



Li-ion Battery Safety Monitor

Early Detection System for Lithium Ion Battery Safety

Electric & Hybrid Marine World Expo 2017

January 18, 2017





- Nexceris Introduction
- Li-ion Battery Safety Problem
- Why Off-gassing is important
- Early Detection Capability
- Product Development Status
- Acknowledgements





ABOUT NEXCERIS

Nexceris, LLC

- Founded in 1994, privately held
- Technology Developer
 - o advanced ceramics, electrochemical devices
- Product Developer
 - o fuel cells, catalysts, sensors and monitors
- Manufacturer/Distributor
 - o fuel cells and related products, sensors
- ISO 9001:2008 certification
 - covers all products and operations
- Changed name from NexTech Materials to Nexceris Oct 2015

www.nexceris.com

January 19, 2017



OUR BRANDS

NTM Sensors provides gas sensors and monitors for hydrogen gas safety



fuelcellmaterials.com

fuelcellmaterials.com is our sales division to supplying high quality fuel cell and battery materials, coatings, and related materials for R&D and OEM markets.





PROBLEM STATEMENT

Lithium Ion Battery Safety

- Lithium-ion batteries are concentrated energy sources that can cause catastrophic events when abused
- In rare cases, batteries can cause catastrophic events even when not subjected to improper conditions
- The desire for safer battery systems is not only the ability to isolate these events when they do occur, but also the ability predict and, ideally, avoid them altogether





LI-ION BATTERY INCIDENTS

High Profile Examples

- Automotive: NHTSA initiated \$8.75M study after lithium ion battery related car fires (2012)
- Marine: Battery fire onboard Campbell Foss hybrid tug boat (2012)
- Aviation: FAA grounds Boeing 787 after issues with lithium ion batteries (2013)
- Military: Battery fire ended the Navy's Advanced SEAL Delivery System Program (2008)
- Consumer Electronics: Samsung recalls millions of Galaxy Note 7 phones (2016)







High energy density batteries are essential for modern military systems:

Navy/Marines: Direct energy weapons, auxiliary power on ships, unmanned underwater vehicles, battery storage/transport

Air Force: Auxiliary power on aircraft, unmanned aerial systems

Army: Soldier power systems, target acquisition systems, UAVs and UGVs









FAILURE MODES





- **Short Circuit:** Rapid release of heat and gas
- Thermal Runaway with Active Materials: Material decomposition, gas evolution, electrolyte combustion
- Electrolyte Degradation, Gas Generation and Flammability: Overpressure and cell venting, flammable electrolyte ejection
- Propagation: Failure is not contained to one cell



BATTERY SAFETY APPROACHES



Lithium-ion battery reliability and safety is generally considered a function of the entirety of the cell, pack, system design, and manufacture

Nexceris approach uses early detection of off-gassing to prevent failure

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OFF-GASSING CHARACTERISTIC

Early Detection of Failure

- Early detection of failure
 through ppm level sensing
- Exothermic cell reactions leads to gas generation
- Heated electrolyte can both vaporize and decompose
- Gas pressure builds in cells
- Gas detection provides unique indicator of state of the cell









Chamber is designed to monitor battery off-gas during abuse testing. Pump allows for bag samples to be collected for third party analysis.



THERMAL ABUSE TESTING

- Early detection demonstrated prior to thermal response of the cell.
- Nexceris off-gas monitor detected ppm levels of gas outside the cell before temperature rise.
- Confirmed gas species with bag sample analysis.







DEMONSTRATION



Off-gas monitoring is capable of providing early warning of thermal runaway ahead of conventional means of voltage and temperature monitoring.



- Nexceris has capability for characterizing failing batteries and designing systems around prevention of catastrophic events
- Enables understanding of battery off-gassing characteristics of all lithium ion cell form factors and chemistries
- Nexceris has tested cylindrical, pouch, and prismatic cells
- Testing completed on wide range of battery chemistries including NMC, LCO, and LTO and continues to characterize off-gassing mechanisms for battery safety stakeholders











THERMAL RUNAWAY MITIGATION

BIC





A lithium ion pouch cell was abused with overcharge to induce failure An enclosure was created to contain the test and simulate a battery module

Testing done with support from Battery Innovation Center





EARLY DETECTION OF THERMAL RUNAWAY







Overcharge failure 5C Charge rate 2.95 minute early indicator Overcharge failure 5C Charge rate Off-gas signal used to stop charge Thermal runaway avoided



USE SCENARIOS





USE SCENARIOS









Lı[±]ıon Tamer[™] AWARE Battery Off Gas Monitor

Product release in Q2 2017

- Integrated with BMS or redundant safety circuit
- Early warning signal for shut-down or other mitigation
- Proprietary algorithms to prevent false positives
- ✤ One monitor per battery module
- Added layer of safety



Hardware





PRODUCT DEVELOPMENT STATUS

We are looking to design our product into next generation military, packaging, laboratory, and maritime systems

- Nexceris is conducting a battery testing program
- Assessing off-gassing characteristics, mitigating actions, and early indication trends
- System integration and customer testing
- Providing beta-prototypes to customers
- Off-gas detection designed for your system
- Visit us at our booth for more information (Booth 5080)

NEXCERIS



Li-ion Tamer Product Team

- Steve Cummings
- Nick Frank
- Bill Dawson



Scott Swartz

Visit us at Booth 5080

Acknowledgements







