Quallion LLC
NTSB Presentation
Sr. VP of Strategy and Business Development
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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

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- End Markets
  - Defense
  - Energy
  - Transportation
  - Medical

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

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

Headquarters
Sylmar, CA
Add’l Manufacturing Site
Santa Clarita, CA
Founded
1998
Employees
176
**Company Milestones**

- **1998**: Developed 7 new cell designs (4 implantable grade); shipped 30,000 production units; plant reached 6,000 unit per month volume.
- **2001**: Zero-Volt™ technology patented; Registered under ISO 9001 & 13485; Zero-Volt™ technology patented (recertified in December 2004).
- **2002**: SaFE-LYTE™ technology patented; Frost & Sullivan Award for Lithium Ion Power Sources.
- **2003**: Title III Award; Registered AS9100.
- **2004**: Boeing Technology Supplier Award; Awarded DOE Anti-Idling Contract.
- **2005**: Tac-Sat IV launch; Title III cell production Line started; Entered Aerospace/Defense market with OGA and CECOM Contracts; Initiated Development of Primary Chemistries.
- **2006**: $7 million California Energy Commission green vehicle manufacturing contract.
- **2007**: Company established in Southern California, USA; Los Angeles County.
- **2008**: Company Milestones.
- **2009**: Boeing Technology Supplier Award.
- **2010**: Awarded DOE Anti-Idling Contract.
- **2011**: Tac-Sat IV launch; Title III cell production Line started.
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)
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

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**Temperature related**

- 90-100 °C : PTC trip temp. (Disconnect the current)

- 110-140 °C : Separator shutdown (Disconnect the current)

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)
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

Overcharge Test Condition
Charge battery pack @6A to 12V, hold voltage @12V till temperature dropping
Thermal Run-away Propagation without Cell Spacing

Connection

Insulation

After Test

After Test
Thermal Dissipation with Cell Spacing
Cell internal protections allowed to function

Connection

After Test

Insulation

After Test