A 12V Start-Stop Li Polymer Battery Pack

PI: Mohamed Alamgir and DaeHong Kim

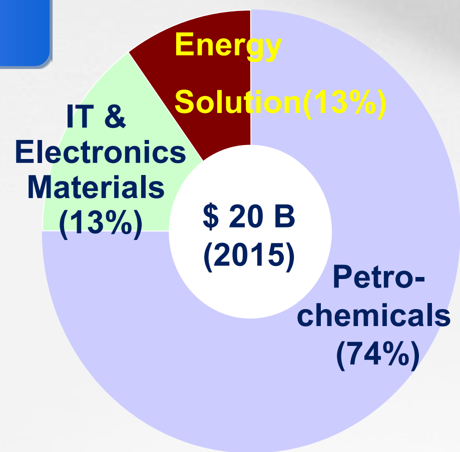
LG Chem Power / LG Chem

June 6, 2016

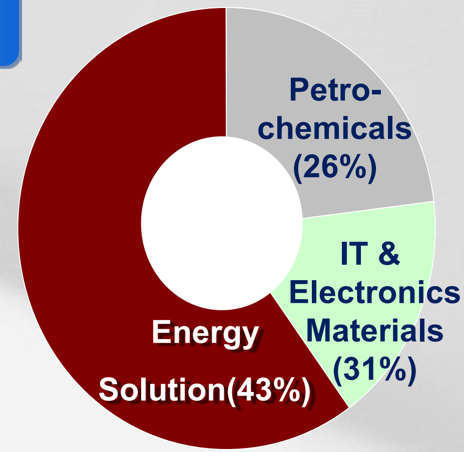
Project ID: ES249

LG Chem

Revenue



R&D Expense



Energy Solution

- Lithium-Ion Batteries for
  - Consumer electronics
  - Vehicle electrification
  - Stationary energy storage

Petrochemicals

- ABS/EP
- NCC/Polyolefin
- PVC/Rubber
- Acrylate

IT & Electronics Materials

- LCD Polarizer
- LCD Glass
- OLED Materials
- Color Filter

LGCPI

- Battery Pack Concepts, Design and Prototype Builds
- Battery Management Systems
- Sales, Customer Support and Warranty Center

Troy, MI

Sales & Pack R&D

LGCMI

- $300M+ investment with ARRA funding
- GM Volt 2 cells + Chrysler Pacifica cells and Battery Pack production

Holland, MI

Cell + Pack Manufacturing

Overview

Timeline

- Project Start: Dec 1, 2014
- Project End: Nov 30, 2016
- Percent complete: 50 %

Budget

- Total project funding: $1.82M
- DOE share: $0.91M
- Contractor share: $0.91M
- Funding for FY15: $0.85M

Barriers

- Cold-Cranking Power
- Cost

Partners

- LG Chem, INL, SNL, NREL
- Project lead: LGCPI

Objectives

- Develop a cell suitable for use in the 12V Start-Stop Battery.
- Optimize the cell chemistry to meet the cold-cranking power requirement.
- Design a low-cost, simplified BMS.
- Deliver cells and battery packs to USABC for testing.
- A key goal of the program is to lower the pack cost to close to the $220 target.

12V Start-Stop Battery Goals

	Units	USABC Under hood target
Discharge Pulse, 1s	kW	6
Max current, 0.5s	A	900
Cold cranking power at -30 °C (three 4.5-s pulses, 10s rests between pulses at lower SOC)	kW	6 kW for 0.5s followed by 4 kW for 4s
Min voltage under cold crank	Vdc	8
Available energy (750W)	Wh	360
Peak Recharge Rate, 10s	kW	2.2
Sustained Recharge Rate	W	750
Cycle life, every 10% life RPT with cold crank at min SOC	Engine starts/miles	450k/150k
Calendar Life at 30°C, 45°C if under hood	Year	15 at 45°C
Minimum round trip energy efficiency	%	95
Maximum allowable self-discharge rate	Wh/day	2
Peak Operating Voltage, 10s	Vdc	15
Sustained Max. Operating Voltage	Vdc	14.6
Minimum Operating Voltage under load	Vdc	10.5
Operating Temperature Range (available energy to allow 6 kW (1s) pulse)		-30 to +75°C
30 °C to 75 °C	Wh	360
0 °C	Wh	180
-10 °C	Wh	108
-20 °C	Wh	54
-30 °C	Wh	36
Survival Temperature Range (24 hours)		-46 to +100
Maximum System Weight	kg	10
Maximum System Volume	L	7
Maximum System Selling Price (@100k units/year)	$	$220

Approach/Strategy

- Study cathode/anode material properties to improve power.
- Characterize and improve their performance especially cold-cranking power by optimizing electrode structures, electrolyte compositions, and separator features.
- Develop low-cost battery pack designs (mechanical, thermal and electrical) to meet the USABC targets.

Technical Accomplishments/Results

- **A number of cathodes and anodes with different compositions and morphologies were studied to enhance cold-cranking power and high temperature durability.**
- **Electrolyte properties were varied to identify formulations optimum from durability and cold-cranking points of view.**
- **Studies were carried out to optimize processing conditions such as aging to enhance cell durability.**
- **Developed low-cost, efficient packaging and thermal solutions. A simplified, low-cost BMS has been developed and incorporated into the pack.**

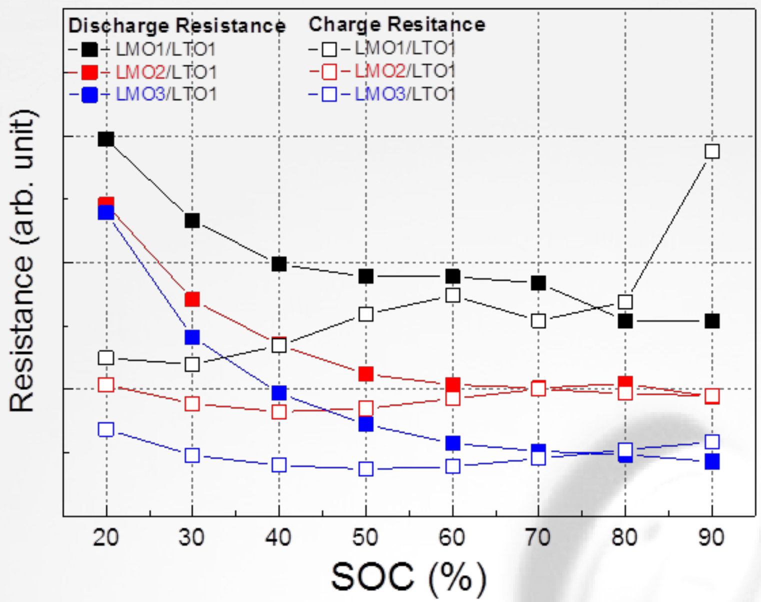
Technical Accomplishments/Results

- **Effect of dopant, surface area and porosities were studied for the cathode material.**
  - ***Higher surface area cathode material results in lower cell resistance but due to increased side-reactions, it needs to be balanced with respect to durability at elevated temperatures.***
  - ***Electrodes of lower porosities lead to lower cell resistance due to enhanced inter-particle contact.***
- **Baseline cells have been delivered to USABC for testing.**

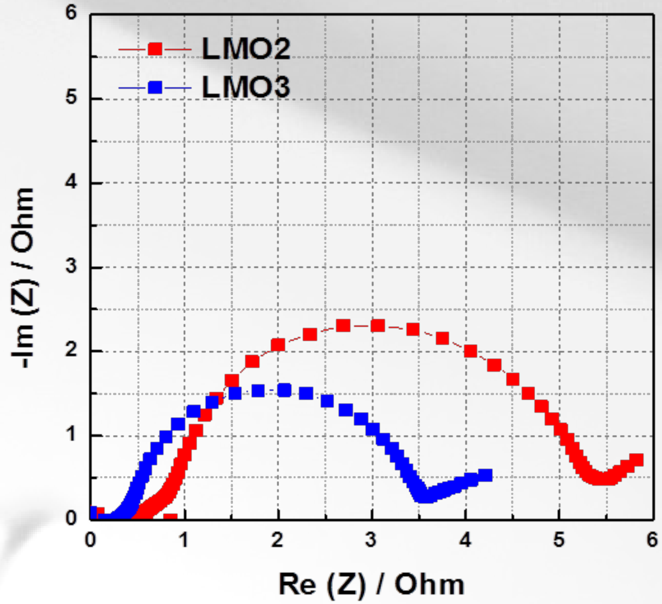
Results- *continued……*

Effect of cathode material surface area

10C-Resistance @25°C, 10s



SOC50 @ -10°C

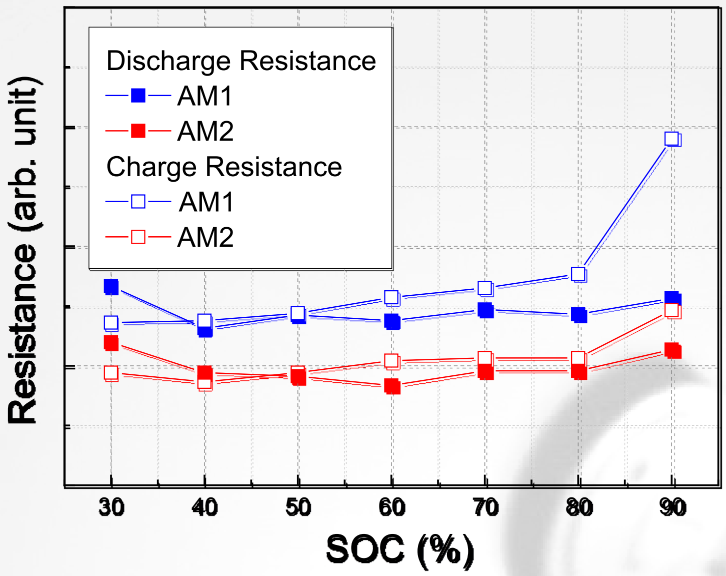


- **Higher surface area cathode material leads to lower cell resistance.** **(Surface Area: LMO1 < LMO2 < LMO3)**

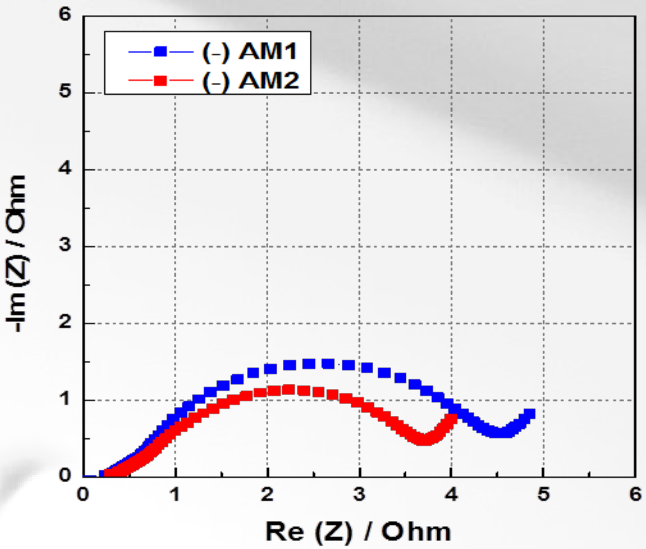
Results- *continued……*

Effect of anode material surface area

10C-Resistance @25°C, 10s



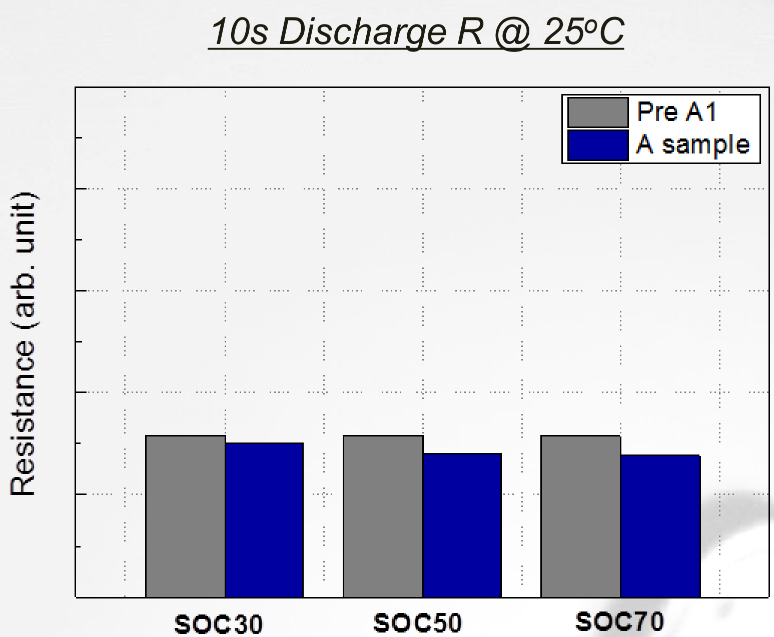
SOC50 @ -10°C

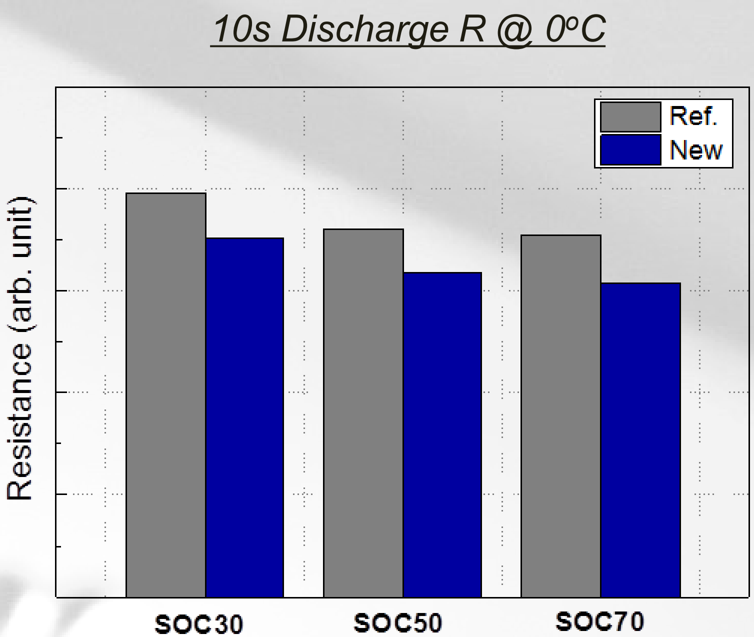


➢ **Higher surface area anode material leads to lower cell resistance.** **(Surface Area: AM1 < AM2)**

Results- *continued……*

Effect of separator on cell resistance



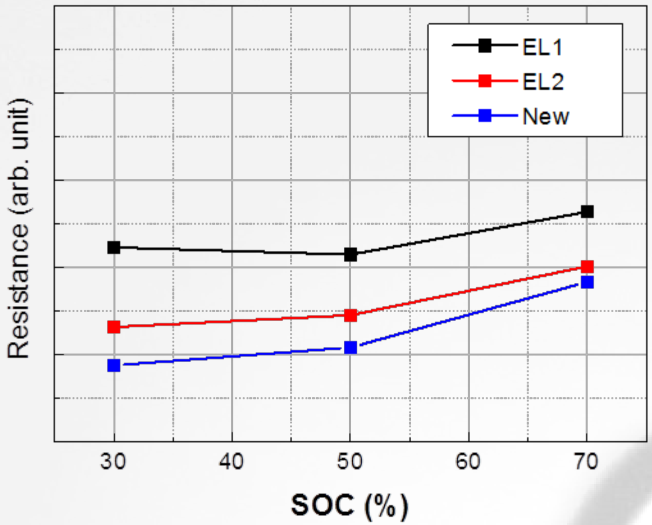


- **A new separator has lower resistance.**

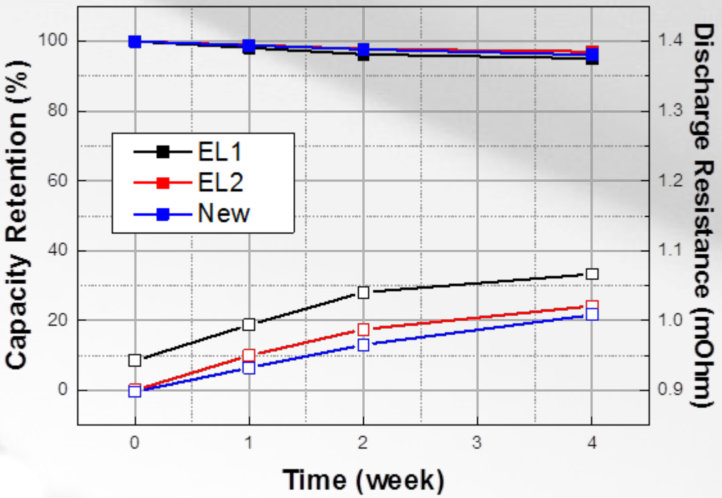
Results- *continued……*

Effect of electrolyte on cell resistance

10s Discharge R @ 0°C



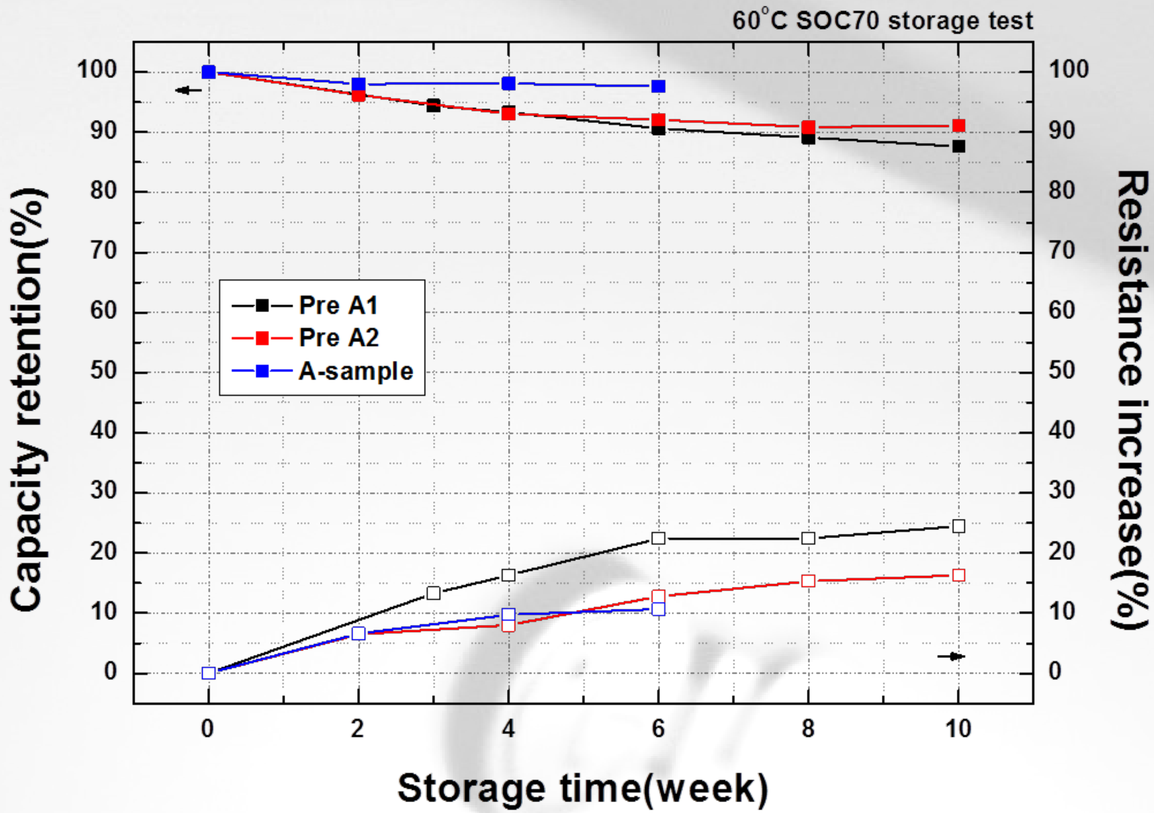
Storage @ 60°C, SOC70 (Capacity & Resistance)



- **New electrolyte shows higher power and improved high temperature durability**

Results- *continued……*

Improvement in the durability of the cell



- **A-sample cell shows superior high temperature durability**

Results- *continued……*

Pack Studies:

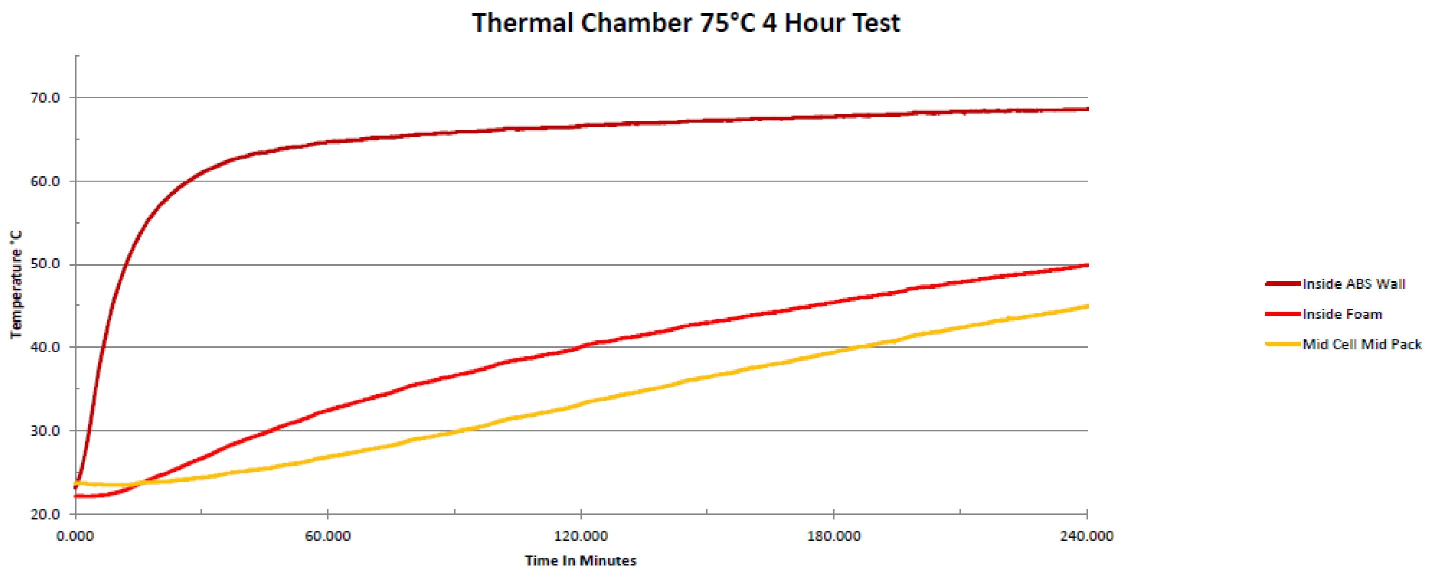
- **Designed, built and tested prototype packs using low-cost packaging, BMS and thermal system.**
- **Initial thermal studies indicate that when the pack is held at 75°C for 4h, the max cell temperatures will be at ~50°C.**
- **Delivered baseline pack to USABC for testing**

Results- *continued……*

Thermal system: Simulation of pack temperature

Chamber Test 75°C for 4 Hours

Cell Temperature of 45 - 50°C after 4 hours

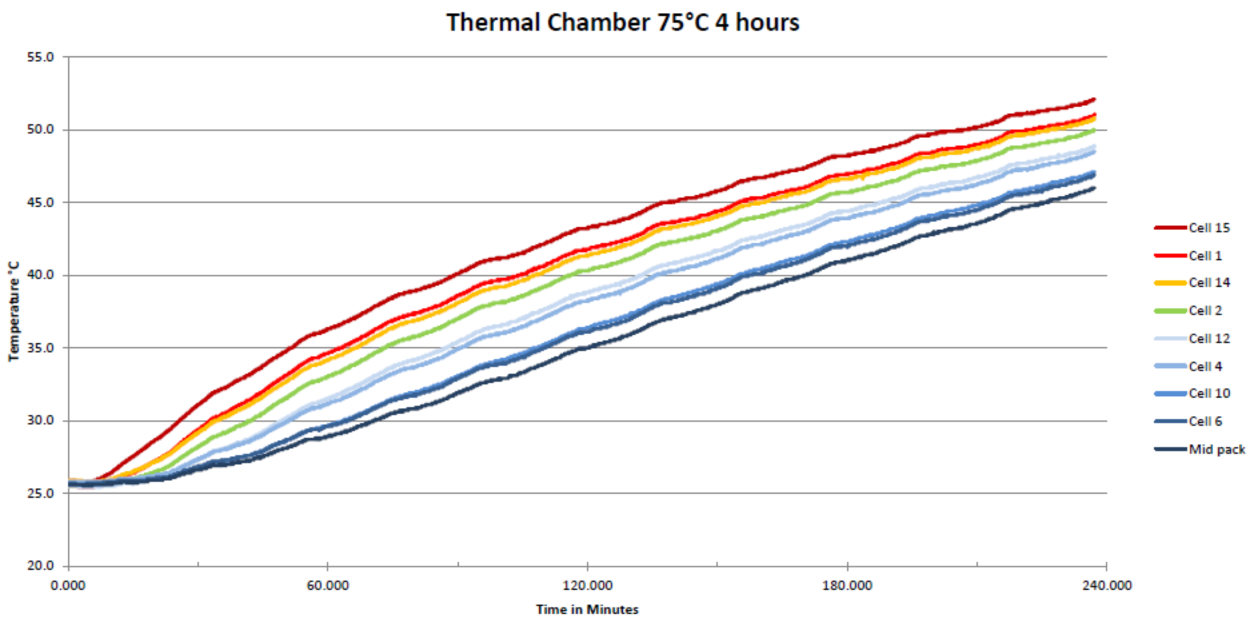


- **Temperatures remains below 50°C after the pack has been soaked at 75°C for 4 hours.**

Results- *continued……*

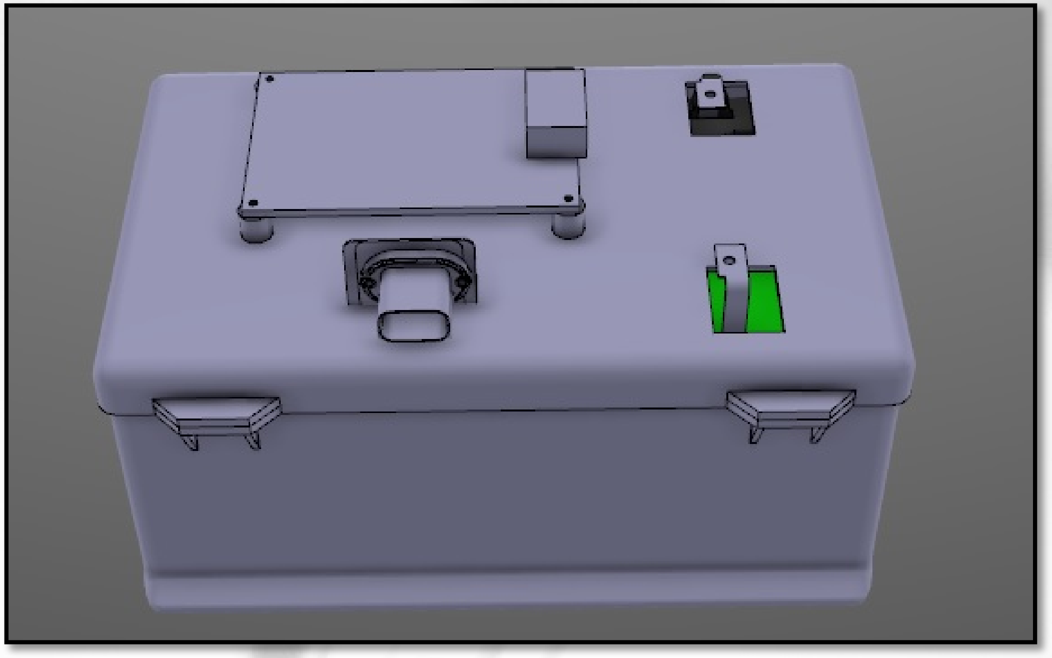
Thermal System: Experimental Data

ΔT Across Pack Experimental



- **Cell temperatures were ~52°C after the pack has been soaked at 75°C for 4 hours.**

USABC12V Prototype Build 1



Delivered to USABC

Future Work

- Further optimization of cell characteristics to improve cold-cranking power, including:
  - Extensive studies of electrolyte compositions to improve cold-cranking power.
  - Evaluation/optimization of separator properties.
- Optimize pack and BMS designs to lower pack cost.
- Final cell and pack deliveries.

Acknowledgment

- LG Chem Cell Team
  - Daehong Kim, Min-A Park, Wonhee Jeong
- LGCPI Pack Team
  - Curtis Chauvin, Evan DeMilner, Scott Dudley, Bob Merriman