CELGARD

Advanced Separators for Vehicle Lithium Battery Applications

Project ID: bat358

J. Ma, I. Jeon, X. Yu, Y. Lu, J. Rapley, S. Reinartz

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Project Overview

Project Title: Advanced Separators for Vehicle Lithium Battery Applications

Lead Organization/Location: Celgard, LLC., 13800 South Lakes Dr., Charlotte, NC 28273

Project Timeline

- ❑ Start: March 3, 2017;
- ❑ End: July 30, 2020.

Barriers

- ❑ Separator high voltage stability in 5V cells
- ❑ High cost of separators
- ❑ Separators cycle life / durability

Budget

- ❑ Total Project Funding: $ 2.5M
  - DOE share: $1.13M
  - Celgard share: $1.37M

Partners

- ❑ Farasis Energy
- ❑ Argonne National Laboratory

Relevance/Objectives

- Overall Objectives
  - To further enable the technical evolution toward 5.0 V lithium batteries by developing advanced separators that are cost effective and durable at higher voltages.
- Objectives this period
  - Down-select fabricated separators based on cycling performance in 2Ah cells at Farasis.
  - Argonne will prepare and qualify coatings on high voltage cathode powder;
  - Fabricate 2Ah cells with stabilized high voltage cathodes and electrolytes and demonstrate high voltage cells performance advantages;
- Impact
  - The development of high voltage stable separators will improve separators durability and cell safety.
  - Enable a separator technology that facilitates commercialization of 5V lithium ion batteries for vehicle applications with improved energy density.

Milestones

Date	Milestone and Go/No-Go Decisions	Status
9/30/2017	Provide USABC six 5V baseline cells from Farasis (GEN I)	Complete
2/28/2019	Provide USABC 12 cells with improved electrodes (GEN II)	On-track
9/30/2018	Provide automotive OEMs participating in USABC with sample rolls (20 m length)	On-track
2/29/2020	Provide USABC 30, 10 Ah cells from Farasis (GEN III)	On-track
7/30/2020	Present a final report that outlines an acceptable separator product for a 5.0 V lithium ion battery system.	On-track

Approach/Strategy - Plan

2017 Q2	2017 Q3	2017 Q4	2018 Q1	2018 Apr	May	June	July	Aug	Sept	Oct	Nov.	Dec.	2019 Jan.	Feb.	Mar.	April	May

Celgard fabricated protected separators

Down-select separator candidates based on cycling

2Ah stabilized 5V cells Demo and Evaluation

Farasis develop prototype 5V cells

Milestone

5V cells cycling and stability over storage

Go / No-Go

Celgard/Farasis/ANL/USABC collaborate and pin-point issues with GEN I 5V cells

Demonstrate stabilized 5V cathode

Go / No-Go

Milestone

Demonstrate stabilized 5V cells

Go / No-Go

- ANL will help stabilizing the 5V cells by coating of cathode;
- Go / No-Go criterion based on dissolution tests and pouch cell cycling performance and storage stability

- Farasis will use stabilize cathode to fabricate/test 1Ah pouch cells;
- Evaluate at designated DOE national labs; Testing using PHEV manual testing protocols

Go / No-Go

Milestone

2Ah stabilized cell design will be used for final project deliverable 10Ah cells

Complete | In Progress

Accomplishments to Date – FY18

- Celgard fabricated and characterized 5 ceramic coated separators
  - Conformal ceramic ultra-thin coatings
  - Conformal ceramic composite ultra-thin coatings
- Celgard fabricated and characterized several polymeric composite separators
  - Functional polymer conformal coatings on polyolefin separators
  - Ceramic/polymer composite coatings
- First generation 5V cells demonstrated by Farasis
  - With proprietary electrolyte, GEN I cells showed encouraging capacity and cycling performance
  - Industry cell size of 1.5Ah
- 5V cell issues identified and strategic approaches planned to stabilize cells
  - Issues identified for capacity fading including cathode dissolution, electrolyte degradation and work plan underway in FY18
- Celgard performed a failure mechanism study by examining harvested separators from 5V cells

Responses to Previous Years Comments

- This project is a new start.

Partners / Collaborations

Farasis Energy – Project Subcontractor

- Provide technical advice on 5V cell design;
- Evaluate 5V cell cycling performance and identify issues;
- Fabricate 2 Ah high voltage cells;
- Fabricate 10 Ah high voltage cells;

Argonne National Laboratory – Project Subcontractor

- Coat cathode powder and evaluate coatings efficiency by dissolution tests;
- Evaluate coatings efficiency by cycling/storage tests in prototype pouch cells (ANL CAMP);
- Prepare kilograms of coated cathode powder to Farasis for cell fabrication;

Remaining Challenges and Barriers

- A primary challenge for advanced separators demonstrated in this project will depend on the successful fabrication of a stabilized 5V cell-testing platform;
- Full evaluation/understanding of separators degradation requires extended time and resources;
- For High voltage cell-testing platform development, cathode dissolution in cells and electrolyte stability in high voltage cells are the primary challenges;

Proposed Future Work

FY18-FY19 Proposed Work will include:

During the FY18 years, Celgard will work with Farasis and ANL on down-selecting fabricated separators and developing protected cathode materials to address the issues identified in earlier 5V cells fabricated by Farasis.

- ANL will coat cathode powder and demonstrate effectiveness of coatings by performing dissolution tests and evaluating cycling and storage performance of prototype cells;
- Celgard and Farasis will evaluate and down-select the separators by cycling in 2Ah pouch cells at room and elevated temperatures;
- Celgard/ANL/Farasis will evaluate the stabilized 5V cells based on cycling and storage stability and finalize the design for 12-month deliverable cells to USABC;

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Summary

Relevance

- Develop cost effective, durable separators with enhanced electrochemical stability for high voltage LIB cells with increased energy density

Approaches

- Separator design - Nanometer ceramic coatings on separators to enhance resistance to electrochemical oxidation
- Separator demonstration - Celgard to produce conformal ceramic coated and polymer composite separators
- Stabilizing 5V cathode - In collaboration with ANL
- Farasis to produce industry size and quality 5V cells

Technical accomplishments

- 5V prototype cell evaluated
- Stability issues with 1st generation prototype 5V cells now identified
- Celgard fabricated and characterized 5 ceramic / composite coated separators
- Additionally Celgard fabricated and characterized 2 polymeric composite separators

Proposed future research

- Down-select candidate separators
- Stabilizing cathode by coatings at ANL
- To demonstrate and evaluate GEN II stabilized high voltage LIB cells