Control Enabling Solutions with Ultrathin Strain and Temperature Sensor System for Reduced Battery Life Cycle Cost

**Program Overview**

**Objective:** Charge cycles in Li-ion batteries result in temperature and strain build-up between electrodes. This program measures both parameters using thin-film sensor arrays and algorithms dynamically modify power limits for wider SOC operation and SOH assessments.

**System Benefits**

- Thin-film sensor arrays monitor temp & expansion at cell level
- Dynamic model-based power limits enable wider SOC operation

**Approach & Benefits**

- Thin-film sensor arrays monitor temp & expansion at cell level
- Dynamic model-based power limits enable wider SOC operation

**Thin-Film Sensor Development**

- 100μm thick sensors for integration between cells
- Combined Pt-RTD temp array and eddy current displacement coil
- <0.1°C temperature sensitivity
- <1μm sensitivity to gap change
- Electronics design to sit within pack

**Model Development**

- Thermal – Surface temperature mapping
- Mechanical – Swelling due to thermal & intercalation
- Electrochemical – Parameter relationship to SOC

**Improved SOC Estimation**

- Force change observable over entire cell SOC larger signal than ΔV
- 30-50% improved SOC estimation – better confidence in utilization window
- Force can be used in addition to voltage for better SOC estimation

**Validation Tests & Demonstration**

- 3-cell test rigs for long-term monitoring of cell capacity
- Open-loop US06 power profile
- Current pack is oversized for power needs
- Used closed-loop power limits to widen SOC & downsize pack
- Benefit demonstration on instrumented pack at Ford

**Program Summary**

- **2015**
  - Only full-scale demonstration with an instrumented pack showing cell utilization benefit at Ford
  - Adaptive battery management that utilizes the strain and temperature model predictions on a sub-set of cells at Ford
  - Achieve >90% strain prediction accuracy for a single defective cell

- **2014**
  - Prototypes of temperature sensor array (50)
  - Demonstrates combined temperature and strain measurement (50)
  - Cell level TEC model (519)
  - Performance and test objectives definition (Ford)

© 2015 General Electric Company - All rights reserved.