Nanocomposite Materials for Lithium-Ion Batteries

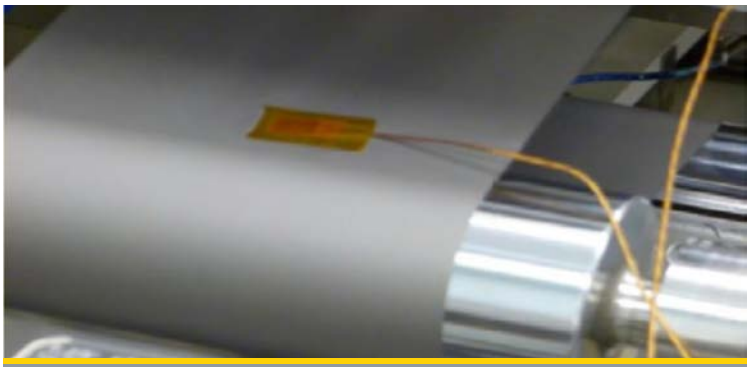
Development and Application of Processing and Process Control for Nanocomposite Materials for Lithium-Ion Batteries

Introduction

In recent years, sales of hybrid electric vehicles (HEVs) have increased and several automakers have also started to market plug-in hybrid electric vehicles (PHEVs). Successful market penetration of PHEVs would significantly reduce automobile tailpipe emissions and help guard against oil price volatility. However, cost, energy storage limitations, and other factors have prevented extensive adoption of PHEVs and HEVs to date.

Nanotechnologies offer a promising solution to these challenges. By supporting the electrification of the drive train in transportation vehicles, nanotechnologies can drive low-cost, widespread reductions in energy consumption and carbon intensity. The development of cost-effective, long-lasting, and abuse tolerant lithium-ion (Li-ion) batteries is an important step in electrifying the drive train and facilitating widespread adoption of HEVs and PHEVs. Nanocomposite materials with the potential to significantly improve battery performance have been developed, but further scale-up and formulation optimization is needed before these materials are market ready.

This project is developing large-scale nanomanufacturing capabilities for nanomaterial systems in order to enhance battery technology for energy efficient transportation and stationary storage applications. Nanocomposite materials used with Li-ion batteries improve the performance of high-power and high-energy applications. Compared to current Li-ion batteries, this technology seeks to provide a 30% improvement in power delivery, along with breakthrough high-temperature durability and lower cell costs. Improving the cycle life, high-temperature durability, and power characteristics of batteries will lead to the implementation of effective, energy efficient transportation vehicles and grid stabilization technologies.



The nanocomposite coating is dried. Thermocouples measure temperature and heat flux during coating of substrate materials.

Photo courtesy of Oak Ridge National Laboratory.

Benefits for Our Industry and Our Nation

Successful development and market penetration of PHEVs will result in direct and indirect energy, environmental, and economic benefits. The direct benefits revolve around replacing the well-to-wheel efficiency of a vehicle driven by an internal combustion engine (estimated to be 20%–30%) with the efficiency of a vehicle powered by an all-electric drive train (estimated to be 39%–71%, depending on the energy source consumed while plugged in). The nanotechnology supported by this research may increase the electric range for PHEV cells by up to 15%, reduce cost, and improve reliability compared with current state-of-the-art batteries. Reducing the PHEV payback time will facilitate market penetration and generate environmental benefits as the market for PHEVs increases. One key environmental impact will be the reduction of greenhouse gas emissions from end-user vehicles that no longer combust gasoline and other petroleum products as fuel.

Applications in Our Nation's Industry

Nanocomposites for Li-ion batteries have many potential applications, including the following:

- Transportation: facilitate replacement of gasoline powered passenger, military, and mass transit vehicles with HEVs, PHEVs, and ultimately all-electric vehicles
- Utilities: safe and reliable stationary energy storage

Project Description

The goal of this project is to develop process control and quality measures for homogeneous and reliable deposition of a nanocomposite coating to be used in Li-ion battery technology, with guidelines for scale-up and mass production of the product. Researchers are developing a fundamental understanding of the nanomaterial structure, and the process coating mechanisms. Ultimately, team members will integrate a quality control approach with science and technology to produce a reliable product that facilitates Li-ion technology for transportation and stationary applications.

Barriers

- Achieving a reliable and homogeneous nanocomposite coating during scale-up from current lab scale
- Developing a high-yield scalable process at low cost for incorporating nanomaterials in Li-ion batteries and understanding how structure may impact properties

Pathways

Researchers are developing an advanced processing technology that offers submicrometer thickness control, while also controlling the structure on the nanoscale. Researchers are also applying fundamental understanding of controllable and reliable electrochemical and mechanical properties. In addition, researchers are developing real-time characterization tools using infrared imaging to ensure quality control during the production process.

Milestones

Work on this project commenced in December 2009.

- Conduct modeling and simulation tasks to obtain processing behavior for drying. (Completed)
- Perform electron microscopy and X-ray diffraction on continuously produced samples (and flawed samples) to characterize materials and coatings. (Completed)
- Complete a mass transfer model to simulate the process and finalize quality control procedure.
- Conduct coating deposition and drying, reformulate the process as needed, and design and conduct pilot tests.

Commercialization

A123 Systems Inc., the primary industrial partner on the project and one of the leading Li-ion battery developers in the United States, is enabling and revolutionizing energy efficient mobility. The company successfully provides safe and affordable Li-ion batteries for limited mileage range HEV-PHEV conversion kits, and is working to provide batteries to automotive companies, as well as to military, mass transit, and fleet vehicle manufacturers.

A123 Systems will use the results of this project to make a key internal development decision that will drive the manufacturing implementation planning and approach at the next stage. As a vertically integrated manufacturer with high volume cell production capability A123 Systems will complete commercialization of this technology through testing, validation and product launch. A123 Systems anticipates the initial market for the product will be large format prismatic cells for hybrid vehicles.

Project Partners

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