QUALLION




Quallion LLC
NTSB Presentation

Sr. VP of Strategy and Business Development
Vincent Visco

Powering Life.

Introduction

- Employing a core strategy of leveraging R&D, niche focus, complementary and synergistic market entries
- One of the largest manufacturers of Lithium ion cells in the United States fortifies barrier to entry hampering potential competitors from entering the space
- Best-of-breed system level approach for advanced battery technologies that involves a core expertise beginning from material selection to cell design and final battery pack configuration

IP Portfolio

- Zero-Volt™
- Matrix Battery™
- FLEX-Power™
- SaFE-LYTE™

Products

- Materials
- Cells
  - Primary
  - Secondary
  - Polymer
- Batteries

End Markets

- Defense
- Energy
- Transportation
- Medical

Headquarters
Sylmar, CA

Add'l Manufacturing Site
Santa Clarita, CA

Founded
1998

Employees
176

US Congressional Districts
Buck McKeon (R)
Brad Sherman (D)

CA State Reps
Senator Alex Padilla
Senator Steve Knight
Assemblyman Boca Negra

Company Milestones

1998
- Company established in Southern California, USA
- Developed 7 new cell designs (4 implantable grade); shipped 30,000 production units; plant reached 6,000 unit per month volume

2001
- Entered Aerospace/Defense market with OGA and CECOM Contracts
- Initiated Development of Primary Chemistries

2002
- Registered under ISO 9001 &13485; Zero-VoltTM technology patented (recertified in December 2004)

2003
- Zero-Volt™ technology patented

2004
- SaFE-LYTE™ technology patented

2005
- Title III Award; Registered AS9100

2006

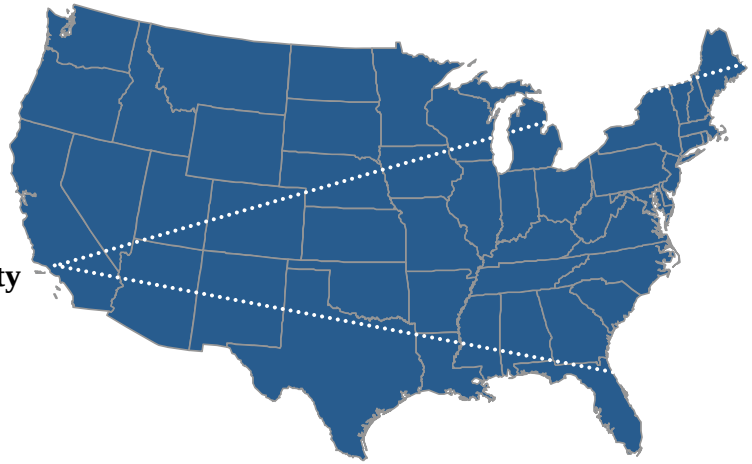
2007
- Frost & Sullivan Award for Lithium Ion Power Sources

2008
- Boeing Technology Supplier Award

2009
- Awarded DOE Anti-Idling Contract

2010
- Tac-Sat IV launch
- Title III cell production Line started

2011
- $7 million California Energy Commission green vehicle manufacturing contract



Los Angeles County

Configuration Control for Materials, Cells and Batteries

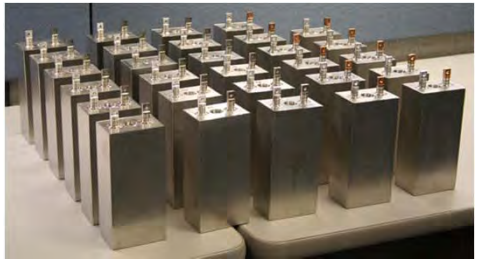
(1) Cathode and Anode Materials Line: LCO, NCA and MCMB production (200kg/month)

(2) Coater: Precision-engineered to Quallion chemistry, roll to roll continuous coating.

(3) Die Cutters: Custom designed, fully automated dual lines with integrated inspection system (3,000 electrodes per day).

(4) Automated Stacker: High speed stacking, single button operation with separator bagging system and inline inspection.

(5) The Product: Up to 5,000 72Ah cells per year (single shift).

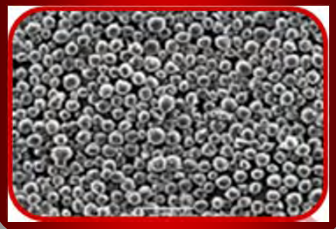


Quallion Vertical Integration Offers a Comprehensive Energy Storage Solution

Battery Market Stratification

Materials

Domestic production of LCO/NCA cathode and MCMB anode. COTS 18650 solution allows for lower cost/multi chemistry options including NMC, Spinel, LFP.

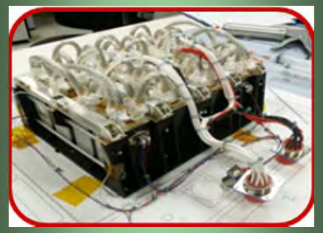


Cell Design

Cell configurations include prismatic, cylindrical, flat stack, wound, large, small, polymer (pouch), hard case and COTS 18650s.

Electronics

Cell and battery management, power, safety, interface, communication (e.g., SM/CAN), balancing, state of health monitoring, modeling, grade of board parts.



Battery Pack

Pack design considerations: safety, interconnects, spacing of cells, thermal gradients, heat ejection, environmental requirements, interface to application.

Quallion is a full service provider with expertise at all stratifications of the battery market.

Recent High Profile Safety Events In Lithium-ion

Summary of fundamental Li Ion issues
Safety – Recent high profile failures

Laptop battery fires

- *Quality problem in cell manufacturing*

Advanced Seal Delivery System

- *Charger failure + large cell (250Ah)*

Summary of fundamental Li Ion issues
Safety – Recent high profile failures

Fisker Karma Fires and Battery Recall

- $60M welding problem

Chevy Volt Side Impact Crash

- Leaking coolant causes short circuit

Lithium-ion Battery Design Considerations

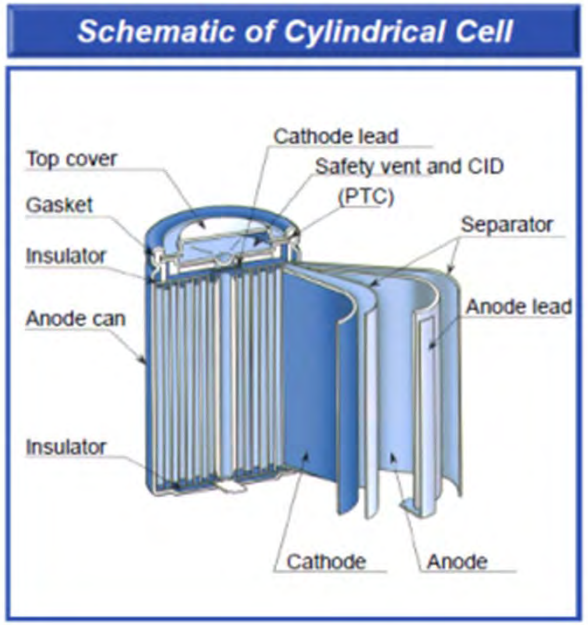
- Can a battery be designed “fail safe”, assuming the manufacturer has a high quality material, cell and battery manufacturing facility/source to limit defects in the construction of the cells/batteries.
- Degradation and safety of the battery can be due to a number of factors including manufacturing control, design and usage (environmental, duty cycle and maintenance).
- Passive and Active Safety Design considerations. Design needs to account for failure mechanism’s.
  - Internal/External short
  - Over voltage/current charge
  - Under voltage discharge
  - Reasonable operating temperature range
  - Handling (i.e. drop, crush etc..)
- Safety Certifications
  - Follow commercial or military standards
  - Self-certify vs independent evaluation
  - Safety tests should be tailored for use in platform/device

Cell Safety Design Elements

- Mostly Passive
- Type of Lithium-ion chemistry
  - LCO, LNCAO, NMC, LFP
  - Variety of organic electrolyte
  - Company proprietary additives or cell design factors
- Internal Safety design features
  - Shutdown Separator
  - PTC
  - CID
  - Safety vents
  - Center pins
- Cell form factors
  - Small and large format cylindrical cells
  - Wound or stacked prismatic
  - Pouch cells

Example of Safety Technology For Single Cell

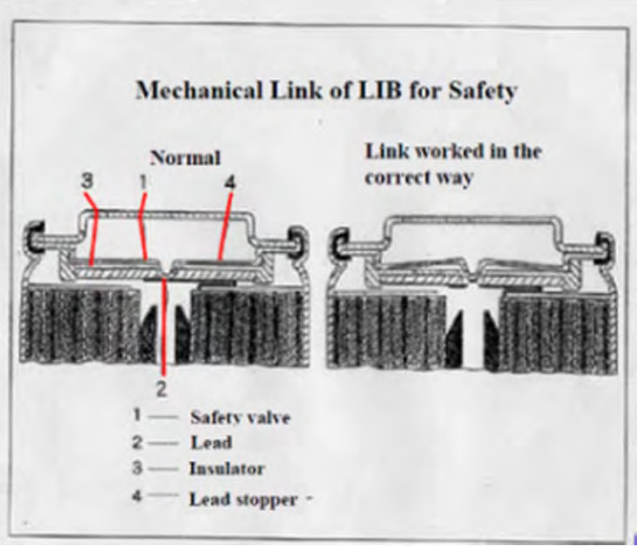
- Shutdown function of separator -
- CID (Current Interrupt Device)
- PTC element
- Safety vent
- Center Pin



Example of Cell Safety Technology

Pressure related

4.3-4.5V : CID activated 150 psi (➔ Disconnect the current)



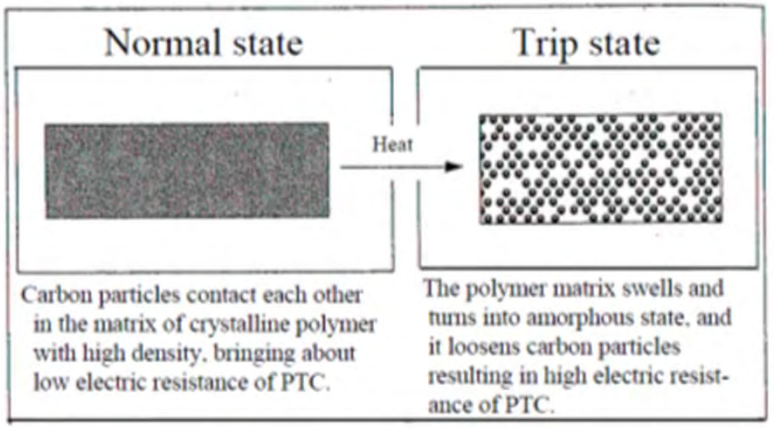
Safety Vent : 200 psi

Low

High

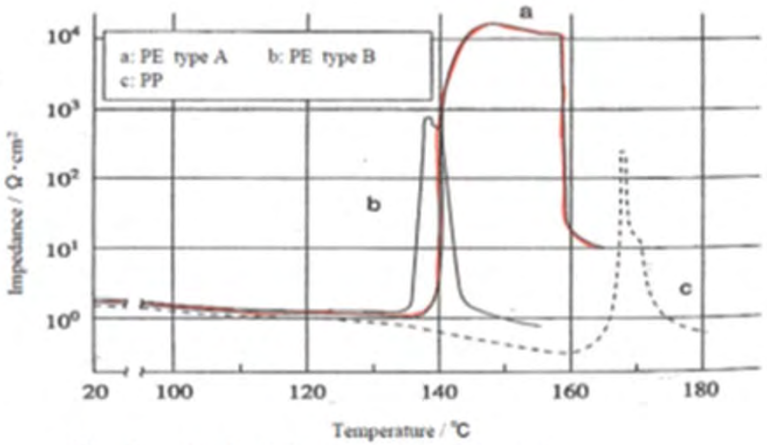
Temperature related

90-100 ^{0}C : PTC trip temp. (➔ Disconnect the current)



Behavior of PTC Element

110-140 ^{0}C : Separator shutdown (➔Disconnect the current)



Shutdown (or fuse) Temperatures of Separator

Ref) Nishi et al, Florida Battery Seminar, 2008

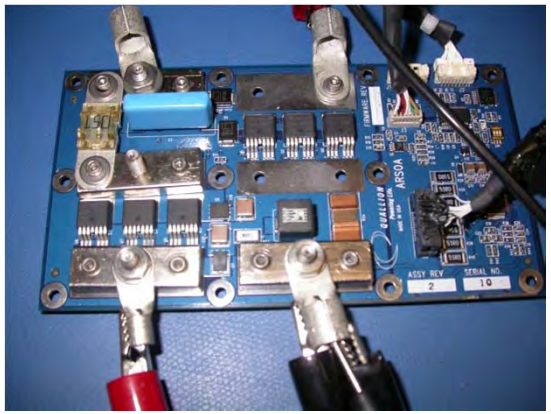
Battery Safety Design Elements

- Active
  - Advanced Battery Management System
    - Charge regulation
    - Protection circuitry
  - Thermal protection (Heaters or cooling system)
  - System or platform protections
  - Proper maintenance
- Passive
  - Small vs Large format cells
  - Cell spacing and thermal paths to battery case
  - Cell insulation from other cells & battery elements
  - Interconnect methods
  - Non active circuitry (i.e. fuses)

Active Safety Design Considerations
Example: Battery Management Electronics

The Battery Management System (BMS) performs the following functions and safety controls:

- Controls charging and charge termination
  - Cell and pack over voltage
  - Cell and pack under voltage
  - Over current charge
  - Over temperature Charge
- Control discharge
  - Over current discharge
  - Over temperature discharge
  - Under temperature discharge
- Hardware short circuit
- Communication



Example: Passive Design Elements
Overcharge Test with Cell Spacing Element

Test Battery

18650 (1.5Ah high power) - 10 cells in Parallel connection.

Capacity- 15.0 Ah

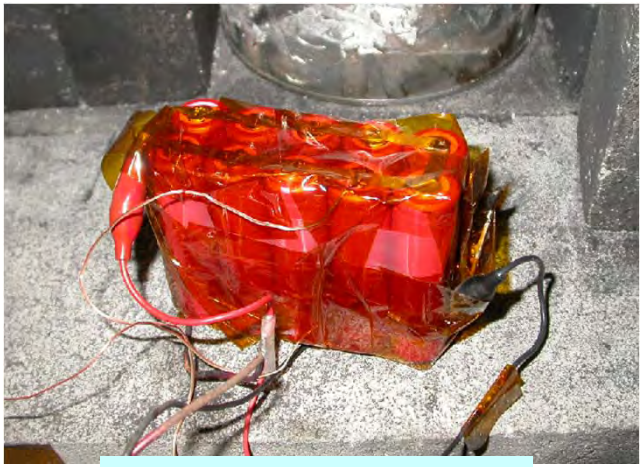
with HAM sleeve

Overcharge Test Condition

Charge battery pack @6A to 12V, hold voltage @12V till temperature dropping

without HAM sleeve

Thermal Run-away Propagation without Cell Spacing



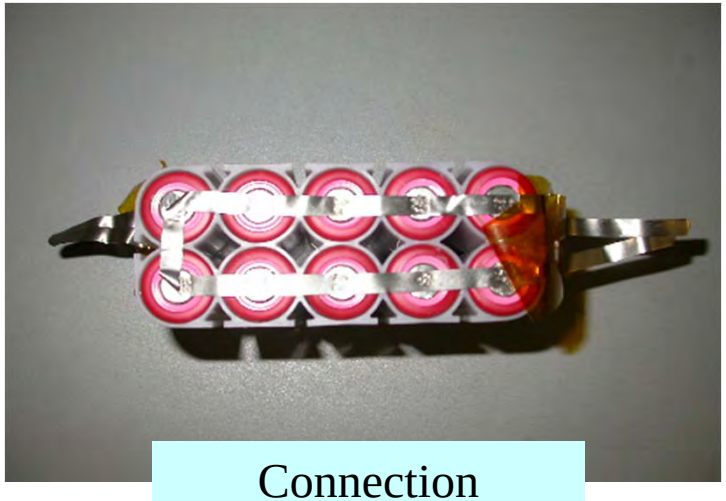
Connection

After Test

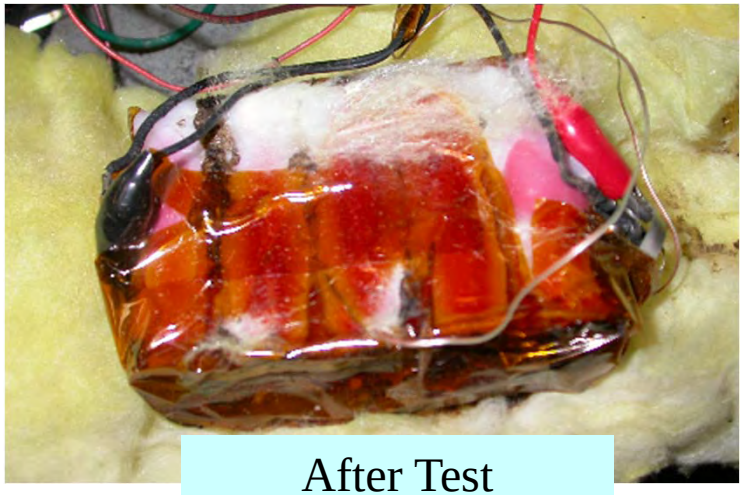
Insulation

After Test

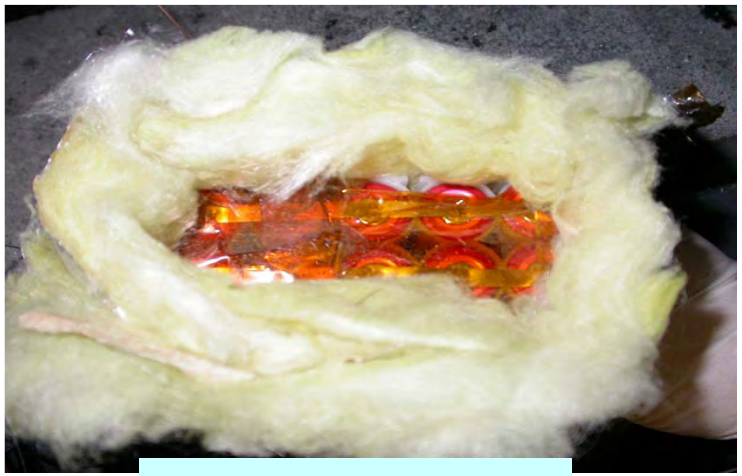
Thermal Dissipation with Cell Spacing
Cell internal protections allowed to function



Connection



After Test



Insulation

After Test

Thank you