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8th Annual International Conference

Lithium Battery Power 2012

December 4-5, 2012
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 2012 is conveniently timed with Battery Safety 2012.

- 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

KNOWLEDGE FOUNDATION
TECHNOLOGY COMMERCIALIZATION ALLIANCE

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3rd Annual
Battery Safety 2012

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Nothing can substitute the benefits derived from attending **Lithium Battery Power 2012**. But if your schedule prevents you from attending, this invaluable resource is available to you. *Note: Documentation is included with conference fee for registered delegates and live and on demand webcasts are available for download.*

Conveniently timed with another special event

Battery Safety 2012

December 6-7, 2012
Las Vegas, NV USA

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Conference Agenda

Tuesday, December 4, 2012

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

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

9:00 **Global Lithium-Ion Batteries Market**

Vishal Sapru, Research Manager, Energy & Power Systems, Frost & Sullivan, Inc.

The presentation will focus on the global market size of the lithium-ion batteries covering consumer, industrial and automotive applications. The presentation will highlight potential opportunities for lithium-ion batteries in renewable applications, utilities among others. The focus will also be on some of the emerging chemistries that can be a competitor for lithium-ion in the future. Talk about mega trends and emerging market.

9:30 **Energy Storage 2030: A Technology Roadmap**

Kai-Christian Möller, PhD, Head of the Project Group Electrochemical Energy Storage, Fraunhofer Institute for Chemical Technology, Germany

For lithium-ion batteries, that are now considered as the key technology for the dissemination of electromobility, a detailed roadmap will be given that has been developed under guidance of Fraunhofer by experts from industry and academic research within the "Innovation Alliance Lithium-Ion-Battery LIB 2015", supported by the German Federal Ministry of Education and Research. The roadmap will classify the expected technological developments such as cell components, resulting cell types and their expected properties for the horizon 2012 – 2030. A chronological ranking of the availability and the properties of materials momentarily under development will be the basis for a road map for the development of effective batteries for the application in electric vehicles in future. Last but not least the chances for competitive technologies such as fuel cells and emerging technologies such as lithium metal batteries and redox-flow batteries will be discussed.

10:00 **Development of Electrolyte Solvents & Additives for High Voltage Cells**

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

High voltage cathode materials, such as >4.3V NMC, LMNO, and Li-rich NMC have greater energy than low voltage NMC/LCO cells, but catalyze oxidation of the electrolyte, leading to rapid capacity fade and impedance growth. Wildcat Discovery Technologies has developed additives that can passivate the cathode material, inhibiting electrolyte oxidation without reducing cell performance. In this talk, we will discuss our latest work in high voltage electrolytes, including:
(1) New, complimentary, additives that further improve cycle life and electrolyte stability;
(2) Optimized formulations, including novel combinations of solvents, salts, and other additives. The resulting electrolyte formulations have shown significant improvement in cycle life, thermal stability, and shelf life for a wide range of high voltage systems, including >4.3V NMC (>400 cycles at 50 °C), LMNO (>800 cycles at 50 C), and Li-rich NMC (>400 cycles).

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

11:00 **Scale Up and Commercialization Activities for New High-Power, High-Energy Cathode Material**

Brian Barnett, PhD, Vice President, TIAX LLC

High performance cathode materials are key to achieving further improvements in Li-ion energy density. TIAX has developed a stabilized, nickelate-class cathode material called CAM-7 which employs innovative dopants to stabilize the $LiNiO_2$ structure and successfully resolve historical long term stability concerns with this class of cathode materials. CAM-7 offers an outstanding combination of cell-level advantages for both high-energy and high-power applications. The material is distinct from other nickel materials and is suitable for both portable and automotive applications. CAM-7 offers advantages over other cathode materials for high-energy and high-power. Several years of development involving material composition optimization as well as process engineering and scale-up have taken place. TIAX is now supplying this material from a mini-plant in Lexington, Massachusetts that successfully demonstrates scale-up of its production process and has recently installed and activated a 50-300 ton per year production facility in Massachusetts. This presentation will address key technical aspects of the design of CAM-7 and of its performance. In addition, the scale-up of CAM-7 synthesis will be described, on-going activities to commercialize this high-energy, high-power cathode material will be summarized and performance data from independent cell-making activities will be reviewed.

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11:30 **Development of Li-Metal Batteries**

Ji-Guang (Jason) Zhang, PhD, Laboratory Fellow, Battery Technology, Energy & Environment Directorate, Pacific Northwest National Laboratory

Rechargeable lithium metal batteries are considered the "holy grail" of energy storage systems. Unfortunately, uncontrollable dendritic lithium growth inherent in these batteries (upon repeated charge/discharge cycling) has prevented their practical application over the past 40 years. We show a novel mechanism which can fundamentally alter dendrite formation. Electrolytes with novel additives that can minimize the dendrite growth during lithium deposition processes will be reported. These additives will not be consumed during the cycling process. Therefore, they can effectively stabilize the lithium anode surface and prevent dendrite growth during long-term charge/discharge cycling of Li-metal batteries.

12:00 **Recent Advances in High-End Li-Ion Cells Development and Production at Yardney Technical Products**

Malgorzata (Maggie) Gulbinska, PhD, Lead Materials Scientist, Yardney Technical Products*

Yardney's batteries are used in multitude of air, land, sea, and space applications and must meet very stringent performance requirements. A close integration of research and development programs with the production efforts at Yardney results in tremendous flexibility and a variety of advanced cell designs available to our customers. This presentation shows the most recent, selected advances in developmental and production lithium-ion cells and batteries made at Yardney. **In collaboration with: F.Puglia, R.Gitzendanner, G.Moore, S.Cohen, S.Santee*

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

2:00 **Development of a Low Cost Lithium Supercapacitor with an Energy Density of 30-40 Wh/kg**

Andrew F. Burke, PhD, Institute of Transportation Studies, University of California-Davis*

There are strong market demands for high power energy storage devices. Some of these demands are met by carbon/carbon supercapacitors (EDLC), but other demands can not be met by those devices because their energy density is too low (about 5 Wh/kg). In recent years there has been considerable research directed toward the development of supercapacitors with energy densities approaching those of lead-acid and nickel cadmium batteries (30-40 Wh/kg) and charge and discharge characteristics similar to those of carbon/carbon supercapacitors. This paper discusses research on the development of a lithium supercapacitor (LSC) and related devices which have energy densities up to 10X that of EDLCs. These devices utilize lithiated graphite in the negative electrode and high specific capacitance carbon in the positive electrode with selected lithium-ion conducting electrolytes. The rated voltages of the devices are 3.4-3.8V. Coin and small (4-6 cm^2) prismatic cells have been constructed using several different carbon materials. The devices were tested both at CNT and UC Davis and their characteristics were used to project those of large devices of the same design. **In collaboration with: Linghong Li and Eric Martin, Caly Nanotechnologies*

2:30 **High Power Wraparound Ultracapacitor for Battery Enhancement**

Shreefal Mehta, PhD, MBA, CEO, Paper Battery Company

A conformal thin ultracapacitor is now available as a patternable sheet with holes if desired. Without adding volume, the accessible energy and life of a battery can be significantly increased. Established print production and breakthrough innovation in architecture is applicable to hybrid devices as well. Applications range from mobile electronics to transportation.

3:00 **Investigation of Lithium Difluoro(Oxalate)Borate (LiDFOB) as Additive in Lithium-Rich Composite Cell**

Qingliu Wu, PhD, Electrochemical Energy Storage Group, Chemical Sciences & Engineering Division, Argonne National Laboratory

Promising rate capability and capacity retention (more than 92% of initial capacity after 100 cycles) were exhibited in cells (graphite/xLi_2MnO_3•y$LiMO_2$) with 2 wt.% LiDFOB as additive. The outstanding cell performances were associated with stable solid electrolyte interface (SEI) film formed on the surface of electrodes derived from LiDFOB. Compared to the LiBOB additive, the main reason responsible for the greatly improved capability and durability in LiDFOB added cells might be attributed to the more stable SEI film with lower interfacial resistance on the surface of anode, the formation of which was facilitated by the reduction of LiDFOB during cycling.

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

4:00 **Multiscale Physical Modeling and Numerical Simulation of Li Ion and Li Air Batteries**

Alejandro A. Franco, Prof Dr, Senior Scientist, Atomic and Alternative Energy Commission of France -CEA, France

In this talk we will present a new multiscale modeling approach for the numerical simulation of Li Ion and Li Air batteries (LIBs and LABs). The model is designed to capture the impact of the chemistry and structural properties of the electrode materials on the macroscopic performance, and includes mechanistic descriptions of some relevant degradation mechanisms such as graphite exfoliation (for LIBs) and oxides-driven pores blocking (for LABs).

4:30 **Changing the Landscape of Lithium Ion Batteries**

Larry Thomas, President and CEO, Primet Precision Materials, Inc.

The urgent need for suppliers of critical raw materials and producers of lithium ion batteries to develop and adopt processes that can: (a) Substantially reduce the cost of producing powders, in turn dramatically reducing the cost of the battery packs for electric vehicles. (b) Be produced at scalable levels in a physical footprint dramatically smaller than current traditional methods. (c) Greatly reduce the energy required to produce, far less than current methods. (d) Be a water-based technology and with little or no waste residual – a green process. (e) Be produced at scalable levels with a much shorter production cycle. These changes will be a "game- changer" in the automotive industry and will create jobs as it lowers the costs of electric vehicles for the average consumer. The global market for lithium ion batteries is about $10 billion per year today, with almost all of that going into consumer handheld devices such as laptops and cell phones. With any level of success in penetrating the automotive market, electric vehicles will double the size of the global market for lithium batteries – but only if the industry respond in a way that makes them cost-effective in vehicle applications.

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5:00 **PANEL DISCUSSION:**
High Energy / High Power, Safe, Reliable, and Inexpensive Lithium-Ion Energy Storage Systems:
Are we there yet? And, what will it take to get there soon?

Facilitator:
Brian Barnett, PhD, Vice President, TIAX LLC

5:45 *End of Day One*

Wednesday, December 5, 2012

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

9:00 **Nanoporous Substrate Materials for Rechargeable Li-Air Batteries**

Hua Cheng, PhD, Research Associate, School of Chemical Engineering & Advanced Materials, Newcastle University, United Kingdom

The rechargeable Li-air battery has a key role to play for the storage of renewable energy and in future electric vehicles. But it suffers from cycling fading and low rate capability; cathode materials (including substrate) were identifies as one of main responsible sources. Here we compare several potential cathode substrates with widely used carbon materials based on results from cycling studies and FTIR measurement. Ag and TiC show promising properties.

9:30 **A New Concept of Lithium Air Battery with Anode and Cathode in Liquid State**

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

Current lithium-air battery research mostly focuses on solid state anode materials including metallic lithium and lithium metal alloys. In this work we have developed a new type of liquid anode where the alkali metal is dissolved to form a solvated electron solution (SES). The advantage of liquid anode is the fast ion transport and stable anode/ceramic membrane electrolyte interface. Moreover, battery system based on anode and cathode both in the liquid state is an ultra-fast "charge" owing to easy refilling the anode and cathode tanks with fresh solutions besides electric charging. A laboratory cell consisting of a liquid anode of Li-SES and liquid cathode open to the ambient air

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atmosphere will be demonstrated. It rates an OCV close to 3V operating at the ambient temperature. Our typical Li-SES comprises a polyaromatic hydrocarbon such naphtalene or bi-phenyl, an organic solvent such THF, which enables lithium to be dissolved. We will also discuss the "phase diagram" of Li-biphenyl-THF system relating to electrical conductivity, as well as the physical-chemical characteristics of Li-SES together with their potential application as the new anode material in lithium-air and lithium-seawater cells.
**In collaboration with: Tan Kim Seng*

10:00 **High Energy Density Lithium Ion Batteries with Hetero-Hybrid Si/Ge-Carbon Nanotube Anodes**

Brian J. Landi, PhD, Assistant Professor, Chemical & Biomedical Engineering, Rochester Institute of Technology

Combined benefits of low pressure chemical vapor deposition (LPCVD) or plasma enhanced chemical vapor deposition (PECVD) Si with Ge nanoparticles and carbon nanotubes has led to an ultra high capacity anode (>1000 mAh/g electrode), along with enhanced coulombic efficiency. Full batteries incorporating properly matched hetero-hybrid anodes with conventional cathodes shows cell improvements in gravimetric energy density over state-of-the-art by more than 50%.

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

11:00 **All Carbon Nanotube Lithium Battery**

David S. Lashmore PhD, CTO, Vice President R&D, Nanocomp Technologies Inc.

Nanocomp technologies is developing an all CNT battery consisting of CNT large sheet current collectors coated with silicon for the anode and stabilized form of sulfur as the active species for the cathode. The safety implications of using an CNT system involve: (1) Self-stabilizing effect of the CNT vs. temperature characteristics that increases the thermal conductivity if there are any temperature excursions e.g. the hotter the system the more heat is conducted away. (2) High strength of the CNT material, and (3) Fatigue resistance of the CNT based systems. It has become apparent that CNT current collectors can replace metals resulting in significant weight savings for battery applications especially for lithium based electrochemistry Nanocomp can product such materials in volume so that for the first time, dissimilar metals such as copper and aluminum need not be used in electrochemical systems, not only saving weight, but more importantly eliminating corrosion couples and enabling more aggressive electrolytes, such as Lithium is (trifluoromethanesulfonyl)imide (LiIm), to be used in lithium based electrochemical systems. Capacity, Energy and Power: Coating of these CNT current collectors with silicon, results in a high capacity electrode with a comparative reduction of electrode resistance; therefore the Joule heating associated with high current performance is less.

11:30 **Development & Scale-Up of Electrode Nanomaterials for Lithium-Ion Batteries**

Ganesh Venugopal, PhD, Director, Energy Products, nGimat LLC

Nanomaterials can play an important role in Lithium-ion batteries by enabling enhanced rate-capability even in electrode compositions that are limited by low Lithium-ion diffusion coefficients. However, few if any scalable processes exist for making true nanomaterials from the "bottom-up". This presentation will review the development and scale-up of Lithium-ion anode and cathode nanomaterials using a proprietary solution combustion process. This process is akin to gas-phase combustion processes that have been used for several decades to make simple nanomaterials like carbon-black and fumed Titania in tonnage, but is capable of high-volume production of complex metal-oxide and metal-phosphate compositions. Examples of pilot-scale production of layered, spinel, olivine and composite electrode nanomaterials and the benefits of using these in batteries will be discussed. 100X Scale-up of the process to achieve higher throughputs using low-cost, environmentally friendly precursor systems and the capability to achieve much higher charge and discharge rates will also be presented.

12:00 **Titanium Oxide Decorated Carbon Nanofiber Webs as Flexible Binder-Free Anode Materials for Lithium-ion Batteries**

Yunhua Yu, PhD, Associate Professor, Beijing University of Chemical Technology, China*

Titanium oxides have been considered as potential alternative materials to traditional carbon-based anodes due to fast charge-discharge capability and better safety. However, the rate capability of the Ti-based oxides is relatively low because of a large polarization at high charge-discharge rates resulting from the poor electrical conductivity and sluggish lithium-ion diffusion. In this work, in order to overcome these drawbacks, a favorable method of distributing TiO_2-B nanowires on carbon nanofibers (CNFs) by using electrospinning

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technique and hydrothermal treatment was proposed to prepare TiO_2-B/CNFs composite as a flexible binder-free anode material for Li-ion batteries.*In collaboration with: Peiwen Li, Xiaolong Jia, Xiaoping Yang*

12:30 *Lunch on Your Own*

2:00 **Tolerance of Li-Ion Pouch Cells to Varied Pressure Space Environments**

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

Lithium-ion pouch cells have shown to be intolerant to long term storage as well as to varied pressure space environments. The pouches swell and leak electrolyte or corrode or cause loss of electrical contact. Batteries launched for NASA's space applications are exposed to vacuum environments as part of their flight acceptance testing to confirm that there is no electrolyte leakage and that the cell seals are not compromised or defective. This is a challenge for li-ion polymer cells due to their inherent nature of swelling under vacuum conditions. It has been observed that in most cases, a good restraint on the cells does not cause a big change or significant degeneration of the cell or battery performance. It was also noticed that only in some cases the cell swelling is noticeable post-vacuum exposure by the wrinkles depending on the time of exposure to the vacuum environment. The study includes pouch cell designs from a few manufacturers and analysis of the pouch material.

2:30 **Serries-Parallel Cell Arrangement Safety**

Michael D. Eskra, President, Eskra Technical Products, Inc.*

Many consumer battery packs contain a series-parallel arrangement of cells to meet capacity and power. Under normal conditions and with typical battery pack management, this arrangement meets safety, cost and cycle life requirements. However, this same pack structure has been shown to potentially develop a unique failure mode, which has not been predicted under normal cell abuse testing. This paper will describe in-field failures which lead us to investigate alternative failure modes. Thermochemical and electrochemical mathematical modeling is used to predict the potential failure modes. Finally a suggested battery management strategy will be suggested which would alleviate the failure mode.*In collaboration with: R.M LaFollette*

3:00 **The Role of the Battery Management System in Ensuring Battery Safety**

Wei He, Researcher, Center for Advanced Life Cycle Engineering (CALCE), University of Maryland

Emphasis has been placed on safer cathode materials such as manganese. However this comes at the cost of energy density. One solution to ensuring safe battery operation independent of the materials is through the battery management system (BMS). This talk will outline the role of the BMS in cell balancing, failure forecasting, and the detection of catastrophic event precursors in order to maximize the operational safety of battery packs. The sensing technologies and data processing that is required to monitor battery safety and initiate autonomous failure prevention actions will be discussed.

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

4:00 **IEC 61427-2 JWG82 - Providing Operators the Tools to Evaluate Renewable Energy Storage**

Steve Carkner, CTO, Panacis, Inc.

Panacis is a developer of Lithium Energy Storage Systems with a focus on mission critical applications for renewable, grid and telecommunication applications. The new standards for evaluation of all energy storage technologies, specifically for renewable energy storage on-grid, will help operators to fairly evaluate a variety of technologies using real-world methodologies. By using these standards, an operator will be able to quickly compare a number of energy storage factors that are often undisclosed or un-tested by storage system manufacturers including round-trip efficiency, thermal performance, durability and heat-loading of the total system. This presentation will introduce some of Panacis lithium energy storage technologies, show some real-world off-grid examples and provide a brief overview of the new IEC standard in development.

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

5:00 **Selected Oral Poster Highlights**

5:15 *Concluding Remarks, End of Conference*

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