Dry Process Electrode Fabrication

Michael Wixom

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Project ID: ES134

Overview

Timeline

- Project start date: Oct. 2011
- Project end date: Oct. 2014
- Percent complete: 31%

Barriers

- Conventional slurry casting processes drive the cost of lithium ion battery electrodes.

Budget

- Total project funding:
  - DOE share $2,992,743
  - Contractors share $1,247,136
- Funding received in FY11 $978,320 (obligated)
- Funding for FY12
  - DOE share $1,160,263
  - Contractors share $481,775

Partners

- Maxwell Technologies is no longer a partner

Objectives of this study

- The Phase I objectives of this program are:
  - PTFE binders have been demonstrated for solvent-free cathodes, but PTFE is not electrochemically stable in a lithium battery anode. Therefore phase I will define a binder system for solvent-free anode fabrication that is stable over 500 cycles to full state of charge.
  - Identify the thickness limit for dry process cathodes that can meet EV rate and cycle life criteria
- The Phase II objectives of this program are:
  - Produce a solvent-free anode material that capacity matches the Phase I cathode.
  - Produce free standing dry process cathode that retains 50% capacity at 1C rate.
  - Validate cost model by running pilot coating line.
  - Deliver 24 cells in SOA EV cell format.

Project Milestones and Decision Points

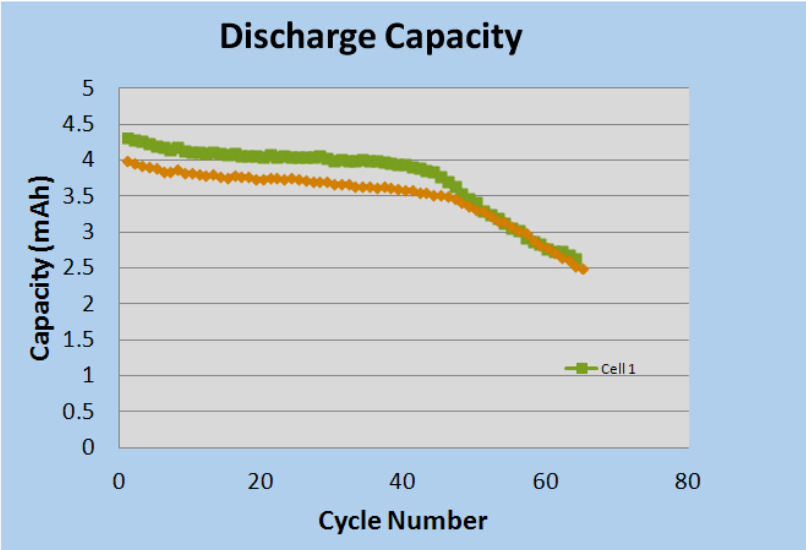
Milestone/Decision Point	Metric	Date
1. Acceptance of mgt plan revisions		0
2. Down-select LMFP, NMC, and pre-coat		4
3. Cathode morphology and mixing conditions specified		6
4. High solid loading anode	>40% solids cast to >3 mAh/cm^2	6
5. Demo. lab prototype cell w/ dry process blended cathode	>100 μm cathode	8
6. Deliver interim cells with dry process blended cathode/wet anode	18 cells, 14 Ah pouch	9
7. Demo dry process anode	Rate/capacity match cathode	12
8. Down-select low cost anode process	50% vs baseline capex + opex	13
9. Scale cathode film to support task 16	10 m	17
10. Lab prototype cell dry anode/dry cathode	Pass EV life test	18
11. Deliver final cells	24 cells, >14 Ah prismatic can	21

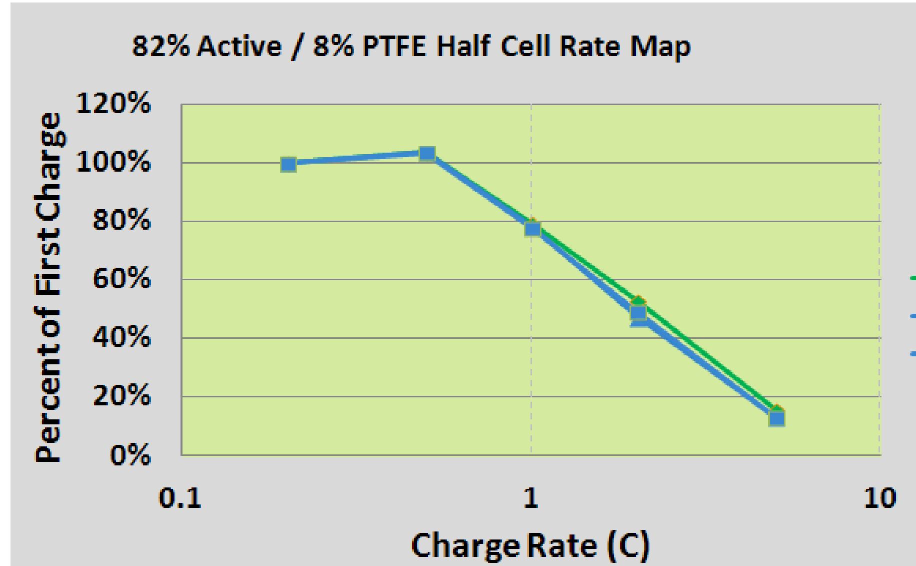
Dates are effective upon approval of revised project management plan.

Approach

- Establish baseline for oxide electrode materials.
- Optimize cathode blend for energy and safety.
- Select electrode powder for compatibility with dry process.
- Increase cathode loading to 2X limit of baseline slurry casting process.
- Produce free standing cathode for lamination.
- Validate cathode manufacturing cost reduction.
- Identify solvent-less anode binder with electrochemical stability at lithium potential.
- Meet anode mechanical and electrode interface requirements at lab scale.
- Demonstrate SOA cell to validate cost reduction.

High energy phosphate blended cathodes are being produced at Navitas.



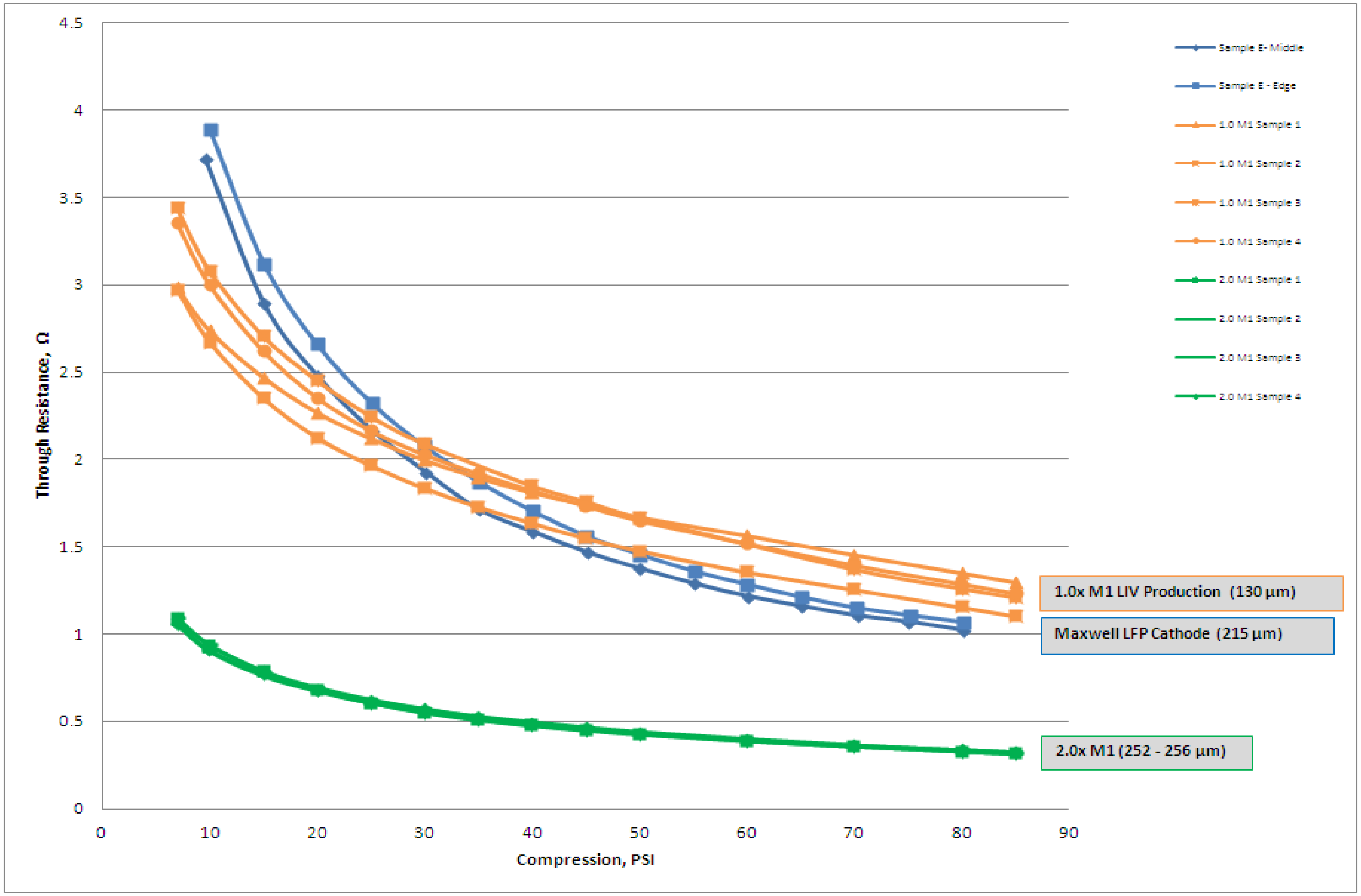


C/5-D/5 37% porous 400 mAh/cm2 loading

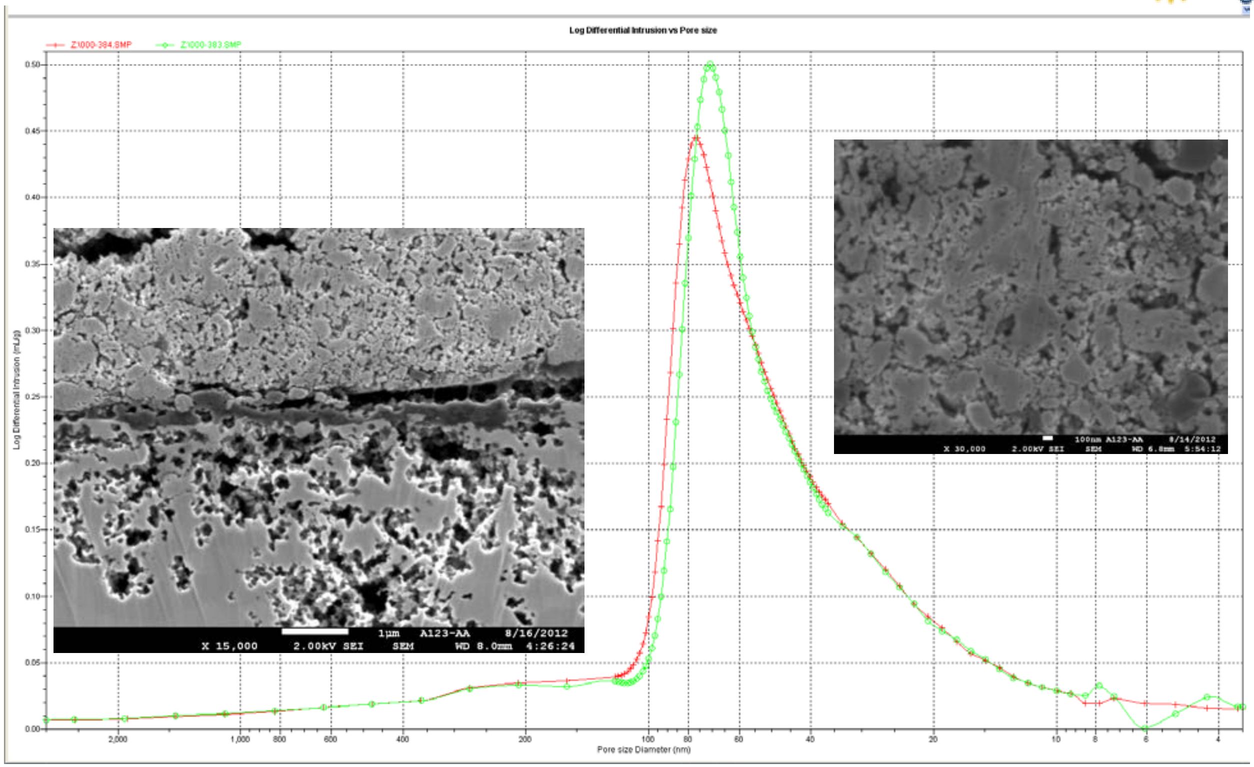
Safer, lower cost option to NMC for EV market

Cycle life needs attention, but rate retention and impedance are acceptable. Formation capacity is >95% theoretical.

Cathodes show through-resistance comparable to production electrodes.

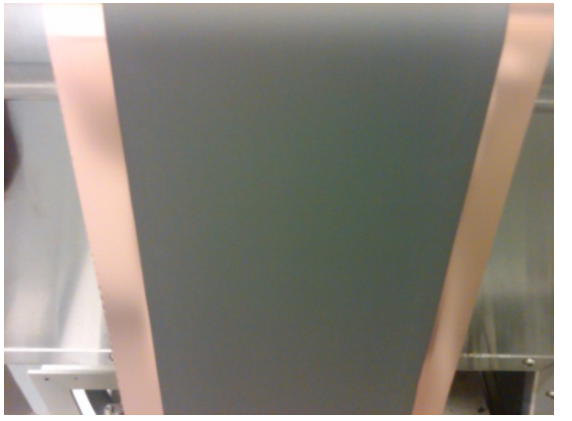


Porosity is comparable to production cathodes



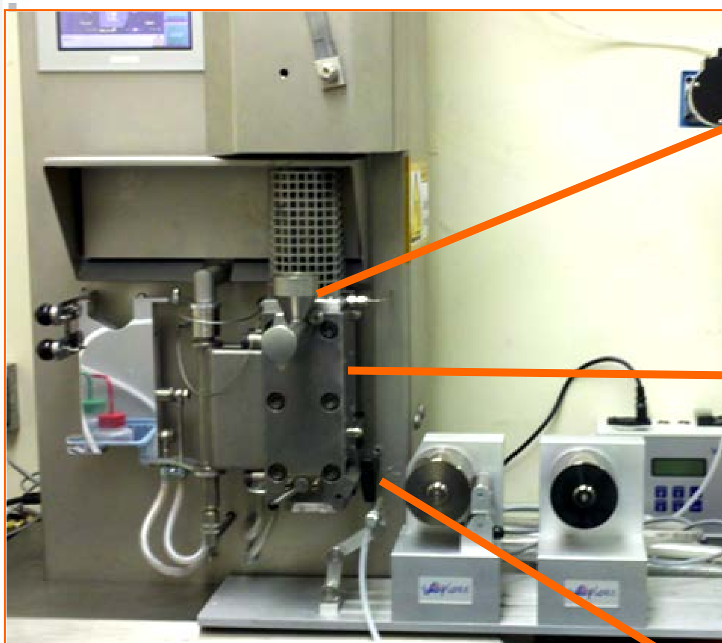
We are meeting target porosity range (34%), but see delamination and de-cohesion in the electrode that may correlate with poor impedance and/or low capacity. Higher porosity targets may be addressed to support ion transport in the 150 µm dry process cathodes c.f 55 µm production electrodes. Q3 report Oct 13

High loaded capacity-matched anode needed for interim cells.

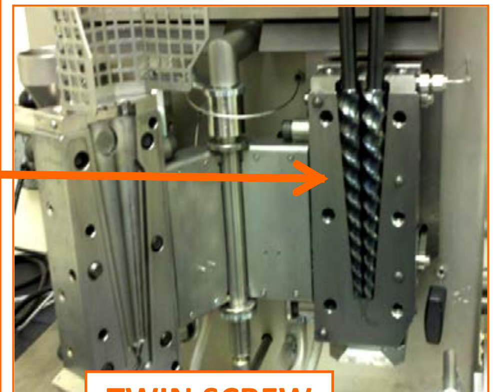


(A) slot-die coater; (B) streak-free wet coating after slot-die; and (C) crack-free dry coating after heat-zone. A crack-free, double-sided anode with a loading of 15mg/cm2 has been fabricated.

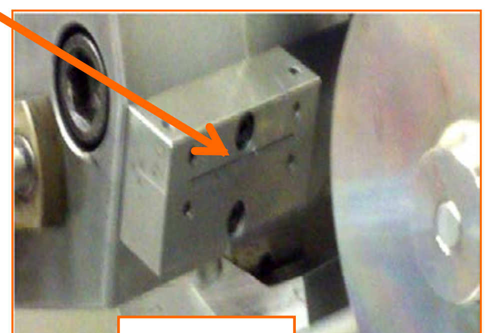
Progress on dry anode – not PTFE.



BATCH FEED



TWIN SCREW



FILM DIE

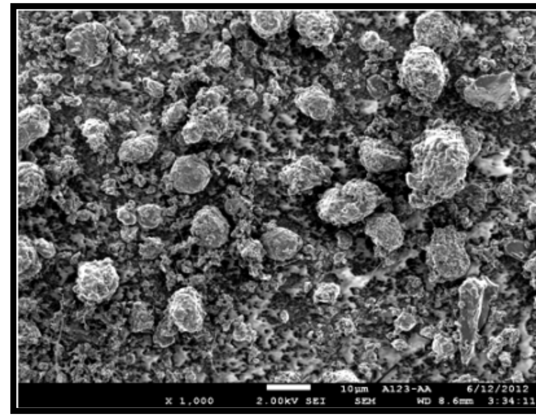
Flexible free standing ~65 µm anode composite after calendering

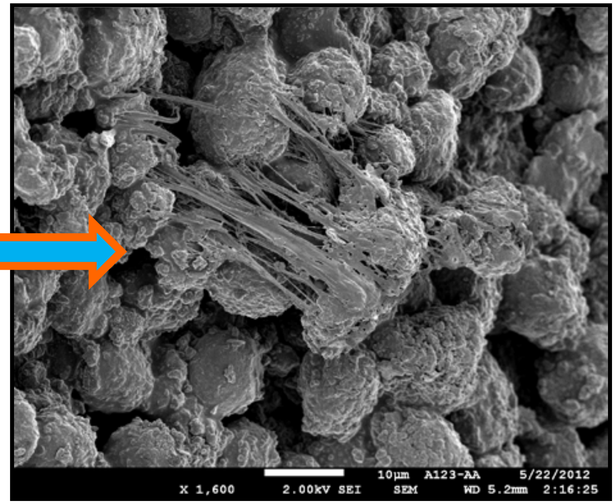
Flexible anode with good adhesion

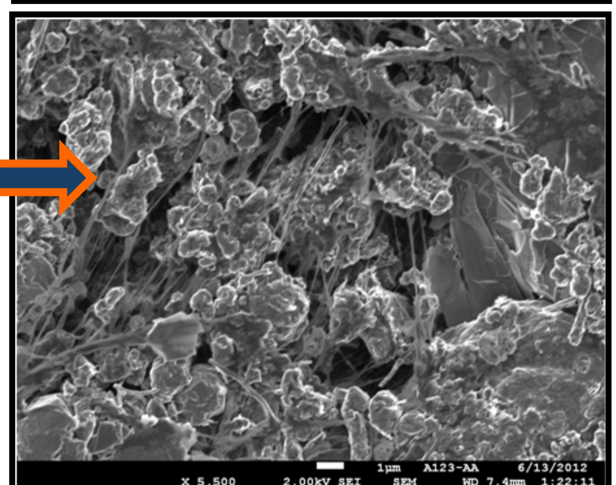
Mechanism: *Micrographs as step through process for 1st successful film*

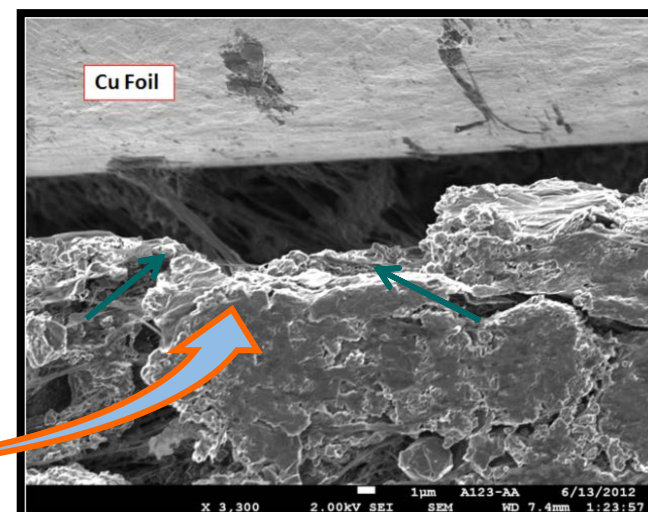
NAVITAS SYSTEMS

1. DRY BLEND
2. FIBRILLIZE
3. 1ST FILM EXTRUSION - COMPRESSION
4. FINALIZE COMPRESSIONS
5. COMPOSITE ON METAL FOIL

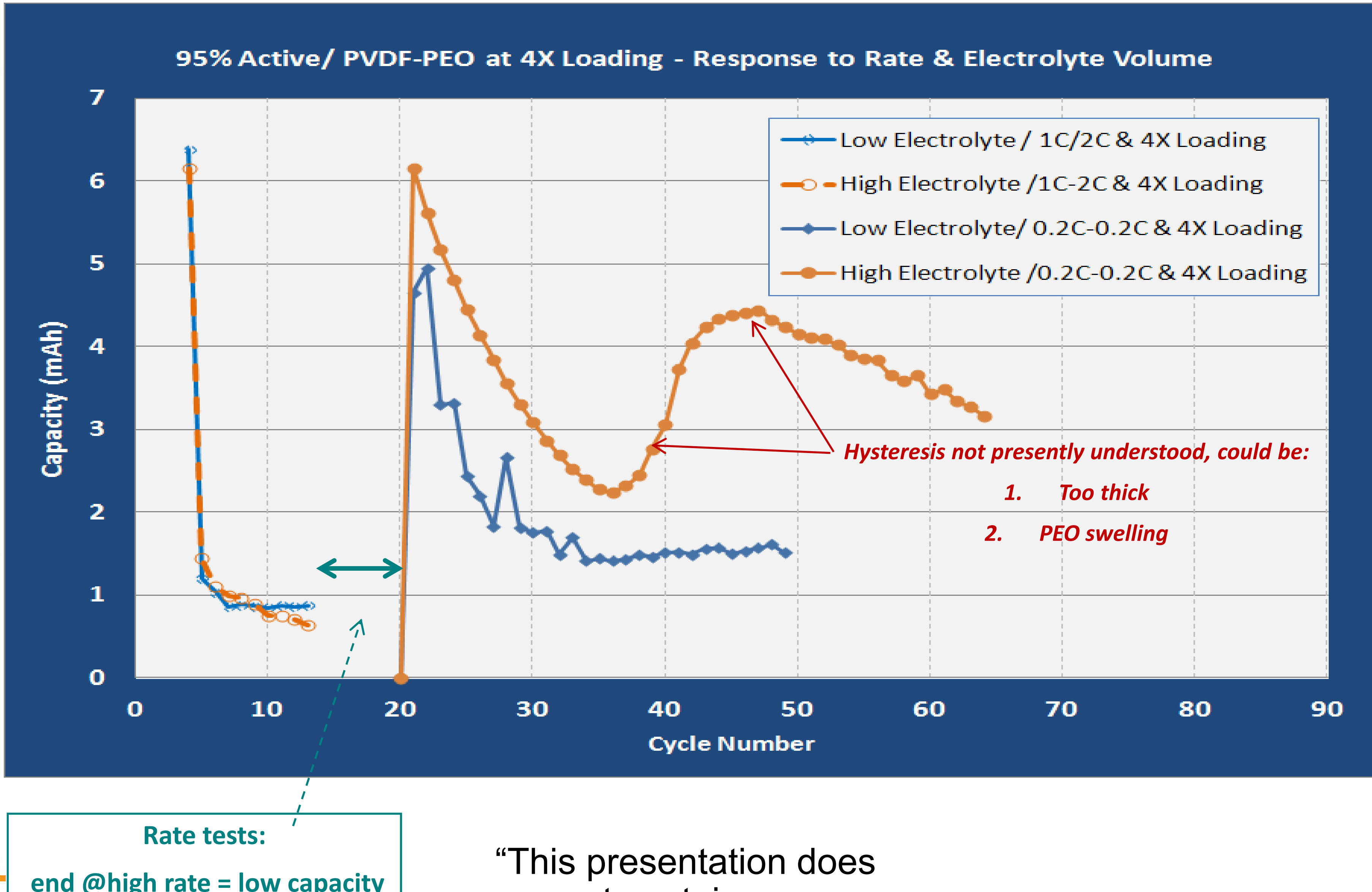








These have 100% Theoretical Capacity at 0.1C



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Collaborations

- No relationship or tech transfer to Wanxiang/A123.
- Maxwell collaboration terminated in March.
- Hands-on consulting with Zn-air industry expert to transfer PTFE electrode fabrication process technology.
- Will also assess transfer of high throughput anode technology from previous AMO program with ORNL and process equipment vendor.

Future work

- Reduce electrode thickness
  - Processing aids to enable flow
  - Volatile pore forming additives
- Higher energy density blended cathodes
- Improve carbon dispersion in cathodes
- Integrate high solid loading thick anode with high throughput radiant energy curing
- Fabricate capacity-matched anode for interim cells
- Assemble and validate interim cells
- Implement heated roll mill for polyolefin anode binders

Summary slide

- The dry electrode process innovation in this proposal will provide the ability to coat thick *and* fast, while eliminating solvents and saving energy.
- The projected readiness level is TRL 7 for the cathodes upon completion of the program, with confidence that the development path will leverage Zn-air or ultracapacitor production technology.
- Sound mechanistic understanding of the cathode process combined with Navitas' understanding of anode binder chemistry/electrochemistry will enable a new binder and dry process for anode.