

5th Annual International Conference

# Lithium Mobile Power<sup>SM</sup> 2009

November 12-13, 2009  
Boston, MA USA

Advances in  
Lithium Battery  
Technologies for  
Mobile Applications



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# Lithium Mobile Power<sup>sm</sup> 2009

Advances in  
Lithium Battery Technologies  
for Mobile Applications

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Industry and academic scientists are encouraged to submit poster titles for this event. One-page abstracts (8 1/2" x 11" with 1-inch margins) must be submitted by email to [submit@knowledgefoundation.com](mailto:submit@knowledgefoundation.com) no later than **October 8, 2009** for inclusion in conference documentation. Additional poster submissions will be accepted until **October 25, 2009** but may not be included in conference documentation. *Note: If you are submitting a poster, you MUST be registered and paid in advance to ensure that a posterboard is reserved for you.*

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### CONFERENCE AGENDA

#### Thursday, November 12, 2009

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

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

##### **APPLICATION DRIVEN LI-ION BATTERY DEVELOPMENT**

#### 9:00 **Materials and Design Strategies for High Power Li-Ion Batteries for HEV and PHEV**

*K.M. Abraham, PhD, Chief Technology Officer, E-KEM Sciences; and Research Professor, Northeastern University*

This presentation will review the state of the art in material choices for cell and battery construction, performance, safety and price of high power Li-ion batteries for HEV and PHEV applications

#### 9:45 **PHEV Battery Performance in a Vehicle to Grid (V2G) Utilization Scenario: A Technological and Economic Analysis**

*Jay Whitacre, PhD, Assistant Professor, Materials for Electrochemical Technologies Lab, Dept Materials Science and Engineering, Carnegie Mellon University\**

This talk will describe work done to examine the degradation of common LiFePO<sub>4</sub>-based Li-ion batteries when used in urban driving conditions combined with afternoon grid-level load shifting (V2G). A technical evaluation of cell performance will be given and an economic model will be presented that shows the potential benefits of using V2G/smart grid technology with PHEV battery packs. \*In collaboration with: S.Peterson and J.Apt, Carnegie Mellon University

#### 10:15 **Transforming Lithium Ion Superpolymer Battery Technology from the Lab to Commercial Electric Vehicles**

*Sankar Das Gupta, PhD, Chairman & Chief Executive Officer, Electrovaya Inc., Canada*

This paper will explore the steps and lessons that Electrovaya has taken with regard to transforming its technology innovations from the lab into commercial electric vehicle applications. Clean transportation is enabled by its energy storage solution. Electrovaya's Lithium Ion SuperPolymer technology has transformed over the years as it has evolved with underlying chemistries, from the earliest days of cobaltate, to phosphate, to manganese. In addition to the fundamentals in nanomaterials and new chemistry innovations, Electrovaya has also focused on the broader elements that are necessary for commercialization of electric vehicle product. This is the focus of this paper. Specifically, it will investigate strategies to overcome thermal variance, vibration tolerance, packaging, and scale-up issues.

10:45 *Networking Refreshment Break, Exhibit/Poster Viewing*

#### 11:15 **Changing the Way the World Views Portable Power**

*Per Onnerud, PhD, Chief Technical Officer, Boston-Power Inc.*

In this presentation, we will share insights into user demand for untethered mobility and the advancements in lithium-ion battery technology poised to fulfill that requirement. New benchmarks in cycle life, performance, reliability, fast charge, environmental sustainability and safety will be highlighted. We will also discuss a new industry model where battery providers work directly with designers of end-products, ranging from portable electronics to vehicles, to deliver whole new generations of products optimized to meet customers' increasing demands for anywhere, anytime mobility.

#### 11:45 **Beyond Li-Ion, A Strategy for Step-Change Improvement in Energy Density**

*Steven J. Visco, PhD, Chief Technical Officer and Vice President, PolyPlus Battery Company*

The invention of protected lithium electrodes (PLEs) enables the development of a new generation of ultra-high energy density batteries. These electrochemical systems are semi-fuel cells where a PLE is coupled with an external redox species supplied to the positive electrode (i.e. oxygen or water). Isolation of the oxidant from the battery housing is expected to yield benefits in terms of safety in that the energy for the cell reaction is not contained in the battery itself; this may be particularly important for large traction batteries. The unique aspects of these PLE cells offer step-change improvements in batteries on land, in the sea, and in medical devices. The state-of-the-art will be covered in the presentation.

#### 12:15 **A123's Nanophosphate Technology for Next Generation High-Power Lithium-Ion Batteries**

*Richard K. Holman, PhD, Senior Development Scientist, Research Manager, A123 Systems*

Abstract not available at time of printing. Please go to [www.KnowledgeFoundation.com](http://www.KnowledgeFoundation.com) for the latest Program updates.

#### 12:45 *Luncheon Sponsored by the Knowledge Foundation's Membership Program*

##### **MATERIALS CHALLENGES - ELECTRODES**

#### 2:00 **Lithium-Ion Batteries Using Ni-Based Cathode Material for High Capacity and Reliability**

*Yasuhiko Hina, Staff Engineer, Lithium-Ion Battery Business Unit, Energy Company, Panasonic Corporation, Japan*

At this time, many mobile devices powered by Li-ion batteries require high energy density. Our solution to satisfy this advanced technology requirement takes advantage of Ni-based cathodes already in use in our Li-ion battery. We will report on the features and benefits of this advanced Ni-based cathode technology.

#### 2:30 **CAM-7: A Unique Cathode Material Providing Both High Energy Density and High Power for Li-Ion**

*Brian M. Barnett, PhD, Vice President of Technology, TIAX LLC*

Culminating several years' work, TIAX has developed CAM-7, a

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unique, high energy, high power, safe cathode material for lithium-ion batteries. CAM-7 is able to offer significant advantages for both automotive applications and non-automotive applications. CAM-7 is a patented lithium nickelate-class material that has been optimized for safety. CAM-7 is unique among cathode material options in that it combines extraordinarily high power capability (more than 130 mAh/g at 100C discharge rate) with the highest available energy density, more than 210 mAh/g to normal charging voltage (4.2 V). This talk will summarize the CAM-7 development effort and present data regarding CAM-7 performance in portable as well as transportation applications.

#### 3:00 High Energy Density Lithium Cells

**Sébastien Patoux, PhD, DRT/LITEN/DTH/LCE, French Atomic Energy Commission - CEA, France**

The presentation will first focus on high capacity ( $\text{LiMO}_2 \cdot \text{LiMn}_2\text{O}_3$ ) layered oxides as a promising solution for the positive electrode of Li-ion batteries. We will present the latest results obtained at CEA-LITEN on this family of materials, with very good reversible capacity at the level of 250mAh/g at room temperature. At the negative electrode, the interest in silicon-carbon composites has been abundantly discussed in the literature. Here, several synthesis routes investigated at CEA-LITEN, from CVD process to mechano-chemical route, and others, will be discussed together with optimization of the electrode making. Results on 2-3Ah prototype cells will finally be reported with a significant improvement in energy density.

#### 3:30 Nano- $\text{Li}_4\text{Ti}_5\text{O}_{12}$ Based Lithium Ion Battery for HEV and PHEV Application

**Veselin Manev, PhD, Director R&D, Altairnano Inc.**

The performance of high specific power & high rate capability cells with nano- $\text{Li}_4\text{Ti}_5\text{O}_{12}$  negative electrodes developed in particular for HEV and PHEV application will be discussed. Data for capacity retention during continuous discharge at up to 80C rate corresponding to 45 sec cell's full discharge duration will be displayed. The cycle life in excess of 25,000 cycles, at 8C charge/discharge rate & 100% DOD will be presented. Particular attention will be paid on the excellent calendar life performance of Altairnano's  $\text{Li}_4\text{Ti}_5\text{O}_{12}$  based cells. A data from accelerated calendar life test suggesting capacity fade below 1% after 25 years calendar life at room temperature will be displayed. Finally the results from safety tests performed on these cells showing no safety events will be displayed.

#### 4:00 Networking Refreshment Break, Exhibit/Poster Viewing

### APPLICATION DRIVEN LI-ION BATTERY DEVELOPMENT - II

#### 4:30 Development of Materials for Advanced Lithium-ion Batteries for NASA's Upcoming Lunar Missions

**Ratnakumar Bugga, PhD, Principal Member Technical Staff, Electrochemical Technologies Group, Jet Propulsion Laboratory, California Institute of Technology\***

The performance requirements for rechargeable batteries are unique for space applications and Li-ion batteries, owing to their superior performance characteristics, and are becoming the

preferred choice for many of NASA's space missions. Yet, there is a need to further extend the performance envelope of Li-ion batteries to enable the upcoming human exploration missions to moon and subsequently to Mars. To address these needs, NASA is undertaking a technology program to develop advanced cathodes and electrolytes for Li-ion cells with enhanced specific energies and safety. Some of our recent results of these studies will be presented here. \*In collaboration with: Marshall Smart and William West

#### 5:00 Large Format Li-Ion Batteries Development at Leclanché

**Karl-Heinz Pettinger, PhD, Chief Executive Officer and Director, Leclanché Lithium GmbH, Germany**

Lithium-ion batteries are becoming more and more important in the world market of energy devices. The applications of a new generation of lithium ion cells goes from automotive to solar, passing through all telecom and standby/emergency applications. All of these and other possible application areas share the same need for reduced material costs, long life, very high safety and increased utilization temperature range. Leclanché has developed large format Li-ion cells for diverse applications. Various cell sizes (10-20 Ah) are currently available and those cells are the building blocks for different batteries design adapted for costumers. In the present paper, we would like to present some development trends and the performance of large format Li-ion cells in terms of specific energy, power and life.

#### 5:30 Ambient Operation of Li/Air Batteries

**Jason Zhang, PhD, Chief Scientist, Battery Technology Energy & Environment Directorate, Pacific Northwest National Laboratory**

Li/air batteries have attracted significant attention recently because their theoretical specific energy is much higher than other battery systems. Most of previous work on Li/air batteries has been done in pure oxygen environment. However, ambient operation is required to realize the full potential of Li/air batteries. Our work on primary Li/air batteries operated in ambient conditions will be reported in this presentation. Various factors (including electrolyte selection, oxygen selective membranes, and high capacity electrode preparations) which affect battery operations will be analyzed. At last, the main challenges on the ambient operation of Li/air batteries will be discussed.

#### 6:00 High Energy Density Li/CF<sub>x</sub> Battery for Soldier Portable Power Sources

**Sheng S. Zhang, PhD, Research Chemist, Sensors and Electron Devices Directorate, U.S. Army Research Laboratory\***

Lithium/carbon monofluoride ( $\text{Li}/\text{CF}_x$  with  $x=1$ ) batteries are known to have the highest theoretical specific capacity among all commercially available primary lithium batteries. These batteries are being developed by the Army to reduce the size of current BA-5590 battery packs for soldier portable power sources. Main problems of  $\text{Li}/\text{CF}_x$  batteries are the low power capability and the initial voltage delay, which are related to the intrinsically low electrical conductivity of  $\text{CF}_x$  material and the slow kinetics of  $\text{Li}/\text{CF}_x$  cell reaction. These problems result in heat generation in the discharge of  $\text{Li}/\text{CF}_x$  batteries, especially at high current rates or at low temperatures. In an ac-impedance spectrum, the slow kinetics is indicated by a high cell reaction resistance ( $R_c$ ) that is considered to be the main source for the heat generation of  $\text{Li}/\text{CF}_x$  batteries. In order to improve power capability of such batteries,

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we attempted two approaches: (1) thermal treatment of  $CF_x$  material in the presence of an organic compound or carbon back as an additional carbon source to form carbon subfluorinate ( $CF_{x-b}$ ) that is known to have better power capability, and (2) use of a  $LiBF_4$ -AN (acetonitrile)/BL ( $\gamma$ -butyrolactone) electrolyte in which the reactivity of metal lithium with AN is suppressed while the substantially high ionic conductivity is remained. In this presentation, we report improvement on the discharge performance of  $Li/CF_x$  batteries by these two approaches.

\*In collaboration with: D.Foster and J.Read

6:30 *End of Day One*

#### **Friday, November 13, 2009**

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

##### **MATERIALS CHALLENGES - ELECTROLYTE**

9:00 **Electrolyte Solution for Li Ion Batteries**

**Doron Aurbach, PhD, Professor, Head of Electrochemistry Group, Dept of Chemistry, Bar Ilan University, Israel**

We review in this talk the main families of solvents relevant to Li ion batteries and the Li salts available as electrolytes. Matching solution compositions to the types of system used (e.g. high voltage systems, batteries with Li metal anode, batteries for low temperatures) is thoroughly discussed. Main electrode-solutions interactions and surface chemistry in conventional & advanced Li ion batteries is reviewed. Thermal reactions of selected important systems are discussed as well. We describe families of ionic liquids that can be relevant to Li batteries and report about new work on this important topic. Possible use of additives for several purposes: electrodes surface modification, enhanced safety features, over-charge protection etc. with several working examples, is discussed as well.

9:30 **Role of Electrolyte on the Formation of Electrode Surface Films in Lithium Ion Batteries**

**Brett Lucht, PhD, Professor of Chemistry, University of Rhode Island**

The development of lithium ion battery (LIB) electrolytes with improved thermal and electrochemical stability for electric vehicle (EV) applications will be presented. Typical LIB electrolytes have poor thermal stability. Significant energy fading occurs after several years. We have conducted an analysis of the reactions of common electrolytes on the surface of the electrodes after initial formation cycling and upon accelerated aging. Additives and novel salts were designed to improve performance.

10:00 **Rechargeable  $MnO_2$  in Aqueous Lithium Electrolyte: Good News and Bad News from a Battery Perspective**

**Manickam Minakshi, PhD, Senior Research Fellow, Dept of Extractive Metallurgy, Murdoch University, Australia**

A new class of rechargeable manganese dioxide electrode ( $MnO_2$ )

in aqueous electrolyte is described. Intercalation of lithium from the LiOH electrolyte into the vacant sites of a host  $MnO_2$  has been achieved electrochemically is good news. The formation of a lithium carbonate layer from a LiOH electrolyte acts as a barrier for protons while permitting lithium ion insertion in aqueous solutions forming lithium intercalated manganese dioxide ( $Li_xMnO_2$ ) upon discharge. This novel mechanism may be a key in transferring primary to secondary batteries using LiOH as electrolyte.

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

##### **SAFETY, TESTING, PERFORMANCE**

11:00 **Lithium Battery Platform Hazard Evaluation and Criteria**

**Clinton Winchester, PhD, Group Leader & Senior Technologist, Naval Surface Warfare Center (NSWC)\***

The Navy has an active risk reduction and risk assessment technical effort aimed at lithium battery powered systems. Recent evolutions are aimed at quantifying risks to platform and personnel safety posed by "large format" lithium batteries, defined as large either as an accumulation of large high capacity cells or an accumulation of distributed batteries that equal equivalent energy storage. These large batteries and battery systems are similar or greater in size to electric vehicles and plug-in electric vehicle systems, utilize significantly more hazardous chemistries, and involve non-ideal conditions for operation and storage. The Navy has undertaken an aggressive risk reduction activity to quantitatively understand, test, and model reactions of large format lithium batteries to determine the survivability and mitigation of these battery fires, chemical releases. This effort will support risk analysis of battery driven events under a variety of ship and submarine casualty models. We will describe the recent events driving the expansion of quantitative, technical assessments in defining risks and casualties, as well as describing various results and initial finds.

\*In collaboration with: D.Fuentevilla, E.Shields, J.Banner, NSWC Carderock; J.Dow, Naval Ordnance Safety and Security Activity; and D.Cherry, Naval Sea Systems Command

11:30 **IEEE 1725 and Cellular Product**

**Snehal Dalal, PhD, Manager, Electrical Practice, Exponent Failure Analysis Associates**

Visit [www.KnowledgeFoundation.com](http://www.KnowledgeFoundation.com) for more details and to view the abstract.

12:00 **Lithium Battery Safety and Performance; Applications of Calorimetry**

**Martyn Ottaway, PhD, Founder, Thermal Hazard Technology, England**

As lithium batteries are being applied to more and more

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applications - commencing with small batteries (e.g. cell phones and laptops) culminating in large batteries, modules and packs (e.g. satellites and cars), there are many and varied challenges that relate to their performance and safety. A key aspect is heat release and thermal management. Calorimetry facilitates a quantitative understanding of thermal (and pressure) issues. Calorimetry has been employed to: (i) Determine effect of heat on and the heat generated by Li Batteries; (ii) Understand aspects such as chemistry change, effects of use and ageing, problems with abuse - overcharging, penetration and crush; (iii) Quantify such effect on all battery size and to measure the thermal distribution over the battery surface; (iv) Measure the pressure generated internally within the battery and externally with the ability to analyze gas products. This presentation will focus on newer areas of applications such as thermal management of automotive packs, rapid discharge issues for vehicle and power tools batteries.

12:30 *Lunch on Your Own*

#### SYSTEM DESIGN & INTEGRATION

**2:00 Product Study Showcase:  
High Performance Li-Ion Battery Separator  
Made of Nanofiber Overlaid Nanowoven**

*Yoshinori Kishimoto, Director, Advanced Functional  
Materials Dept, Hirose Paper Mfg. Co., Ltd., Japan\**

Visit [www.KnowledgeFoundation.com](http://www.KnowledgeFoundation.com) for more details and to view the abstract

\*In collaboration with: Shoji Okada, Hiroki Nanko

**2:30 Internal Short Circuit in Li-Ion Cells**

*Hossein Maleki, PhD, Staff Scientist, Motorola Energy  
Systems Group, Motorola*

Today's Li-ion cells using LiCo<sub>2</sub> as cathode material are potentially vulnerable to internal short circuit (ISCr). We have investigated the effects of ISCr on thermal stability of Li-ion cells of various sizes (130 - 1100 mAh) using a combination of experimental (small nail penetration, small indentation, and cell pinch), thermal modeling,

and IR-imaging. Among these, only the cell pinch test provides reasonable approximation of a high risk ISCr event. ISCr location plays a critical role in the consequences of an ISCr event. The effects of cell capacity and state of charge on ISCr are also evaluated.

**3:00 Modeling of Battery Systems/Installations for Automotive Apps**

*Richard Johns, PhD, Automotive Director,  
CD-adaptco, United Kingdom*

Visit [www.KnowledgeFoundation.com](http://www.KnowledgeFoundation.com) for more details and to view the abstract.

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

**3:45 Designing the Battery Management System  
(BMS)**

*Ken Chisholm, Vice President of Engineering,  
Vecture Inc., Canada*

The presentation provides an informative and useful appreciation of the considerations, methods and realisation of the battery management system (BMS). Safety, energy management (fuel gauging), cell balancing and embedded charging are considered. Other system functions such as DC/DC conversion are briefly discussed with the pack becoming a wider utility sub system component. The realisation of the BMS in a hot cramped world (heat, space & connectivity) is reviewed. Completing the presentation a discussion on assembly and testing of the battery pack.

**4:15 Li-Ion Battery Life Expansion -  
Charging and Discharging Strategies**

*Kathryn Miles, PhD, Chief Technology Officer,  
EEtrex Incorporated d/b/a Hybrid Plus, Inc.*

Visit [www.KnowledgeFoundation.com](http://www.KnowledgeFoundation.com) for more details and to view the abstract

**4:45 Selected Oral Poster Highlights/Concluding  
Discussion**

**5:15 End of Conference**

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