Development of Large Format Lithium Ion Cells with Higher Energy Density

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ES-127

Overview

Timeline

- Project start date: Oct. 1, 2011
- Project end date: Oct. 4, 2014
- Percent complete: ~2%

Barriers

- Barriers addressed
  - Increase energy density of lithium ion battery
  - Reduce the cost
  - Maintain good cycle life

Budget

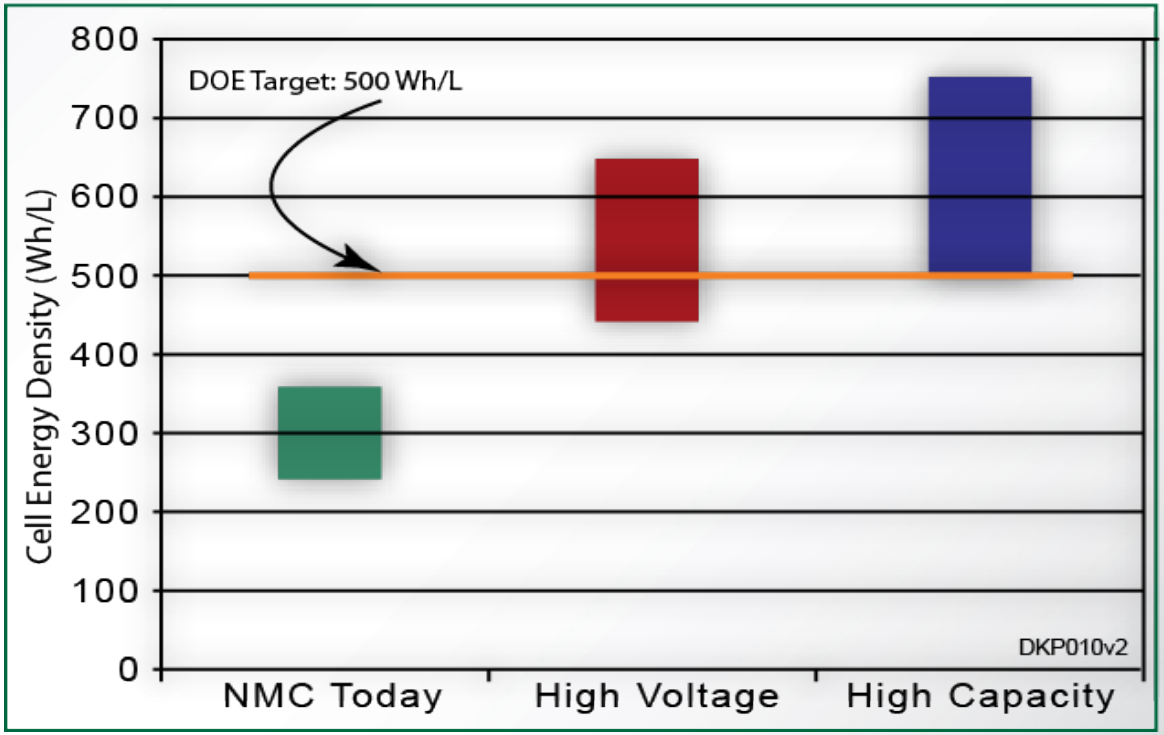
- Total project funding
  - DOE share: $4,986,984
  - Dow Kokam share: $2,431,606
- Funding received in FY11: $1,957,460
- Funding for FY12: $997,560

Partners

- Dow Kokam – Project Lead
- Wildcat Discovery Technology – Cathode Materials
- Oak Ridge National Lab – Testing Services
- Dow Chemical – Anode Materials

Project Objectives

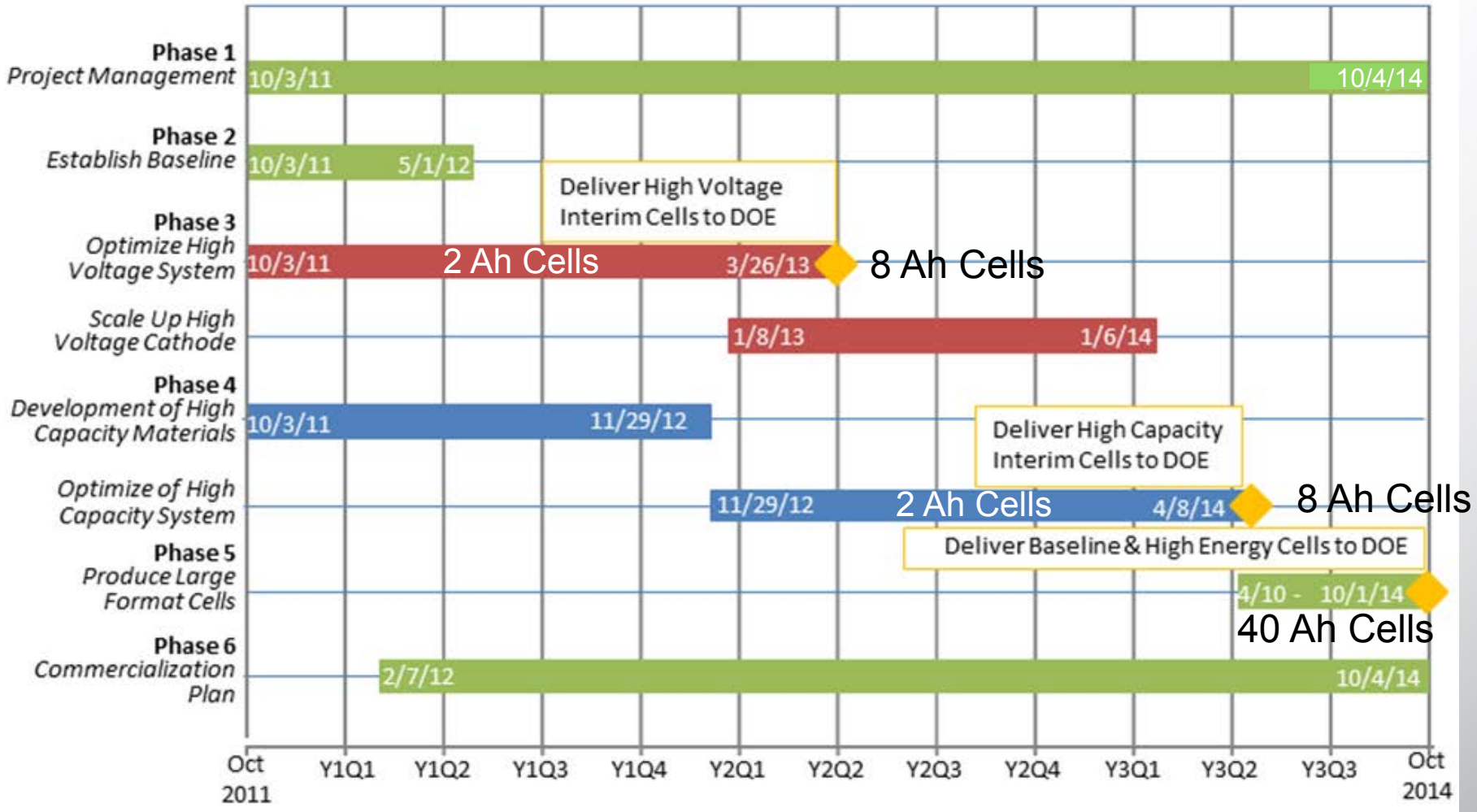
- To research, develop, and demonstrate Li-ion battery cells that are capable of achieving an energy density of >500 Wh/l and a power density of >500 W/l while maintaining comparable performance standards in terms of cycle life (300-1000 cycles at 80% depth of discharge), calendar life (5-10 years), and durable cell construction and design capable of being affordably mass produced.



Project Scope

- **Phase 1:** Mobilize Resources, Implement Project Management Plan, Institute Project Controls
- **Phase 2:** Establish Model & Performance Baseline NMC/Graphite Cell, Establish Baseline Capacity For Cells, Install Equipment
- **Phase 3:** Optimize High Voltage Cell Design And Finalize Materials Development, Scale Up High Voltage Cathode Material, Produce High Energy Interim Cells, Estimate Costs
- **Phase 4:** Develop And Optimize High Capacity Materials And Cell Designs, Produce High Energy Interim Cells, Estimate Costs
- **Phase 5:** Produce And Deliver Large Format Baseline And High Energy Cells
- **Phase 6:** Verify Achievement Of Cost Goals And Develop Commercialization Plan

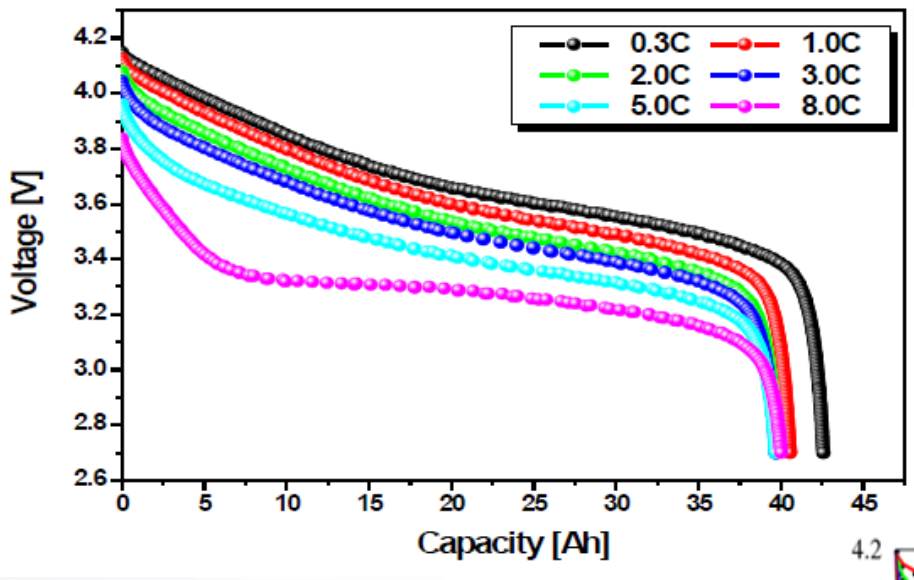
Approach


Phase 1
Project Management
10/3/11
10/4/14
Phase 2
Establish Baseline
10/3/11
5/1/12
Deliver High Voltage
Interim Cells to DOE
Phase 3
Optimize High
Voltage System
10/3/11
2 Ah Cells
3/26/13
8 Ah Cells
Scale Up High
Voltage Cathode
1/8/13
1/6/14
Phase 4
Development of High
Capacity Materials
10/3/11
11/29/12
Deliver High Capacity
Interim Cells to DOE
Optimize of High
Capacity System
11/29/12
2 Ah Cells
4/8/14
8 Ah Cells
Deliver Baseline & High Energy Cells to DOE
Phase 5
Produce Large
Format Cells
4/10 - 10/1/14
40 Ah Cells
Phase 6
Commercialization
Plan
2/7/12
10/4/14
Oct
2011
Y1Q1
Y1Q2
Y1Q3
Y1Q4
Y2Q1
Y2Q2
Y2Q3
Y2Q4
Y3Q1
Y3Q2
Y3Q3
Oct
2014

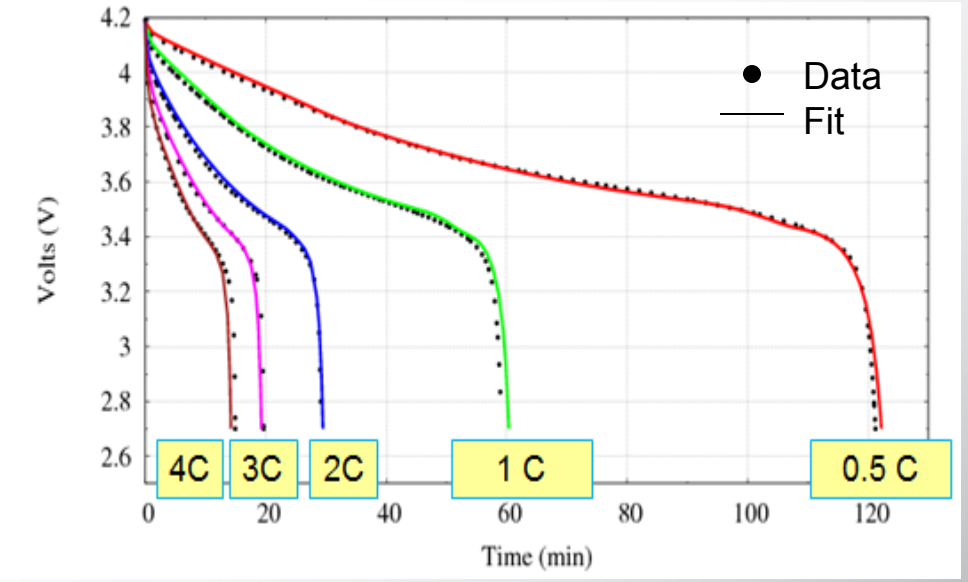
Baseline Data

Item	Value
Rated Capacity (Ah)	40
Nominal Voltage (V)	3.7
Maximum Discharge Current (Amp)	320 Continuous 480 Pulsed < 10 sec
Operating Temperature Range (C)	-20 to 60
Weight (g)	1030
Cell Dimensions (mm) Length X Width X Height	222.0 X 214.0 X 10.7
Energy Density (Wh/L)	290

Electrochemical Modeling of Baseline Data



Cell performance modeling will be employed to verify cell design parameters

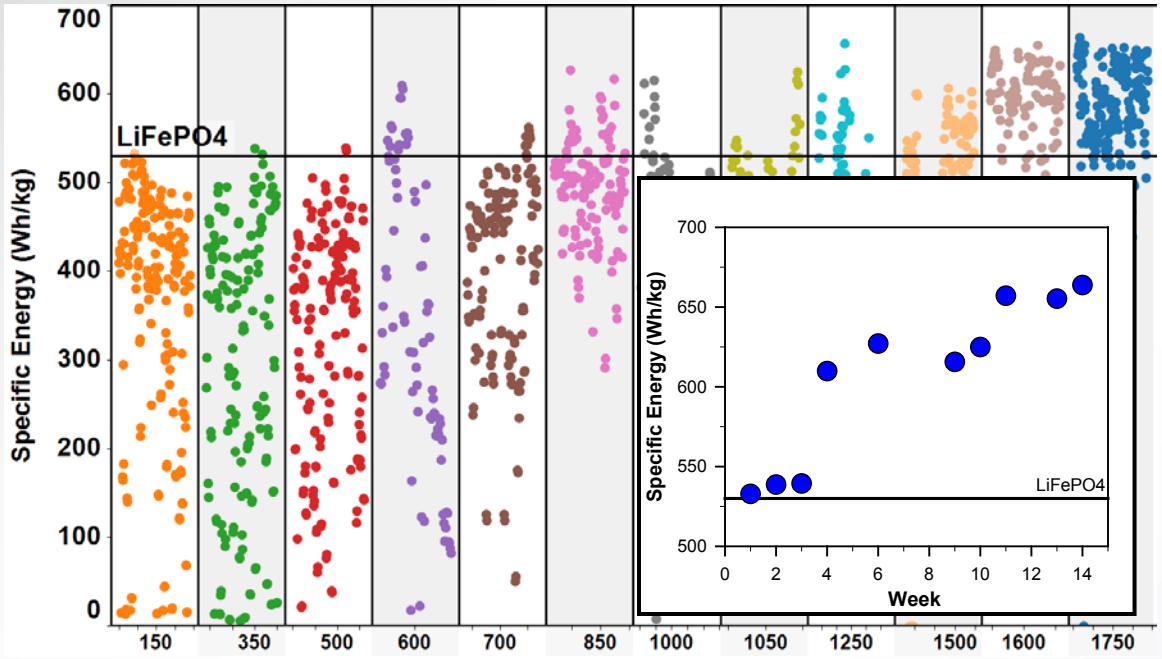


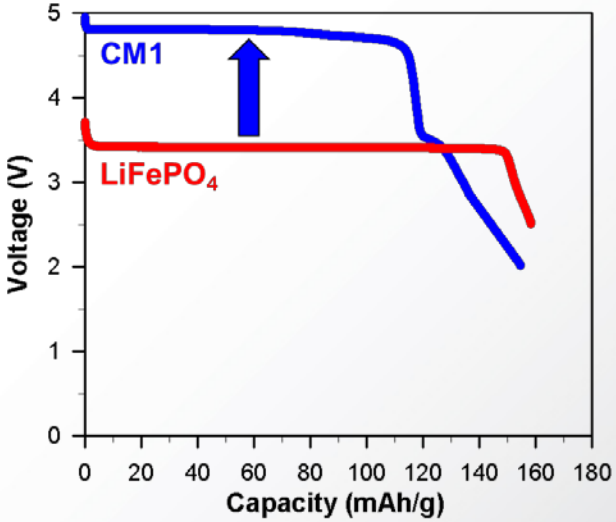
High Voltage Cathode Materials

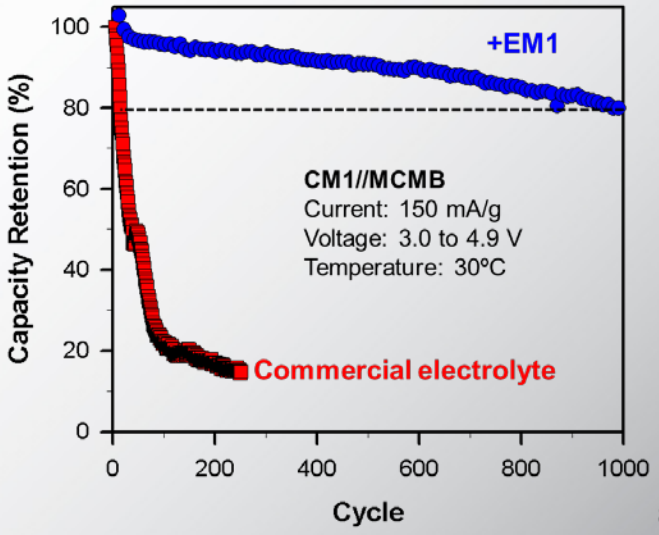
DOW KOKAM
Power to move the world

Wildcat Discovery Technologies

Wildcat Discovery is to provide cathode materials based on lithium cobalt phosphate olivine structure







High Capacity Cathode Materials

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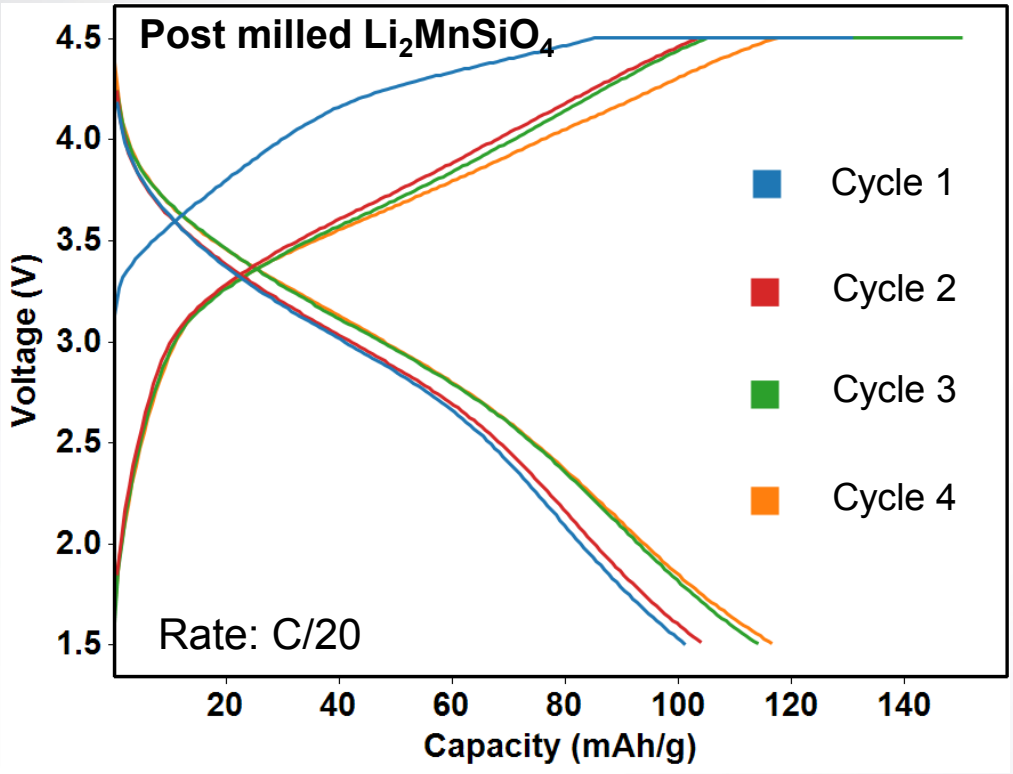
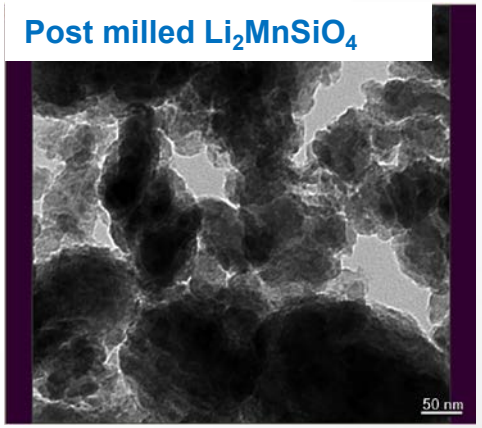
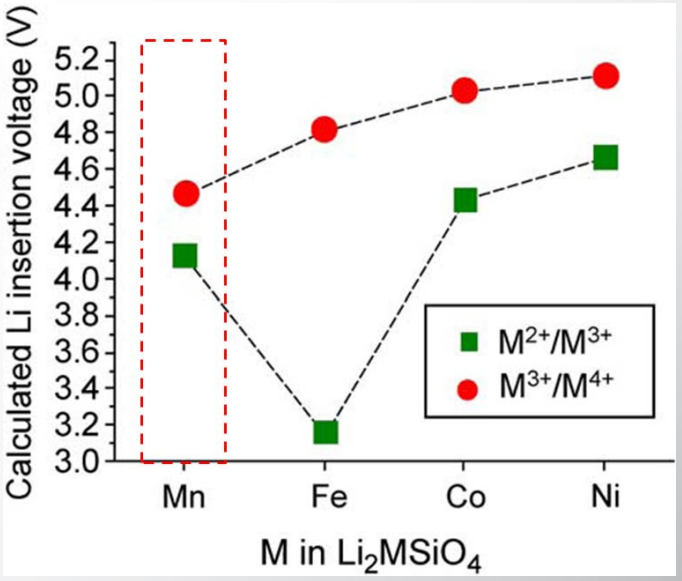
Wildcat Discovery Technologies

Lithium Manganese Silicate (Li_2MnSiO_4) offers the potential for specific capacities as high as 330mAh/g at >4.0V in theory



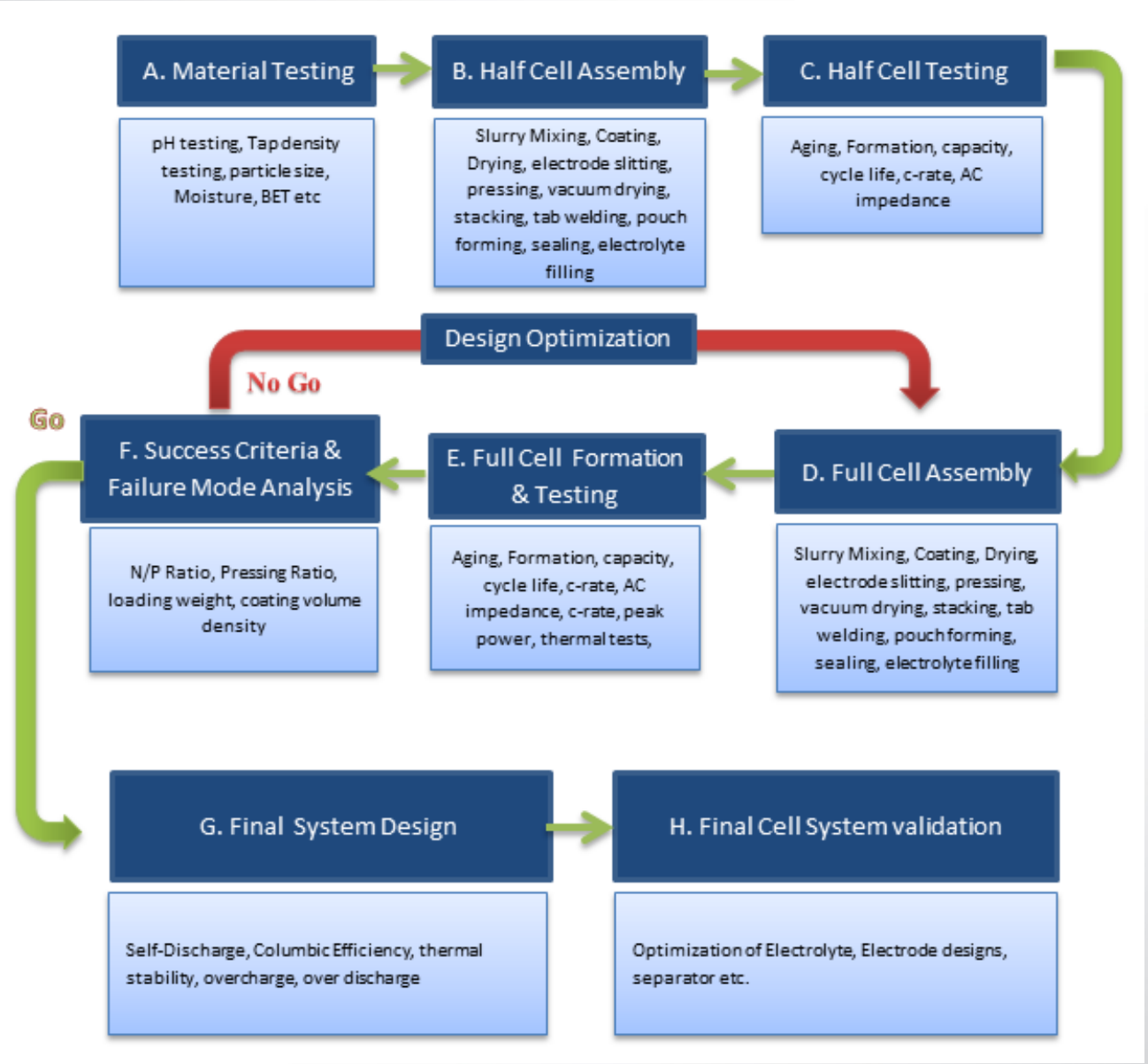




High Capacity Anode Materials

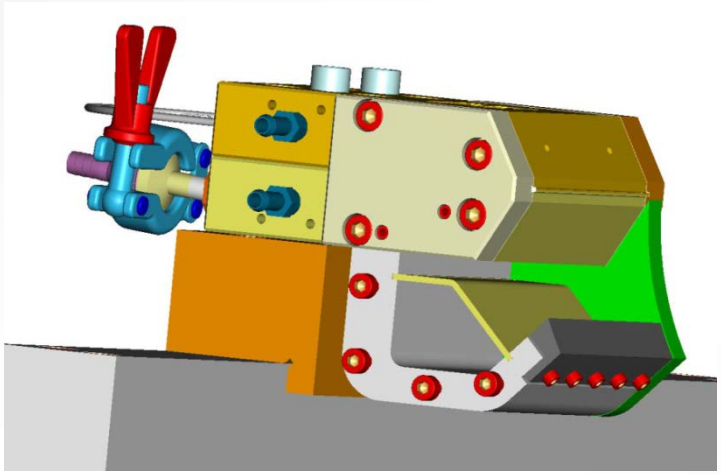
- Two silicon-base anode material have been selected, both have specific capacity above 800 mAh/g
- Physical and electrochemical characterization is underway
- Alternative lithiation process may be required to improve the first-cycle efficiency

Process Flow for Cell Development

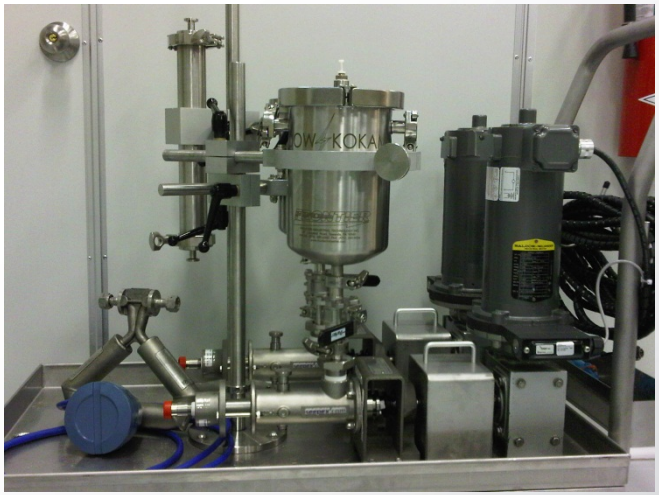


Low Volume Slot Die Coating System

- A slot-die coating system with a scaled-down coating head and a precision low-volume slurry delivery system has been developed for R&D activities
- The engineered die is mounted on a commercial-scale coating line to produce high quality coatings with as little as 150 ml of slurry, rather than in liters
- Electrodes produced will be highly representative of those made under mass-production environment



Slot die coating head



Slurry delivery system

Performance Targets

	Voltage (V)	Specific Capacity (mAh/g)		Energy Density(Wh/L)		
	Nominal Voltage	Cathode	Anode	64X95 mm format	100X106 mm format	216X216 mm format
Baseline NMC/Graphite	3.7	138	252	193	253	324
HV System/Graphite	4.8	150	252	290	380	480
HV System/Si-C	4.8	150	750	>360	>500	>600
HC System/Graphite	3.7	300	252	300	400	500
HC System/Si-C	3.7	300	600	>450	>600	>700

- Calculations are based on
  - Material properties
  - Internal Dow Kokam models

Status of Work

- Completed:
  - Initial screening of high capacity anode materials
  - Preliminary cell performance model developed
  - Establishment of test procedures
  - Development of high throughput synthesis and screening methodology for high capacity cathode targets
  - Validation of a low-volume slurry mixing & delivery system to simulate mass-produced electrodes
- In progress
  - Design of low volume slot die complete – awaiting delivery
  - Initial scanning of alternative high capacity cathode material concept approach
  - Evaluation of high voltage cathode materials for cell design
  - Evaluation of high capacity anode materials for cell design
  - Production of baseline cells

Summary

- Dow Kokam is working to increase the energy density of its large format lithium ion cells to 500 Wh/L, by incorporating phosphate-based high voltage materials, high capacity silicon-based anodes, and high capacity cathodes
- Wildcat Discovery is a partner to supply the next-generation cathode materials and electrolytes
- A low-volume slot die coating system has been developed, allowing us to simulate mass-production environment in an R&D laboratory with high degree of confidence
- A cell performance model is developed that can predict cell performance data reliably