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October 29-30, 2007

San Diego, CA USA

Advances in Lithium Battery Technologies for Mobile Applications

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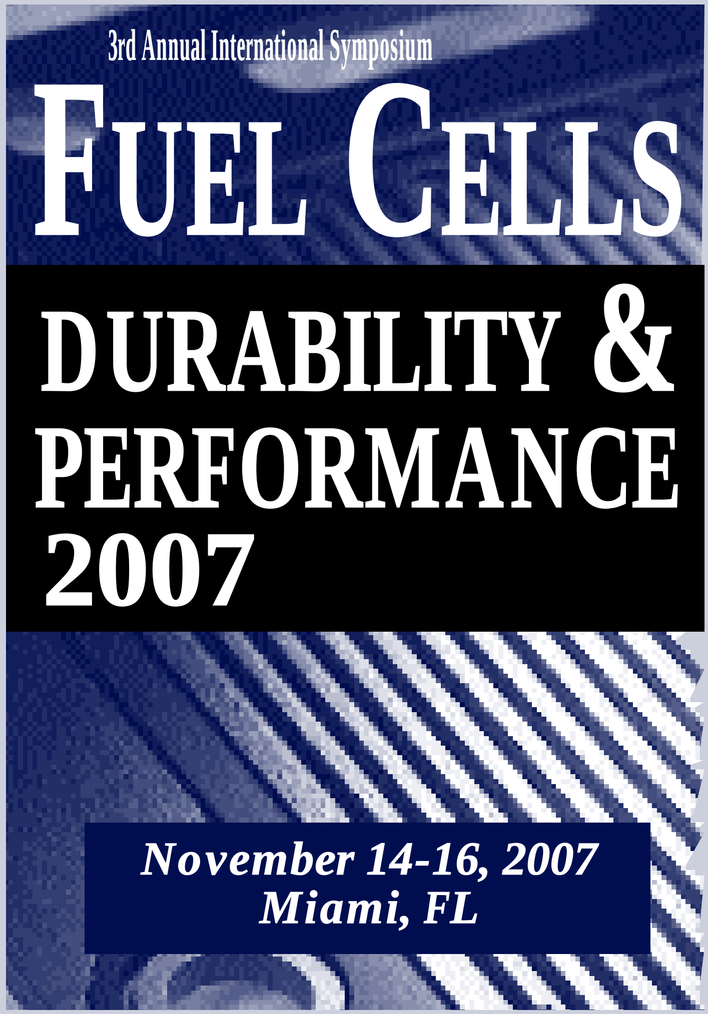

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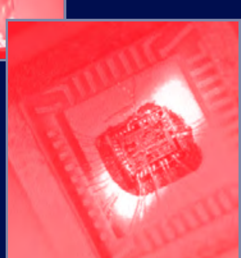

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LITHIUM MOBILE POWER℠ 2007

Advances in Lithium Battery Technologies for Mobile Applications

CONFERENCE AGENDA

Monday, October 29, 2007

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

APPLICATION DRIVEN LITHIUM BATTERY DEVELOPMENT

8:45 Cellphone Energy Gap: Myth or Reality?

Stuart Robinson, Director, Handset Component Technologies, Strategy Analytics, United Kingdom

The demands on a cellphone's battery just keep growing, with more features and functions being added to each new generation of handset. Drawing upon our end-user research of cellphone usage patterns, combined with analysis of the power consumption trends of critical components, this presentation will highlight some of the key findings from Strategy Analytics' cellphone battery budget analysis. It tackles two key questions: Where does all the energy go in a cellphone? And, is the cellphone Energy Gap going to grow or shrink in future?

9:15 Energy Technologies for Portable Power

Jerry Hallmark and Ramkumar Krishnan, Energy Technologies,Motorola Embedded Systems Research Labs, Motorola

Today's portable communications devices are becoming more complex with new features being added to extend capabilities. There is also an increasing need for extended operation "in the field" without the ability to recharge batteries from the grid. This is causing an "energy crisis" and Motorola is evaluating several new energy technologies, including fuel cells, to address these issues. Advanced materials and nanotechnologies are being evaluated for these energy applications. Comparison of energy storage/generation technologies such as Lithium batteries (thin film solid state vs. conventional Li-ion), fuel cells and other energy harvesting methods such as photovoltaics will be made and various application scenarios of these technologies will be discussed. Energy requirements and solutions for a range of applications will be presented, including cell phone handsets and accessories, 2-way radios and telecom basestations.

9:45 SAFT's Very High Power Li-Ion Technology

Kamen Nechev, PhD, Senior Scientist/Advanced Technology Manager, Saft Specialty Battery Group, SAFT

SAFT specializes in developing and providing solutions based on Very High Power (VHP) Li-ion. This is an industrial technology capable of 8kW/kg for 2 second long and 12kW/kg for millisecond long pulses. SAFT has built and delivered a number of battery systems supporting emerging Directed Energy applications. The VHP technology is also the only electrochemical energy storage system providing sufficient power at low temperature required for aircraft applications. Due to this unique capability it is the heart of the 270V emergency battery for F-35 aircraft.

10:15 Powering Robotic Ocean Observing Systems

James G. Bellingham, PhD, Chief Technologist, Monterey Bay Aquarium Research Institute

Mobile robots, capable of operating unattended by humans for days to months at sea, are revolutionizing the way scientists, the military, and the commercial world explore and observe the ocean. Energy storage is a fundamental limitation, and designers of AUVs (Autonomous Underwater Vehicles) go to great lengths to minimize power consumption and maximize energy storage. Reliability and safety are particularly important considerations, as operational conditions at sea are demanding, and vehicles operate at high ambient pressures (up to 9000psi). This talk will provide an overview of emerging ocean observing systems, their energy needs, and operational requirements.

10:45 Refreshment Break, Exhibit/Poster Viewing

MATERIALS CHALLENGES FOR LITHIUM BATTERY DEVELOPMENT AND IMPLEMENTATION: ELECTRODES / SEPARATOR / ELECTROLYTE

11:15 Materials Challenges for the Next Generation Li-Ion Battery Electrode Materials

Sanjeev Mukerjee, PhD, Professor, Laboratory for Electrochemical Advanced Power (LEAP), Northeastern University

This presentation will provide an overview of the current state of the art materials as applied for various Li-ion battery technologies including their increased use in small and medium scale portable devices to the present thrust towards safe, cheap and reliable HEV and PHEV applications. Prospects for new materials developments will be discussed from the purview of their structural and charge transfer characteristics. Transition to new materials formulation and synthesis enabling unique interfacial characteristics will be presented within the context of new technology initiatives.

11:45 A Novel, Ceramic-Coated Separator Membrane for Safer Lithium-Ion Rechargeable Batteries

Soonho Ahn, PhD, Vice President Batteries R&D, LG Chem Research Park, Korea

Separator membrane's main role is to physically isolate positive and negative electrodes while maintaining passage of electric current. Unexpected short-circuits across the membrane induce hot spots where thermal runaway may break out. Internal short-circuits are generally believed to occur either by protrusions on the electrode surface or by shrinkage of the membrane upon heating. We have engineered separator membranes that possess very high thermal and mechanical stability and can prevent the internal short-circuits.

12:15 The Use of Solid Electrolytes to Enable Next Generation High Energy Density Batteries

Steven J. Visco, PhD, Vice President of Research, PolyPlus Battery Company*

The introduction of high energy density Li-ion batteries in the early 1990s was timely for the portable electronics industry as battery life was emerging as a key issue for mobile computing and telecommunications. However, it is clear that significant advances in battery technology are needed in order to keep pace with the demands of these industries as well as emerging markets such as hybrid electric vehicles, plug-in hybrids, and electric utility backup. The transition to higher energy battery chemistries will require innovative approaches to do so safely and at reasonable cost. One such approach involves the use of solid electrolyte membranes, either in bulk or thin-film form. This presentation will discuss various strategies of designing next generation technologies (including lithium metal and sodium metal chemistries) based on the unique properties of true solid electrolyte membranes. *In collaboration with: E. Nimon, B. Katz, L. De Jonghe, and M.-Y. Chu

12:45 Li-Ion Battery Electrolytes Formulated with Ionic Liquid Materials

Victor R. Koch, PhD, President and CEO, Covalent Associates, Inc.

A new family of Li-ion battery electrolytes that incorporate ionic liquid materials has been developed. Such electrolytes are specifically designed to operate over a wide temperature range. These electrolytes possess excellent transport properties at low temperature coupled with high thermal stability. Li-ion cells incorporating the new formulations may be discharged at rates as high as C/4 at -50˚C. Such cells also demonstrate excellent cycle life at room temperature and acceptable cycle life at temperatures as high as 80˚C.

1:15 Luncheon Sponsored by:

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SAFETY, RELIABILITY AND PERFORMANCE

2:15 Abuse Tolerance Issues for Li-Ion Cells

E. Peter Roth, PhD, Advanced Power Sources R&D Department, Sandia National Laboratories

Li-ion cells are increasingly used in commercial applications ranging from small portable electronic devices to large modules for hybrid-electric vehicles. The new proposed plug-in hybrid vehicles will necessarily incorporate greater levels of stored electrical energy. These cells will therefore have to demonstrate even higher levels of abuse tolerance. We will present the latest safety performance data on several Li-ion chemistries during abuse testing under such conditions as over-temperature and overcharge. We will discuss the fundamental mechanisms affecting abuse tolerance and the future of new cell chemistries.

2:45 Safe and Reliable Power Sources for Mission Critical Applications

Robin Sarah Tichy, PhD, Technical Manager, Micro Power Electronics

Catastrophic safety issues - ranging from under-performance to explosions - with battery systems have heightened safety concerns. This presentation will address the common causes of battery system failures, provide design guidelines and techniques for portable device manufacturers, and address the often neglected topic of battery system reliability. The design guidelines cover battery pack authentication technology, over voltage/current protection circuits, recommended charging regimens, battery alternatives and their affiliated volatility. In order to numerically compare the reliability of different topologies, analytic solutions must be derived, based on developed reliability diagrams and established probability density functions. After a review of the issues and industry standards in battery reliability, Micro Power Electronics will present a model and comparison of the reliability of redundant parallel cell strings.

3:15 Safety Mechanism for Lithium Polymer Batteries

Arno Perner, General Manager R&D, Varta Microbattery GmbH, Germany*

To guarantee the entire spectrum of the safety requirements all components of the cell have to be chosen carefully and have to be adjusted in a proper way. The separator has to guarantee the safe insulation of the electrodes, also under abusive conditions. Polyolefin separators meet these requirements and provide for a disconnection of the cell via a “shutdown” mechanism before critical temperatures can be reached in the cell. In case of overcharge the safety function of the separator will be maintained by electrolyte additives. These have an inhibitory effect on the reaction between electrolyte and overcharged electrodes and prevent the thermal run-away in the battery. The electrode active materials are also safety relevant. The safety of the cell will be increased, if for example $LiCoO_2$ is replaced by $LiNiCoMnO_2$. *In collaboration with: T.Wöhrle, M.Pompetzki, C.Wurm, P.Haug, and M.Kohlberger

3:45 Refreshment Break, Exhibit/Poster Viewing

4:15 Quallion Matrix Battery Design

Hisashi Tsukamoto, PhD, CEO and CTO, Quallion LLC

Quallion has developed a superior packaging solution for lithium-ion cells in our Matrix Battery Design (MBD), which has demonstrated high reliability, survivability, longevity and safety. Cycling tests performed on a 7S-6P matrix battery configuration demonstrated minimal voltage degradation up to 3000 cycles, in spite of physically disconnected a cell every 1000 cycles. Author will present this performance data of various MBD packs for vehicle, energy storage and other applications.

4:45 Navy and Marine Corp Lithium Battery Mobile Power Safety

Daphne Fuentevilla, Clint Justin Govar, and Clinton Winchester, Naval Surface Warfare Center (NSWC)

Lithium batteries dominate in Navy and Marine Corps mobile power systems where high energy and high power needs must be balanced by system requirements, risk tolerance, availability, and cost. Lithium battery technologies in fieldable systems are advancing in terms of deployment in new operational environments, the prevalence of larger battery assemblies and a wider variety of lithium chemistries, the use of rechargeable in place of non-rechargeable batteries, and even various hybrid options such as metal-air, battery-capacitor, and battery-solar power. This talk will focus on the safety challenges these lithium battery advancements present for the Navy and the Marine Corps.

5:15 Advanced Lithium Ion SuperPolymer Batteries for Automotive Applications

Sankar Das Gupta, PhD, Chairman, President & CEO, Electrovaya Inc., Canada

The talk will outline a new advance in technology, where a High Energy density lithium ion polymer battery with energy density of 180 - 210 Wh/kg is used in automotive applications, which needs moderate rates of up to 10C pulses. Applications of this battery in a PHEV (Ford Escape), a battery electric Fleet van (80kWh), a HEV (10kWh) in a small car (30kWh) will be discussed. Safety and performance of these electric vehicles will be analyzed.

5:45 Selected Oral Poster Highlights

6:00 Discussion, End of Day One

Tuesday, October 30, 2007

8:00 Exhibit/Poster Viewing, Coffee and Pastries

APPLICATION DRIVEN LITHIUM BATTERY DEVELOPMENT II

8:45 Lithium-Ion Batteries as Energy Storage Systems for New Power Trains in Automobiles

Klaus Brandt, PhD, Chief Executive Officer, Lithium Technology Corporation (LTC)

The combustion engine is the power source of today's automobiles. To date, alternative systems such as electric motors have not been commercially successful. Today's commercially viable concepts use mixed solutions, which is the Hybrid Electrical Vehicle (HEV). The energy storage system is a major key component in HEVs for an efficient operation. Energy storage systems with better energy and power performance, such as lithium-ion batteries enable enhanced operational characteristics, which will promote mass public adoption for HEV. The presentation describes the performance, the benefit and the feasibility of lithium-ion batteries in hybrid electric vehicles.

NOVEL ELECTRODE TECHNOLOGIES TO IMPROVE SYSTEM PERFORMANCE I: ANODE AND CATHODE

9:15 Nano-Structured $Li_4Ti_5O_{12}$ /$Li_{1.06}Mn_{1.94}O_4$ Battery System for HEV Applications

Khalil Amine, PhD, Senior Fellow, Manager, Advanced Battery Program, Argonne National Laboratory*

Lithium manganese oxide spinels have attracted significant attention for high-power applications, such as hybrid electric vehicles, due to their low cost, outstanding power capability, and low reactivity towards non-aqueous electrolytes when charged. However, the dissolution of the manganese ion and its impact on the graphite negative electrodes, results in rapid capacity fade and impedance rise of the graphite/spinel lithium-ion cells. To address the life issue of this system, we investigated the effect of replacing graphite anode with new nano-structured $Li_4Ti_5O_{12}$ on the life, power and low temperature performance of the system. The negative electrode material investigated was a nano-structured $Li_4Ti_5O_{12}$ with 1 to 2 micron secondary particle and nano primary particle developed recently at Argonne national Laboratory. This system shows outstanding power performance of 5 Kw/kg exceeding any existing lithium ion battery system. In addition the cell based on this new system cycle extremely well with over 2500 full cycle at 55°C with no capacity loss. Preliminary test shows that the - $Li_4Ti_5O_{12}$ /$Li_{1.06}Mn_{1.94}O_4$ battery system meet the 7 KW cold cranking power at -30°C and shows outstanding safety characteristics. *In collaboration with: I.Belharoauk, J.Liu, A.Jansen, and Z.Chen

9:45 Advanced Anode Materials for Mobile Energy Application

Hitoshi Matsumoto, Senior Researcher, Battery Materials Laboratory, R&D Division, Science & Technology Research Center Inc., Mitsubishi Chemical Group, Japan*

We report on the technology development and measurements of performance and such electrochemical characteristics as irreversible capacity and rate capability for both natural and artificial graphite with different particle shape at high density level (>1.7g/cm^3). Comparison of BET surface area for each particle type with active electrode area (Cdl) evaluated by AC impedance method shows linear proportionality, which character depends on the type of used binder and the shape of particles. This also affects the irreversible capacity characteristics. These results as well as the prospects for use of these anode materials in LIBs for mobile application will be discussed. *In collaboration with: H.Uono, H.Satou, T.Kamada, M.Ue

10:15 Advanced Lithium Ion Technology for PHEV and HEV Applications

Tibor Kalnoki-Kis, PhD, General Manager-EEI Gainesville Facility, Electro Energy, Inc.

Electro Energy has successfully demonstrated its bipolar wafer-cell Ni-MH technology through a 220V, 30 Ah, 6 kWh battery system used in a HEV-to-PHEV conversion. A similar system is currently being developed utilizing EEI's Li-Ion technology, which provides high energy capability, while minimizing wasted space and reducing weight and volume. EEI has recently fabricated and tested Li-Ion cells using new and innovative electrode materials. This presentation provides the test data and demonstrates the capability and advantages of EEI's Li-Ion technology for HEV and PHEV applications.

10:45 Refreshment Break, Exhibit/Poster Viewing

11:15 High Energy Density Layered Oxide Cathodes for Mobile Applications

Arumugam Manthiram, PhD, Professor, Materials Science and Engineering Program, The University of Texas at Austin

Lithium ion batteries have revolutionized the portable electronics market, but their energy density is limited since only 50% of the theoretical capacity of the currently used layered $LiCoO_2$ cathode can be utilized in practical cells. This presentation will focus on the development of complex layered oxide solid solutions between $LiMO_2$ (M = Mn, Co, and Ni) and Li_2MnO_3 that exhibit two times higher capacity than the $LiCoO_2$ cathode. The structure-property-performance relationships of these cathodes and the challenges facing them will be discussed.

11:45 Thermodynamics and Stability of Cathode Materials for Lithium Ion Batteries

Rachid Yazami, PhD, Director, CNRS-CALTECH International Laboratory on Materials for Electrochemical Energetics, California Institute of Technology

Cathode materials for lithium ion batteries based on transition metal oxides and lithium iron phosphate were investigated by both electrochemical thermodynamics measurements system (ETMS) and by thermal aging at their initial charge state in lithium half cells. The aim is to correlate the observed crystal structure degradation to the thermodynamics data such including the enthalpy and entropy of lithium intercalation and de-intercalation. Most stable materials tend to generate less heat.

12:15 High Capacity Sulfur Composite Cathode Material for Li-Ion Batteries

Xiangming He, PhD, Institute for Nuclear and New Energy Technology, Tsinghua University, People's Republic of China

Electrochemical characteristics of sulfur composite electrode cathode for rechargeable lithium batteries will be presented. Voltage plateaus, over-charge, deep discharge, cycleability and performance at different temperatures and current densities will be reported. The sulfur composite shows normal cycling performance after deep discharge to 0.0 V. Charging voltage can not exceed 4.0 V under constant current charging conditions, indicating that sulfur composite improves intrinsic safety of Li-ion batteries. The assembly of 044026 type sulfur composite/Li plastic packing batteries shows the advantage for the energy density over conventional Li-ion batteries.

12:45 Lunch on Your Own

NOVEL ELECTRODE TECHNOLOGIES TO IMPROVE SYSTEM PERFORMANCE II: PHOSPHATE BASED TECHNOLOGIES

2:00 $LiFePO_4$/Ionic Liquid-FSI/Graphite Safe Technology for HEV and PHEV Applications

Karim Zaghib, PhD, Institut de Recherches á Hydro-Québec, Canada

HQ technologies are based on using the low cost $LiFePo_4$-based material as cathode, natural graphite and LTO as anode. For the large scale battery use of ionic liquid based FSI anion and LiFSI as salt has great potential for this application; these ILs have no vapor pressure and no flammability. Only the FSI ionic liquids were found to be compatible with graphite. Electrochemical performance and Ragone plot will be shown and discussed.

2:30 Kinetics of the Phase Transition During Discharge of the $LiFePO_4$ Electrode

Jan L. Allen, PhD, Research Chemist, Sensors & Electron Devices Directorate, U.S. Army Research Laboratory

During discharge of a $LiFePO_4$ positive electrode based lithium ion battery, $FePO_4$ is converted to $LiFePO_4$. This electrochemical phase transformation has been investigated by use of kinetic modeling. The analysis gives insight into the dimensionality of the phase transformation and information about the rate determining step which can be useful for design of improved electrodes. Measurements at different temperatures allowed for an estimate of the activation energy for the electrochemical $FePO_4$ to $LiFePO_4$ transformation.

3:00 Small Magnetic Polaron Effect in $LiFePO_4$: The Key for Electrochemical Performance in Li-Ion Batteries

Christian M. Julien, PhD, Professor, Institut des Nano-Sciences de Paris, Université Paris6, France

The electronic structure of $LiFePO_4$ and delithiated $FePO_4$ is revisited, in the light of the previous calculations taking into account the Coulomb correlation potential for d-electrons. The nature of the optical transitions across the energy gap is investigated. In $LiFePO_4$, these are intra-atomic Fe^{2+}-Fe^{3+} transitions suffering a strong Franck-Condon effect due to the local distortion of the lattice in $FePO_4$, which an indirect evidence of the formation of small polaron. This is at contrast with the situation met in the much more covalent delithiated phase where the optical transition across the energy gap is associated to a transfer of electron from the p-states of the oxygen and the d-states of iron ions. The small polarons in $LiFePO_4$ are associated to the presence of Fe^{3+} ions introduced by native defects in relative concentration $[Fe^{3+}]/[Fe^{2+}+Fe^{3+}] = 3x10^{-3}$ in the samples known to be optimized with respect to their electrochemical properties. The nearest iron neighbours around the central polaron site are spin-polarized by the indirect exchange mediated by the electronic charge in excess. These small magnetic polarons are responsible for the interplay between electronic and magnetic properties that are quantitatively and self-consistently analyzed. *In collaboration with: A.Mauger, CNRS and F.Gendron, Université Paris6

3:30 Refreshment Break, Exhibit/Poster Viewing

4:00 Routes to Improve Lithium Iron Phosphate for Battery Applications

Margret Wohlfahrt-Mehrens, PhD, ZSW - Zentrum für Sonnenenergie- und Wasserstoff-Forschung, Germany

Lithium iron phosphate is a very attractive alternative cathode material for high power lithium ion batteries. This material exhibits advantages in terms of low raw material costs, long cycle and calendar life and excellent safety characteristics. Many efforts have been made to enhance the rate capability of $LiFePO_4$ by designing nano-particle or nano-structured materials, by coating with carbon or by doping the $LiFePO_4$. Recently, high power lithium ion batteries with $LiFePO_4$ as cathode material have been introduced to the market. The electrochemical performance depends significantly on the synthesis parameters and on the surface coating. In this study we discuss various routes to improve $LiFePO_4$ and their impact on power and life performance.

4:30 Chemical and Electrochemical Reactivity of Intermediate Li_xFePO_4 Phases

Thomas J. Richardson, PhD, Staff Scientist, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory

The role of intermediate phases in the interconversion of $LiFePO_4$ and $FePO_4$ has been a subject of considerable controversy. Although well-defined single phase solid solutions exist at elevated temperatures for all values of X, non-stoichiometry near the end members at room temperature has been seen in some samples and not in others. The results of a systematic investigation of the structures and reactivity of intermediate olivine phase will be presented.

5:00 Large Format Li-ion cells with $LiFePO_4$ Cathode Material

Kamen Nechev, PhD, Senior Scientist/Advanced Technology Manager, Saft Specialty Battery Group, SAFT

SAFT has developed $LiFePO_4$ technology for its defense markets. So far two cell sizes have been built and tested - 10Ah and 25Ah. It is well known to everyone in the battery community that large cells do not behave the same as small cells. The performance of these fairly large cells in terms of specific energy, power and life will be described. Comparisons with other standard Li-ion chemistries will be made. Behavior under abuse conditions will also be discussed.

5:30 Selected Oral Poster Highlights

5:45 Concluding Discussion, Closing Remarks, End of Conference

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