

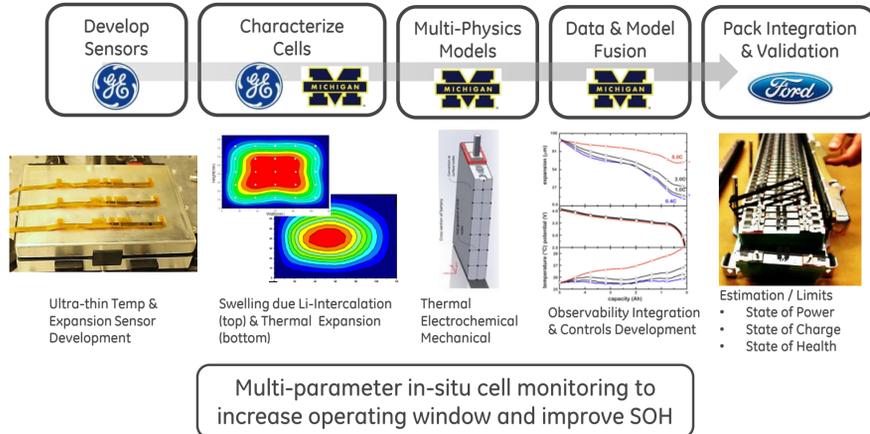
Control Enabling Solutions with Ultrathin Strain and Temperature Sensor System for Reduced Battery Life Cycle Cost

ARPA-E Project DE-AR0000269

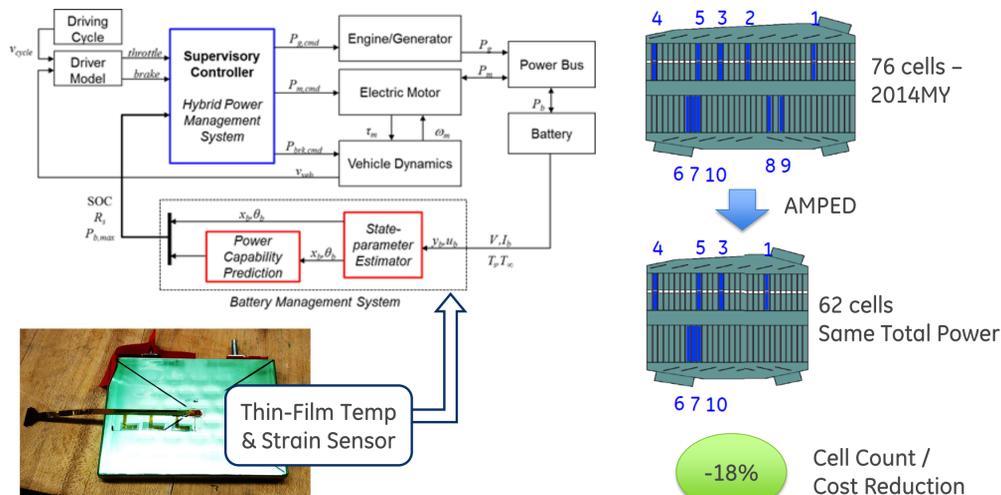
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Program Overview

Objective: Charge cycles in Li-Ion batteries result in temperature and strain buildup 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

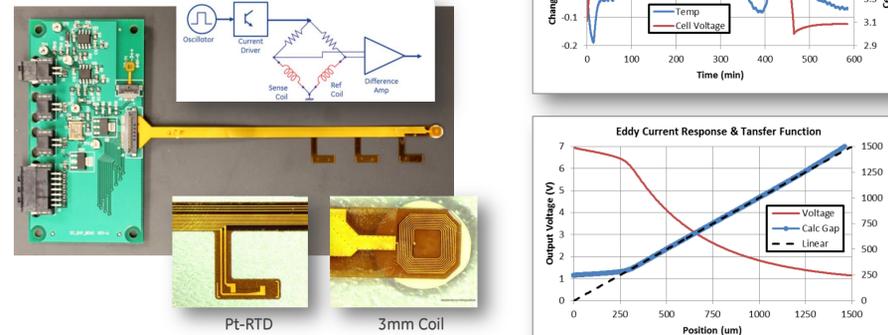


Approach & Benefits:

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

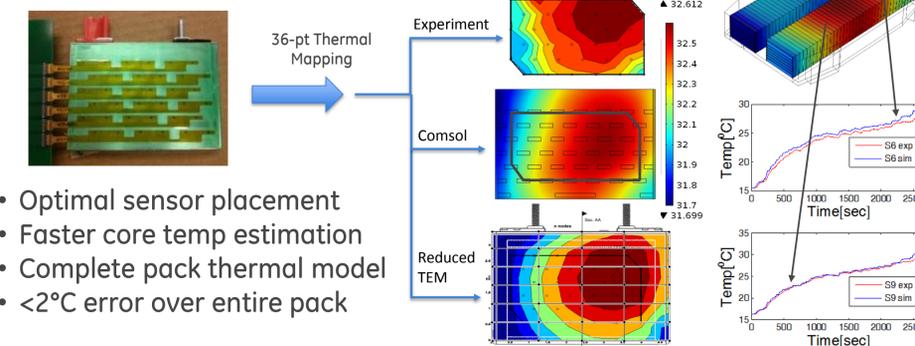
Thin-Film Sensor Development

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

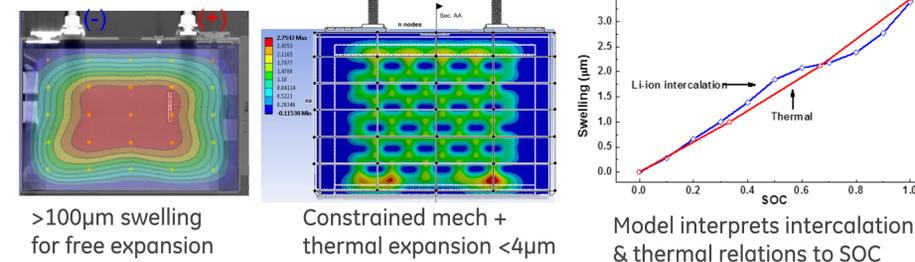


Model Development

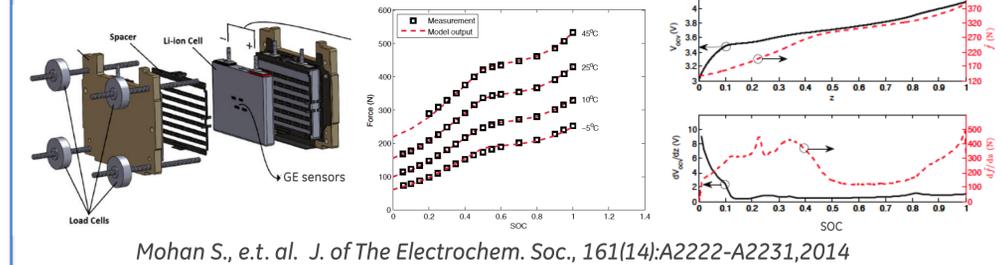
- Thermal - Surface temperature mapping
- Mechanical - Swelling due to thermal & intercalation
- Electrochemical - Parameter relationship to SOC



Electrode swelling due to lithium intercalation and thermal expansion



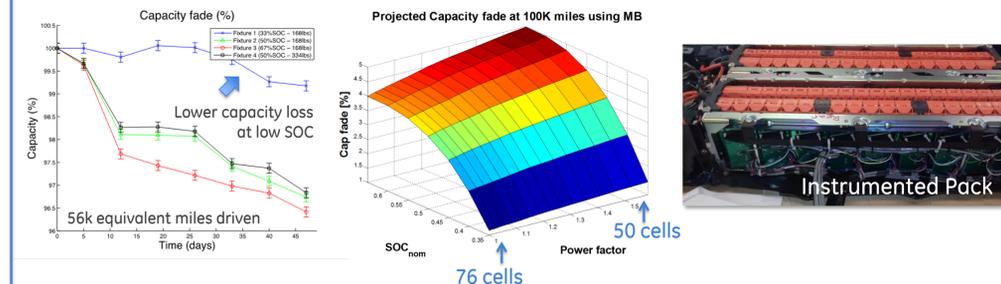
Improved SOC Estimation



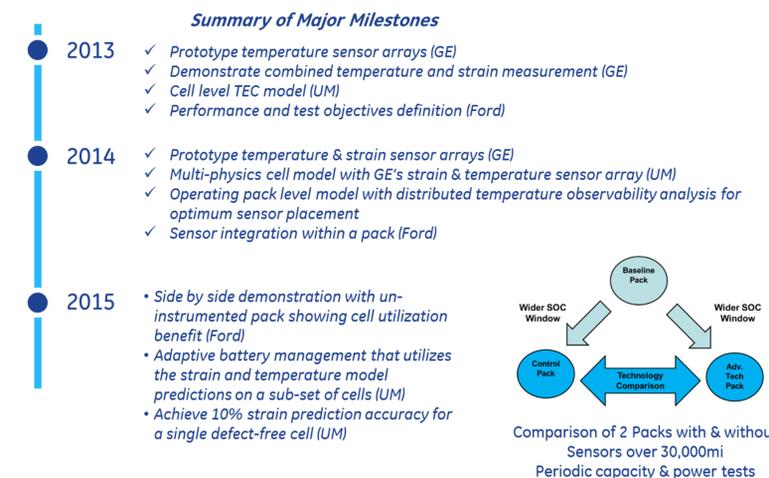
- Force change observable over entire cell SOC (larger signal than ΔV)
- 30-50% improved SOC estimation - better confidence in utilization window
- Force can be used in addition to voltage for better SOC estimation
 - U.S. Utility Patent Application No. 62/043,519

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



Oh, et. al. J. Power Sources, 267(0):197 - 202, 2014.

