Development and application of processing and process control for nano-composite materials for lithium ion batteries

Advanced Characterization and Process Control of Coatings

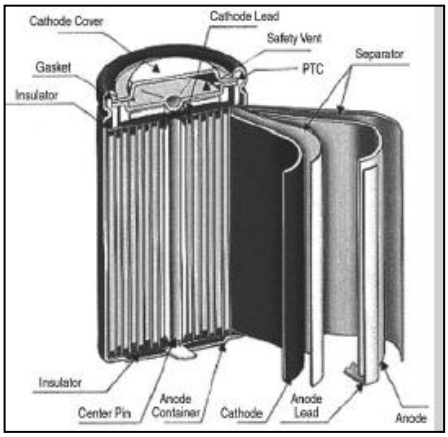
Background

Domestic auto manufacturers have struggled to introduce hybrid electric vehicles (HEV) and develop plug-in hybrid electric vehicles (PHEV), even during periods of high gasoline prices and unstable oil supplies. An important step for a continued effort to deploy electric vehicles is the development of cost effective, long lasting, and abuse tolerant batteries. Lithium ion battery technology is projected to be one of the energy storage driving technologies for the electrification of automotive drivetrains and for providing stationary storage solutions to enable the effective use of renewable energy sources. This technology is already in use for low-power applications such as consumer electronics and power tools. Extensive research and development has enhanced the technology to a stage where safe and reliable lithium ion batteries will soon be utilized in hybrid electric and electric vehicles and connected to solar cells and windmills. However, safety of the technology is still a concern, service life is not yet sufficient, and costs are too high.

A123 Systems Inc. is one of the leading battery developers in the United States enabling and revolutionizing energy efficient mobility. The company provides safe and affordable Li-ion batteries for limited mile range HEV – PHEV conversion kits. A newly developed nano-composite material with potential to significantly improve device performance has been developed by A123. However, to bring the new material from the lab scale to market, there is a need to optimize the formulation and scale up the process while maintaining the nano-scale functionality of the material. Additionally, low cost processing and quality control measures have to be developed for successful implementation of this material into a safe and reliable lithium ion battery cell.

Technology

ORNL will utilize A123 Systems Inc.'s proprietary material for the development of low cost processing technology. New processing technology will be developed including advanced deposition techniques which offer sub-micrometer thickness control and a drying and post treatment technology, all the while controlling the microstructure on the nano-scale. ORNL is providing unique facilities for ceramic processing, photonic processing, in-situ characterization and quality control.

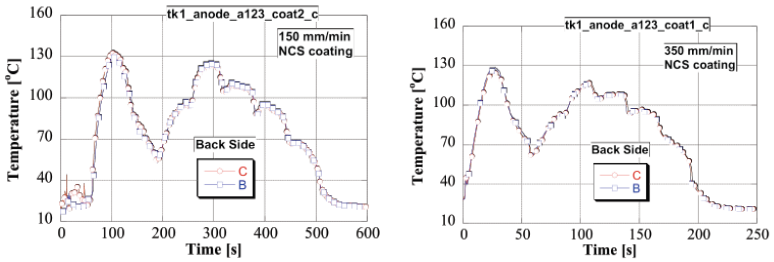


Advanced Battery Structure

ORNL's advanced characterization work will include microscopy, XRD, thermophysical property measurement, particle size and morphology analysis, and surface energy and pore volume measurement. ORNL will also analyze the manufacturing process through flaw detection, off-line quality control, drying analysis, and development of a computational drying model.

Results

To model the coating and curing process a data acquisition system from ORNL was used to acquire coating temperatures during processing. The incident heat fluxes were measured using a heat flux sensor. The temperature data were acquired at different locations on the substrate by thermocouple. A temporary drop in coating temperature when the coating enters the oven was revealed. The effect of these temperature variations on coating performance will be further investigated.



Temperature changes during coating curing illustrating temperature drop as material enters furnace

ORNL has also begun in-situ optical microscopy study of the drying process. Proof of concept work on a simulated production line demonstrated that morphological changes that occur in the coating during drying could be observed optically. Modifications are planned for the system to better control drying rates and substrate interaction with the coating.

Benefits

- HEV and PHEV's will reduce tailpipe emissions and reduce US dependence on imported fuels
- More reliable, less expensive and longer lived batteries will increase deployment of HEV and PHEVs
- A newly developed nano-composite material will improve battery performance
- Characterization and process control is needed to optimize production and performance of this material
- Advance processing and characterization technology from this project can be applied to other advanced energy storage challenges

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