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7th Annual International Conference

Lithium Battery Power 2011

November 7-8, 2011
Las Vegas, NV USA

Conference Program

Recent significant innovations within lithium-ion batteries have propelled the technology into a position in the marketplace far exceeding recent market survey results. Breakthroughs in new battery chemistries, novel electrode and electrolyte materials, system integration for a vast array of mobile and portable applications, from micro medical devices to high-energy/high-power automotive, have paved the roadmap for an emerging market with unlimited potential. Lithium Battery Power 2011 is conveniently timed with Battery Safety 2011.

- Application driven lithium ion battery development
- New lithium chemistries for better electrodes and higher LIB performance
- Advanced lithium ion battery technologies for higher safety, reliability and performance
- From novel materials and components to systems design and integration
- Role of nanotechnology in improving power and energy density
- Novel electrolyte technologies for higher power and energy density

Conveniently timed with

2nd Annual
Battery Safety 2011

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Battery Safety 2011

November 9-10, 2011
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Conference Agenda

Monday, November 7, 2011

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

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

9:00 **Rechargeable Batteries for the 300-Mile Electric Vehicles and Beyond**

K.M. Abraham, PhD, Chief Technology Officer, E-KEM Sciences

Today's lithium ion batteries are unable to satisfy the energy density and cost requirements of 300-mile all-electric vehicles. New rechargeable batteries have to be identified and developed in order to meet this challenge. A brief update of lithium ion technology will be provided with its energy density and cost evolution in the foreseeable future. New materials and battery systems for meeting the driving range of extended range all-electric vehicles will be discussed along with updates on the rechargeable Li-air and Li-sulfur batteries.

9:30 **Recent Advances in Rechargeable Battery Technology: An Overview**

Ralph J. Brodd, PhD, Director, Kentucky - Argonne Battery Manufacturing Research and Development Center

Recent work on new electrode materials and structures will be reviewed along with comments and the implication for their ability to meet demands for the high performance, cycle life as well as cost for electric vehicle applications. The increased interest in electric vehicle batteries has stimulated significant new work on cell components, including anodes, electrolytes and separators. A potential issue is available resources relating to the supply critical elements for large scale vehicle cell production. While the availability of lithium resources is assured, other elements such as nickel and cobalt will require consideration and recycling as the market expands. Exciting new systems such as lithium alloy anode materials and lithium - air cells are beginning to challenge Li-ion system for utility in vehicle applications.

10:00 **Subsonic Ultra Green Aircraft Research (SUGAR) Study Results: Hybrid Electric Propulsion with Advanced Battery Technology**

Marty Bradley, PhD, Technical Fellow, Principal Investigator, Subsonic Ultra Green Aircraft Research The Boeing Company*

This presentation summarizes the work accomplished by the Boeing Subsonic Ultra Green Aircraft Research (SUGAR) team in a NASA study looking at future concepts and technologies for commercial aircraft in the 2030-2035 timeframe. The team developed a comprehensive future scenario for world-wide commercial aviation, selected baseline and advanced configurations for detailed study, generated technology suites for each configuration, conducted detailed performance analysis, calculated noise and emissions, assessed technology risks and payoffs, and developed technology roadmaps for key technologies. A wide portfolio of technologies was identified and evaluated to address the NASA goals. The highest payoff technologies were identified as hybrid-electric gas turbine propulsion and advanced modular batteries. Compared to today's aircraft, fuel burn reductions of up to 90% and energy use reductions of greater than 55% are possible. To achieve this, significant advances in battery technology are needed and aviation specific challenges need to be addressed. The goal of this presentation is to begin a dialog between the aviation industry and battery technology and system experts to eventually enable the benefits identified in this study to come to fruition. **In collaboration with: D.Coates, Boeing; R.Delrosario, NASA Glenn Research Center; R.Wahls, NASA Langley Research Center*

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

11:00 **Zero-Volt Technology with High Power Characteristics**

Hisashi Tsukamoto, PhD, CEO, CTO and Co-Founder, Quallion LLC

Quallion has developed Zero-Volt™ technology (US Patent 6,596,439) for medical implantable Li-ion battery. This technology allows Li-ion battery deep discharged to "zero volt" and stored prolonged time, and be able to recharge without any damage. Quallion recently advanced this technology for high power Li-ion battery for military applications. We believe this technology can benefit calendar life and safety for various commercial applications
including EV.

11:30 **How Long Will Automotive Li-Ion Last In Real-World Applications?**

Kandler Smith, Senior Researcher, National Renewable Energy Laboratory*

Laboratories run around-the-clock aging tests to try to as quickly as possible gain an understanding of how long new Li-ion battery designs will last under certain duty-cycles. Such tests, however, are generally accelerated and do not consider possible dwell time at high temperatures and states-of-charge. Furthermore, automotive duty-cycles are highly variable, making it difficult to span the realm of real-world duty-cycles in the laboratory. To overcome these issues, battery life-predictive models provide guidance as to how long Li-ion batteries may last under real-world electric-drive vehicle applications. Worst-case aging scenarios are extracted from hundreds of real-world duty-cycles developed from vehicle travel surveys. **In collaboration with: M.Earleywine, S.Santhanagopalan, A.Pesaran*

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12:00 **How to Have Your Cake & Eat It Too - An Investigation into Innovation-Driven High Performance, Cost-Effective Battery Systems**

Gitanjali DasGupta, Manager, Electric Vehicle Division, Electrovaya, Canada

Large battery systems for automotive and utility applications is a rapidly developing market segment. The most pressing challenges for large-format applications are generally agreed to be lower battery cost and improved performance. In this paper, Electrovaya investigates the three pillars of the cost structure to demonstrate how advanced technology and clean manufacturing processes can drive both reduced cost and exceptional performance.

12:30 *Luncheon Sponsored by The Knowledge Foundation Membership Program*

2:00 **Translating High Capacity Materials into High Energy Density, High Performance Cells**

Brian M. Barnett, PhD, Vice President, TIAX LLC

For several years, TIAX has been developing a stabilized nickelate cathode material that provides a unique combination of both high capacity and high power, and is an excellent option for portable, transportation and specialty applications. This material has now been implemented in cells by multiple manufacturers of lithium-ion cells, a process that necessarily involved development of detailed cell designs as part of the implementation. Most materials developers are not able to make cells, and yet cell-level performance is the ultimate requirement and cell-level performance sets the most pertinent materials targets. We have found that a combination of cell design models and relevant experimental data can help bridge the gap to cell level performance and also set appropriate development targets. This presentation illustrates the challenge of identifying relevant active materials targets to deliver enhanced performance at the cell level. In addition to the impact of TIAX new stabilized nickelate-based cathode material at the cell level, the presentation puts in a cell-level context some of the other recent high capacity materials developments for lithium-ion anodes and cathodes.

2:30 **An Update on the Materials Development at JPL for Enhancing the Specific Energy and Safety of Li-Ion Cells**

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

For enhancing the future NASA missions that will involve robotic as well as human exploration, we will need rechargeable batteries with improved specific energy and safety. Under a NASA-sponsored program and in collaboration with other centers and external partners, we have been developing new cathode materials with higher voltage and enhanced specific energy, as well as electrolyte formulations with high voltage compatibility and reduced flammability. In this paper, we will present the performance characteristics as well as basic electrochemical studies of the materials in laboratory cells. **In collaboration with: W.West, M.C.Smart*

3:00 **NCM Cathode Materials with High Energy Density for the Emerging Automotive Market**

Kirill Bramnik, PhD, Global Product Technology Manager, Battery Materials, BASF Corporation

NCM (Nickel-Cobalt-Manganese based oxides) cathode materials for Li-ion batteries employ a unique combination of Lithium and Manganese rich mixed metal oxides and have successfully substituted LCO in many consumer applications. It is also the material of choice for large auto-batteries due to lower costs, intrinsically higher safety and extended cycling stability. Moreover, the enhanced stability of the NCM chemistry enables development of new battery systems, which can be charged to the higher voltages and leads to a substantially higher energy storage capacity than currently available materials. The increased capacity of such materials goes hand in hand with reduced costs and therefore offers a number of advantages for battery makers. Dedicated design of particles together with high purity makes BASF materials well suited for demanding applications such as batteries for automotive drivetrains.

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

4:00 **Discovery of 5V Cathode and Electrolyte Materials via High Throughput Methods**

Steven Kaye, PhD, Chief Scientific Officer, Wildcat Discovery Technologies

Wildcat Discovery Technologies has developed a high throughput synthesis and screening platform for battery materials. Wildcat's system produces materials in bulk form, enabling evaluation of its properties in a standard cell configuration. This allows simultaneous optimization of all aspects of the cell, including the active materials, binders, separator, electrolyte and additives. Wildcat is using this high throughput system to develop new electrode and electrolyte materials for a variety of battery types (primary, secondary, aqueous, non-aqueous). In this talk, I will discuss results from our latest discovery programs, including new 5V cathodes and electrolytes with >700 Wh/kg and significantly improved cycle life in full cells.

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4:30 **Application Driven Lithium-Phosphate Technology Development for Next Generation High-Power Lithium-Ion Batteries**

Speaker to be confirmed

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

5:00 **Transition Metal Oxynitride as Electrode Material for Rechargeable Li-Ion Battery**

Xiao-Jun Wang, PhD, and Reinhard Nesper, Prof Dr, Laboratory of Inorganic Chemistry, Swiss Federal Institute of Technology (ETH), Switzerland

Transition metal oxides have been widely studied as promising electrode materials in Li-ion batteries. In principle, transition metal oxynitrides have better electrical conductivity and higher theoretical capacity than oxides. But they are investigated rarely due to their crystal structural instability and restricted chemical synthesis method. In this talk, synthesis and characterizations of nanoparticles of niobium (V) oxynitride, namely NbON, will be presented, and the electrochemical behaviors vs. lithium will be discussed as well. NbON has the baddeleyite (ZrO2) structure with monoclinic symmetry (space group P21/c). Nanoparticles of NbON were synthesized from thermal decomposition of ammolysized NbOCl3. By using elemental analysis and neutron diffraction, this compound was determined to be NbO1.3(1)N0.7(1) instead of NbON. Samples exhibiting the morphologically feature as 3-5 nm nano-sized particles were observed. Our study indicates that NbO1.3(1)N0.7(1) coated with 4.6 weight-% of carbon has much more stable and reversible cycling performance than the pure sample. When the cutoff potential was set at 0.05V and 1V, the measured capacities reached 500 Ah/kg and 100Ah/kg during the first discharge and then stabilized at 250 Ah/kg and 80 Ah/kg in subsequent cycling, respectively.

5:30 **PANEL DISCUSSION: Application Driven Innovation - a Key to Lithium Ion Batteries Commercial Success**

6:00 *End of Day One*

Tuesday, November 8, 2011

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

9:00 **Hybrid Si/Ge-Carbon Nanotube Anodes for Lithium Ion Batteries**

Brian J. Landi, PhD, Assistant Professor, Microsystems Engineering, Rochester Institute of Technology

Free-standing carbon nanotube (CNT) electrodes are shown to effectively support ultra-high capacity materials like Si and Ge for anodes in lithium ion batteries. The research has demonstrated both Si and Ge-CNT anodes with high reversible anode capacity (>1000 mAh/g), and using select metallization show excellent power density and modest cycling performance. The impact of this research is electrode technologies capable of enhancing today's battery energy density to exceed 300 Wh/kg.

9:30 **Lithium Intercalation in Nanoscale Electrode Materials: Silicon Nanostructures**

Corey T. Love, PhD, Materials Engineer, U.S. Naval Research Laboratory

Many intercalation materials can only achieve high specific capacity at the nanoscale. Using nanostructured silicon as a model anode material, we show the dependence of lithium capacity on morphology and structure. The electrochemical performance of several silicon nanostructures (nanoparticles, nanowires, nanoporous architecture) will be presented. We are working to identify and control the mechanical and electronic stability of nanostructured silicon for improved cycle life performance. The ability of nanostructures to maintain stability compared to bulk materials will also be discussed.

10:00 **Can Si Nano-Materials Provide High Energy Density in Li-Ion Cells without Cycle Life Compromise?**

Yimin Zhu, PhD, Director of Battery and Fuel Cell, Nanosys, Inc

Many attempts have been made to utilize silicon's large storage capacity for lithium in practical Li-ion battery applications. Up to now, no efficient, durable and cost effective solution has been presented. Nanosys' method of architecting novel materials for particular technical applications from the bottom up not only results in the desired specific materials properties but also allows for designing its materials to fit existing processes and manufacturing equipment. This presentation will show how, through the use of architected silicon nano-materials, the cell energy density can be dramatically increased simply by replacing graphite in the anode manufacturing process with our cost-effective Si composite while achieving high cycle efficiency and cycle life.

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

11:00 **State of Health Assessment of Lithium Batteries from Thermodynamics Studies**

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

We have developed a new technique based on thermodynamics measurements performed on lithium half- and full-cells aimed at assessing the state of health (SOH) of electrode materials and of full batteries. Entropy, enthalpy and free energy state functions are determined by following the temperature dependence of OCV at different states of charge of the cell. Thermodynamics data are correlated with characteristic phase transitions taking place in anode and cathode materials, which are found to be SOH dependant. In the presentation we will show thermodynamics data collected with anode and cathode materials at different SOH. We will discuss on how the SOH assessment can be used to improve the battery safety and may be to proactively prevent battery thermal events.

11:30 Lowering Cost with Water: Green Manufacturing for Li-Ion Batteries

Jacob Muthu, PhD, Vice President, Research & Development, International Battery*

The large scale adoption of Li-ion batteries is limited due to cost and safety. Safety issues may be addressed by selecting the right combinations of chemistries. In this paper, we present results for large format Li-ion batteries manufactured using water based processes and how it reduces cost without affecting the cell performance as compared to traditional solvent based Li-ion battery manufacturing. Results focus on safe and environmentally friendly $LiFePO_4$ chemistry.
**In collaboration with: M.Mamari, C.Crane, H.Georges*

12:00 Factors of Carbon Coating Affecting the Properties of $LiFePO_4$/C Composites

George Ting-Kuo Fey, PhD, Dept of Chemical and Materials Engineering, National Central University, Taiwan, R.O.C.

In the search for new generation cathode materials for lithium-ion batteries, $LiFePO_4$ stands out due to its low toxicity, low raw materials cost, and remarkable thermal stability. The main obstacle to commercial applications is the poor electrical conductivity of pristine $LiFePO_4$, which can be overcome by effective carbon coating. The electrochemical performance of the $LiFePO_4$ material is affected significantly by carbon coating. The following factors of carbon coating will be discussed in the presentation: 1) thickness, 2) particle size, 3) morphology, 4) surface area, 5) the ID/IG ratio, 6) uniformity, 7) particle shape. These factors can be evaluated by choosing proper carbon sources, using a suitable process, applying a ball milling technique, controlling calcination temperature, or optimizing particle size and surface area of carbon precursors.

12:30 *Lunch on Your Own*

2:00 A Multi-Scale Modeling Framework for Li-Ion Batteries

Partha P. Mukherjee, PhD, Staff Scientist, Oak Ridge National Laboratory

In this work, we present a multi-scale modeling approach for Li-ion batteries (LIB). The modeling framework consists of a volume averaged macroscopic model and a particle-resolved mesoscopic model. The macroscopic model relies on a rigorous volume averaging approach based on a single-domain formulation where complex geometries are incorporated with the numerical algorithms guaranteeing stability and convergence. In contrast to the multi-domain, pseudo-2D formulation with intermediate boundaries (anode/separator/cathode) based on the porous electrode theory, this unified formulation takes into account geometric multi-dimensionality (1D, 2D and 3D), electrode/electrolyte spatial arrangements and spatio-temporal variations in the physico-electrochemical properties. The mesoscopic model is based on fully resolved, statistically rigorous microstructure models of the battery electrodes using finite-volume technique with Cartesian cut-cell approach to account for the interfaces. We specifically study the solid state transport of Li in packed beds representative of typical electrodes and evaluate effective property and surface vs. bulk Li concentration relations. These scaled-up quantities are deployed in the macroscopic model described above. In this presentation, we describe the multi-scale modeling formalism with special emphasis on the influence of particle morphology (shape, size distribution) and particle-particle interactions on the transport (species, charge, and thermal) limitations and resulting performance implications in both the conventional and 3-D electrode architecture scenarios for the Li-ion battery.

2:30 Materials Design for the Lithium Conductive Material

Taku Onishi, PhD, Dept of Materials Chemistry, and The Center of Ultimate Technology for Nano-Electronics, Mie Univerisity, Japan

The perovskite-type transition metal compounds are well known to have the lithium ion conductivity. Under the operation temperature of lithium battery, the stable crystal structure is required for the high lithium ion conductivity. In this study, we theoretically designed the new lithium ion conductive perovskite with the thermally stable sturucture.

3:00 Improved Electrochemical Properties of $LiNi_{0.5}Mn_{1.5}O_4$ Spinel Material by Surface Modification with $AlPO_4$ Coating

Hyo-Ree Seo, Yong-Ju Jeong, & Keon Kim, Dept of Chemistry, Korea University, South Korea; and Cheol-Woo Yi, Dept of Chemistry & Institute of Basic Science, Sungshin Women's University, South Korea

The attractive cathode material, $LiNi_{0.5}Mn_{1.5}O_4$ for lithium ion batteries was synthesized and its surface was modified by coating $AlPO_4$ by a sol-gel method. This research is aimed to figure out the effects of $AlPO_4$ surface coating to pristine $LiNi_{0.5}Mn_{1.5}O_4$. 1 and 3 wt.% $AlPO_4$ was coated and we checked the $AlPO_4$ particles were well distributed on the surface of $LiNi_{0.5}Mn_{1.5}O_4$ its electrochemical performance was characterized by galvanostatic cycle tests between 3.0 and 4.95 V versus Li/Li+ at 0.5 C-rate. Among them, the 1 wt.% $AlPO_4$ coated-$LiNi_{0.5}Mn_{1.5}O_4$ showed enhanced electrochemical performances, especially improved cycle and lifetime capabilities because of the effective diminishing the contact of the electrodes and electrolyte, which give an effect of the formation of the SEI films on the surface of $LiNi_{0.5}Mn_{1.5}O_4$. Also, the improved lithium-ion diffusion were demonstrated with the lower Rs and Rc by EIS. Besides, the

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modified $LiNi_{0.5}Mn_{1.5}O_4$ showed the stable reversibility at the high temperature, 55˚C. The improved kinetics and electrochemical properties are discussed in detail.

3:15 *Networking Refreshment Break, Exhibit/Poster Viewing*

3:45 **Surface Modification with $LiCoO_2$ for Improving the Electrochemical Properties of $LiNi_{0.5}Mn_{1.5}O_4$**

Eun-Ah Lee, Hee-Seon Choi, & Keon Kim, Dept of Chemistry, Korea University, South Korea; and

Cheol-Woo Yi, Dept of Chemistry & Institute of Basic Science, Sungshin Women's University, South Korea

Lithium-ion batteries are now considered to be the technology of choice for future hybrid electric and full electric vehicles. The $LiMn_2O_4$ spinel has been investigated as a 4 V cathode material for lithium-ion batteries. However, poor capacity retention due to the Jahn-Teller effect of Mn^{3+} hinders. A common way to overcome these defects is to replace Mn with another transition metal. Among them spinel $LiNi_{0.5}Mn_{1.5}O_4$ material is one of the promising and attractive cathode materials because of its high voltage (4.7 V), acceptable stability, highest discharge capacity (146.7 mAh/g), and good cycling performance. But the capacity fading was occurred when the temperature increased. Therefore, we synthesized $LiCoO_2$ which is the one of the low cost, environmentally friendly cathode material in the surface with different ratio of 2.5, 5.0 and 10 wt. % by sol-gel method. And we investigated their charge and discharge performances with 0.2 C-rate between 3.0 - 4.9 V cut-off regions at room temperature and evaluated temperature, 55˚C. The 2.5 wt. % $LiCoO_2$-added $LiNi_{0.5}Mn_{1.5}O_4$ showed the best capacity and cycle abilities with 136 mAh/g.

4:00 **Lithium Batteries as Replacements for Lead Acid Applications**

Jim Hodge, PhD, Chief Technical Officer, K2 Energy Solutions, Inc.

The fundamental voltage of the lithium iron phosphate (LFP) chemistry enables the manufacture of batteries with voltages closely matching those of lead-acid batteries. Consequently, LFP batteries can be fabricated that are "drop-in" replacements for lead-acid for a wide variety of applications. These LFP batteries offer significant advantages over lead acid in terms of both cycle life and capacity.

4:30 **Exhibitors and Sponsors Showcase Presentations**

5:00 **Selected Oral Poster Highlights and Open Discussion**

5:30 *Concluding Remarks, End of Conference*

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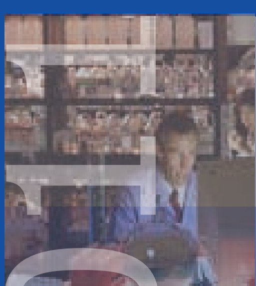

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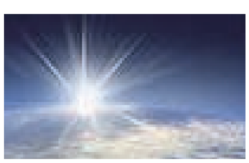

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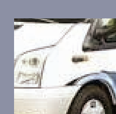
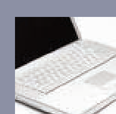


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