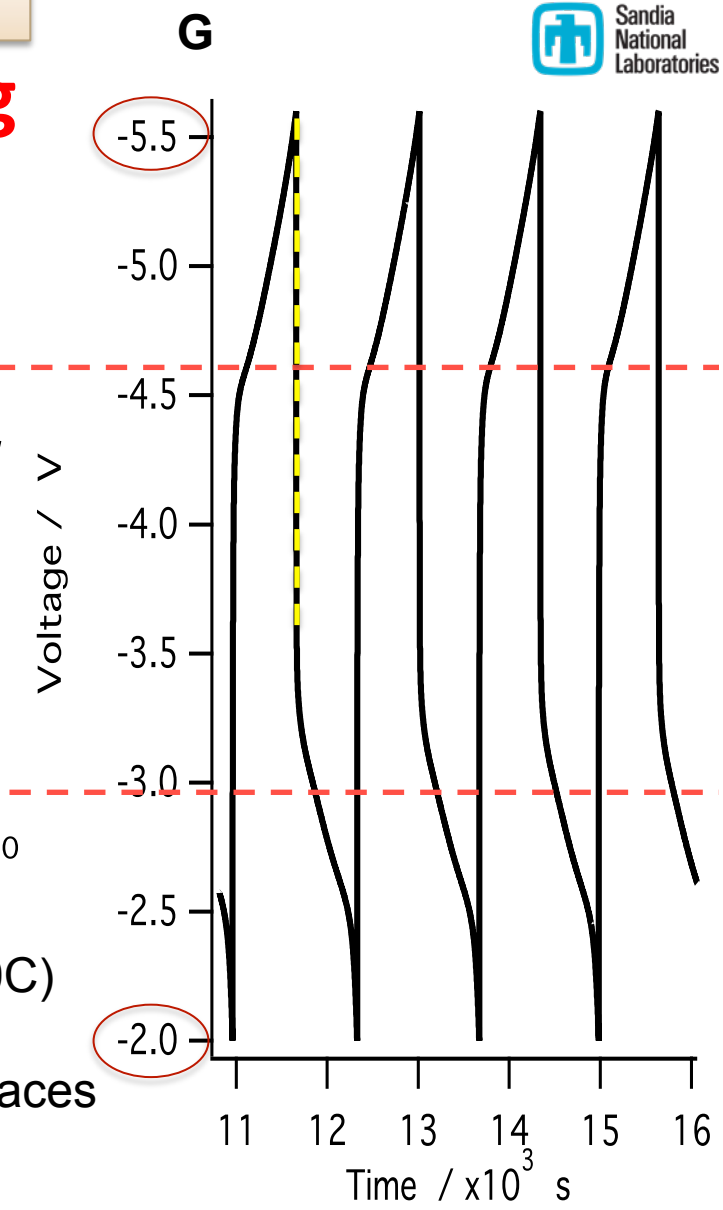
Extended voltage-range cycling



Full charge in 5h (1/5C)
Full capacity



Full charge in 40s (90C)
Low capacity due
to potential lost at interfaces



High Power + High capacity