Phase I Project Summary

PSI-6225

Firm: Physical Sciences Inc.
Contract Number: NNX10CD32P
Project Title: Safer Battery with Switchable Coating

Identification and Significance of Innovation: (Limit 200 words or 2,000 characters whichever is less)
Advances in anode and cathode chemistries continue to increase the potential energy density of secondary lithium ion battery systems increasing the potential danger on catastrophic failure especially from internal shorts at 100% SOC. Physical Sciences Inc. (PSI) demonstrated the application of switchable polymer (SWP) coatings to both the cathode current collector and active materials. On short-circuit or overdischarge, the SWP coatings limited the current passed thereby preventing rapid discharge and unsafe conditions. The SWP can be reversibly "switched" from an insulator to a conductor upon oxidation permitting normal battery operation.

Technical Objectives and Work Plan: (Limit 200 words or 2,000 characters whichever is less)
Technical Objectives:

1. For a cathode electrode formed with the SWP layer on the surface demonstrate:
   - Less than 5% loss in electrical conductivity in the oxidized state.
   - Two orders of magnitude increase in the resistivity in the reduced state.
   - Less than 3% difference in the discharge capacity at a C/5 rate as compared to a cell constructed with an uncoated cathode.
   - 20 cycle capacity fade within 1% of that for the uncoated cathode at a C/5 rate.
   - Less than 5% capacity fade after discharge to 0.6V vs. lithium.
2. On discharge to 600mV vs. lithium, demonstrate two orders of magnitude decrease in the current passed.
3. For a low capacity pouch cell with the proposed electrode and carbon anode, demonstrate lack of fire or thermal runaway upon overdischarge and external shorting.
4. Develop a plan for scaling the coating technique to the production of >100g batches of cathode material.

The specific tasks were as follows: evaluate coating of cathode electrode interfaces; optimize conductive polymer coating of cathode material; electrochemical performance evaluation; electrochemical evaluation after abuse testing; Failure testing of pouch cells; optimization and scale-up; management and reporting.

Technical Accomplishments: (Limit 200 words or 2,000 characters whichever is less)
The Phase I accomplishments include:

- Application of active SWP coatings to both the aluminum current collector and cathode material.
- 95% reduction in the low voltage charge pass on overdischarge to 0.6V on application of an SWP layer to the cathode material and current collector.
- Overdischarge to 0.6V was shown to not impact the discharge capacity of coated cells.
- Short-circuit testing of SWP coated pouch cells demonstrated a 70% reduction in the initial discharge current and 45% reduction in the cell heating rate.
- Demonstration of equivalent discharge capacity on coating of cathode current collector and active cathode material.
- 20 cycle capacity fade for SWP coated Al cells was shown to be within 0.5% of that for uncoated cells.
- Techniques were developed for applying the coatings that may be readily scaled up using the current methods and commercially available larger versions of the same equipment.

NASA Application(s): (Limit 100 words or 1,000 characters whichever is less)
The proposed technology could be utilized in all battery applications to improve their safety. In particular application of the technology in human-rated systems could enable battery systems to achieve the two fault NASA human-rated safety requirement. Incorporation in NASA's high and ultra-high energy cell designs would substantially reduce the potential for catastrophic failure on the development of internal shorts or overdischarge. Mission applications include portable power for astronaut equipment; storage systems for crew exploration vehicles and spacecraft; and stationary energy storage applications such as base power or peaking power applications.

Non-NASA Commercial Application(s): (Limit 200 words or 2,000 characters whichever is less)
The initial market for the proposed technology is the military where battery safety is paramount. The increased tolerance to overdischarge and shorting offered by the proposed coatings would improve the safety of battery systems. The technology can be further extended to commercial devices such as hybrid electric vehicles, cordless power tools, remote sensing devices, and portable communications such as cell phones and two-way radios.

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