



Battery 2013 Safety

4th Annual International Conference

Conference Agenda

November 14-15, 2013 • San Diego, CA USA

Thursday, November 14, 2013

8:00 *Registration, Exhibit Viewing/Poster Setup, Coffee and Pastries*

8:50 **Organizer's Welcome and Opening Remarks**

9:00 **The Right Path to Safety: Chemistry or System?**

Sam Jaffe, Senior Research Analyst, Navigant Research

Does a safe battery systems come from matching a safe chemistry for a particular application or from the safety engineering built into the integrated system? The answer is both, but this presentation will look at how different firms approach the safety issue (including A123, LG Chem and Tesla) and how their approaches have impacted costs and project success.

9:30 **Battery Level Safety and Safety Validation**

**Larry J. Yount, President & CTO, LaunchPoint Energy and Power - LEAP LLC; and
Gary Houchin-Miller, Manager, Advanced Battery Systems, Power Solutions, Johnson Controls, Inc.**

The safety of a Li-ion battery involved both chemistry and systems issues, including BMS performance. A Safety Analysis might begin with the BMS, but must be broadened to address all battery issues, including the potential for cell-level thermal runaway.

10:00 **Characteristics of Cells before a Thermal Runaway and How to Prevent it by a Better Battery Management System (tentative title)**

Michael Pecht, PhD, PE, Director, Center of Advanced Life Cycle Engineering (CALCE) Electronics Products and Systems, Professor of Applied Mathematics, University of Maryland

James Post, Executive Product Manager, Director, Battery Condition Test International Ltd, Hong Kong

Abstract is not available at time of publishing. Please visit www.KnowledgeFoundation.com for the latest Program updates.

10:30 *Networking Refreshment Break, Exhibit/Poster Viewing*

11:00 **SENSOR: Embedded Fiber-optic Sensing Systems for Advanced Battery Management**

Peter Kiesel, PhD, Principal Scientist, and Ajay Raghavan, PhD, Senior Scientist, Palo Alto Research Center (PARC), a Xerox Company*

Under the ARPA-E AMPED program for advanced battery

management systems, PARC and LG Chem Power are developing SENSOR (Smart Embedded Network of Sensors with an Optical Readout), an optically based smart monitoring system prototype targeting batteries for electric vehicles (EVs). The system will use fiber optic sensors embedded inside Lithium-ion battery cells to measure parameters indicative of cell state in conjunction with PARC's low-cost, compact wavelength-shift detection technology and intelligent algorithms to enable effective real-time performance management and optimized battery design. This talk will give an overview of the project, the underlying enabling technologies, and then cover some promising initial experimental results from the project, including internal cell signal data and state estimation using fiber optic sensors embedded in Li-ion pouch cells over charge-discharge cycles.*In collaboration with: W.Sommer, A.Lochbaum, T.Staudt, B.Saha, S.Sahu, Bokkyu Choi, Jeffrey West, and Mohamed Alamgir

11:30 **Safety of Large Li-Ion Battery Systems**

Bart Mantels, Project Coordinator, VITO unit Energy Technology, Belgium

Until now, no systematic and comprehensive assessment of Li-Ion system safety exists for large grid-connected electric energy storage systems. This project developed and validated a framework for assessing the safety and reliability of large battery systems throughout the entire life cycle and at all levels of the system, building upon the generally accepted failure mode, effect analysis (FMEA) approach. This is a bottom-up analytical safety assessment that searches for potential failure modes, which is widely used in product development.

12:00 **The Advancements of Battery Management Systems**

**Michael Worry, CEO, Nuvation; and
Jonathan P. Murray, Bloomy Energy Systems**

Today's batteries rely on an advanced Battery Management System (BMS) for optimal operation, and with properly engineered precision closed loop electronics, there is little excuse for the recent news catching the attention of the popular press. We will explore the complexity of a large format lithium pack in a custom electric race car (E.Rex) that has a top speed of 160mph and a 200+ mile range with 1000A+ current surges on a 350VDC battery pack. The design considerations for a large format BMS including monitoring the voltage and balancing hundreds of cells, redundant electronics and a fault-tolerant system design, along with the need for multiple levels of physical, electrical and software noise immunity will be discussed. The ability to safely, accurately, and repeatedly test and simulate standard and nonstandard pack events ensures the BMS critical functionality is always operating correctly. Having a common test platform throughout the design, validation, and manufacturing process of a BMS reduces production costs and improves system reliability.



Battery 2013 Safety

4th Annual International Conference

Conference Agenda

November 14-15, 2013 • San Diego, CA USA

12:30 Luncheon Sponsored by the Knowledge Foundation Membership Program

2:00 **Presentation title to be confirmed**

Rachid Yazami PhD, Professor, School of Materials Science and Engineering, Nanyang Technological University, Singapore

Abstract is not available at time of publishing. Please visit www.KnowledgeFoundation.com for the latest Program updates.

2:30 **Electrochemical-Calorimetric Studies for The Determination of Heat Data of 40 Ah Lithium Ion Pouch Cells**

Carlos Ziebert, PhD, Researcher, Institute for Applied Materials & Applied Materials Physics, Karlsruhe Institute of Technology, Germany*

Commercial 40Ah NMC Li-Ion pouch cells were cycled under isoperibolic and adiabatic conditions at rates up to 1C in an accelerating rate calorimeter to investigate performance and thermal behavior. Heat capacities, and total generated heat were measured after calibration using Al alloy dummy cells and the latter was separated into reversible and irreversible parts by potentiometric and current interruption technique. All these data are needed for thermal modeling and management. *In collaboration with: E.Schuster, H.J.Seifert

3:00 **Nail Penetration Tests of Commercial 18650 Type Lithium-Ion Cells and an Introduction of the BMBF Project SafeBatt**

Jan Haetge, PhD, Research Scientist, MEET - Battery Research Centre, Westphalian Wilhelms University of Muenster, Germany

The presentation introduces nail penetration tests and the BMBF project SafeBatt. Nail penetration tests in adiabatic conditions were performed in an accelerating rate calorimeter (ARC) to generate internal short circuits in commercial 18650 lithium-ion cells. We tested a selection of cell chemistries with different states of charges (SoC). Through performing the measurements in adiabatic conditions, a detailed description of the temperature and pressure progress during the battery abuse is feasible. For future studies the ARC will be extended with further analytic instruments to perform online analytic measurements of the evolving gaseous products. The beacon project SafeBatt is funded by the German Federal Ministry of Education and Research (BMBF). The consortium consists of automotive manufacturers, supplying companies and academic institutions which cooperate to enhance the reliability and safety of lithium-ion batteries. The project focuses on improving the cell chemistry to increase the intrinsic safety of the battery and the implementation of sensors to monitor the safety relevant parameters inside the cell. Another topic is the optimization and standardizing of safety test procedures to validate safety concerns for state-of-the-art batteries and batteries with improved cell chemistry. MEET contributes with aging and safety tests of full cells and develops electrolytes with enhanced safety. *In collaboration with: Mathias Reichert,

Markus Börner, Falko Schappacher and Martin Winter

3:30 **Networking Refreshment Break, Exhibit/Poster Viewing**

4:00 **An Easy Test Method to Differentiate Material System Safety Level**

Deng-Tswen Shieh, PhD, Researcher, Dept of Lithium Battery Reliability Design, Material & Chemical Research Laboratories, Industrial Technology Research Institute, Taiwan R.O.C.

For nail penetration test the signal of voltage and temperature are important safe index. Up to now temperature detection is only capable of measuring surface of the battery, what happened on the point of short is keen to be understood. The special design with thermocouple embedded inside the tip of nail can help us detect real temperature reliably and do quantitative analysis. With such method and device, we test lithium-ion battery cell by introducing different nail shape and material under different test conditions. This test method has the capability to quantify the safety of battery to several levels and therefore guide the material system design quantitatively, which can be a good screening method to differentiate the safety level of battery and material system design.

4:30 **Gaining Compliance to IEC 62133, 2nd Edition**

Rich Byczek, Global Technical Lead for Electric Vehicle and Energy Storage, Intertek

For manufacturers of products using rechargeable batteries, the recent release of the second edition of IEC 62133 has introduced a number of revisions affecting their equipment. The primary changes affect lithium-ion cells and lithium-ion batteries, as well as nickel cadmium and nickel metal hydride cells and batteries. During this presentation, Intertek expert Rich Byczek will walk you step-by-step on how to come into compliance with the second edition of IEC 62133.

5:00 **Exhibitor/Sponsor Showcase Presentations**

Friday, November 15, 2013

8:00 **Exhibit/Poster Viewing, Coffee and Pastries**

9:00 **Are Soft Short Tests Good Indicators of Internal Li-Ion Cell Defects?**

Judith Jeevarajan, PhD, Battery Group Lead for Safety and Advanced Technology, NASA Johnson Space Center

Several methods exist that can predict whether a li-ion cell has



Battery 2013 Safety

4th Annual International Conference

Conference Agenda

November 14-15, 2013 • San Diego, CA USA

an internal defect. Some of those are self-discharge tests at end of charge voltages, soft short tests at the end of discharge voltages, etc. It is also not clear if these tests are a good reflection of contaminants or other types of defects inside the cell. This paper will address the topic of whether there is a good method to detect internal cell defects in li-ion cells.

9:30 **Development of an On-Demand Internal Short Circuit (NREL/NASA)**

Matthew Keyser, Senior Engineer, Vehicles and Fuels Research, National Renewable Energy Laboratory

NREL has developed a device to test one of the most challenging failure mechanisms of lithium-ion (Li-ion) batteries—a battery internal short circuit. Many members of the technical community believe that this type of failure is caused by a latent flaw that results in a short circuit between electrodes during use. As electric car manufacturers turn to Li-ion batteries for energy storage, solving these safety issues becomes significantly more urgent. Due to the dormant nature of this flaw, battery manufacturers have found it difficult to precisely identify and study. NREL's device introduces a latent flaw into a battery that may be activated to produce an internal short circuit. NREL uses the internal short circuit device to better understand the failure modes of Li-ion cells and to validate NREL's abuse models. The device can be placed anywhere within the battery and can be used with both spirally wound and flat-plate cells containing any of the common Li-ion electrochemical systems. Producing a true internal short, the device is small compared to other shorting tools being developed by industry and does not rely on mechanically deforming the battery to activate the short, as do most of the other test methodologies. With the internal short in place, the battery can be used and cycled within normal operating conditions without activating the internal short device. This allows the battery to be aged prior to activation. The internal short produced by NREL's device is consistent and is being developed as an analysis tool for battery manufacturers and other national laboratories as well as OEMs. This has broad-reaching applications as automakers bring electrified vehicles to market in larger numbers. NREL's presentation will outline the differences in the voltage and temperature response between the four different types of internal shorts within a battery. We will also present results showing the difference between a foil to foil internal short when a shutdown and non-shutdown separator are used in an 18650 LiCoO₂ cell.

10:00 **Li-Ion Battery Safety Test for High Power Applications**

JaeSik Chung, PhD, CTO, PCTest Engineering Laboratory

The adoption rate of LiB in high power applications has getting increased but the test information for its cell abuse and safety test was not reported much yet compare to that of small portable electronics. Besides, the operating conditions and usage environment of the high power application, especially power tool application, are much harsher than that of small portable electronics so that the test items and conditions for

the high power application should be considered more carefully to simulate adequately the cell abuse conditions in connection with the devices. In this presentation, we will report the cell abuse safety testing (simulation in electrical, mechanical and thermal and thermal behaviors) for the high power application cells and compare the results between cell capacities and will discuss about those implications.

10:30 **Networking Refreshment Break, Exhibit/Poster Viewing**

11:00 **Leclanché Highly Safe Titanate Lithium-Ion Batteries**

Hilmi Buqa, PhD, R&D Manager, Leclanché SA, Switzerland

Advanced titanate-based cell technology entails the very high safety of Leclanché batteries; cells pass successfully the most severe safety tests, with impressively low level of reaction in response to abusive conditions. Moreover, Leclanché unique separator technology ensures unparalleled thermal stability of cell, adding extra safety in case of overheating or short-circuit. Innovative, unprecedented Leclanché water-based production process, applied to all electrodes, minimizes environmental impact of cell manufacturing, while improving performances. *In collaboration with: Gianluca Deghenghi, Pierre Blanc

11:30 **Enhanced Battery Safety through In-Situ Coatings**

Christopher M. Lang, PhD, Group Lead – Energy Technologies, Physical Sciences Inc.

Safe, high performance cells are required to power next generation technologies. However, increasing energy densities of batteries tighten the required tolerances and the potential for catastrophic system failure. Physical Sciences Inc. has developed *in-situ* coatings that maintain the required high performance levels, while improving the abuse tolerance of cells. This presentation will discuss the results of these development efforts and highlight the performance benefits these technologies offer.

12:00 **An Experimental Study on Heat Evolution inside a Lithium-Ion Battery Cell by Embedded Fiber Bragg Gratings**

Gwo-Shyang Hwang, PhD, Scientist, Department of Mechanical Engineering, National Taiwan University, Taiwan R.O.C.*

The performance and safety of Li-ion batteries have close relationships with the thermal environment inside and outside battery cells. It is well-known that poor thermal management will result in fast degradation of Li-ion batteries and even a hazardous condition such as thermal run-away. Hence, a vast amount of research has been devoted to studying the thermal behavior of Li-ion cells and its relation with the electrochemical and chemical processes during charge and discharge. However, due to the lack of direct measurements of temperature inside the Li-ion cells, it was normally resorted to numerical



Battery 2013 Safety

4th Annual International Conference

Conference Agenda

November 14-15, 2013 • San Diego, CA USA

simulations based on thermal-electrochemical models in the past research. Although the simulation results appear to have good agreements with experimental data excluding interior temperature of battery cells, it is difficult to verify the accuracy of the simulated thermal behavior inside battery cells. In this research, the Fiber Bragg Grating (FBG) sensor is adopted as an embedded temperature sensor for a Li-ion battery cell by exploiting its merits: it is chemically inert; it can withstand high temperature (up to 250 °C for non-decay reflection spectra), and it can be connected in series (multiplexing). Besides the average temperatures, temperature gradients along a fiber grating can be derived from its measurements in real-time. Based on the measured average temperatures and temperature gradients inside a Li-ion cell, insights of the thermal behavior of a Li-ion battery can be obtained. *In collaboration with: K-H.Chang, K.Li, C-C.Ma, D-W.Huang

hazards model (PHM) that establishes a framework ideally suited for performing reliability estimates for lithium-based batteries. We establish the notion of covariate trajectories, which can include both intrinsic battery factors (morphology, etc.) and extrinsic factors (environmental histories, in particular). The methodology allows prediction of battery reliability among a discrete set of non-stationary stochastic environments or along an arbitrary stochastic covariate trajectory. Such scenarios are typical for batteries, which are typically used for portable and mobile applications such as electric vehicles. The framework yields the expected value of prognostic statements, sample realizations, and a non-parametric estimate of the corresponding distributions in order to infer extreme event probabilities. Implementation of the model itself is well within the capabilities of current embedded processing architectures commonly found on battery-powered systems.

12:30 *Lunch on Your Own*

2:30 **Safer Batteries Through Predictive Simulation**

2:00 **Realistic Multivariate Modeling of Lithium Batteries Using a Proportional Hazards Methodology**

George M. Lloyd, PhD, Staff Scientist, ACTA Inc., and P. P. Mukherjee, PhD, Prof, Energy and Transport Sciences Laboratory, Texas A&M University

We overview the methodology underlying a proportional

John A. Turner, PhD, Group Leader, Computational Engineering & Energy Sciences Group, Oak Ridge National Laboratory

Modern battery packs store a significant amount of electrochemical energy that can pose a safety risk uncontrollably released. A comprehensive computational model for the battery configurations would enable us to expand the parameter space of adverse conditions and

Take advantage of attending all three key battery industry events



Advanced Energy Technology Congress



3 Key Industry Events Conveniently Timed & Co-Located



November 12-15, 2013 • San Diego, CA USA