Rolled-Ribbon
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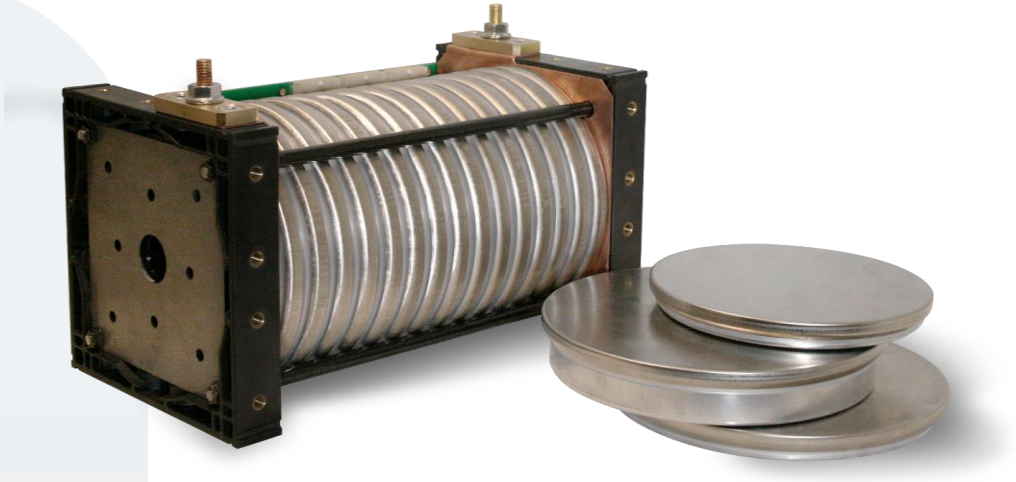
Rolled-Ribbon®

The New Standard for High-Power High-Capacity Li-ion Batteries



Joel Sandahl, President & CEO

March 16, 2021

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Li-ion Cells

Cell = Electrochemical Formulation + Cell Package

Cylindrical

Pouch

Prismatic

Current Cell Packages

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New Cell Package!

Why a new cell package?

- The Problem
  - Current cell packages are designed for low-power low-capacity
  - They do not scale up well for high-power high-capacity requirements
  - Performance decreases, cost increases
  - Impedance and thermal issues emerge, difficult/impossible to solve
  - Heat is the archenemy of electrochemistry

- The Solution – Rolled-Ribbon®
  - Reduces impedance
  - Provides unparalleled thermal performance
  - Infinitely scalable, no cost penalty
  - Compatible with all present Li-ion electrochemical formulations
  - Every Li-ion electrochemical formulation performs better in a Rolled-Ribbon package

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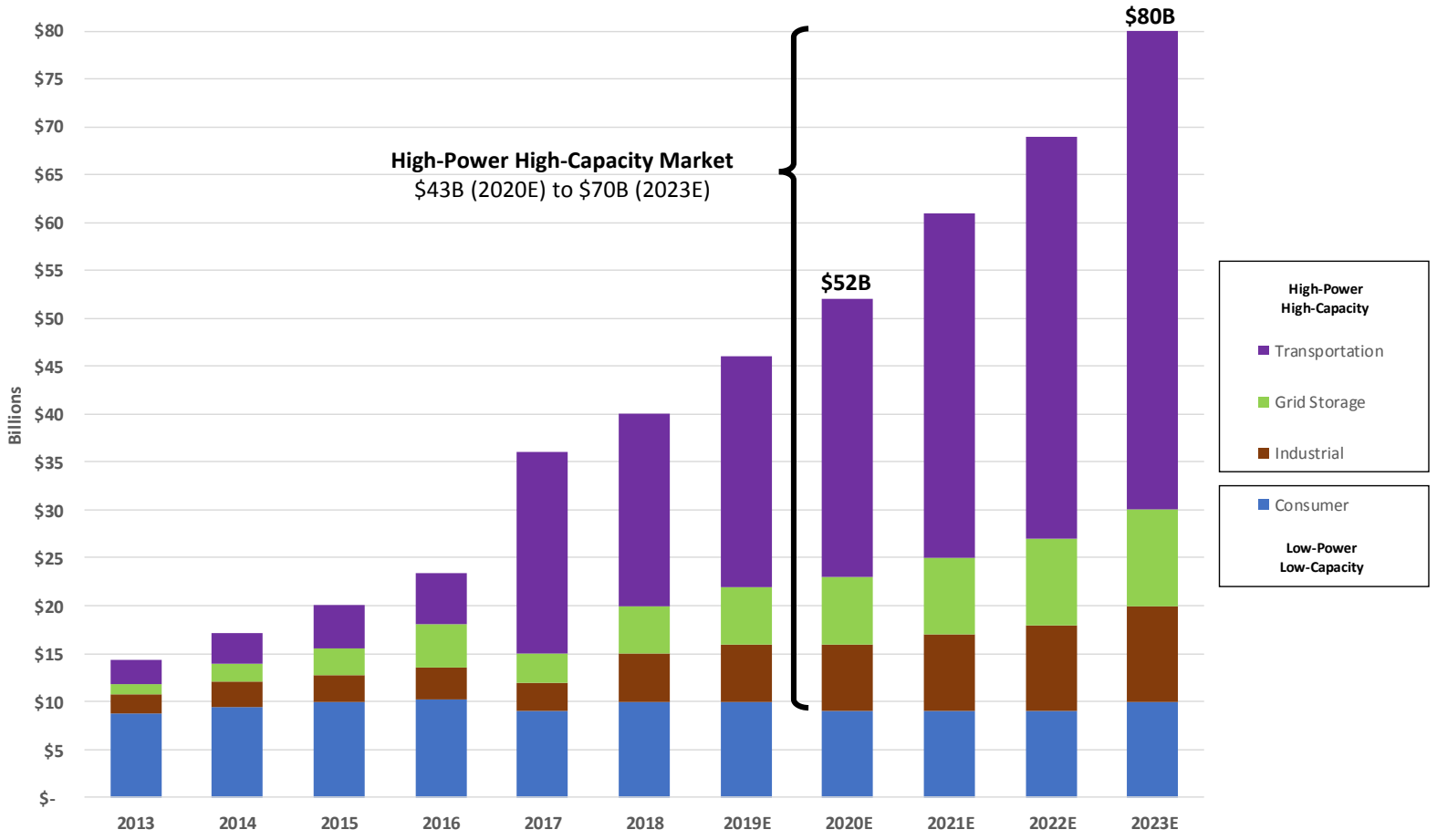
Why does this matter?



Source: RRBC (derived from Avicenne Energy data)

Note: Exclusive of Military

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Structure of Current Cell Packages

Cylindrical

Electrode Configurations:

Wound-Tabbed

Pouch

Electrode Configurations:

Wound-Tabbed
Stacked-Tabbed

Prismatic

Electrode Configurations:

Wound-Tabbed
Stacked-Tabbed

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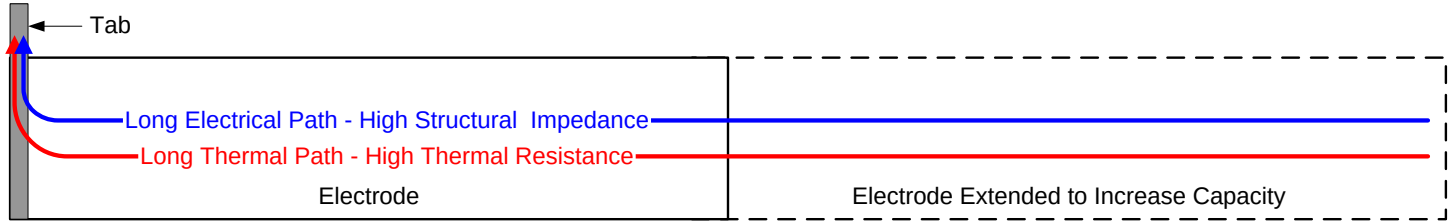
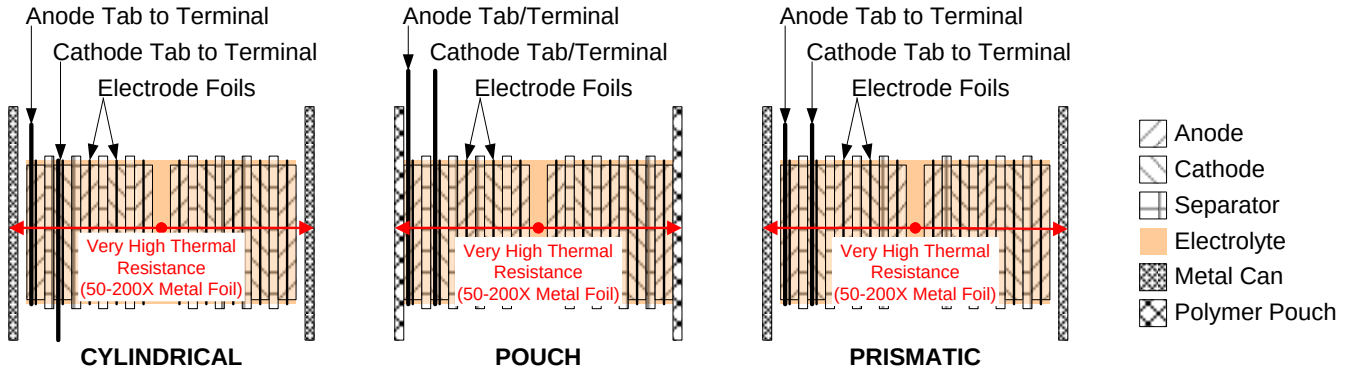
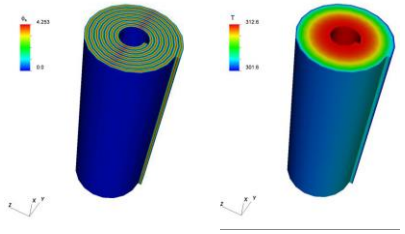
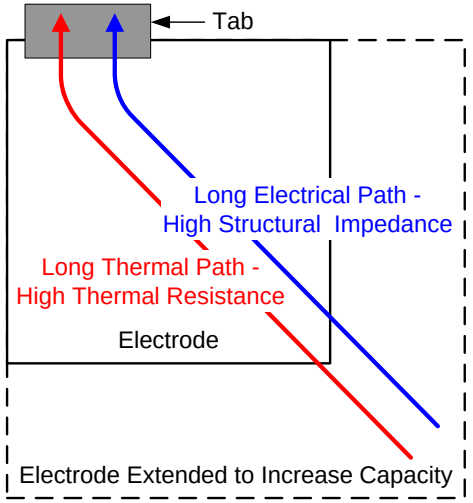
Wound-Tabbed Cells

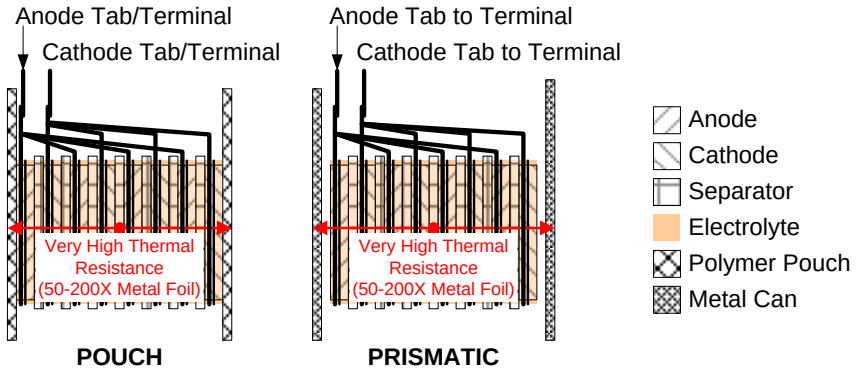


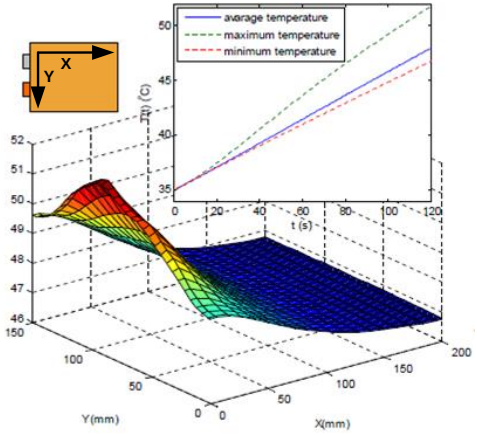


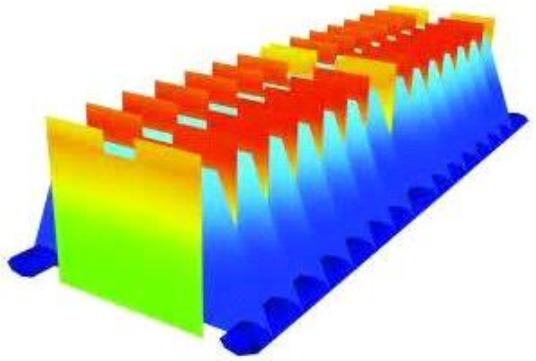


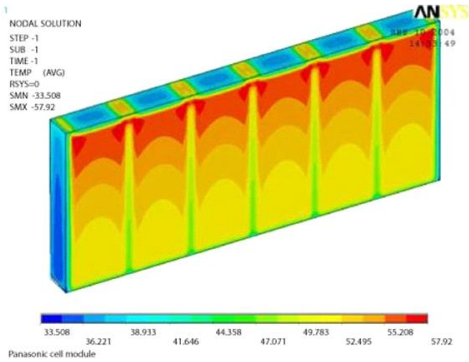
Stacked-Tabbed Cells











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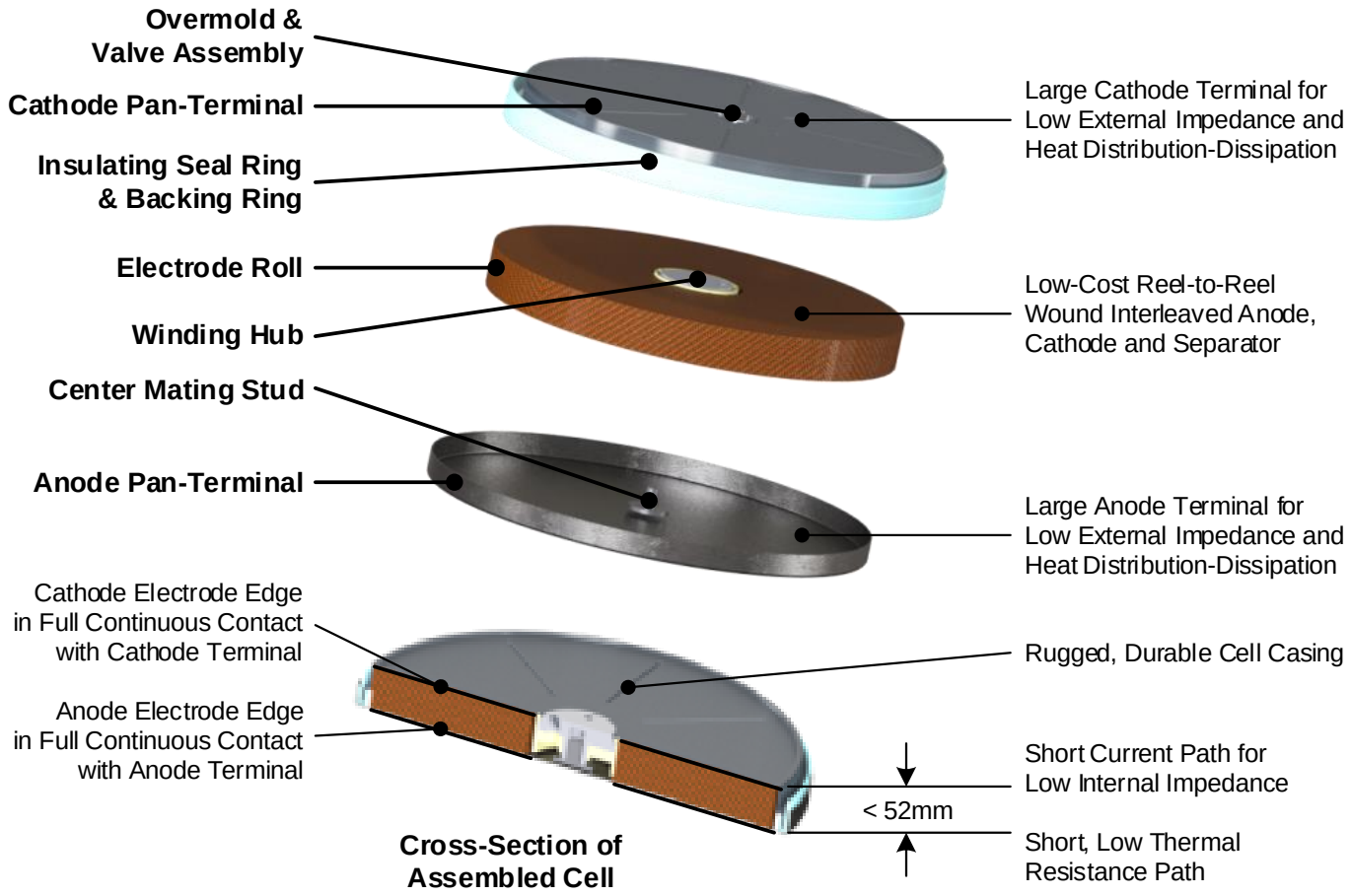
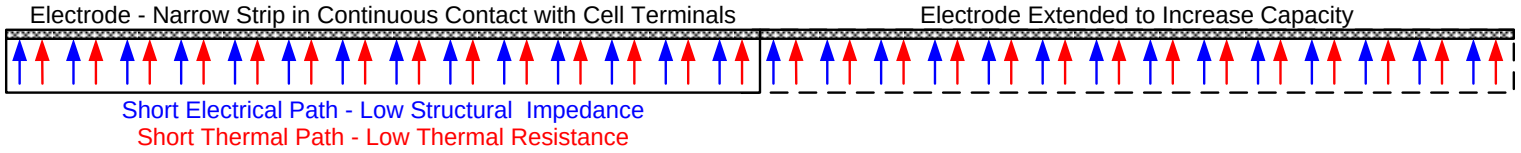
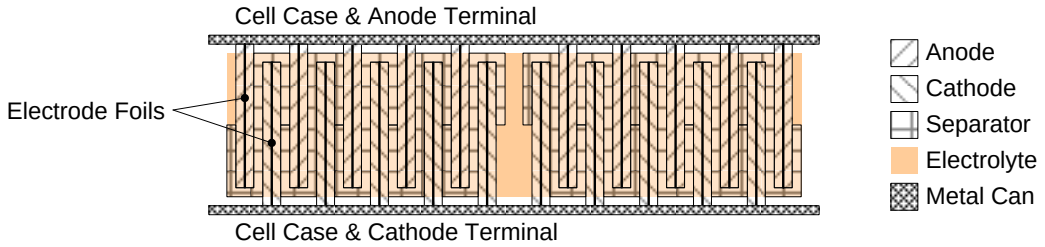
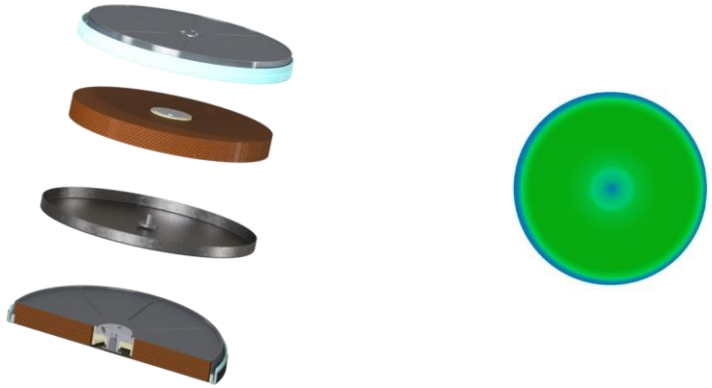
Structure of Rolled-Ribbon Cell Package



Rolled-Ribbon Cells







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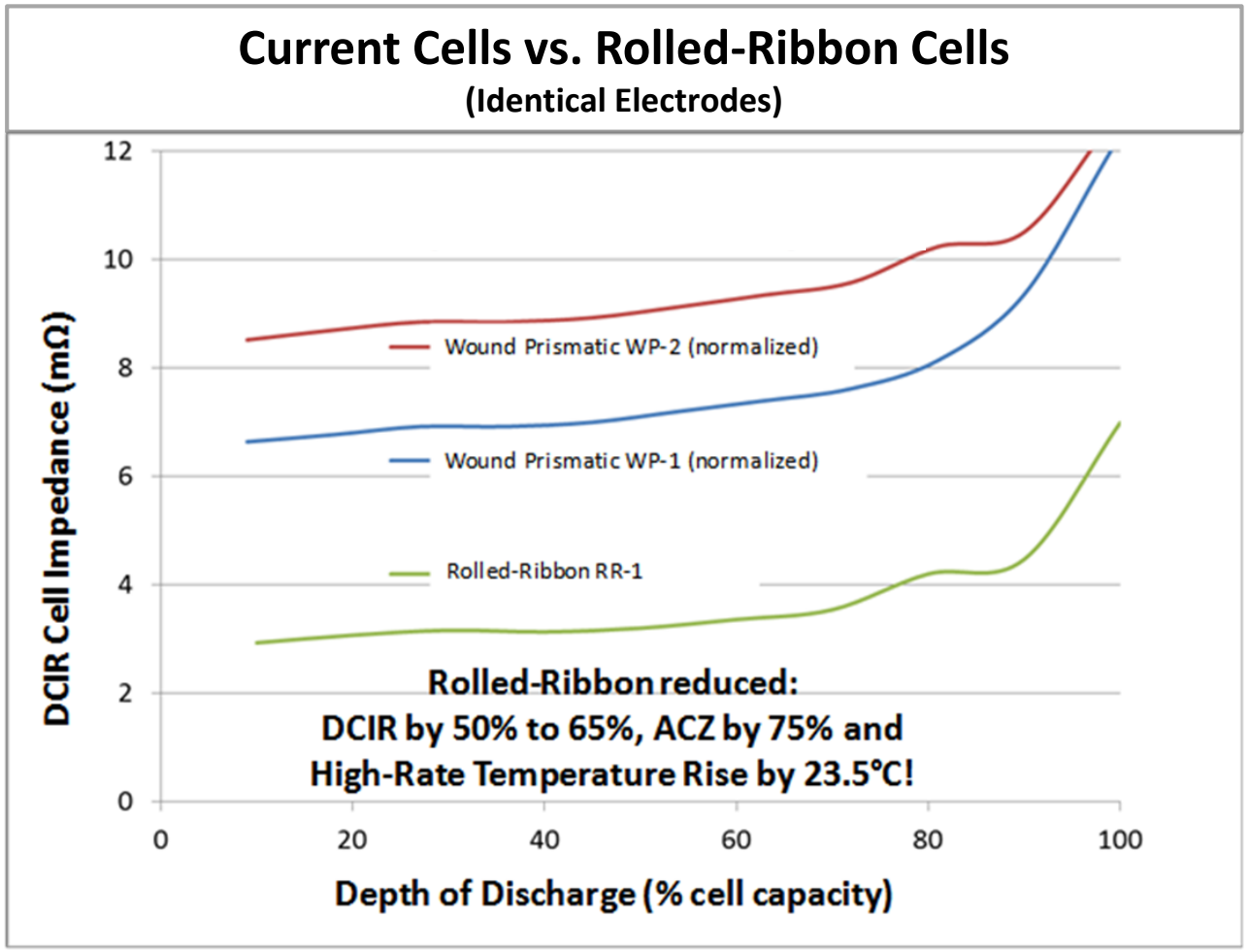
Cell Test Results – Impedance, Power



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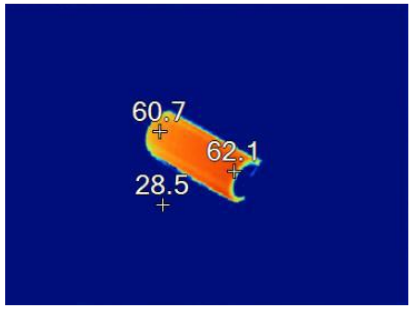
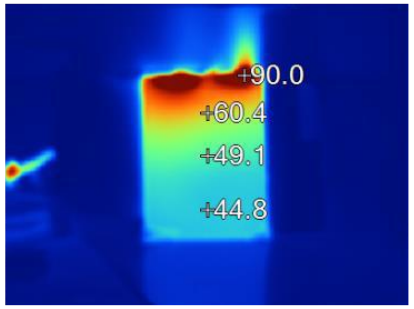
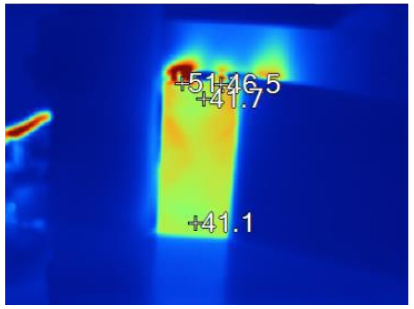
Cell Test Results – Thermal



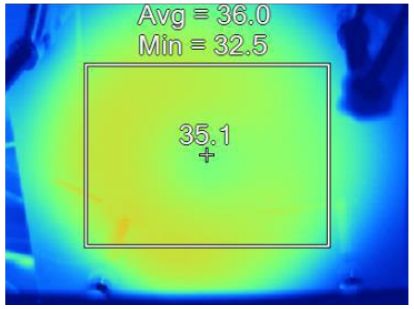
Cylindrical



Pouch



Prismatic



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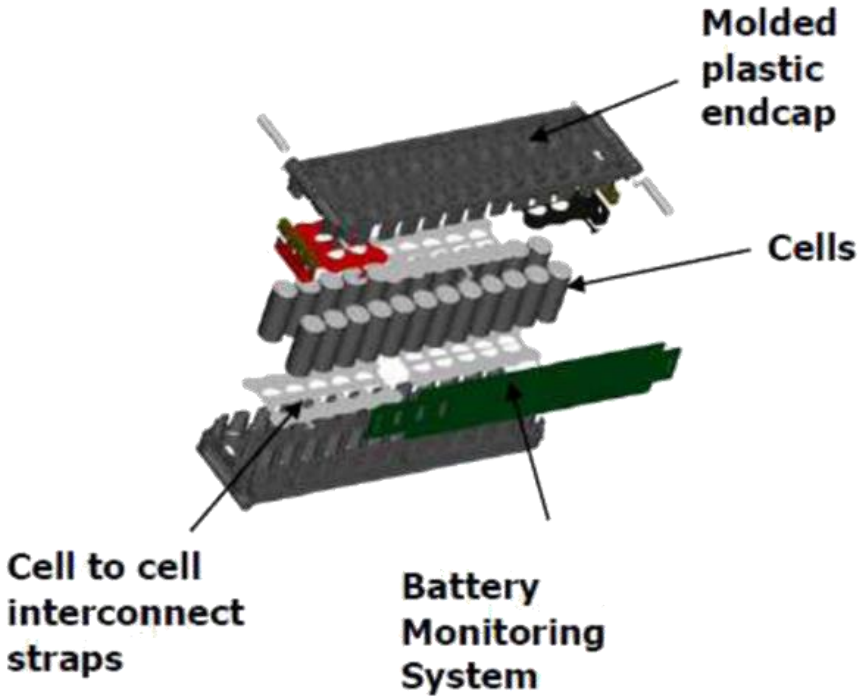
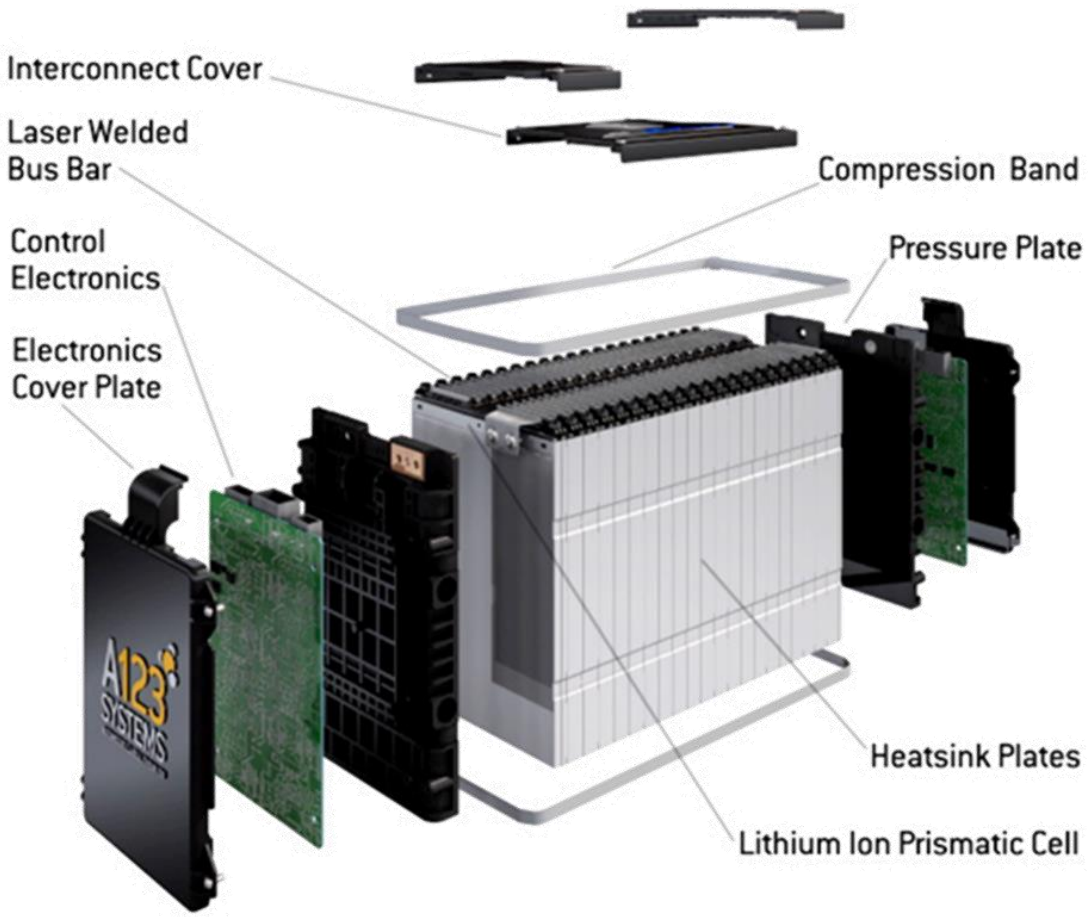
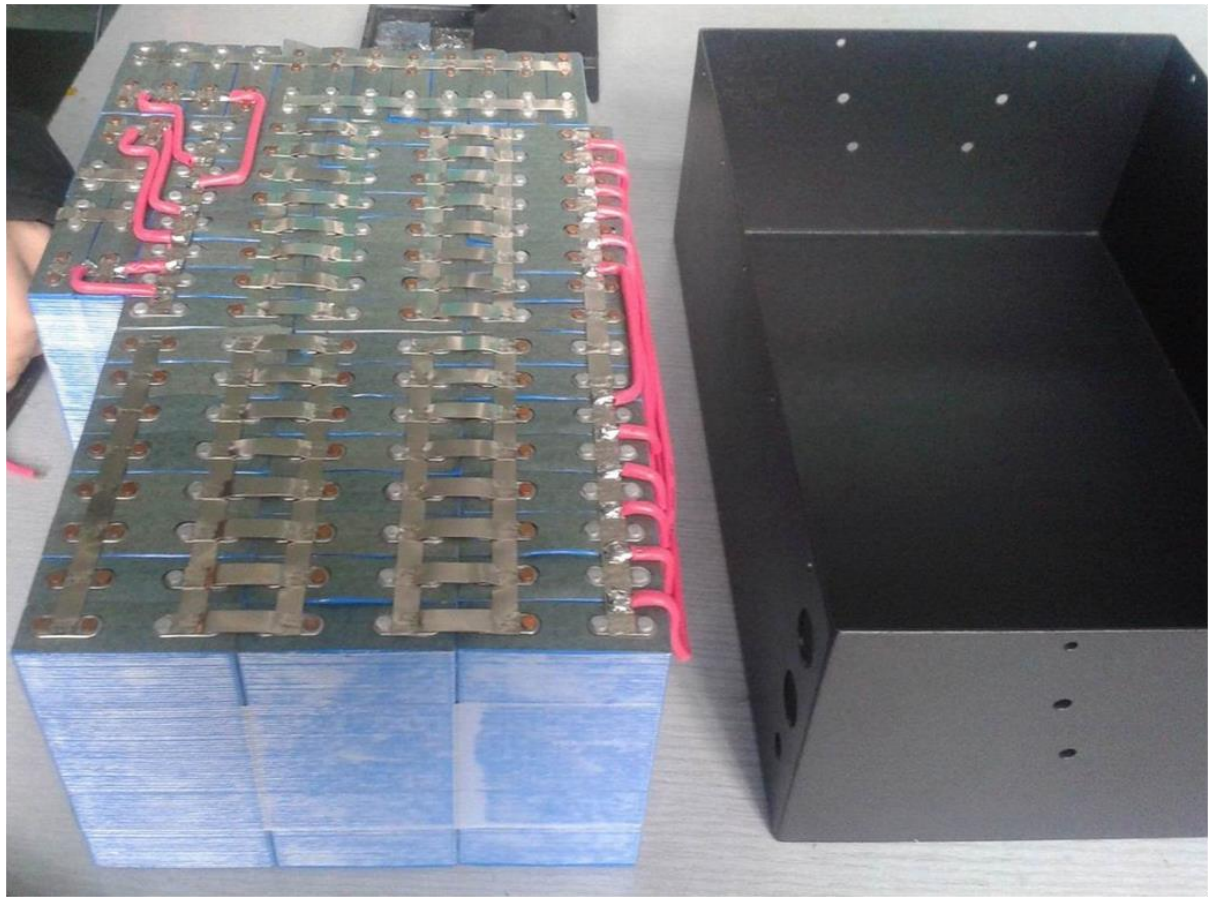
Cylindrical Battery Module



Pouch Battery Module



Prismatic Battery Module



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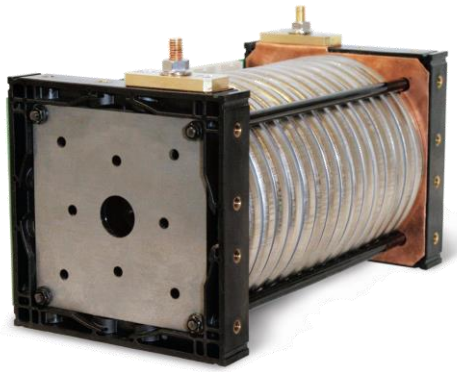
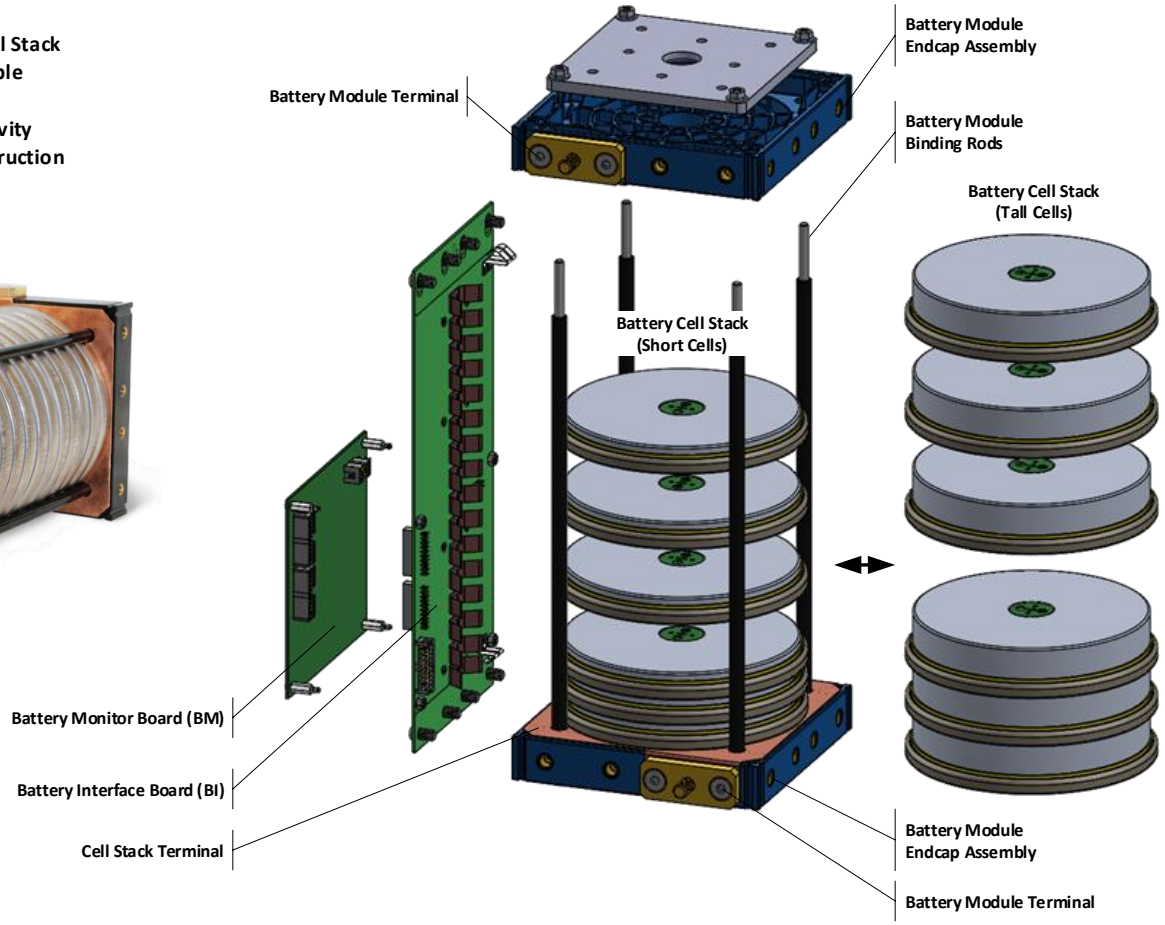
Rolled-Ribbon Battery Module

- ✓ Flexible, Modular, Scalable
- ✓ Stacked-Cell Design
- ✓ No Wire Harness to Cell Stack
- ✓ No Welding – Serviceable
- ✓ High-Rate Capability
- ✓ High Thermal Conductivity
- ✓ Rugged, Durable Construction





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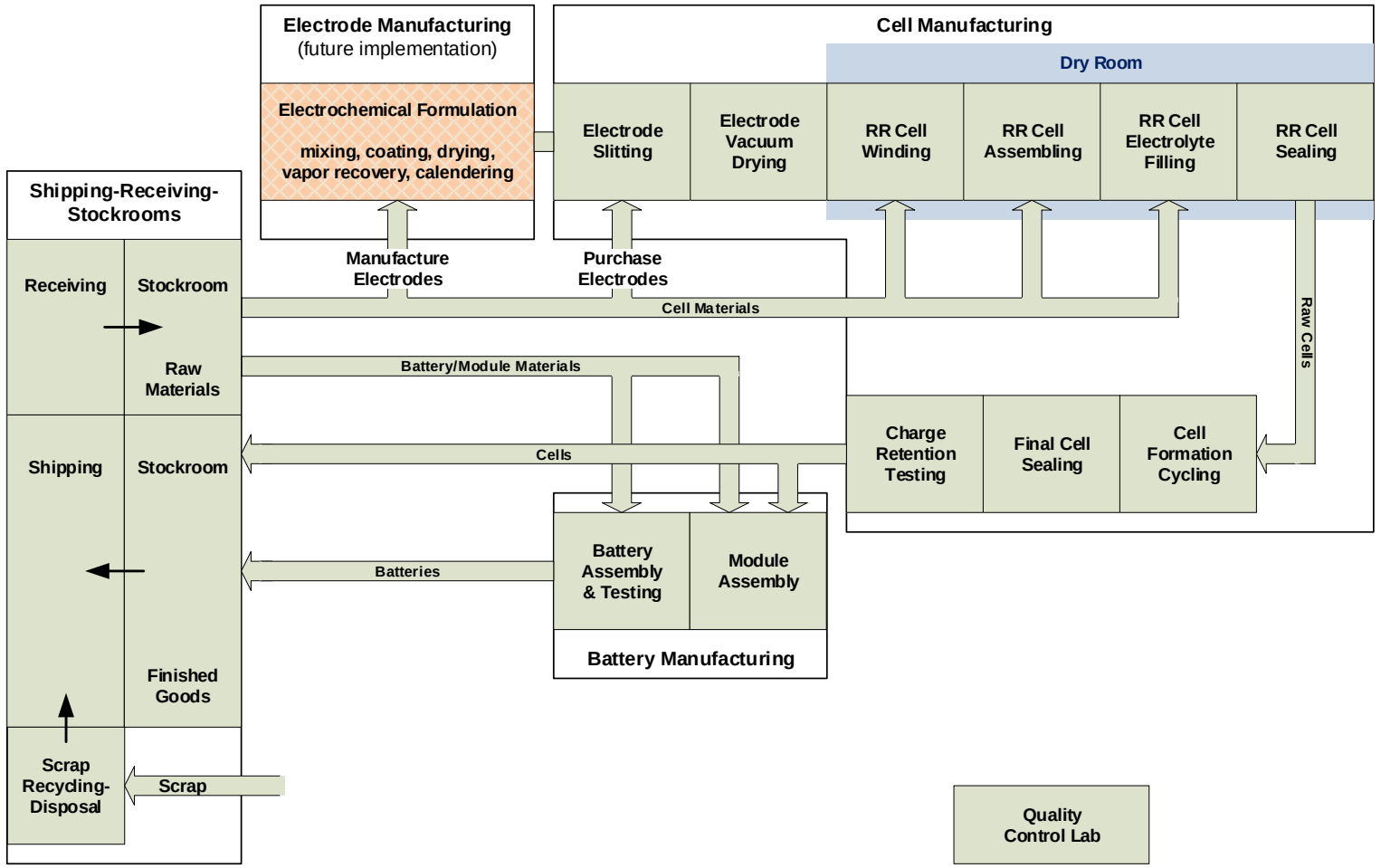
Rolled-Ribbon Manufacturing Flow



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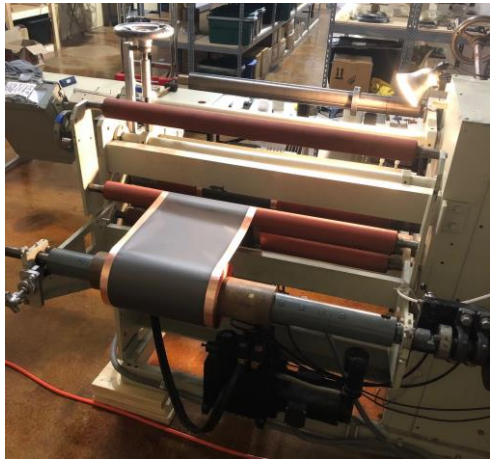
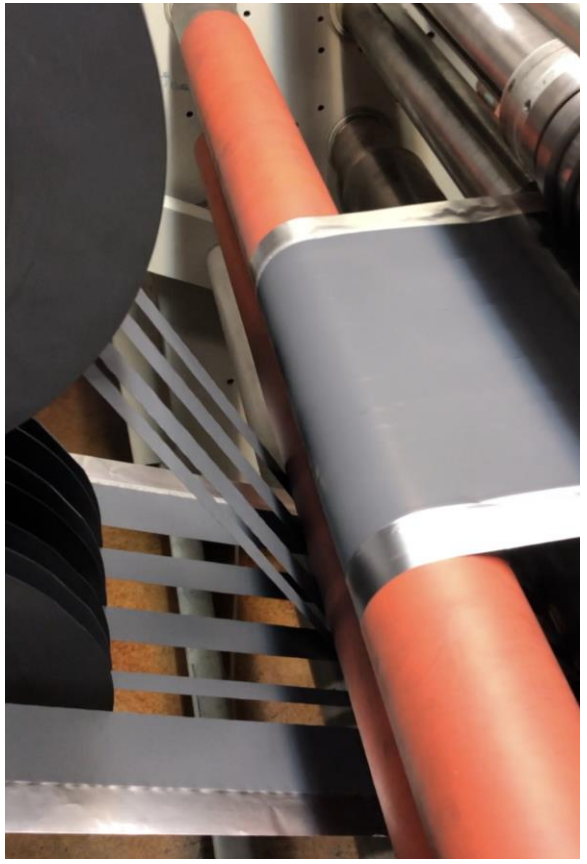
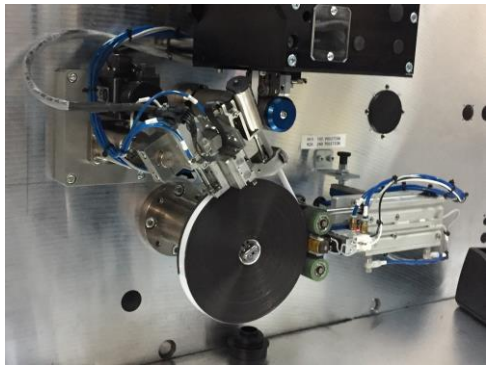
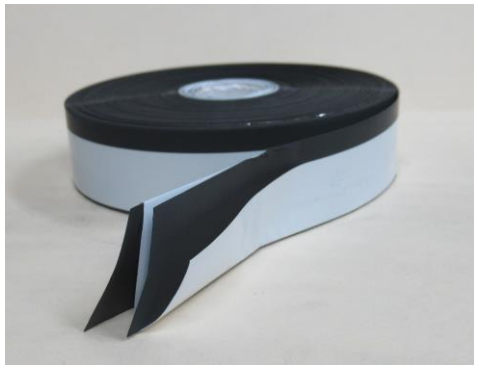
Rolled-Ribbon Electrode Slitting





Rolled-Ribbon Electrode Roll Winder





Rolled-Ribbon Electrode Roll *(mirrored)*

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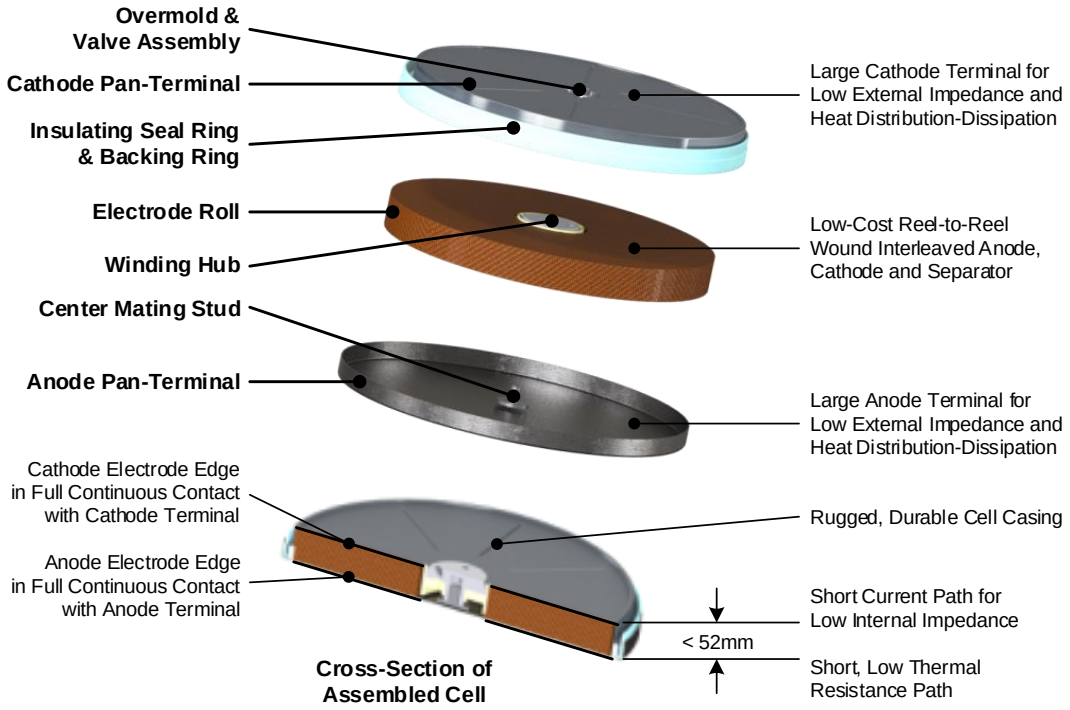
Rolled-Ribbon Cell Assembly



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LFP: 136 x 15 mm, 3.2V @ 15Ah
LFP: 165 x 15 mm, 3.2V @ 22Ah
LFP: 165 x 15 mm, 3.2V @ 45Ah

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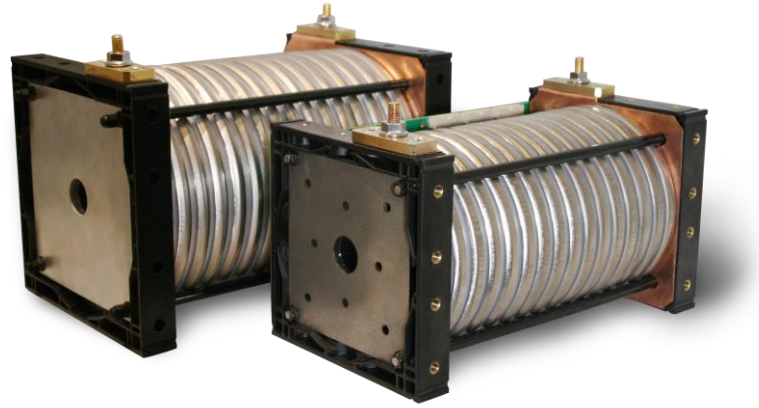
Rolled-Ribbon Battery Modules

48V @ 4.5kWh & 2.25kWh



48V @ 1,000Wh & 720Wh

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Summary & Key Takeaways

- Technical Issues
  - Cell package designs are not equal
  - Internal temperature is what matters
  - Low thermal resistance between cell electrodes and casings is key
  - Cells establish foundation (set upper limit of performance)
- Conventional Cells
  - Poor power capabilities – impedance and thermal issues
  - Poor thermal properties – difficult to extract heat
  - Don’t scale up well – higher power/capacity -> poorer performance
- Rolled-Ribbon Cells
  - Better power capabilities
  - Unparalleled thermal performance (50-200X)
  - Scales up well – higher power/capacity don’t degrade performance
  - Better cells – better batteries!

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Questions?

For additional information:

Website: www.rolled-ribbon.com

E-Mail: info@rolled-ribbon.com