Lithium Ion Electrode Production NDE and QC Considerations

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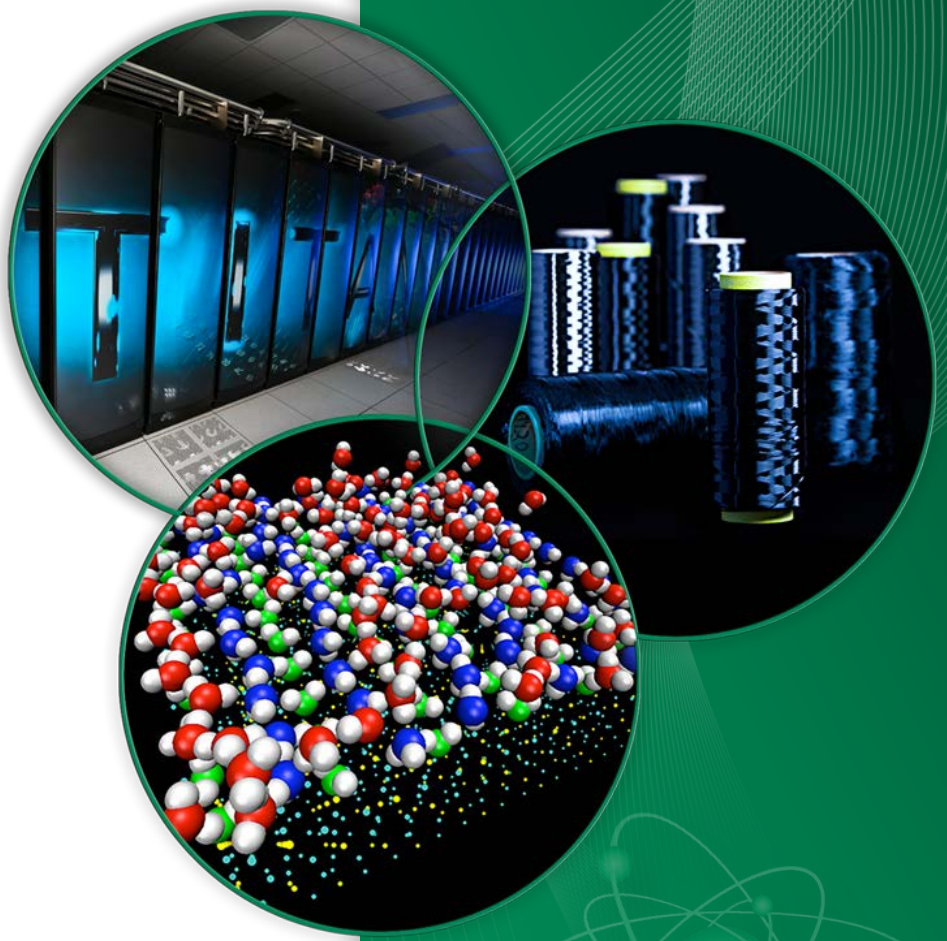
EERE Quality Control Workshop



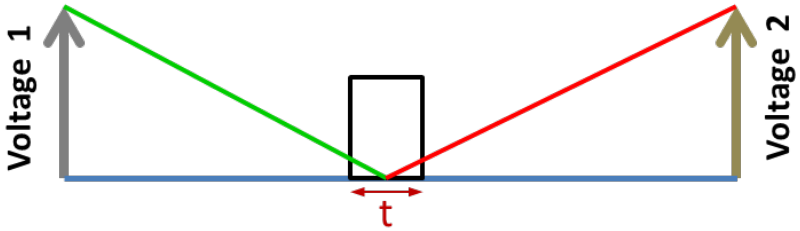
Lithium Ion Electrode Production QC State-of-the-Art

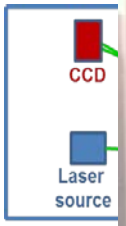
- In-Line Measurement
  - Conventional in-line thickness and/or areal weight by beta transmission gauge:
    - Thickness measurement precision of ±0.2% over 2-1000 µm
    - But expensive equipment (several hundred thousand dollars or more)
    - And ionizing radiation hazard (typically 300-1000 mCi sources)
  - Optical inspection with HR-CCD cameras (only uses visible light for detection).
  - Optical and beta transmission techniques provide no compositional information.
- Off-line Measurement
  - XRF for areal weight (requires removal of sample from roll).
  - Optical microscopy
- Without feedback loops to electrode dispersion mixing and deposition steps, even the best NDE methods will not reduce scrap rate (i.e., ***electrode*** QC).
- However, ***cell*** QC will still be improved by simply removing scrap to avoid assembling defective electrode area into cells.
- Pass/fail criteria must be established industry wide for NDE methods to be meaningful and provide electrode and cell QC.

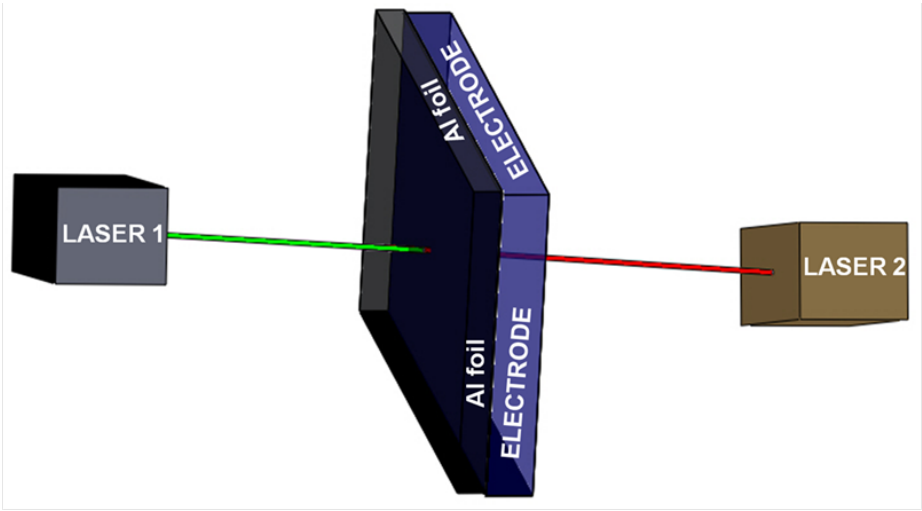
New Directions in Lithium Ion Electrode In-Line NDE

- Low-cost IR laser thickness measurement (can be done in multiple point scans across the web or an entire line scan).
- Low-cost IR thermography for defect identification for flaws not observable with optical methods (using a background heat source and IR camera).
- Acoustic agglomerate-size measurement of electrode dispersions as they are being pumped from the mixing tanks to the slot-die cavity.
- Thermal diffusivity measurement of electrodes to determine porosity via IR thermography.
- Could XRF instruments be engineered to be compatible with coating line speeds and give high enough accuracy on areal weight?
- Others such as spectrophotometric analysis for thickness *and* areal weight uniformity across roll.
- Three greatest needs:
  1. Pass/fail criteria for electrodes
  2. Correlation of defects with cell performance and capacity fade
  3. Feedback loops from coating to deposition

Construction of laser caliper (Keyence sensors) system on a slot-die coater to measure thickness



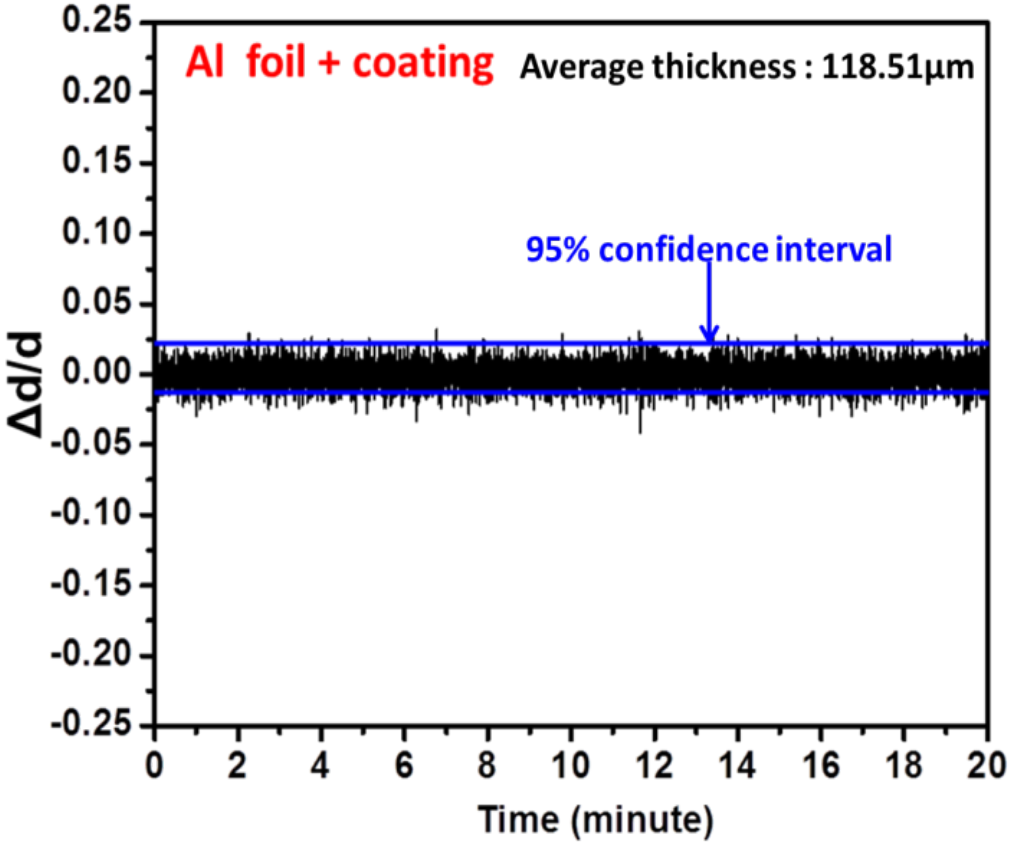




D. Mohanty, J. Li, R. Born, L.C. Maxey, R.B. Dinwiddie, C. Daniel, and D.L. Wood, “Non-destructive evaluation of slot-die-coated lithium secondary battery electrodes by in-line laser caliper and IR thermography methods,” *Analytical Methods*, DOI:10.1039/C3AY41140K **(2013)**

High-Voltage Lithium-Manganese-Rich Cathode (TODA HE5050) Thickness Measurement

Uniform wet-thickness during coating



Average thickness of cathode coating :

118.51 ± 2.57 µm

Where *d* represents the thickness value and Δd is the difference between two contiguous data.

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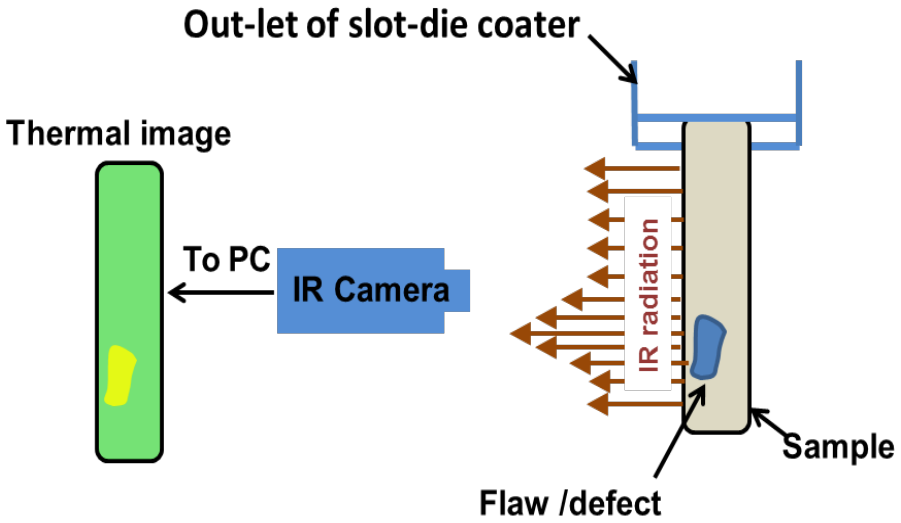
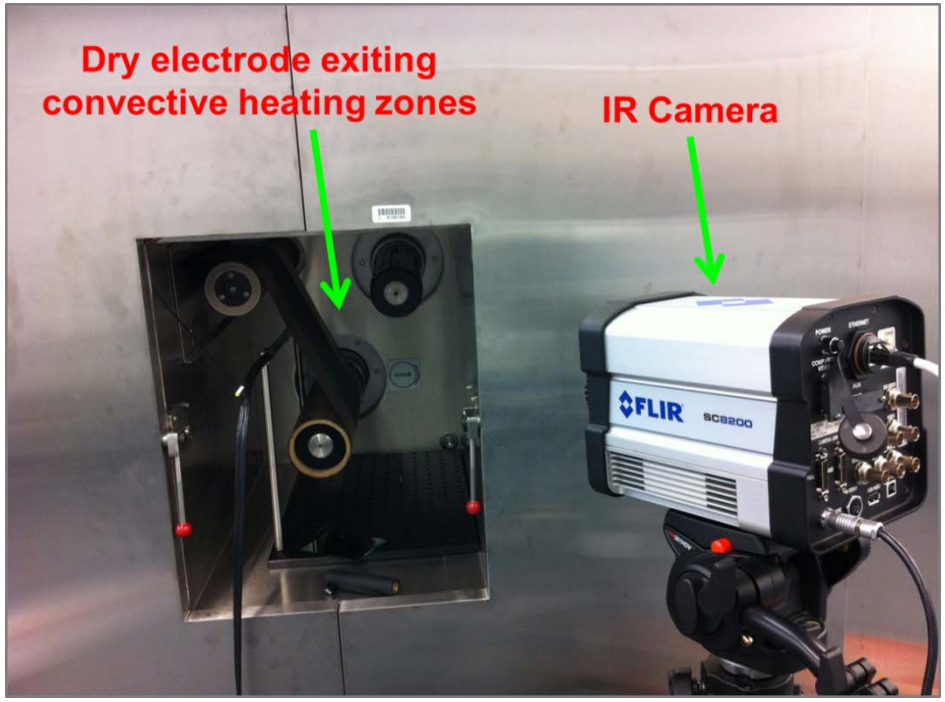
IR Thermography Setup with ORNL Slot-Die Coater

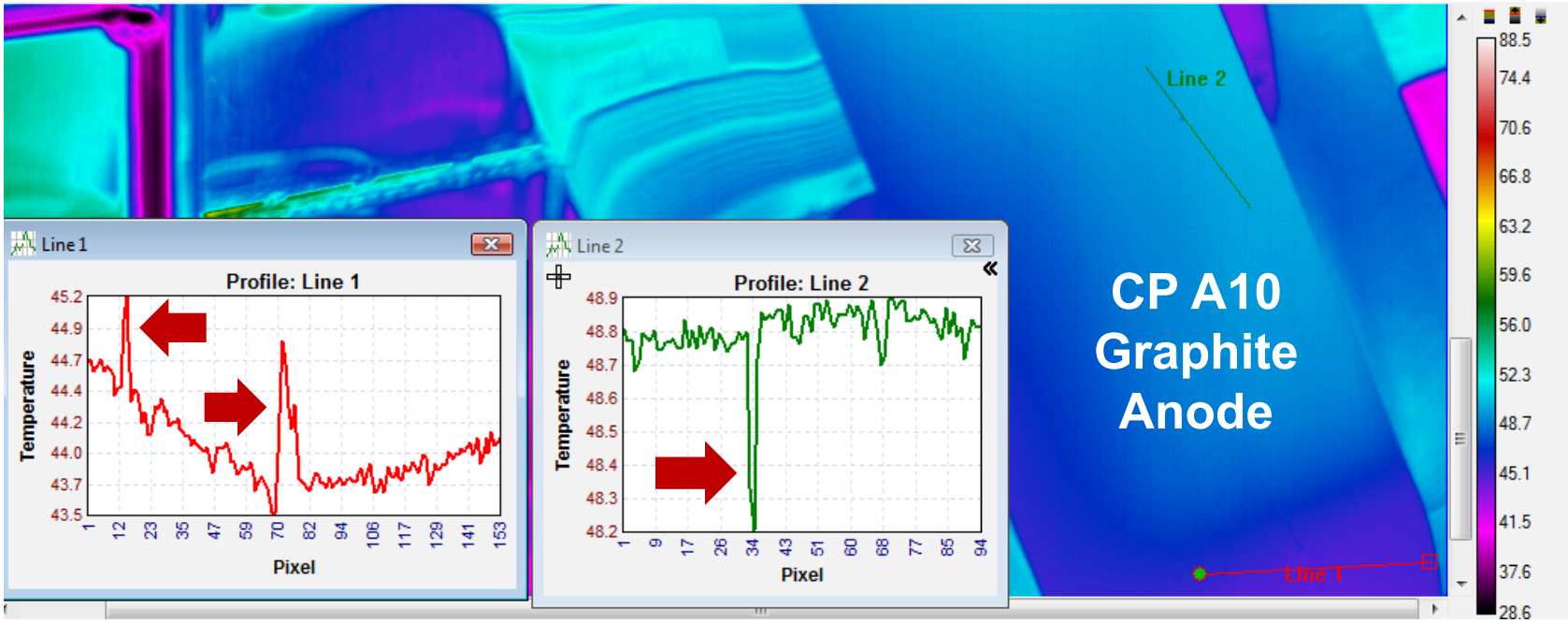


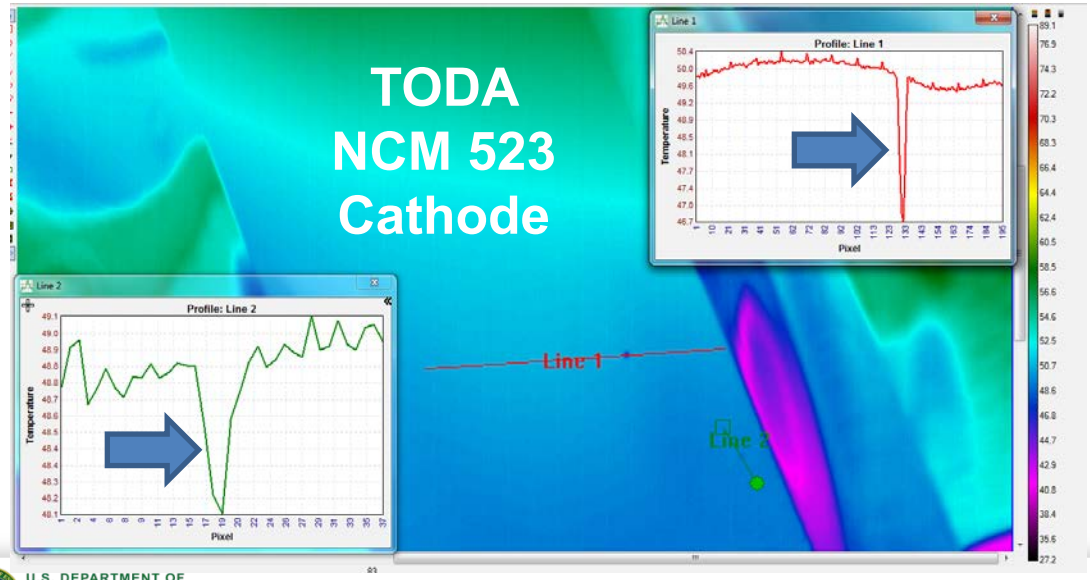
Schematic of IR thermography method to detect flaws in dry electrodes

- Current IR Camera: FLIR SC-8200
- Lens: 25 mm, no filters or extender rings
- Flash System: Hensel 6000 Joules
- Flash Power: 60%



IR Imaging Detects Different Defects





- A temperature increase across defect region corresponds to a blister or agglomerate where heat can't be released as fast.
- Temperature decreases correspond to pinholes and divots where heat is released faster.