Scale Up of Dry Process for Lithium Ion Electrode Manufacturing

Scale Up for Lithium Ion Electrode Manufacturing

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Defense Logistics Agency

2015 Joint Services Power Expo
Cincinnati Ohio 25-27 August

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Scale Up of Dry Process for Lithium Ion Electrode Manufacturing

- Phase I
  - DLA Battery Network Short Term Project
  - Develop an Alternative Electrode Manufacturing Process, Enabling *Just-in-Time* Delivery of Lithium Ion Batteries for the Defense Community
  - Demonstrate a Laboratory Style Proof of Concept Process for the Manufacture of Electrodes

Scale Up of Dry Process for Lithium Ion Electrode Manufacturing

- Phase II (Midway Through 24 Month Project)
  - Expand Upon The Proof-of-Concept Line To A Fully Capable Electrode Fabrication Line And Expand The Cell Testing Effort.
  - Verify The Optimum Operating Parameters And Production Capability For Continuous Fabrication Of Electrode Materials.
  - Delivery Of A Design Package For The Commercial-Scale Manufacturing Line

Scale Up of Dry Process for Lithium Ion Electrode Manufacturing

- The Problems
  - Existing Lithium Ion Manufacturing is Normally Dedicated to One Cell Type with One Capacity
  - Changes are Expensive Due to Capitalization Requirements and Time to Implement
  - Majority of Commodity Cells Being Purchased for Government and Military Applications are Manufactured in Japan and China
  - Majority of Existing Manufacturing is Product Specific; One Machine = One Product
  - US has Little Control of Product Consistency from Foreign Manufacturers
  - Counterfeit Batteries

Scale Up of Dry Process for Lithium Ion Electrode Manufacturing

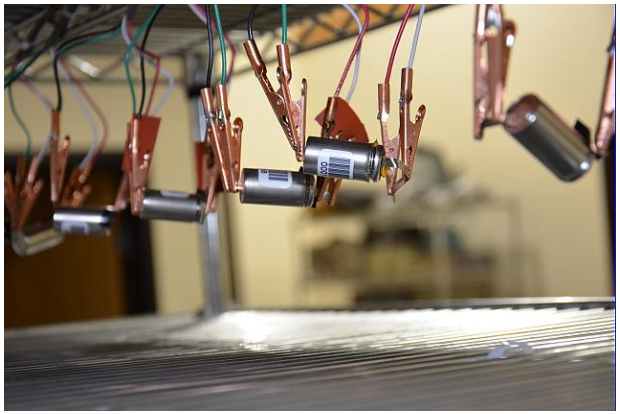
- Goals of the Program
  - Ability to Produce Multiple Electrode Chemistries and Designs from the same Equipment
  - Allow Small Lots of Different Types of Batteries from the Same Line
  - Reduce Level of Work in Process and Scrap
  - Rapid and Inexpensive Change-Over
  - Minimization of Capital Requirements, Enabling Sustainable Business Decisions for the Manufacturer
  - Eliminate the Use of Solvents (NMP and MEK, Known Carcinogens)
  - 100% Dry Process
  - Process Should be Independent of Active Materials
  - Uniform Porosity, Density and Thickness Control

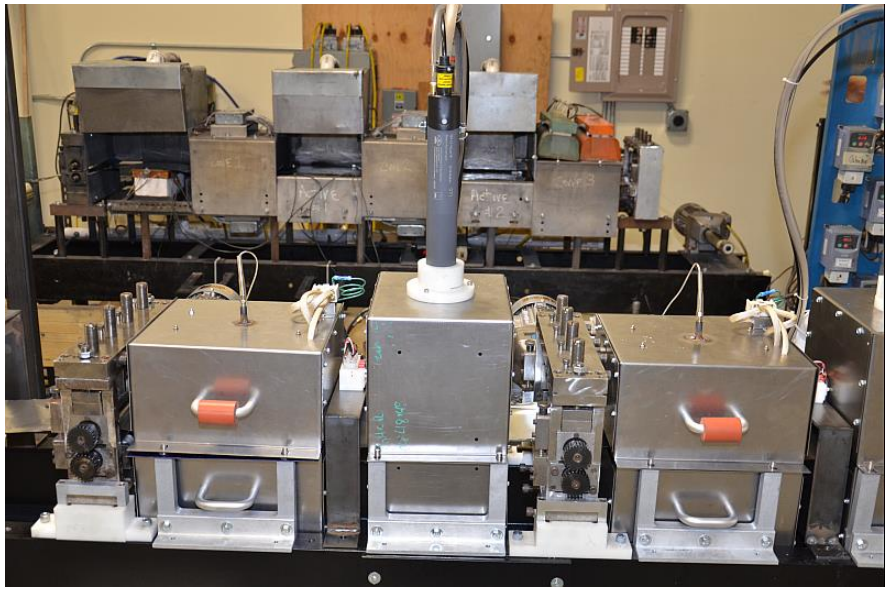
Scale Up of Dry Process for Lithium Ion Electrode Manufacturing

- What We've Achieved
  - Developed Prototype Manufacturing Line
  - 100% Dry Process
  - Eliminated All Solvents
  - Drastically Reduced Footprint Needed for Manufacturing, Reducing Capitalization Costs
  - Demonstrated Quick Change-Over Between Chemistries Allowing Short-Run or Specialized Production

Scale Up of Dry Process for Lithium Ion Electrode Manufacturing

- What We've Achieved
  - Estimated 40% Manufacturing Cost/Ah Savings
  - Cells Built and Tested, With Comparable Characteristics to Solvent Cast Electrode
  - Patent Filed





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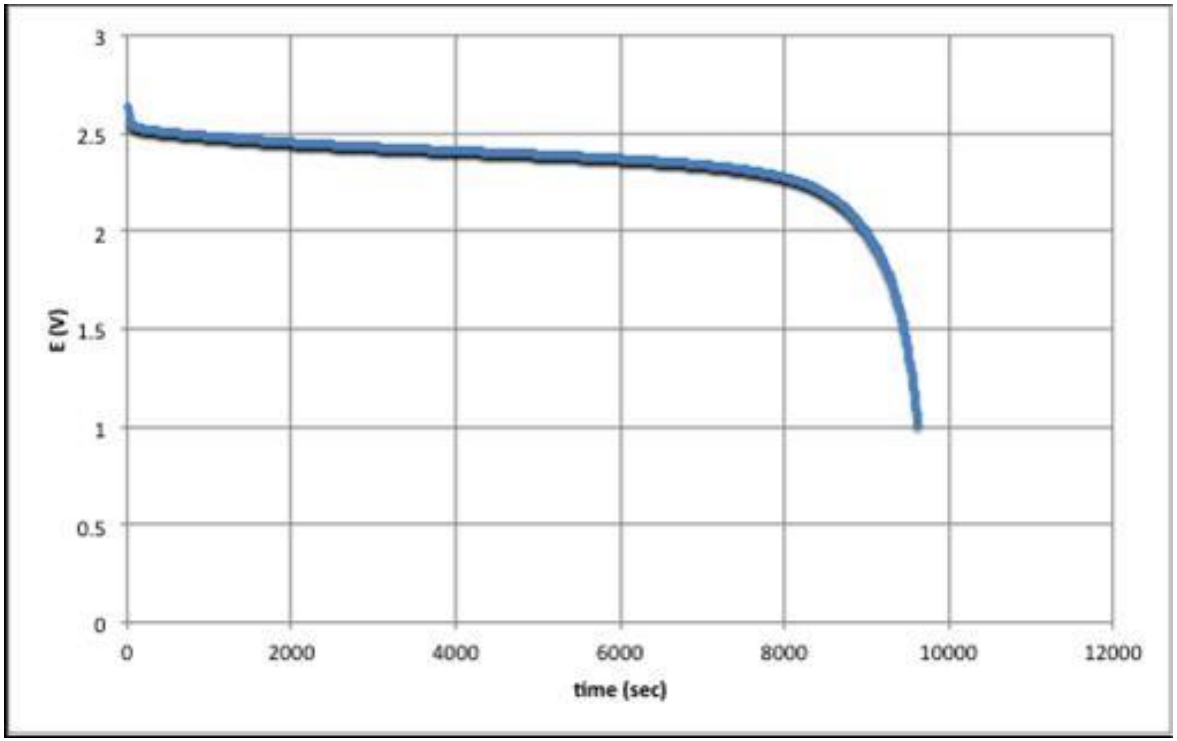
Electrodes Exhibit Comparable Characteristics to Solvent Cast Electrodes



Discharge, Anode ltd, LTO Cell #34 0.485mAh/cm^2

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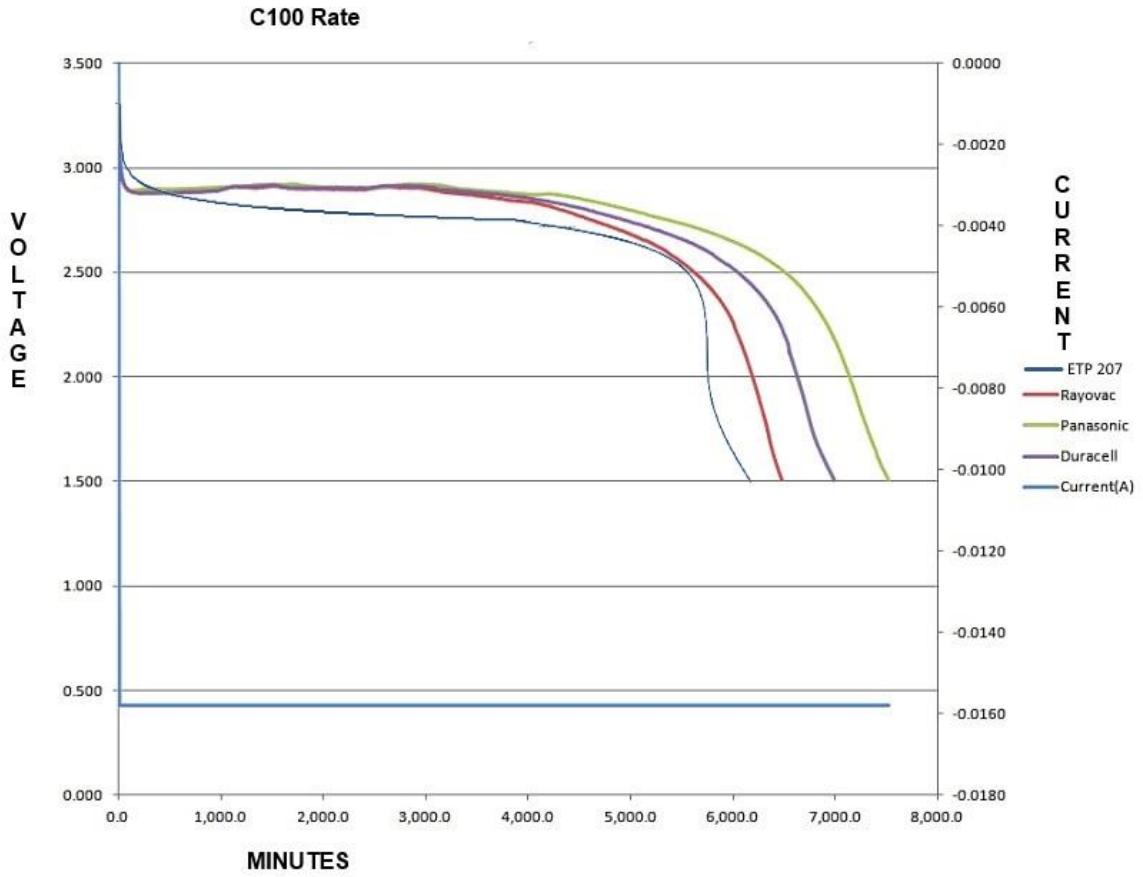

Scale Up of Dry Process for Lithium Ion Electrode Manufacturing

- 40% Cost Savings/Ah (Estimated)
  - 50-75% Reduction in Capital Equipment
    - 75% Reduction in Mixing Capital
    - 50% Reduction in Drying Capital
    - 50% Reduction in Coating Capital
    - 100% Reduction in Solvent Recovery Capital
  - 30% Reduction in Labor Costs
    - Simplification of Processes
  - 40% Reduction in Utility Costs
    - Space Needed, Energy Cost
    - Work In Process Reduction

Scale Up of Dry Process for Lithium Ion Electrode Manufacturing

- The Process
  - Charged Fluidized Bed Depositing on Grounded Current Collector with a Series of Heated Stations
  - Applies to All Common Active Materials and Particle Sizes
  - Utilizes the Same Binder and Active Materials as Conventional Manufacturing
  - Introduces no Solvents, Eliminates Drying Steps
  - Electrode is Immediately Ready for Cell Construction

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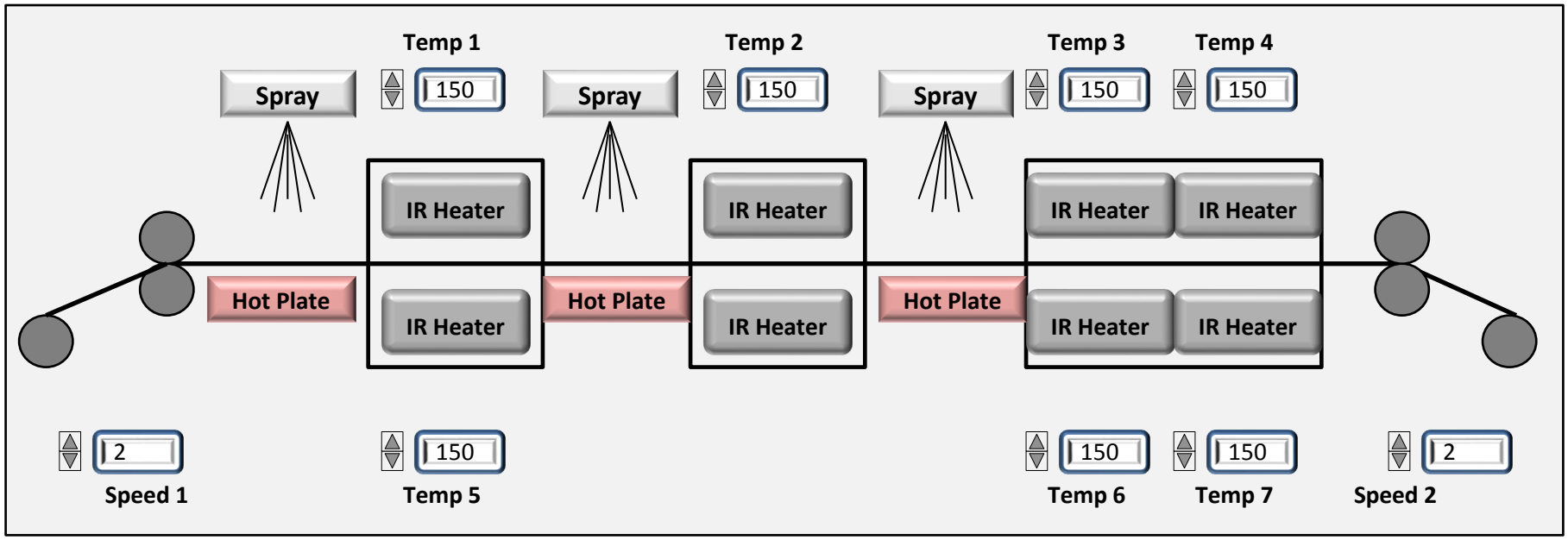

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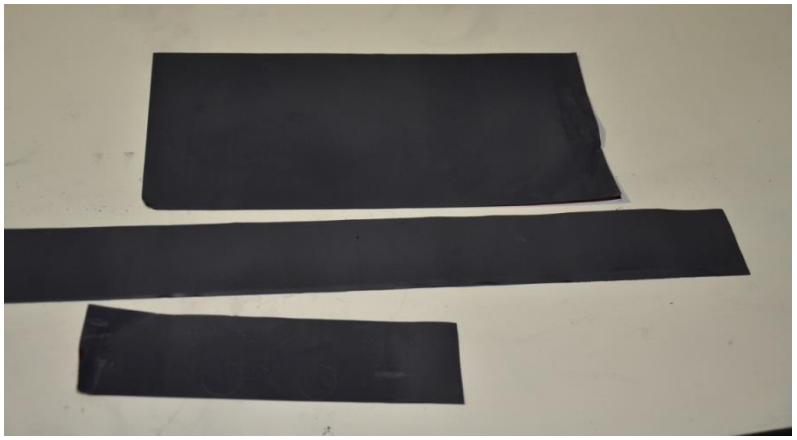
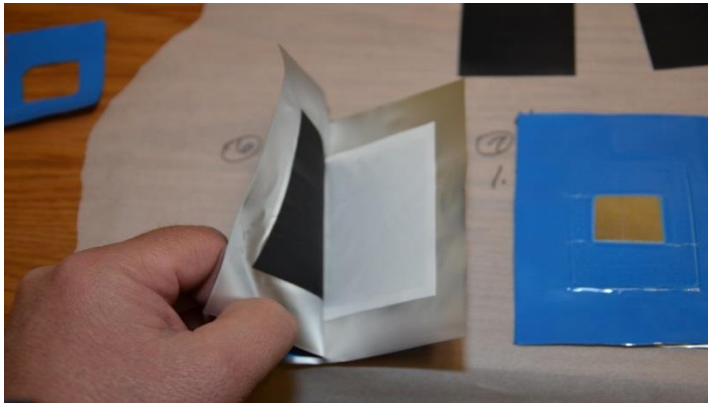


ETP Dry Processed Electrodes Before Manufacturing Into…..

Cylindrical Cells and



Pouch Cells for testing

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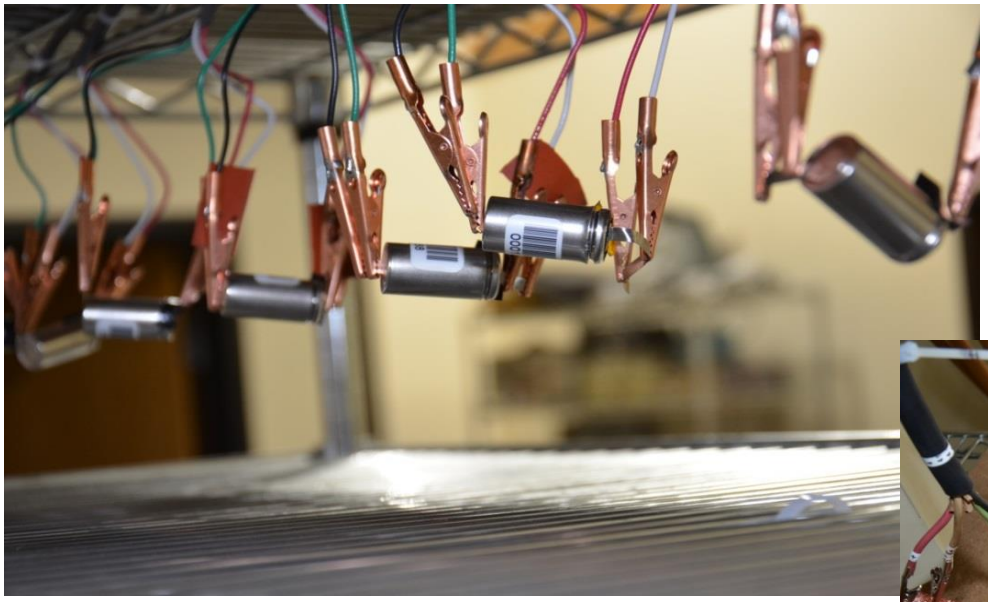

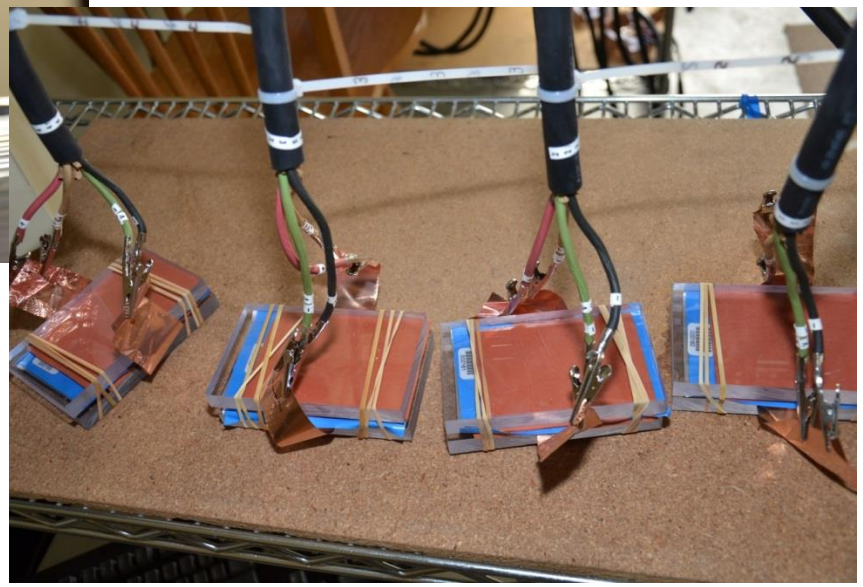

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Scale Up of Dry Process for Lithium Ion Electrode Manufacturing

- Process Allows for Quick Change Over
- Electrode Performance Is As Good or Better Than Solvent Cast
- Process Allows for Varying Particle Size With Defined Layers
- Process Uses the Same Binder and Active Materials and Ratios, as Conventional Solvent or Wet Cast Manufacturing
- Works With Varieties of PVDF

Scale Up of Dry Process for Lithium Ion Electrode Manufacturing

- Electrodes From 12 um to 500 um Thickness
- Cell Testing
  - Exceptional High Rate Performance >100 to 330 C Rate Demonstrated
  - Fade Rates Appear to be Similar or Improved Compared to Solvent Cast (150 to 400 Cycles C/3)
  - Life Testing Still needs to be Validated.

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Acknowledgements

ETP would like to acknowledge

MEGTEC Systems for their participation

and

COR Matt Hutchens of DLA BattNet for his support