Industry Day at Berkeley Lab
Lab Scale Cell Fabrication

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April 29, 2015

LBNL

Equipment

Mixers and Coaters

In glove box

Non-aqueous

In hood

Aqueous

Equipment

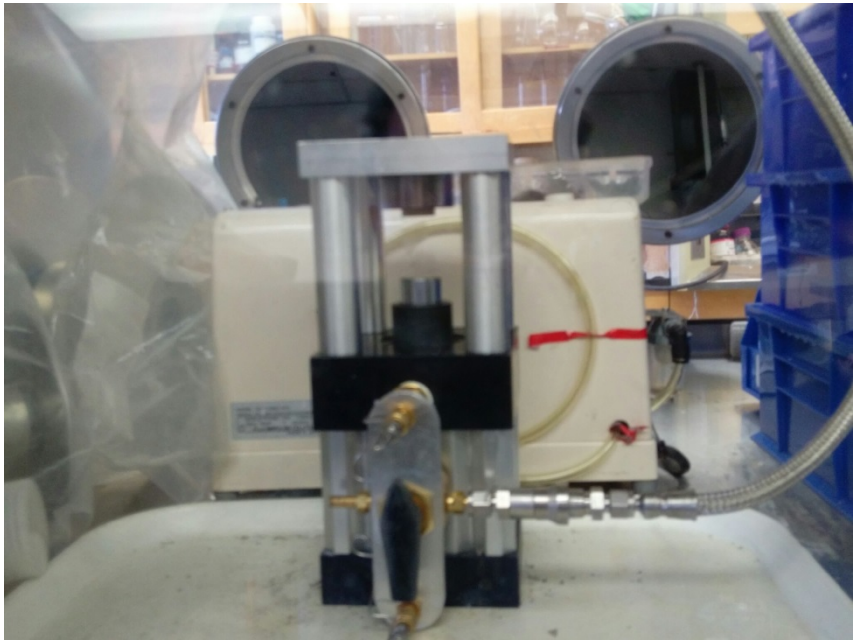
Calender

Includes hot calendering

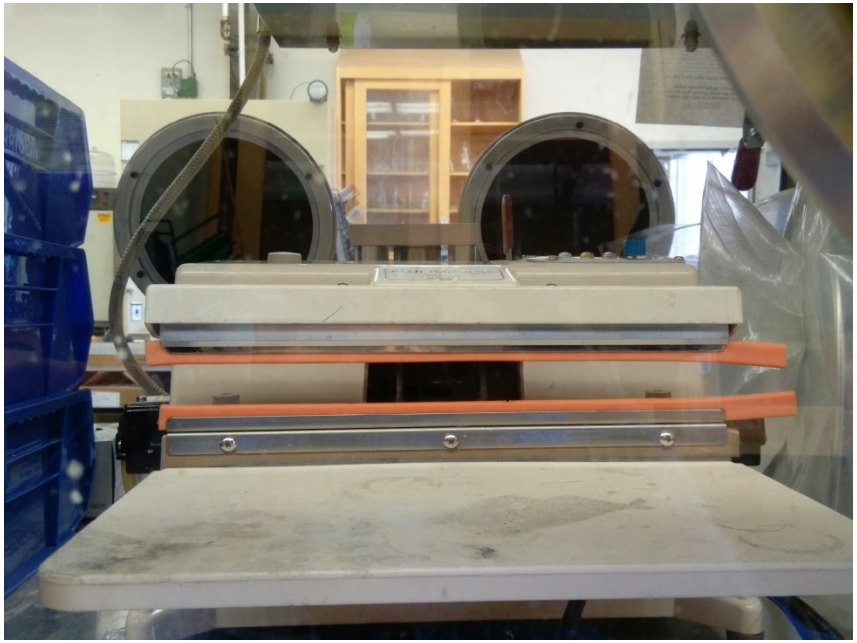
Equipment

Cell Assembly

Coin Cells



Pouch Cells



In a glove box with electrolyte.

Equipment

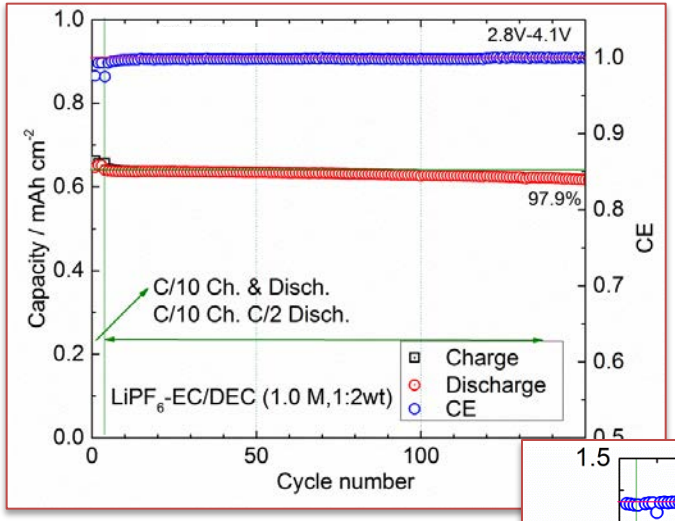
Testing

Approaching 400 Test Channels with Environmental Chambers to test In.

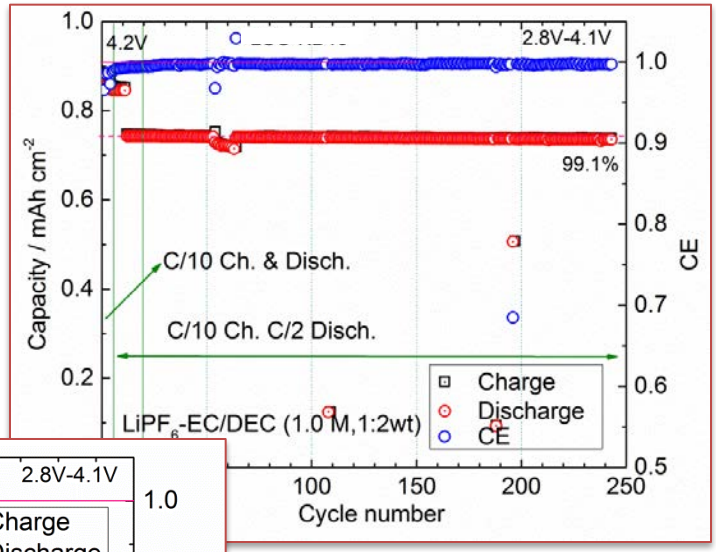
Make "Good" Cells

vs. Li

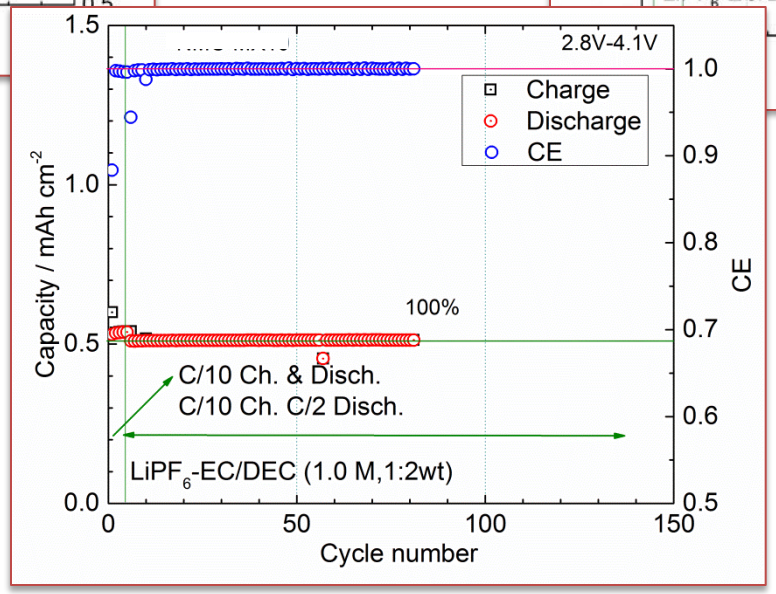
LCO



HV-LCO



NCM

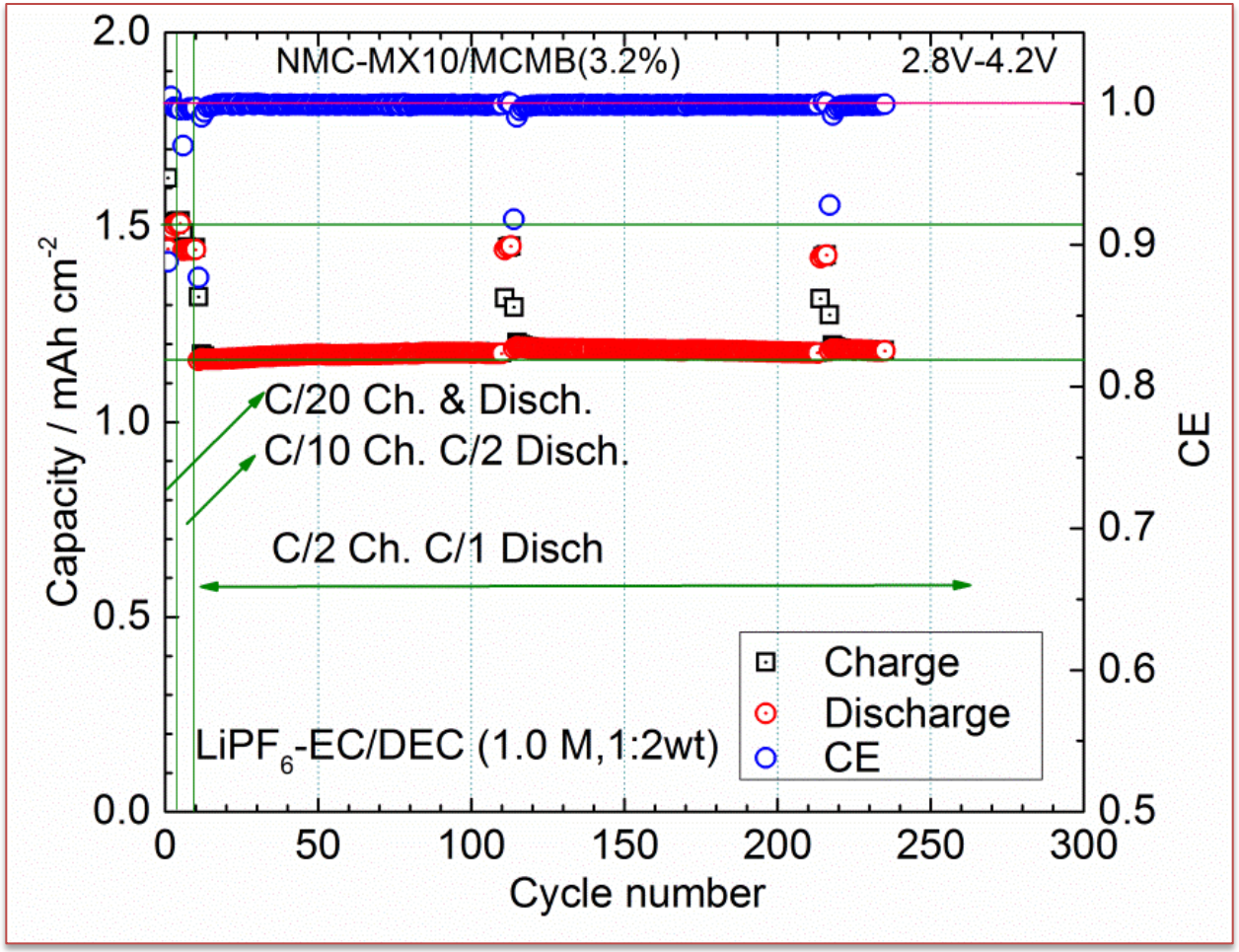


First time cells made; 10 g of powder for each.

Make "Good" Cells

vs. Gr.

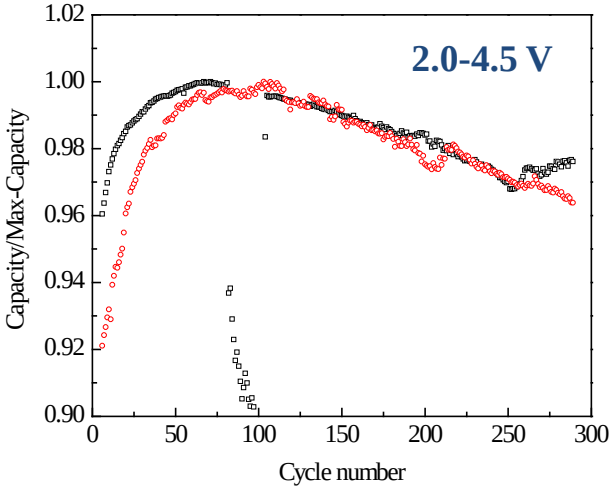
Full cells in a pouch (12 cm^2).

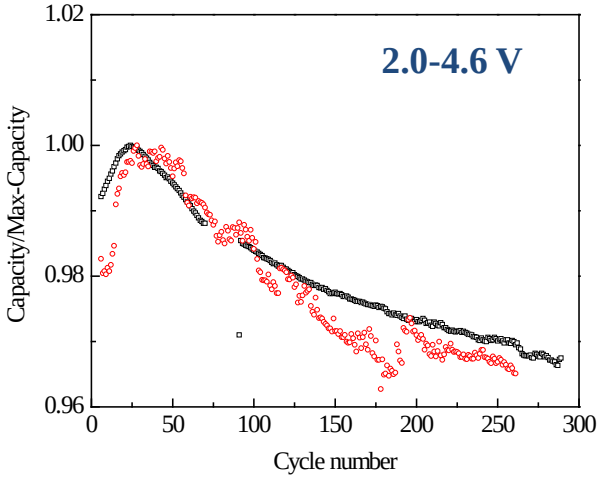


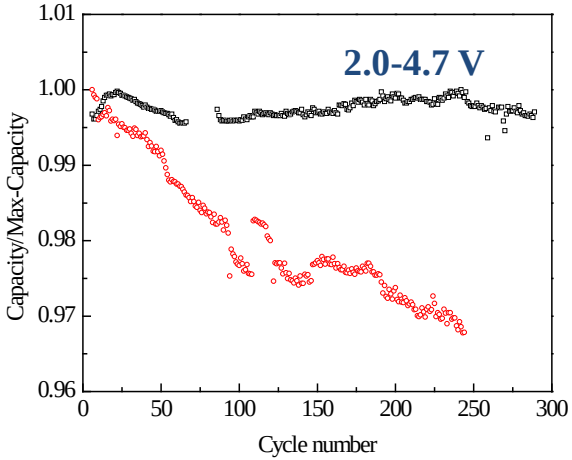
Make "Good" Cells

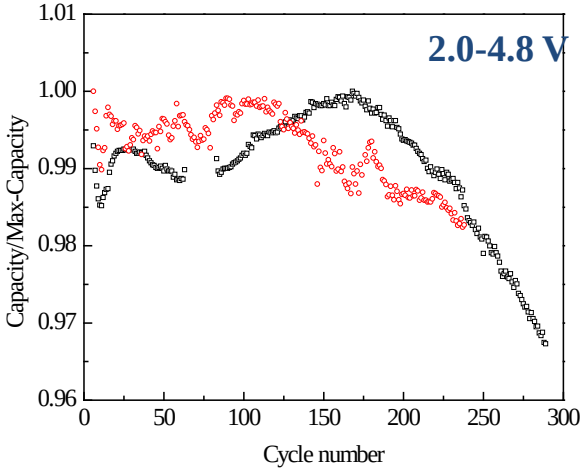
Direct comparison to industry electrodes

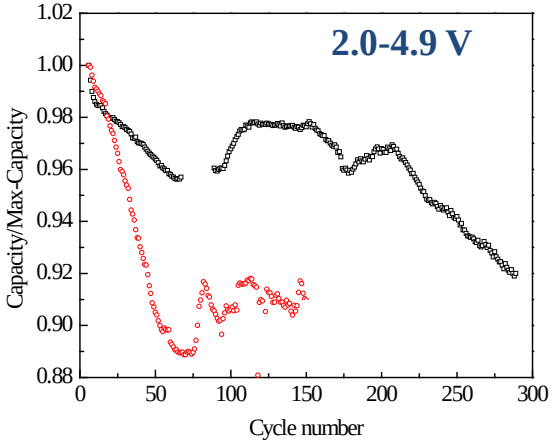
vs. Li











LBNL

Ind. Partner

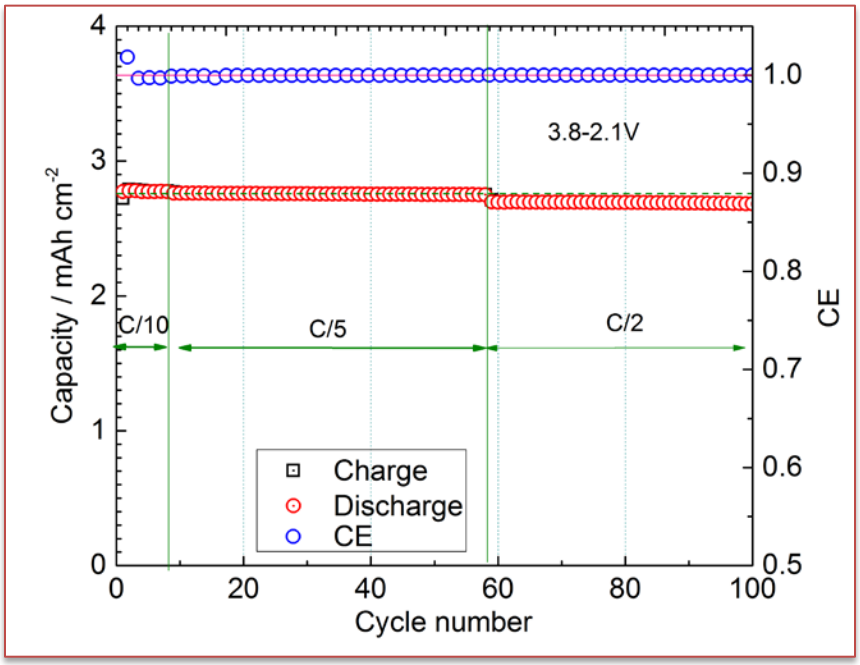
Ours stack up well.

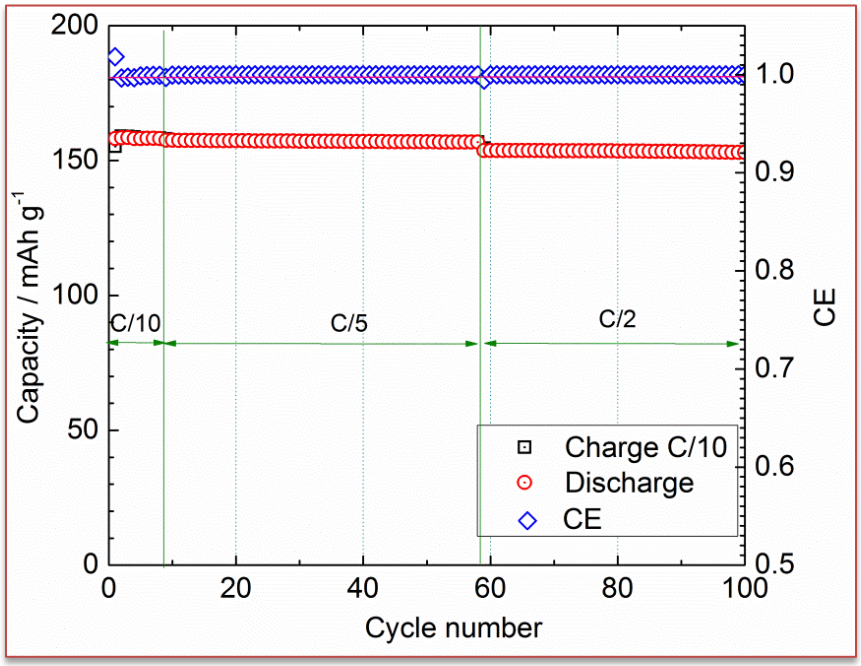
Make "Good" Cells

vs. Li

High Loading Electrodes.

LFP



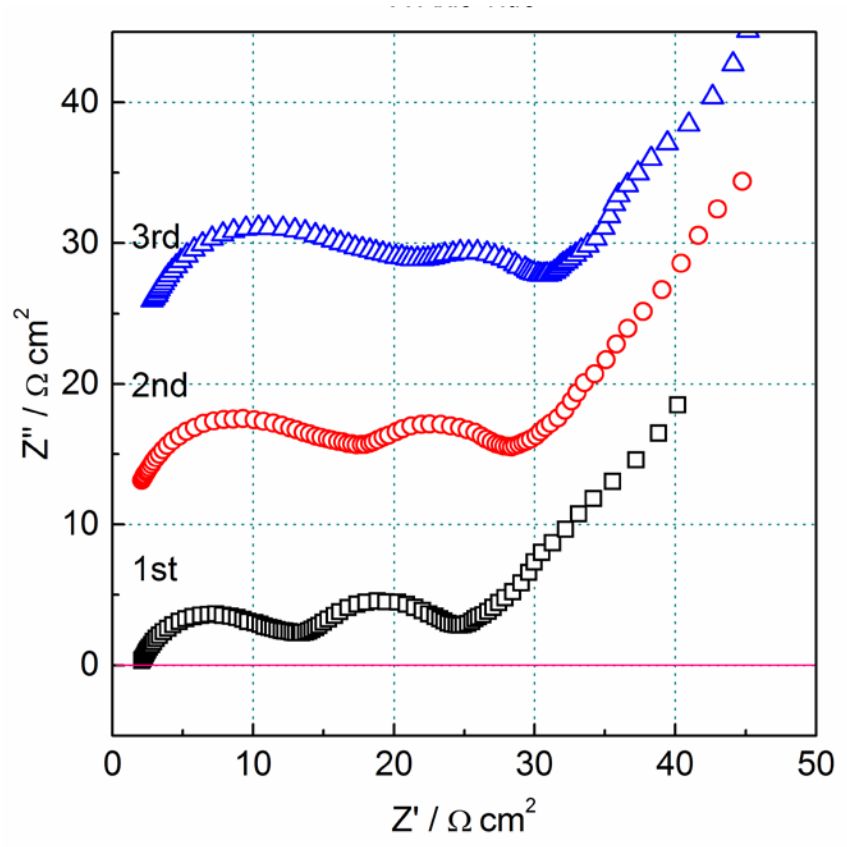


Very good cycleability.

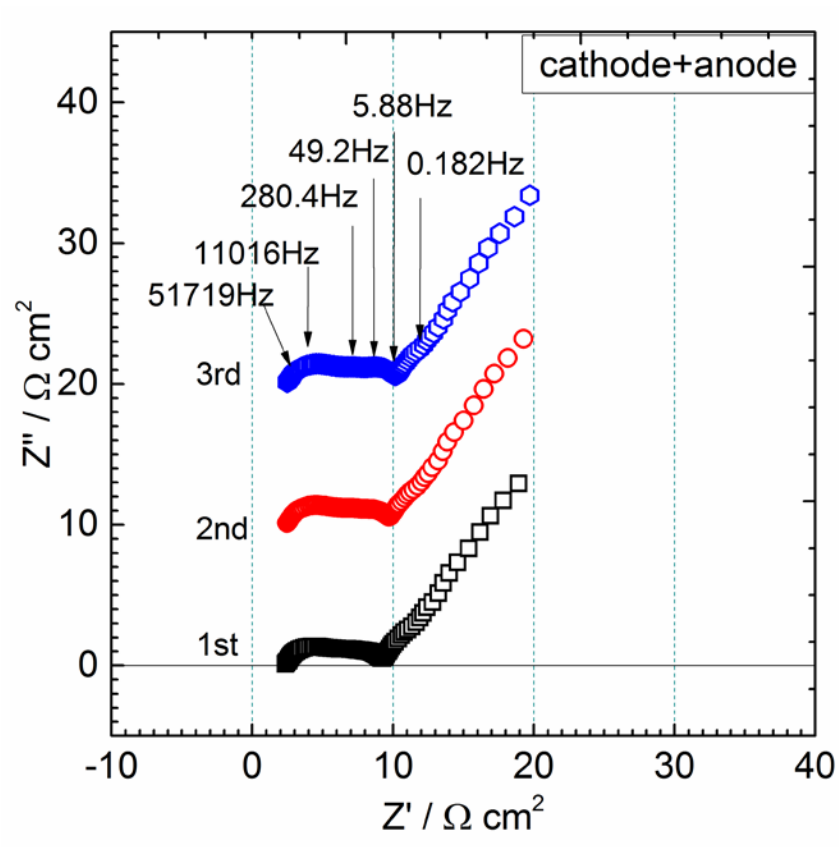
Cell Analysis

vs. Gr.

NEI#4



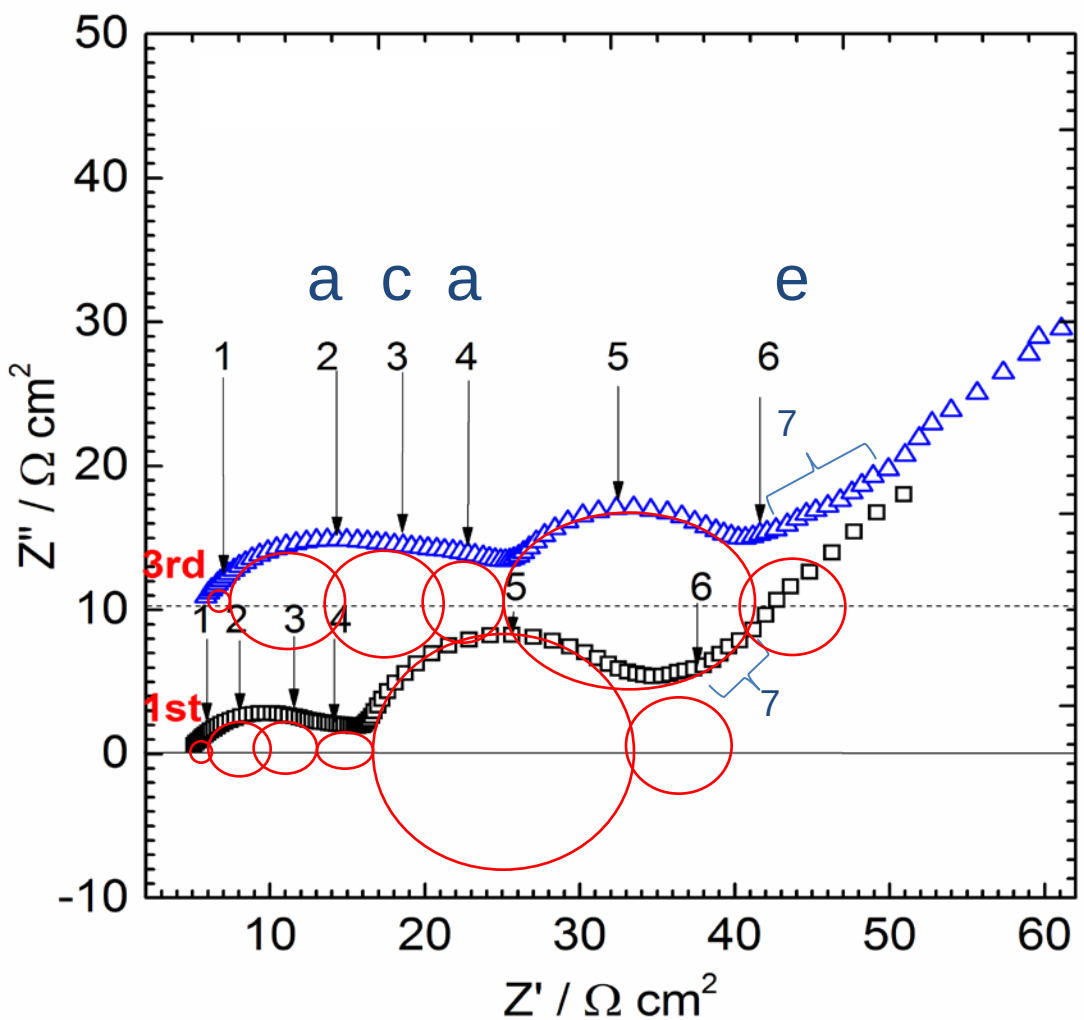
NCM



Within the first charge, NMO cells have a lot of impedance.

Cell Analysis

vs. Gr.



Three electrode cells allow us to assign the source of impedance rise.

Testing Protocols

- Assist the USACB in developing their test manuals for EV and PHEVS.
- Developed a protocol for ESIC.
  - Define performance metrics
  - Define performance tests

Testing Protocols

Performance Metrics

Goals for Energy Storage (sine wave discharge; sine wave charge)			
End of Life Characteristics at 23°C	**Units**	**System Level**	
Discharge Time	hours	4	
Maximum Discharge Power	MW	1	
Charge Time	h	6	
Minimum Round Trip Energy Efficiency	%	75	
Calendar Life	years	15	
Selling Price	$/kW	150	
Operating Environment	°C	-30 to 50	
Maximum Operating Voltage	kV	150	
Minimum Operating Voltage	V	80	
Unassisted Operating at Low Temperature	%	>70% energy @ Pmax at -20°C	
Survival Temperature	°C	-40 to 57	
Additional Battery Characteristics Based on Numbers Provided Above			Formula
Discharge Time Constant	hours	1.27	= discharge time / pi
Energy of Battery	MWh	2.55	= 2 x time constant x Pmax
Average Discharge Power	MW	0.64	= energy of battery / time of discharge
Maximum Charge Power (assuming min. efficiency)	MW	0.89	= pi/2 x energy / efficiency / time of charge
Average Charge Power	MW	0.57	= energy / efficiency / time of charge
<P>/E ratio, Discharge	h^{-1}	0.25	= average discharge power / energy
Cycle Life	Cycles	5475	= 365 x Calendar Life
Time of Discharge of Unassisted Operating at Low Temperature	h	2.8	= pi/2 x 0.7 x energy / Pmax
Battery designed based on most difficult challenge (Pmax discharge, Pmax Charge, or Unassisted Operation)			

Testing Protocols

Tests

- Cycling tests
  - Define cycles that address the requirements of the application
  - Accelerated cycles
- Celendar tests
  - Aging accelerated by temperature
- Reference performance tests
  - Full battery size based on unit tested
  - Energy remaining
  - Power capability
  - Make estimates of end-of-life

Summary

- Make quality cells
  - Pouch or coin
  - Full or half
  - Just 10 g is needed – right the first time.
- Analyze for Failure
  - Side reactions
  - Assigning sources of impedance rise
- Experience in developing testing protocols.